Annual Report

2005-06

Indian Institute of Tropical Meteorology

(An Autonomous Institute of the Ministry of Science and Technology, Govt. of India)

Dr. Homi Bhabha Road, Pashan, Pune - 411 008, Maharashtra, India

E-mail : lip@tropmet.res.in Phone : 91-020-25893600

URL : http://www.tropmet.res.in Fax : 91-020-25893825

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CONTENTS

Foreword

It is my great pleasure to present the Annual Report of the IITM for the year 2005-06. The progress reported in this Report is a culmination of the concerted efforts of all the employees of the Institute nurtured by the able guidance of my predecessor Dr. G.B. Pant during his tenure as Director up to 30 November 2005 and my colleague Dr. P.C.S. Devara, who shouldered the responsibility as Head of the Institute and looked after the current duties of the Director till I joined the IITM as Director on 1st June 2006.

The theoretical and modeling study of the climate system in general and Indian monsoon in particular and their variabilities complemented by in-situ observations and diagnostic studies is the backbone of the research of the IITM. The research results led to 61 papers published in peer reviewed journals together with 75 papers in books, reports and proceedings of conferences during the year. Highlights from the research are presented in the Annual Report. I would like to compliment my colleagues at IITM for some of the major contributions during the past year. Noteworthy amongst them are estimation of change in monsoon climate under different climate change scenarios using downscaling with a regional climate model, unraveling of air-sea interaction over the Indian monsoon region that may be responsible for long monsoon breaks and measurement of ion concentration and atmospheric electric conductivity over sea on board Sagar Kanya during the ARMEX period indicating that seasonally averaged values of total as well as polar conductivity are much higher during the monsoon than during the pre-monsoon season.

The year 2005-06 witnessed a number of significant events and activities. Worth mentioning is the organization and hosting of the Indo-UK Workshop on Regional Climate Change held during 23-27 January 2006. Another noteworthy event was the IGBP Workshop on Global Change and Annual Meetings and Joint Sessions of the Scientific Steering Committee (JSC) of the IGBP and WCRP, all held on different dates during 3-11 March 2006 that witnessed confluence of a galaxy of world leaders in various aspects of climate science. IITM had the honor to host the JSC of WCRP for the first time anywhere in Asia.

The Indian Institute of Tropical Meteorology (IITM), a relatively young Institution, started on 17th November 1962 as a research unit of the India Meteorological Department (IMD), became independent autonomous Institute on 1st April 1971. The mandate of the IITM is to carry out basic research in all aspects of tropical atmosphere-land-ocean system and to contribute to the improvement of the weather and climate

Visit of Shri Jagjit Singh Rana, Minister of Maharashtra State for Agriculture to the IITM on 27 August 2005 for discussions with the scientists regarding intense rainfall in various regions of Maharashtra during the monsoon season of 2005 and to formulate a system of early warning of such incidences, and visit of a Standing Parliamentary Committee on Science & Technology and Environment & Forests, Government of India on 27 September 2005 to assess and evaluate the working of the Institute were the important events of the year.

Several of our scientists received honours and awards in recognition of their outstanding performance in research output. Dr. G. Beig received the Norbert Gerbier Mumm International Award of the WMO for the year 2005 which was presented to him in a ceremonial function at Geneva, Switzerland. Several of the scientists have been working on the specialized committees and bodies of international repute.

IITM continued its collaboration with various scientific departments of the Government of India, universities, academic and research institutions in India and abroad. The scientists actively participated in various national and international multi-institutional observational programmes like STORM, CTCZ, ICARB, SCOUT-O3, etc. and collected valuable data for deeper understanding of various processes controlling weather and climate. Many of the scientists continued to provide consultancies and technical expertise in hydrometeorological studies and operational cloud seeding experiments to central and state government agencies and departments.

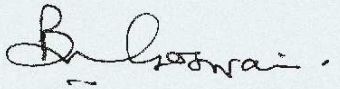
IITM has been benefited by a number of exchange visits of its scientists for meetings, conferences, brainstormings and specialized research collaborations in the country and abroad. A good number of scientists from other organizations visited the IITM, delivered lectures and had interactions with the scientists. IITM had research collaborations with several organizations of foreign countries.

IITM has been contributing significantly to the country's need for trained manpower in atmospheric and oceanic sciences. The M.Tech. Programme in Atmospheric Science jointly run with the University of Pune trains 10 students each year. In addition, projects of several M.Tech. students from Andhra University and Cochin University are guided at IITM. Five Ph.D.s were produced during the year. In order to improve the quality of students for our Ph.D. programme, the number of Research Fellowships was doubled to 21 in 2005. IITM also provided expertise to various academic Institutions and scientific organizations through specialized invited lectures of its scientists.

Several developmental programmes for improvement in the infrastructure were undertaken during the year by developing laboratories and adding sophisticated scientific instruments. However, a major need of a high performance computer with automatic storage and retrieval facility remains unfulfilled and will be taken up in next year. A facelift to the front portion of the office building by beautiful landscaping and construction of an ultramodern conference hall on the second floor of the library building have provided a pleasant and conducive atmosphere in the Institute.

IITM has inducted a fairly good number of young scientists and research fellows. Efforts are underway to provide them a good training in basic atmospheric science and in some specialized areas like modeling so that the IITM can have a large number of experts for the country's monsoon prediction programme and tackling the challenging research problems.

I express my sincere thanks to the Governing Council for its support and guidance to the Institute for its growth. I am thankful to all my colleagues for their devotion and dedication to work. I am confident that every one of the IITM family will exert and use all potential to improve IITM research, qualitatively as well as quantitatively, to place this Institute at a prominent place on the map of the World.



B.N. Goswami
Director

Highlights

Research

- Experimental forecasts of seasonal monsoon rainfall for the year 2005 using dynamical general circulation models and statistical models were provided to the India Meteorological Department (IMD) as an input for the preparation of national forecasts.
- IITM has taken a national lead in generating high resolution regional climate change scenarios for two time slices, one corresponding to the present (1961-1990) and the other for the future (2071-2100), using Hadley Center Regional Climate Model (PRECIS). These scenarios, developed based on the future projections of SRES GHG emissions, form the basis for the impact assessment studies being carried out by different research groups in India relating to agriculture, water resources, human health etc.
- Climate projections of summer monsoon precipitation during the 21st century under the radiative forcing of doubled CO_2 scenario were examined over South and East Asia from the outputs of coupled climate models under IPCC AR4. While some models projected a possible extension of the summer monsoon precipitation period into early autumn over South Asia, lengthening of the period from late spring through early autumn was projected over East Asia.
- Extensive Global Climate Model (GCM) sensitivity experiments conducted corroborated the hypothesis that the El Niæo events with warmer SSTs in the central Pacific produce much stronger droughts in India. This has significant implications for the seasonal forecasting of Indian summer monsoon rainfall.
- Hydrometeorological studies of various river basins at different regions in India were carried out to identify severe rainstorms, temporal distribution of design raindepths and estimates of probable maximum and mean seasonal precipitation.
- A coupled feedback between the tropical Indian Ocean circulation and the southwest monsoon winds, has been discovered, on sub-seasonal / intra-seasonal time-scales, which is pivotal in forcing long-lasting breaks in the monsoon rainfall over India and occurrence of droughts over the subcontinent. This new understanding should foster major improvements in the ability to predict the monsoonal rains on time-scales of days-to-weeks.
- Exceptional very heavy rainfall event over Santa Cruz on 26 July 2005 was studied using satellite data obtained from various national and international satellites viz. KALPANA-1, METEOSAT-5, DMSP and TRMM. Changes developed in visible-infrared imageries, deep convection, geophysical parameters and precipitation rates at different times of observations were studied one day before and one day after the event to observe drastic variations generated in meteorological parameters during complete life cycle of the event. The event was also studied using diagnostic and modeling approach. Large-scale synoptic scale system over India was found favourable for producing intense convection over the place and advection of moisture from the Arabian Sea.
- The 3-D ocean model study (MOM4) showed that the contribution of surface heat flux is significant in the initial phase of termination of eastern cooling during all the positive dipole years.

- Influence of anthropogenic emissions on tropospheric ozone and its precursors over Indian region during 1990s has been assessed using 3-D Chemistry-Transport Model with assimilated winds and new emission inventory of pollutants. Results indicated that during 90s, variation in ozone is of the order of 6-10% per decade near the surface, which becomes around 4-7% in the free troposphere. The maximum decadal increase in CO and NOx has been found to be around 10-18% and 20-30% respectively near the boundary layer.

- Data on ion concentration and atmospheric electric conductivity obtained over sea onboard Sagar Kanya during the ARMEX period showed that seasonally averaged values of the total as well as polar conductivity are much higher during the monsoon than during the pre-monsoon season. Variations of intermediate and large ion concentrations have been explained by postulating the generation of highly charged large ions by bubble breaking process caused by the breaking waves during the strong southwesterly surface winds in monsoon season.

Awards and Honours

- Dr. G. Beig received the Norbert Gerbier-Mumm International Award of the World Meteorological Organization for the year 2005 in a proclamation ceremony at Geneva, Switzerland on 29 June 2005 on behalf of all the co-authors for their paper entitled, **Review of mesospheric temperature trends,** published in the journal Review of Geophysics, December 2003.

- Dr. Nityanand Singh received the 13th SAARC (South Asian Association for Reginoal Cooperation) Regional Award for Young Scientists - 1995 for the sole-authored paper **'Optimizing a network of raingauges'** over India to monitor summer monsoon rainfall variation, published in International Journal of Climatology, volume 14, 1994, 61-70. The Award received in April 2005 consisted of citation, cash prize and a medal.

- The paper entitled, '**Long lead predictions of Indian summer monsoon rainfall from global SST evolution'** by **A. K. Sahai, A.M. Grimm, V. Satyan** and **G.B. Pant** published in Climate Dynamics, Volume 20, 2003, 855-863 received the 16th IITM Silver Jubilee Award for the year 2003.

- The paper entitled **'Atmospheric electric conductivity and the aerosol measurements during the fog over the Indian Ocean',** by **C.G. Deshpande** and **A.K. Kamra** published in Atmospheric Research, Volume 70, 2004, 77-87, has been adjudged for the 17th IITM Silver Jubilee Award for the year 2004.

- Dr. Devendraa Siingh has been awarded the Fellowship by the Department of Science and Technology (DST), Govt. of India under the Better Opportunities for Young Scientists in Chosen Areas of Science and Technology (BOYSCAST) Programme in the field of 'Long range transport of air pollution' at the Institute of Environmental Physics, University of Tartu, Tartu, Estonia.

- Shri S. Mahapatra was awarded the Second Prize for Overall Performance in the Second SERC School on Aviation Meteorology with Special Emphasis on Thunderstorms and its Modeling, at the hands of Air Marshal B. N. Ghokhale (AVSM, VN) of Indian Air Force, Air Force Administrative College, Coimbatore during 9 - 28 May 2005.

- Dr. P.C.S.Devara has been elected as Fellow of the Maharashtra Academy of Sciences.

- Dr. G. Beig has been nominated as a Reviewer by the United Nations Environment Programme (UNEP) of the World Meteorological Organization (WMO) for the Scientific Assessment of Ozone Depletion, 2006.

Events

- Shri Jagjit Singh Rana, Minister of State for Agriculture, Government of Maharashtra visited the Institute on 27 August 2005 for discussion with the scientists of the Institute regarding intense rainfall in various regions of Maharashtra and to formulate a system for early warning of similar incidents.
- Parliamentary Standing Committee on Science and Technology, Environment and Forests visited the Institute on 27 September 2005.
- Institute celebrated its 44th Foundation Day on 17 November 2005.
- Institute has signed a Memorandum of Understanding (MoU) with The Energy and Resources Institute (TERI), New Delhi to provide consultancy services on climate change scenario development as part of a World Bank sponsored study on vulnerability assessment to climate variability and change.
- Institute participated in the Science Expo-2005 at Nehru Science Centre, Worli, Mumbai during 23-27 November 2005 and in the Multimedia Campaign conducted by the Media Units of the Ministry of Information and Broadcasting in Maharashtra at Karad during 26 - 30 December 2005, and organized a Scientific Exhibition, Scientific Films and Power Point Shows on the research activities of the Institute at both the events.

Organisation of Seminars, Symposia, Conferences, Workshops and Meetings at IITM

- Third Meeting of Advisory Committee of the Department of Science and Tecnology, Govt of India on WP/RASS on 18 May 2005.
- Two Brain Storming Sessions in the areas viz., (i) Numerical Modelling for Weather and Climate, and (ii) Observational Studies of Cloud Physics, Aerosols, Trace Gases and Boundary Layer including Atmospheric Convection were organised on 19 and 20 July 2005 respectively.
- First Meeting of the Working Group III: Computing and Human Resources of the Department of Science and Technology, New Delhi was held on 23 September 2005 under the Chairmanship of Dr.G.B. Pant, Director.
- One-day Brain Storming Session on Urban Aerosol Climatology was organised on 25 November 2005 at the IITM-Delhi Branch, New Delhi to review and discuss various experimental as well as modelling techniques for better understanding and characterization of aerosols and their effects.
- 2nd Workshop on WP/RASS of the Department of Science and Technology, Govt. of India was held on 28 November 2005. The workshop was devoted to applications of WP/RASS datasets.
- National Seminar on Indian Climate: Past, Present and Future was organised on 29 November 2005.
- A Steering Committee Meeting on Composition of Asian Deposition (CAD) was held during 4-5 December 2005.
- UK-India Workshop on Regional Climate Change, Variability and Impacts: Scientific Perspectives was hosted and organised during 23-27 January 2006. The Workshop was sponsored by Department of Science and Technology, Govt. of India, British Council and Royal Society, U.K.
- International Geosphere Biosphere Programme (IGBP) Workshop on Global Change was hosted and organised on 3 March 2006.

- A Scientific Steering Committee (SC) Meeting of the IGBP was held during 4 - 7 March 2006.
- A Joint Session of the SC-IGBP and JSC-WCRP Meeting was held during 6 - 7 March 2006.
- Joint Scientific Committee - World Climate Research Programme (JSC-WCRP) Meeting was organised during 6-11 March 2006.
- Annual Workshop–Monsoon 2005 jointly with the India Meteorological Department under the aegis of the Indian Meteorological Society - Pune Chapter (IMSP) was held at the Central Training Institute, India Meteorological Department, Pune on 23 December 2005.
- First Meeting of the Scientific Steering Committee (SSC) of the National Project CTCZ Continental Tropical Convergence Zone) of the Department of Science and Technology, Govt. of India was organised during 20-21 January 2006.

Infrastructural Development

- Dual Polarization Micro Pulse LIDAR facility has been acquired and installed in the Institute. This is a unique mobile LIDAR system for investigating aerosol-cloud-climate interactions to understand the impact of aerosols and clouds on weather, climate and hydrological cycle. It has real-time-mode (unattended) operation with ultra-high space-time resolution data that can be used for aerosol characterization, cloud composition, atmospheric dynamics and wave activity studies covering from surface to about 120 km.
- Laser Raman Spectrometer, a double monochrometer spectrometer has been installed at the Institute to investigate the molecules present in a particular sample and chemical composition of aerosols collected from different atmospheric conditions.
- An automatic sun tracking sun/sky radiometer (Prede Model POM-01L) has been installed at the IITM New Delhi Branch to monitor aerosol optical properties at the urban location under the ICARB Campaign.
- A Hydrometeerological Laboratory has been developed with lastest computational factilities.
- A state of art Conference Hall with all the latest presentation facilities and internet connectivity has been built on the second floor of the Library Building.
- Students' Hostel of the Institute has been renovated and named as "Prof. R. Ananthakrishnan Students' Hostel."

Special Field Observational Programmes

- A Field Experiment was organized in the Nilgiri Forest Region, Bangalore during 21-28 May 2005 for tree-ring sample collection.
- Institute scientist participated in a coordinated experimental programme as a part of Stratosphere Climate Links with Emphasis with the Upper Troposphere Lower Stratosphere (SCOUT-O3) initiated by the European Union and coordinated by the Cambridge University, U. K.
- Extensive Field Campaigns were arranged to monitor the levels of ozone and its precursors (NOx, CO) in the vicinity of sugar factories and background site during 13 - 23 January 2006.
- Institute scientists participated in the ISRO – GBP Programme of Integrated Campaign for Aerosols, Gases and Radiation Budget (ICARB) organized for two months from 18 March 2006. Marine, land and airborne measurements were arranged onboard ship, at the Institute and on an instrumented aircraft respectively.

Overview

Forecasting Research

Forecasting Research Division has formulated its research programmes for understanding and prediction of the monsoon rainfall on short, medium- and long-range time scales and also for understanding and prediction of meso-scale systems including tropical cyclones. Following are the objectives of the Division:

- Study of mesoscale systems and mesoscale modelling.
- Study of planetary boundary layer characteristics using LASPEX and BOBMEX data.
- Application of satellite data in weather forecasting
- Inter-annual and decadal scale summer monsoon variability over India and its association with El Nino Southern Oscillation, North Atlantic Oscillation, and Indian Ocean Dipole / Zonal Mode and Tele-connections of monsoon variability over South and East Asia.
- Evaluating coupled climate model simulations.
- Study of energetics of waves and wave to wave interaction.
- Study of secondary heat sources.

Numerical Weather Prediction Research and Meso-scale Modelling

(S.S. Vaidya, J. Sanjay, D.K. Trivedi,
P. Mukhopadhyay, S. Joshi, S. Taraphdar)

Simulation studies of weather systems

Simulation studies were carried out for two weather systems viz., a pre- monsoon thunderstorm at Machallipattanam (2 June 2005) over east coast of India and a weak cyclonic circulation associated with feeble low pressure area over south peninsular India during 12-15 April 2001. Two sets of forecast results were obtained, one using Advanced Regional Prediction System (APRS) Model and the other using Weather Research and Forecast (WRF) Model. The model performances were compared by examining the predicted parameters like mean sea level pressure, wind, moisture fields and rainfall. The rainfall prediction was assessed qualitatively by comparing the spatial distribution with satellite cloud images and quantitatively by comparing rainfall rates with Tropical Rainfall Measuring Mission (TRMM) products and/or the observed station values reported in the Indian Daily Weather Reports. It was found that in case of idealized simulation of thunderstorm, APRS Model predicted well the spatial distribution of rainfall which is consistent with the clouding in satellite cloud images. It also simulated the diverging winds at lower levels associated with downdraft producing meso-high during mature/dissipation stage of thunderstorm which is a characteristic meso-scale feature. WRF model failed to predict these features. In case of a weak cyclonic circulation simulation experiment, APRS model was able to simulate the rainy area better compared to those produced by WRF model. Both the models failed to produce the observed heavy precipitation rates.

Idealized simulation of tropical cyclone

The MM5 model was utilized to study the influence of latitudinal effect, b- effect, environmental flow and its vertical shear on the idealistic simulation of a tropical cyclone. A very weak vortex was created using empirical relation with coriolis parameter corresponding 10^{o} latitude. The whole model integration domain was considered as ocean with sea surface temperature of 30^{o} C. Initializing with this vortex the model was integrated with 50 km horizontal resolution for 5 days. While simulated on an f-plane, the model simulated vortex remained practically stationary and reached the intensity

of very severe cyclonic storm after the 5 days of integration. When the model was integrated with coriolis parameters corresponding to the grid latitudes, the simulated cyclone moved northwestward as expected from the b- effect. To study the impact of origin of latitude, the vortices were created with coriolis parameters corresponding 5°, 10° and 15° latitudes. Although there was no significant change in the simulated intensity of the cyclones, but the vortex initialized at higher latitudes produced a little stronger cyclone.

Validation of short range precipitation forecasts using a new gridded dataset

Precipitation fields from the Pennsylvania State University - National Center for Atmospheric Research (PSU - NCAR) fifth generation Mesoscale Model (MM5) were validated with a new gridded precipitation analyses over the Indian region for July 1998. The main goal of this study was to understand how the precipitation forecasts from a mesoscale model were useful for estimating temporal variability in regional precipitation. The newly gridded analyses on 1° latitude - longitude grid was based on a large number of daily rain gauge station records over the Indian land mass and on satellite derived precipitation estimates over the adjoining oceans. The performance of three commonly used methods for gridding rain gauge station observations was compared forJuly - August 1998. The Cressman analysis was found to be relatively better choice for preparing gridded precipitation analyses. Short range (one day) precipitation forecasts from MM5 at 50-km resolution, initialized using the Japan Meteorological Agency–Global Energy water Experiment (GEWEX) Asian Monsoon Experiment (JMA - GAME) reanalysis data, were compared with this newly gridded precipitation data set. The temporal variability in MM5 forecasts was found to be relatively better over central and southern India. The MM5 forecasts were found to have good skill for moderate precipitation categories (less than 4 cm/day) **(Fig. 1)**.

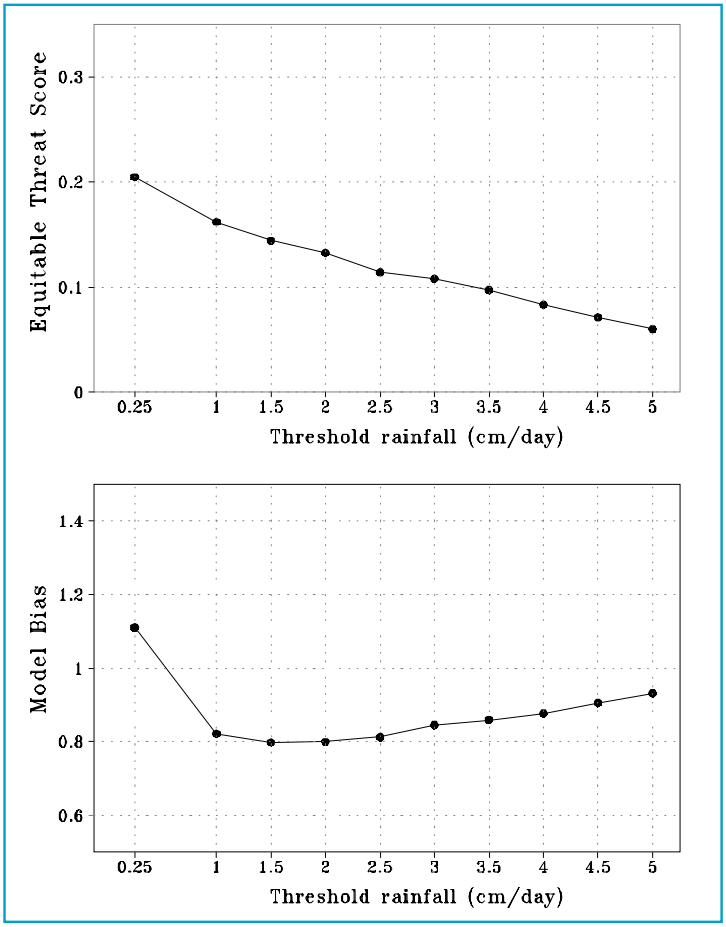


Fig. 1: Precipitation statistical scores for MM5 Day-1 forecasts during July 1998 for various grid box precipitation thresholds: Equitable Threat Score (top) and Model Bias (bottom).

Diurnal variations over Indian region in reanalysis data

The performance of diurnal variations in the 6 hourly National Center for Environmental Prediction (NCEP) - Department of Energy (DOE) reanalysis -2 was studied for two contrasting seasons during a good (1998) and a bad (2002) monsoon year. Preliminary results indicated that the reanalysis data are able to reproduce the diurnal variations in both the years reasonably well in near surface parameters. It was found that the surface air temperature diurnal anomalies over the land are depicted well by the reanalysis, with larger amplitudes for weak monsoon conditions **(Fig. 2)**.

For mean sea level pressure, the semidiurnal variations were found to be dominant, although the amplitude seemed to be slightly overestimated. The study would be very useful as the diurnal variations in this data set over Indian region have not been discussed previously even though reanalysis data have been widely used for monsoon research.

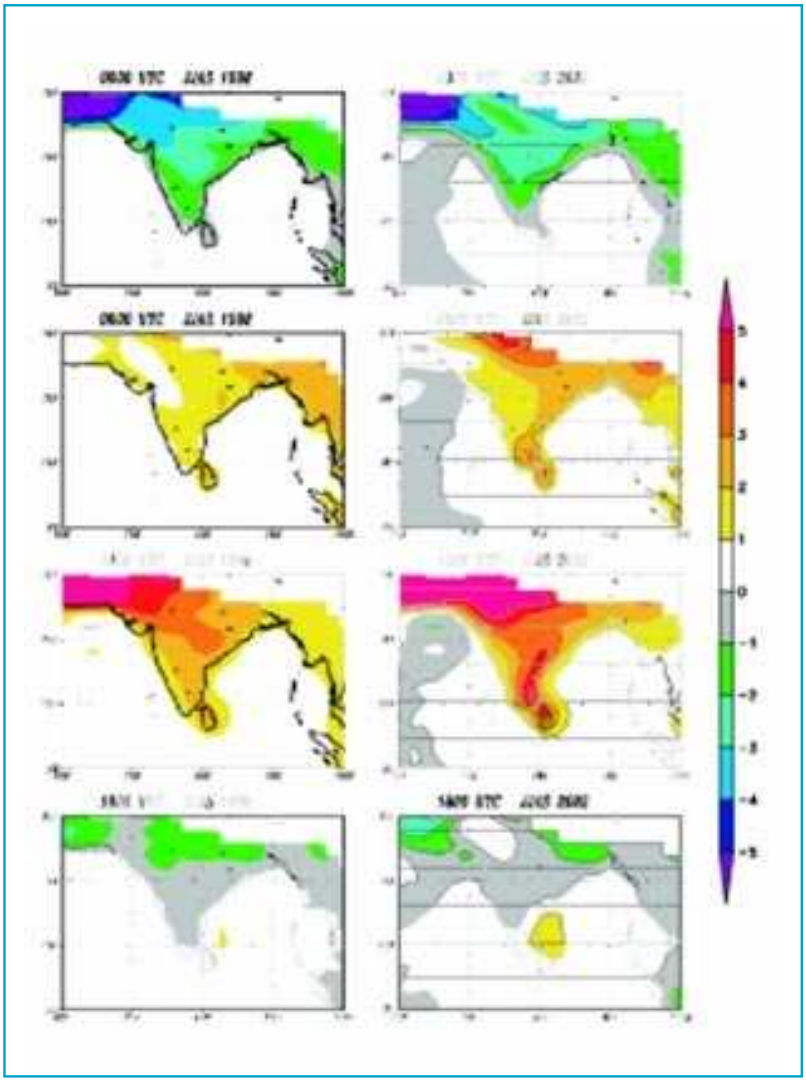


Fig. 2: Mean diurnal anomalies (relative to daily mean) of JJAS 1998 (left) and 2002 (right) for 2-m air temperature (°C) at 0000, 0600, 1200 and 1800 UTC from NCEP-DOE reanalysis data sets.

Study on Nor'westers of Gangetic Bengal

Nor'westers are the thunderstorms that appear during pre-monsoon months over Gangetic Bengal. Extensive study was carried out to identify and analyse the stages of formation, maturity and dissipation of the systems, track of the system and spatial and temporal distribution of the precipitation caused by the systems. The hourly Doppler Radar observations were utilized for the Nor'wester events of 16 April, 30 April and 8 May 2003. At the noon time (0600 UTC) the deep convection is found to initiate over Bihar plateau and this initial indication of intense convection is generally detected by satellite observation as the location is out of range of Doppler radar. It was found that the systems reach maturity during 0900~1100 UTC and start dissipating during 1200~1400 UTC. It was also found that the systems cover a distance of 250~ 300 km with in 6 hours with an average speed of around 50 km/hr. At maturity the Doppler radar showed the deep convection reaching a height of 16~18 km. The storms were also found to have split into two during dissipative stages and one of the two splitted storms move subsequently towards Bay of Bengal and the other towards Bangladesh. Storms were found to either come from west originating from Orissa and otherwise from northwest getting originated from Bihar plateau. It was conclusively shown that the Doppler radar observations are able to capture in great detail the life cycle and the internal structure of the systems. The composite of Doppler and satellite observations are able to resolve the details of these mesoscale events which otherwise remain unknown to us. This approach can be utilized for early detection and warning of these severe weather systems over Gangetic Bengal.

Study of heavy precipitation event

Simulation of Mumbai heavy rainfall precipitation (944 mm) during 26-27 July 2005 was attempted with non-hydrostatic version 6.0 of Regional Atmospheric Modeling System (RAMS). The model was run in two nested grid of horizontal resolution 48 and 16 km respectively. TheNCEP operational six hourly analyses at 1° x 1° resolution were utilized to initialize the model. The model was run for 48 hours starting from 0000 UTC of 26 July. The model produced temperatureand humidity profiles matched wel with the observed profiles. The model simulation showed heavy rainfall activity (> 100 mm) along the west coast and ~110 mm of accumulated rainfall around Santa Cruz. The time section of simulated rainfall showed that the heavy rain starts at around 1200 UTC and continued till 0000 UTC of 27 July.

Extended Range Weather Prediction Research

(R.H. Kripalani, S.S. Dugam, S.D. Bansod, A.A. Kulkarni, N.V. Panchawagh, S.B. Kakade, S.S. Sabade, S.R. Inamdar)

Response of the Asian monsoon to doubled atmospheric CO_2: coupled climate model projections

The South (in particular India) and East Asian (in particular China, Japan and South Korea) summer monsoon precipitation variability is examined from the simulated 20th century and projected 21st century outputs of the 22 coupled climate models performing coordinated experiments leading to the Intergovernmental Panel on Climate Change 4th Assessment Report (IPCC AR4). Future projections under the radiative forcing of doubled CO_2 scenario were examined using the multi-model ensemble technique.

Six models viz., CGCM3.1 (Canada), CNRM-CM3 (France), ECHAM5/MPI-OM (Germany), MIROC3.2 hires (Japan), MIROC3.2 medres (Japan) and UKMO-HadCM3 (UK) that generate the most realistic 20th century monsoon climate over South Asia projected an average increase in monsoon precipitation of 8.2%. Models also suggested possible extension of monsoon period into early autumn.

Projections over East Asia based on multi-model ensemble of 19 models revealed an average increase in mean summer monsoon precipitation of 7.8%. Models suggested a possible lengthening of the summer monsoon precipitation period (late spring through early autumn).

Extreme monsoons over East Asia: possible role of Indian Ocean zonal mode

Influence of the Indian Ocean Zonal Mode on the extreme summer monsoon rainfall over East Asia (China, Korea, and Japan) was investigated applying techniques of correlation and composite analysis. Results revealed that the positive phase of this mode enhances summer monsoon activity over China, but suppresses the monsoon activity over Korea-Japan sector 3 to 4 seasons later. The relationship was found to be more consistent and stronger over the Korea-Japan region than over China.

The connections between Indian Ocean and the East Asian monsoons could be established through two channels via the northern Eurasian region or via the southern Indonesian through flow sector. The anomalous heating over the Indian sub-continent could modulate the occurrence of an anomalous anticyclone northwest of India by a Rossby-type response to the tropical heating located off the equator (Gill 1980). This anomalous anticyclone could perturb the flow in the mid-latitude westerlies and induce a response downstream through zonal Rossby wave propagation.

To examine the above scenario composite differences for the 500 hPa geopotential heights during the autumn of the 5 extreme zonal mode events and for the winter, spring and summer seasons following these extreme events were computed and presented in **Fig. 3**. Composite differences were prepared for the positive minus negative events.

The positive anomalies north of 40° N and west of 40° E (SON0 panel) indicated subsidence as suggested by Rodwell and Hoskins (1996). The main feature of the winter season (DJF+1 panel) was the intensification of the Aleutian low as was evident by negative height anomalies centered around 40° N 150° W. During the spring season (MAM+1 panel) a well-organized Rossby wave-train structure prevailed over the northern hemisphere mid-latitudes with alternate negative and positive anomalies emanating from western Eurasia. The summer season (JJA+1 panel) suggested a diffused NPSH centered around 45°N 170° W.

Korea-Japan region is found to be under the influence of dry northerly winds inhibiting rainfall activity, consistent with the negative relationship between ZMI and monsoon rainfall over Korea and Japan. On the other hand the weak anomalous anticyclonic circulation centered around 20°N 120°E (JJA + 1 panel) strengthens the southerly low-level jet along the China coast transporting moist air from the Pacific into China and enhances the monsoon activity, again consistent with the positive ZMI/CMR relationship.

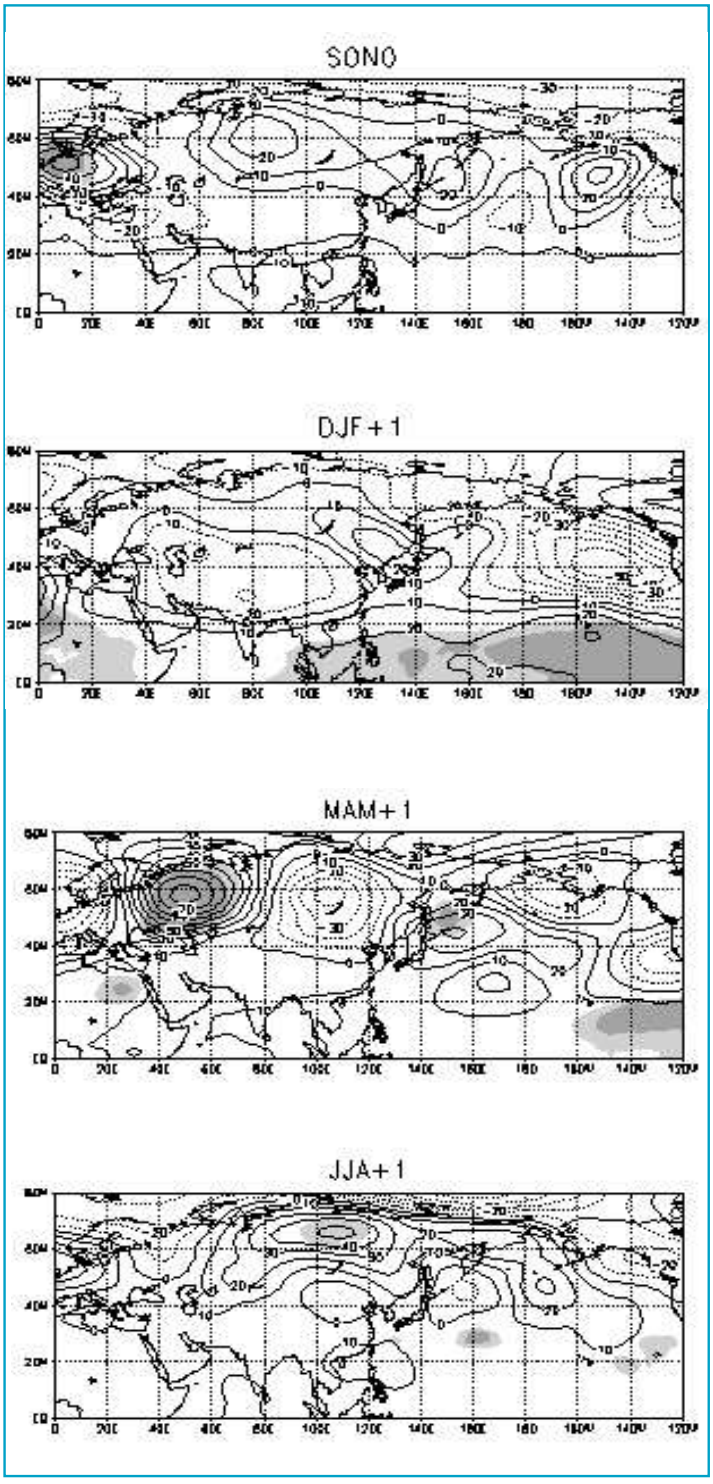


Fig. 3: Composite seasonal differences of 500 hPa geopotential heights in meters for the extreme zonal mode events (positive minus negative) for the autumn (SON0) and for the following winter (DJF+1), spring (MAM+1) and summer (JJA+1). Light (dark) gray shading illustrates the significance of the difference at 5 (1) % level.

Weather insurance with respect to rainfall

In a collaborative project with National Insurance Academy on "Wether Insurance with respect to rainfall" in Phase II, the crop insurance scheme has been developed for important crops like cotton, groundnut, jowar, bajra, maize, redgram, greengram, castor, tur, soyabean, paddy and sugarcane for 330 districts spread over Andhra Pradesh, Uttar Pradesh, Rajasthan, Karnataka, Maharashtra, Madhya Pradesh, Orissa, West Bengal, Assam, Bihar, Jharkhand, Chattisgadh, Kerala, Tamilnadu, Uttaranchal, Haryana, Meghalay and Gujarath. Two products viz., sowing failure and seasonal rainfall product were designed.

Mechanism of Indian Ocean Dipole – East Asian Monsoon connections: NCAR CAM simulations

The impact of the dipole mode on the summer monsoon variability over East Asia was investigated by dynamical approach. The Community Atmospheric Model Version 2 (CAM2) of the National Center of Atmospheric Research (NCAR) was used to perform the numerical experiments. These included the control run with climatological sea surface temperatures (SSTs) and two perturbed runs with SST distribution associated with the positive (warmer western equatorial Indian Ocean and cooler eastern Indian Ocean) and negative (cooler west and warmer east) phases of the dipole mode super-imposed on climatology.

Results revealed that the peak positive phase of the dipole during autumn induces heavy snow during winter / spring over eastern Eurasia north of the Korea-Japan sector and the heavy snow during spring suppresses the warming rate, transporting cold and dry air from north, weakening the cross equatorial flow and the East Asian summer monsoon circulation. This results in subdued summer monsoon rainfall activity over East Asia in particular over Korea-Japan, South China and the adjacent west Pacific region. The memory for delayed impact of the three seasons later is carried by the winter/spring snow over eastern Eurasia.

Association between mid-tropospheric geopotential heights and the Indian summer monsoon rainfall

The relationship between mid-tropospheric geopotential circulation over the Northern Hemisphere and Indian summer monsoon rainfall (ISMR) were examined using the monthly 500 hPa geopotential heights and the ISMR data for the period 1958 to 2003. The analysis demonstrated a dipole structure in the correlation pattern over the East Pacific Ocean in the month of January, which intensifies in February and weakens in March. The average 500 hPa geopotential height over the eastern tropical Pacific Ocean during February (index one) was found to have a significant positive relationship (r = 0.72) with the ISMR. In addition, the surface air temperature anomaly over North-West Eurasia during January (index two) was found to be strongly related with the subsequent summer monsoon rainfall. These relationships were found to be consistent and robust during the period of analysis and the indices were found to be independent of each other. In view of this, a multiple linear regression model was developed for the prediction of the ISMR using index one and index two and the empirical relationships were verified on independent data. The forecast of the ISMR, using the above model, was found to be satisfactory.

Studies on Monsoon and Tropical Weather Systems

(U.V. Bhide, M.Y. Totagi, V.R. Mujumdar, P.V. Puranik, S.M. Bawiskar, S.P. Ghanekar, M.D. Chipade)

Influence of ultra-long waves (waves 1 and 2) on the intra-seasonal variability of southwest monsoon

Analysis of the recent NCEP/NCAR wind (u, v) data for six years (2000-2005) showed that the daily rainfall over India during monsoon (1 June to 30 September) varies in phase with the lower tropospheric energetics of ultra-long waves (waves 1-2) over low latitudes **(Fig. 4)**. The study can be used as a complimentary tool for the operational short range forecast of the southwest monsoon rainfall over India.

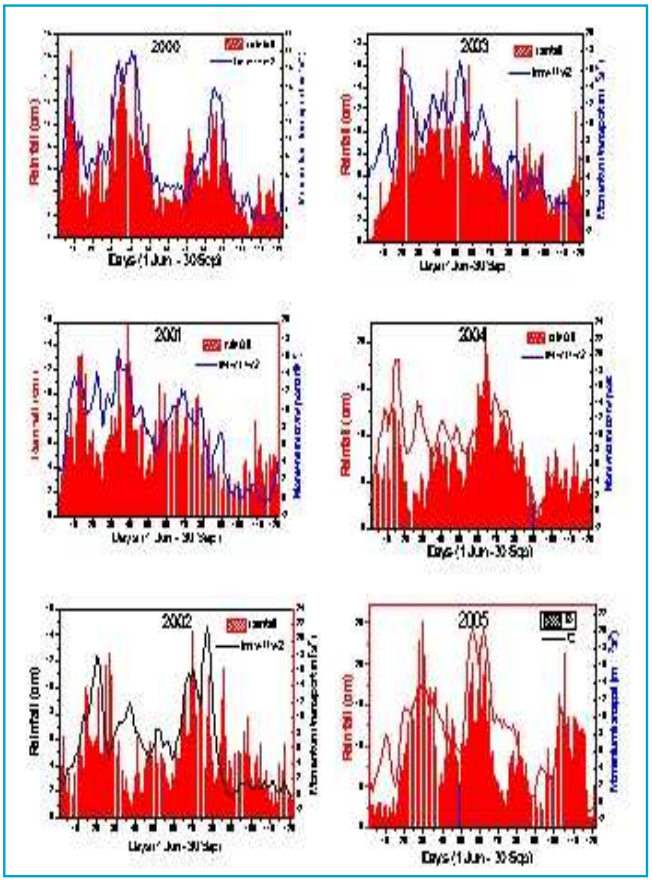


Fig. 4: Comparison of temporal variations of daily all India rainfall and daily momentum transport of waves 1 and 2 at 850 hPa at 10° N during monsoon season.

Large scale atmospheric turbulence and transport processes in the wave number frequency domain

To gain an insight into the contribution due to the motion of eddies of various sizes and frequencies, it is necessary to analyze the power and cross spectra of the large scale atmospheric motion and transports in the wave number frequency space.

A most generalized method was developed for analyzing the longitude-time spectra in the wave number frequency space. The governing equations for the computation of momentum, sensible heat and kinetic energy exchanges of the large scale atmospheric motions in the wave number frequency domain were derived. This method permits the analysis of the transient waves in terms of their length scale, phase speed and direction of motion and the relative importance of the forward and backward moving waves can be evaluated. Further, the linear and non-linear effects of velocity and temperature fields on the kinetic and internal energies, and the meridional transport of sensible

heat and angular momentum in the wave number frequency domain can be studied globally or for either of the hemispheres. Moreover, the wave number (space) domain and frequency (time) domain can become particular cases of wave number frequency domain.

Prediction of onset of monsoon for 2005

A regression equation was developed, to predict the date of onset of Indian summer monsoon over Kerala by using the information of the characteristic peak (observed to occur about 5 to 8 weeks prior to onset) in weekly cumulative thunderstorm frequencies over selected stations of south peninsula in the month of April. Based on the information available on operational mode (real-time basis) for April 2005, the onset date was predicted as 5th June which was exactly the same as observed date of the India Meteorological Department, i.e. with zero error. This technique can be used in operational forecast for the onset prediction on real time scale.

Influence of mid-tropospheric condition on active/weak monsoon

Comparison of mean profiles of relative humidity, qe and qes for moist ascent of the active and weak phases during BOBMEX-99 showed cooler and relatively less moist mid-troposphere weak phase (Phase II) suggesting suppressed convective activity.

Development of depressions in the Bay of Bengal

Analysis of the vertical time section over eastern and western India, for relative humidity, vertical velocity and vorticity during monsoon season of 1997, 1998, 1999 and 2002 revealed that the low pressure systems intensified into depressions over Bay of Bengal (ES) in presence of strong low level cyclonic vorticity and deep moist layers of atmosphere, preferably when the middle tropopsheric atmosphere of western part of India (WS) was relatively dry and had deep layers of subsidence. In absence of such an in-phase relationship only weak systems were observed to form over the Bay of Bengal.

Secondary Data Utilization Centre (SDUC)

The satellite cloud imageries received daily at SDUC were archived and displayed for weather updates. The onset, advance, established and withdrawal phases of monsoon 2005 as well as various weather systems formed during the season were monitored. The cloud images were utilized for "Current Weather Discussions" organized in the Institute during Monsoon 2005. Visitors including national and international media personnel, students of different schools, colleges, training institutes etc. visited the centre and seen the usefulness of cloud imageries in observing the general monsoon system and recent developments in the weather system of India.

Satellite Meteorology and Applications of Satellite Data in Weather Forecasting

(P.N. Mahajan, S.K. Sinha, R.M. Khaladkar, S. Nair, S.G. Narkhedkar, M. Mahakur, A. Prabhu)

Application of satellite data to climate research

INSAT IR pixel data for 15 May - 15 June 1999 and 15 May - 15 June 2001 were obtained from the India Meteorological; Department and processed. Outgoing longwave radiation (OLR) values were generated over the domain longitude 40^0 - 100^0 E and latitude 10^0S - 40^0N at 2.5 x 2.5 and 1.0 x 1.0 latitude/longitude grids for 1999 and 2001 respectively. The OLR values generated at the Institute were compared with the corresponding values of the India Meteorological Department. It was found that both the data sets match with each other in statistical sense and with OLR patterns. The work was carried out under the pilot project of ISRO entitled, "Application of satellite data to climate research". For this study past INSAT data would be processed and OLR data would be generated at better resolution.

Estimation of winds from satellite data

Winds were estimated using the METEOSAT-5 IR images obtained during 1st week of November 2004. Water vapour intercept method was used to apply semi-transparency corrections in the height assignment method using IR and WV radiances. The theoretical radiances for various heights at the opaque clouds were simulated from the NCEP/NCAR reanalyzed temperature and moisture profiles using a RT model.

Study of cyclonic storm

Sea surface wind speed and rainfall associated with a very severe cyclonic storm formed over Arabian Sea during 22-28 May 2001 was studied with the help of scatterometer (Quikscat) data and TRMM Microwave Imager (TMI) data. It was noticed that wind speed varied from 15 to 35 m/s in different stages of the cyclone. Winds of 15-20 m/s were noticed one day before the formation of low pressure system. At a very severe cyclonic stage, on 27th May 2001, strong winds of the order of 25 - 30 m/s were observed at about 250 km. from the centre of the cyclone in the south - west sector over the sea. Comparison of scatterometer winds with MSMR derived sea surface wind speeds over the same region showed that the scatterometer winds are stronger than the MSMR winds by about 10-15 m/s. Well organized convection was noticed from 22 to 26 May with Maximum rain rate of 16-20 mm/hr occurring in southern or southwest sector of the cyclone up to about 200 km.

Exceptionally heavy rainfall instance study

Exceptionally very heavy rainfall over Santacruz on 26 July 2005 was monitored using satellite data obtained from various national and international satellites viz. KALPANA-1, METEOSAT-5, DMSP and TRMM. Changes developed in visible-infrared imageries, deep convection, geophysical parameters and precipitation rates at different times of observations were studied one day before and one day after this event to observe drastic variations generated in the meteorological parameters during complete life cycle of this disastrous event. It was revealed from the satellite inputs that on 26 July integrated water vapour (60 mm), cloud liquid water content 0.3 mm), deep convection (85 W/m^2) and precipitation rates (50 mm/hr) were of maximum value in the region of vortex, when TRMM satellite was passing over Santacruz. Development and enhancement of the vortex over the off shore trough was available on 26th July only. Hence, satellite derived parameters observed on 25th and 27th July showed less magnitude as compared to 26th July. Results obtained from the integrated approach of multiple satellites certainly formulate effective strategy to take precautionary measures during the development of such disastrous event **(Fig. 5 and 6).**

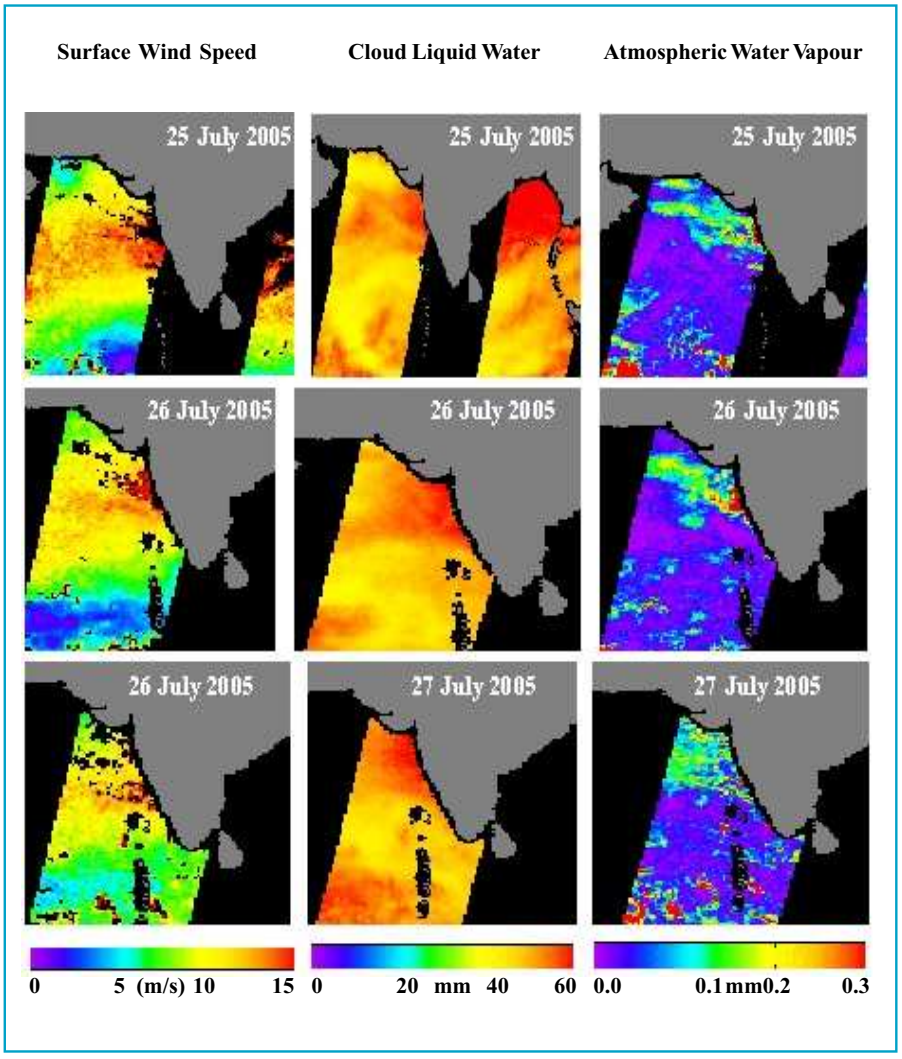


Fig. 5: DMSP F13 SSMI monitored variations in geophysical parameters during 25 to 27 July 2005

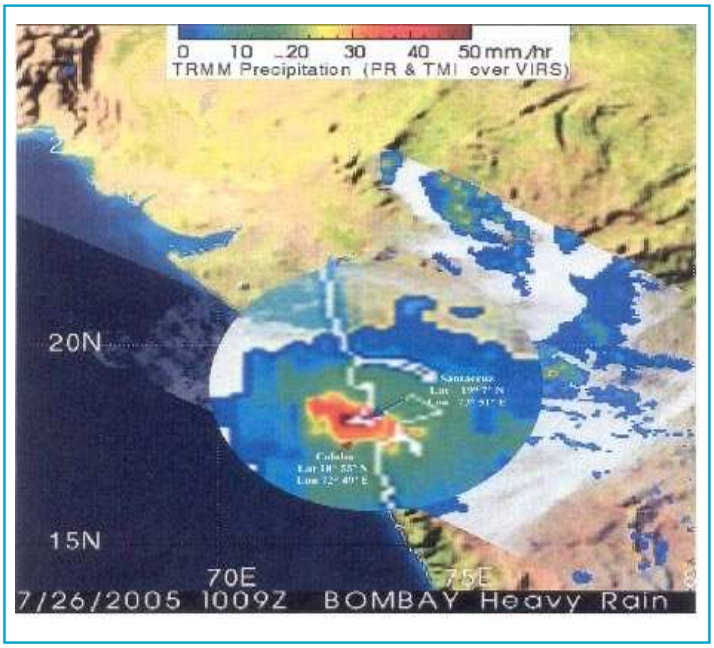


Fig. 6 : TRMM measured precipitation rates for excessive to very heavy rainfall event over Santacruz on 26 July 2005.

Mesoscale objective analysis of daily rainfall

A mesoscale objective analysis scheme for producing daily rainfall analysis on a regular latitude/longitude grid over the Indian monsoon region was used. The Barnes scheme was applied to interpolate irregularly distributed daily rainfall data on to a regular grid. The spatial resolution of the interpolated arrays was 0.25^0 of latitude X 0.25^0 of longitude. Daily rainfall derived from INSAT IR radiances and raingauge observations were combined to produce this analysis. Some objectively determined constraints were employed in this study. Weights were determined as a function of data spacing. In order to achieve convergence of the analysed values three passes through the data were considered and automatic elimination of wavelengths smaller than twice the average data spacing. The case of a typical westward moving monsoon depression during1994 monsoon season was selected to represent the characteristics of the analysed rainfall. Objective analyses of six days (16 to 21 August 1994) were carried out using Barnes three pass scheme. Weighting function scale length parameter (^{c} , denominator in the exponential Guassian weight function) was varied from over a range of values and the root mean square (rms) errors were computed to select the appropriate value of ^{c}. The value of the ^{c} depends on the number of correction passes being performed and on the density of the observations. The characteristics of the output field from this analysis system were examined by comparing the analysed rainfall with the observed values.

Air-Sea Interactions in Tropical Monsoons

(P. Seetaramayya, S. G. Nagar, T. Venugopal, S. Mahapatra, U. Iyer, G.R. Chinthalu, A.R. Dhakate)

Comparison of air mass characteristics of marine atmospheric boundary layer over southeast Arabian Sea during ARMEX-2003

ARMEX-2003 minisonde data (air temperature, dew point temperature and wind field) for the periods 23 March - 7 April 2003 (P1) and 23 May to 7 June 2003 (P2) were analyzed to understand the dynamical and thermodynamical characterristics of the air mass in the marine atmospheric boundary layer at a stationary position 9.22°N, 74.51°E in the southeast Arabian Sea (SEAS). At this location the mini warm pool (SST = 30°C) warming phase originates in March–April and spreads outwards subsequently. During both the periods no significant weather system was formed. The onset of monsoon over Kerala took place on 8th June (delayed by one week from its normal date i.e. 1st June). **Fig. 7** shows the vertical time section of wind vectors at the stationary location of the ship during P1 and P2. The wind field in general showed considerable fluctuations both in time and height. Comparison of the wind fields during P1 and P2 showed that the winds in the upper levels are stronger than those during P2, without much change in direction. During P1 the dry and cool northwesterlies prevailed below 850 hPa with a maximum speed of 4-8 m/s at 900 hPa, northeasterlies between 850-680 hPa with a jet speed of 14 - 16 m/s at 750 hPa. Similar wind patterns also prevailed during P2 but with less intensity. A sudden change in the wind structure occurred on 5th June with a lull in the upper levels and wind direction changing from northwest to southwest below 850 hPa. These southwesterlies were predominant on 6th and 7th June with a maximum wind speed of 10 - 14 m/s at 900 hPa. The wind field did not show any prior indication of the onset of monsoon except on 5th June.

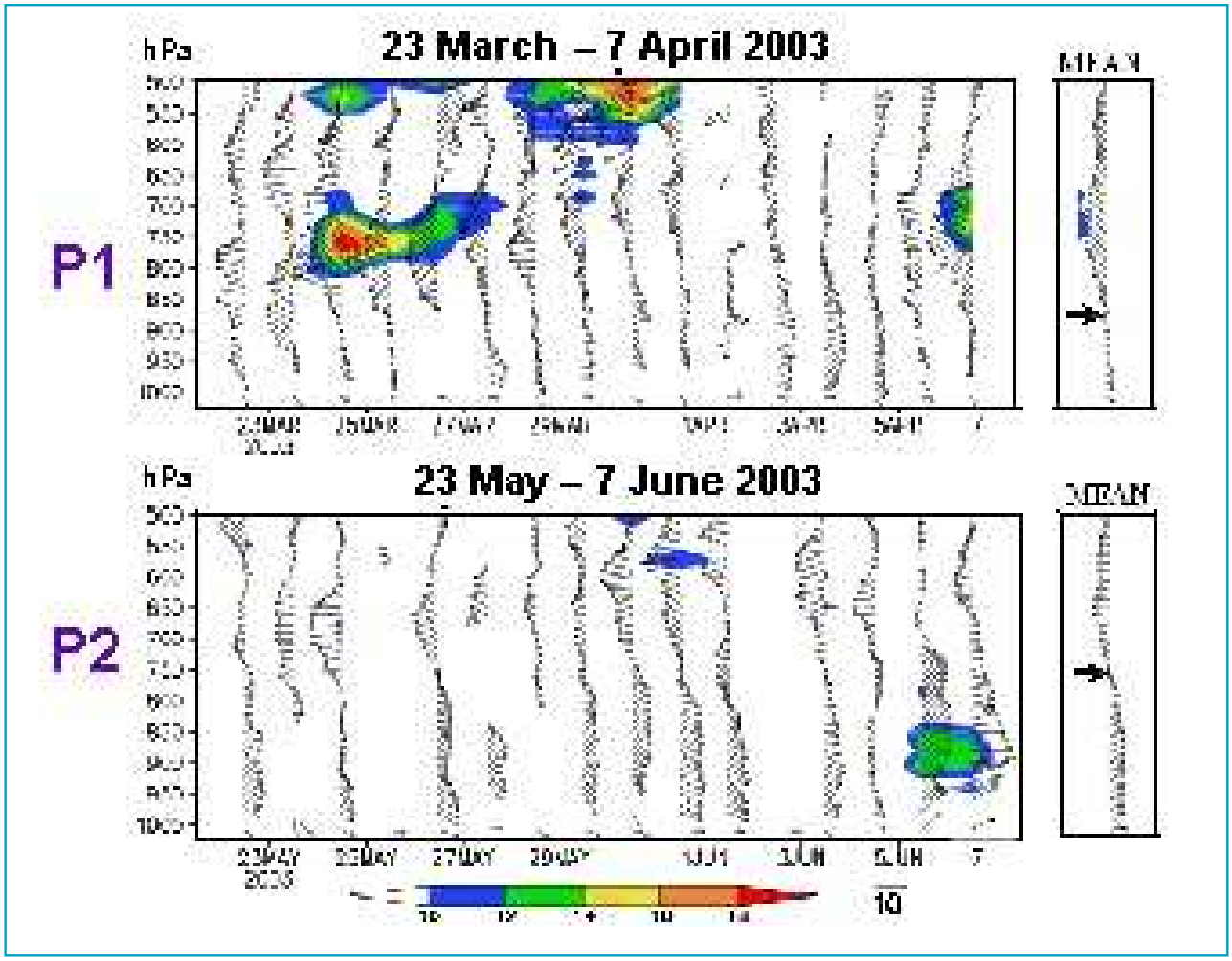


Fig. 7: Vertical Time Section of wind vectors over the stationary position at 9.22°N, 74.51°E in the southeast Arabian Sea during P1 and P2.

Fig. 8 shows the mean profiles of thermodynamic conserved variables (e.g. virtual potential temperature θ_v, equivalent potential temperature θ_e, saturated equivalent potential temperature θ_{es} and specific humidity q,) for P1 and P2. Based on these thermodynamic parameters, which are useful for identifying air-mass characteristics, the marine atmosphere was divided into different layers such as sub-cloud layer, cloud layer, inversion layer (IL), transition layer and the residual layer (via Fig.8). A minimum θ_e of 327.5 K (air mass of northern origin) was seen at 4.2 km (620 hPa) which represents top of the marine atmospheric boundary layer. The marine atmosphere showed dryness between 1 km and 3.5 km during P1. Whereas, substantial increase in moisture (2-3 g/kg), in association with a change in wind direction from northeasterly (in P1) to southwesterly (in P2) in the middle levels, with a minimum θ_e of 335 K (air mass of southern origin) at 2 km (800 hPa) was observed during P2. This value of 335 K was about 8 K higher than that during P1 (327 K) at that level. **Fig. 8** shows the closeness of θ_e curve to the vertical solid line of constant θ_e (340 K) is a measure for identifying incursion of moisture favourable for deep convection and the vertical dash line of constant θ_{es} (moist adiabatic) from the base of cloud is a measure of low level stability and convection properties. Multilayer clouds (Cu and Sc) were seen during P1. Whereas, during P2 even though there is an incursion of moisture in the atmosphere for deep convection to occur as seen from θ_e and θ_{es} profiles, a deficit in moisture existed which inhibited the formation of deep clouds over the stationary position of the ship.

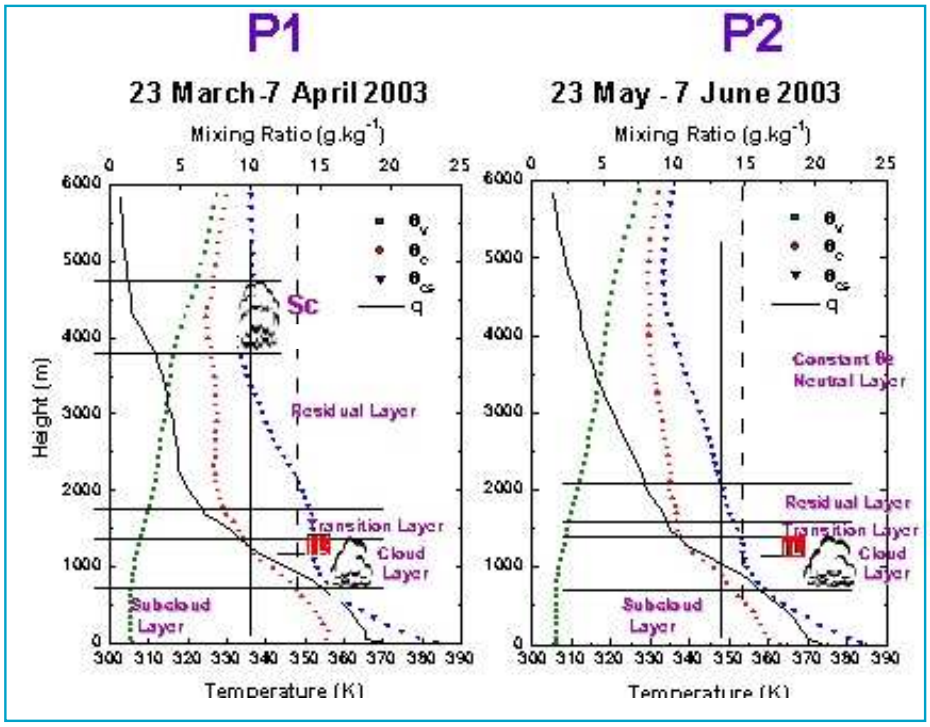


Fig. 8: Mean thermodynamic profiles during P1 and P2 at 9.22°N, 74.51°E in the southeast Arabian Sea during ARMEX-2003.

Study of divergence and vorticity fields in an unusually developed cyclonic storm over the Bay of Bengal during September 1997

A cyclonic storm developed close to the Andhra coast (within 1^0 from coastline) at 15^0N, 84^0E and moved parallel to the east coast of India over the Bay of Bengal during 23-26 September 1997. Very heavy rainfall of 40 cm was observed at Kakinada on 24 September 1997 when the system came close to the coast. The rainfall of 12-21 cm was recorded over the other coastal stations. Satellite imageries (INSAT 1D) were used to identify cloudy and cloud free areas. Divergence and vorticity were computed over the domain 5^0 - 25^0N, 75^0 - 100^0E for 19 - 26 September 1997 using NCEP reanalysis data. The analyses of these fields revealed that an intense active phase of this cyclonic storm was associated with strong convergence and cyclonic vorticity (implying upward motion) up to 500 hPa. The maximum value of convergence was $-8x10^{-6}$/s at 850 hPa and 500 hPa and $-7x10^{-6}$/s at 700 hPa. Similarly maximum value of cyclonic vorticity was $7x10^{-5}$/s at 850 hPa and 700 hPa and $6x10^{-5}$/s at 500 hPa. Further it was observed that in some sectors when rainfall was not observed, cloud free areas are associated with divergence and anticyclonic vorticity implying downward motion. The divergence and vorticity fields at different levels using the NCEP reanalysis wind data were found to help in forecasting the rainfall patterns over the cyclone domain.

Role of low level jet (LLJ) and precipitable water content (PWC) on the monsoon rainfall activity in July over Peninsular India

The NCEP / NCAR reanalysis data were used to analyze precipitable water content (PWC), meridional wind at the equator (cross equatorial flow) and vector wind at 850 hPa (Low Level Jet) to study the influence of these parameters on the monsoon rainfall in July over peninsular India for the two contrasting monsoons 2002 (drought year) and 2003 (normal year). The study revealed a sharp fall in PWC (from 47 to 38 kg/m^2) between 16 June and 1 July during 2002 whereas such sharp fall was absent (PWC~ 44 - 48 kg/m^2) in 2003.The PWC during July was much lower (38 - 44 kg/m^2)in 2002 than in 2003 (46 - 51 kg/m^2) which led to deficient rainfall (departure from normal rainfall - 51 %) in July 2002. Further, the cross equatorial flow was strong over east of 77°E during July 2002 which indicated that the moisture convergence was over the west Pacific region. In 2003, the cross equatorial flow was strong over west of 77°E during July 2003 which indicates that the moisture convergence was over west equatorial side. The weaker LLJ (10-13 m/s) was directed south of peninsular India which carried the moisture to the oceanic region rather than the Indian peninsular region whereas, in 2003 the stronger LLJ (15-25 m/s) carried the moisture over the Indian subcontinent resulting normal rainfall (departure from normal rainfall 7%).

Climatology and Hydrometeorology

Climatology and Hydrometeorology Division has formulated its research programmes which include advanced scientific research as well as useful rainfall and climatic information for practical purposes. Following are the objectives of the Division:

- To extend climatic records maximum possible backward in pre-instrumental era using high-resolution proxy sources such as historical documents, tree-rings etc. in order to study climatic variability on centennial scales.
- To better understand structure, physics and dynamics of summer monsoon as well as northeast monsoon circulation, identify their teleconnections and develop empirical predictive model for rainfall across India using instrumental, satellite-derived and NCEP/NCAR dataset.
- To assess numerical simulations of global climate using General Circulation Models (GCMs) with particular reference to simulation of the Indian summer monsoon; and to develop high-resolution future climate scenarios using appropriate empirical/dynamical downscaling techniques.
- To assess the impact of climate variability in various socioeconomic sectors like agriculture, water resources, human health etc. and to develop methodologies for optimal utilization of climatic information in these sectors.
- To develop longest possible homogeneous rainfall and temperature series for the whole country as well as different administrative, meteorologic, hydrologic and physiographic units using instrumental observations in order to document chief features of interannual and decadal variability of the climatic parameters, as well as tendency in occurrence frequency of extreme weather/climatic events.
- To determine time (hourly) distribution of rainfall amount during large-scale, heavy rain spells over the different river basins for various water resources applications.
- To identify severe rain spells using depth-area-duration (DAD) and depth-duration (DD) analyses for storm transposition and maximization in order to get reliable estimate of probable maximum precipitation (PMP) and probable maximum flood (PMF).

Regional Aspects of Global Climate Change and Variability

(K. Rupa Kumar, L.S. Hingane, H.P. Borgaonkar, A.B. Sikder, S.K. Jadhav, D.R. Kothawale, J.V. Revadekar, R. K. Yadav, S. Ram, K. Kamala, S.S. Bhandare)

Dendroclimatology

Western Himalaya

Tree growth and climate relationship was studied using tree-ring samples collected from high-altitude, near-glacier tree-ring chronologies. The Western Himalayan monthly anomalies of temperature and rainfall were constructed by applying response function analysis. The characteristic feature of response function analysis displayed similar patterns of positive response to temperature conditions during winter months to tree growth observed in all chronologies. No other season's temperature or rainfall showed such coherent relationship with tree-ring variations. Their response to winter temperature may be due to the winter warmth. A century long instrumental records of temperature over the region also indicated significant increasing trend in winter temperature during past few decades. The warm weather in winter may result in thawing of tissues leads to affect the subsequent growth which gives positive relationship between winter temperature and tree growth. Such significant higher growth in recent years was not observed in middle to low altitude chronologies of Himalaya which are away from the direct influence of the glacier activities. Records of glacial mass balance of six glaciers were used to correlate with tree-ring chronologies from Gangotri and Kinnor region **(Fig. 9)**.

General pattern of relationship between glacial mass balance and tree-ring variation was found to be inversely correlated. The mass balance data of Gara and Gor glacier were about 10 years, which was longest among the six glaciers. The positive mass balance of 1976, 1982, 1983 and 1989 clearly indicated corresponding low tree growth index and

negative mass balance of 1977, 1984, 1985, and 1987 correspond to higher tree growth index. The inverse relation was also observed with winter (October-February) temperature and glacial mass. This approach has been found to b e useful to study the positive and negative snow mass balance events in the past.

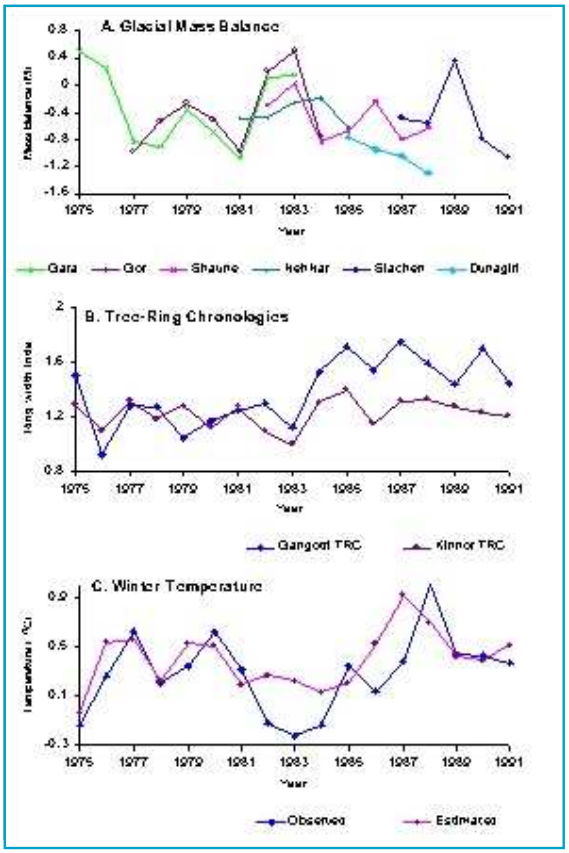


Fig.9: Relationship between glacial mass balance, tree-ring index and winter temperature over Western Himalaya.

Central and Peninsular India

Few tree-ring index chronologies of *Tectona grandis* (Teak) recently collected from central and peninsular India were prepared. **Fig. 10** indicates the longestliving teak tree-ring index chronology from Sunkham, Kerala (A.D. 1500 - 2003). Statistics of these chronologies showed moderately high value of mean sensitivity, common variance and signal to noise ratio. This indicated high dendroclimatic potential of the species. Correlation analysis shows negative association of pre-monsoon temperature and strong positive relationship with pre-monsoon and monsoon rainfall. These relationships were mainly related to availability of moisture which is a function of both temperature and precipitation. Pre-monsoon higher temperature creates severe moisture stress condition during the early phase of growing season of teak. However, it was seen that the small amount of precipitation during pre-monsoon is conducive for tree growth. Rainfall influences cambial activity in teak. Pre-monsoon showers break cambial dormancy, and higher rainfall contributes to a greater amount of wood formation.

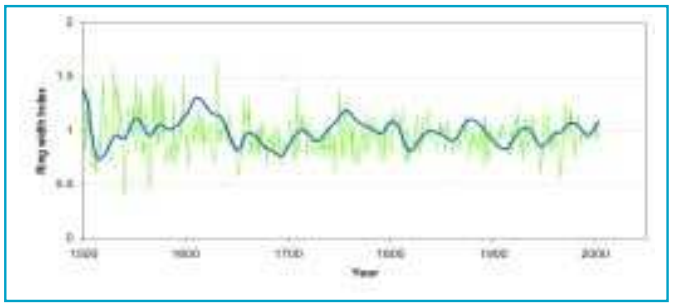


Fig. 10 : Teak (Tectona Grandus) Ring Width Index chronology, Sunkham, Kerala, South India (A.D. 1500 –2300).

Cyclonic disturbances in warming scenario

The PRECIS simulations for baseline (1961-1990) and for the warming scenario (2071 - 2100) were used to assess the effect of Climate Change on the frequency of monthly and seasonal cyclonic disturbances over the Indian region. The cyclonic disturbances were identified using the pressure departures at the centre of the disturbance and the low level winds **(Fig. 11).**

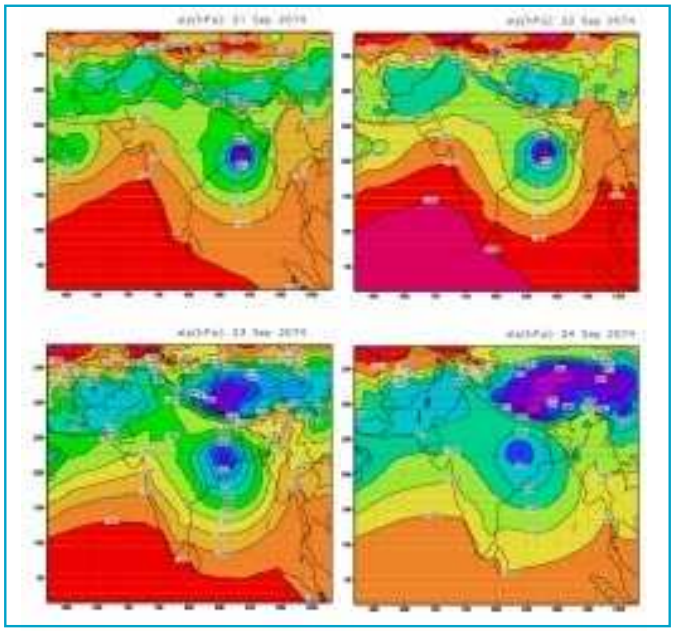


Fig.11 : A cyclonic storm simulated with PRECIS.

The analysis indicated that the cyclonic disturbances during monsoon season may be less frequent but more intense in the warming scenario.

Trends in frequency of occurrence of extreme temperature events over India

Extreme events such as hot days, cold days, hot nights and cold nights in daily maximum and minimum temperatures were identified using well spread 121 Indian stations for the period 1970-2003 during each winter and spring seasons and time series of extreme temperature events were constructed for all-India and 7 homogeneous regions. It was seen that during winter season, frequency of occurrence of hot days and hot nights shows significant increasing trend over most part of the country. Hot days (Figure 12) and cold nights significantly decrease over northern parts of the country. India as whole, cold nights decrease faster than cold days **(Fig. 13).**

During the spring season, hot days significantly increase over peninsular India whereas hot nights increase over most part of country except central part where hot nights significantly decrease **(Fig. 12).** There is no significant change in occurrence of colds days and cold nights over country except at few places where significant decreasing trends are observed. India as a whole, there is no statistically significant increasing or decreasing trend in occurrence of extreme events **(Fig. 13).**

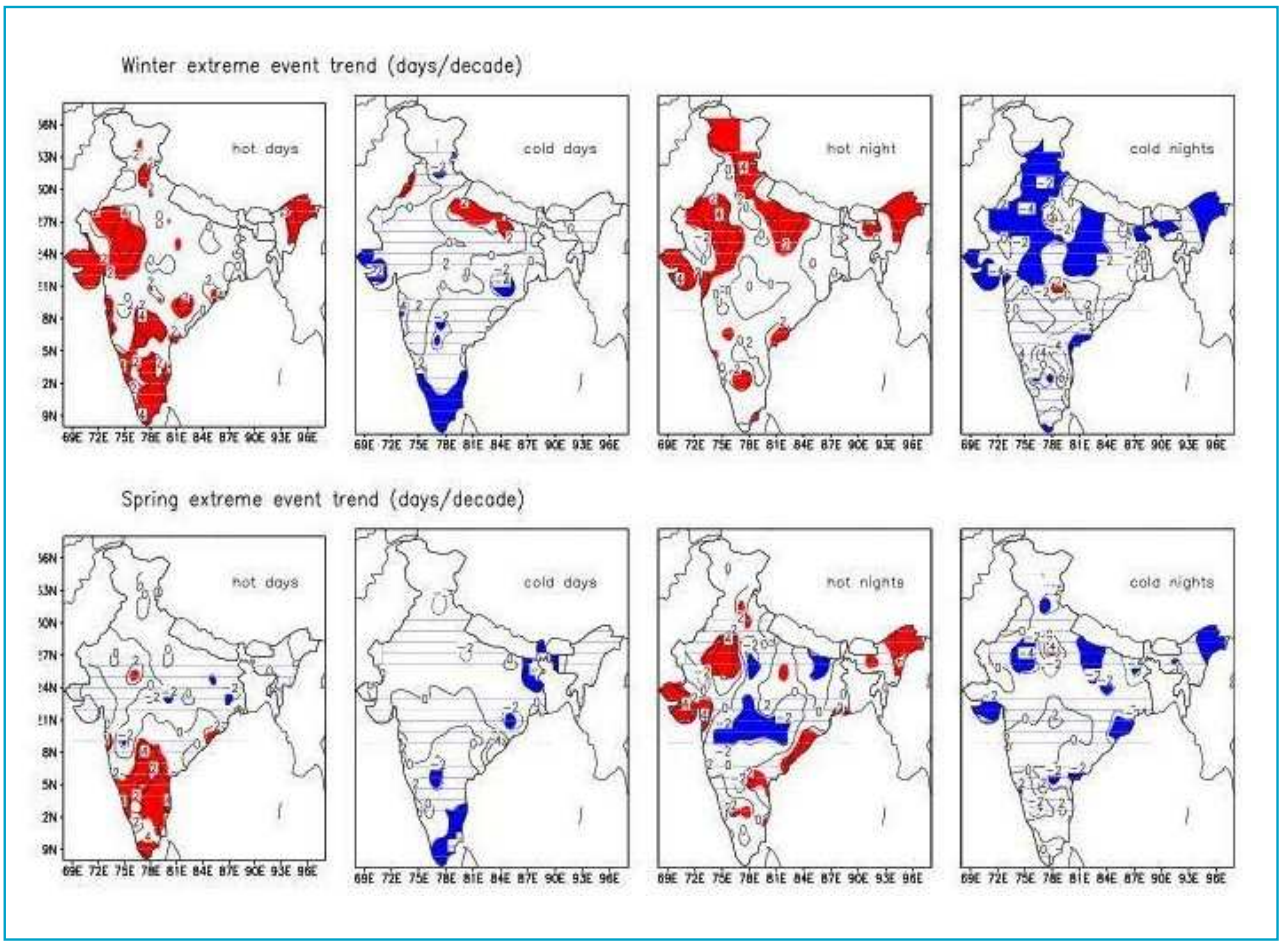


Fig. 12: Spatial patterns of trends in seasonal extreme temperature events (shaded area indicates trend significant at 5% level, red for increasing and blue for decreasing, 1970 – 2003.

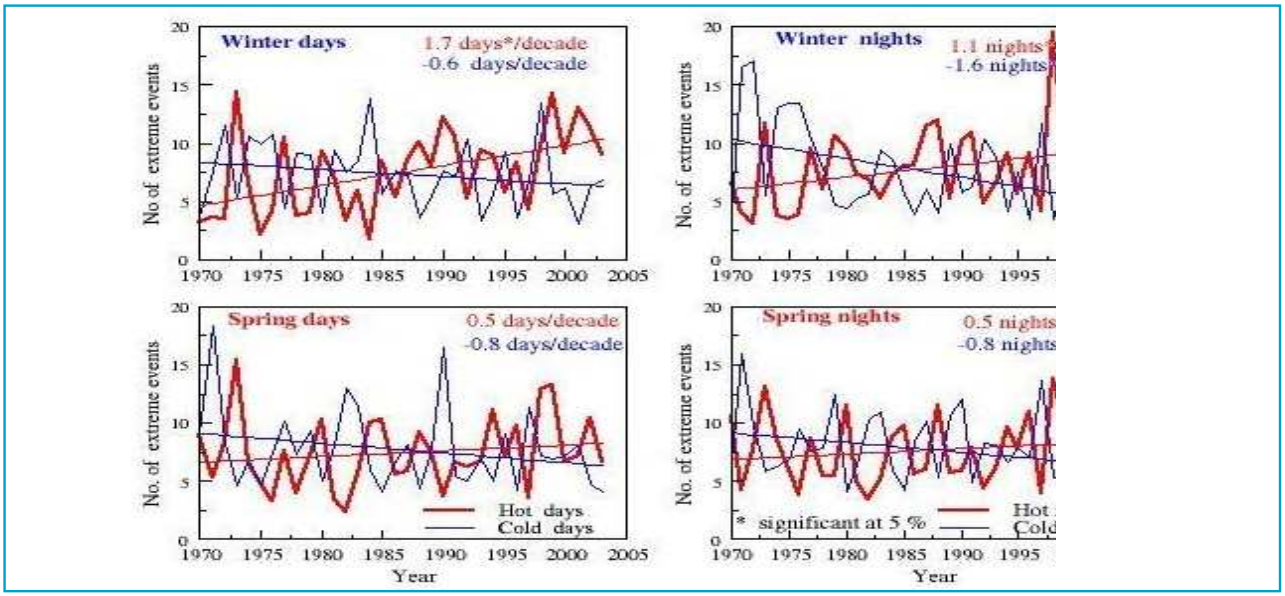


Fig. 13: Trends in occurrence of extreme temperature events over India.

Trend analysis of low pressure systems over the Indian region for the period 1891-2000

Occurrence of a closed low pressure area formed due to low, depression or cyclonic storm is termed as Low Pressure System (LPS). The intensity of LPS is categorized into two parts, one is only lows (LOW) and the other is depressions/storms (DDS). The days experiencing lows are named as LOW Days and the days experiencing depressions/storms are abbreviated as DDS Days. The time series was prepared for frequency and duration of LOW, DDS and LPS for the period 1891 - 2000.

In the context of global warming it is very much likely that there may be significant changes in the frequency and duration of LPS over Indian Ocean. In view of this, the LPS data sets were subdivided into two sub periods viz.1891 - 1945 and 1946 - 2000 and subjected to trend analysis by applying Mann-Kendall rank statistics test. In **Fig. 14** the fitted trend lines are shown for frequency of LOW, DDS and LPS for the periods 1891-1945 and 1946-2000. The LOWs showed significantly increasing trend by 0.95/10 years whereas DDS has significantly decreasing trend by 0.86 /10 years after 1946. Due to opposite trends in the frequency of LOWs and DDS, the time series of the frequency of LPS was found to be stationary. There is a significant increasing trend (5.9 days/10 year) in the duration of LOWs whereas duration of DDS is significantly decreasing (2.6 days/10 year) after 1946. The duration of LPS days is increasing at the rate of 3.4 days/10 year.

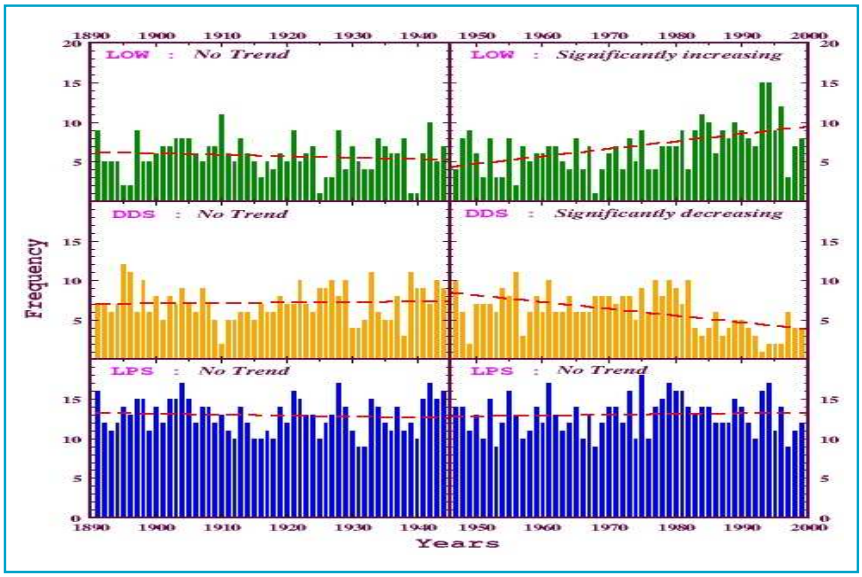


Fig. 14 : The frequencies of lows (LOW) have significantly increased while those of depressions/cyclonic storms (DDS) have significantly decreased during the southwest monsoon season for the period 1946 - 2000. The frequency of total low pressure systems (LPS) remained unaltered during the period.

Future climate change scenarios for India during the 21st century

Performance of the models in simulating the Asian summer monsoon climate over India to transient increase in future greenhouse gas and aerosols in the earth's atmosphere was examined using extensive data generated from the different coupled atmosphere-ocean general circulation models (AOGCMs) that are available at IPCC Fourth Assessment (AR4) model data portal performed at many centers of the country. Considering all the land-points in India according to the resolution of each AOGCM, the annual cycle as simulated by the different AOGCMs for the 20 th century has been calculated. The mean monsoon rainfall as simulated by most of the models was underestimated in the rainy season, while a few models like CCSR-HR, CCSR-MR, GISS-E-R, and GISS-E-H overestimated the observed climatology. Increase in the surface air temperature showed the higher temperature in the pre-monsoon months in most of the models except in GISS-E-H, IAP and NCAR-PCM1, On the whole, it was seen that the models reproduce the annual cycle of rainfall reasonably well. The investigations for the 21st century using SRES A2 for three different decades 2020s (2011-2040), 2050s (2040-2069) and 2080s (2070- 2099) indicated that the changes of annual temperature around 2°C to 4.5°C, as projected by 14 climate models. While the changes in the monsoon rainfall for different time slices vary over 1.5 to 3.5 mm/day **(Fig.15).** Overall, performance of the GFDL-CM-2.1 in representing the monthly mean precipitation and surface air temperature is the best among all the models.

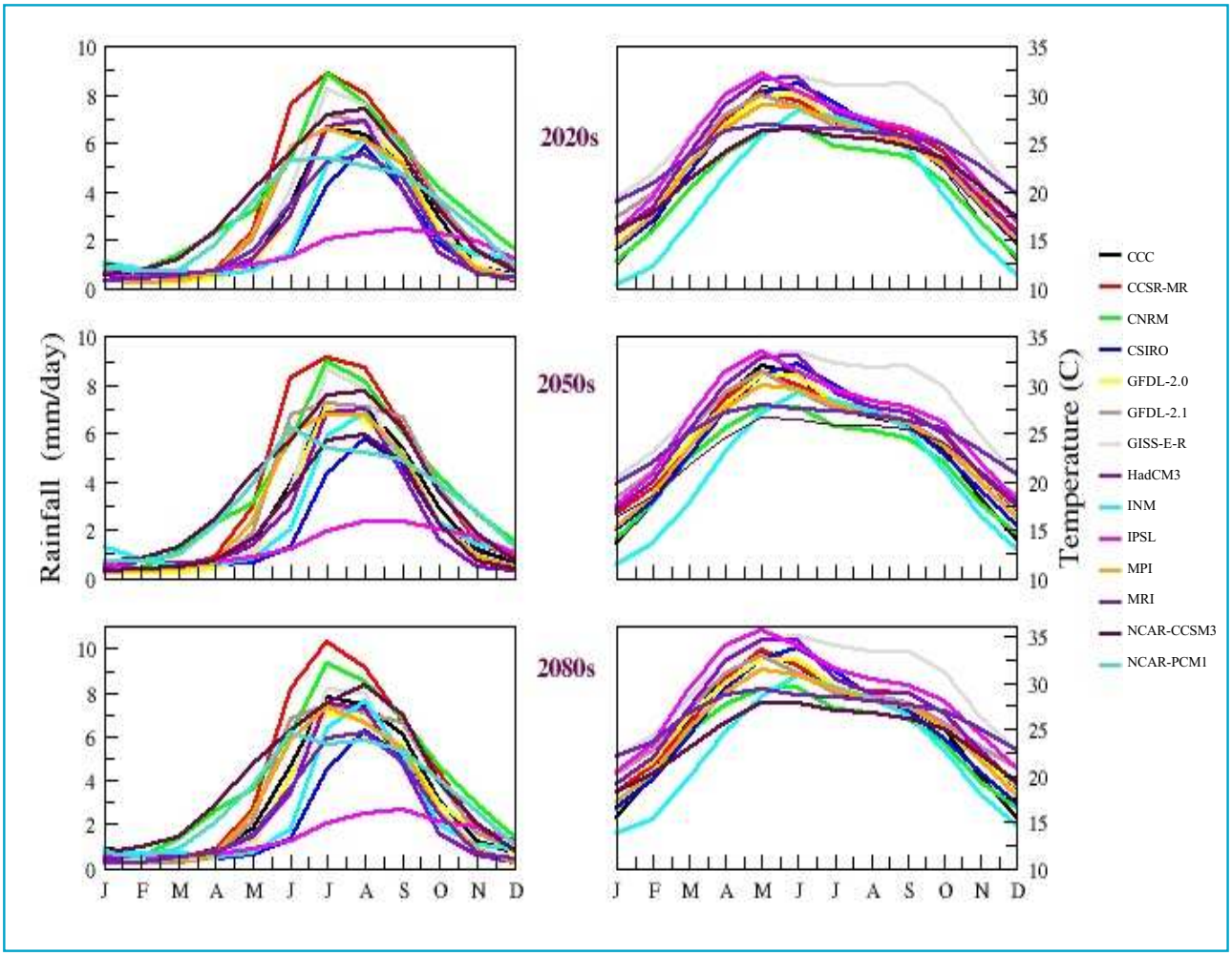


Fig. 15 : Annual cycle of monthly mean rainfall and surface air temperature climatology averaged over the land region of Indian continent as simulated in the 2020s, 2050s and 2080s for different AOGCMs in SRES A2.

Climate Applications in Agriculture, Water Resources and Public Health

(K. Krishna Kumar, C.M. Mohile, A.A. Munot, S.K. Patwardhan, S.D. Patil, Preethi Bhaskar)

Simultaneous relationship (coupling) between Indian summer monsoon rainfall and nino 3.4 SST

It is well documented that Indian monsoon rainfall is influenced by the sea surface temperatures (SSTs) over eastern equatorial Pacific during monsoon months. Warmer SST anomaly over eastern equatorial Pacific leads to below normal monsoon rainfall over India. To get better insight into this relationship and to understand the influence of nino 3.4 SST over monthly monsoon rainfall and to bring out the significant changes in these relationships in the course of time, sliding 30-year correlation coefficients between monthly rainfall and monthly nino3.4 SST were computed. Strong consistent coupling between all-India June rainfall and June SST for the 30-year period corresponding to central years 1885-1925 (with a few exceptions afterwards) was seen. In the recent period no significant relationship was observed between June rainfall and June SST. For all-India and the NW-India the relationship between rainfall and SST for July and August is oscillatory. In very broad sense it is seen that when July rainfall and July SST is significantly related, the relationship between August rainfall and August SST is weak and vise versa. The relationship between September rainfall and September SST for all-India, the NW-India and the WC-India was found to be highly significant for a much longer period compared to the other months with the CCs being significant after 1920s.

Monsoon characteristics in climate change scenarios

The high-resolution regional simulations generated using PRECIS were studied in detail to evaluate the model skills in representing the regional climatological features, especially the summer monsoon characteristics like onset of monsoon, active/break cycles and the cyclonic disturbances. To assess the model skill in simulating these characteristics, various parameters like wind, OLR, mean sea level pressure and rainfall were analysed for both baseline(1961-1990) and future (2071 - 2100) scenarios. The analysis of PRECIS simulated daily rainfall over Kerala did not show significant change in the mean onset date against the observed onset date. The sharp and sudden increase in the rainfall over Kerala, with onset was very well captured by the model **(Fig. 16).** The variability of monsoon onset date is likely to be more in the future. The model simulated onset dates over Kerala and West Rajasthan suggested that the northward progress of monsoon is likely to be fast in the warming scenarios. The active and break phases were defined using low level winds at the grid point in Bay of Bengal. The rainfall, wind and OLR data were analysed to examine the characteristics associated with the active/break phases. Increase in the rainfall over foothills of Himalaya and northeastern states during break was well represented in the model. The composite analysis of rainfall suggested that the active spells are likely to be more intense in warming scenarios.

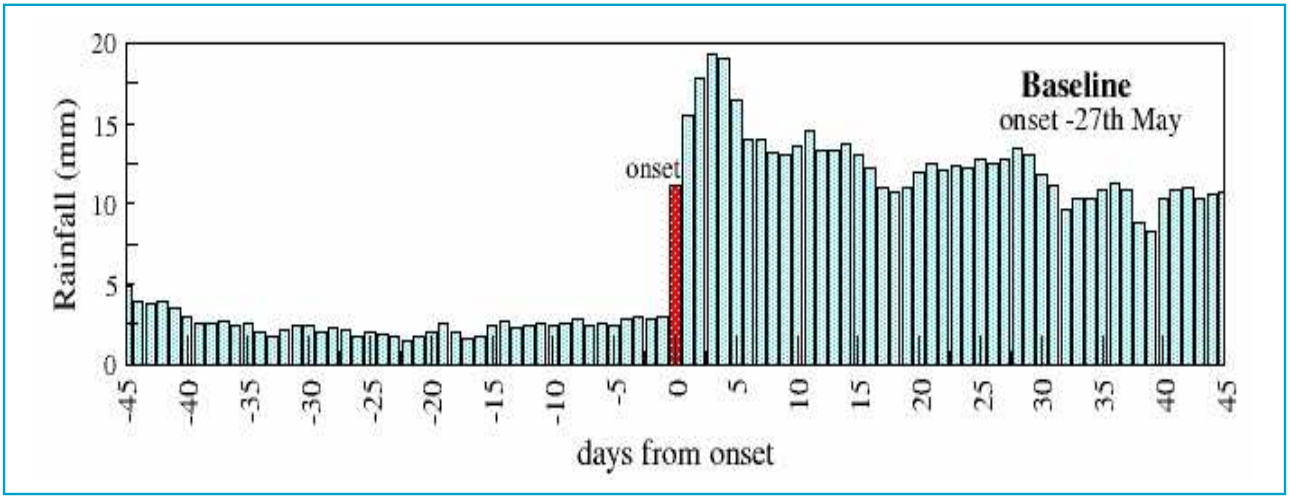


Fig. 16 : Daily rainfall composite over simulated by PRECIS.

Energy balance and the relationship between the cloud radiative forcing and Indian summer monsoon rainfall

Using satellite measured radiative fluxes from the Earth Radiation Budget Experiment (ERBE) and cloud data from International Satellite Cloud Climatology Project (ISCCP) for the period 1985-1989 during monsoon season (June - September), the spatio-temporal variability of cloud radiative forcing (CRF) during El Nino/La Nina events that affect the Indian monsoon activity was examined. The seasonal (June - September) mean rainfall, CRF components (shortwave - SWCRF, long wave - LWCRF and net - NWCRF) and cloud physical properties (high cloud amount - HCA, cloud optical depth-COD and cloud tops - CTH) averaged in the Indian region are presented in **Fig. 17.** Strong inter-annual variability with high rainfall in 1988 and low in 1987 was seen. Similar to rainfall, the CRF components and cloud properties were found to undergo year-to-year changes with maximum magnitude in 1988 and minimum in 1987 suggesting the association between them. The variation of shortwave and long wave cloud radiative forcing is presented in **Fig. 18.** Non-linearity in the relation was prominently seen between these forcings when long wave forcing was higher than 75 W/m^2. The area averaged shortwave and long wave cloud radiative forcing during the summer monsoon season was also not similar. The ratio 'N' of shortwave to long wave cloud radiative forcing was found to be higher indicating more imbalance over the region.

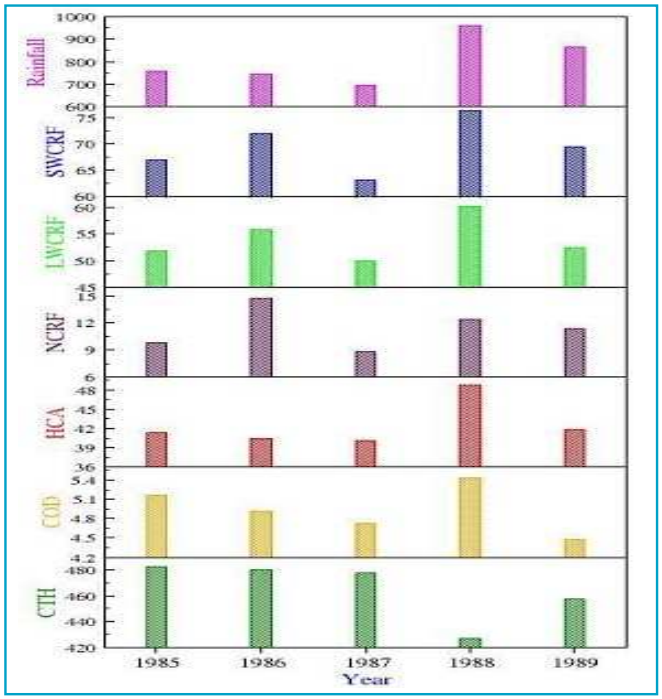


Fig. 17 : Seasonal variation of rainfall, CRF and CPP during 1985-89

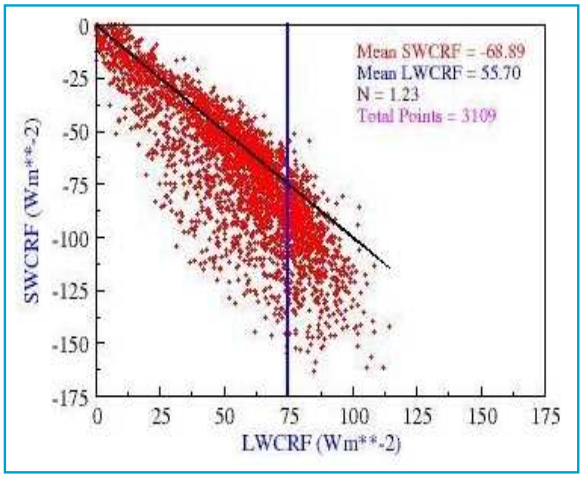


Fig. 18 : Variation of average SWCRF and LWCRF during 1985 - 89.

Tropospheric ozone over the Indian region

Anthropogenic production of CH_4 from paddy fields and that of NO_2 and CO from burning of biomass and fossil fuel were estimated over the Indian region based on the data from India's National GHGs inventory for 1990 and ADB (http://static.teriin.org/climate/ghg.htm, http://static.teriin.org/climate/ghg.htm#ADB98)**.** The relationship between meteorological parameters (i.e. tropopause height, 200 hPa geopotential height and outgoing long wave radiation) derived based on NCEP reanalysis and tropospheric ozone was also studied using monthly mean satellite measurements of TOMS/SBUV Tropospheric Ozone Residual (TOR) data (http://asd-www.larc.nasa.gov/TOR/TOR Data_and_Images.html) during the period 1979- 2001. The time series of tropospheric ozone during 1979-2001 showed increasing tendency. The annual distribution of ozone was found to be higher during spring and summer monsoon months. Inter-annual variability showed maximum values of ozone during El Nino events. Estimates of CH_4, NO_2 and CO over the Indian region were found to be higher compared to the global values indicating more anthropogenic production of ozone precursor gases in this region. The relationship between the seasonal distribution of the tropospheric ozone and meteorological parameters appeared remarkably higher over northern parts of the country during summer monsoon season as compared to other

seasons. This suggested that such an association was because of the deep convection present in summer over the Indian region and that in turn raises the tropopause height and tropospheric ozone as well. It was seen that the presence of tropospheric ozone over the north India is closely related to the northward movement of the deep convection.

Hydrometeorological Studies of River Basins for Applications in Water and Power Resource Projects

(B.N. Mandal, N.R. Deshpande, B. D. Kulkarni, R. B. Sangam, S. S. Mulye, S. S. Nandargi, Dhaval Prajapati, A. K. Verma)

Analysis of severe rainstorms for estimation of design raindepths over the Krishna river basin

Daily rainfall data of 570 stations in and around the Krishna basin during 102 years (1901 - 2002) were examined to identify severe rainstorms that have occurred over different zones / sub-catchments of the basin. By considering the geographic location, orography and rainfall characteristics, the entire Krishna basin was divided into nine zones **(Fig. 19).** Eight to ten severe rainstorms over each of these nine zones were selected for detailed analysis by Depth-Duration (DD) or Depth-Area-Duration (DAD) methods according to the suitability of the respective zones. DD analysis was carried out over eight zones located near and along the west and east coasts to estimate areal average raindepths.

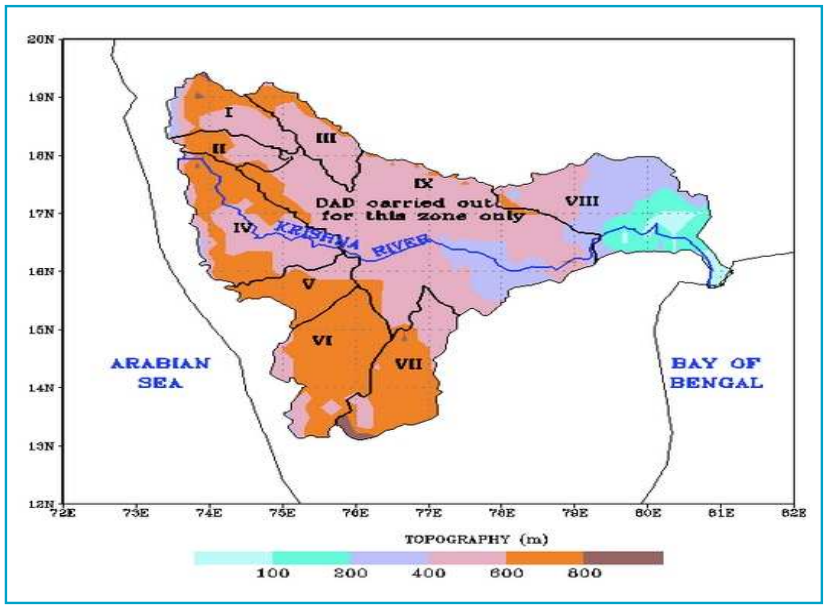


Fig. 19 : Nine zones of the Krishna river basin.

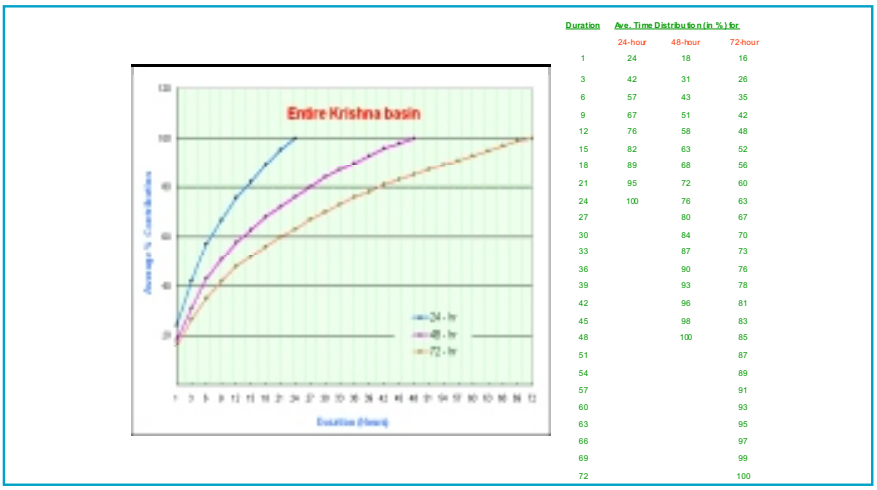
Severe rainstorms were analysed by DAD method over zone nine, the plain area region located over the central portion of the basin. Three severe rainstorms of 28-30 September 1964, 21-23 September 1949 and 13-15 July, 1965 which occurred over and near this zone were transposed over this zone to have maximum raindepths. 29 September 1964 (1-day) and 21-23 September 1949 (2 and 3-day) were found to contribute SPS raindepths over this zone after transposition. SPS raindepths for different durations over each of the nine zones were adjusted with Moisture Maximization Factors (MMFs) of severe rainstorms to work out PMP raindepths by physical method. Isohyetal patterns of the 3-day transposed rainstorm patterns of 21-23 September 1949 over Zone IX is shown in **Fig.20**.

Fig. 20 : Transposed Isohyetal map of 21-23 Sept., 1949 (3-day) rainstorm over Zone – IX of the Krishna basin.

Time distribution analysis over the Krishna river basin in peninsular India and Siang basin in Northeast India

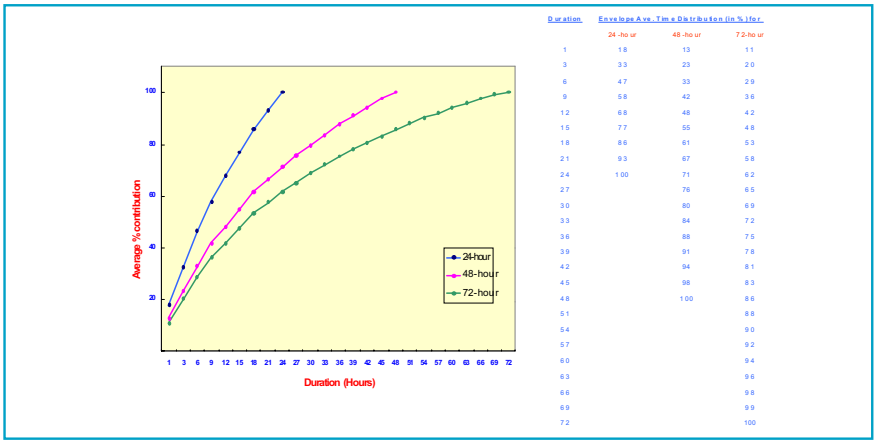
Time distribution analysis was carried out over nine zones and the entire Krishna river basin in the Peninsular India using 16 self recording rain gauge (SRRG) stations' data for their available records from 1969 and over the Siang basin (area 14039 sq. km.) in northeast India using 8 SRRG stations data from 2001-2004.

Heavy rain spells were selected on the basis of heaviest rainfall received by each of the stations using a threshold value. For all the selected rain spells, hourly rainfall distribution for maximum 1,3,6,9,12.....24-hr, 48-hr and 72-hr were estimated and based on that average time distribution during different hours for each of the stations were worked out separately. These average time distribution for each of the stations were then plotted and envelope time distribution curves were then drawn for maximum 24 - hr, 48 - hr and 72 - hr. Hourly break up for different shorter intervals were then estimated from those envelope curves. **Figs. 21** and **22** show the envelope average time distribution curves over the entire Krishna river basin and the Siang basin in northeast India with time distribution breakup for maximum 24 - hr, 48 - hr and 72 - hr respectively. Using these average time distribution, design rain depths of shorter intervals can be estimated.



Duration	Ave. Time Distribution (in %) for		
	24-hour	48-hour	72-hour
1	24	18	16
3	42	31	26
6	57	43	35
9	67	51	42
12	76	58	48
15	82	63	52
18	89	68	56
21	95	72	60
24	100	76	63
27		80	67
30		84	70
33		87	73
36		90	76
39		93	78
42		96	81
45		98	83
48		100	85
51			87
54			89
57			91
60			93
63			95
66			97
69			99
72			100

Fig. 21 : Average Time distribution curves for 24- hr, 48- hr and 72- hr durations for the entire Krishna river basin.



Duration	Envelope Ave. Time Distribution (in %) for		
	24 -hour	48 -hour	72-hour
1	18	13	11
3	33	23	20
6	47	33	29
9	58	42	36
12	68	48	42
15	77	55	48
18	86	61	53
21	93	67	58
24	100	71	62
27		76	65
30		80	69
33		84	72
36		88	75
39		91	78
42		94	81
45		98	83
48		100	86
51			88
54			90
57			92
60			94
63			96
66			98
69			99
72			100

Fig. 22 : Average Time distribution curves for 24- hr, 48- hr and 72- hr durations based on SRRG stations inside the Siang river basin.

Design storm studies over the Siang basin in Northeast India

Design storm study in the form of 1, 2 and 3 day Standard Projects Storm (SPS) and Probable Maximum Precipitation (PMP) over the Siang basin (area 14,039 sq.km.) in northeast India over six zones was carried out using about 80 stations data located in and around the basin for their available records by hydrometeorological and statistical methods. By considering the orography of the study region, analysis of severe rainstorms was carried out by Depth-Duration (DD) method. Average areal rain depths over each zone were computed, DD curves were constructed and from the envelope DD curves, SPS values were estimated. SPS rain depths based on analysis of severe rainstorms and extreme rainfalls were adjusted with suitable Moisture Maximization Factor (MMF) to obtain PMP rain depths over different zones. Estimates of statistical PMP were also made for comparison. 20 - 22 July, 2002 rainstorm was found to be the most severe rainstorm over the basin which contributed SPS rain depths. **Fig. 23** shows the isohyetal patterns of 3 day July, 2002 rainstorm over the basin.

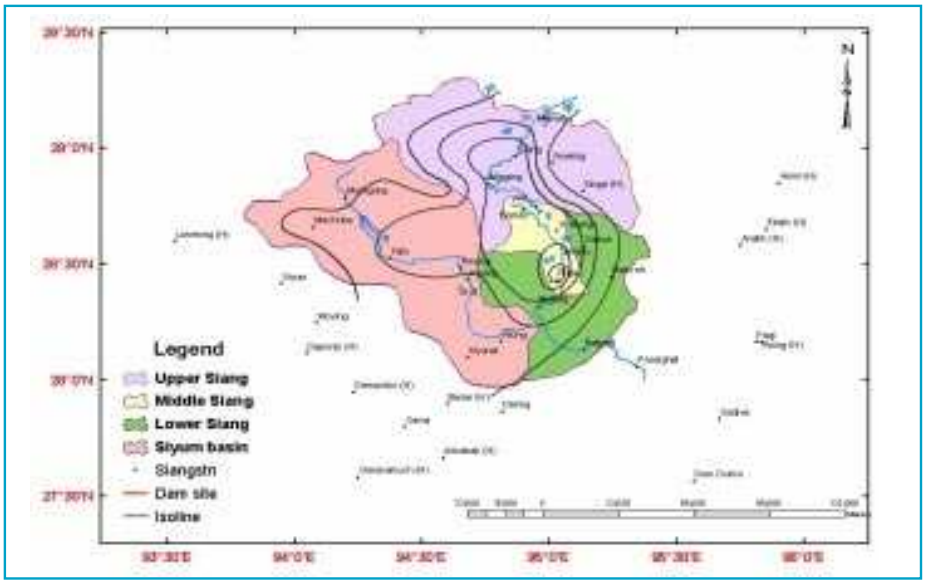


Fig. 23 : Isohytal map of 20-22 July 2002 (3-day) rainstorm over the Siang river basin.

Rainstorm analysis by objective method, its comparison with estimates made by planimetering over the Krishna basin

Long period daily rainfall data of 321 stations in the Krishna river basin during the period 1901-2002 were analysed to select severe rainstorms over the basin. The spatial patterns of those selected severe rainstorms were made by using GrADS Version 1.8 (Grid Analysis and Displaying System). Severe rainstorms were then analysed by Depth-Area-Duration (DAD) method to estimate areal rain depths over different areas and durations by objective method. The same were compared with areal rainfall values calculated by planimetering the rainstorms isohyets. Areal rain depths obtained by both the above methods were found to be well comparable.

Hydrometeorological analysis over the upper Siang basin in Tibet

Hydrometeorological analysis was carried out over the Upper Siang basin in Tibet (area 2,49,186 sq. km.) using precipitation data of 3 stations (1992-2004) from the National Hydroelectric Corporation (NHPC) Ltd., Faridabad, 6 stations data} (1994-1999) from NASA website and re-analyzed gridded data (1958-1999) (1.875 X 1.875 degree grid size). Using the above data, tentative estimates of mean seasonal, annual precipitation and highest ever-recorded 1, 2 and 3 day precipitation were made. Estimates of Standard Project Storms (SPS) based on extreme precipitation were also provided.

Changes in Rainfall Pattern and Hydrologic Regimes over India and their Relationship to Global Warming

(N. Singh, N. A. Sontakke, H. N. Singh)

Relationship between OLR and rainfall variations over and across India

Spatial and temporal variation in rainfall over India is quite large, and it is not compatible with features of other meteorological parameters, pressure, temperature, wind, radiation, geopotential height et., on regional and global scales. The OLR was then chosen as an alternate parameter which is regarded as reliable proxy of convection, cloudiness and rainfall over the tropics. Long period (1974 - 2004) satellite - derived monthly OLR data were used. The data on spatial resolution 2.5° latitude x 2.5° longitude grid was available for the whole globe but its potential application is restricted to tropics i.e. for 40°N - 40°S. The dataset was developed using observations of several satellites and two instruments viz. (i) the Very High Resolution Radiometer (VHRR), which flew on board NOAA satellites prior to NOAA 6 with the window channel 10.5-12.5 µm, and (ii) the Advanced Very High Resolution Radiometer (AVHRR), since the launch of TIROS N with the window channel 10.5-11.5 µm for TIROS N and NOAA 6 but 11.5 - 12.5 µm for NOAA 7 onwards.

Sixty eight (68) 2.5° x 2.5° latitude - longitude grids provided a complete coverage of geographical spread of the country. Brief description of important features of the NOAA OLR (1974 - 2004) and rainfall (1974 - 2003) fluctuations as approximated by the least-squares linear trend and the correlation coefficient (CC) between the two parameters was

provided for the whole country, 11 partly overlapping regions (extreme north India, northwest India, Ganga Plains, northeast India, Central India, East Coast (S), East Coast (N), West Coast (WC), West Coast (S), south peninsular India, and central peninsular India, and 68 individual grids.

Seasonal and annual OLR (1974-2004) and rainfall series (1974-2003) for the whole country are shown in **Fig. 24** which also presents the scatter diagram between the two parameters. The most noticeable feature was the sharp decreasing trend in OLR during monsoon season which was indicative of increased convection and cloudiness. But the monsoon rainfall fluctuation over the country showed slight decreasing trend during the corresponding period. Decreasing trend in OLR was seen during each of the four monsoon months, June -0.49, July -0.32, August -0.35 and September -0.29 W/m^2/yr, while positive trend was observed during June (+0.7 mm/yr) and September rainfall(+0.21mm/yr) and negative trend during July (-1.46 mm/yr) and August rainfall (-0.91 mm/yr). The correlation coefficient (CC) between monsoon monthly OLR and the rainfall series (1974-2003) was as June-0.76, July -0.42, August -0.23 and September -0.71.

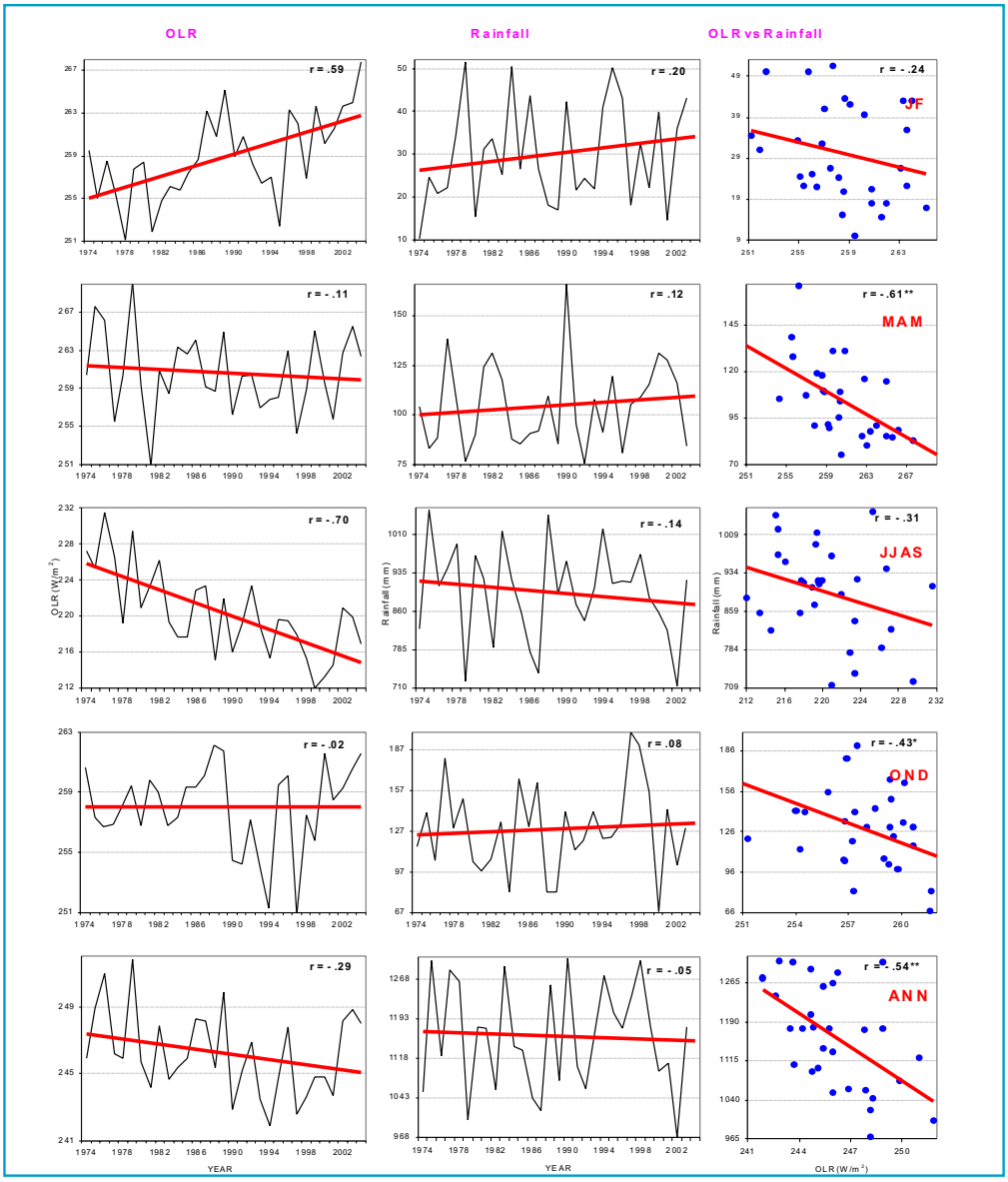


Fig. 24 : Seasonal and annual OLR and rainfall fluctuation over the whole country.

Trends were estimated for 11 subjectively identified overlapping regions **(Fig. 25).** The trend in monsoon OLR was found to be negative for the different regions, but in monsoon rainfall it was positive for northeast India, extreme north India, central India, Gangetic Plains and northwest India and negative for others **(Fig. 26).** During each of the four monsoon months (June, July, August and September) the trend in both OLR and rainfall was negative over majority of the regions. Analysis of trend for individual grids indicated decreasing tendency in monsoon OLR over the entire country. However, negative trend in monsoon rainfall was observed over 67% area of the country. During the monsoon months the area of the country with negative trend in OLR fluctuation was 100% in June, 98% in July and August, 85% in September, and that in rainfall fluctuation was 22% in June, 67% in July, 61% in August and 51% in September respectively. Broadly, over major parts of the country both OLR and rainfall showed decreasing trend during the monsoon season which is a paradoxical result. There appeared to be some change in altitudinal distribution of clouds due to global warming and associated changes in atmospheric circulations.

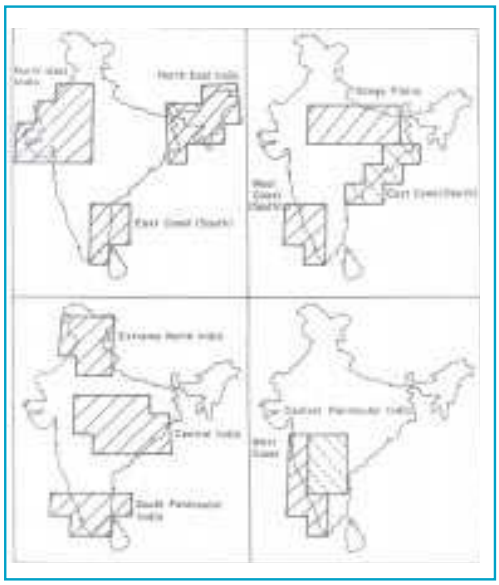


Fig. 25 : Homogeneously Orographically coupled rainfall regions of India

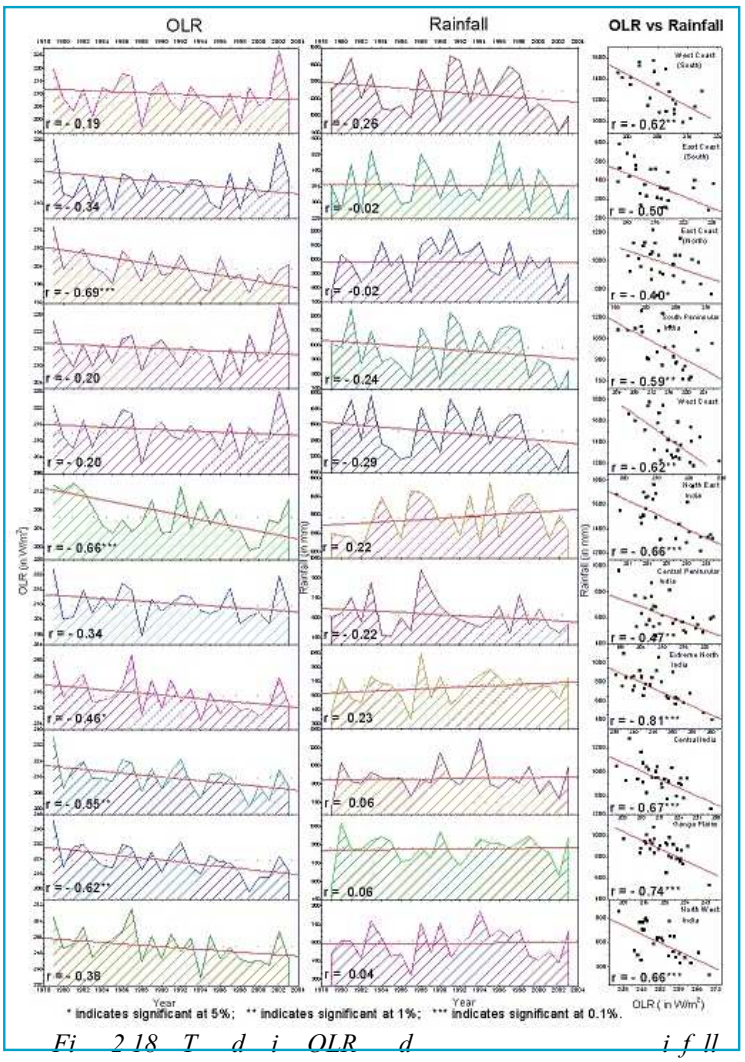


Fig.26 : Trends in OLR and summer monsoon rainfall variation over the eleven zones.

During winter (January - February), summer (March-May) and post-monsoon (October- December) the area of the country with negative trend in OLR was found to be 19%, 65% and 50% respectively; and with negative trend in rainfall 26% 33% and 47% respectively.

Trend in OLR over India was found to be consistent with negative trend in monthly and seasonal OLR fluctuation over the monsoon regime (40°N- 40°S and 40°-150° E) and the global tropics.

Changes in geopotential height and ambient temperature across the globe

Geopotential height and ambient temperature of 10 standard isobaric levels from 850 hPa to 100 hPa for the period 1949- 2004 (56 years) were examined to understand the recent trends of the atmospheric general circulation and the secondary circulations.

Area-averaged monthly sequence (1949-2004) of geopotential height and ambient temperature for 10° latitude belt from pole-to-pole was subjected to normality test using Fisher's g-statistic test. The different climatic series prepared using the NCEP/NCAR dataset were normal (or Gaussian) except few isolated cases which were found marginally different from normal distribution. The distribution characteristics of the climatic parameters for different 'centres of action' were also examined and found to be normally distributed. Analyses of upper air observations were intended to understand dynamics and mechanism of relationship across the transect 'global atmospheric thermal condition > general atmospheric circulation > Asian monsoon circulation > Indian monsoon circulation > frequency and intensity of rain-producing disturbances convection / clouding / rainfall across India'.

Preliminary climatic change analysis by calculating difference in the mean geopotential height and ambient temperature from first half (1949 - 1976) to second half (1977 - 2004) of the data period (1949 - 2004) brought out some notable features. For four representative months of the annual weather cycle (January, April, July and October) change in the geopotential height is presented in **Fig. 27.** Highest increase in geopotential height was seen over 40°S - 50°S belt- the rise was least in the lower levels and increased progressively upward. Towards South Pole of this belt the change declined rapidly and became negative for 850 hPa up to 250 hPa though it remained marginally positive for 250, 150 and 100 hPa levels. Towards North Pole decrease in the geopotential height change was gentle for different isobaric levels. Spatial pattern of the ambient temperature changes was consistent with the geopotential height change for different isobaric levels up to 150 hPa. For 100 hPa over south temperate region was opposite to that of the tropospheric geopotential height trends. This appeared related with the phenomenon of 'ozone hole'. Increasing trend was noticed in the thickness between isobaric levels 700 and 300 hPa over India which was indicative of diffusing tendency in the cloud layer. This might be one of the reasons for decline in rainfall over major parts of the country though enhanced convection was suggested by the OLR observations. Regional variation in trends of the geopotential height would strengthen the NH extratropical westerlies, consequent upon which there will be lesser eddies, mid tropospheric cyclone and troughs over Mediterranean region. These changes in circulation affect the temporal and spatial distribution of rainfall occurrences across India.

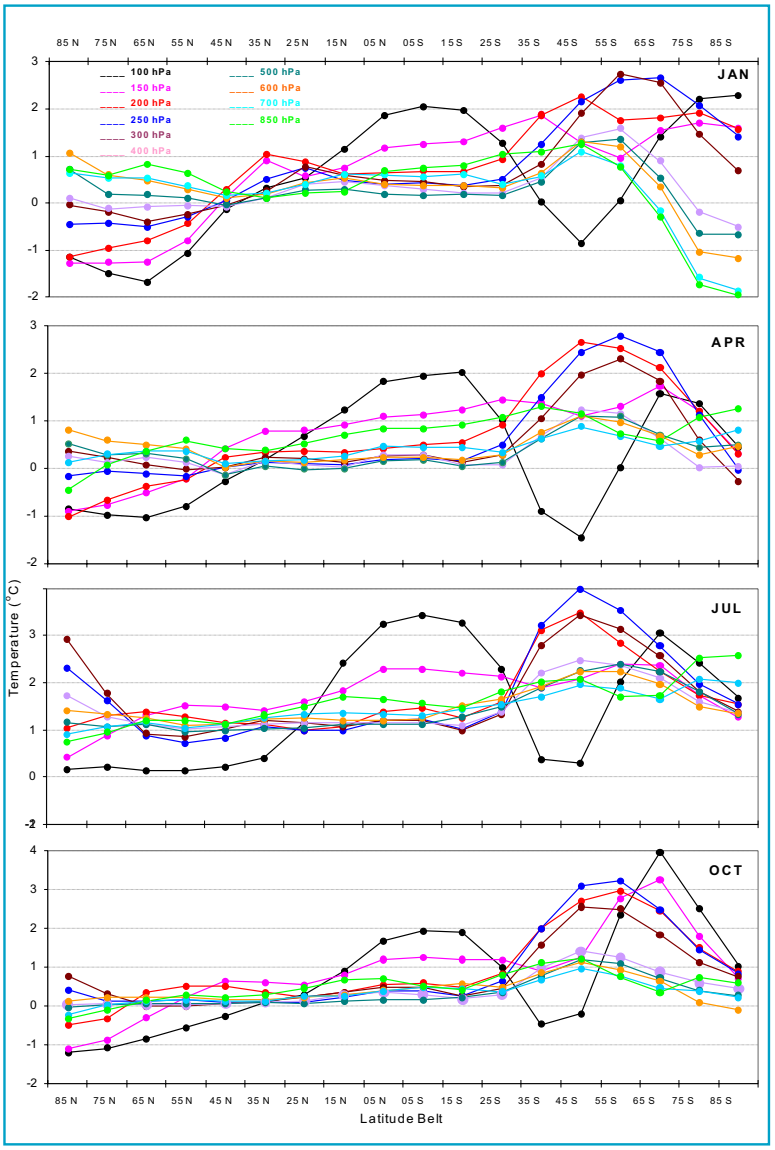


Fig. 27 : Changes in geopotential height (GPH) of 10 mandatory isobaric levels across the globe from the period 1949 - 1976 to the period 1977 - 2004.

Physical Meteorology and Aerology

Physical Meteorology and Aerology Division has undertaken thrust area research programmes which are aimed at promoting better understanding of the atmospheric physical and chemical phenomena relating to the following topics:

- Physics of tropical monsoon clouds, precipitation mechanisms and atmospheric electrical / boundary layer processes.
- Active and passive remote sensing of the atmospheric aerosols and trace gases, and radiation budget.
- Precipitation chemistry, acid rain, atmospheric aerosols and tropospheric chemistry.
- Atmospheric chemistry, dynamics of the middle atmosphere vis-à-vis the troposphere-stratosphere coupling, monsoon activity and climate change.
- Spectroscopic measurements of atmospheric minor constituents and climatic effects.

Physics and Dynamics of Tropical Clouds

(R. Vijayakumar, S.S. Kandalgaonkar, S.B. Morwal, M.K. Kulkarni, A.S. Nath, R.S. Maheskumar, M.I.R. Tinmaker)

Variations in lightning activity over the Indian region

Spatio-temporal variability of lightning activity over the Indian land mass region (8°-33°N, 73°-86°E) was studied using monthly satellite based lightning flash grid (5° x 5°) data for 5-year (1998-2002) period. These data were examined for studying the annual, seasonal and spatial distribution of the lightning activity. The study revealed a nonlinear relationship between lightning flash density and latitude on the annual time scale, linked with the convective activity, large-scale circulations, land mass gradient and orography of the region under study **(Fig. 28)**. On the seasonal time scale, the nonlinear positive relationships were observed in the pre-monsoon and monsoon seasons whereas a bimodal variation was observed in the post- monsoon season. The comparison of flash density with maximum surface air temperature showed the existence of nonlinear relationship between the two parameters. The approximate range of increase of flash density per 1°C rise in temperature was 20 to 44% respectively. The lightning flash density showed a pronounced semi-annual oscillation over the latitude belt 8°-28°N.

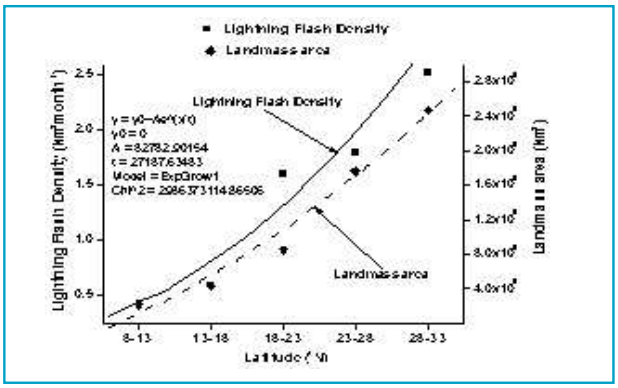


Fig. 28 Latitudinal variations of lightning flash density and landmass area during 1998-2002

Study of convection over the Baramati region

Cloud seeding operations were carried out over the Maharashtra State during the summer monsoon season (June to September) of 2004. During the same period two C-band radars were operated, each at Shegaon and Baramati. The radars made continuous scans (at an interval of 6 minutes) of the cloud, and enormous amount of data of cloud reflectivity were collected over these two stations.

Utilizing the data of cloud reflectivity on 4 July 2004 over the Baramati region a case study was carried out to investigate some features of the prevailed convection over this region. The heights of the cloud cells were computed at every grid point for each observational time. The clouds were categorized into three types based on the height of their tops viz. (1) shallow (heights $\leq$ 2 km), (2) warm (2 < heights $\leq$ 6 km) and (3) cold (6 < heights $\leq$ 20 km).

From this case study it was seen that the percentage of these clouds were 20.6%, 37.1% and 43.4% respectively of the total cloud cover observed on 4 July 2004. As the percentage of the warm and cold clouds together was more than 70%, this day was declared suitable for conducting both types of cloud seeding i.e. warm and cold.

Cloud model study of 26 July 2005 heavy rainfall event over Mumbai

The large scale synoptic system on 26 July 2005 which produced the exceptionally heavy rainfall (94.4 cm) over Mumbai region was studied using diagnostic and modeling approaches. Large-scale synoptic scale system over India was found favorable for producing intense convection over the place and advection of moisture from the Arabian Sea. The Radiosonde sounding data of 26-27 July 2005 collected at Santa Cruz, Mumbai was utilized as input to the 2DTD cloud model. The model used was a two-dimensional, slab-symmetric, time-dependent model with a grid interval of 200 m in the x and z directions. The domain of the model was 19.2 km in both width and height. An attempt was made to simulate the vertical velocity, radar reflectivity and the total rainfall amount on 26 July 2005 utilizing this model. The cloud model simulated quite well the exceptionally heavy rainfall and its spatial distribution**.** The simulated cloud base heights were found to be in good agreement with those derived from skew-T analysis. The simulated updrafts were of the order of 2/3 mps, with peaks reaching 6 to 8 mps. The maximum radar reflectivity was around 50 dBZ and the vertical sheared flow produced down drafts and updrafts over separate regions in the cloud environment.

Also, the model produced vertical velocities within the cloud showed maxima at 10 km height with a range 3 m/s to 9 m/s **(Fig. 29)**. Generation of the rotation within the cloud was inferred from the development of vertical component of vorticity due to tilting term in the vorticity equation, which suggested the existence of meso-cyclone over Santacruz. The model produced circulation parameters were analyzed to understand the anchoring and maintenance of the meso-cyclone. The study showed that the exceptionally heavy rainfall was due to the presence of stationary meso-cyclone. Thus, the present study showed that the 2DTD cloud model could produce most of the features of the convective cloud complex that prevailed on 26 July 2005 over Mumbai region resulting in a heavy rain spell.

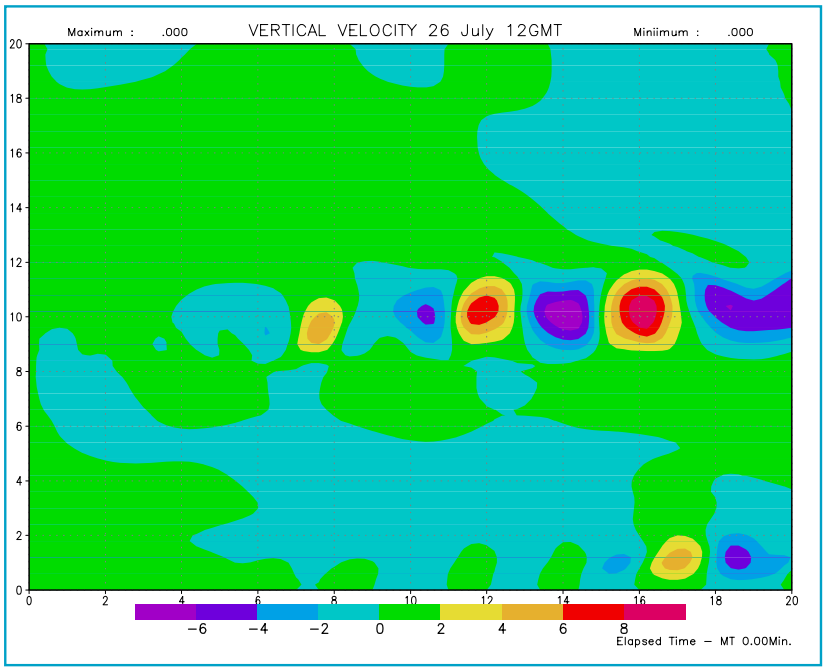


Fig. 29 : Spatial distribution of the vertical velocity at 12 UTC of 26 July. X-axis is the west-east distance (km) through the location of Santacruz; Y axis is height (km).

Comparison of rainfall data collected using AWS and derived from radar

Improvement of the present quantity of precipitation measurement is important to achieve progress in our understanding of the monsoonal rainfall over a region. Measurement of rain with a conventional rain gauge (Automatic Weather Station, 60 min integration time) is available for some of the stations in the Maharashtra State during the summer monsoon season (June to September) of 2004. During the same period two C-band radars were also operated over the Maharashtra State as a part of the Rain Enhancement Program. The radars made continuous scans of the cloud reflectivity in the season. The horizontal domain consisted of 670 X 670 grid points at the resolution of 750 meters. There were 26 levels in the vertical at 0.5° intervals. One volume scan was carried out in every 6 minutes interval, thus providing 240 scans in a day. This provided a unique opportunity to study the convection

in a detailed manner over the region. The radar measured the cloud reflectivity factors over the circular area of 250 km radius at 6 minutes interval. the Rain Enhancement Program of the Maharashtra A study of comparison of observed and radar-derived rainfall was carried out from the data collected during State Government. Two stations viz., Mahan (18°32'10"N, 73°02'14"E) and Padalshi (17°25'38"N, 73°57'14"E) of very heavy and heavy rainfall respectively were considered for the purpose of comparison. The radar reflectivity factors on 4 July 2004 were used to compute the precipitation over these stations. From the reflectivity data two dimensional cells with reflectivity exceeding some threshold value were identified. These cells were grouped into volume cells satisfying the same condition. Using the volume of these cells the rainfall over the region under observation was estimated. Rainfall estimated using radar-derived data and the rainfall recorded over the station using automatic rain gauge were compared. The study showed a good agreement between the two under the assumption that 60% of the convective cells contributed towards the rain.

Remote Sensing of the Atmosphere using Lidar, Radiometric and other Ground Based Techniques

(P.C.S. Devara, P.E. Raj, Y. Jaya Rao, G. Pandithurai, K.K. Dani, K. Madhu Chandra Reddy, S.K. Saha, S.M. Sonbawne, R.L. Bhawar, U.P. Shinde, S.M. Deshpande)

Argon-ion lidar, and radiometric obervations of aerosols and precursor gases

Vertical profiles of atmospheric aerosols in the lower troposphere were collected on 58 days during the period 01 April 2005 to 31 March 2006 using the Argon-ion lidar system equipped with a new computer controlled scanning and data acquisition system. Aerosol optical depth, ozone and precipitable water observations were made on 184 clear sky days during the above one year period using multi-wavelength sunphotometer and ozonometer. Extensive comparison of these parameters was made by collecting observations from two identical sets of such radiometers at the same location.

Estimation of dust optical thickness from TOMS and Sun-photometer data over Pune

The Absorbing Aerosol Index (AAI), derived from the Total Ozone Mapping Spectrometer (TOMS) data for the period 1999-2003 was used as quantitative measure for monitoring dust aerosols. The Dust Optical Thickness (DOT) was derived from AAI and dust proportion present over Pune was calculated. The DOTs were computed at 500 nm wavelength for the pre- and post-monsoon months during 5-year period (1999-2003). The results indicated that (i) there is copious addition of dust particles during pre-monsoon due to high convective activity and frequent occurrence of dust storms and (ii) due to the presence of more scattering aerosols, the proportion of dust is relatively smaller in winter than that in pre-monsoon.

Radiometric observations of aerosols and pre-cursor gases over Maitri during 24th Indian Antarctica Expedition

Extensive field experiments using multi-spectral solar radiometers and a wideband shortwave (SW) pyranometer were conducted at Maitri during the 24th Indian Scientific Expedition to Antarctic from January to February 2005. The preliminary results of the analysis of data indicated that (i) the mean AOD at 500 nm varied from 0.013 to 0.069 with an average value of 0.042, (ii) the Angstrom exponent, which is an indicator of aerosol size distribution, ranges between -0.26 and 0.77 with an average value of 0.24, (iii) the total column ozone (TCO) and column water vapor (CWV) are found to vary from 240 DU to 320 DU with an average value of 289 DU, and from 0.14 cm to 0.36 cm with an average value of 0.26, respectively **(Fig. 30)** and (iv) the average surface short-wave forcing due to aerosols, estimated from the combined aerosol optical depth and down-welling radiative flux measurements showed cooling at the surface with a value varying between 5 and 30 W/m^2.

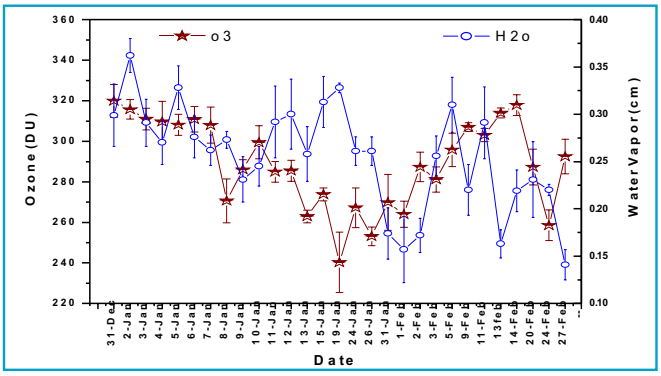


Fig. 30 : Daily mean variations in TCO and PWC (H_2O) over Maitri. The vertical bars denote standard error in the estimation.

Aerosol radiative forcing derived from sun/sky radiometer and LIDAR observations at Pune

Extensive aerosol observations were carried out at the Institute in Pune using a Prede (Model POM-01L) sun/sky radiometer and a bi-static Argon ion lidar during February 2004, which also coincided with the ISRO-GBP Land Campaign-I experiments. The sun/sky radiometer was operated daily at every 15 minute interval during day-time to derive column aerosol optical parameters such as aerosol optical depth (AOD), single scattering albedo (SSA), asymmetry parameter (ASY) while the lidar was operated daily in the early-night period to derive vertical distributions of aerosol number density. The daily mean AOD, SSA and ASY and lidar-derived aerosol concentration profile data, thus obtained were used in a discrete-ordinate radiative transfer model to derive aerosol radiative forcing at the surface and at the top-of-the-atmosphere (TOA) and they are shown plotted in **Fig. 31.** Day-to-day variation in aerosol radiative forcing at the surface (SWF_{sfc}) was found to vary between -20 and -45 W/m^2 whereas at the TOA (SWF_{toa}) it ranges from -10 to +5 W/m^2. Mean aerosol forcing values are -34–2 and -4–1 W/m^2, respectively at the surface and at the TOA. This implies that about 30 W/m^2 is absorbed in the atmosphere leading to enhanced heating in the lower atmosphere.

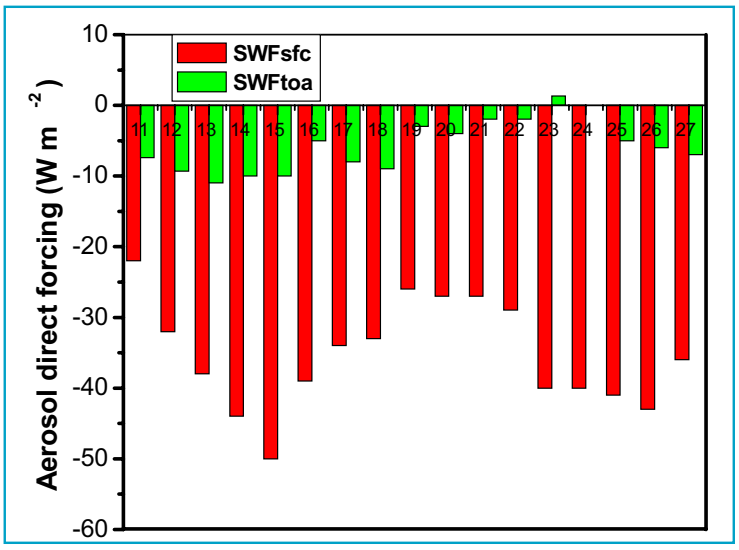


Fig. 31 : Day-to-day variation in aerosol SW direct radiative forcing derived using sun/sky radiometer and lidar observations.

Time-size cross-sections of aerosol volume-size distribution

The size spectra of aerosol volume were retrieved from the automatic polarized CIMEL sun-sky radiometric observations carried out at the Institute during fall transition of 2004 and winter of 2004-2005. For this purpose, the sky radiance almucantar measurements were acquired from the spectral channels at 440, 670, 870 and 1020 nm of the radiometer. By using an inversion algorithm aerosol volume size distributions were obtained over a range of sizes from 0.05 to 15µm together with spectrally dependent complex refractive index and single scattering albedo from spectral sun-sky radiance data illustrates the time-size cross-sections of the volume particle size distributions obtained during the fall transition of 2004 and winter of 2005. It was observed that almost all the size distributions have bimodal structure with high values (0.4) of [DV(r) / Dln (r)] during the winter, and low values (0.18) of [DV(r)/Dln (r)] during the fall transition period. The retrieved size distributions were found to exhibit bimodality with shapes visually close to log-normal curves. The aerosol volume size distributions were also found to be in agreement with Angstrom parameter derived from aerosol optical thickness measured concurrently in the 440-870 nm wavelength region. The fine-mode particles observed during October-November 2004 epoch were considered primarily due to aerosol-rich nuclei of continental origin and due to anthropogenic smoke aerosol from bio-mass / bio-fuel burning associated with domestic practices during January-February 2005 time period. The coarse-mode aerosol particles observed during both the epochs were considered essentially as a result of anthropogenic components from the use of fossil fuel and also partly due to different particle production/formation processes, and source region including long distance transport of soil dust.

Optical, physical and radiative characteristics of aerosols during winter over Agra and Delhi

As part of the Nation-wide Land Campaign (LC-II) experiments of the ISRO conducted during the month of December 2004, extensive measurements of aerosol optical, physical and radiative properties and water vapor were made over Agra (27 °10′N, 78°05′E, 169 m AMSL) and Delhi (28°38′N, 77°10′E, 213 m AMSL) by deploying Sunphotometer and Ozonometer versions of MICROTOPS-II, and CIMEL sun-sky radiometer. Although the spatial separation

between these two experimental sites was not large, the observed aerosol behavior was found to be quite different on many occasions because of vivid changes in the surrounding environments and modulating effects of meteorological conditions on air mass characteristics over these two experimental sites. The results revealed that (i) At both Agra and Delhi, the column AODs followed spectral dependence according to the scattering theory. Greater values of AOD (close to or more than 1) were found on the days associated with either fog or haze or both. (ii) The variations in the Angstrom parameter showed higher values (abundance of accumulation-mode particles, possibly due to urban) mostly during haze, and smaller values (coarse-mode rich particles) during fogy- and clear-sky conditions (iii) The aerosol size spectra, retrieved from the spectral distributions of AOD observed over Agra and Delhi showed bi-modal structure with abundance of accumulation-mode particles during fogy and hazy occasions, and coarse-mode particles even during clear-sky conditions, which indicated the influence of local sources as well as from father places through transport processes. The accumulation-mode particles were considered primarily due to aerosol-rich nuclei of continental origin and due to anthropogenic smoke aerosol from bio-mass/bio-fuel burning activities, while the coarse-mode aerosol is considered primarily as a result of anthropogenic components from the use of fossil fuel and also partly due to different process and source region including long-range transport of soil dust (iv) The sun-sky radiometer derived combined aerosol optical depth and solar almucantar sky radiance measurements over Delhi were used to compute refractive index of aerosols at the station. The refractive indices showed larger real values indicating particles of scattering type during non-haze conditions, while greater imaginary values implying presence of anthropogenic absorbing aerosols, particularly on the days associated with haze / fog activity. (v) The dependence of single scattering albedo (SSA) and asymmetry parameter (ASYMP) on wavelength during different atmospheric conditions during the period of study exhibited that, on most of the days, the SSA values were close to or more than 0.9 indicating that the aerosol particles over the experimental site are basically of scattering type, and greater phase functions indicating more coarse-mode particles showing pronounced dust and urban aerosol loading over Delhi and (vi) In all, the aerosol loading was found to be larger over Delhi as compared to Agra. At both the stations, the influence of local as well as long-range transport of pollutants, as revealed by the back trajectory analysis, was found to play significant role in modifying the aerosol properties vis-à-vis regional climate.

Application of MODIS surface albedo in aerosol radiative forcing estimations

Surface albedo values at different spectral bands were calculated from the black sky albedo (directional hemispherical reflectance) and white sky albedo (bi-hemispherical reflectance) products from the MODIS using representative optical depth values observed over Pune for winter and pre-monsoon months. MODIS derived spectral surface albedo data were used along with sun/sky radiometer derived aerosol optical parameters in a radiative transfer model to estimate radiative forcing in the short-wave (0.3 - 3.0 um) and long-wave (3.0 - 50.0 um) spectral regions. The total (SW + LW) radiative forcing was found to be -23, -1.5 W/m^2, respectively, at the surface and at the TOA for winter season. During pre-monsoon, the net radiative forcing was found to be -29, 1.5 W/m^2.

Direct radiative effects of aerosols on the evolution of atmospheric boundary layer

The impact of tropospheric aerosol scattering and absorption effects on the evolution of the atmospheric boundary layer (ABL) over Anand (22 °35' N, 72°55' E), Gujarat, a tropical semi-arid site in Western Indian region was studied from the datasets collected during the LASPLEX (Land Surface Processes Experiment) employing the Santa Barbara Discrete Ordinate Radiative Transfer (SBDART) model. The results indicated that the absorbing aerosols influence more on ABL evolution and associated latent heat and sensible heat fluxes as compared to their counter part of scattering aerosols.

Mobile lidar observations of aerosols and clouds

A compact Dual Polarization Micro Pulse Lidar (DPMPL) facility has been installed at the Institute in November 2005. This unique experimental facility has several exciting capabilities and advantages over many lidar systems available elsewhere in respect of its real-time-mode (unattended) operation with ultra-high space-time resolution data that can be used for aerosol characterization, cloud composition, atmospheric dynamics and wave activity studies covering from surface to about

120 km. This lidar system has been operated on about 30 days up to March 31, 2006 including through-out-night on December 30-31, 2005, and obtained high space-time resolution observations of extinction and linear depolarization profiles of aerosols and clouds up to 30 km. Some interesting results relating to evolution of boundary layer structure and stratification, and isotropy/ anisotropy (sphericity) property of aerosols were obtained.

Long-term changes and trends in aerosols of different size fractions

The aerosol optical depth (AOD) observations carried out on clear-sky days using Microtops II at six wavelengths (380, 440, 500, 675, 870 and 1020 nm) covering from ultraviolet to near infra-red region over Pune for the period from May 1998 to February 2006 were examined**.** The monthly mean AODs at the above wavelengths were subjected to regression analysis. The results showed an increasing trend of varying per cent in AODs at different wavelengths corresponding to aerosol particles of different size fractions. The study indicated 24% and 13% increase in AOD respectively at fine and sub-micron particle loading while it showed 33% decrease in AOD at coarse-mode particles. This suggested significant increase in anthropogenic addition of fine aerosol particles mainly due to the changes in land-use pattern changes associated with constructional activities as compared to the naturally driven coarse-mode particles.

Study of the structure of atmospheric subsidence over Pune in March 2004 and 2005 using wind profiler derived vertical winds

An extended heat wave condition existed over Pune (18.31° N, 73.58° E, 559 m AMSL) during the pre-monsoon month of March 2004 with a long spell nearly of one month duration, with above normal temperatures. In contrasting, March 2005 showed a long spell of below normal temperatures. The vertical velocity data measured by UHF 404 MHz wind profiler at Pune were utilized for the study. The wind profiler has typical height coverage of 1-10 km with a resolution of 300 meters. Hourly averaged vertical wind velocity profiles were obtained four times a day from 0800 to 1700 hrs IST in March 2004 and 2005. These mesoscale vertical velocities were used to understand the maintenance of long spell of above-normal (in March 2004) and below-normal (in March 2005) surface temperatures over Pune.

The mean structure of the vertical distribution showed two cell structures predominately upward motion extending up to 2-3 km and downward motion in the 3 - 6 km range in March 2004 while it showed upward motion extending all the way up to 6 km in March 2005. In 2004, with the progress of the day, the subsidence penetrates to the lower levels reaching around 1 km in the afternoon hours while during 2005 upward motion existed in the layer 2.0 to 3.5 km and subsidence penetration was confined to levels above 1 km. The effect of advection and vertical velocity on temperature variability at the surface during March 2004 and 2005 were compared and discussed in this study.

Development of Raman Lidar Technique for the study of atmospheric constituents

A simple and straight forward line-of-sight Raman lidar system has been developed for detection and path-averaged concentration determination of various atmospheric constituents using a multi-wavelength Argon-ion laser at its two prominent wavelengths viz., 514.5 nm and 488.0 nm as transmitter, and a dual holographic grating - based high spectral resolution spectrometer (scan range from 200 to 720 nm) along with a detector connected to a 25-cm diameter Newtonian telescope through a fiber optical cable as receiver. This technique makes use of the shift in wavelength of the probing wavelength (Raman shift). By conducting experiments during the pre-sunset period on different days, prominent Raman-shifted peaks were recorded at 535.2 nm, 554.07 nm, 561.34 nm and 605.2 nm the Argon-ion laser wavelength of 514.5 nm. These peaks were identified to be due to the presence of nitrogen dioxide, carbon dioxide, ethylene and methane respectively in the atmosphere. Shifted peaks were also captured at 568.9 nm for the Argon-ion laser beam at wavelength of 488.0 nm, which corresponds to methane. The Raman-shifted peaks showed temporal variation in their strength, which is a measure of concentration of the respective constituents. The main reason for these variations is considered to be due to changes in source characteristics of gases and dynamics of the atmosphere such as the effects of local turbulence involving wind, temperature, humidity etc.

Effect of aerosols on UV-B radiation

The ultra-violet (UV) radiation reaching the earth's atmosphere is categorized in to three parts: UV-A (320-360 nm), UV-B (280-320 nm) and UV-C (100-280 nm). UV-B rays pose the greatest risk of skin cancer. The three primary mechanisms regulating the

amount of UV-B reaching the earth's surface are ozone, cloud cover and aerosols. A precision UV-B pyranometer has been installed and in regular operation at the Institute since April 2004. UV-B irradiances (mW/m ^{2}) were derived at 1-minute interval using instruments' calibration coefficient. An attempt was made to study the effect of aerosols on ground-reaching UV-B irradiance by selecting about 15 clear-sky days in November and December 2004. Mean UV-B irradiances in zenith angle range up to 60^0 and daytime mean aerosol optical depth at 500 nm was used to estimate aerosol radiative forcing efficiency (Feff) in UV-B and it was found to be about 412 mW/m^2. As a case study, on a typical clear-sky day, UV-B irradiances were computed for different aerosol optical depths in the range from 0.1 to 1.0 in steps of 0.1 for pure scattering (SSA = 1.0), strong absorbing (SSA = 0.8) type of aerosols and clean conditions. The difference in UV-B fluxes with aerosols and clean conditions for every 15-minute intervals was averaged for 24 hours to compute aerosol forcing for 0.8 and 1.0. Forcing efficiency values were -105, -349 mW/m^2 for SSA 1.0 and 0.8, respectively. Higher forcing efficiency observed in the present study was probably due to the variability in total column ozone and precipitable water content.

Air Pollution and Precipitation Chemistry

(P.S.P. Rao, D.M. Chate, G.A. Momin, K. Ali, P.D. Safai, S. Tiwai, Y. Tiwari, D. Singh, P.S. Praveen, S.S. Kewat, A.A. Ranade)

Aerosols and fog chemistry at Agra during Land Campaign II

Studies were carried out on aerosols and fog chemistry at Agra, during 1-31 December 2004 under the ISRO-GBP Land Campaign II. The results revealed (i) Total Suspended Particulates (TSP) levels during day time were found to be about 1.5 times higher than that during night time which could be attributed to more convection and turbulence as well as more human activities during day time. During foggy days, the average TSP was found to be more (487 mg/m^3) compared to the non foggy days (349 mg/m^3). Chemical composition of TSP indicated that the ionic components (SO_4, NO_3, Cl, NH_4, and F) were higher during the foggy period than those during the non foggy period. The fine size particles contributed more during the fogy period than during the non-foggy period. (ii) The average diurnal variation of Black Carbon (BC) showed one peak in the morning (0800 hrs) and the other in the night (2300 hrs). Low concentrations were observed during afternoon hours (1200 hrs to 1800 hrs). A good correlation was observed between TSP and BC during the non-foggy days but no correlation was seen during the foggy days. BC formed about 9% of TSP during nighttime whereas, during daytime, it formed only 3%. (iii) The pH of fog water varied between 6.25 and 6.63 indicating the alkaline nature. NH_4 was dominant among cations, while SO_4 was dominant among anions shows histogram indicating different chemical constituents recorded in fog formed over Agra during 20 - 23 December 2004.

Study of acidity of raindrops by uptake of gases and aerosol pollutants

Uptake of pollutant gases and aerosols by freely falling raindrops influence the vertical distributions of atmospheric pollutants and pH of raindrops **(Fig. 32).** Raindrop pHs were computed using one-dimensional time-variant model including SO_2 and NH_3 absorption, aqueous chemical reactions and aerosol capture. The study revealed that the magnitude of pH increases with the raindrop size and fall distance from the cloud base. This may be attributed to the increase in the Ca concentration with fall distance as it neutralizes the acidic components (e.g. SO_4^{2-}).

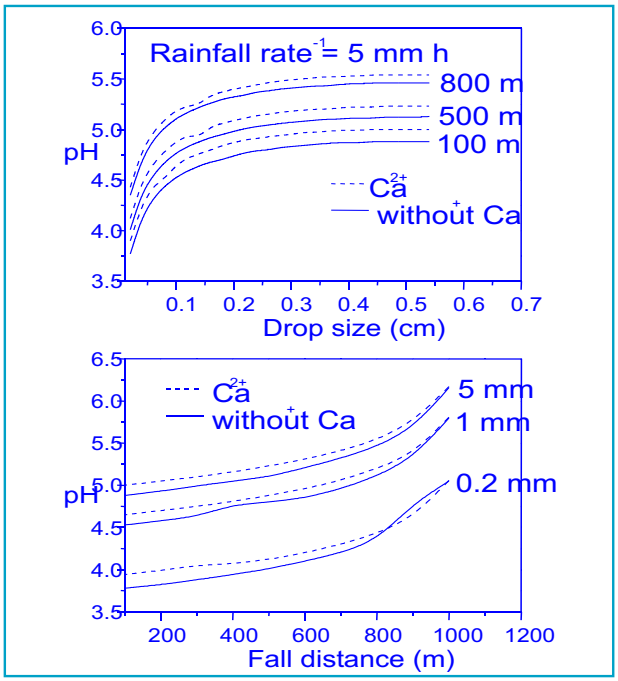


Fig.32 : pH of raindrop with fall distance and drop size with aerosols and without aerosols.

Concentrations of carbonaceous aerosols at Pune

Under the ISRO-GBP sponsored project " Role of aerosols and black carbon in the atmospheric radiation budget studies", continuous measurements on black carbon aerosols are being carried out at Pune since July 2004, using an Aethalometer (Magee Sci. Inc., USA, AE-42) at 880 nm wavelength, at the interval of 5 - min. time base and at flow rate of 3 LPM. Results of these observations revealed that during 2005, concentrations of black carbon at Pune were maximum in winter (DJF), followed by those in the post-monsoon (October- November). Minimum concentrations were observed in the monsoon (June, July, August, September) **(Fig. 33).** In fact, average value in the winter (7.38 mg/m^3) was double than that in summer (3.25 mg/m^3) and was about 6 times more than in monsoon (1.31 mg /m^3). This feature was mainly due to the prevailing meteorological conditions in the respective seasons. During post-monsoon and winter, winds are mostly from the NE direction, bring in the pollutant-rich air masses from continental regions whereas, during summer, westerlies and north westerlies are predominant and during monsoon, majority of the winds are from SW. All these winds during summer and monsoon seasons bring in the air masses rich with marine components. In addition, during the winter months, ventilation coefficients are low due to low mixing height and less wind speeds. This leads to less dispersion of pollutants, especially the submicron size ones like back carbon, sulphates, nitrates and ammonium aerosols. Wash-out mechanism due to precipitation is the other major reason for low concentrations in the monsoon. In summer, even though being a dry period, where burning incidences are occasional, concentrations of black carbon are less compared to winter, mainly due to high convective activity which is responsible for the dispersal of fine sized aerosols.

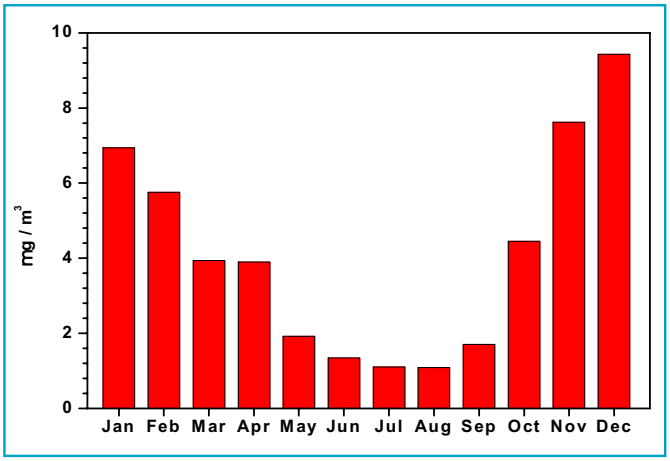


Fig. 33: Monthly mean black carbon (BC) concentrations at Pune during 2005.

Atmospheric Chemistry, Modelling and Dynamics

(G. Beig, I.S. Joshi, S.S. Fadnavis, S. Roy, P. Buchunde, S.S. Gunthe, V. Singh, S. Sahu)

Impact of Indian chemical emissions on the level of tropospheric ozone in the South Asian region

The anthropogenic emissions of the ozone precursors (CO, NOx, non-methane hydrocarbons) are likely to be the dominant source for the production of ozone in the south Asian region. The impact of emissions of ozone precursors in the Indian subcontinents was investigated on the tropospheric abundance of ozone in the surrounding south Asian region. The study used the Chemistry-Transport Model (MOZART) forced with dynamical fields provided by meteorological analyses and new emission inventories for 2001 **(Fig. 34)**. The influence of Indian emissions in the boundary layer ozone for the south Asian region is almost negligible but it is strong in the free troposphere for the monsoon month of July because the vertical gradient is much stronger and the high concentration values over the Indian region are immediately transported upwards and spread horizontally. Model calculations suggested that the Indian sources enhanced the surface ozone mixing ratio by 2 - 7 ppbv in the Eastern side and by 1-4 ppb in the western side of the Indian subcontinent during the monsoon month of July when southwest monsoon became vigorous over almost the entire Indian sub-continent and transport of air masses from the southwest of India is strong. During the pre-monsoon period, the northern, north-eastern and north-western parts of the Asia were characterized by very weak winds and chemicals emitted over India were spread efficiently over these regions. The monsoon trough connecting the low - pressure of western India (Gujarat and Rajasthan) with the Bay of Bengal was established and the wind pattern below (in terms of pressure level) the trough was south-westerly whereas above the trough it was weak south easterly. Thus transport of air masses from the southwest was strong, hence the ozone displaced towards the northeast along with some lateral spreading in the north.

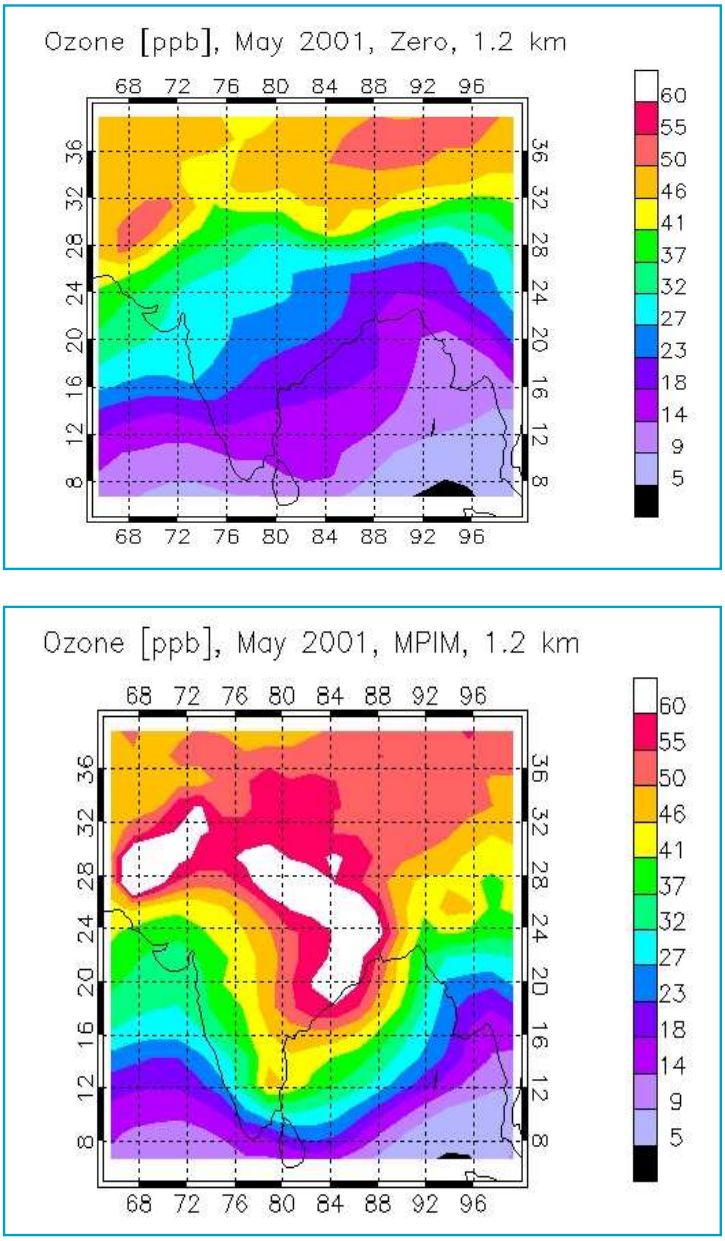


Fig. 34 : Distribution of ozone near the boundary layer over the Indian geographical regions (A) when Indian emissions from local resources are considered as zero, which is attributed as the impact of south Asian emissions (long range transport) on the distribution of ozone over India; (B) Normal distribution of ozone over the Indian geographical region (reference level) for comparison.

Sunrise-sunset variability in long term trends of temperature and ozone for tropical stratosphere

Sunrise and sunset long term variability of temperature and ozone over tropical stratosphere was investigated using Halogen Occultation Experiment (HALOE) aboard Upper Atmospheric Research Satellite (UARS) observations for the period October 1991-August 2004 over the 0-30°N tropical belt. Trends in sunrise and sunset time series were obtained separately. Both sunrise and sunset temperature trend profiles showed almost similar nature, with highest cooling trends around 33-35 km. Both sunrise and sunset temperatures showed cooling trend of ~2-3 k/decade over lower stratosphere while, upper stratosphere (35-50 km) showed cooling trend of 0.5-2.5 k/decade. However, vertical structure of monthly variation in temperature of sunrise and sunset trend distribution differed. Stronger cooling was observed during summer in sunset trends and during winter and spring in sunrise trend distribution. The vertical profiles of ozone trends (%/decade) for sunrise and sunset ozone concentration showed similar nature with no significant trend above 42 km. Small positive (~3%/decade) ozone trends were observed near 25km and -8%/decade above 32 km. Sunrise as well as sunset ozone trends did not show much seasonal variation.

An update to the trends in the meso-pause region temperature

Some new results along with some modified results by revisiting the older temperature profile data sets were reported in recent time which was reviewed and an update was prepared. The most important advancement was the improvement in understanding of two important aspects of long-term trends in temperature i.e. indications of a strong seasonality (monthly variability) in the mesospheric temperature trends and some insight into the interpretation of varying long term trend features. The variation in some minor constituents especially ozone appears to play an important role in the mesospheric temperature trends. Another factor, probably of the human origin, that can affect the mesospheric trends, is the reported increase in water vapour concentration, which affects the chemistry of mesosphere and lower ionosphere, and noctilucent clouds. Gravity wave is also likely to play an important role in better understanding of the temperature trend features.

Wavelet analysis of ozone variations over tropics

To study variation in ozone due to quasi biennial oscillation (QBO) and wave interaction, data of ozone volume mixing ratios obtained from microwave limb sounder (MLS) aboard the Upper Atmospheric Research Satellite (UARS) for the period October 1991 - April 1999, were decoded and extracted over the tropical stratospheric region (40 °S to 40 °N). Wavelet analysis was used for analyzing localized variations of power within a time-frequency space, to determine both the dominant modes of variability and how those modes vary in time. Ozone volume mixing ratio time series was de-trended and the seasonal variation removed prior to subjecting the series to the wavelet transform. Vertical distribution of ozone anomaly showed that over the lower stratosphere the QBO amplitude is ~0.4-1 ppm with negative phase while over the upper stratosphere it reduces to ~0.1-1.2 ppm with reversal of phase.

Latitude-altitude structure of ozone QBO over the tropical-subtropical stratosphere (40 °S-40 °N) was also explored by analyzing the data for the period 1992-1999 using the multifunctional regression model. The inferred QBO in ozone showed two maxima located at 22 hPa and 10 hPa with coefficient of 2-3% per 10 m/s centered at the equator. The equatorial maxima were out of phase with each other. Subtropics near 14 hPa exhibited two peak structures but of opposite sign to that of equatorial maximum near 10 hPa. Variation of ozone QBO during different seasons revealed that a pattern of positive maximum near 10 hPa with two subtropical negative minimum appeared during DJF which was faded away with the progression of seasons. Simultaneously, similar patterns appeared near 4.6 hPa which got strengthened with the progression of seasons. Over the equatorial region, positive (zonal winds westerly) coefficients overlaid negative (zonal winds easterlies) coefficients which were descended with time. Negative QBO coefficient >5% per 10 m/s were observed during February - March over the 10 °-20 °N latitudinal band. Strong QBO coefficients varying between -6 to +6% per 10 m/s were observed between 10 - 2.6 hPa over the subtropical region.

Association between heliospheric current and Indian summer monsoon

The relation between heliospheric current sheets and Indian summer monsoon rainfall was studied. The rainfall data for 17 meteorological sub-divisions (Jammu & Kashmir, Rajasthan, East Madhya Pradesh, West Madhya Pradesh, East Konkan, West Rajasthan, Madras, Coastal Andhra Pradesh, Coastal Mysore, Interior Mysore, North & South Mysore, Kerala, Sourastra & Kutch, Gujarat, Madya Maharashtra, Maharashtra, Vidarbha) were collected from the Indian Daily Weather Reports Published by the India Meteorological Department. The rainfall data were collected from 1964 - 1994 for the monsoon period (June - September). For the same period heliospheric current sheets data were collected from the Solar Terrestrial Working Documents up to 1978 and from 1978 to 1994 from Prof. Tinsely. Average values of actual rainfall for each month and each year are calculated then average rainfall of June-September values were calculated for each region. Actual rainfall data were bifurcated into two groups, one falling under (-,+) crossing events and. The other falling under (+,-) crossing events. Correlation coefficients between the actual rainfall values and the (-,+) / (+,-) crossing events were calculated separately. It was observed that the Indian summer monsoon rainfall in all the states was having an in phase relation with (-,+) crossing events **(Fig. 35)** i.e. magnetic sector boundary polarity towards the sun followed by more summer monsoon rainfall activity.

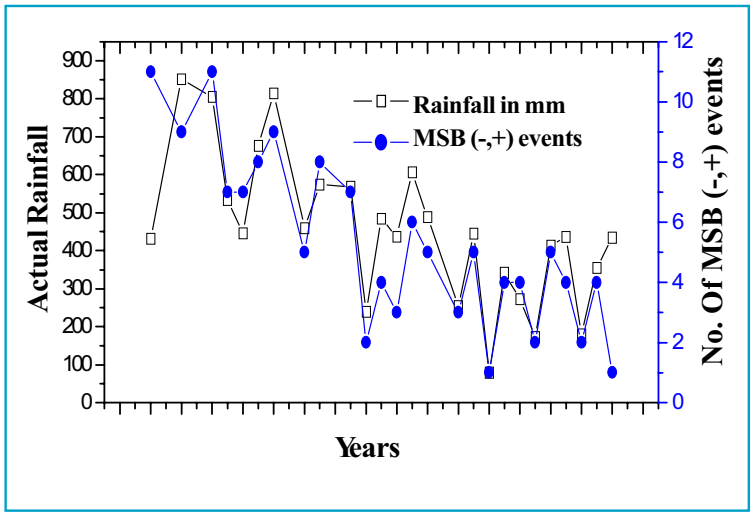


Fig. 35 : Association between heliospheric current and Indian summer monsoon during 1962-1996.

Association between cyclonic storms / depressions and MSB crossing events

A study has been carried out to examine the relationship between number of cyclonic storms and depressions forming over tropical seas and Magnetic Sector Boundary (MSB) Crossing Events. Cyclonic storm and magnetic data for the period from 1964 to 1995 were used in the study. The results indicate that number of cyclonic storms and depressions is having in-phase relation in June and September and out-of-phase relation in October and December with (-,+) and (+,-) MSB crossing events, respectively.

Coupling geomagnetic storm activity, stratospheric total ozone transport between high-low latitudes and Indian summer monsoon rainfall

Monthly means of geomagnetic activity data (aa Index) during May and June-September for 41-year period (1958-1998) were collected from Solar Geophysical Data. Monthly means of total ozone data for Alma Ata (42.3 °N, 76.9 °E), New Delhi (28.6 °N, 77.2 °E), Kodaikanal (10.2 °N, 77.5 °E), for the 41-year period (1958-1998) during May to September were obtained from the "Ozone Data for the World". Percentage rainfall departures of rainfall data for India as a whole during June-September from their 41-year normal were worked out. Also the mean meridional wind differences between New Delhi and Trivandrum from 1958-1998 were calculated. The monthly mean values of aa Index and ozone values were subjected to 1-2-1 smoothing. The three stations considered for ozone data were approximately situated along the same meridian. In order to get an idea of the transport mechanism of total ozone, the monthly mean differences in total ozone were worked out between Alma-Ata-Kodaikanal, Delhi-Kodaikanal and Alma-Ata-New Delhi. To study the relation between geomagnetic activity and ozone transport between low and high latitudes, correlation coefficients between total ozone differences and aa Index during May to September (1958-1998) were calculated and plotted**.** The correlation coefficients between the meridional wind differences (v) between (New Delhi and Thi ruvananthapuram) at 850, 500 and 100 hPa and ozone differences between Alma Ata and Kodaikanal, New Delhi and Kodaikanal, and Alma Ata and New Delhi during May-September were calculated. Values of correlation between aa Index and meridional wind differences at 850, 500 and 100 hPa were also calculated. It was inferred from the analysis that (i) maximum meridional winds in the north are associated with northward transport of total ozone from south to north at 850 and 500 hPa levels, (ii) increase in geomagnetic activity and more ozone differences between Alma-Ata minus Kodaikanal are associated with decrease in monsoon rainfall activity, and (iii) equator ward transport of ozone during the periods of high geomagnetic activity and maximum meridional winds in the north during June - September are associated with less Indian summer monsoon rainfall.

Impact of sugar factory on ozone and other pollutants

Measurements of several atmospheric pollutants viz., oxides of nitrogen, carbon mono-oxide, ozone and hydrocarbons were made during December 2005 January 2006 at the surface in a campaign mode in the vicinity of sugar factory located around Pune region with an aim to study the impact of the sugar industries on the level of indoor and outdoor ozone and other secondary pollutants. These gases in the sugar factory premises are mainly emitted by baggasse burning in the boilers to generate the steam and partly by molasis. Preliminary analysis based on the limited data (December-January) collected for the past 2 years revealed that during daytime indoor and outdoor levels of NOx, CO, O_3 and hydrocarbons remained unchanged under the influence of sugar factory environment. However, pollution level during nighttime consistently indicated an enhanced level when compared with background level. The nighttime values were found to be higher than the reference level by about 20-30%. The nighttime perturbation was attributed to the difference in the emission and deposition rates of these pollutants in the shallow boundary layer.

Measurement and Monitoring of Atmospheric Minor Constituents

(D. B. Jadhav, A. L. Londhe, C. S. Bhosale, G. S. Meena, B. Padmakumari, A.L. Sagar, H.K. Trimbake, S. H. Kulkarni)

Comparison of ozone from space-borne and ground-based measurements

Zenith sky scattered light observations were carried out using the UV-visible spectrometer for the study of NO_2, O_3, H_2O and O_4 in the atmosphere. Vertical profiles of O_3 were derived from ground-based zenith sky observations, which were compared with ozone profiles obtained from ozone-sondes (*in-situ*). The total column density values of O_3 retrieved from vertical profiles were also compared with TOMS satellite column values. They were found in good agreement.

Twilight photometer observations and data analysis

The twilight photometer was being operated manually from April 2005 to March 2006 at the Institute. The experiment was being carried out during evening twilights i.e., from the time of sunset to about 45 to 50 minutes during clear sky conditions. The photometer data were analyzed and vertical profile of aerosol index was derived in terms of logarithmic gradient of twilight scattered intensity. The existence of a persistent narrow stratospheric aerosol layer peaking at ~20 km was observed in most of the twilight profiles.

Ozone variability over Indian latitudes

TOMS monthly total column ozone grid point data over Indian latitudes from 5.5°-35° N and 70°-95° E were collected for the period 1997 to 2004. These data were utilized to study annual variation and trends in ozone over different latitudes. Gradual shift in the occurrence of ozone maxima wais observed over different latitudes. The maximum was found to occur earlier (March) at higher latitudes as compared to lower latitudes (June). Almost negligible negative trend is observed.

Monsoon circulation induced variability in total column ozone over India –A case study

The intra-seasonal variability of daily total column ozone (TCO) over 12 Indian stations was studied. TOMS (Total Ozone Mapping Spectrometer) daily data from May to September for five years (1998-2002) were utilized in the study. The power spectrum analysis of daily TCO data showed three dominant modes of periods 3-8 days (synoptic), 10-20 days (quasi bi-weekly, qbw) and 30-60 days (Madden Julian Oscillation, MJO) similar to that found in the Indian Summer Monsoon Rainfall (ISMR). Mean spatial distribution of the activities of these intra-seasonal modes in TCO variability over Indian region was studied **(Fig.36)**.

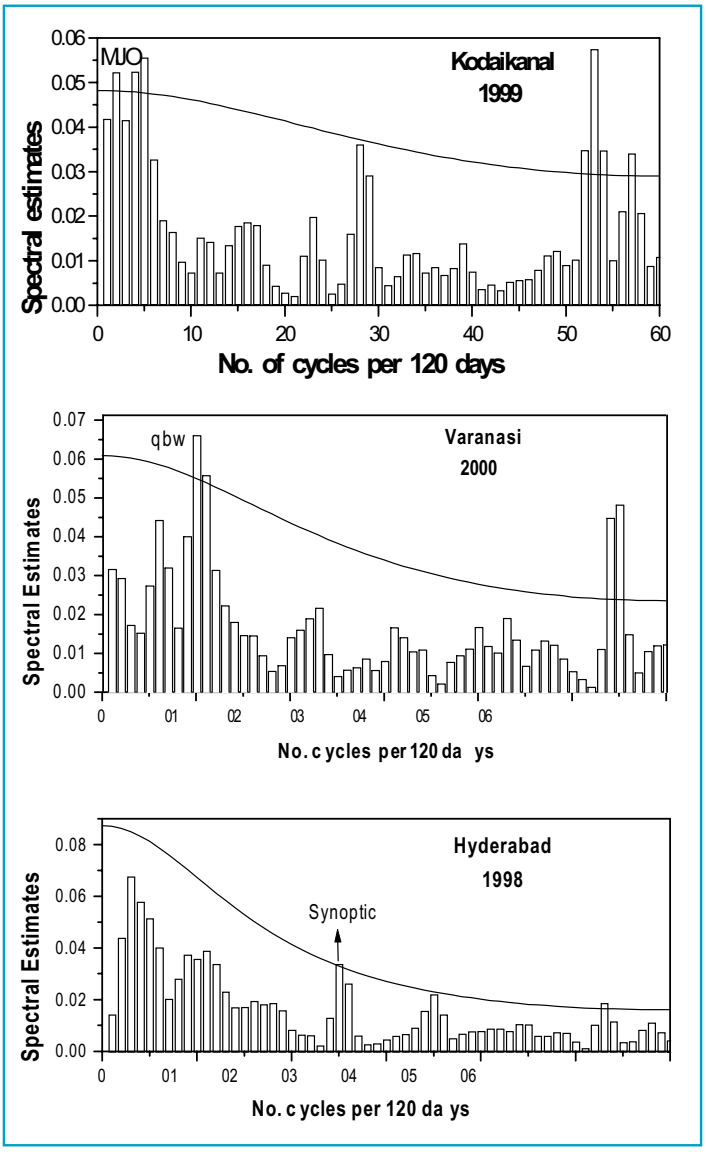


Fig. 36 : Power spectrum of daily TCO. The Curved line represents the 95% level of significance.

The spatial distribution of the synoptic mode shows the strongest activity over central India. The qbw mode showed strongest activity over northwest India. The MJO mode showed strongest activity over northern most and southern most parts of India.

Photometric observations of meteoric dust in the middle atmosphere during Leonid activity during 2001-2003 over India

Twilight photometric technique was used to demonstrate the perturbations of middle atmosphere by the presence of tiny particles delivered after an encounter with cemetery dust trails like the one produced by 55P/Tempel -Tuttle. The presence of meteoric dust in the atmosphere from the Leonid activity that occurred from 2001 to 2003 was detected by the twilight photometer operated Pune (18.5° N, 73.9° E), India **(Fig. 37)**. The November 2001 and 2002 Leonid storms, and the 2003 November outburst, caused significant enhancements of dust from just above the meso-pause to the lower stratosphere. The study revealed formation of meteoric dust layers at mesospheric levels and their subsequent descent to lower altitudes. It was interesting to note that the detection of the meteoritic contribution was made possible by the present volcanically quiescent condition of the middle atmosphere. The Leonid outburst took place on the early morning of 14 November over East Asia. 13 November showed the atmospheric condition well before the outburst. After the outburst enhanced layer was seen on 16 November morning and was descended by ~20 km on 17 November morning. Again a broad enhancement seen between 65 - 95 km on 20 November morning was due to another Leonid outburst on 19 November. This layer was descended to lower altitudes by 25 November and finally no enhancements were seen on 28 November.

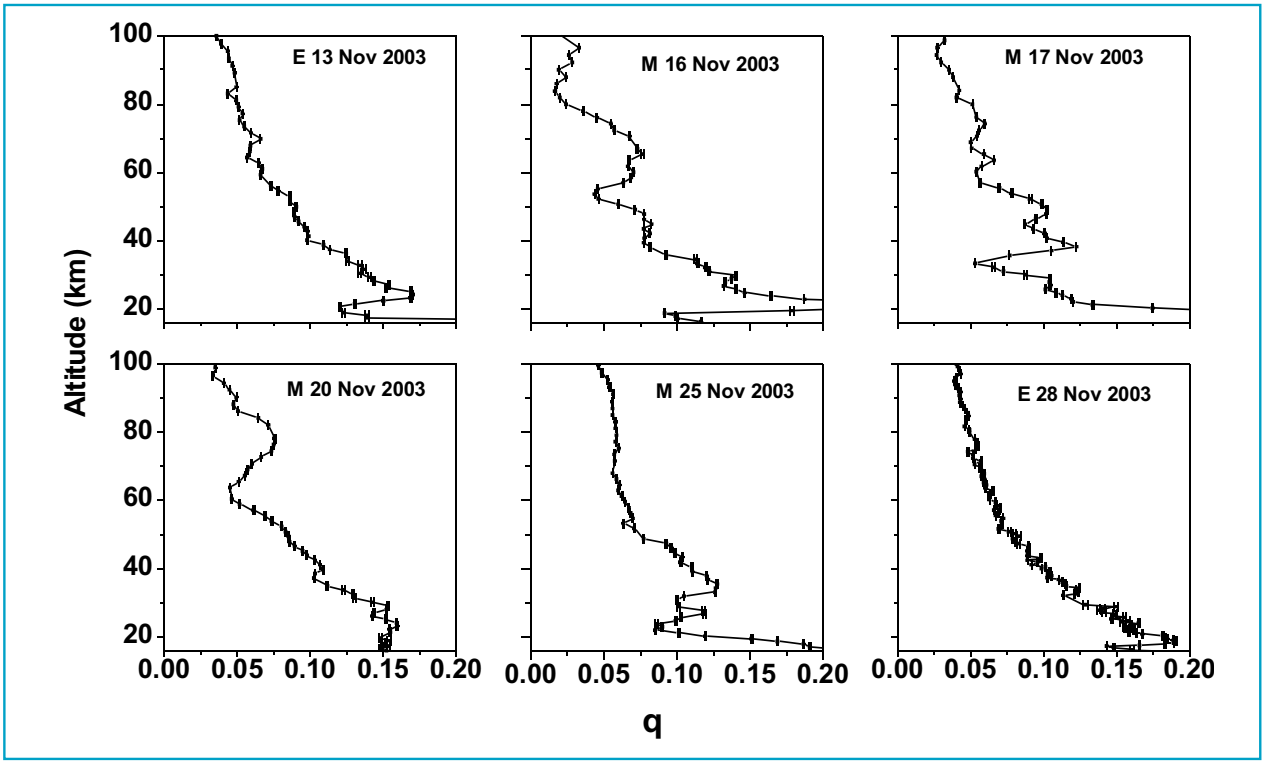


Fig. 37 : Logarithmic gradient of morning (M) and evening (E) twilight intensity (q) curves for November 2003.

Instruments and Observational Techniques

Instruments and Observational Techniques Division designs and develops instruments and techniques forobservations and carries out field and laboratory experiments. The Division conducts its research with the following objectives:

- To measure the atmospheric electrical, meteorological parameters and aerosols over land, ocean and in clean environments to study the global electric circuit.
- To reconstruct lightning channels using acoustic signals.
- To develop instruments for the measurements of atmospheric electrical parameters at Antarctica.
- To study the micro- physical processes such as evaporation, distortion, oscillation, collision and coalescence of millimeter size water drops in a vertical wind tunnel in presence and absence of vertical and/or horizontal electric fields.
- To study the scavenging of aerosol particles by charged and uncharged water drops.

Simulation Techniques for Cloud Physics Studies

(A.K. Kamra, Deen Mani Lal, M. N. Kulkarni, R.V. Bhalwankar)

An experiment was conducted in the vertical wind tunnel to investigate the combined effect of electrical forces and chemical impurities in rain water on cloud microphysical processes by suspending water drops loaded with sulphate and nitrate ions in presence of horizontal electric field. The drops were photographed using a 16 mm movie camera. The analysis show that the distortion of the drops is more for impure water drops than for distilled water drops.

An experiment was being conducted to study the effect of turbulence on the breakup characteristic of water drops falling at the terminal velocity below a vertical free fall tube. Observations were made for the breakup of drops of particular size at different turbulence levels. Preliminary analysis showed that the number of splinter droplets is maximum at a particular critical value of turbulence.

Surface Observations of Atmospheric Electricity and Electrical Properties of Clouds

(A.K. Kamra, S.D. Pawar, V. Gopalakrishnan, C.G. Deshpande, P. Murugavel, Deen Mani Lal, Devendraa Siingh, S.D. Ghude, K.P. Johare, V. Pant, Ramesh Kumar)

Thunderstorm electrification studies

The measurements of surface electric field, the Maxwell current and thunder made below a moderate size hailstorm were analysed to study the evolution of lightning activity in a tropical hail storm. The storm exhibited an almost constant frequency of one cloud-to-ground (CG) flash every 1 to 2 minutes over the whole active life of the storm. The ratio of intracloud (IC) to CG flashes, IC/CG increased with the increase in total flash rate. In convective stage of the storm, almost every subsequent lightning-induced field-change is of opposite polarity. Moreover, the two subsequent field-changes of opposite polarity occur as a pair with a time difference of 2 - 20 s. In between the convective and mature stages, the storm exhibits the phenomenon of rain gush and the field excursion associated with falling precipitation. Development of mature stage was marked with rapid transitions in the surface electric field and the Maxwell current polarities from negative to positive, sharp increase in total flash rate and IC/CG ratio, change of lightning-induced field changes to almost exclusively negative polarity and possibly lifting up of the charging region in the storm. Dissipating stage of the storm witnessed hail and rain showers, sharp transition of electric field and the Maxwell current from positive to negative polarity and occurrence of a few positive CG discharges. The observations strongly demonstrated that some lightning flashes are capable of transporting charge to the region of opposite polarity. Such charge transport can trigger another discharge in the storm or even significantly modify the charge distribution in the storm so as to change the nature of all subsequent flashes.

Characteristics of the end-of-storm-oscillation (EOSO) in the atmospheric surface electric field observed beneath isolated air-mass thunderstorms at Pune were studied. It was observed that the durations of the EOSO at Pune are shorter than those for the supercell thunderstorms occurring at Florida and convective air-mass thunderstorms at New Mexico. During the EOSO periods, the frequency of lightning decreases very much but some flashes exhibit unique features of charge transportation associated with them. A case of an 'inverted EOSO' was discussed in a storm with inverted polarity of electrical dipole. These observations were consistent with the convective mechanism scenario of the EOSO in which the surface field meters are exposed to the upper positive charge of the cloud by the downdrafts.

Analysis of the Antarctica data

The electric field and the air-earth current data obtained during the 24th Indian Scientific Expedition to Antarctica were analyzed to study the effect of solar- terrestrial relations (i.e Kp index and Dst value) on global atmospheric electric circuit. The data of the concentration and size distribution of aerosols obtained during the said Antarctic Expedition were analyzed and studied.

Analysis of PESO data

The analysis of aerosol data obtained during the Pilot Expedition to the Southern Oceans (PESO) showed that the size distribution of aerosol exhibits a bimodal distribution with maxima at 0.9 μm and 2.0 μm throughout the cruise. Some larger particles of diameter up to 10 μm were also observed when the ship encountered a cyclone with wind speed as high as 32 m/sec. The formation of coarse mode particle may be associated with the mechanical processes of wave breaking and bubble bursting due to high winds on ocean surface.

Study of chemical composition of atmospheric aerosols

An experiment was conducted to study the various volatile components present in the aerosol using thermal volatilization technique. In this technique, air samples were heated to different pre-determined temperatures using a thermodenuder to remove particular component present in the sample. The size-distribution of aerosols was measured by using Scanning Mobility Particle Sizer. Continuous measurements of number concentration and size distribution of aerosols were made.

Whistler studies during magnetospheric disturbance

Whistler-triggered emission obtained during main phase of magnetospheric storm (Kp index from 4^+ to 4^- and Dst value from 22nT to -49nT) at Varanasi were analysed. The study showed that these emissions may be triggered in the equatorial region of L-value lying between 1.9 and 2.4 by the non-linear doppler-shifted cyclotron resonance interactions. The associated magnetospheric parameters such as parallel resonance energy, wave magnetic field, interaction length, transverse resonant current of the participating particles during the normal and storm periods were computed. The effect of thermal velocity of the plasma particles on the energy of resonantly interacting energetic electrons was evaluated theoretically. The effect of magnetic disturbances on resonant interaction was also studied. The results were found to be useful in the modeling of VLF emissions and in the study of dynamics of precipitating electrons in the atmosphere.

Installation of Scanning Mobility Particle Sizer (SMPS) onboard the aircraft during ICARB

The air inlet tube installed beneath the Beachcraft aircraft

Boundary Layer and Land Surface Processes Studies

Boundary layer and Land Surface Processes Studies Division designs and develops instruments and techniques for observations and carries out field and laboratory experimental studies relating to the atmospheric boundary layer and land surface processes. Following are the research programmes undertaken by the Division:

- Integration of instruments / observational techniques to study the structure of the atmospheric boundary layer.
- Land surface processes studies to understand and simulate the energy balance over different vegetation and soil conditions.
- Study of the dynamics of the atmospheric surface layer over land and ocean surfaces.

Investigation and Modeling of Land Surface Processes in the Atmospheric Boundary Layer

(S. Sinha, M.N. Patil, R.R. Joshi, R.T. Wagmare)

Analysis of LASPEX Data

An attempt was made to identify the appropriate scales for the wind data over the stations covered in the Land Surface Processes Experiment (LASPEX). The study indicated that the effective scales of the wind, used in derived parameters, such as divergence, depend upon both the components of the scales. The effective scale was representative of the large-scale field if the component scales combine in the proper proportion to generate the large-scale field. This aspect is important to the large-scale modelers in examining the field data for verification purposes.

Seasonal distribution of soil temperature with vegetation and rainfall was studied using the LASPEX data of 1997 from the semi arid region of western India (Gujarat), over five stations having different soil and vegetation properties. The soil temperature at a depth of 40 cm and 1 m was investigated in order to study the heat flow in this layer in different seasons. Investigations revealed that the region of 40 - 100 cm depth shows upward transport of heat in winter period and downward transport in summer season. An event of precipitation over the region was examined with respect to regaining the soil temperature to pre-precipitation conditions. Soil temperature up to the depths 40 cm was reduced drastically due to percolation of rainfall. Sensitivity of soil temperature distribution with respect to the removal of vegetation around the soil temperature gadget was also studied. It was found that the vegetation has a control on surface temperature by reducing the amount of heat that penetrates into the soil by means of lowering the ground soil temperature **(Fig. 38)**.

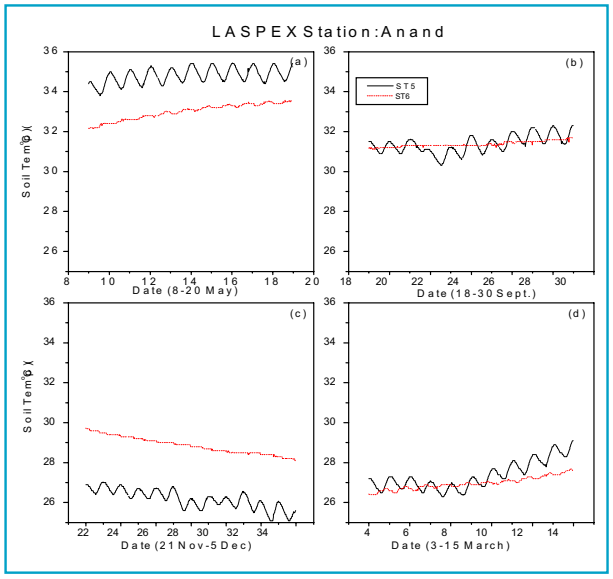


Fig. 38 : Distribution of soil temperature at 40 cm (ST5) and 100 cm (ST6) depths observed over Anand in different months

Evolution of atmospheric boundary layer

During the LASPEX conducted in the Gujarat region, radiosonde observations were collected over a station Anand (22 ° 35'N, 72° 55'E). Three representative months April, June and November with dry, wet and vegetated soil conditions respectively were selected for the study. Height of the boundary layer from the profiles of potential temperature (ϑ) and virtual

potential temperature (θ_v) was estimated using these observations to study the impact of soil moisture and vegetation on the growth of boundary layer. The analysis showed that the boundary layer attains peak height in the afternoon hours for all the above mentioned three conditions (**Fig. 39**). The boundary layer height was maximum in April, at 14.30 IST with low/no vegetation condition and low soil moisture availability. Due to low soil moisture content, more sensible heat flux was available for boundary layer heating. The boundary layer height was lowest in June at 5.30 IST with maximum soil moisture, reduced sensible heat flux and a little increase in soil heat flux.

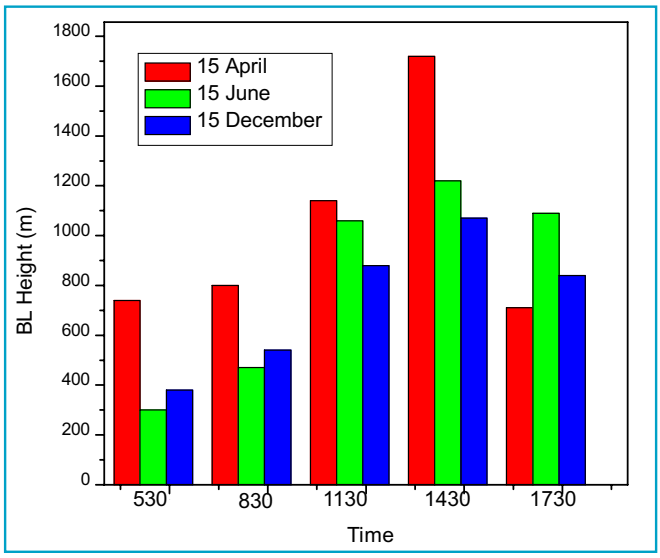


Fig 39 : Diurnal variation of estimated boundary layer height on 15 April, 15 June and 15 December, 1997.

Experimental Study of Exchange Processes in the Atmospheric Boundary Layer over Continental and Marine Environment

(S. Sivaramakrishnan, T. Dharmaraj, B.S. Murthy, S.B. Debaje, R. Latha, Cini Sukumaran)

Field observations

Measurement of turbulence as well as mean meteorological parameters and surface fluxes of solar radiation, momentum, heat, water vapour and carbon dioxide were carried out at the '*IITM Atmospheric Boundary Layer Field Laboratory*' at the National Centre for Antarctica and Ocean Research (NCAOR), Goa in order to study the dynamics of coastal atmospheric surface layer.

LASPEX and ARMEX data dnalysis

Water vapour and CO_2 data collected during ARMEX were analyzed to study their correlation with surface layer stability **(Fig. 40)**. Significant negative correlation coefficient (ρ,-ve) in the unstable (z/L, -ve) atmospheric conditions corroborated inverse relationship in the time variation of CO_2 and water vapour (decrease in CO_2 with increase in water vapour). Spectral analysis of these parameters showed the meso and large scale signatures besides micrometeorological peaks and the -5/3 power law relation in the inertial subrange.

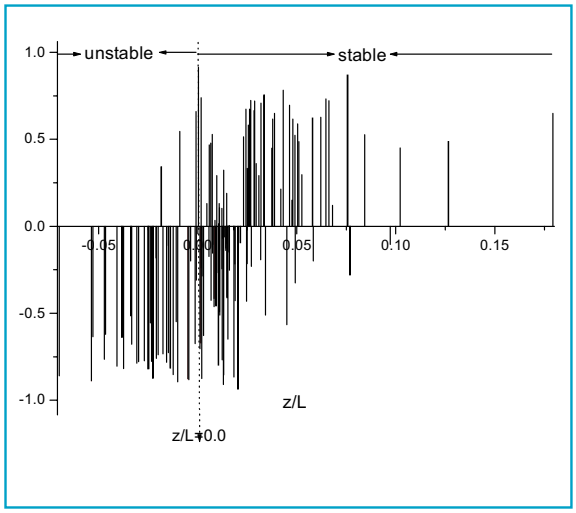


Fig. 40: Correlation coefficient (ρ) between CO_2 and water vapour densities as a function of stability (z/L).

Wind and temperature data from LASPEX and ARMEX were subjected to stationarity test in time. Similarity parameters were computed and categorized against stability classes. Micro-meteorological spectrum of wind and temperature at 4 m AGL at Anand (normalized by variance and frequency weighted) showed peaks of times scale 1 - 2 minutes at the low frequency end. Besides the inertial sub range characteristics (-2/3 slope) of the spectrum, on some occasions white noise and slopes of -1 denoting buoyant sub-range characteristics were depicted in the inertial sub range instead of -2/3 slope. This showed anisotropy in turbulence possibly introduced by inhomogeneity of terrain (**Fig. 41**).

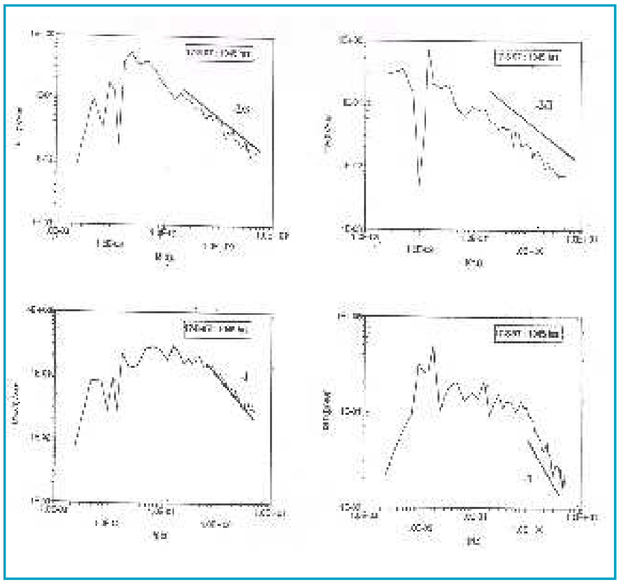


Fig. 41: Spectrum of wind at 1045 hrs on 17 August 1997

Measurements of surface ozone, solar radiation, air temperature and relative humidity in the institute's campus

Continuous measurements of surface ozone (O_3), incoming solar radiation, surface air temperature and relative humidity have been carried out at the Institute's campus. These measurements have been found to be useful to study the atmospheric chemistry of ozone and its precursors. A photochemical model was developed for short-term prediction of chemical species such as ozone and its precursors.

Impact of Tsunami on surface ozone

Unusual changes were observed in ozone and NOx concentrations after the giant Tsunami waves struck Tranquebar (11°N, 79.9°E) on the east coast of the southeast India on 26 December 2004. The average maximum O_3 concentration was unusually reduced by about half at 1500 IST and minimum O_3 increased by more than twice in the morning 0600 IST due to Tsunami impact **(Fig. 42a)**. The O_3 concentration abnormally increased during night reaching maximum in the morning (0600 IST) and decreased in the daytime attaining minimum at noon with 1σ standard deviation. Similarly average daytime and nighttime NOx also increased from 5.6 −0.35 to 9.5−0.66 ppbv and 6.5– 0.22 to 9.2 –0.34 pp bv respectively with 1σ standard deviation due to Tsunami impact **(Fig. 42b)**. The unusual changes in the diurnal variations of O_3 was found to be due to the possible changes in the photochemical production and destruction of O_3, while changes in NOx were attributed to the physical and chemical changes in natural and anthropogenic activity after The Tsunami. The diurnal variation of O_3 and NOx got restored to their normal pattern after about 30 days from the Tsunami event. increase in oxides of nitrogen (NOx) and other ozone precursor emissions by different sources such as additional oxidation of volatile organic compounds by chlorine radical. The chlorine radical, found to be emitted from the sea salt aerosols, which is a natural process.

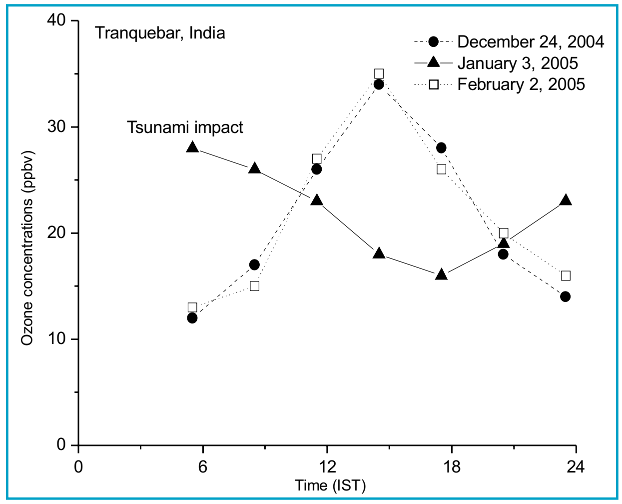


Fig. 42a: Diurnal variation of ozone concentrations on 24 December 2004 (filled cicles), 2 February 2005 (open squares), and 3 January 2005 (filled up triangles) during Tsunami impact.

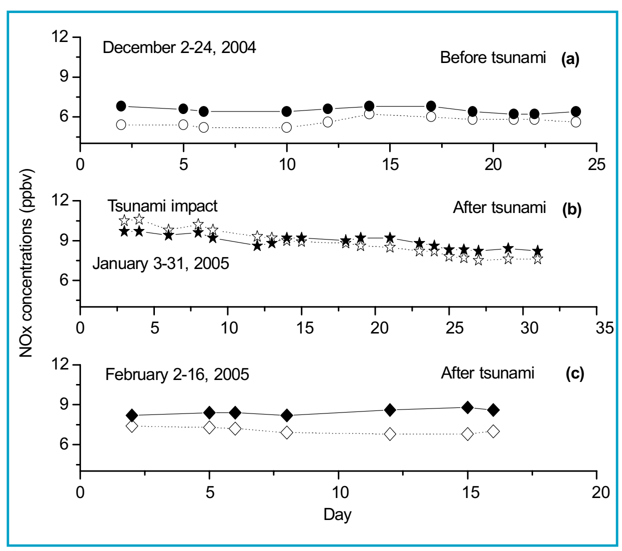


Fig. 42b: Daily variation in the NO_x concentrations before and after Tsunami impacts during different periods.

Effect of chlorine radical emissions on surface ozone at coastal sites in India

Measurements on surface ozone were carried out at three rural sites (Poombuhar, Tranquebar (11° N, 79.9° E, 9 m) and TR Pattinam) along and across Coromandal coast of Tamilnadu, India in the month of December 2000 and 2002 and in the month of April 2001 and 2003 with an array at five locations from coast to inland (0, 2, 4, 10 and 20 km). These measurements showed lesser ozone concentration in the inland (20 km) than that of the coast **(Fig. 43).** It was seen that the increase in ozone near the coast is attributed to the increase in oxides of nitrogen (NOx) and other ozone precursor emissions by different sources such as additional oxidation of volatile organic compounds by chlorine radical. The chlorine radical, found to be emitted from the sea salt aerosols, which is a natural process.

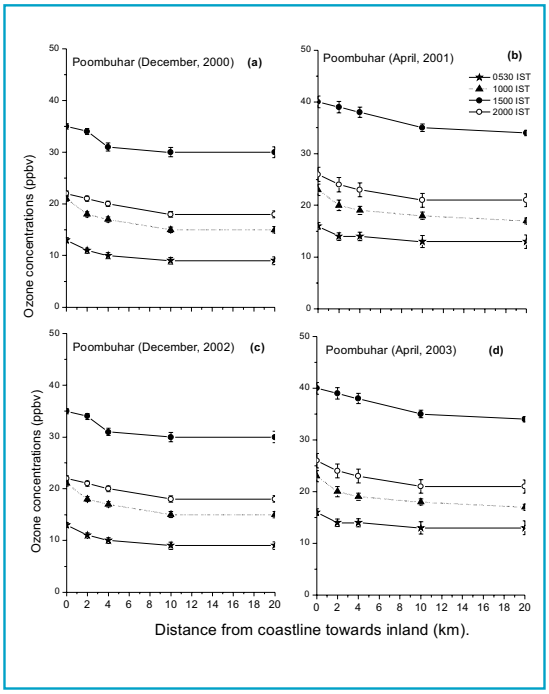


Fig.43: Spatiotemporal variation of ozone concentrations measured across the coastline at Poombuhar in December and in April averaged for 6 days in a month. Vertical bars are one sigma standard deviation. Ozone decreases toward inland from the coastline.

Effect of micrometeorological parameters on radionuclide emission and atmospheric electric field

Effect of micrometeorological parameters on radionuclide emission and atmospheric electric field was studied. It was seen that the micrometeorological parameters modify the atmospheric electric field locally hence it defines the major mechanism of modification. Radionuclide concentration or convection as proxies to conductivity and space charge are deterministic for electric field alterations depending on the intensity of the prevailing radionuclide concentration or convection. The atmospheric electric field, at times when thermal and mechanical forces are negligible as in the case of strong surface layer inversion, could be decisive on the pollutants forming layered pattern by virtue of their dipole momentum and strongly affect the particulate dry deposition by means of the active electro-phoretic force. Winter season is most conducive to this situation **(Fig. 44).**

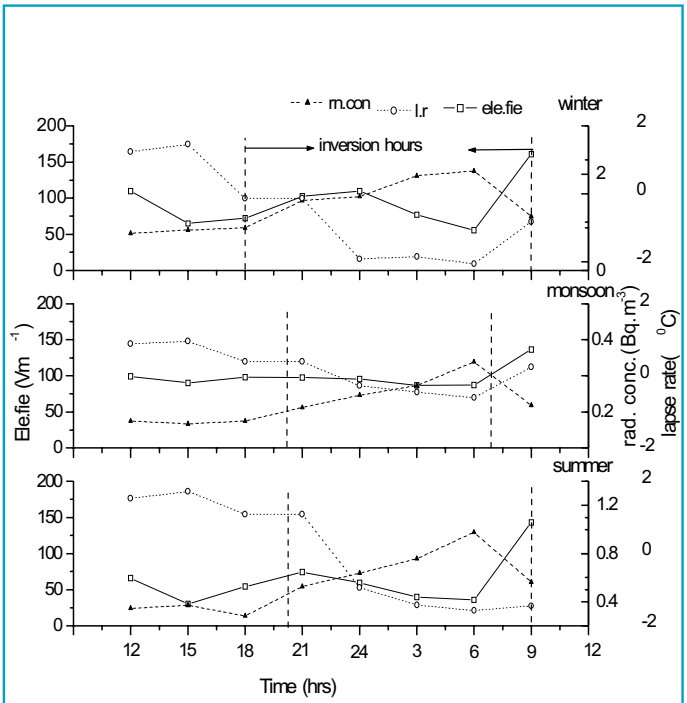


Fig.44 : Variation of electric field, lapse rate and radionuclide concentration with inversion hours marked for each season (electric field and lapse are hourly averages whereas radionuclide is three hourly observations).

Theoretical Studies

Theoretical Studies Division conducts theoretical studies for understanding atmospheric and oceanic circulations with special reference to southwest monsoon. Following are the research programmes undertaken by this Division:

- Development of diagnostic models for the study of (i) Regional energetics in the grid point domain (ii) Tropical belt energetics in the wave number and frequency domains and (iii) Global energetics in the spectral domain.
- Development of numerical models to diagnose the linear and nonlinear interactions among different spatial and temporal scales of monsoon flow.
- Development of simple reduced gravity as well as thermodynamic ocean circulation models for understanding dynamics and physics of Indian Ocean circulation and SST variability.
- Development of simple coupled ocean atmosphere model for understanding global circulation.
- Development of regional three dimensional multi-level ocean model for understanding surface and sub-surface temperature and circulation of Indian Ocean.
- Application of numerical ocean model for studying oceanic response to moving cyclones in the tropical Indian Ocean.
- To promote post- graduate academic programmes in Atmospheric Sciences.

Studies on Dynamical Ocean Modelling

(P.S. Salvekar, M.K. Tandon, C. Gnanaseelan, Prem Singh, A.A. Deo, P.R.C. Reddy, A.B. Parekh, D.W. Ganer, B. Thomson, J.S. Chowdary, B.H. Vaid)

Three dimensional OGCM studies (use of MOM 4 model)

The Modular Ocean Model version 4 (MOM 4) with the zonal resolution 1 °, varying meridional resolution 0.3° at equator to 0.7° at 25°N and 1.5° at 40° S and vertical levels was integrated over the Indian Ocean north of 40°S from the state of rest for a period of 20 years. Input to the model was obtained from National Centre for Atmospheric Research (NCAR), USA. After spin up, the model was integrated for a period of 43 years from 1958 - 2000 with inter-annually varying all the forcings from the NCAR. The model simulated sea surface temperature anomaly (SSTA) showed good agreement with the observed anomalies during the Dipole mode years (e.g. October 1994, October 1996 and November 1997). The model simulation showed a maximum cooling of 2°C at surface and of about 5°C in the subsurface (at 80 m depth) on the eastern side during November 1997, which was well comparable with the observations. The model simulated subsurface temperature was well comparable with SODA subsurface temperature in all the years. The anomalous circulation pattern simulated in the Bay of Bengal confirmed the role of Wyrtki Jets in Bay of Bengal circulation. The model simulated salinity fields during positive dipole years showed positive salinity anomalies in the southeastern equatorial Indian Ocean, while negative anomalies were found in the central equatorial Indian Ocean. The salinity variability in the equatorial Indian Ocean affects the surface and subsurface temperature through formation or erosion of barrier layer **(Fig. 45)**.

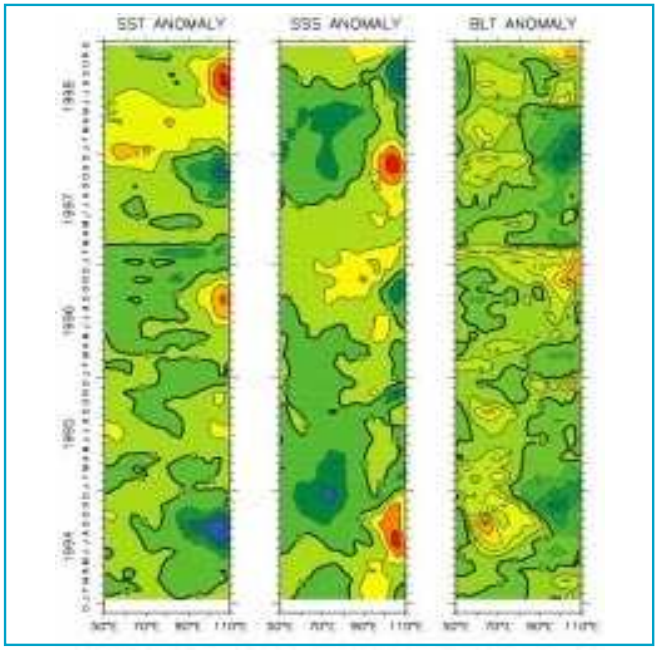


Fig. 45: Hovmollers of SST, SSS and BLT anomalies averaged over 10°S to equator.

The Modular Ocean Model Version 4 (MOM4p0c) was used to study the oceanic processes associated with the Indian Ocean Dipole (IOD) mode events in the tropical Indian Ocean. The model successfully simulated the cooling/warming trend in the region during dipole mode years. The heat budget analysis of the model simulated fields revealed that the positive surface heat flux and vertical advection terminate the IOD co-occurring with El Nino, whereas horizontal and vertical advections are responsible for IOD termination during the non-El Nino years. The contribution of surface heat flux is significant during the initial phase of termination during all dipole years. The dipole termination during the negative dipoleyear 1996 was mainly caused by the anomalous negative surface heat fluxes and horizontal advection.

Three dimension ocean model study using multi level sigma coordinate POM model

The three dimensional sigma coordinate POM ocean model with horizontal resolution 1° x 1° and 21 levels from surface to deep ocean was used to simulate surface and subsurface currents in the model region 35.5° - 99.5° E, 24.5° S - 25.5° N using ECMWF monthly mean climatological surface forcings and Levitus climatology for internal forcings. The model solution demonstrated strong annual cycle and significant variability in the subsurface circulation. During Boreal winter, surface Somali current had southward direction, but this feature was not seen beyond 70 meter depth. Reversal in the direction of Somali Current was present only in the shallow upper layer up to 50 to 70 meter depth. Subsurface Somali current was found to be northward throughout the year. Also it was found that in the western Arabian Sea southward undercurrent north of 5°N was present throughout in spring and summer.

The model was modified to use NCEP reanalysis wind forcings and Levitus climatology. Surface winds south of 38° S in the Indian Ocean were found to remain almost unaltered throughout the year. Therefore, 40° S can be considered as natural boundary for surface forcings and hence model domain considered was of 40° S-30° N, 30°-120° E. NCEP reanalysis data were downloaded for their interpolation on model grid

Ocean response to moving cyclones

The 1‰ layer reduced gravity ocean model (‰x ‰) was integrated for the life span of the observed tropical storm of 2004, TC 04A (4 - 7 November) in the Arabian Sea. The right bias in the model ULTD field was not clearly seen but the maximum cooling of 2.5°C was seen on the right of the track. The sensitivity of the ocean response to higher model resolution was studied further for this cyclone. It was seen that the model fields become strong as the resolution increases. The cooling is increased from 2.5° Cto 4° C as the resolution is increased from ‰ to 1/12° The ULTD field showed more increase in downwelling than in the upwelling for the higher resolution. After reducing the initial temperature gradient across thermocline in the 1/12° resolution model, the simulated temperature change was compared with the observed temperature change from TMI SST during the passage of the cyclone. The observed cooling of 1.5º C occurred during the passage of TC 04A **(Fig. 46),** whereas the model temperature change showed the cooling of 2.5 °C, which was overestimated. This difference between model simulated and observed cooling may be due to high salinity of the Arabian Sea as compared to that of Bay of Bengal, which was not incorporated in the model.

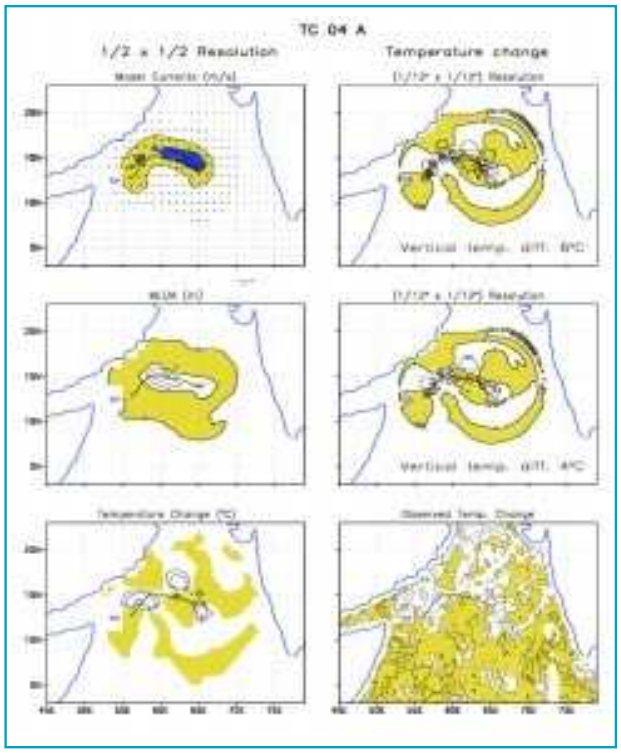


Fig. 46: Model currents, mixed layer depth anomaly and temperature change on the last day of the cyclone TC 04A with ‰x ‰ resolution (left panel) and temperature change with high resolution model compared with the observed one. Solid line drawn is the storm track. Positive values indicating downwelling or warming are shaded.

Further, fifteen cases of the cyclones over northern and southern Indian Ocean during last decade were selected. The 1‰ and 2‰ reduced gravity ocean models over the region 35°-115°E, 30°S-25°N were used to simulate the thermal structure during the period of cyclone. The simulated temperatures showed cooling of sea surface of the order of 1° to 3° C for most of the cyclones depending upon their intensity, movement, size, etc. This cooling was in response to the upwelling caused by the entrainment due to the storm winds. Further, the model SST anomalies were compared to the observed SST anomalies. The region of cooling in association with the cyclonic circulation was well simulated and was in agreement with the observed cooling. The model simulated SST anomalies were found to be weaker than the observed ones, on ac count of less intensity of the actual cyclones provided as input to the model.

Watermass transport in the Arabian Sea using Argo observations

The information acquired from Argo floats such as temperature and salinity profiles was used to study the water mass properties in the Arabian Sea for the years 2002 to 2004. During the southwest monsoon season the impact of early onset of southwesterlies was noticed on the upper ocean temperature and salinity in the western Arabian Sea. Through out the year two salinity maxima were noticed over the northern Arabian Sea. In the eastern Arabian Sea salinity maximum at the intermediate levels is due to Red Sea Water (RSW) which is more prominent in summer. In the western Arabian Sea salinity maximum related to RSW was persisted through out year. Evidence of watermass transports from source regions over the Arabian Sea was established from Argo float trajectories and wind driven ocean transports. During summer monsoon northward movement of Argo float over the western Arabian Sea and southward movement in the eastern Arabian Sea are found to be consistent with wind driven transports.

Kelvin and Rossby waves in the Indian Ocean

Finite Impulse Response (FIR) filter was used to filter Topex/Poseidon Sea surface height anomalies during 1993 - 2001 (10 days averaged data) and Simple Ocean Data Assimilation (SODA) sea surface height anomalies during 1958 - 2001 (monthly average data) over the Indian Ocean (20° S - 20° N and 40° - 120° E), into Kelvin (semi annual and trimestral) and Rossby waves (semi-annual, annual and biennial) components. Dipole-like spatial structure was observed in the biennial Rossby waves from both the data sets, which characterises the Indian Ocean Dipole period **(Fig. 47)**.

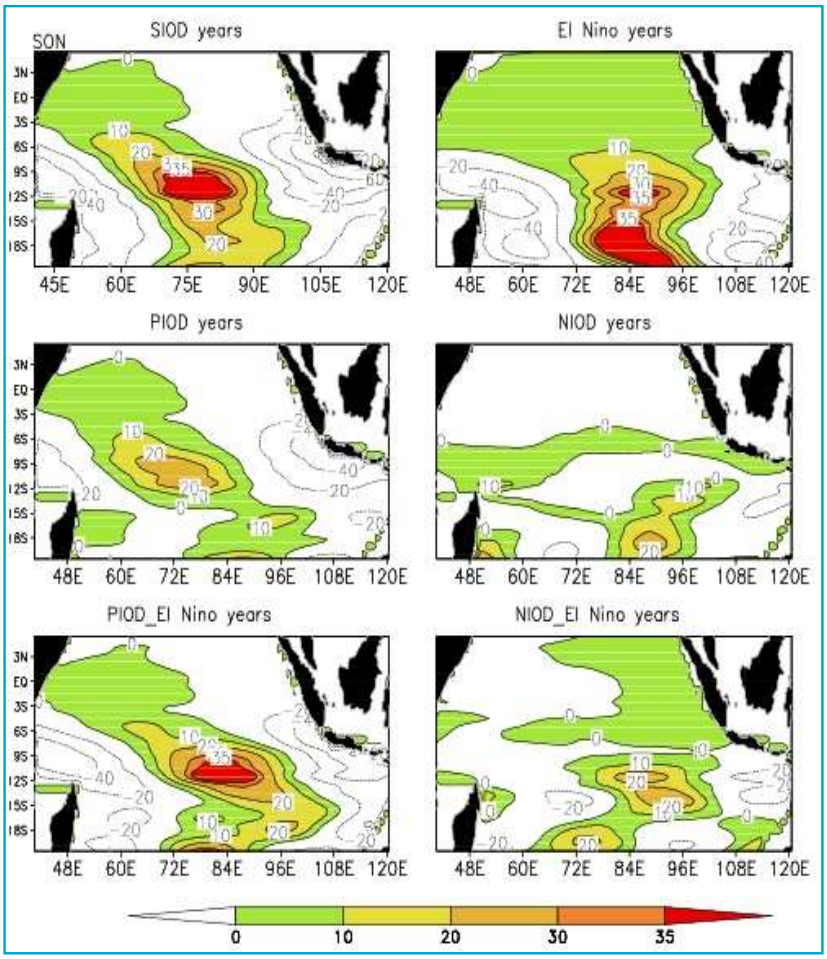


Fig. 47: Biennial Rossby wave averaged over September, October and November.

Anomalous downwelling biennial Rossby waves along 1.5° S were seen propagating westward from the eastern boundary, more than one year prior to the formation of the every positive Indian Ocean dipole. Simultaneously, upwelling counterparts were also seen in the east during the

peak Indian Ocean Dipole time giving a see-saw zonal gradient to the thermocline in the equatorial Indian Ocean. The westward propagating downwelling biennial Rossby wave signals can be considered as the predictor for the Indian Ocean Dipole. The propagation of equatorial annual and semi-annual Rossby waves from Topex/ Poseidon data was seen as twin gyres on both the sides of the equator. During the Indian Ocean dipole years (i.e. 1994 and 1997) a drag in the propagation of equatorial annual Rossby waves were observed near 75°-80° E, for which wind stress and wind stress curl (75°-85° E) were seen to play an important role.

Anomalous downwelling trimestral Kelvin wave propagation during October to December 1994 terminated the basin-wide coupled process. Moreover, during Indian Ocean Dipole events concurrent with El Nino (e.g. 1997) such downwelling trimestral Kelvin waves were absent.

Identification of the Pacific Twin Gyres (PTGs) and their role in inducing warmer temperatures in the El Nino 3.4 domain

After identifying the Twin Gyres in the Equatorial Indian Ocean, the possible existence of such gyres along the tropics in the Pacific was also examined. For this purpose the WOCE observed currents, TOPEX derived SSHs, observed SSTs from TAO, satellite derived SSTs from AVHRR and finally with the MIT-OGCM outputs were thoroughly studied. It was found that Twin gyres are also present in the El Nino domain of the eastern Pacific and are named as the Pacific Twin Gyres (PTGs). During the non-El Nino years the Gyres have a cyclonic pattern of circulations, while during the El Nino years, the circulation pattern is anticyclonic. It was also found that these PTGs have a profound effect in inducing warmer temperatures in the 3.4 domain through their anti-cyclonic circulations which bring about the sinking phenomena that in turn cause increased SSTs in the region. The signature of the PTG's influence in the 3.4 domain was also reflected in the eastward steeping/ tilt of the thermocline. It was seen that the interaction of the Rossby and Kelvin waves in the Equatorial Pacific can be studied through these PTGs.

Influence of El Nino on Rossby wave propagation

Influence of El Nino on the propagation of biennial and annual Rossby waves in the Indian Ocean was observed. It was noted that El Nino not only strengthens the annual and biennial Rossby waves in the Indian Ocean but it forms late (i.e. when there is El Nino in the Pacific Ocean, annual and biennial Rossby waves in the Indian Ocean start late). The biennial and Rossby waves in the Indonesian through flow region (12.5°-7.5°S) of Indian Ocean are linked with biennial and annual Rossby waves in the Indonesian through-flow region (12.5°-7.5°S) of Pacific Ocean. This study supports the intrinsic link between Indian Ocean dipole and El Nino.

Diagnostic Studies Using NCEP-NCAR reanalysis data

To understand the interannual variability in the formation of Mini Warm Pool (MWP, SST=30.5 °C) and its impact on the formation of onset vortex (OV) over East Central Arabian Sea (ECAS) weekly SST data and 850 hPa wind fields were analysed from May to June for the period 1992 - 2003. The analysis revealed that the MWP was formed over the region 10° - 15° N, 65° - 75° E and retained there for a long time (2 to 3 weeks) during the years 1994, 1998, 2001, 2002 and 2003. Whereas, in the rest of the years the MWP was formed during early May but wiped off either in the last week of May or first week of June prior to the onset. The 850 hPa wind field showed that the OV developed into an intense system only during the years 1994, 1998 and 2001 to the north of the MWP and on the northern flank of the low level jet axis which approached to the southern tip of India just prior to the onset of monsoon similar to the vortex of MONEX -79. The area averaged zonal kinetic energy (ZKE) over the Western Arabian Sea (WAS) domain 5° S-20° N, 50-70° E showed a minimum value of 5-15 m^2/s^2 prior to the monsoon onset over Kerala (MOK) and a maximum value of 40 - 70 m^2/s^2 during and after MOK while for ECAS (domain 65°-75° E, 8°-15° N) the ZKE showed 5-15 m^2/s^2 prior to the MOK and a maximum of 280 m^2/s^2 after MOK.

Diagnostic study using satellite observations

Study was undertaken to understand and predict the onset date of the Indian Summer Monsoon (ISM) over Kerala and its interannual variability. The daily outgoing longwave radiation (OLR) data, which would be used as a proxy for tropical convection, were from the Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA) operational polar orbiting satellites. The study was conducted using gridded (2.5°×2.5°) daily mean OLR

data having spatial range 90° N - 90° S to 0.0° - 357.5° E only for last eight years during 1974- 2005. The average daily OLR difference between Nino3.4 region over Eastern Pacific and East of Madagascar (EOM) over Southern Indian Ocean reached its minimum value only once after mid- April and prior to mid - May for each year from 1998 to 2005. This study helped predict the probable onset date for ISM about 6 to 7 pentads in advance.

Diagnostic study using TMI SST

Work was undertaken to understand and predict the onset date of the Indian Summer Monsoon (ISM) in relation with SST variations in the Tropical Indian Ocean. As a first step TMI (TRMM Microwave Imager) data set was used to analyze SST variations in the North Arabian Sea, Near Somali Coast and West Equatorial Indian Ocean from 1st April to 15th June for each year during 1998 to 2005. This study has been found to be helpful to predict the probable onset date for the Indian summer monsoon about 30 days in advance.

Mixed layer model study

A two dimensional advective mixed layer ocean model was developed over the north Indian Ocean north of 20°S. An OGCM simulated surface currents were used to derive the temperature advection in the model. The model was forced by the NCEP surface fluxes. The model simulated the interannual variability in the mixed layer temperature during 1993 to 2000. Indian Ocean Dipole observed during 1994 and 1997 were well simulated by the model. The basin wide warming observed during March to May 1998 was also simulated by the model.

Studies on Atmospheric Energetics in the Wavenumber and Frequency Domain

(P. S. Salvekar, D. R. Chakraborty, S. S. Desai, N. K. Agarwal, S. De, S. S. Naik, R. S. K. Singh, M. S. Deshpande)

Inter-time scale Interactions over the Indian region

Diagnostic energetic study was carried out in the frequency domain to improve the understanding of the impact of Madden-Julian oscillations (MJOs) during pre-monsoon (March to May) and monsoon (June to September) seasons of 1996, 1997 and 1998 using NCEP data over the region 40° - 120° E and Equator - 30° N. The results revealed that the seasonal mean flow is the important source of kinetic energy (KE) for the maintenance of transient low frequency oscillations (LFOs) on MJO time scale during pre-monsoon and monsoon seasons except for the year 1997 which comes under the episode of El-nino. Nonlinear scale interactions in KE trigger the MJO activities over regions even remote from the main convective zones during pre-monsoon period. The results further suggested that if the intraseasonal oscillations could influence the seasonal mean significantly, they could give rise to internal low frequency variation of the monsoon.

Energetics over the oceanic regions in the frequency domain

A study addressing the growth of energy in the lower troposphere (850 hPa) on the time scale of MJO was performed using the NCEP / NCAR reanalysis daily u and v over the Indian Ocean (10°S-10°N, 60°-110°E), Western Pacific Ocean (10 °S-10°N, 150°-130°E) and Central Pacific (10°S-10°N, 160°-180°W) for the period 20 May- 31 September 2004. Tropical instabilities provided a rich family of tropical disturbances over these oceanic regions that appeared to be ready and waiting to interact with the MJO time scales. In this study it was seen that the energy and its growth contributed by the MJO time scale by the way of inter-time scale interactions over the Indian Ocean and western Pacific play a significant role (about 50 to 60% of total energy interactions) during the monsoon season. The results suggested a strong teleconnection of MJO activities over Indian Ocean and western Pacific.

Ocean atmosphere interactions in the frequency domain

The study over the Indian Ocean domain (10° S to 10° N, 60° to 110° E) based on the analysis of a couple of models (Max Plank Institute Ocean Model and FSU GSM Atmosphere Model) daily u and v were analyzed for the period March 1996 to March 1997 and the study showed that the Planetary Boundary Layer exhibited a general strong value of eddy momentum fluxes on the MJO time scale at all latitudes. The contribution by the synoptic time scales was roughly 15 percent of the total transports and was all directed from ocean to atmosphere. The results on the computation of wave energy fluxes in the frequency domain showed the important role an interactive SST has in stratification on different temporal scales to influence the characters and maintenance of the MJO.

Nonlinear error energy budget of a forecast model in the medium range tropical weather forecasts

To address the scale dependent features of the nonlinear error characteristics over tropics during the two contrasting seasons, the systematic and random error energy growth rate and the different dynamical terms like flux, generation and conversion in the error energy growth rate equations were studied in Fourier spectral (wave number) domain over 30°S-30°N global tropics using NCEP (MRF) wind field up to 7-day forecasts for winter (DJF, 2000-01) and summer (JJA, 2001) months. The dominant spectra of the systematic error energy growth rate were observed at the wave number 1 and 3 during winter and at the wave number 1 and 4 during summer months. Similarly, the spectral distribution of the random error energy growth rate showed the dominant spectral band of wave number 3-8 or 4-9 with the largest growth rate at wave number 5 and 6 for maximum number of forecast days during both the seasons. The dominant wave numbers shown in the error growth rates were also observed as the largest spectra of the respective error variance. Fluxes of the systematic and random error energy converge at the predominant wave number of the respective error variance. As far as the generation terms are concerned in the error growth rate equations, the systematic and random error generates at those wave numbers where the respective error showed its largest variance. The dominant spectra of the different dynamical terms were explained in terms of the nonlinear error energy exchanges among different wave numbers through the individual triad interactions. Analysis showed that the major source of the large scale tropical error is associated with the synoptic and sub-synoptic scale phenomena occurred over tropics.

Diagnostic study of the super active monsoon period during 2005

During 2005, in the monsoon season, few heavy spells of rainfall occurred in the last week of June and last week of July. Most of the subdivisions reached normal rainfall state only because of the abnormal heavy spells in the last week of June and July. These unusual activities were studied by examining the dynamics (D, z, w) and physics (Q_H, Q_L) during the period 21-30 June and 22-31 July using NCEP reanalysed daily zonal and meridional wind (u and v), temperature (T) and relative humidity (q) from surface to 200 hPa, over the region 50°-100° E and EQ-30° N. Dynamic instability characteristics were studied throughout the period mentioned above by computing static stability (s) and meridional gradient of potential vorticity (Q_y). All the results showed that the atmosphere is highly unstable in the lower troposphere near 700-800 hPa and necessary condition for baroclinic instability is satisfied **(Fig. 48)** in the boundary layer for all the days. Further, zonal and meridional winds in the x-p (15°N) and y-p (80°E) plane were also examined. The existence of small scale cyclonic circulations in the boundary layer, effect of strong surface friction around15°-20° N and inversion at 5°-6° N were seen in the y-p plane for all the days. Maximum intensity of z (6.5×10^{-5} m/ s) and w (-6×10^{3} mb/ s) near 23°N, 68°E up to 400 hPa indicated that the offshore trough is active

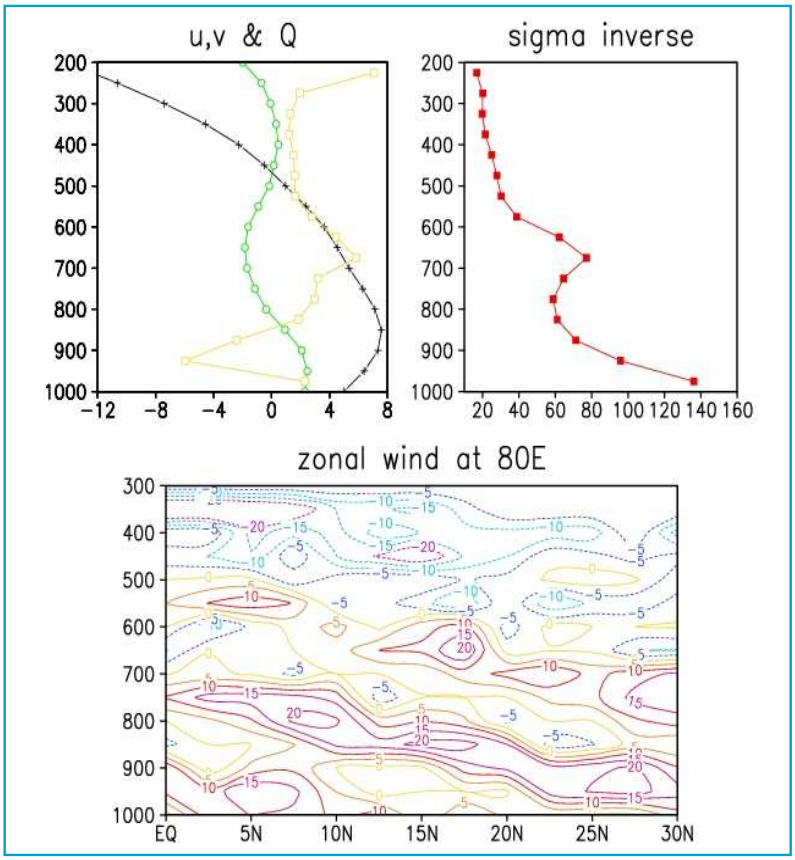


Fig.48: Vertical profiles of u & v (m s^{-1}), s $^{-1}$(mb^2 s^2 m^{-2}), Q_y (10^{-11} $m^{-1}s^{-1}$) and zonal wind in y-p plane at 80°E on 26 July 2005.

in both the June and July cases as a result of which very heavy rainfall received throughout the days. Eastward tilt in the vertical was clearly seen from the zones of upward motion. This supported the baroclinic mechanism for the synoptic scale monsoon depression which was present during the period. Strong low level convergence in the boundary layer, intense upward motion and high intensity in the heat source in the mid troposphere together indicated that the growth of the system is due to CISK mechanism.

Application of MM5 model for super cyclone in the Bay of Bengal

Role of ocean-atmosphere as coupled system in the genesis of tropical cyclones in the Indian Seas was studied using a non-hydrostatic, z coordinate system Atmosphere Mesoscale model MM5. The case of Orissa Super Cyclone (October 1999) was tested. Sensitivity experiments were carried out to see the impact of domain size (in terms of grid points in X and Y direction - Large: 150 x 150 grid points, Medium: 100 x 100 and Small: 50 x 50) with five different cumulus parameterization schemes (AK, BM, Grell, KF and KF2) on a single domain simulation of Bay of Bengal Super cyclone **(Fig. 49)**. European Centre for Medium Range Weather Forecasts (ECMWF) 40-year Reanalysis dataset (ERA-40) with 2.5° x 2.5° horizontal resolution was used as initial and boundary conditions for nterpolated to model grid model integration of five days 26 - 31 October 1999. Horizontal resolution was 50 km. The results showed that the model issensitive to domain size. The position of simulated system was found to be highly dependent on the domain size. The results of Small Domain with Kain Fritsch 2 parameterization scheme were found to be comparable with ERA-40 data. Small Domain was studied further for higher resolution (25 km) with same five parameterization schemes. Higher resolution increased the accuracy in the intensity prediction of the storm but deviated in the prediction of track.

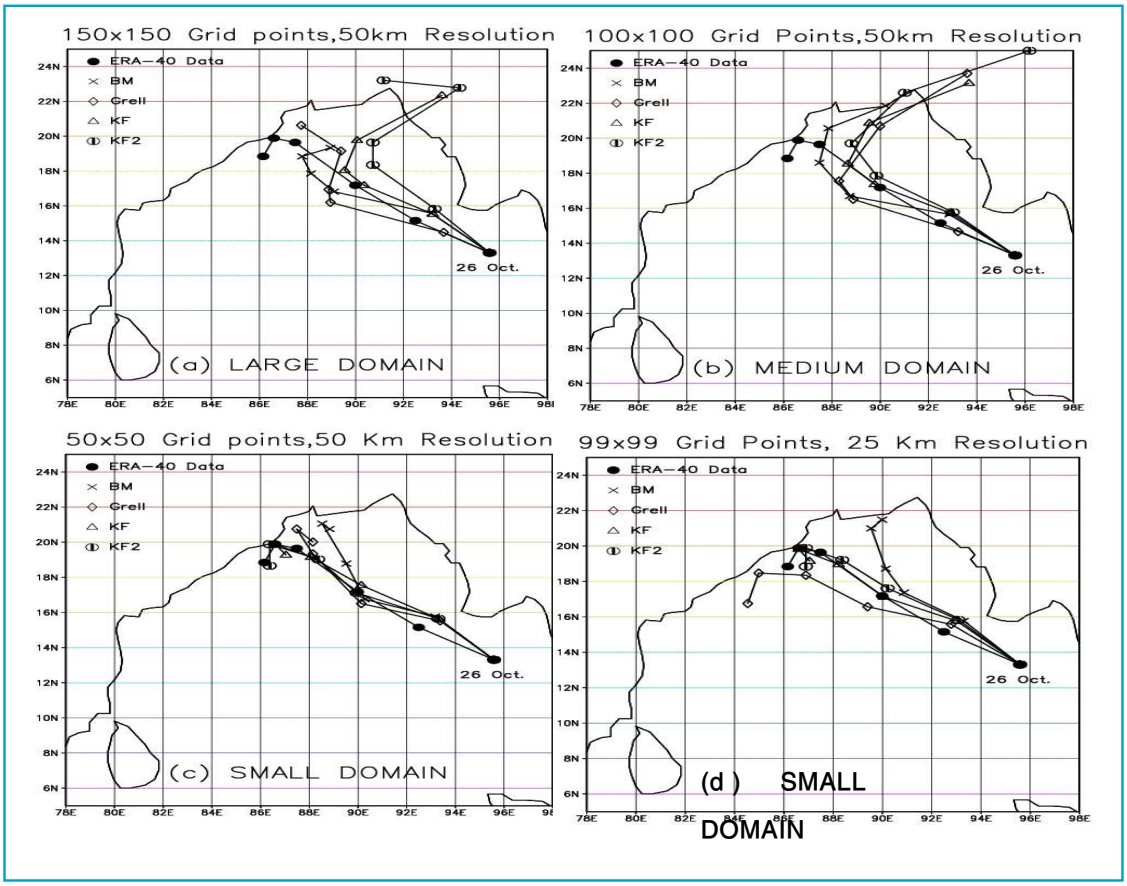


Fig. 49: Tracks of simulated cyclone using cumulus parameterization schemes viz. Betts Miller, Grell, Kain Fritsch 2 with 50 km horizontal resolution, for (a) Large Domain (b) Medium Domain (c) Small Domain and (d) Small Domain with 25 km horizontal resolution.

Climate and Global Modelling

The Climate and Global Modelling Division conducts global modelling studies to understand the physical and dynamical processes in the climate system. The current research programs focus on the following objectives

- Comprehensive study of the physical and dynamical processes relating to global and monsoon climate, their variability and change on different time scales.
- Development and improvement of physical and mathematical models capable of simulating climate, its variability and change due to natural and anthropogenic factors and validation of the results of the climate models.
- Application of general circulation models for seasonal forecasting of monsoon rainfall.

Diagnostics and Modelling Studies of Long Term Trends and Variability of Climate Over the Indian – Asia Pacific Regions

(R. Krishnan, J.R. Kulkarni, A.K. Sahai, S.K. Mandke, M.S. Mujumdar, S.P. Gharge)

Coupled air - sea interactions in the tropical Indian Ocean environment and impending monsoonal drought

Monsoon droughts over the Indian subcontinent emanate from failures in the seasonal (June-September) monsoon rains. While prolonged dry-spells ("monsoon-breaks") pervade on sub-seasonal/intra-seasonal time-scales, the underlying causes for these long-lasting anomalies have been elusive. In a recent study an ocean-atmosphere dynamical coupling on intra-seasonal time-scales, in the tropical Indian Ocean, which is pivotal in forcing extended monsoon-breaks and causing droughts over the subcontinent was reported. This coupling involves a self-sustaining feedback between the monsoonal flow and thermocline depth in the Equatorial Eastern Indian Ocean (EEIO), in which an anomaly of the monsoon circulation induces down-welling and maintains a higher-than-normal heat-content. The warm and deep mixed-layer in the near-equatorial Indian Ocean drives anomalous convection in the atmosphere, which suppresses the monsoon Hadley circulation and reinforces the anomalous westerly winds and low-level convergence over the equatorial region. It has been revealed that the intra-seasonal evolution of the ocean-monsoon coupled system holds the key to unlocking the dynamics of monsoon droughts. This new understanding should foster major improvements in our ability to predict the monsoonal rains on time-scales of days-to-weeks. The Indian Ocean-Monsoon coupled feedback is illustrated in the **Fig.50**.

General Circulation Model Systematic Error Correction and Seasonal Prediction Using Artificial Neural Network

(A. K. Sahai, R. Krishnan, J. R. Kulkarni, S. K. Mandke, M. A. Shinde, S. P. Gharge)

Impact of climate change on active/break spells of Indian summer monsoon

The influence of climate change on active/break spells of Indian summer monsoon simulated by ten coupled models, under the Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR4), was investigated by comparing their number, duration and the spatial pattern of composite rainfall anomaly with control simulation. The impact of climate change was assessed from two experiments viz., 1% per year CO_2 increase to doubling (1pctto2x) and 1% per year CO_2 increase to quadrupling (1pctto4x). Fig.51 shows the rainfall anomaly associated with break monsoon condition as simulated by the GFDL_CM2.1 model in the control, 1pctto2x and 1pctto4x scenarios. The simulations suggested that the rainfall reduction over India during monsoon breaks is larger in the global warming scenarios as compared to the control experiment **Fig. 51**.

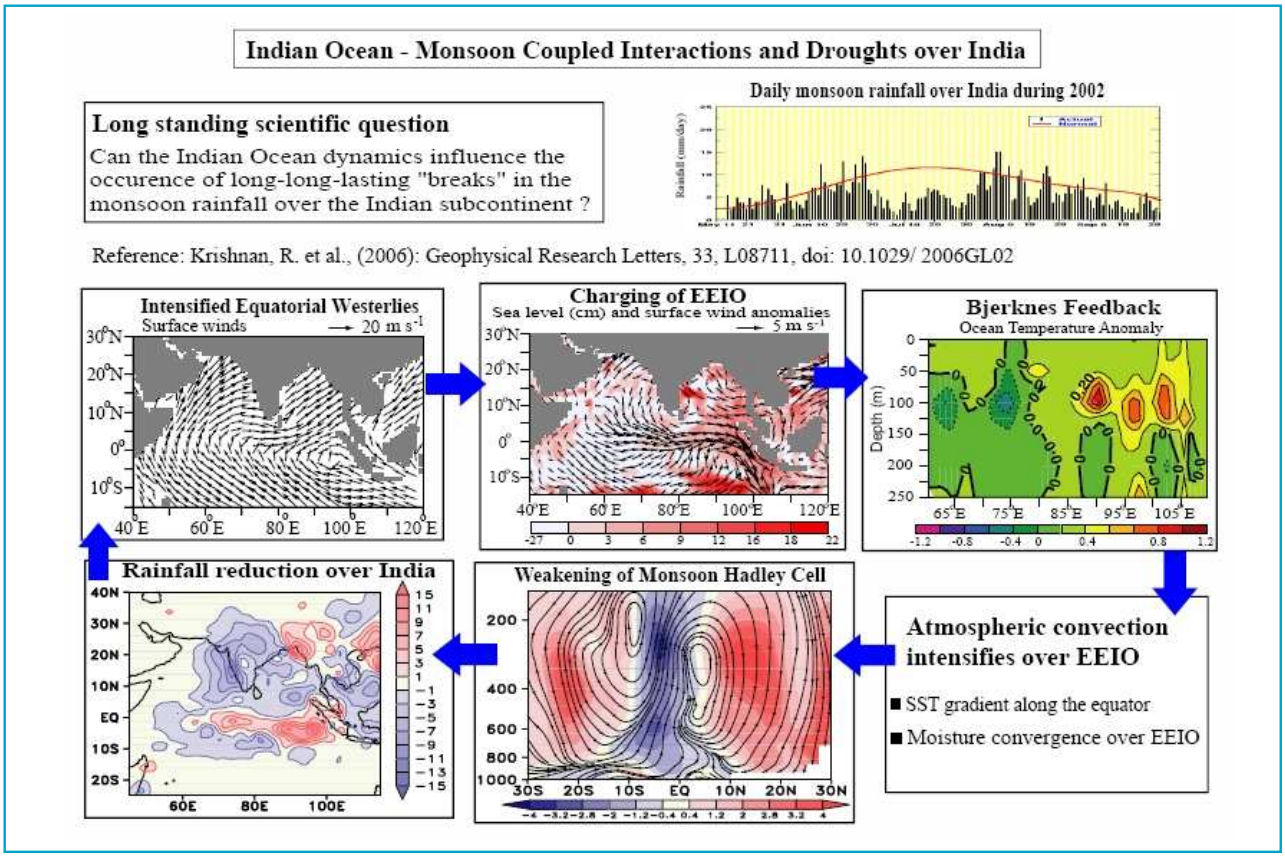


Fig. 50 : Indian Ocean Monsoon coupled interactions and droughts over India

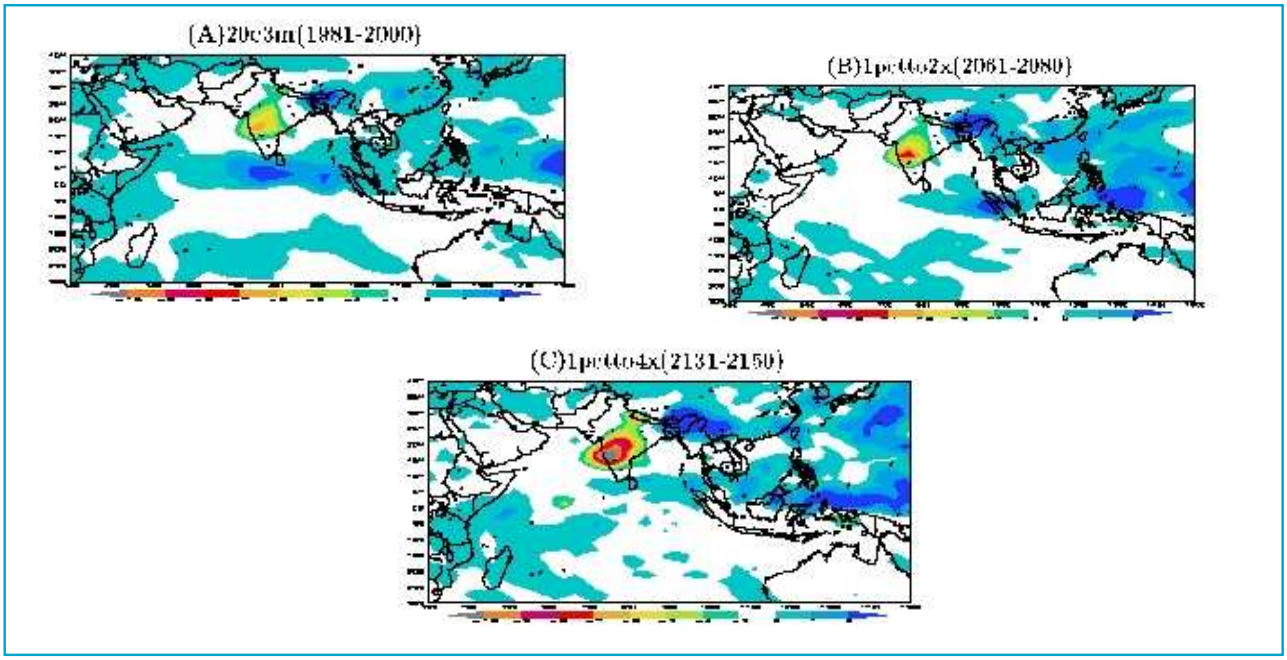


Fig.51: Simulation of break-monsoon rainfall anomaly in the present-day and global warming scenarios

A non linear classification of intraseasonal phases of monsoon using the self organizing map algorithm.

The synoptic states during monsoon season are classified according to the states of rainfall and dynamical parameters. The states of rainfall are referred to as having an active phase, a break phase and the normal state. As the name implies the rainfall activity is much more pronounced during the active state than the normal and is highly subdued during the break state. The circulation features, the pressure patterns and all other meteorological parameters are known to have different characteristic features in different states. While all these facts are well known, the simulation or prediction of rainfall patterns is rather poor in atmospheric models, though the dynamical features are well simulated. A scheme was developed to classify the states of rainfall according to the dynamical features and it was verified whether such scheme is able to classify realistically the rainfall states as observed in the synoptic charts. The Self Organizing Map (SOM) algorithm developed by Kohenen was used for this purpose. Basically this cluster algorithm is an unsupervised learning artificial neural network technique which effectively includes the non-linearity in the data.

The input data series for the classification were taken from ERA40 (ECMWF) reanalysis global data for the years 1980 - 2001 for the parameters viz., precipitation, u-wind (850 mb and 200 mb), v-wind (850 mb and 200 mb), geopotential height (500 hPa), mean sea level pressure, specific humidity at 850 mb and the monthly SST. Based on these input data series the parameters were classified accordingly as 3 x 3 SOM nodes. The information of the rainfall was not used for the classification. It is found that the SOM nodes are able to classify the states having one high active phase, an acute break phase and at least one normal state. The other states were the transition states. Based on the result it was inferred that if all the circulation and other dynamical features are well captured in a model the rainfall states can be obtained in tune with the observation. The classification also showed that the active states and break states are more stable states (more probability of staying in those states) than the other states. It was concluded that the artificial neural network technique can be applied to quantify the classification of qualitative synoptic features which will also show the quantification of rainfall.

ENVIS - Centre

('Acid Rain and Atmospheric Pollution Modelling' and Sustainable Development Network Partners on 'Climate Change')

The broad objective of the ENVIS Centre is to to furnish and disseminate the information on the subject area "Acid Rain and Atmospheric Pollutants", to enrich the available database for India and to convert data into information. Following are the detailed objectives of the Centre:

- To develop qualitative as well as quantitative database for primary as well as secondary data sets related to all the atmospheric pollutants viz. Carbon Mono-Oxide (CO), Oxides of Nitrogen (NOx), Ozone (O_3), and Suspended Particulate Matters, etc. and acid rain records in terms of acidification index.
- To classify the database on the basis of type, quality and acquisition and web linking of the database to serve the purpose of obtaining all the data at one site.
- To encourage the dissemination of current knowledge on the subject area and related information through periodic newsletter, papers in journals, reports, etc.
- To make society aware about the subject area, visits /open house for common public and provide voluntary consultation services to educate and create awareness about the subject area to fulfill the need of the bottom end user.
- The objective of the SDNP on climate change is to support the Sustainable Development of the resources by integrating the resources available in the existing Environmental Information System (ENVIS) centre.

Acid Rain and Atmospheric Pollutant Modelling Center

(G.B. Pant, G. Beig, S. Jain, A. K. Solanki, H. Pathakh)

The ENVIS website on Acid Rain and Atmospheric Pollutant Modelling at the Indian Institute if Tropical Meteorology, Pune, has further advanced in the last one year enriching the subject area. As per the guidelines, larger emphasis has been placed to publicize and increase the awareness about the existing ENVIS facility and its information on the thematic area. Qualitative as well as quantitative databases were developed which were regularly updated for primary as well as secondary data sets related to all the atmospheric pollutants viz. Carbon Mono-Oxide (CO), Oxides of Nitrogen (NOx), Ozone (O_3) and acid rain records in terms of acidification index. The database of the above mentioned pollutants was made available for online visualization and dissemination through web, on request. The abstract indexing service related to atmospheric pollutants and climate change was initiated in this year which was periodically updated. Many more links to provide the information and secondary data sources were added. Provision has been made to obtain other relevant data sets from the parent institutes by means of direct link. To encourage the dissemination of current knowledge on the subject area and related information, periodic newsletter, papers in journals and reports are being published both as hard copy as well as soft copy by displaying on the Internet. About 500 web based queries related to subject area were received and adequately answered during the year. Major achievements in this year are outlined below:

1. The primary as well as secondary database related to acid rain and atmospheric pollution have been considerably enhanced and enriched during this year. Number of links to new databases on atmospheric pollution have been added. The new links on information which have been added in this year are discussed below.

   a) Primary Data Sets: Generation of online primary data base for several pollutants like Ozone, NOx, CO, VOCs, Black Carbon, etc. The data have been classified on the basis of duration, length of the series, sampling interval, and location. Online Graphic Visualization of above mentioned pollutants on hourly /daily / monthly scales Geographical distribution of the level of pollutants for Indian subcontinent on resolution of $1^o x 1^o$ in latitude and longitude using regional chemical transport pollution model.

   b) Secondary Data Sources: Links to secondary data sets have been enhanced. Rich availability of data on this subject area has been made available at the site of CPCB: *http://www.cpcb.nic.in/* ; Pollutants: SO_X, NO_2, RSPM and SPM; Stations: Major cities in most states; Period: Discrete (sampling: 16 Hrs, selected days); Averaging: Daily average. The MPCB: *http://mpcb.mah.nic.in/* (Since 1997); Pollutants: SO_X, NO_2, RSPM; Stations: Pune, Nashik, Nagpur and Aurangabad; Period: Discrete; Averaging: Daily Average; NEERI: *http://www.neeri.nic.in/* (Past 10 Years). Several institutes/agencies are also monitoring the air pollutants and their links have been given for the information and exploration.

2. The ***national language interface*** in Hindi has been developed for the ENVIS site. A link to this web page has been given in the main page of ENVIS site. Similarly, the ***regional language interface in Marathi*** has been developed. The regional language in Pune, which falls under Maharashtra State, is Marathi. As per the mandate, the information has been designed and made available in Marathi for public awareness and a link "*regional interface"* has also been made available on the ENVIS site (*http://envis.tropmet.res.in/marathi.htm).* This is a major achievement of the year. This interface gives greater insight into ENVIS as the information available at this site is useful for a common man.

3. ***The ENVIS awareness programme:*** *S*everal visits for school children, general public, students from universities and colleges were arranged. Almost five hundred students visited the ENVIS Centre on various occasions such as Institute's open house events like National Science Day, World Water Day, World Meteorological Day, Ozone-Day etc. To encourage the dissemination of current knowledge on subject area and related information, periodic news letters, papers in journals and reports were published, both as hard copy and soft copy by displaying on internet. As a part of an international event at IITM, a one-day "**IGBP Workshop on Global Change** " was

arranged on 3rd March 2006 which had direct relevance to the subject area of the IITM's Environmental Information System (ENVIS) Centre and Sustainable Development Network Programme (SDNP). This event was planned on this occasion with an objective to have an opportunity to highlight the Institute's activities and progress in the field of global climate change.

4. ***Abstracting service:*** This has been initiated in e-form and kept in our ENVIS website. So far we could make sufficient collections on the subject area Acid Rain and Atmospheric Pollution covering latest publications.

Sustainable Development Network Partners (SDNP) on 'Climate Change'

In this year the IITM-ENVIS node has been assigned as ***SDNP Network Partner on Climate Change***. In this direction a new webpage (*http://envis.tropmet.res.in/sdnp*) has been developed separately and linked to the ENVIS main page of the Institute. A database development for climate change under SDNP programme has been initiated. In the SDNP site, data related to air pollution and climate change have been transferred to information as per the objective of SDNP and links in SDNP site (in conjunction with existing ENVIS site) such as (i) Home (ii) About SDNP (iii) Objectives (iv) Climate change (v) Organizations (vi) References/publications (vii) ENVIS-IITM (viii) Interview (ix) Contact us etc. have been introduced.

Under the SDNP programme on climate change, an attempt was made to transfer the data into information by means of visualization and interpretation of results. Useful information related to climate change extracted from the ENVIS data sets was generated. Attempt was also made to present the converted scientific information in the form of movies and posters. Information collected as part of the SDNP programme on Climate Change is summarized below:

Scientific evidence of the destabilizing human influence on global climatic systems is continuing to build, creating a growing momentum for a response. The Intergovernmental Panel for Climate Change (IPCC), an international body of atmospheric scientists, in its *Third Assessment Report*, states that "There is new and stronger evidence that most of the warming observed over the past 50 years is attributable to human activities." The report concludes that the "human influences will continue to change the atmospheric composition throughout the 21st century and that change will persist for many centuries." India is concerned about the climate change because of its potential impacts affecting the ecosystem and biosphere being an issue of global change. It has not yet fully understood that what can happen due to the global change, related atmospheric perturbations and its impact. A large number of scientists believe that human activities, which have increased atmospheric concentrations of carbon dioxide (CO_2) by 35% from pre-industrial values of 280 parts per million (ppm) to 378 ppm over the past 100 years, are leading to an increase in global average temperatures. Global temperatures have already risen 0.6°C (0.9°F) in the past 100 years, and, will rise further (IPCC). There is significant concern that human activities, such as the burning of fossil fuels, industrial production, deforestation, and certain land-use practices are increasing atmospheric concentrations of carbon dioxide (CO_2), and other trace gases such as methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6), which may lead to changes in the chemical composition and physical dynamics of Earth's atmosphere. Historically, CO_2 has been the most important, but those other atmospheric trace gases are radiatively active, and thereby can contribute to a greenhouse warming of the lower atmosphere. Carbon dioxide concentrations are on the rise since the early days of industrialization.

Query-answer Statistics in ENVIS site for 2005-06

Sr. No.	Subject Area	Queries Received	Mode of Feed back provided
1.	Air Pollution	65	Answers /responses were provided through online feedback form electronically as well as by hard copy sent by post. In addition, numbers of queries were received telephonically.
2.	Acid Rain	22	
3.	Climate Change	70	
4.	Global Warming	77	
5.	Ozone effects	44	
6.	Data Quality and availability	21	

Sponsored Research Projects

In addition to the on-going research programmes the Institute undertakes sponsored projects for specific studies. The details of the sponsored projects operational during the year are given below:

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
1.	Atmospheric Aerosol Loading from IRS-P3 MOS Sensors Data	Dr. P.C.S. Devara	1997-2006	8.20	Space Applications Centre, Indian Space Research Organisation
2.	Management Perspectives to Seasonal Climate Forecasts in Mixed Cropping System of Southern India's Semiarid Tropics	Dr.K.Krishna Kumar	2002-2006	7.02	Global Change System for Analysis, Research and Training / Asia Pacific Network
3.	Aerosol Optical Characterization and Investigation of Aerosol Radiative Forcing at the Surface and Top of the Atmosphere	Dr. G. Pandithurai	2001-2005	3.62	Department of Science and Technology, Govt. of India / National Science Foundation,USA
4.	Impact of Climate Change on Water Resources	Dr. G.B. Pant	2001-2005	29.50	Ministry of Environment and Forests, Govt. of India/ Dept. of Environment, Food & Rural Affairs, Govt. of U.K.
5.	Indian Climate Change Scenario for Impact Assessment	Dr. K. Rupa Kumar	2001-2005	48.50	Ministry of Environment and Forests, Govt. of India/ Dept. of Environment, Food & Rural Affairs, Govt. of U.K.
6.	Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change	Dr. K. Rupa Kumar	2003-2005	6.20	Indo French Centre
7.	Observational Study of Aerosol Radiative Forcings on the Surface Reaching Solar Flux (Fast Track Scheme for Young Scientists)	Dr. R.S. Maheskumar	2001-2005	9.36	Department of Science and Technology, Govt. of India
8.	Surface Climatology of Western Himalaya	Dr. K. Rupa Kumar	2001-2005	9.90	Snow and Avalanche Study Establishment, Defence Research and Development Organisation, Govt. of India
9.	Numerical Modelling of the Upper Ocean Mixed Layer over Indian Ocean Region using Satellite Data	Dr. C. Gnanaseelan	2001-2005	7.764	Department of Science and Technology, Govt. of India
10.	Atlas of Spatial Features of Moisture Regimes and Rainfall of India during 19th and 20th Centuries	Dr. N. Singh	2001-2005	20.71	Department of Science and Technology, Govt. of India

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
11.	Experimental and Theoretical Studies of Secondary Pollutants and Ozone for Chemical Forecasting	Dr. D.B.Jadhav	2001-2005	29.65	Department of Science and Technology, Govt. of India
12.	Climate Change Projection for India and Assessment of the Associated Agricultural and Human Health Impact	Dr.K.Rupa Kumar	2003-2005	18.00	National Communication (NATCOM), Ministry of Environment and Forests, Govt. of India
13.	Dendroglaciological Studies of High Altitude Glacier Sites of Western Himalaya	Dr. H.P. Borgaonkar	2002-2005	4.92	Snow and A valanche Study Establishment, Defence Research & Development Organisation, Govt. of India
14.	Studies of Lightning Discharges During Pre-monsoon and Post- Monsoon Thunderstorms over Pune	Dr. (Smt.) S.S Kandalgaonkar	2002-2005	6.36	Department of Science and Technology, Govt. of India
15.	Lidar Sounding of Aerosols in the Lower Atmosphere and their Impact on Local Climate and Environment (Fast Track Scheme for Young Scientists)	Dr. G.Pandithurai	2002-2005	7.44	Department of Science and Technology, Govt. of India
16.	Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System	Dr. G.B. Pant	2002-2005	22.43	Department of Science and Technology, Govt. of India
17.	Air-Sea Interactions in the Indian Ocean Region (DOD / INDOMOD 10th plan programme)	Dr. R.Krishnan	2002-2007	106.80	Department of Ocean Development, Govt. of India
18.	Data Assimilative Sigma Coordinate Numerical Model for the North Indian Ocean (DOD / INDOMOD 10th plan programme)	Dr. C.Gnanaseelan	2002-2007	41.75	Department of Ocean Development, Govt. of India
19.	Influence of Columnar Aerosol, Ozone and Water Vapour on the Evolution of Warm Pool over the Southern Arabian Sea	Dr. P.E. Raj	2003-2004	10.08	Department of Science and Technology, Govt. of India
20.	Environmental Information System (ENVIS) Node on Acid Rain and Atmospheric Pollutants Modelling	Dr. G. Beig	2005-2006	4.04	Ministry of Environment and Forests, Govt. of India
21.	Monitoring of Pollutant Species in Rain Water / Dust Fall in Different Environments around the National Capital Region of Delhi	Dr. S.Tiwari	2003-2005	11.16	Department of Science and Technology, Govt. of India
22.	Atmospheric Boundary Layer over the Arabian Sea during ARMEX Thermodynamic Aspects	Dr. (Smt.) S.B. Morwal	2003-2005	2.88	Department of Science and Technology, Govt. of India

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
23.	Application of Satelitc Data to Climate Reserarch	Dr. G.B. Pant	2003-2006	15.50	Indian Space Research Organisation (ISRO) Govt. of India.
24.	Optical Remote Sensing Studies of the Atmospheric Boundary Layer Characteristics Using Laser Radar	Dr. P.C.S.Devara	2003-2005	1.31	DST (Indo-Bulgarian Inter-Governmental Program of Co-operation in Science and Technology)
25.	Role of Aerosols and Black Carbon in Atmospheric Radiation Budget Studies	Dr. P.D. Safai	2003-2006	33.94	Indian Space Research Organisation (ISRO), Govt. of India
26.	Modelling of Tropical Aerosol Radiative Forcing Using Satellite, Lidar and Radiometric Aerosol Database and Surface Radiation Measurements	Dr. G.Pandithurai	2003-2006	9.62	Indian Space Research Organisation (ISRO), Govt. of India
27.	Multi-Site Characterization of Tropical Aerosol Direct Radiative Forcing Using Measurements	Dr. P.C.S.Devara	2003-2006	42.40	Indian Space Research Organisation (ISRO), Govt. of India
28.	Science of Climate Change	Dr. K. Rupa Kumar	2004-2005	5.50	British High Commission, New Delhi
29.	Preparation of Generalized PMP Atlases for the Krishna and the Indus River Basins	Dr.G.B.Pant	2004-2006	42.00	Central Water Commission (CWC), New Delhi
30.	Monsoon Variability Studies with Regional Climate Models using Satellite Derived Surface Parameters: Validation and Application	Dr. G.B. Pant	2004-2007	16.00	Space Applications Centre, Ahmedabad
31.	Direct Radiative Forcing due to Aerosol and Precursor Gases over Antarctic Region	Dr.P.C.S.Devara	2004-2007	42.25	Department of Ocean Development Govt. of India
32.	Atmospheric Pollutants and Chemical Weather under Different Environments	Dr.G.Beig	2005-2008	31.98	Department of Science and Technology, Govt. of India
33.	Impact of Long Term Solar Variability on the Middle Atmosphere Chemical Climate using Satellite Data and Model Simulation	Dr.G.Beig	Mar.2005-Mar.2008	6.73	Climate and Weather of the Sun Earth System (CAWSES), Indian Space Research Organisation

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
34.	Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang Basin	Shri B.N. Mandal	15 months (15 Jul. 2005 onwards)	10.00	National Hydroelectric Power Corporation (NHPC), Faridabad
35.	Pilot Experiments to the STORM Project	Shri S. D. Pawar	March 2006 - February 2007.	4.70	Department of Science and Technology, Govt. of India
36.	Examining Indian Monsoon Variability in Coupled Climate Model Simulations and Projections	Dr. (Smt.) A.A. Kulkarni	2006-2009	13.50	Department of Science and Technology, Govt. of India
37.	Development of a Regional Atmosphere-Ocean Coupled Modelling Strategy for Predicting Indian Summer Monsoon	Dr. K. Krishna Kumar	November 2005 – November 2008	29.16	Department of Science and Technology, Govt. of India
38.	Measurements and Study of Ozone under Different Environments (Conducive of Vegetation and Agriculture Fields)	Dr. A. L. Londhe	2006-2008	15.80	Department of Science and Technology, Govt. of India
39.	Physical and Chemical Characteristics of Aerosols	Dr. P.S.P. Rao	February-May 2006	1.50	Space Applications Centre, Indian Space Research Organisation
40.	Aerosol Characterization and Radiative Forcing	Dr. P.C.S. Devara	February-May 2006	1.30	Space Applications Centre, Indian Space Research Organisation
41.	Atmospheric Brown Cloud Asia	Dr. P.S.P.Rao	2005 - 2009	(about 17.00 lakhs) 31,200 Euros	Swedish International Development Cooperation Authority (SIDA), Stockholm, Sweden
42.	Laser Radar Characterization of Atmospheric Aerosols and Clouds in the Boundary Layer and Free Troposphere	Dr. P.C.S. Devara	2006-2009	4.50	Indo-Bulgarian Program of Cooperation in S & T, Department of Science and Technology
43.	Atmospheric Chemistry-Aerosol-Climate Interactions	Dr. P.S.P. Rao Co-PI With Bose Institute, Kolkatta	2005-2010	-	Department of Science and Technology, Govt. of India
44.	Chemical Behaviour of Aerosol, Greenhouse Gases, Trajectory Analysis and Impact of Particulate Matter Loading on Human Health	Dr. P.C.S.Devara Co-PI With Bose Institute, Kolkatta	2005-2010	-	Department of Science and Technology, Govt. of India

Other Special Events and Activities

Visit of Minister

Shri Jagjit Singh Rana, Minister of State for Agriculture, Government of Maharashtra visited the Institute on 27 August 2005 for discussion with the scientists of the Institute regarding intense rainfall in various regions of Maharashtra and to formulate a system for early warning of similar incidents.

Visit of Parliamentary Committee

Parliamentary Standing Committee on Science and Technology, Environment and Forests, Government of India visited the Institute on 27 September 2005.

Awards

The Norbert Gerbier-Mumm International Award of the World Meteorological Organization for the year 2005 was presented to Dr. G. Beig in a proclamation ceremony at Geneva, Switzerland on 29 June 2005. Dr. Beig received the award on behalf of all the co-authors for their paper entitled "Review of Mesospheric Temperature Trends" published in the journal Review of Geophysics, December 2003.

Dr. N. Singh received the 13 th SAARC (South Asian Association for Regional Cooperation) Regional Award for Young Scientists – 1995 for his paper entitled 'Optimizing a network of raingauge over India to monitor summer monsoon rainfall variation', published in the International Journal of Climatology, 14, 1994, 61-70. The Award received in April 2005 consisted of citation, cash prize and a medal.

The paper entitled, 'Long lead predictions of Indian summer monsoon rainfall from global SST evolution' published in Climate Dynamics, Vol. 20, 2003, 855 – 863 by A.K. Sahai, A.M. Grimm, V. Satyan and G.B. Pant received the 16th IITM Silver Jubilee Award for the year 2003.

The paper entitled 'Atmospheric electric conductivity and the aerosol measurements during the fog over the Indian Ocean' published in Atmospheric Research, Vol. 70, 2004, 77 - 87 by C.G. Deshpande and A.K. Kamra, has been adjudged for 17th IITM Silver Jubilee Award for the year 2004.

Shri S. Mahapatra received the Second Prize for Overall Performance in the Second SERC School on Aviation Meteorology with Special Emphasis on Thunderstorms and its Modelling, held at the Air Force Administrative College, Coimbatore during 9 - 28 May 2005. The award was presented by Air Marshal B. N. Ghokhale (AVSM, VN), Indian Air Force.

The Excellent Performance Awards for the year 2004 were received by Smt. K.M.V. Sheikh, Assistant for Administrative Category, Shri P.S. Jagtap, Mechanic Gr.I for Technical Category and Shri C.R. Joshi, Office Attendant for the Non-Technical Maintenance Category. The awards were presented on the occasion of the 44th Foundation Day of the Institute on 17 November 2005.

Honours

Dr. A.K. Kamra has been nominated as a Member, Scientific Steering Committee for the Continental Tropical Convergence Zone (CTCZ) Field Campaign under the Indian Climate Research Programme (ICRP). He has also been nominated by the DST as a Member of Programme Implementation Committee (PIC) of Severe Thunderstorm – Observational and Regional Modeling (STORM) project by Department of Science and Technology, New Delhi.

Dr. P.C.S. Devara has been elected as Fellow of the Maharashtra Academy of Sciences. The Fellowship was awarded to him in the Induction Ceremony at National Chemical Laboratory (NCL), Pune on 28 October 2005.

Dr. Devara has been elected as Member, Editorial Boards of the Journals 'Atmosfera' and 'Aerosol and Air Quality Research'.

Dr. Devara chaired a scientific session on LC II Results over Agra at a Meeting to discuss results of experiments conducted during December 2004 under the Nation wide Campaign organized by the ISRO

Dr. Devara organized the 4 th Asian Aerosol Conference (AAC 2005), under the aegis of the Indian Aerosol Science and Technology Association (IASTA), at Mumbai during 13-16 December 2005. He chaired a scientific session of the conference.

Dr. Devara has been elected as Chairman, Executive Council of the Indian Meteorological Society – Pune Chapter (IMSP) for the period 2005-2007.

Dr. Devara has been elected as Chairman of the Technical Evaluation Committee for procurement of Radiation Instruments for the India Meteorological Department.

Dr. G. Beig was nominated as Co-convener of the symposia JSII02 entitled "Long-term trends in the upper atmosphere" held at the IAGA 2005 Scientific Assembly, Toulouse, France, 18-29 July 2005. He has been bestowed with Guest Editors for a special issue of "Journal of Atmospheric and Solar Terrestrial Physics", U.K. and Chief Guest Editor for a special issue of the Trend Workshop "Journal of Physics and Chemistry of the Earth", Europe.

Dr. P.S.P. Rao has been nominated as Member of the Steering Committee of an International Body on Composition of Asian Deposition (CAD).

Dr. Devendraa Siingh, Shri S.M. Sonbawne and Shri. Vimalesh Pant, participants of the 24 th Indian Antarctica Expedition, received a memento at the hands of Shri Kapil Sibal, Honourable Minister of State for Science and Technology and Ocean Development in the Debriefing Session held at India Habitat Centre, New Delhi on 25 May 2005.

Dr. Devendraa Siingh has been awarded the Fellowship by the Department of Science and Technology (DST), Govt. of India under the Better Opportunities for Young Scientists in Chosen Areas of Science and Technology (BOYSCAST) Programme in the field of 'Long range transport of air pollution' at the Institute of Environmental Physics, University of Tartu, Tartu, Estonia.

Shri V. Gopalakrishnan has been elected as Member of the National Council of the Indian Meteorological Society and Dr. G. Pandithurai as Secretary of the Executive Council of the Society's Pune Chapter (IMSP), both for the period 2005-2007.

Organisation of Workshops/Meetings/ Seminars etc.

International

UK - India Workshop on "Regional Climate Change, Variability and Impacts: Scientific Perspectives" was organized and hosted by the Institute during 23-27 January 2006 at the initiative of the Department of Science and Technology, Govt. of India and the Royal Society with the support of the British Council and British High Commission, New Delhi. Dr. P.C.S. Devera, Director-In-Charge welcomed the delegates and guests. Dr. Vasant Gowariker, Professor Satish Dhawan Distinguished Professor, ISRO and Chairman, The Rajiv Gandhi Science and Technology Commision, Govt. of Maharashtra inaugurated the Workshop on 23 rd January 2006. Prof. Julia Slingo, Director, NERC Centre for Global Atmospheric Modelling, Department of Meteorology, University of Reading, Reading, U.K. led the U.K. delegates of the Workshop. A special press conference with a panel of eminent scientists in climatology from India and U.K. was organized in the evening of the first day of theWorkshop. The Deputy British High Commissioner, Mr. Mark Runacres addressed the Workshop on 25 th January 2006. About 88 eminent experts from U.K. and India participated in this Workshop.

On this occasion, a popular lecture of Prof. Julia Slingo, Director, Center for Global Atmospheric Modelling, University of Reading, U.K. was organized on 24 Janauary 2006 at 06:30 pm at Chandrashekhar Auditorium of the Inter University Centre for Astronomy and Astrophysics (IUCAA), University of Pune campus. Prof. Slingo delivered lecture on "Is our climate changing? What does the future hold?" The lecture received overwhelming response from students, academicians and scientific community of Pune.

The following International Workshop and Meetings were hosted by the Institute during 3-11 March 2006:

- One-day IGBP (International Geosphere Biosphere Programme) Workshop on "Global Change" was held on 3 March 2006. The Workshop was inaugurated by Prof. Madhav Gadgil, Indian Institute of Science, Bangalore. The Workshop began with keynote addressesby Dr. Carlos Nobre, Chairman, SC-IGBP on "Improving the Sustainability of the Living Earth: Challenges for the Next Decade of IGBP Science" and by Dr. A.P. Mitra, Former Chairman, Indian National Committee - IGBP on " India and IGBP: New Initiatives". The inaugural session was followed by eleven presentations of the renowned scientists in the field.

- 21st Annual Meeting of the Scientific Steering Committee of the IGBP (SC-IGBP) was held during 4 - 7 March 2006.

- Annual Meeting of the Joint Scientific Committee (JSC) of the World Climate Research Programme (WCRP) (JSC-WCRP) was organized during 6 - 11 March 2006. The JSC-WCRP, which provides scientific guidance for the WCRP, consists of world leaders in climate-related disciplines in atmospheric, oceanic, hydrological and polar sciences. In their discussions, the JSC, the directors and the project leaders from WCRP core projects (CliC, SPARC, GEWEX, CLIVAR), Panels and Working Groups focused on the implementation of WCRP's Strategic Plan, Prof. Ann Hendersen-Sellers, the new Director of the WCRP, outlined her vision for the future of international climate research.

- Joint Session of the SC-IGBP and JSC-WCRP Meeting was held during 6 - 7 March 2006. This Session was inaugurated by Dr. P.S. Goel, Secretary, Department of Ocean Development, Government of India.

Around 100 scientists from all over the globe participated in these meetings and Workshop. These events gave an opportunity to review, jointly, the IGBP projects and the ESSP (Earth System Science Partnership) activities. The IGBP-WCRP joint session was found to be instrumental in continuing and enhancing the collaboration between the two programmes.

National

Third Meeting of Advisory Committee on WP/RASS was held at the Institute on 18 May 2005 under the chairmanship of Dr. P. Balaram Rao from National Remote Sensing Agency, Hyderabad.

Two Brain Storming Sessions in the areas Numerical Modelling for Weather and Climate, and Observational Studies of Cloud Physics, Aerosols, Trace Gases and Boundary Layer including Atmospheric Convection were held at the Institute on 19 and 20 July 2005, as suggested by the Research Advisory Committee of the Institute. Dr. (Smt.) Sulochana Gadgil and Dr. G. S. Bhat from Indian Institute of Science, Bangalore, and Dr. R. Ramesh and Prof. Shyam Lal from Physical Research Laboratory, Ahmedabad were the outside expert members. The Research Advisory Committee again met on 10 October 2005.

First Meeting of the Working Group III: Computing and Human Resources of the Department of Science and Technology, New Delhi was held at the Institute under the Chairmanship of Dr.G.B. Pant, Director, on 23 September 2005.

A one-day Brain Storming Session on 'Urban Aerosol Climatology' was organized at the IITM-Delhi Branch, New Delhi on 25 November 2005 to review and discuss various experimental as well as modeling techniques for better understanding and characterization of aerosols and their effects. Dr. A.P. Mitra, National Physical Laboratory, New Delhi delivered its inaugural address.

The Department of Science and Technology, New Delhi organized the 2nd Workshop on WP/RASS on 28 November 2005 at the Institute under the Chairmanship of Prof. P.B.Rao. The Workshop was devoted to applications of WP/RASS datasets. Lectures were delivered by the scientists who have used / proposed to use the datasets.

National Seminar on Indian Climate: Past, Present and Future was organized on 29 November 2005. Eminent scientists from different scientific organizations, and scientists, research fellows / project personnel of the Institute participated in the seminar.

A Steering Committee Meeting on Composition of Asian Deposition (CAD) was held at the Institute during 4 - 5 December 2005. The CAD project is a part of the IGBP-IGAC program and its main focus is to obtain high quality data on the deposition, both through precipitation and dry deposition of compounds of Sulfur, Nitrogen and other biologically important trace constituents. The Meeting was chaired by Prof. Henning Rodhe of Stockholm University, Sweden. Delegates from other Asian countries such as Singapore, Japan, UK and Thailand also participated in the meeting.

The Annual Workshop – Monsoon 2005 was organized jointly by the India Meteorological Department and the Indian Institute of Tropical Meteorology under the aegis of the Indian Meteorological Society - Pune Chapter (IMSP), at the Central Training Institute, India Meteorological Department, Pune on 23 December 2005.

The Department of Science and Technology and Government of India have undertaken a National Project CTCZ (Continental Tropical Convergence Zone) for coupled land - atmosphere - ocean summer monsoon systems over India in an integrated fashion. The purpose of the CTCZ national project is to improvise the

observational understanding of the representative monsoon processes with the aim to improve rainfall forecast and applications to climate, water resources and agriculture. First Meeting of the Scientific Steering Committee (SSC) for CTCZ was held at the Institute during 20-21 January 2006. Scientists representing the Institutions proposed to participate in the CTCZ programme made presentations of their proposals.

Infrastructural Development

Hydrometeorological Laboratory

Hydrometeorology Laboratory of the Institute was inaugurated at the hands of Dr. C.D. Thatte, Former Secretary, Ministry of Water Resources, and Chairman, Central Water Commission (CWC), New Delhi and Secretary General (Hon.), International Commission on Irrigation and Drainage (ICID) on 11 October 2005

Students' Hostel

The Student's hostel of the Institute has been renovated and named as "Prof. R. Ananthakrishnan Hostel" on 11 April 2005 on his 95th birth anniversary. Prof. Ananthakrishnan was former Director and Honorary Scientist of the Institute.

Laser Raman Spectrometer Laboratory

Laser Raman Spectrometer has been installed at the Institute in November 2005. It is a double monochrometer spectrometer. Argon ion laser is used as source. It will operate at two wavelengths 514.5 nm in green region and 488.0 nm in blue region. This system will be used to investigate the molecules present in a particular sample and chemical composition of aerosols collected from different atmospheric conditions.

Dual Polarization Micro Pulse Lidar Facility

Dual Polarization Micro Pulse Lidar facility was inaugurated at the hands of Shri G.K. Agarwal, Principal General Manager, Bharat Sanchar Nigam Ltd., Pune, the Chief Guest of the 44th Foundation Day celebration of the Institute held on 17 November 2005.This unique mobile LIDAR facility has been acquired for investigating Aerosol- Cloud- Climate Interactions to understand the impact of aerosols and clouds on weather, climate and hydrological cycle. It has real-time-mode (unattended) operation with ultra-high pace-time resolution data that can be used for aerosol characterization, cloud composition, atmospheric dynamics and wave activity studies covering from surface to about 120 km.

Sun Tracking Sun/Sky Radiometer

An automatic sun tracking sun/sky radiometer (Prede Model POM-01L) has been installed at the IITM New Delhi Branch on 17th February 2006 to monitor aerosol optical properties at the urban location under the ICARB Campaign.

Sustainable Development Network Partners (SDNP) on Climate Change

The Environmental Action Program (EAP) was implemented to strengthen the environmental services in India for integrating environment in all developmental program through improving environment assessment, and environmental awareness. The Indian Chapter of Sustainable Development Network Partners (SDNP) is being implemented by the Environmental Information System (ENVIS), Ministry of Environment and Forest (MOEF) in collaboration with India-Canada Environment Facility (ICEF). The ICEF has sanctioned the project on SDNP -ENVIS for two years from June 2005. Twenty thematic areas have been selected for the project and relevant ENVIS centers have been supported for developing SDNP network. Based on progress and merit of the ENVIS center, IITM-ENVIS has been chosen as one of the Sustainable Development Network Partners (SDNP) on the thematic area "Climate Change" with a view to enhance availability of climate change information through sustainable development network partner. Under this program, an attempt was made to transfer the data into information by means of visualization and interpretation of results from the data to a simplest possible language. A new WEB site (http://envis.tropmet.res.in/sdnp) has been developed. In the SDNP website useful information related to climate change extracted from the ENVIS data sets has been generated. Attempt has also been made to present the converted scientific information in the form of movies and posters.

Memorandum of Understanding

Memorandum of Understanding between the Institute and The Energy and Resources Institute (TERI), New Delhi, was signed to provide consultancy services on climate change scenario development as part of a World Bank sponsored study on vulnerability assessment to climate variability and change.

A tower of 12 m height has been erected in the campus of the Centre for Advanced Studies in Agricultural Meteorology (CASAM), College of Agriculture, Pune. In order to collaborate the tower observations planned for the mutual interests in the field of land surface interaction and agricultural meteorology a Memorandum of Understanding (MoU) has been signed between the Director, IITM, Pune and the Vice Chancellor, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Special Field Observational Programmes

A Field Experiment was organized in the Nilgiri Forest Region, Bangalore during 21-28 May 2005 for tree-ring sample collection. Dr. G.H. Schleser and Dr. G. Helle, Forschungs Zentrum, Germany also participated in the experiment.

As a part of Stratosphere Climate Links with Emphasis with the Upper Troposphere Lower Stratosphere (SCOUT-O3), a coordinated experimental programme involving different experimental platforms initiated by the European Union and coordinated by the Cambridge University, UK has been launched in India. Dr. Y. Jaya Rao of this Institute coordinated and participated in the aircraft measurements as part of SCOUT-O3 at Hyderabad during 6-10 November 2005.

Extensive Field Campaigns were arranged with an objective to monitor the levels of ozone and its precursors (NOx, CO) in the vicinity of sugar factories and background site during 13 - 23 January 2006 at Shri Sant Tukaram Co-op Sugar Factory Ltd., Kasarsai and Dam site (background), Irrigations Department, Kasarsai.

Under Atmospheric Brown Cloud project field measurements of aerosol size distribution, wet / dry deposition, observation on soot in air and precipitation and monitoring of meteorological parameters were carried out at Sinhagad, a high-latitude station near Pune. Continuous observations on TSP, mass size distribution of aerosols, black carbon, PM_{10}, $PM_{2.5}$ and $PM_{1.0}$ particles and meteorological parameters, were also undertaken at Sinhagad in the months of December 2005 and January 2006, for the study of the role of aerosols and black carbon in atmospheric radiation budget. Continuous observations on black carbon, PSP, PM_{10}, $PM_{2.5}$ and $PM_{1.0}$ were carried out at Pune also.

Institute scientists participated in the ISRO– GBP Programme of Integrated Campaign for Aerosols, Gases and Radiation Budget (ICARB) organized for two months from 18 March 2006. Under this campaign marine observations on board Sagar Kanya over Bay of Bengal, Indian Ocean and Arabian Sea, land observations at the Institute in Pune and its New Delhi branch, and airborn measurements on an instrumented aircraft were arranged. Vertical distribution, size distribution and optical depths of aerosols, total column ozone and water vapour, net radiation and down-welling SW radiative flux, total suspended particulates and mass size distribution were measured during the programme.

Publications

Prof. G.C. Asnani, WMO Professor of Meteorology (Retd.) and Honorary Fellow of the Institute published a three volume book entitled, "Tropical Meteorology". This is a revised edition of the earlier two volume book published in 1993.

Under the DST project, 'Atlas of spatial features of moisture regions and rainfall of India during 19th and 20th centuries' following four parts of the Atlas have been prepared:

- Atlas of spatial features of rainfall of India: 1871-2003. Part I, 334 pp
- Longest instrumental rainfall series of different homogeneous zones, states and meteorological subdivisions of India: 1813-2003. Part II, 173 pp
- Longest instrumental rainfall series of major and minor river basins of India: 1813-2003, Part III, 165 pp
- Longest instrumental rainfall series of physiographic divisions /subdivisions and provinces of India: 1813-2003. Part IV, 211 pp

Science Popularisation

Institute participated in the Science Expo - 2005 at Nehru Science Centre, Worli, Mumbai held during 23 - 27 November 2005. A Scientific Exhibition, Scientific Film and Power Point Shows on PC and a lecture on "A Meteorological Aspect of the Exceptional Heavy Rainfall over Mumbai on 26/27 July 2005" by Shri J.R. Kulkarni were arranged. S/Shri V.R. Mujumdar, K.K. Dani, V.H. Sasane and C.T. Jadhav were the volunteers nominated for the Institute's participation. Shri Mujumdar and Shri Dani acted as judges for selection of winners of various scientific contests organized by the Nehru Science Centre on the occasion of the Science Expo-2005.

Institute participated in the Multimedia Campaign conducted by the Media Units of the Ministry of Information and Broadcasting in Maharashtra at Karad during 26 - 30 December 2005. A Scientific Exhibition, Scientific Film and Power Point Shows on PC were arranged. S/Shri P.V. Puranik, S.S. Sabde, K.K. Dani and V.H. Sasane were the volunteers nominated for the Institute's participation.

Institute celebrated National Science Day on 28 February 2006, World Water Day on 22 March 2006 and World Meteorological Day on 23 March 2006 at the Institute's premises in a befitting manner. On these occasions Scientific Exhibition, Scientific Film Show, Open Day for general public and visit of students from schools/colleges were arranged. Popular scientific lectures viz., 'Imperatives of Nurturing Nature' by Dr. Prakash Gole, Founder Trustee and Executive Director, Ecological Socity, Pune on the occasion of National Science Day, and two lectures of the Institute's scientists viz.,'Water, Climate and Culture' by Dr. Nityananda Singh and 'Natural Disasters in India' by Shri J.R.Kulkarni were arranged as part of the World Water Day and World Meteorological Day, respectively.

Dr. M. S. Mujumdar delivered an invited lecture on 'Modelling Aspects of Monsoon'at the Baburao Gholap Mahavidyalaya, Pune, on theoccasion of its National Science Day Seminar on 28 February 2006.

Foundation Day Celebration

The Institute celebrated its 44th Foundation Day on 17 November 2005 at its premises at Pashan. Shri G.K. Agarwal, Principal General Manager, Bharat Sanchar Nigam Ltd., Pune was the Chief Guest of the function. Prof. Arun Nigvekar, Former Chairman, UGC and Director, Science and Technology Park, Pune was the Chairperson of the function. Dr. D.A. Mooley, Assistant Director (Retired) of the Institute was the Guest of Honour. The function included presentation of the Annual IITM Silver Jubilee Award for the scientific research paper and the Excellent Performance Awards specially established by the Institute for its Administrative, Technical and Non-Technical Maintenance staff. Silver Jubilee Award lecture by the award winning scientist and a special scientific lecture on 'Why knowledge has gained so much importance in 21st century' by Prof. Nigvekar were also arranged on this occasion. In the afternoon a special session was arranged for prize distribution to the winners of various sports activities arranged by the IITM Recreation Club. Mr. Joseph DSouza, Secretary, Pune District Chess Association was the Chief Guest of this session. The prizes were distributed at the hands of the Chief Guest. The Foundation Day celebration was concluded by a cultural programme.

Vigilance Awareness Week

Vigilance Awareness Week was celebrated during 7-11 November 2005. Employees of the Institute took the pledge on this occasion. An essay competition was organized for the employees of the Institute. The Week was concluded with a lecture on "Self Awareness and Public Consciousness for Clean Environment" by Smt. Vijaya Joshi, Volunteer of the Uttishtatha Jagruta, a Non-governmental Organisation. Award of cash prizes were presented to the first three winners of the essay competition at the hands of Smt. Vijaya Joshi.

International Women's Day

Institute celebrated the International Women's Day on 8 March 2006. Prof.Ann Hendersen-Sellers, Director, World Climate Research Programme (WCRP) delivered a lecture on "Women and Geophysiology: Empowerment of Planet Earth". She was on official visit to India to participate in the IGBP Workshop, Scientific Steering Committee of the IGBP and Joint Scientific Committee of the WCRP, all held at the Institute during 3 - 11 March 2006. Prof. Sulochana Gadgil, Indian Institute of Science, Bangalore was the Guest of Honour of the celebration.

Observance of Anti-Terrorism Day

Institute observed 'Anti-Terrorism Day' on 21 May 2005. On this occasion a pledge was administered to all the employees of the Institute.

Computer and Data

The Computer and Data Division provides centralized computing services to the scientists, research fellows, students and other employees of the Institute through HP-9000/735, Linux based e-mail, Website and Internet. The present computational facilities available in the Institute are HP-9000/735, 160 PCs with requisite softwares and accessories, 25 servers/workstations, a few laptops, a terrestrial leased line internet connectivity of 512 KBPs bandwidth, state of art connectivity and display facility to the conference and seminar halls, and intranet in the Institute's office campus. Support was provided for the functions of the Accounts, Purchase and Stores by preparing various specialized computer programs. Different meteorological data sets were procured from the India Meteorological Department and provided to the users by changing their formats as per the users' requirements.

Library, Information and Publications

The Institute's Library, Information and Publications Division serves as the Information System in Meteorology and Atmospheric Sciences.

The Library has built an information base of about 28000 publications consisting of books, monographs, back volumes of journals, scientific / technical reports, seminars / symposia proceedings, reprints, abstracts, bibliographies, global meteorological data, geophysical data, maps, atlases, theses etc. and national/international current journals covering a wide range of subjects in Atmospheric Sciences.

During the year 267 books and reports in Meteorology and allied subjects were added. 92 Periodicals of national/international origin were subscribed to out of which 34 were with on-line access. Several scientific and technical reports were received from the other National and International Organisations on complimentary and exchange basis. Computerized data bases for books, journals, reprints and other publications have been prepared and some of them have been linked to the Institute's website.

The Division has maintained liaison with Institutions, Universities and Ministries. A number of reports on the research activities and plan schemes of the Institute were prepared and sent to the Department of Science and Technology, India Meteorological Department, Universities and Research Institutes.

Technical services like photocopying, photography, drafting, drawing, printing and binding were provided. Information on Institute's website was updated from time to time.

Programmes for popularisation of meteorology among students and public were arranged. by organising open days and scientific exhibitions depicting research activities of the Institute on the occasion of important events, such as visit of Scientific Committees, celebration of National Science Day, World Meteorological Day, Institute's Foundation Day etc. Students and trainees visiting the Institute under their study tour programmes were taken round the Institute to see its laboratories, computers, library and satellite pictures receiving centre.

Management

The Institute functions as an autonomous organisation under the Department of Science and Technology (DST), Government of India. The management of the Institute vests with its Governing Council at the apex level. The Governing Council is constituted by the DST every two years and consists of five ex-officio members and four scientist members. The scientist members of the Council are nominated by the DST. The Director General of Meteorology is the Ex-officio Chairman of the Council. The Governing Council held its meetings on 5 May 2005 and 21 December 2005. The Institute maintains close collaboration and interaction with other organisations working in the field of Meteorology, particularly with the India Meteorological Department (IMD), National Centre for Medium Range Weather Forecasting (NCMRWF), Indian Space Research Organisation (ISRO), Indian Institutes of Technology, Universities and other scientific organisations associated with academic and research work in Atmospheric and Oceanic Sciences.

Administration

The Administration provides support for the personnel management, finance, purchase, stores, capital works and maintenance of buildings and campus.

Personnel Profile

As on 31 March 2006 the Institute had its staff under different categories as shown below:

Research I	78
Research I- A	52
Scientific	03
Technical	32
Administrative	41
Non-Technical Maintenance	43
Total	**249**

Staff changes

Twenty employees were appointed. Nineteen employees under different categories left the Institute during the year as shown below:

Retirement on Superannuation

Shri V.K. Asrani 31 May 2005
Administartive Officer

Smt. A.A. Kulkarni 31 May 2005
Scientist 'B'

Shri P. Seetaramayya 31 July 2005
Scientist 'E'

Dr. (Kum.) P.L. Kulkarni 31 July 2005
Scientist 'C'

Shri A. Bandyopadyay 31 January 2006
Scientist 'C'

Smt. U.V. Bhide 31 January 2006
Scientist 'C'

Shri D.V. Naidu 31 March 2006
Laboratory Assistant

Voluntary Retirement

Smt. S.S. Madiwale 1 April 2005
Lower Divisional Clerk

Shri G.S. Dusane 1 June 2005
Laboratory Attendant

Shri H.N. Zende 19 August 2005
Watchman

Shri V.S. Kulkarni 1 September 2005
Junior Technical Officer

Shri. S.P. Yadav 1 February 2006
Upper Divisional Clerk

Shri. T.S. Devkate 15 February 2006
Upper Divisional Clerk

Resignation

Smt. A.C. Saritha 1 April 2005
Senior Scientific Assistant

Dr. (Smt.) B.P. Shukla 29 April 2005
Scientist 'B'

Kum. S.P. Nikam 15 April 2005
Senior Scientific Assistant

Kum. C.B. Sailaja 31 August 2005
Senior Scientific Assistant

Shri A. Bhisikar 19 December 2005
Junior Technical Officer

Shri D.S. More, Senior Assistant passed away on 20 August 2005

Status of SC / ST / OBC Reservations

	SC	ST	OBC	Total
Research I	12	5	8	**25**
Research I-A	5	4	2	**11**
Scientific	2	1	-	**3**
Technical	6	2	1	**9**
Administrative	5	5	-	**10**
Non-Technical Maintenance	14	3	2	**19**
Total	**44**	**20**	**13**	**77**

Employment of Ex-servicemen

Reservation for the ex-servicemen was made at 10% in Group 'C' and 'D' posts of the Institute. The percentage of ex- servicemen at the Institute vis-à-vis total number of employees in Group 'D' was 2.3%.

Staff Council

The Staff Council is an elected body representing employees of the Institute in different categories and acts as a forum for discussion on matters of common interest to the employees and for increasing efficiency. The Staff Council could not be formed during the year due to non-receipt of nominations.

Academic Council

The Academic Council is a body consisting of scientists in the grade of Scientist 'D' and above. It considers all the matters relating to scientific projects of the Institute and ensures team work and team spirit in the Institute for achieving its aims and objectives. Fourteen meetings of the council were held during the year.

Advisory Committee

The Advisory Committee consisting of Heads of Divisions considers policy matters of the Institute. During the year five meetings of the Committee were held.

Finance

Budget

The main funding agency for the Institute is the Department of Science and Technology. The budget estimates and the actual expenditure for the period 2005-2006 are as follows:

(Rs. in lakhs)

	Opening Balance	Other Income	Grant Received	Total	Actual Expenditure
Plan	**-**	**23.25**	**850.00**	**873.25**	**859.43**
Non-Plan	**-**	**-**	**220.00**	**220.00**	**220.00**
Sponsored Projects	**72.49**	**-**	**158.75**	**231.24**	**115.67**
Total	**72.49**	**23.25**	**1228.75**	**1324.49**	**1195.10**

The Auditors appointed by the Governing Council M/s M.S. Godbole and Associates, Chartered Accountants, Pune conducted the audit for the year 2005-06.

Purchase and Stores

The Institute acquired scientific equipment and accessories, data acquisition and storage systems, personal computers, work stations, enhancing systems and accessories to the existing computer systems and office furniture items.

During the period the following purchases were made:

- **Equipment** : Rs. 176.70 lakhs
- **Dead Stock** : Rs. 5.04 lakhs
- **Consumables** : Rs. 24.28 lakhs

Official Language Implementation

Hindi Cell works under Administrative Wing of the Institute as per rules and directives regarding Official Language Implementation. All general circulars and office orders were issued in bilingual format. With the guidance of Official Language Implementation Committee, Hindi Cell looks after Hindi translation and arranges Hindi Training for officers and employees in different cadres. Two employees were nominated for "Pragnya" course held by Hindi Teaching Scheme during the year. Both the candidates successfully completed the course. In addition to the regular use in administrative work, the use of Hindi is being promoted in scientific work. Scientists of the Institute presented their scientific work in Hindi at various seminars and workshops. They also attended the seminars/ workshops held in Hindi.

The Institute celebrated Hindi Week during 16–21 September 2005. On this occasion, competitions in Hindi were organised. Shri Anil Joshi, Post Master General was the Chief Guest. The prizes to the winners of the competitions were given away by the Chief Guest. Dr. G.B. Pant, Director of the Institute presided over the function.

IITM Recreation Club

The Recreation Club continued to provide sports and library facilities to the members, which include the employees, research assistants, research scholars and project associates.

The Club awarded prizes to the children of the Institute's employees who had exhibited excellent performance in S.S.C., H.S.C., Diploma, Graduation and Post-Graduation Examinations held in the Academic Year 2005-2006 under different disciplines. Prizes were also given to the employees who acquired higher academic qualifications during the year.

Annual Sports Tournaments were organised. A few lectures by the eminent personalities were arranged during the year. The Recreation Club started several new activities for the benefit of the Institute's employees, such as Football Coaching Facility, Cultural programmes, etc.

The Institute's employees participated in various tournaments organised by the Central Government Employees Welfare Co-ordination Committee, Pune and won prizes and honours. They were felicitated on the occasion of the 44rd Foundation Day Celebration of the Institute held on 17 November 2005 and received prizes at the hands of Shri Joseph D'Souza, Chief Guest of the Cultural Function. Employees retiring from the service were felicitated with a silver coin on behalf of the recreation club.

Garden Committee

The Garden has been given a face-lift by re-engineering the front portion of the building, as change is the law of life. The near pristine lawns, the exotic flowers and the heaving fountains added glamour to the already beautiful scenario. Colourful foliage and texture and green and luscious lawns have created an ambience that is conducive towards fostering a healthy mindset of the entire workforce at the Institute. The Garden Committee carried on the work of maintenance of the garden keeping in mind the ecological balance and scenic veracity of the campus. Tree plantation was done by Shri P.G. Narayanan, Chairman, Standing Parliamentary Committee on 27 September 2005. A Special Tree plantation programme was organised on 17 November 2005 by some revered Guests of the Institute and on 15 August 2005 by the employees.

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15. **International Workshop for Editors and Authors for MAIRS SA RAP Volume on Global Environmental Change and the South Asian Region: an Assessment of the State of the Science, and South Asia Committee (SASCOM) Meeting**, Colombo, Sri Lanka, 11 - 12 July 2005
(G.B. Pant, K. Rupa Kumar)

16. **IAGA and ICMA Joint Symposium (JSMA03) on Short-Term Variability and Long Term Changes in the Lower and Middle Atmosphere**, Toulouse, France, 18 - 29 July 2005
(Beig G.)

- ***Beig G.,*** *Singh V, Roy S. and Peshin S. K., Long-term trends in stratospheric ozone over tropical India.*
- *Fadnavis S.S. and* ***Beig G.****, Seasonal variation of trend in temperature and ozone over the tropical stratosphere.*
- *Fadnavis S.S. and* ***Beig G.****, Solar cycle response of temperature and ozone through vertical structure of tropical stratosphere.*
- *Fadnavis S.S. and* ***Beig G.,*** *Solar trends in mesospheric and mesopause region temperature - An update.*

17. **IAGA Conference (JSII02) on Long-Term Trends in the Upper Atmosphere** (IAGA Division II and ICMA), Toulouse, France, 20 July 2005
(Dr. G.Beig)

18. **Workshop on Scientific Investigations during 25th Indian Antarctic Expedition,** National Centre for Antarctic and Oceanic Studies, Goa, 21 - 22 July 2005
(G.B. Pant, S. Sonbawne)

19. **BIMSTEC Workshop on Weather and Climate**, New Delhi, 21 - 23 July 2005
(G.B. Pant, K. Krishna Kumar)

- ***Krishna Kumar K.,*** *Weather and climate modeling at IITM.*

20. **Scientific Assembly of the International Association of Meteorology and Atmospheric Sciences (IAMAS 2005),** Beijing International Convention Centre (BICC), Beijing, China, 2 - 8 August 2005
(P.C.S. Devara)

- ***Devara P.C.S.,*** *Shinde U.P, Pandithurai G., Raj P. E. and Dani K.K., Spectral and temporal variability of absorption, optical and physical properties of aerosols over Pune, India.*

21. **National Workshop on Tsunami Hazards along the Indian Coast**, Indian Institute of Science, Bangalore, 3 - 4 August 2005
(B.H. Vaid)

22. **Workshop on Technical and Scientific Terminology and Implementation of Official Language Policy**, Coimbatore, 22 - 24 August 2005
(B.C. Morwal)

23. **3rd SPARC Data Assimilation Workshop and SPARC Workshop on Stratospheric Winds**, Banff, Canada, 12- 14 September 2005
(Y. Jaya Rao)

- ***Jaya Rao Y.,*** *Devara P.C.S., Rao N.D., Kumar B. Y., Nee J. B. and Chiang C.W., Lidar and radar observations of UT/LS dynamics over tropical and sub-tropical stations.*

24. **Short Term Training Programme on Environmental Management and Social Aspects of River Valley Project**, National Water Academy, Khadakwasla, Pune, 12 -16 September 2005
(N.A. Sontakke)

25. **National Workshop on Geoinformatics in Water Sector**, National Water Academy, Khadakwasla, Pune, 22 - 23 September 2005
(N. Singh, N.R. Deshpande, B.D. Kulkarni, A.K. Verma)

- ***Deshpande N.R.,*** *Mandal B.N., Kulkarni B.D. and Verma A.K., Rainstorm analysis using computer technique and its comparison with estimates made by manual method over the Krishna basin.*

- ***Singh N.,*** *Singh H.N. and Sontakke N.A., Monsoon OLR and rainfall variation across India in relation to tropospheric temperature pattern using Geoinformatics.*

26. **Seminar on Atmospheric Chemistry, University of Rajasthan,** Jaipur, 28 September 2005
(P.C.S. Devara and Dr. G. Beig)

- ***Beig G.****, Ion chemistry in the troposphere and stratosphere, Seminar on Atmospheric Chemistry (Invited Talk).*

- ***Devara P.C.S.****, Air pollution chemistry, Seminar on Atmospheric Chemistry (Invited Talk).*

27. **7th Conference on Agriculture and Forest Meteorology**, University of Sangju, Sangju, South Korea, 29 - 30 September 2005
(R.H. Kripalani)

- ***Kripalani R.H.*** *and Oh J.H., Impact of CO_2 increase on South Asian monsoon rainfall.*

28. **Workshop on Oceanographic Features of the Indian Coastal Waters**, Naval Physical and Oceanographic Laboratory, Kochi, 6 - 7 October 2005
(S. Sivaramakrishnan) (Chaired a session)

- ***Sivaramakrishnan S.****, Air-Sea interactions experiments on surface fluxes over ocean / sea - a review (Invited Talk).*

29. **Brain Storming Session on the Scientific Program and Thrust Areas in Polar Science during 11th Five Year Plan**, National Centre for Antarctic and Ocean Research, Goa, 7 - 8 October 2005
(A.K .Kamra)

30. **5th International Symposium on Asian Monsoon System (ISAM5)**, Yongpyong Resort, South Korea, 11 - 15 October 2005
(R.H. Kripalani)

- ***Kripalani R.H.,*** *Kulkarni A.A., Sabade S.S., Oh J.H. and Chaudhari H.S., South and East Asian summer monsoon precipitation variability: Coupled model projections under IPCC AR4.*

- ***Kripalani R.H.*** *and Oh J.H., Influence of the Indian Ocean zonal mode on East Asian summer monsoon: Possible mechanism.*

31. **3rd Megha-Tropiques Indo-French Workshop under the ISRO-CNES Joint programme on Atmosphere, Climate Science and Oceanography,** Space Application Centre, Ahmedabad, 17 - 20 October 2005
(R. Krishnan, P.N. Mahajan)

32. **First Workshop on SDNP (Sustainable Development Network Partners) of Environmental Information System,** Anna University, Chennai, 21 October 2005
(G. Beig)

33. **4th Korea-Mongolia Joint Seminar on Environmental Changes of Northeast Asia**, Pukyong National University, Busan, South Korea, 22 - 23 October 2005
(R.H. Kripalani)

- ***Kripalani R.H.****, Oh J.H. and Chaudhari H.S., Impact of CO_2 increase on east Asian monsoon.*

34. **National Level Brain Storming Workshop on Indian Urban Air Quality 2005,** National Environmental Engineering Research Institute, Nagpur, 24 - 25 October 2005
(G.B. Pant)

35. **First Workshop on Astroparticle Physics and Space Science: Scope of the National Facility in the Eastern Himalayas**, Bose Institute, Darjeeling, 3 - 5 November 2005
(A.K. Kamra, P.C.S. Devara)
(Dr. Kamra Chaired a session)

- ***Devara P.C.S.****, Aerosols, radiation and climate (Invited Talk).*

- ***Kamra A.K.****, Atmospheric electric conductivity and aerosols (Invited Talk).*

36. **Synthesis Workshop and Stakeholder Meeting of APN project**, Hyderabad, 9 - 11 November 2005
(K. Rupa Kumar)

37. **CSI-2005: 40th Annual National Convention of Computer Society of India**, Computer Society of India, Hyderabad Chapter, Hyderabad, 9 - 12 November 2005
(A.R. Seshagiri)

38. **International Round Table Conference on Understanding and Prediction of Summer and Winter Monsoon**, Jakarta, Indonesia, 21 - 24 November 2005
(S.K. Patwardhan)

- ***Patwardhan S.K.**, Characteristics of Indian summer monsoon in a warming scenario.*

39. **Workshop on Himalayan Palaeoclimate during Quaternary (HIMPAQ) - the Indian Story**, Geo Forschungs Zentrum, Potsdam, Germany, 22 - 24 November 2005
(K. Krishna Kumar, H.P. Borgaonkar)

- ***Borgaonkar H.P.**, Tree-Ring thickness, density and overall potential from India.*
- ***Krishna Kumar K.,** Present Status and Future Scenario for the Asian SW-Monsoon.*

40. **Brain Storming Session on Urban Aerosol Climatology**, Indian Institute of Tropical Meteorology- New Delhi Branch, New Delhi, 25 November 2005
(G. B. Pant, A.K. Kamra, P. C. S. Devara, D.B. Jadhav, P. S. P. Rao, G. A. Momin)

- ***Devara P.C.S.**, Climate diagnostics from long-term lidar and radiometric measurements of urban aerosols over Pune (Invited Talk).*
- ***Jadhav D.B.**, Stratospheric aerosols and their signature on Pune rainfall (Invited Talk).*
- ***Kamra A.K.**, Aerosol cloud interactions (Invited Talk).*
- ***Rao P.S.P.**, Aerosol and precipitation chemistry (Invited Talk).*

41. **Evaluation Workshop of the Western Region**, Center for Environmental Education, Ahmedabad, 25 - 26 November 2005
(G. Beig)

- ***Beig G.,** Acid rain and atmospheric pollutants (Invited Talk).*

42. **Workshop on Palaeoclimates**, University of Pune, 25 - 27 November 2005
(K. Rupa Kumar)

- ***Rupa Kumar K.,** Tree-ring studies in India: Status and scope.*

43. **Second Workshop for Applications of WP/RASS Data Sets**, Indian Institute of Tropical Meteorology, Pune, 28 November 2005
(G.B. Pant, A.K. Kamra, P.C.S. Devara, R. Vijayakumar, J.R. Kulkarni, P. Mukhopadhyaya, K.M.C. Reddy, R.R. Joshi, S.H. Damle, S.M. Despande, Narendra Singh)

- ***Kulkarni J.R.,** Use of RASS data for THORPEX events.*
- ***Mukhopadhyay P.,** Mesoscale modelling of thunderstorm over Pune, (Invited Talk).*

44. **American Geophysical Union (AGU) Fall Meeting 2005**, San Francisco, U.S.A., 5-9 December 2005
(G. Pandithurai)

- ***Pandithurai, G.**, Pinker R.T., Devara P.C.S., Raj P.E., Jaya Rao Y., Dani K.K., Maheskumar R.S., Sonbawne S.M., Saha S.K., Bhawar R. and Shinde U.P, Aerosol Climatology at Pune, Western India: Implications to direct radiative forcing and heating rates.*

45. **42nd Annual Convention of Indian Geophysical Union and Meeting on Earth System Processes Related to Earthquakes, Tsunamis and Volcanic Eruptions**, Barkatulla University, Bhopal, 7 - 9 December 2005
(I.S. Joshi, C.S. Bhosale, R.M. Khaladkar, A.A. Deo, G. Meena, S.B. Kakade, D.W. Ganer, U.K. Singh, S. Taraphadar)

- ***Bhosale C. S.,** Meena G. S.**,** Kulkarni J. R. and Jadhav D. B.**,** Role of transient eddy transport in troposphere- stratosphere coupling during two contrasting years of monsoon activity.*

- ***Deo A. A.*** *and Ganer D. W., Temperature change in the Indian Ocean during the passage of cyclones as revealed from the simple ocean models.*

- ***Dugam S.S.*** *and Kakade S.B., Indian Ocean warming in association with North Atlantic Oscillation.*

- ***Ganer D. W.*** *and Deo A. A.***,** *Simulation of mini warm pool and cold pool in the Indian Ocean.*

- ***Joshi I.S.,*** *Effects of geomagnetic storms and sudden Ionospheric disturbances on stratosphere and troposphere trremperatures.*

- ***Khaladkar R.M.,*** *Narkhedkar S.G. and Mahajan P.N., Capability of different numerical models in forecasting high rainfall events of Indian summer monsoon.*

- ***Meena G. S.,*** *Bhosale C. S. and Jadhav D. B., Study of diurnal and seasonal variations of NO_2,O_3, H_2O and O_4.*

- ***Singh U. K.*** *and Salvekar P.S., Prediction of the onset date of Indian summer monsoon from TMI SST data over the northwest Indian Ocean.*

46. **4th International Symposium on Terrestrial Environmental Changes in East Eurasia and Adjacent Area**s, Gyeongju, South Korea, 7 - 9 December 2005
(R.H. Kripalani)

- ***Kripalani R.H.*** *and Oh J.H., Snow depth variability over West and East Eurasia: impact on South and East Asian monsoons.*

47. **National Seminar on Tsunamis and Other Natural Coastal Hazards over India,** Department of Meteorology and Oceanography, Andhra University, Visakhapatnam, 10 - 12 December 2005
(B.H. Vaid, K. Seshagiri Rao)

- ***Seshagiri Rao K.,*** *Agarwal N.K. and Chakraborty D.R.***,** *Non-linearity of MJO over oceanic region during tropical monsoon.*

- ***Vaid B.H.,*** *Gnanaseelan C., Polito P.S., Chowdary J.S. and Salvekar P.S., Westward propagating twin gyres in the Arabian Sea from Topex / Poseidon altimetry data.*

48. **4th Asian Aerosol Conference (AAC-2005),** Mumbai, 13-16 December 2005
(P. C. S. Devara, P. S. P. Rao, D.M. Chate, G. Pandithurai, P.D. Safai, B. Padamakumari, S. Tiwari, R.S. Maheskumar, S.K. Saha, S.M. Sonbawane, V. Pant, R.L. Bhawar, U.P. Shinde, S.S. Gunthe, Vikas Singh)
(Dr. P.C.S. Devara delivered Inaugural Address and also chaired a Session)

- ***Bhawar R. L.*** *and Devara P.C.S., Estimation of dust optical thickness from TOMS and sun-photometer data over Pune.*

- ***Chate D.M.,*** *Ali. K., Rao P.S.P, Safai P.D., Praveen P.S. and Devara P.C.S., Study of acidity of raindrop by uptake of gases and aerosol pollutants during rain.*

- ***Devara P.C.S.,*** *Raj P.E., Saha S.K., Shinde U.P. and Dani K.K., Characterization of aerosols over Delhi and Agra during 2 nd land campaign program.*

- ***Devara P.C.S.,*** *Shinde U.P., Raj P.E., Pandithurai G., Dani K.K. and Safai P.D., Variability of aerosol absorption optical thickness over a tropical urban station, Pune, India.*

- ***Gunthe S.,*** *Singh V. and Beig G.***,** *Impact of sugar industries on ambient pollution level*

- ***Maheskumar R.S.,*** *Devara P.C.S., Raj P.E., Dani K.K., Saha S.K. and Sonbawane S.M., Direct radiative forcing of atmospheric aerosols over different environments.*

- ***Padmakumari B.,*** *Londle A.L., Jadhav D.B. and Trimbake H.K., Detection of Meteoric Contribution to Stratospheric Aerosol – by Twilight Sounding Method.*

- ***Pandithurai G.****, Devara P.C.S., Pinker R.T., Raj P.E., Jaya Rao Y., Dani K.K., Maheskumar R.S., Sonbawane S.M., Saha S.K. and Bhawar R., Aerosol radiative forcing derived from sun/sky radiometer and LIDAR observations at Pune, India.*

- ***Pandithurai G.,*** *Pinker R.T., Devara P.C.S., Takamura T., Raj P.E., Dani K.K. and Maheskumar R.S., Large differences in diurnal variability of urban aerosol optical parameters during winter and pre-monsoon seasons in western India.*

- ***Pant V.,*** *Deshpande C.G. and Kamra A.K., Size distributions of micron-size aerosol particles over the southern Indian Ocean.*

- *Praveen P.S.,* ***Safai P.D.,*** *Devara P.C.S., Pandithurai G., Kewat S., Rao P.S.P., Momin G.A., Ali K., Chate D.M. and Singh A.K., Some comparitive studies on surface and radiometric aerosol observations over tropical urban city, Pune.*

- ***Rao P.S.P.*** *, Some comparative studies on surface and radiometric aerosol observations over tropical urban city, Pune.*

- ***Rao P.S.P.,*** *Praveen P.S., Kewat S., Safai P.D., Ali K., Tiwari S., Momin G.A. and Chate D.M., Aerosol characteristics at Agra during ISRO-GBP Land Campaign II.*

- *Rege R., Potdar M.B., Badrinath K.V.S.,* ***Devara P.C.S.,*** *and Agarwal, B.P.****,*** *Mapping of aerosol optical parameters over land using multi-spectral IRS-P4 OCM satellite data.*

- ***Safai P.D.,*** *Praveen P.S., Kewat S., Rao P.S.P., Ali K. and Chate D.M., Studies on diurnal variation of black carbon aerosols during pre-monsoon and post-monsoon season at Sinhagad, a rural hillstation in western India.*

- *Saha S.K.,* ***Devara P.C.S.,*** *Raj P.E. and Dani K.K., Impact of precipitation on lidar-derived aerosol concentration over Pune.*

- ***Shinde U.P.,*** *Devara P.C.S., Raj P.E. and Pandithurai G., Seasonal inhomogenity in aerosol microphysical properties and its relationship with meteorological and long-range transport processes.*

- ***Singh V.,*** *Gunthe S. S. and Beig G., Impact of aerosol rich inversion layer on air pollutants near the surface over semi-urban site Pune.*

- ***Sonbawne S.M.*** *and Devara P.C.S., Radiometric observations of aerosol and precursor gases over Maitri during 24 th Indian Antarctic Expedition: Preliminary results.*

- ***Tiwari S.,*** *Ranade, A. and Singh, D., Use of multivariate analysis for determining source of solutes found in wet atmospheric deposition in Delhi.*

49. **Annual Workshop-Monsoon 2005**, Indian Meteorological Society, Pune Chapter, India Meteorological Department, Pune, 23 December, 2005
(All the Members from the Institute)

    - ***Kulkarni J.R.,*** *Dynamical and statistical prediction experiments: monsoon 2005.*

    - ***Kulkarni J.R.,*** *Mesocyclone : Responsible for the exceptional heavy rainfall over Mumbai on 26/27 July 2005 as inferred from cloud model.*

    - ***Mahajan P.N.*** *and Prabhu A.A., Satellite synergy for exceptional very heavy rainfall over Santacruz on 26 July 2005.*

    - ***Mukhopadhyay P.,*** *Real data simulation of heavy precipitation event using 3D mesoscale models.*

    - ***Sahai A.K.,*** *Dynamical and statistical prediction experiments: monsoon 2005.*

50. **Ninth All Indian Official Language Conference,** Pondicherry, 27 - 29 December 2005
(K. Ali, B.C. Morwal)

51. **Workshop on Data Assimilation in Atmospheric and Oceanic Modelling,** Indian Institute of Science, Bangalore, 2 - 6 January 2006
(S.G. Narkhedkar, P. Mukhopadhyay)

52. **APN Regional Workshop on Climate Extreme Indices and Indicators for Monitoring Trends in South Asia**, Islamabad, Pakistan, 2 - 6 January 2006
(G.B. Pant, K. Rupa Kumar, N.R. Deshpande)

- ***Deshpande N.R.,*** *Climate Extremes Indices generated by 'Reclimdex' software for some representative stations in India.*

- ***Rupa Kumar K.,*** *Future climate scenarios for South Asia (Invited Talk).*

- ***Rupa Kumar K.,*** *Introduction to extreme climate indices (Invited Talk).*

53. **European Research Course on Atmosphere**, University of Joseph Fourier, Grenoble, France, 6 January - 13 February 2006
(R. Chattopadhyay)

54. **Group Monitoring Workshop on Weather and Climate Research Programmes**, Indian National Science Academy, New Delhi, 11 - 12 January 2006
(N. Singh, P.E. Raj, S.B. Morwal)

- ***Morwal S.B.,*** *Atmospheric boundary layer over the Arabian Sea during ARMEX-Thermodynamic Aspect.*

- ***Raj P.E.,*** *Influence of columnar aerosol, ozone and water vapour on the evolution of warm pool over the southeast Arabian Sea.*

- ***Singh N.,*** *Atlas of spatial features of moisture regions and rainfall of India during 19th and 20th centuries.*

55. **National Conference on Atmosphere Ocean Interaction and Monsoon Variability (ATMOCIN-2006)**, Cochin University of Science and Technology, Kochi, 11 - 13 January 2006.
(P.N. Mahajan, I.S. Joshi, S.G. Nagar, A. A. Munot, S.S. Dugam, D. R. Kothawale, S. K. Jadhav, S.D. Patil, S. S. Sabade, S. Nair, S.S. Naik, M.D. Chipade, S. Joseph, S. Taraphdar)

- *Bawiskar S.M. and* ***Chipade M.D.,*** *High latitudinal trough during winter and monsoon variability.*

- ***Dugam S.S.*** *and Kakade S.B., Spatial and temporal rainfall variability in association with MJO.*

- ***Jadhav S.K.,*** *Performance of the southwest monsoon 2005 in association with the low pressure systems over the Indian region.*

- ***Joseph S.,*** *Sahai A. K. and Mandke S.K., Study of Indian summer monsoon long break spells.*

- ***Joshi I.S.,*** *Association between magnetic sector boundary crossing events and Indian summer monsoon rainfall activity.*

- ***Kothawale D.R.,*** *Relationship between SST over Indian seas and Indian monsoon rainfall.*

- *Kulkarni A.A.,* ***Sabade, S.S.*** *and Kripalani R.H., Intra-seasonal Oscillations during contrasting Monsoons.*

- ***Mahajan P.N.****, Satellite feed back for mitigating natural hazards of severe weather systems.*

- ***Munot A.A.,*** *Long range prediction of Indian summer monsoon rainfall.*

- ***Nagar S. G****., Seetaramayya P. and Dhakate A. R., Comparison of air mass characteristics of marine atmosphere boundary layer (MABL) over southeast Arabian Sea during ARMEX-2003.*

- ***Nair S.,*** *Kulkarni P.L. and Mahajan P.N.* ***,*** *Dynamics associated with the early onset of monsoon in 1997 and 2004.*

- ***Naik S.S.*** *and Salvekar P.S., Physics and dynamics of atmospheric circulation over Indian region during super active monsoon period in 2005.*

- ***Patil S.D.,*** *Energy balance over the Indian region using multiple satellite data during summer monsoon season.*

- ***Taraphdar S.*** *and Sanjay J., Diurnal variations in NCEP reanalysis during Indian summer monsoon.*

56. **UK - India Workshop on Regional Climate Change, Variability and Impacts: Scientific Perspectives,** Indian Institute of Tropical Meteorology, Pune, 23 - 27 January 2006
(G.B. Pant, A.K. Kamra, P.C.S. Devara, K. Rupa Kumar, P.S. Salvekar, N. Singh, R. Krishnan, S. Sinha, P.N. Mahajan, J.R. Kulkarni, B.N. Mandal, G. Beig, A.K. Sahai, K. Krishna Kumar, H.P. Borgaonkar, N.R. Deshpande, S.K. Patwardhan, A.B. Sikder, S.K. Mandke, M.S. Mujumdar, J.V. Revadekar, Preethi Bhaskar, K Kamala, S. S. Bhandare, R.K. Yadav)

- ***Krishna Kumar K.,*** *Some new perspectives on the variability and prediction of Indian Summer Monsoon rainfall.*

- ***Krishnan R.,*** *Coupled ocean-atmosphere interactions and predictability of monsoon droughts.*

- ***Rupa Kumar K.,*** *Observational features of rainfall and temperature variability over India.*

57. **XIV National Space Science Symposium (NSSS-2006)**, Andhra University, Visakhapatnam, 9-12 February 2006
(G. Beig, I. S. Joshi, P.V. Puranik, B. Padma Kumari, R.S. Maheskumar, G.R. Chintalu, H.N. Singh, S.S. Gunthe, V. Singh, C. Sheethala)

- *Bawisksar S.M.,* ***Puranik P.V.*** *and Chipade M.D., Lower tropospheric waves and rainfall during Monsoon.*

- ***Beig G.,*** *Atmospheric trace gases and their environmental and climatic impacts (Invited Talk).*

- ***Beig G.,*** *Impact of south Asian chemical emissions on the tropospheric ozone level in India.*

- ***Chinthalu G. R.,*** *Nagar S. G, Seetaramayya P. and Dhakate A. R., Comparative study of weak and active phases of off shore trough during ARMEX-2002.*

- *Fadnavis S.S. and* ***Beig G.,*** *11 year solar cycle effects on temperature and ozone in the tropical stratosphere.*

- ***Gunthe S.S.*** *and Beig G.,* *Wintertime maximum in surface ozone concentrations at a semi urban site Pune.*

- ***Joshi I.S.,*** *Association between total ozone sunspot numbers and AA index.*

- ***Maheskumar R.S.,*** *Morwal S.B., Kulkarni J.R. and Vijayakumar R.,* *Simulation of heavy rainfall events using 2-DTD cloud model.*

- *Morwal S.B.,* ***Maheskumar R.S.,*** *Kulkarni J.R. and Vijayakumar R., Comparison of observed and radar derived rainfall.*

- ***Padmakumari B.,*** *Londhe A.L., Jadhav D.B. and Trimbake H.K., Stratospheric aerosol layer variability during volcanically quiescent period – by twilight method.*

- ***Patil S.D.,*** *Spatio-temporal variations in the tropospheric ozone over Indian region in relation to the anthro-pogenic activities and meteorological parameters.*

- *Polade S., Fadnavis S.S. and* ***Beig G.,*** *Isolation of tropical stratospheric ozone QBO in MLS data by wavelet analysis.*

- ***Seethala C.****, Pandithurai G., Murthy B.S. and Devara P.C.S., Direct radiative effects of aerosols on the evolution of atmospheric boundary layer.*

- ***Singh H.N.,*** *Annual cycle and interannual variations of the NOAA OLR over global tropics in relation to rainfall across India.*

- ***Singh V.*** *and Beig G.,* *26-year data record of atmospheric ozone over tropical India from TOMS: Implications for ozone trends in the stratosphere and troposphere.*

- *Vijayakumar R., Kulkarni J.R., Morwal S.B.* *and* ***Maheskumar R.S.****, Characteristic features of monsoon clouds as derived from 5-CM Doppler radar.*

58. **International Conference on Mesoscale Processes in Atmosphere, Ocean and Environmental Systems**, Indian Institute of Technology Delhi, New Delhi, 14 -17 February 2006
(S.G. Nagar, B.S. Murthy, S.S. Dugam, A. A. Kulkarni, S. M. Bawiskar, S.S. Sabade, B.H.Vaid, U.K. Singh, M. S. Deshpande, S. M. Deshpande)

- ***Bawisksar S.M.,*** *Chipade M.D. and Puranik P.V., Influence of ultra-long waves on Intra-seasonal variability of monsoon.*

- ***Deshpande M.S.*** *and Salvekar P.S, Impact of domain size on the numerical simulation of Bay of Bengal tropical cyclone.*

- ***Deshpande S.M.,*** *Kulkarni J.R., Joshi R.R., Devara P.C.S. and Raj P.E., A comparative study of structure of atmospheric subsidence over Pune in March 2004 and 2005 using Wind Profiler.*

- ***Dugam S.S.*** *and Kakade S.B., Association of North Atlantic Oscillation with warming of the world oceans.*

- ***Kulkarni A.A.****, Sabade, S.S. and Kripalani R.H., Interaction between Indian Ocean dipole and monsoon over South and East Asia.*

- ***Murthy B.S.,*** *Cini S., Dharmaraj T. and Sivaramakrishnan S., Characteristics of the atmospheric surface layer over a tropical coastal station.*

- ***Nagar S. G.,*** *Dhakate A. R. and Seetaramayya P., Evolutionary feature of marine boundary layer over the Arabian Sea prior to the onset of monsoon over Kerala during ARMEX - 2003.*

- ***Sabade S.S.,*** *Kulkarni A.A. and Kripalani R.H.****,*** *Intra-seasonal oscillations during monsoon 2002 and 2003.*

- ***Singh U.K.,*** *Application of digitised INSAT IR data for studies of super cyclonic storm of Orissa (1999) and monsoon depression (1998).*

- ***Vaid B.H.,*** *Gnanaseelan C., Polito P.S. and Salvekar P.S., Influence of Indonesian throughflow on the annual and biennial Rossby waves.*

59. **All India Official Language Conference** , Madgaon, Goa, 16 - 18 February 2006
(A. A. Ursekar)

    - ***Ursekar A.A.,*** *Hindi and computerization.*

60. **C-DAC and CERN Collaborative Workshop on GRID and High-Speed Networking** , Centre for Development of Advanced Computing, Pune, 24 February 2006
(M.K. Tandon, S.B. Morwal, S.U. Athale, Preethi Bhaskar)

61. **National Seminar on Atmospheric Science,** Sri Krishnadevaraya University, Anantapur, 24-25 February 2006
(P.C.S. Devara)

    - ***Devara P.C.S.****, Lidar and radiometric sounding of atmospheric aerosols, gases, clouds and winds (Invited Talk).*

62. **Raman Memorial Conference,** Department of Physics, University of Pune, Pune, 24-25 February 2006
(S. Halder)

    - ***Halder S.*** *and Mukhopadhyay P. Life cycle of two Nor'westers using Doppler Radar, Meteosat-5 imageries and Tephigram analyses.*

63. **International Geosphere Biosphere Program (IGBP) Workshop on Global Change**, Indian Institute of Tropical Meteorology, Pune, 3 March 2006
(G.B. Pant, A. K.Kamra, P.C.S. Devara, D.B. Jadhav, K. Rupa Kumar, P.S. Salvekar, S. Sivaramakrishnan, R. Krishnan, P.E. Raj, P.N. Mahajan, J.R. Kulkarni, B.N. Mandal, G. Beig, A.K. Sahai, P.S.P. Rao, K. Krishna Kumar, A.L. Londhe, Shri C.M., Mohile, A.B. Sikder, S.K. Mandke, S.B. Debaje, G. Pandithurai, G.A. Momin, K. Ali, S.S.Sabade, P.D. Safai, M.S. Mujumdar, B. Padma Kumari, P. Mukhopadhyay, J.V. Revadekar, S.S. Fadnavis, S. Roy, R.S. Mahesh Kumar, R. R. Joshi, R.K. Yadav, V. Pant, R.L. Bhawar, S.H. Kulkarni, S.S. Bhandare, Shri U. K.Singh S.S. Gunthe, V. Singh, S.K. Sahu, S.M. Deshpande, S. S.Sharma)

    - ***Beig G****, Atmospheric Chemistry and Global Change (Invited talk).*

    - ***Krishnan R.,*** *Kulkarni J.R., Sahai A. K., Mandke S.K..,Mujumdar M.S., Coupled air-sea interactions in the tropical Indian Ocean and monsoon environment.*

    - ***Rupa Kumar K.,*** *Climate change scenarios for India.*

64. **Workshop on the Organization and Maintenance of Tropical Convection and the Madden Julian Oscillation**, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, 13 - 17 March 2006
(R. Krishnan, K. Krishna Kumar, A.A. Kulkarni)

    - ***Krishna Kumar K.,*** *Impact of climate change on the intraseasonal oscillation of the Indian summer monsoon.*

- ***Krishnan R.,*** *Ramesh K. V., Samala B. K., Meyers G., Slingo J.M. and Fennessy M.J., Coupled air-sea interactions in the tropical Indian Ocean environment.*

- ***Kulkarni A.A.****, Sabade, S.S. and Kripalani R.H., Intraseasonal oscillations during contrasting monsoons.*

65. **UK-India Education Research Initiative (UKIERI) Research Cooperation Conference**, British Council India, New Delhi, 14 March 2006
(P.C.S. Devara, K. Rupa Kumar)

66. **National Workshop on Dynamics and Simulation of Extreme Rainfall: Case Studies of Recent Events**, Centre for Mathematical Modelling and Computer Simulation, Bangalore, 16 - 17 March 2006
(S.S. Kandalgaonkar)

- ***Kandalgaonkar S.S.,*** *Lightning activity observed on an exceptionally heavy rainfall day over Mumbai*

67. **Workshop on Physics of Cloud Seeding and Weather Modification Technologies** , Jawaharlal Nehru Technological University, Hyderabad, 19 - 20 March 2006
(R. Vijayakumar)

- ***Vijayakumar R.****, Weather modification - basic concepts.*

68. **WMO-KMA International Workshop on Collaborations for Weather Disaster Prevention and Mitigation**, Korea Meteorological Administration, Seoul, South Korea, 20 March 2006
(R.H. Kripalani)

- ***Kripalani R.H****., Weather and climate-related disaster management in India (Invited talk).*

69. **Brain Storming Session on Severe Thunderstorms - Observational and Regional Modeling (STORM),** Kolkata, 21-22 March 2006
(A K Kamra)

70. **National Conference on Long Range Forecasting 2006,** India Meteorological Department, New Delhi, 23 March and 22 April 2006
(A.K. Sahai)

- ***Sahai A.K.,*** *Dynamical and statistical prediction experiments: monsoon 2005.*

71. **National Workshop on Cloud Physics,** Centre for Earth Science Studies, Thiruvananthapuram, 24-25 March 2006
(R. Vijayakumar, S.B. Morwal, R.S. Maheskumar)

- ***Vijayakumar R.,*** *IITM's contribution to cloud physics and weather modification- a review.*

72. **Workshop on Disaster Management,** Dr. MCR Human Resource Development Institute of Andhra Pradesh, Hyderabad, 24 - 25 March 2006
(P.N. Mahajan)

73. **Fourth Basic Urban Air Quality Management (BUAQM) Seminar on Urban Air Quality Monitoring,** Environmental Management Centre (EMC), Pune, 28 - 29 March 2006
(S. Roy, S. K. Sahu, S. Jain)

74. **INDO-UK Workshop on Earth Observations for Weather and Climate (EOWC),** Space Application Centre, Ahmedabad, 28 - 30 March 2006
(R. Krishnan, P.N. Mahajan)

- ***Krishnan R.,*** *Global climate modelling in India.*

(Authors shown in bold presented the papers)

PAPERS PUBLISHED

Journals	:	61
Proceedings, Books, Report etc	:	75

PAPERS PRESENTED : 137

Participation in Meetings

Dr. G.B. Pant

- Programme Advisory Committee (PAC) Meeting, Aryabhatta Research Institute of Observational Sciences (ARIOS) Nainital, 18-20 April 2005
- Meeting of the Department of Science and Technology, Physical Research Laboratory, Ahmedabad, 2 May 2005
- United Nations Framework Convention on Climate Change (UNFCCC) Meeting, Ministry of Environment and Forests, New Delhi, 3 May 2005
- Intergovernmental Panel on Climate Change (IPCC) Authors Meeting, The Energy and Resources Institute (TERI), New Delhi, 4 May 2005
- Meeting, Centre for Wind Energy Technology (C-Wet), Chennai, 9 May 2005
- Meeting of Intensification of Research in High Priority Areas (IRHPA) Department of Science and Technology Project relating to Setting-up of National Facility at Bose Institute, Darjeeling, Bose Institute, Mayapuri, Darjeeling, 22 May 2005
- 2nd Meeting of the Research Advisory Committee of the Department of Ocean Development, New Delhi, 10 June 2005
- Meeting of the Departmental Interview Board, Bhabha Atomic Research Centre (BARC), Mumbai, 22 June 2005
- Meeting called by the Secretary, Department of Science and Technology to discuss the prospects of 2005 Monsoon, New Delhi, 4 July 2005
- Meeting of Purchase Committee constituted for the Establishment of Aerosol Monitoring Network for India Meteorological Department, Thiruvananthapuram, 17 July 2005
- Meeting of the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005
- Scientific Advisory Committee Meeting, Space Physics Laboratory, Thiruvananthapuram, 10 - 12 August 2005
- Meeting of Observational Networking and Forecasting System of IMD, India Meteorological Department, New Delhi, 18 August 2005
- Meeting of National Coordination Committee for Antarctic Programme, Department of Ocean Development, New Delhi, 18 August 2005
- Meeting of Programme Advisory Committee in the area of Oceanography and Atmospheric Sciences, Department of Ocean Development, New Delhi, 24 August 2005
- Meeting of Centre for Astroparticle Physics and Space physics; a National Facility at Bose Institute, Indian Institute of Tropical Meteorology New Delhi Branch, New Delhi, 25 August 2005
- Project Meetings under the Joint Indo-UK Programme on the Impacts of Climate Change in India, New Delhi, 8 September 2005
- Meeting of the Indian Lead Authors of the IPCC AR4, The Energy Resources Institute, New Delhi, 20 October 2005
- Participation in the IPCC Working Group 1 Fourth Assessment Report Third Level Authors Meeting, Christchurch, New Zealand, 12-15 December 2005

Dr. A. K. Kamra

- 2nd Joint Scientific Working Group on Megha Tropiques Meeting, Indian Space Research Organisation (ISRO), Bangalore, 8 - 9 April 2005

- Ordinary General Meeting and the Sectional Committees (05 and M2) Meetings, Indian National Science Academy, New Delhi, 13 - 17 April 2005
- Meeting of the Purchase Committee to purchase Equipment for Establishment of Aerosol Monitoring Network of India Meteorological Department, Space Physics Laboratory, Thiruvananthapuram, 16-17 July 2005
- Meeting of the Physical Science Research Committee and Project Monitoring Session, New Delhi, 11 August 2005
- Meeting of the Purchase Committee to purchase Equipment for Establishment of Aerosol Monitoring Network of India Meteorological Department, India Meteorological Department, Pune, 17 August and 11 September 2005
- Annual Meeting of the Indian Academy of Science, Tircuhirappalli, 11 - 13 November 2005
- Programme Implementation Committee Meeting of Severe Thunderstorm Observations and Regional Modelling (STORM) project of the Department of Science and Technology, Govt. of India, Indian Institute of Technology Delhi, New Delhi, 6 - 7 January 2006
- First Meeting of the Scientific Steering Committee on Continental Tropical Convergence Zone (CTCZ) project of the Department of Science and Technology, Govt. of India, Indian Institute of Tropical Meteorology, Pune, 20 - 21 January 2006
- 14th Session of the Commission for Atmospheric Sciences (CAS) of the World Meteorological Organisation, Cape Town, South Africa, 16 - 24 February 2006

Dr. P.C.S. Devara

- Project Management Board (PMB) Meeting to monitor the progress of the DST-sponsored Project relating to Development of High Power Lidar System for Atmospheric Science Studies, Aryabhatta Research Institute and Observational Science (ARIES), Nainital, 17 May 2005
- DST-sponsored IRHPA Project Meeting relating to Setting-up of National Facility at Bose Institute, Darjeeling, Bose Institute, Mayapuri, Darjeeling, 22 May 2005
- Meeting of the Technical Evaluation Committee, India Meteorological Department, Pune, 11, 12 and 18 July, and 10 and 11 September 2005
- INDOFLUX Network Meeting of the Department of Science and Technology, Govt. of India, Indian Institute of Tropical Meteorology, Pune, 29 July 2005
- Programme Advisory Committee Meeting in the area of Oceanography and Atmospheric Sciences, Department of Ocean Development (DOD), New Delhi, 24 August 2005
- Technical Specifications Committee Meetings for the purchase of equipment sanctioned by DST to Bose Institute in connection with the setting up of a National Facility for Astro-particle Physics and Space Science Studies at Bose Institute Campus, Darjeeling, IITM-Delhi Branch Office and National Physical Laboratory, New Delhi, 25 August 2005
- Selection Committee Meeting for recruitment of manpower for the National Facility at Darjeeling, Bose Institute, Kolkata, 27 August 2005
- Technical Evaluation Committee Meeting for procurement of Radiation and Solar Radiometric Equipment for augmenting network of India Meteorological Department, India Meteorological Department, Pune, 10 and 11 September and 28 October 2005
- Meeting on Results of Land Campaign-II, ISRO-GBP, Physical Research Laboratory, Ahmedabad, 19 - 21 September 2005
- Meeting on IITM-SAC Collaboration on Aerosol Mapping Using Satellite Remote Sensing Data, Indian Institute of Tropical Meteorology, Pune, 21-23 November 2005

- Pre-plan Meeting of the Integrated Campaign of Aerosols, Gases and Radiation Budget (ICARB), Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvanatapuram, 9 - 10 January 2006 and delivered a lecture, "Aerosol and Trace Gases observation programme over ship, at Pune and Delhi during ICARB period"

- 9th Meeting of the Programme Advisory and Monitoring Committee on Weather and Climate Research Programme (WCRP), Indian National Science Academy, New Delhi, 13 Jaunuary 2006

- 1st Meeting of the Scientific Steering Committee for Continental Tropical Convergence Zone (CTCZ) Field Campaign under Indian Climate Research Program of the Department of Science and Technology, Govt. of India, Pune, 20 - 21 January 2006

- Meeting on Indo-Flux Science Plan Document Preparation and Implementation, Department of Science and Technology, New Delhi, 7 February 2006

- Meeting of the Project Management Council (PMC) of the INDOMOD SATCORE Project on Megha-Tropiques, International Centre for Ocean Information System (INCOIS), Hyderabad, 8 February 2006

- Meeting of the Joint Science Working Group, Indian Space Research Organisation Head Quarter, Bangalore, 11 February 2006

- Meeting on Indian participation in the International atmospheric Brown Cloud (ABC), New Delhi, 13 February 2006

- Meeting on DST IRHPA Project on Centre for Astroparticle Physics and Space Sciences: A National Facility at Bose Institute, Bose Institute, Kolkatta and Darjeeling, 17 - 21 March 2006

Dr. K. Rupa Kumar

- Third Meeting of Scientific and Technical Committee (STC) of Extended Range Project, Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi, 29 April 2005

- Meeting of the Indian Authors Contributing to the Fourth Assessment Report (AR4) of the IPCC organized by the Ministry of Environment and Forests (MoEF), Govt. of India, The Energy and Resources Institute (TERI), New Delhi, 4 May 2005

- Participation in the IPCC Working Group1 AR4 Second Lead Authors' Meeting, Bejing, China, 10 - 12 May 2005

- CLIVAR Asian-Australian Monsoon Panel (AAMP) Meeting, Irvine, USA, 18 -19 June 2005

- Meeting on the project "Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang basin", Indian Institute of Tropical Meteorology, Pune, 6 July 2005 and 28 February 2006

- NATCOM Consultative Meeting on Impacts of Climate Change on Water Resources, Agriculture, Health, Extreme Events and Coastal Zones, Indian Institute of Technology Delhi, New Delhi, 22 July 2005

- First Meeting of the Expert Panel for Fast Track Scheme for Young Scientists in Earth and Atmospheric Sciences, New Delhi, 27 July 2005

- Meeting on the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005

- Meeting on the SASE Project, Indian Institute of Tropical Meteorology, Pune, 18 August 2005

- Joint Indo-UK Project Meetings, New Delhi, 7 - 8 September 2005

- Meeting of the Technical Advisory Committee for India's Second NATCOM, Ministry of Environment and Forests (MoEF), New Delhi, 28 September 2005

- Meeting to discuss the role of river water discharge into the Bay of Bengal in the lower salinity and higher sea surface temperatures observed over the Bay, Indian Academy of Sciences, Bangalore, 15 October 2005.

- Meeting of the Indian Lead Authors (LAs) to the IPCC AR4 convened by the Ministry of Environment and Forests (MoEF), New Delhi, 20 October 2005,
- Second Meeting of ADCOS Science Panel (ASP-4) on Climate and Weather Science, Indian Space Research Organization, Bangalore, 8 - 9 November 2005
- Stakeholder Meeting of the APN Project, Hyderabad, 9 - 11 November 2005
- Regional Launch Meeting of the Indo-UK Project Results, British High Commission in India, Chennai, 17 November 2005
- Participation in the IPCC Working Group-I Fourth Assessment Report Third Lead Authors Meeting, Christchurch, New Zealand, 12 - 15 December 2005
- First meeting of the Scientific Steering Committee (SSC) for Continental Tropical Convergence Zone (CTCZ), Indian Institute of Tropical Meteorology, Pune, 20 - 21 January 2006
- IPCC-WGI AR4 Chapter 11 Lead Author Meeting, Seoul, South Korea, 1 - 3 February 2006
- Third meeting of the TARC for the project "Preparation of generalized PMP Atlases for the Krishna and Indus river basins", Central Water Commission, New Delhi, 13 February 2006

Dr. (Smt.) P.S. Salvekar

- Meeting of Women Scientists programme - A (WOS-A) of the Department of Science and Technology, National Institute of Oceanography, Goa, 2 May 2005
- Meeting in connection with proposed new course of M.Tech. in Ocean Science, University of Pune, 7 May 2005
- Meeting of the Selection Committee for Research Associate, University of Pune, Pune, 6 February 2006
- Project Management Council (PMC) Meeting of the INDOMOD - SATCORE Projects, International Centre for Ocean Information System, Hyderabad, 8 February 2006

Dr. S. Sivaramakrishnan

- Meeting of the Technical Evaluation Committee for Surface Meteorological Instruments, Indian Meteorological Department, Pune, 27 - 28 October 2005, 30 November - 2 December 2005 and 21 - 22 March 2006

Dr. R. Krishnan

- Second Meeting on Experimental Extended Range Monsoon Prediction (ERMP) 2005, Centre for Mathematical Modelling and Computer Simulation, Bangalore, 12 - 13 July 2005
- Seasonal Prediction of Indian Monsoon (SPIM) Discussion Meeting, Indian Institute of Science, Bangalore, 27 November 2005
- Seasonal Prediction of Indian Monsoon (SPIM) Discussion Meeting, Centre for Development of Advanced Computing (C-DAC), 19 December 2005
- Meeting of the Project Management Council (PMC) of the INDOMOD SATCORE Project on Megha-Tropiques, International Centre for Ocean Information System (INCOIS), Hyderabad, 8 February 2006
- Atmospheric Brown Cloud (ABC) Meeting, National Physical Laboratory, New Delhi, 13 February 2006

Dr. R. Vijayakumar

- Meeting with Honourable Minister for Science and Technology and Secretary DST to discuss the science, methodology and the feasibility of using the technique of cloud seeding for augmentation of rainfall, New Delhi, 21 April 2005
- Meeting on Artificial Rain Seeding 2005 with the Chief Secretary, Government of Maharashtra, Water Resources Department, Mantralaya, Mumbai, 21 June 2005
- Maharashtra Government Cloud Seeding Experiment Tender Evaluation Committee Meeting, Nasik, 25 July 2005

- Expert Committee Review Meeting on Cloud Seeding Project - 2006, Jawaharlal Nehru Technological University (JNTU), Hyderabad, 18 - 20 March 2006.

Dr. P.E. Raj

- Atmospheric Aerosol Loading Over Land from Remote Sensing Data, Space Applications Center, Ahmedabad, 21 September 2005
- Results of Land Campaign-II, ISRO-GBP, Physical Research Laboratory, Ahmedabad, 19 - 21 September 2005

Shri B.N. Mandal

- Meeting with the Central Water Commission (CWC) officials and the C-DAC scientists regarding digitization of maps and other relevant points for the CWC sponsored project work on "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", C-DAC, Pune, 28 April 2005
- Meeting on the project "Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang basin", Indian Institute of Tropical Meteorology, Pune, 6 July 2005 and 28 February 2006
- Meeting of the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005
- Third Meeting of the TARC for the project "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", CWC, New Delhi, 13 February 2006
- Meeting in connection with Rainfall Climatology and Preparation of Monthly, Seasonal and Annual Isohyetal Maps with GIS Compatability for the Krishna and Pennar Rriver Basins, Indian Institute of Tropical Meteorology, Pune, 14 March 2006
- Project meeting on 'Digitization of generalised PMP Atlas work over the Krishna river basin using Geographic Information System (GIS), C-DAC, Pune, 20 March 2006

Dr. G. Beig

- Young Scientists Committee Meeting of the IAGA (International Association of Geomagnetism and Aeronomy), Prague, Czech Republic, 30 March - 1 April 2005

Dr. A.K. Sahai

- Second Meeting on Experimental Extended Range Monsoon Prediction (ERMP) 2005, Centre for Mathematical Modelling and Computer Simulation, Bangalore, 12 - 13 July 2005
- INDOFLUX Network Meeting of the Department of Science and Technology, Govt. of India, Indian Institute of Tropical Meteorology, Pune, 29 July 2005
- Seasonal Prediction of Indian Monsoon (SPIM) discussion Meeting, Indian Institute of Science, Bangalore, 27 November 2005
- Seasonal Prediction of Indian Monsoon (SPIM) discussion Meeting, Centre for Development of Advanced Computing (C-DAC), 12 January 2006
- Meeting on Long-range Forecasting – 2006, India Meteorological Department, New Delhi, 23 March 2006

Dr. P.S.P. Rao

- Results of Land Campaign-II, ISRO-GBP, Physical Research Laboratory, Ahmedabad, 19 - 21 September 2005
- Pre-plan Meeting of the Integrated Campaign of Aerosols, Gases and Radiation Budget (ICARB), Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvanathapuram, 9 - 10 January 2006 and presented a paper, "Aerosol and wet / dry deposition over ship, at Pune and Delhi during ICARB period, Pre-plan Meeting of the Integrated Campaign of Aerosols, Gases and Radiation Budget (ICARB)".
- Indian Participation in International Atmospheric Brown Cloud (ABC) Programme,, New Delhi, 13 February 2006

Dr. K. Krishna Kumar

- NATCOM Consultative Meeting on Impacts of Climate Change on Water Resources, Agriculture, Health, Extreme Events and Coastal Zones, Indian Institute of Technology Delhi, New Delhi, 22 July 2005
- Discussion Meeting on Statistical Forecasting, Indian Institute of Science, Bangalore, 25 and 27 July 2005
- NATCOM-2 Consultative Meeting, Centre for Sustainable Technologies, Indian Institute of Science, Bangalore, 26 July 2005
- Meeting on the SASE Project, Indian Institute of Tropical Meteorology, Pune, 18 August 2005

Dr. A.L. Londhe

- 2nd Meeting of Project Assessment Committee - Atmospheric Sciences (PAC-AS), Atmospheric Science Division Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, 18 - 23 April 2005
- Meeting for Assessment of Support Staff, National Chemical Laboratory, Pune, 23 September 2005

Dr. (Smt.) S. S. Kandalgaonkar

- 2nd Meeting of Project Assessment Committee - Atmospheric Sciences (PAC-AS), Atmospheric Science Division Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, 18 - 23 April 2005

Dr. H.P. Borgaonkar

- PAGES (Past Global Changes) Second Open Science Meeting, Beijing, China, 10 - 12 August 2005
- Meeting on the SASE Project, Indian Institute of Tropical Meteorology, Pune, 18 August 2005
- Meeting in connection with the project Dendroglaciological studies over high altitudesnear glacier sites of Western Himalaya, Snow and Avalanche Study Establishment, Chandigarh, 14 - 19 October 2005

Shri C.M. Mohile

- Meeting in connection with the ongoing SASE project, Snow and Avalanche Studies Establishment (SASE), Chandigarh, 25 - 28 July 2005
- Meeting on the SASE Project, Indian Institute of Tropical Meteorology, Pune, 18 August 2005

Smt. N. R. Deshpande

- Meeting with the Central Water Commission (CWC) officials and the C-DAC scientists regarding digitization of maps and other relevant points for the CWC sponsored project work on "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", C-DAC, Pune, 28 April 2005
- Meeting on the project "Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang basin", Indian Institute of Tropical Meteorology, Pune, 6 July 2005 and 28 February 2006
- Meeting of the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005
- Meeting on the SASE Project, Indian Institute of Tropical Meteorology, Pune, 18 August 2005
- Meeting in connection with Rainfall Climatology and Preparation of Monthly, Seasonal and Annual Isohyetal Maps with GIS Compatability for the Krishna and Pennar Rriver Basins, Indian Institute of Tropical Meteorology, Pune, 14 March 2006

Dr. B. D. Kulkarni

- Meeting with the Central Water Commission (CWC) officials and the C-DAC scientists regarding digitization of maps and other relevant points for the CWC sponsored project work on "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", C-DAC, Pune, 28 April 2005
- Meeting on the project "Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang basin", Indian Institute of Tropical Meteorology, Pune, 6 July 2005 and 28 February 2006

- Meeting of the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005
- Meeting in connection with Rainfall Climatology and Preparation of Monthly, Seasonal and Annual Isohyetal Maps with GIS Compatability for the Krishna and Pennar Rriver Basins, Indian Institute of Tropical Meteorology, Pune, 14 March 2006
- Project Meeting on 'Digitization of generalised PMP Atlas work over the Krishna river basin using Geographic Information System (GIS), C-DAC, Pune, 20 March 2006

Shri R.B. Sangam

- Meeting with the Central Water Commission (CWC) officials and the C-DAC scientists regarding digitization of maps and other relevant points for the CWC sponsored project work on "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", C-DAC, Pune, 28 April 2005
- Meeting on the project "Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang basin", Indian Institute of Tropical Meteorology, Pune, 6 July 2005 and 28 February 2006
- Meeting of the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005
- Meeting in connection with Rainfall Climatology and Preparation of Monthly, Seasonal and Annual Isohyetal Maps with GIS Compatability for the Krishna and Pennar Rriver Basins, Indian Institute of Tropical Meteorology, Pune, 14 March 2006

Dr. Y. Jaya Rao

- User Scientists Interactive Discussion Meeting, National Atmospheric Research Laboratory, Tirupati, 23 September 2005
- Scientific discussion meetings with coordinator of SCOUT-O3 experimental program and other scientists, Hyderabad, 7 November 2005

Dr. M.N. Patil

- Meetings of the Selection Committee for the post of Apprentice, India Meteorological Department, Pune, 12 September 2005

Dr. B. S. Murthy

- INDOFLUX Network Meeting of the Department of Science and Technology, Govt. of India, Indian Institute of Tropical Meteorology, Pune, 29 July 2005

Shri A.B. Sikder

- Meeting in connection with the project Dendroglaciological studies over high altitudes near glacier sites of Western Himalaya, Snow and Avalanche Study Establishment, Chandigarh, 14 - 19 October 2005

Dr. C. Gnanaseelan

- Meeting in connection with proposed new course of M.Tech. in Ocean Science, University of Pune, 7 May 2005

Smt. S.K. Mandke

- Seasonal Prediction of Indian Monsoon (SPIM) Discussion Meeting, Centre for Development of Advanced Computing (C-DAC), 12 January 2006

Dr. (Smt.) A.A. Kulkarni

- Programme Advisory Committee Meeting of the Department of Science and Technology, Govt. of India, New Delhi, 13 January 2006

Shri J. Sanjay

- RCM/ISRO-GBP Meeting, Space Applications Centre (SAC), Bopal Campus, Ahmedabad, 20 March 2006

Dr. G. Pandithurai

- American Geophysical Union Fall Meeting, Moscone Convention Center, San Francisco, U.S.A., 5 - 9 December 2005 and Presented a paper, "Aerosol Climatology at Pune, Western India: Implications to direct radiative forcing and heating rates" by Pandithurai G., "Pinker R.T., Devara P.C.S., Raj P.E., Jaya Rao Y., Dani K.K., Maheskumar R.S., Sonbawne S.M., Saha S.K., Bhawar R.L.and Shinde U.P.

Shri G.A. Momin, Dr. K. Ali, Dr. P.D. Safai, Shri K.K. Dani, Shri S.K. Saha and **Shri U. P. Shinde**

- Results of Land Campaign-II, ISRO-GBP, Physical Research Laboratory, Ahmedabad, 19 - 21 September 2005

Shri S.S. Mulye

- Meeting with the Central Water Commission (CWC) officials and the C-DAC scientists regarding digitization of maps and other relevant points for the CWC sponsored project work on "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", C-DAC, Pune, 28 April 2005
- Meeting on the project "Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang basin", Indian Institute of Tropical Meteorology, Pune, 6 July 2005 and 28 February 2006
- Meeting of the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005
- Meeting in connection with Rainfall Climatology and Preparation of Monthly, Seasonal and Annual Isohyetal Maps with GIS Compatability for the Krishna and Pennar Rriver Basins, Indian Institute of Tropical Meteorology, Pune, 14 March 2006

Smt. S.S. Desai

- Quarterly Meeting of Pune Nagar Rajabhasha Karyanwayan Samittee, National Chemical Laboratory, Pune, 14 December 2005

Dr. S.M. Bawiskar

- Annual Monsoon Review Meeting 2005 held in Chennai, 17 January 2006

Dr. D.R. Kothawale

- Departmental Promotion Committee Meeting for the promotion of Lower Division Clerk to Upper Division Clerk, Office of the Deputy Director General of Meteorology (Surface/Instruments), India Meteorological Department, Pune, 22 August 2005

Shri S.D. Patil

- Selection Committee Meeting for the post of Mech. Gr.II, India Meteorological Department, Pune, 6 and 9 September 2005

Shri S.P. Ghanekar

- 1st Meeting of the Scientific Steering Committee on Continental Tropical Convergence Zone (CTCZ), Indian Institute of Tropical Meteorology, Pune, 20 - 21 January, 2006

Dr. M. S. Mujumdar

- Seasonal Prediction of Indian Monsoon (SPIM) discussion Meeting, Centre for Development of Advanced Computing (C-DAC), 19 December 2005

Shri P. Mukhopadhyay

- Programme Advisory Committee on Atmospheric Sciences (PAC-AS) Meeting, Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, 18 - 19 April 2005

Smt. J.V. Revadekar

- Meeting on the SASE Project, Indian Institute of Tropical Meteorology, Pune, 18 August 2005

Dr. (Kum.) S.S. Nandargi

- Meeting with the Central Water Commission (CWC) officials and the C-DAC scientists regarding digitization of maps and other relevant points for the CWC sponsored project work on "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", C-DAC, Pune, 28 April 2005
- Meeting on the project "Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang basin", Indian Institute of Tropical Meteorology, Pune, 6 July 2005 and 28 February 2006

- Meeting of the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005

- Meeting in connection with Rainfall Climatology and Preparation of Monthly, Seasonal and Annual Isohyetal Maps with GIS Compatability for the Krishna and Pennar Rriver Basins, Indian Institute of Tropical Meteorology, Pune, 14 March 2006

Smt. S.U. Athale

- Meeting for Assessment of Support Staff, National Chemical Laboratory, Pune, 23 September 2005

Maj. Gen. S.S. Sharma

- Meeting in connection with the ongoing SASE project, Snow and Avalanche Studies Establishment (SASE), Chandigarh, 25 - 28 July 2005

- Meeting on the SASE Project, Indian Institute of Tropical Meteorology, Pune, 18 August 2005

Shri S.S. Bhandare

- Meeting with the Central Water Commission (CWC) officials and the C-DAC scientists regarding digitization of maps and other relevant points for the CWC sponsored project work on "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", C-DAC, Pune, 28 April 2005

Shri A. K. Verma

- Meeting with the Central Water Commission (CWC) officials and the C-DAC scientists regarding digitization of maps and other relevant points for the CWC sponsored project work on "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", C-DAC, Pune, 28 April 2005

- Meeting on the project "Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang basin", Indian Institute of Tropical Meteorology, Pune, 6 July 2005 and 28 February 2006

- Meeting of the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005

- Meeting in connection with Rainfall Climatology and Preparation of Monthly, Seasonal and Annual Isohyetal Maps with GIS Compatability for the Krishna and Pennar Rriver Basins, Indian Institute of Tropical Meteorology, Pune, 14 March 2006

Shri D. Prajapati

- Meeting with the Central Water Commission (CWC) officials and the C-DAC scientists regarding digitization of maps and other relevant points for the CWC sponsored project work on "Preparation of Generalized PMP Atlases for the Krishna and Indus River Basins", C-DAC, Pune, 28 April 2005

- Meeting on the project "Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) with Time Distribution for Projects over Rainfed Areas in the Siang basin", Indian Institute of Tropical Meteorology, Pune, 6 July 2005 and 28 February 2006

- Meeting of the Project "Preparation of Generalised PMP Atlases over the Krishna and Indus River Basins", Indian Institute of Tropical Meteorology, Pune, 29 July 2005

- Meeting in connection with Rainfall Climatology and Preparation of Monthly, Seasonal and Annual Isohyetal Maps with GIS Compatability for the Krishna and Pennar Rriver Basins, Indian Institute of Tropical Meteorology, Pune, 14 March 2006

Seminars

By Visitors

Dr. Pratap Singh, National Institute of Hydrology, Roorkee

- Hydrological studies of snow and glacier-fed basins,15 April 2005

Dr. G.H. Schleser and **Dr. G. Helle,** Forschungs Zentrum, Germany

- Palaeoclimatology using stable isotopes in tree-rings and laminated sediments, 20 May 2005

Dr. Pramod Aggarwal, Department of Environmental Sciences, Indian Agricultural Research Institute, New Delhi

- Impact of Climate Change on Indian Agriculture - Current understanding and future priorities, 25 May 2005

Dr. R. Venkatesan , Indira Gandhi Centre for Atomic Research, Kalpakam

- On-line operational mesoscale meteorological dispersion program for nuclear emergency, 20 June 2005

Dr. S.N. Das , Regional Research Laboratory, Bhubaneswar

- Air Pollution Studies at RRL, Bhubaneswar, 28 July 2005

Dr. H. Annamalai, International Pacific Research Center, University of Hawaii, Honolulu, U.S.A.

- Asian summer monsoon in a global warming scenario, 2 August 2005

Dr. Andrew Robertson , International Research Institute for Climate Prediction (IRI), New York, U.S.A.

- Hidden Markov models for analysing daily rainfall spatio-temporal variability, 9 August 2005

Dr. Akiyo Yatagai , Research Institute for Humanity and Nature, Kyoto, Japan

- Analysis of daily precipitation over Asian monsoon region: orographic enhancement, 6 September 2005

Shri Yogesh Kumar Tiwari , Max-Plank Institute, Germany

- CO_2 from Space : Confronting first retrievals using satellite data with forward simulations and aircraft measurements,9 September 2005

Dr. L. Granat, Stockholm University, Stockholm, Sweden

- Atmospheric brown cloud – contributions from Stockholm University, 15 September 2005

Dr. J. Vivekanandan, National Center for Atmospheric Research (NCAR), Boulder, Colorado, U.S.A.

- Detection and estimation of liquid droplet using radar and radiometer, 22 September 2005

Kum. Pratima Raykar, Environmental Management Centre, Mumbai

- Relationship between urban heat islands and urban morphology, a case study of Ahmedabad, 4 October 2005

Dr. Prakash Bhave, Physical Scientist, National Oceanic and Atmospheric Administration (NOAA), U.S.A.

- Modeling of Fine Carbonaceous Particulate Matter over the United States, 9 December 2005

Dr. Dewan Abdul Quadir , SAARC Meteorological Research Centre (SMRC), Dhaka, Bangladesh

- Current research activities at SMRC, 15 December 2005

Dr. Lochan Prasad Devkota, SAARC Meteorological Research Centre (SMRC), Nepal

- Long range forecasting of Nepal monsoon, 15 December 2005

Mr. Bob Cary, Sunset Laboratory Inc., U.S.A.

- Carbon Aerosol Analyser for the measurement of Organic/Elemental carbon, 1 February 2006

Dr. S.V.M. Satyanarayana, Indira Gandhi Centre for Atomic Research, Kalpakkam

- Transport of contaminants in indoor environment, 17 February 2006

Prof. Mark Cane, Lamont-Doherty Earth Observatory of Columbia University, U.S.A.

- El Nino, present, past and future, 27 February 2006

Dr. Prakash Gole, Founder Trustee and Executive Director, Ecological Socity, Pune

- Imperatives of nurturing nature (National Science Say Lecture), 28 February 2006

Dr. Martin P. Hoerling, Scientist, National Oceanic and Atmospheric Administration – Climatic Data Centre (NOAA - CDC), U.S.A.

- Origins of Indian monsoon variability, 24 March 2006

- The great paradox of Indian monsoon failure, 28 March 2006

By Institute Scientists

Dr. (Smt.) N.A. Sontakke

- Indian monsoon in the changing global environment, 1 st April 2005

Dr. P.C.S. Devara

- Spectral and temporal variability of absorption, optical and physical properties of aerosols over Pune, India, 25 July 2005

Dr. H.P. Borgaonkar

- Recent warming over western Himalaya, India observed from tree-ring estimates since A.D. 1603, 3 August 2005

Dr. R. Vijayakumar

- Diurnal variation of convection over semi-arid region of north peninsular India as revealed by C-band radar, 12 August 2005

- Meteorological aspects of the exceptional heavy rainfall over Mumbai on 26 July 2005, 26 August 2005

Shri J.R. Kulkarni

- Heavy rainfall over Mumbai, 27 August and 5 September 2005

- Use of RASS data for THORPEX events, 28 November 2005

- Natural disasters in India (World Meteorological Day Lecture), 23 March 2006

Dr. Y. Jaya Rao

- Lidar and radar observations of UT/LS dynamics over tropical and sub-tropical stations, 6 September 2005

- UTLS dynamics – aircraft measurements during SCOUT-03 programme, 2 December 2005

- Aerosol characteristics at Agra during during ISRO-GBP Land Campaign II, 9 December 2005

Shri S. Mahapatra

- Pune weather conditions, 10 October 2005

Shri V. R. Mujumdar

- Monsoon 2005, 11 October 2005

Dr. G. Pandithurai

- Seasonal variability in urban aerosols: Implications to radiative forcing and heating rates, 18 November 2005

Dr. N. Singh

- Meteorological research - nature of existence, psychology, philosophy and religion, 25 November 2005
- Water, Climate and Culture, (World Water Day Lecture) 22 March 2006

Dr. K. Rupa Kumar

- Regional aspects of climate change, 29 November 2005
- Observational features of rainfall and temperature variability over India, 23 January 2006

Dr. P.S.P. Rao

- Aerosol characteristics at Agra during ISRO-GBP Land Campaign II, 9 December 2005

Shri D.M. Chate

- Study of acidity of raindrop by uptake of gases and aerosol pollutants during rain, 9 December 2005

Dr. P.D. Safai

- Some comparative studies on surface and radiometric aerosol observations over tropical urban city, Pune, 9 December 2005

Dr. (Smt.) B. Padma Kumari

- Detection of meteoric contribution to stratospheric aerosol – by twilight sounding method, 9 December 2005

Dr. R.S. Maheskumar

- Direct radiative forcing of atmospheric aerosols over different environments, 9 December 2005

Smt. A.A. Prabhu

- Overview of utilisation of IRS-P4 MSMR Data for polar sea-ice studies, 13 December 2005

Smt. S.S. Fadnavis

- Anthropogenic and Natural Variability in some minor constituents and temperature of the tropical middle atmosphere, 9 January 2006

Shri H.N. Singh

- Observed climatic changes in OLR, Cloud cover and rainfall across India: Linking hydroclimatic variations to large scale atmospheric circulation, 9 January 2006

Dr. K. Krishna Kumar

- Some new perspectives on the variability and prediction of Indian Summer Monsoon rainfall, 24 January 2006

Dr. B.S. Murthy

- Characteristics of the atmospheric surface layer over a tropical coastal station, 10 February 2006

Shri. G.S. Meena

- Intellectual property rights and WTO related issues, 22 February 2006

Shri Prem Singh

- Intellectual property management and technology transfer, 24 February 2006

Smt. J.V. Revadekar

- Observed trends and future projections of extremes in precipitation and surface temperature over India, 22 March 2006

Dr. S. Tiwari

- Study of precipitation chemistry in the Environment of North India, 31 March 2006

By Research Fellows and Students

Shri S.M. Deshpande

- Wind Profiler and Radio Acoustic Sounding Systems at Pune, 28 April 2005

Shri. M. Muhsin

- Characterization of Boundary layer aerosols using LIDAR, 11 May 2005

Shri B.H. Vaid

- Tsunami hazards along the Indian coast, 2 September 2005
- Influence of Indonesian through flow on biennial and annual Rossby waves in the Indian Ocean, 10 February 2006

Shri D. Prajapati

- Journey of hydrometeorological studies - past and present, 25 October 2005

Shri B. Thompson

- Interannual variability in the circulation and salinity over north Indian Ocean: an OGCM study, 8 November 2005

Shri Vimlesh Pant

- Measurements of atmospheric aerosols and ions at Antarctica, 22 November 2005
- Size distributions of micron size aerosol particles over the southern Indian Ocean, 9 December 2005

Kum. R. L. Bhawar

- Estimation of dust optical thickness from TOMS and sun- photometer data over Pune, 6 December 2005

Shri U. P. Shinde

- Seasonal inhomogeneity in aerosol microphysical properties and it's relationship with local meteorological and long range transport process, 6 December 2005
- Variability in aerosol absorption optical thickness over a tropical urban station, 9 December 2005

Shri Rajib Chattopadhyay

- ISO Variability study and the objective classification of rainfall patterns :A non-linear approach, 20 December 2005

Shri S. Taraphdar

- Diurnal Variations in NCEP reanalysis during Indian Summer Monsoon, 3 January, 2006

Kum. Susmitha Joseph

- Study of Indian summer monsoon long break spells, 3 January 2006

Kum. C. Seethala

- Direct radiative effect of aerosols on the evolution of atmospheric boundary layer, 7 February 2006

Shri U.K. Singh

- Application of digitized INSAT IR data for studies of super cyclonic storm of Orissa (1999) and monsoon depression (1998), 10 February 2006

Smt. M.S. Deshpande

- Impact of domain size on the numerical simulation of Bay of Bengal tropical cyclone, 10 February 2006

Shri S. H. Kulkarni

- Study of Aerosols using Raman Spectroscopy, 20 February 2006

Shri Shailendra Kewat

- Studies on black carbon aerosols at a tropical urban Station, Pune, 20 February 2006

Academic Activities

Teaching and Research Support to Universities

Dr. G.B. Pant, Dr. A.K. Kamra, Dr. P.C.S. Devara, Dr. K. Rupa Kumar, Dr. (Smt) P.S. Salvekar, Dr. P.N. Mahajan, Shri J.R. Kulkarni, Dr. G. Beig, Shri Prem Singh, Smt. S.K. Mandke, Dr. (Smt) A.A. Kulkarni, Smt. A.A. Deo, Dr. Kaushar Ali and Dr. Devendraa Siingh were bestowed with the title of "Adjunct Professor" of the Department of Atmospheric and Space Sciences, University of Pune, Pune for the Academic Year 2005-2006 for providing teaching support in running the M.Tech. (Atmsopheric Physics) course under the Memorandum of Understanding with the University of Pune, Pune.

Recognition as Research Guide

Dr. K. Rupa Kumar, Dr. M.N. Patil and Dr. (Smt.) A.A. Kulkarni have been recognized as a guide for M.Phil. and Ph.D. (Space Science), and Dr. (Smt.) S.B. Morwal, Dr. G. Pandithurai and Dr. P.D. Safai have been recognized as guide for M.Phil and Ph.D. (Physics) by the University of Pune, Pune.

Award of Ph.D. Degree by University of Pune, Pune

Student	Thesis	Guide
Shri D. R. Kothawale	Surface and upper air temperature variability over India and its influence on the summer monsoon rainfall	Dr. K. Rupa Kumar
Shri P. Mukhopadhyay	Prediction of thunderstorms and heavy precipitation events over Indian region	Dr. S.S. Singh
Shri K. V. Ramesh	Numerical modelling of air-sea interactions in the Indo-Pacific region	Dr. R.Krishnan
Smt. B. Padmakumari	Study of stratospheric aerosols by passive remote sensing technique	Dr. D.B.Jadhav
Shri D. R. Jadhav, (Department of Instrumentation, University of Pune)	Automation and development of instruments for atmospheric studies	Dr. D.B. Jadhav (Co-Guide)

Thesis Submitted to University of Pune, Pune for the Award of Ph.D. Degree

Student	Thesis	Guide
Shri J.R. Kulkarni	Indian Summer monsoon variability analysis: intraseasonal to climate scales using wavelet transform	Dr. G.B.Pant
Shri D. M. Chate	Study of Collision efficiencies of water drops, scavenging coefficient and evolutions of atom-spheric aerosol size distribution by rain events	Dr. P.C.S. Devara
Shri S. G.Narkhedkar	Objective Analysis for Meteorological Parameters and Data Assimilation over Indian and adjoining region	Dr. S.K. Sinha

Nominations as External Examiner / Paper Setter

Scientist	Degree Examination, University
Dr. P.C.S. Devara, Dr. (Smt.) P.S. Salvekar, Dr. G. Beig, Dr. K. Ali	• M.Tech. (Atmospheric Physics), University of Pune, Pune
Dr. P.C.S. Devara, Shri J.R. Kulkarni	• M.Tech. Institute of Armament Technology (Deemed university), Pune
Dr. G. Beig	• Ph.D. (Physics), Delhi University, New Delhi
Dr. R.S. Maheskumar	• M. Sc. (Space and Atmospheric Science), University of Pune, Pune
Dr. P.N. Mahajan	• Viva-voce of Meteorologists Gr. II Training Batch-19, India Meteorological Department, Pune

Research Guidance Provided

Student	Course	Project Title	IITM Guide
Shri A. S. Panickar	M. Tech. (Atmospheric Science), Cochin University of Science Technology, Kochi	Raman Lidar Detection of Atmospheric Constituents and and Aerosol Radiative Forcing over Pune	Dr. P.C.S. Devara
Kum. C. Sheetala	M. Tech. (Atmospheric Science), Cochin University of Science and Technology, Kochi	Investigation of atmospheric boundary layer characterstics of different aerosol absorptions: an observational and modeling approach	Dr. G. Pandithurai
Shri K. Seshagiri Rao	M.Sc. Atmopspheric Science), Andhra University, Visakhapatnam	Nonlinearity of Madan-Julian Oscillation over the tropical ocean regions during summer monsoon	Shri D. R. Chakraborty
Shri K. C. Pattnayak,	M.Sc. (Atmospheric Science), Andhra University, Visakhapatnam	Variability of easterly waves over Indian region during summer monsoon	Dr. A.K. Sahai
Shri A. Mishra	M.Tech. (Atmopsheric Physics), University of Pune, Pune	Simulation of Indian summer monsoon rainfall using NCAR-Climate models	Dr. K. Krishna Kumar
Shri S.D. Polade	M. Tech. (Atmospheric Physics), University of Pune, Pune	Spatio-temporal Structure of QBO and SAO in Ozone and Temperature over the Tropical Stratosphere	Dr. G. Beig
Shri. S. Haldar	M.Tech. (Atmospheric Physics), University of Pune, Pune	Studies of Norwesters over Gangetic Bengal	Dr. P. Mukhopadhyay

Student	Course	Project Title	IITM Guide
Shri K. Budhavant	M. Tech. (Atmospheric Physics), University of Pune, Pune	Studies on dry and wet depositions at high altitude station, Sinhagad	Dr. P.S.P. Rao
Shri P. Murugavel	M. Tech. (Atmospheric Physics), University of Pune, Pune	Physical and chemical properties of the atmospheric aerosol using thermal volatilization	Dr. A.K. Kamra

Also, 28 students of M.Sc. (Physics), 16 Students of B.E. and one student of B.Sc. from various colleges under the University of Pune received research guidance from the scientists of this Institute and completed their project work as part of their degree course. Dr. D.B. Jadhav, Dr. N. Singh, Dr. A.K. Sahai, Dr. P.S.P. Rao, Dr. (Smt.) I. S. Joshi, Dr. (Smt.) N.A. Sontakke, Dr. A.L. Londhe, Dr. (Smt.) S.S. Kandalgaonkar, Dr. H.P. Borgaonkar, Dr. Y. Jaya Rao, Shri S.D. Pawar, Dr. M.N. Patil, Dr. B.S. Murthy, Dr. (Smt.) S.B. Morwal, Shri V. Gopalakrishnan, Dr. S.B. Debaje, Shri S. Mahapatra and Dr. (Smt.) B. Padma Kumari provided guidance to the students.

Lectures Delivered Outside

Scientist	Lecture, Venue, Date
Dr. S. Sivaramakrishnan	• Some aspects of atmospheric boundary layer and measurements, National Centre for Antarctca and Ocean Research, Goa, 20 April 2005
Dr. (Smt.) N.A. Sontakke	• Spatial variability of Indian Rainfall, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, 2 May 2005 • Trends in the NCEP-NCAR reanalysis MSL, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, 2 May 2005
Dr. K. Krishna Kumar	• Some new perspectives on variability and prediction of Indian summer monsoon rainfall, Indian Institute of Science, Bangalore, 3 June 2005 • Weather and Climate Modelling at IITM, National Centre for Medium Range Weather Forecasting, New Delhi, 21 - 22 July 2005
Dr. P.C.S. Devara	• Three presentations in connection with the Indo-Bulgarian Cooperation in Research Program on (i) Optical Remote Sensing Studies of the Atmospheric Boundary Layer Characteristics Using Laser Radar (Completed Project), (ii) Laser Radar Characterization of Atmospheric Aerosols and Clouds in the Boundary Layer and Free-troposphere (Fresh Project), and (iii) Proposal for a Workshop on Atmospheric Boundary Layer Studies, Meeting of the Programme Advisory Committee on Oceanography and Atmospheric Sciences, Department of Ocean Development (DOD), New Delhi, 24 August 2005
Dr. N. Singh	• Sabhyata Aur Sahitya Par Jalvayu Ka Prabhav, Agharkar Research Institute, Pune, 14 September 2005
Dr. H.P. Borgaonkar	• Dendroglaciological studies over high altitudes near glacier sites of Western Himalayas, Snow and Avalanche Study Establishment (SASE), Chandigarh, 18 October 2005 • Tree-ring studies in India, Tree-Ring Laboratory., Kasetsart University, Bangkok, Thailand, 2 March 2006 • Global Climate Change, Abhinav Vidyalaya and Junior College, Dombivili, 23 December 2005

Scientist	Lecture, Venue, Date
Dr. G. Beig	• Greenhouse effect in the upper atmosphere, Physical Research Laboratory, Ahmedabad, 11 November 2005
Shri J.R. Kulkarni	• Heavy rainfall over Mumbai, Nehru Science Centre, Mumbai, 24 November 2005
Smt. N.R. Deshpande	• Results based on Climate Extreme Indices generated by 'Rclimdex' software for some representative stations in India, APN Regional Workshop on Climate Extreme Indices and Indicators for monitoring trends in South Asia, Islamabad, Pakistan, 6 January 2006
Dr.P.C.S. Devara	• Aerosol and trace gases observation Programme over ship, and at Pune and Delhi during ICARB period, Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvanantpuram, 10 January 2006 • Lidar and Radiometric Applications to Environmental Pollution, Institute of Armament Technology (DRDO), Pune, 28 February 2006 • Observational Techniques: Radars and Lidars, University of Pune, 13 March 2006
Dr. P.S.P. Rao	• Aerosol and wet / dry deposition over ship, at Pune and Delhi during ICARB period, Pre-plan Meeting of the Integrated Campaign of Aerosols, Gases and Radiation Budget (ICARB), Space Physics Laboratory, Vikram Sarabhai Space Center (VSSC), Tiruvananthapuram, 10 January 2006
Dr. R. Krishnan	• Indian Ocean-monsoon coupled interactions and monsoon droughts over India, Atmospheric Brown Cloud (ABC) Meeting, National Physical Laboratory, New Delhi, 13 February 2006
Dr. M.S. Mujumdar	• Modelling Aspects of Monsoon, Baburaoji Gholap Mahavidyalaya, Pune, on the occasion of National Science Day Seminar, 28 February 2006

Expertise Provided

Course	Scientists and Lectures
2nd SERC School on Aviation Meteorology with Special Emphasis on Thunderstorm and its Modelling, Faculty of Meteorology, Air Force Administrative College, Coimbatore, 9 - 28 May 2005	**Dr. A.K. Kamra** • Thunderstorm Electrification and its Effect on Aircraft (26 May 2005) • Weather and Atmospheric Electricity (27 May 2005) • Global Electric Circuit –The Classical Concept (27 May 2005) **Dr. R. Vijayakumar** • Cloud Physics and Warm Cloud Modification (12 and 13 May 2005) **Shri S. Mahapatra** • Numerical study of Thunderstorms by Meso-scale Models (17 May 2005) • Cumulonimbus Clouds – an Introductory Review (23 May 2005) **Dr. P. Mukhopadhyay** • Real Data Simulation of Thunderstorm over Cochin (24 May 2005)

Course	Scientists and Lectures
Workshop on Space Meteorology, University of Pune, Pune, 1 - 14 March 2006	**Dr. P.C.S. Devara** • Observational Techniques: Radar and Lidars (13 March 2005)
Ninth Training Course on Applications of Geo-informatics in Water Sector, National Water Academy, Pune, 22 August - 2 September 2005	**Dr. N. Singh** • Monitoring Indian Monsoon System using Ground-based Observation and Satellite Remote Sensing (23 August 2005)
Department of Atmospheric and Space Sciences,University of Pune, Pune to check the fulfillment of compliances given by ERDAS India Pvt. Ltd., about their GIS Software, 2 January 2006	**Dr. P.N. Mahajan**

Training Undergone

Participants	Training
Shri S.D. Pawar	• Use of Lab View Software, National Instrument, Bangalore, 4 - 8 April 2005
Shri S. Mahapatra, Smt. M.S. Deshpande	• Second SERC School on Aviation Meteorology with Special Emphasis on Thunderstorms and its Modelling, Air Force Administrative College, Coimbatore, 9 - 28 May 2005
Shri M. Mahakur	• Post Graduate Course on Satellite Meteorology and Global Climate, CSSTEAP (UN) Space Applications Centre, Ahmedabad, 1 August 2004 - 30 April 2005
Shri H. N. Singh	• Short Term Training Course on Watershed Management, National Water Academy, Khadakwasla, Pune, 16 - 20 August 2005 • 10th Training course on the 'Applications of Geoinformatics in Water Sector', National Water Academy, Khadakwasla, Pune,10 - 20 January 2006
Dr. (Smt.) N.A Sontakke	• Short Term Training Programme on Environmental Management and Social Aspects of River Valley Project, National Water Academy, Pune, 12 - 16September 2005
Shri A. K. Verma	• Training Programme on Microwave Remote SensingData Processing and Analysis for Glacier and Snow Studies, Indian Institute of Technology, Mumbai, 24 - 28 October 2005
Shri Prem Singh	• Programme on Intellectual Property Rights and World Trade Related Issues, Administrative Staff College of India, Bella Vista, Hyderabad, 5-9 December 2005 • Third International Training Programme in Intellectual Property Management and Technology Transfer, Science and Technology Park, University of Pune, Pune, 5-11 February 2006
Shri B.C. Morwal	• Special Training Programme on Terminology and Official Language Implementation, Kanyakumari, 23 - 25 January 2006
Shri G.S. Meena	• Program on Intellectual Property Right and WTO Related Issue, Administrative Staff College of India, Hyderabad, 23-27 January 2006
Shri J. Sanjay	• Advanced Training program and Tutorial on Weather Research and Forecasting (WRF) Model System and Joint WRF Development for Weather and Climate Studies in Tropics, Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi, 18 February-1 March 2006

Participants	Training
Smt. A. A. Shiralkar	• Second National Workshop (Training) on the Right to Information Act, National Institute of Public Administration, Bangalore, 24-25 February 2006
Shri D.W. Ganer	• Advanced Training Course in Meteorology, India Meteorological Department, Pune, March - September 2006

Fellowship/Membership of Scientific Committees

Scientist	Fellowship/Membership of
Dr. A. K. Kamra	• Scientific Steering Committee for the Continental Tropical Convergence Zone (CTCZ) Field Campaign, Indian Climate Research Programme (ICRP) of the Department of Science and Technology, Govt. of India • Programme Implementation Committee for Severe Thunderstorm Observations and Regional Modeling (STORM) Project of the Department of Science and Technology, Govt. of India • Physical Sciences Research Committee of the Council of Scientific and Industrial Research • Sectional Committee - V of the Indian National Science Association (INSA)
Dr. P.C.S.Devara	• Fellow of the Maharashtra Academy of Sciences • Chairperson, Executive Council, Indian Meteorological Society - Pune Chapter (IMSP) for the period 2005-2007 • Member, INDOFLUX Science Plan Committee, Department of Science and Technology, Govt. of India • Member, Technical Evaluation Committee constituted by Department of Science and Technology/ India Meteorological Department for procurement of Radiation Instruments for India Meteorological Department (IMD) • Member, Editorial Board of the Instrumental Journal of Aerosols and Air Quality Research• Member, Editorial Board of the Journal Atmosfera • Member, Governing Council, Instrument Society of India
Dr. R.H. Kripalani	• Member of International Editorial Board for the (i)International Journal of Climatology, (ii) Korean Journal of Atmospheric Sciences and (iii) Korean Journal of Earth Science Society
Dr. G. Beig	• Co-convener of the symposia JSII02 entitled “Long-term trends in the upper atmosphere” held at the IAGA 2005 Scientific Assembly, Toulouse, France, 18-29 July 2005
Dr. P.S.P. Rao	• Member of the Steering Committee of an International Body on Composition of Asian Deposition (CAD)
Dr. (Smt.) S. G. Nagar	• Member, Indian Physics Association, Pune Chapter
Dr. B.S. Murthy	• Member, INDOFLUX Science Plan Committee, Department of Science and Technology, Govt. of India
Shri V. Gopalakrishnan	• Member, Executive Council of the Indian Meteorological Society – Pune Chapter (IMSP) for the period 2005-2007
Dr. G. Pandithurai	• Secretary, Executive Council of the Indian Meteorological Society - Pune Chapter (IMSP) for the period 2005-2007
Dr. Devendraa Siingh	• Member, Programme Implementation Committee for Severe Thunderstorm Observations and Regional Modeling (STORM) Project of the Department of Science and Technology, Govt. of India

Deputation Abroad

Dr. G.B. Pant

- Participation in the International Workshop for Editors and Authors for MAIRS SA RAP Volume on 'Global Environmental Change and the South Asian Region: an Assessment of the State of the Science', South Asia Committee (SASCOM) Meeting, and visit to Sri Lankan Meteorological Department, Colombo
  Sri Lanka
  (9 - 16 July 2005)

- Participation in the IPCC Working Group 1 Fourth Assessment Report Third Lead Authors Meeting Christchurch
  New Zealand
  (9 - 16 December 2005)

- Participation in APN Regional Workshop on Climate Extreme Indices and Trends in South Asia, Islamabad
  Pakistan
  (31 December 2005 - 7 January 2006)

Dr. A.K. Kamra

- Participation as a Principal Delegate from India, 14th Session of the Commission for Atmospheric Sciences (CAS) of World Meteorological Organisation, Cape Town
  South Africa
  (16 - 24 February 2006)

Dr. P.C.S. Devara

- Participation in the Scientific Assembly of the International Association of Meteorology and Atmospheric Sciences (IAMAS 2005), Beijing International Convention Centre (BICC), Beijing
  China
  (31 July - 9 August 2005)

- Inspection of Dual Polarization Micro Pulse Lidar (DPMPL), at M/s Foretech Systems Pte. Ltd. Penang
  Malaysia and Singapore
  (1 - 7 October 2005)

Dr. K. Rupa Kumar

- Participation in the IPCC Working Group1 AR4 Second Lead Authors' Meeting, Bejing
  China
  (8 - 14 May 2005)

- Participation in the (i) PAN-WCRP Monsoon Modelling Workshop, Irvine, (ii) CLIVAR Asian-Australian Monsoon Panel (AAMP) Meeting, Irvine, (iii) 6th WRF Users' Workshop, Boulder, (iv) Indo-US Workshop on Joint High Performance Computing for Regional Weather and Climate, Boulder, and (v) visit to the Centre for Sustainability and Global Environment (SAGE), Madison
  U.S.A.
  (12 June - 5 July 2005)

- Participation in the International Workshop for Editors and Authors for MAIRS SA RAP Volume on Global Environmental Change and the South Asian Region: an Assessment of the State of the Science, and South Asia Committee (SASCOM) Meeting, Colombo
  Sri Lanka
  (9 - 16 July 2005)

- Visit to various Institutions in UK for discussions on Indo-UK Workshop on Climate Variability and Change
  U.K.
  (19 - 26 November 2005)

- Participation in the IPCC Working Group 1 Fourth Assessment Report Third Lead Authors Meeting Christchurch
  New Zealand
  (9 - 16 December 2005)

- Participation in APN Regional Workshop on Climate Extreme Indices and Trends in South Asia Islamabad
  Pakistan
  (31 December 2005 - 7 January 2006)

- Participation in the IPCC-WGI AR4 Chapter 11 Lead Authors' Meeting, Seoul
  South Korea
  (31 January - 5 February 2006)

Dr. R. Krishnan

- Participation in the Workshop on Organization and Maintenance of Tropical Convection and Madden Julian Oscillation, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste
  Italy
  (11 - 19 March 2006)

Dr. P.N. Mahajan

- Participation in 4th WMO Data Assimilation International Symposium, Prague
  Czech Republic
  (16 - 24 April 2005)

Dr. R.H. Kripalani

- Visiting Professor, Integrated Climate System Modelling Laboratory, Department of Environmental and Atmospheric Sciences, Pukyong National University, Busan
  South Korea
  (1 July 2005 - 30 June 2006)

Dr. G. Beig

- Participation in Young Scientists Committee Meeting of the IAGA (International Association of Geomagnetism and Aeronomy), Prague
  Czech Republic
  (28 March - 3 April 2005)

- As a Guest Scientist, Max-Planck Institute of Technology and to receive Norbert Gerbier-Mumm International Award 2005, Hamburg,
  Germany and
  participation in the IAGA General Assembly Toulouse
  France
  (31 May - 2 August 2005)

Dr. K. Krishna Kumar

- Participation in the scientific discussion in connection with the project under APN/START, Department of Primary Industries and Fisheries Toowoomba
  Australia
  (23 September - 9 October 2005)

- Participation in Workshop on Himalayan Palaeoclimate during Quaternary (HIMPAQ) – the Indian Story, Geo Forschungs Zentrum, Potsdam
  Germany
  (20 - 27 November 2005)

- Participation in the Workshop on Organization and Maintenance of Tropical Convection and Madden Julian Oscillation, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste
  Italy
  (11 - 19 March 2006)

Dr. N.A. Sontakke

- Work as Senior Associate and participation in the Spring Colloquim on the Physics of Weather and Climate: Regional Weather Predictability and modeling of Energy Technologies, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste
  Italy
  (5 April - 15 June 2005)

Dr. H.P. Borgaonkar

- Participation in the PAGES (Past Global Changes) Second Open Science Meeting, Beijing
  China
  (8 - 16 August 2005)

- Participation in Workshop on Himalayan Palaeoclimate during Quaternary (HIMPAQ) - the Indian Story, Geo Forschungs Zentrum, Potsdam
  Germany
  (20 - 27 November 2005)

- Discussions on Collaborative Research Activities in the field of Asian Dendroclimatology, Kasetsart University, Bangkok
  Thailand
  (27 February -5 March 2006)

Smt. N. R. Deshpande

- Participation in APN Regional Workshop on Climate Extremes Indices and Trends in South Asia Islamabad
  Pakistan
  (31 December 2005 - 7 January 2006)

Smt. S.K. Patwardhan

- Participation in the International Round Table Conference on Understanding and Prediction of Summer and Winter Monsoon, Jakarta
  Indonesia
  (19 - 26 November 2005)

Dr. Y. Jaya Rao

- Participation in the 3rd SPARC Data Assimilation Workshop and SPARC Workshop on Stratospheric Winds, Banff
  Canada
  (10 - 18 September 2005)

Dr. C. Gnanaseelan

- Visiting Research Associateship Florida State University
  U.S.A.
  (16 August 2005 - 11 August 2006)

Dr. (Smt.) A.A. Kulkarni

- Participation in the Workshop on Organization and Maintenance of Tropical Convection and Madden Julian Oscillation, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste
  Italy
  (11 - 19 March 2006)

Dr. G. Pandithurai

- Participation in the Scientific Discussions, University of Maryland and AGU Fall Meeting Moscone Convention Center, San Francisco
  U.S.A.
  (21 November - 14 December 2005)

Dr. S. Tiwari

- Participation in the International Conference on Acid Rain - 2005, Prague
  Czech Republic
  (11 - 20 June 2005)

Shri R. Chattopadhyay

- Participation in the European Research Course on Atmsophere, University of Joseph Fourier Grenoble
  France
  (6 January - 13 February 2006)

Visitors

International

Dr. G.H. Schleser and **Dr. G. Helle**
Forschungs Zentrum**, Germany**
19 - 31 May 2005

Dr. H. Annamalani
International Pacific Research Centre,
University of Hawaii, Honolulu, **U.S.A.**
2 August 2005

Dr. Andrew W. Robertson
Scientist, International Research Institute for Climate Prediction (IRI), The Earth Institute, Columbia University
U.S.A.
7 - 9 August 2005

Dr. Akiyo Yatagai
Research Institute for Humanity and Nature
Kyoto
Japan
5 - 6 September 2005

Dr. Lennart Granat
Stockholm University, Stockholm
Sweden
8 - 17 September 2005 and 23 - 29 March 2006

Mr. Erik Engstrom
Stockholm University, Stockholm
Sweden
8 - 17 September2005

Dr. J. Vivekanandan
Scientist-III, National Center for Atmospheric Research (NCAR), Boulder, Colorado
U.S.A.
22 September 2005

Dr. Lochan Prasad Devkota
SAARC Meteorological Regional Centre,
Nepal and
Dr. D.A. Quadir
SAARC Meteorological Regional Centre
Bangladesh
1 - 16 December 2005

Prof. Mark Cane
Lamont-Doherty Earth Observatory, Columbia University, New York
U.S.A.
27 February - 1 March 2006

Dr. Martin P. Hoerling
NOAA-CDC, Boulder
U.S.A.
22 - 30 March 2006

National

Prof. P.V. Joseph
Chairman, Severe Thunderstorm: Observational and Regional Modelling (STORM) Committee
Department of Science and Technology
New Delhi
28 - 30 April 2005

Shri R.K. Gupta
Director and
Shri. Vinod Kaul, Deputy Director
Central Water Commission
New Delhi
27 - 29 April 2005

Dr. Ashok Kaushal, Dr. Manoj Khare and **Shri Binay Kumar**
C-DAC,
Pune
20, 24 May 2005

A Group of Science Teachers
Maharashtra Science Teachers' Association
Pune
9 May 2005

Smt. Anima Biswal and **Smt. Malthi Priya**
Department of Environmental Sciences
Indian Agricultural Research Institute
New Delhi
17 - 30 May 2005

Dr. Pramod Aggarwal
Head, Department of Environmental Sciences
Indian Agricultural Research Institute
New Delhi
24 - 25 May 2005

Dr. G.S. Gujral
Head, Science and Technology and
Dr. Manjula Rao
British Council, Mumbai
28 June 2005

Shri Shankaracharya
Chief Engineer (Hydrology) National Hydroelectric Power Corporation Ltd. (NHPC)
Faridabad
6 July 2005

Dr. S.N. Das
Scientist F Regional Research Laboratory
Bhubaneswar
28 - 29 July 2005

Shri S.K. Das
Member (D&R), CWC and Chairman, TARC of the CWC Project
Dr. Srinivas
Director and
Dr. Joshi
Chief Engineer, National Water Academy
Pune
29 July 2005

Dr. A. Ganju
Director, Snow and Avalanche Study Establishment (SASE), Chandigarh
18 August 2005

Shri Jagjit Rana
Minister of State for Agriculture
Govt. of Maharashtra, Mumbai
27 August 2005

Dr. N.C. Mahanti
Birla Institute of Technology, Ranchi
1 September 2005

Kum Pratima Raykar
Environmental Management Centre, Mumbai
4 October 2005

Dr. C.D. Thatte
Former Secretary, Ministry of water Resources and Chairman, Central Water Commission, New Delhi and Secretary General (Hon.) International Commission on irrigation and Drainage (ICID)
11 October 2005

Parliamentary Standing Committee on Science & Technology, Environment & Forests, headed by Shri P.G. Narayanan,
New Delhi
27 September 2005

Trainee Officers
Common Specialization Course
School of Artillery, Devlali
14 October 2005

Trainee Officers
Modelling and Simulation Course,
Indian Institute of Armament Technology, Pune
25 October 2005

M.Tech. (Geophysics) Students
Banaras Hindu University, Varanasi
16 December 2005

Shri S.D. Shukla
Engineer, National Hydroelectric Power Corporation Ltd., Faridabad
20 - 21 Dec 2005

Trainees of Fundamental and Agricultural Meteorology,
College of Agriculture
Pune
21 December 2005

Dr. S.V.M. Satyanarayana
Indira Gandhi Centre for Atomic Research
Kalpakkam
16 - 17 February 2006

Shri G.V.K. Rao
Ground Water Consultant and
Shri Y.V.S. Reddy
Deputy Executive Engineer, Inter State and Water Resources (ISWR), Hyderabad
14 March 2006

Shri R.K. Gupta
Director, Hydrology (South)
Central Water Commission, New Delhi

Dr. Manoj Khare
Scientist, C-DAC, Pune
20 March 2006

Dr. Umesh Kulshreshta
Scientist C Indian Institute Chemical Technology
Hyderabad
23 - 27 March 2006

Academic Faculty

Name	Specialisation	E-mail Address	Academic Qualifications
Dr. G.B. Pant	Climate, Climatic Change, Palaeoclimatology, Monsoon Variability and Prediction	gbpant@tropmet.res.in	M.Sc., Ph.D.
Dr. A.K. Kamra	Atmospheric Electricity, Cloud Physics, Aerosol Physics	karma@tropmet.res.in	M.Sc., Ph.D.
Dr. P.C.S. Devara	Atmospheric Optics, Remote Sensing of Atmospheric Aerosols and Trace Gases, Aerosol-Climate Interactions	devara@tropmet.res.in	M.Sc., Ph.D.
Dr. D.B. Jadhav	Spectrometric Techniques for Atmospheric Chemistry, Radiation, Atmospheric Electricity	dbj@tropmet.res.in	M.Sc., Ph.D.
Dr. K. Rupa Kumar	Climate Change, Monsoon Variability and Prediction, Dendroclimatology, Climate Impact Studies	kolli@tropmet.res.in	M.Sc., Ph.D.
Dr. (Smt.) P.S. Salvekar	Monsoon Disturbances, Simulation of Atmospheric and Oceanic Circulation, Human Resource Development for Atmospheric Sciences	pss@tropmet.res.in	M.A., Ph.D.
Dr. S. Shivaramakrishnan	Atmospheric Boundary Layer, Wind Tunnel Simulations	siva@tropmet.res.in	M.Sc., Ph.D.
Dr. Nityanand Singh	Hydrometeorological Studies, Rainfall Prediction on Shorter Spatial and Temporal Scales	nsingh@tropmet.res.in	M.Sc., Ph.D.
Dr. R. Krishnan	Climate Modelling	krish@tropmet.res.in	M.Sc., Ph.D.
Shri S. Sinha	Theoretical and Experimental Atmospheric Boundary Layer Studies	ssinha@tropmet.res.in	M.Sc.
Dr. R. Vijayakumar	Cloud Physics, Numerical Modelling of Clouds	vijay@tropmet.res.in	M.Sc., Ph.D.
Dr. P.E. Raj	Optical and Radio Remote Sensing of the Atmosphere, Environmental Studies, Aerosol-Climate Interactions	ernest@tropmet.res.in	M.Sc., Ph.D.
Dr. P.N. Mahajan	Satellite Data Applications for Weather Forecasting	mahajan@tropmet.res.in	M.Sc., Ph.D.
Shri J.R. Kulkarni	Monsoon Variability and Prediction, Nonlinear Dynamics and Chaos, Climate Modelling	jrksup@tropmet.res.in	M.Sc.

Name	Specialisation	E-mail Address	Academic Qualifications
Smt. S.S. Vaidya	Numerical Weather Prediction with Special Emphasis on the Physical Processes	ssvady@tropmet.res.in	M.Sc.
Dr. R. H. Kripalani	Asian Monsoon and Climate Variability	krip@tropmet.res.in	M.Sc., Ph.D.
Shri B.N. Mandal	Hydrometeorological Studies for Different River Basins and Regions	mandal@tropmet.res.in	B.Sc.
Dr. G. Beig	Atmospheric Chemistry, Ozone Pollution, Greenhouse Gases-3D Chemical – Climate Modelling, Air Pollution Modelling	beig@tropmet.res.in	M.Sc., Ph.D.
Dr. A.K. Sahai	Climate Variability	sahai@tropmet.res.in	M.Sc., Ph.D.
Dr. L.S. Hingane	Climate Change Studies	hingane@tropmet.res.in	M.Sc., Ph.D.
Dr. P.S.P. Rao	Air Pollution, Precipitation Chemistry	psprao@tropmet.res.in	M.Sc., Ph.D.
Dr. (Smt.) I.S. Joshi	Upper Atmosphere, Ionosphere and Environmental Sciences	indira@tropmet.res.in	M.Sc., Ph.D.
Dr. K. Krishna Kumar	Monsoon Variability and Prediction, Global Teleconnections and Climate Application	krishna@tropmet.res.in	M.Sc., Ph.D.
Dr. (Smt.) N.A. Sontakke	Climate Variability and Prediction with Special Reference to Indian Monsoon	sontakke@tropmet.res.in	M.Sc., Ph.D.
Dr. S.K. Sinha	Objective Analysis including Satellite Input for NWP	sinha@tropmet.res.in	M.Sc., Ph.D.
Shri D.R. Chakraborty	Atmospheric Energetics in the Wavenumber and Frequency Domain	drc@tropmet.res.in	M.Sc.
Dr. (Smt.) S.G. Nagar	Boundary-Layer Meteorology and Air-sea Interaction Process	nagar@tropmet.res.in	M.Sc., Ph.D.
Dr. A.L. Londhe	Monitoring of Atmospheric Constituents, Twilight Spectroscopy	londhe@tropmet.res.in	M.Sc., Ph.D.
Dr. (Smt.) S.S. Kandalgaonkar	Thunderstorm Climatology and Related Meteorological Parameters	sskandal@tropmet.res.in	M.Sc., Ph.D.
Dr. H.P. Borgaonkar	Long-term Climate Variability over Monsoon Asia, Dendroclimatology, Palaeoclimatology	hemant@tropmet.res.in	M.Sc., Ph.D.
Shri M.K. Tandon	Development of Scientific Computing Techniques for Atmospheric Sciences	tandon@tropmet.res.in	M.Sc.
Dr. T. Venugopal	Boundary-Layer Meteorology and Air-sea Interaction Process	tvgopal@tropmet.res.in	M.Sc., Ph.D.

Name	Specialisation	E-mail Address	Academic Qualifications
Shri C.M. Mohile	Climate Change, Frequency of Tropical Cyclones, Climate Database Management	mohile@tropmet.res.in	M.Sc.
Shri M.Y. Totagi	Monsoon Energetics	frdmail@tropmet.res.in	M.Sc.
Shri C.S. Bhosale	Monitoring of Atmospheric Constituents, Twilight Spectroscopy	bhosale@tropmet.res.in	M.Sc.
Shri T. Dharmaraj	Atmospheric Boundary Layer, Instrumentation	dharam@tropmet.res.in	B.E.
Dr. A.A. Munot	Monsoon Rainfall Variability, Teleconnection and Prediction	munot@tropmet.res.in	M.Sc., Ph.D.
Smt. N.R. Deshpande	Hydrometeorological Studies for Different River Basins and Regions	nrdesh@tropmet.res.in	M.Sc., M.Phil.
Smt. S.K. Patwardhan	Climate Change, Monsoon Variability and Teleconnections	patwar@tropmet.res.in	M.Sc.
Dr. B.D. Kulkarni	Hydrometeorological Studies for Different River Basins and Regions	bdkul@tropmet.res.in	M.Sc., Ph.D.
Shri R.B. Sangam	Hydrometeorological Studies for Different River Basins and Regions	sangam@tropmet.res.in	B.Sc.
Dr. Y. Jaya Rao	Optical and Radio Remote Sensing of the Atmosphere	jrao@tropmet.res.in	M.Sc., M.Tech., Ph.D.
Shri S. D. Pawar	Atmospheric Electricity, Aerosol Physics	pawar@tropmet.res.in	M.Sc.
Dr. M.N. Patil	Land Surface-Atmosphere Interactions	patil@tropmet.res.in	M.Sc., Ph.D.
Dr. B.S. Murthy	Theoretical and Experimental Studies of Atmospheric Boundary Layer	murthy@tropmet.res.in	M.Sc., Ph.D.
Dr. (Smt.) S.B. Morwal	Atmospheric Boundary Layer	morwal@tropmet.res.in	M.Sc., Ph.D.
Shri A.B. Sikder	Long-term Climate Variability over Monsoon Asia, Dendroclimatology, Palaeoclimatology	sikder@tropmet.res.in	B.Sc., B.A., M.Sc.,
Shri D.M. Chate	Air Pollution Studies	chate@tropmet.res.in	M.Sc.
Shri S.S. Dugam	Monsoon Variability and Prediction with NAO and ENSO	dugam@tropmet.res.in	M.Sc.
Shri V. Gopalakrishnan	Cloud Physics, Atmospheric Electricity	gopal@tropmet.res.in	M.Sc.
Shri Prem Singh	Ocean Modelling and Simulation Studies	psg@tropmet.res.in	M.Sc., M.Phil.

Name	Specialisation	E-mail Address	Academic Qualifications
Shri S.D. Bansod	Monsoon Variability and Teleconnection	erp@tropmet.res.in	M.Sc.
Dr. C. Gnanaseelan	Ocean Modelling and Data Assimilation	seelan@tropmet.res.in	M.Sc .,M.Tech., Ph.D.
Smt. S.K. Mandke	Climate Modelling	amin@tropmet.res.in	M.Sc.,M.Tech.
Shri N.K. Agarwal	Atmospheric Energetics in Wavenumber Frequency Domain	nka@tropmet.res.in	M.Sc., M.Phil., PGDCA
Dr.(Smt.) A.A. Kulkarni	Monsoon Variability and Teleconnections	ashwini@tropmet.res.in	M.Sc., Ph.D.
Dr. S.B. Debaje	Studies on Surface Ozone and Atmospheric Chemistry	debaje@tropmet.res.in	M.Sc., Ph.D.
Shri J. Sanjay	Numerical Weather Prediction with Special Emphasis to Mesoscale Modelling and Boundary Layer Processes	sanjay@tropmet.res.in	M.Sc.
Dr. G. Pandithurai	Atmospheric Aerosols and Remote Sensing	pandit@tropmet.res.in	M.Sc., PGDCA, Ph.D.
Shri S. Mahapatra	Numerical Weather Prediction, Regional and Mesoscale Modelling, Initialization Techniques	mahap@tropmet.res.in	M.Sc. (Tech.), M.Tech.
Shri G.A. Momin	Air Pollution Studies	momin@tropmet.res.in	M.Sc.
Shri S.S. Mulye	Hydrometeorological Studies for Different River Basins and Regions	mulye@tropmet.res.in	B.Sc.
Shri R.M. Khaladkar	Satellite Meteorology, Weather Forecasting	khaldkr@tropmet.res.in	M.Sc., M.Tech., PGD
Smt. S.S. Desai	Atmospheric Dynamics, Global Spectral Energetics	ssd@tropmet.res.in	M.Sc.
Shri V.R. Mujumdar	Indian Monsoon	vrmujumdar@hotmail.com	B.Sc.
Dr. S.M. Bawiskar	Studies of Monsoons and Tropical Weather Systems	monsoon@tropmet.res.in	M.Sc., Ph.D.
Shri D.K. Trivedi	Numerical Weather Prediction, Tropical Cyclone Modelling	trivedi@tropmet.res.in	M.Sc.
Smt. A. A. Deo	Application of Ocean modeling, Studies of Upper Oceanic Processes in Different Time and Space Series	aad@tropmet.res.in	M.Sc., M.Phil.
Dr. K. Ali	Cloud Physics and Radar Meteorology, Air Pollution Studies	kaushar@tropmet.res.in	M.Sc. (Tech.), Ph.D.

Name	Specialisation	E-mail Address	Academic Qualifications
Dr. D. R. Kothawale	Climate Change, Monsoon Variability and Prediction	kotha@tropmet.res.in	M.Sc., Ph.D.
Shri P.V. Puranik	Studies of Monsoons and Tropical Weather Systems	monsoon@tropmet.res.in	B.Sc.
Shri S.K. Jadhav	Studies on Low Pressure Systems over the Indian Region	skj@tropmet.res.in	B.Sc.
Smt. N. V. Panchawagh	Extended Range Prediction	panchwag@tropmet.res.in	M.Sc.
Shri S.D. Patil	Climate and Climatic Change, Ozone Variability	patilsd@tropmet.res.in	M.Sc.
Smt. M.K. Kulkarni	Atmospheric Electricity	mnkulk@tropmet.res.in	M.Sc.
Smt. Latha R.	Atmospheric Electricity	latha@tropmet.res.in	B.Tech.
Shri G.S. Meena	Atmospheric Minor Constituents	gsm@tropmet.res.in	M.Sc.
Shri S.B. Kakade	Monsoon Variability and Prediction with NAO and ENSO	kakade@tropmet.res.in	M.Sc.
Shri S.P. Ghanekar	Studies of Monsoons and Tropical Weather Systems	ghanekar@tropmet.res.in	M.Sc.
Shri S.G. Narkhedkar	Objective Analysis including Satellite Data in Weather Forecasting	narkhed@tropmet.res.in	M.Sc.
Shri S.S. Sabade	Monsoon Variability and Teleconnections	sabade@tropmet.res.in	M.Sc.
Dr.C.G. Deshpande	Aerosol Physics, Atmospheric Electricity	cgdesh@tropmet.res.in	M.Sc., Ph.D.
Smt. Sathy Nair	Satellite Meteorology and Applications of Satellite Data in Weather Forecasting	sathy1957@hotmail. com	B.Sc.
Dr. P.D. Safai	Surface Ozone, Atmospheric Aerosols and Precipitation Chemistry	safai@tropmet.res.in	M.Sc., Ph.D.
Dr. M.S. Mujumdar	Climate Modelling	mujum@tropmet.res.in	M.Sc., Ph.D.
Shri K.K. Dani	Remote Sensing of Atmospheric Aerosols and Trace Gases	kundan@tropmet.res.in	B.Sc.
Dr. M.C. Reddy	Remote Sensing of Atmospheric Aerosols and Trace Gases	madhucomcom@rediff.com	M. Sc.,Ph.D.
Shri M. Mahakur	Applications of Satellite Data in Weather Forecasting	mmahakur@tropkmet.res.in	M.Sc., M.Tech.,PGD
Smt. M.N. Kulkarni	Atmospheric Electricity	mnkulk@tropmet.res.in	M.Sc.

Name	Specialisation	E-mail Address	Academic Qualifications
Dr. (Smt.) B. Padma Kumari	Atmospheric Minor Constituents	padma@tropmet.res.in	M.Sc., M.Tech., Ph.D.
Dr. S.Tiwari	Air Pollution, Precipitation Chemistry	mbtiwari.yahoo.com	M.Sc., Ph.D.
Shri P. Murugavel	Atmospheric Electricity, Aerosol Physics	pmvelu@tropmet.res.in	B.E.
Smt. S.R. Inamdar	Extended Range Prediction	srinam@tropmet.res.in	M.Sc.
Smt. U. Iyer	Satellite Meteorology and Applications of Satellite Data in Weather Forecasting	usha@tropmet.res.in	M.Sc.
Dr. P. Mukhopadhyay	NWP and Meso-scale Modelling of Thunderstorms, Heavy Precipitation Events	mpartha@tropmet.res.in	M.Sc., Ph.D.
Smt. J.V. Revdekar	Extreme Weather Events, Climate Change, Monsoon Variability	jvrch@tropmet.res.in	B.Sc., M.Sc.,
Smt. S.S.Fadanvis	Atmospheric Chemistry, Ozone Pollution, Greenhouse Gases- 3-D Chemical-Climate Modelling	suvarna@tropmet.res.in	B.E., M.Tech.
Dr. (Kum) S.S.Nandargi	Hydrometeorological Studies for Different River Basins and Regions	nshobha@tropmet.res.in	M.Sc., Ph.D.
Shri D.M. Lal	Atmospheric Electricity, Cloud Physics	dmlal@tropmet.res.in	M.Sc.,PGDCA
Kum. S. Roy	Atmospheric Chemistry, Ozone Pollution, Greenhouse Gases- 3-D Chemical-Climate Modelling	somnporiti@tropmet.res.in	M. Sc., ADCA
Dr. R.S. Maheskumar	Remote Sensing of Atmospheric Aerosols and Trace Gases, Cloud physics	mahesh@tropmet.res.in	M.Sc., M.Tech., Ph.D.
Smt. A.A. Prabhu	Satellite Data Applications for Weather Forecasting	amitaprabhu@tropmet.res.in	M.Sc.
Dr.(Smt.) R.R.Joshi	Investigation and modelling of Land Surface Processes in Atmospheric Boundary layer, Wind Profiler, Remote Sensing Devices	rrjcpt@tropmet.res.in	M.Sc., Ph.D.
Dr. Devendraa Siingh	Atmospheric Electricity, Global Electric Circuit, Sferics and Whistlers, ELF/VLF emissions in Ionosphere/ Magnetosphere, Space Plasma Physics and Space Weather	dksingh@tropmet.res.in	M.Sc., Ph.D.
Shri R.K. Yadav	Seasonal Forecasting	yadav@tropmet.res.in	M.Sc.(Tech.)
Dr. Samir Pokherel	Rainfall Retrival, radiative Transfer Modelling	samir@tropmet.res.in	M.Sc., Ph.D.

Name	Specialisation	E-mail Address	Academic Qualifications
Shri A.B. Parekh	Remote Sensing, Physical Oceanography Air-sea Interaction	anant@tropmet.res.in	M.Sc.
Kum B. Preethi	Monsoon Variability	preethi@tropmet.res.in	M.Sc., M.Tech.
Shri G.R. Chintalu	Air sea interaction studies in tropical monsoons & Atmospheric boundary layer process studies over land and ocean.	chintalu@tropmet.res.in	M.Sc.
Smt. Asha Nath	Atmospheric Electricity	asha@tropmet.res.in	B.Sc.
Smt. R.V. Bhalwankar	Simulation Techniques in Cloud Physics	rohini@tropmet.res.in	M.Sc.
Smt. S.S. Naik	Monsoon Studies	snaik@tropmet.res.in	M.Sc.
Shri S.De	Deterministic predictability in the perspective of nonlinear error characteristics study of a prognostic model in the medium range tropical weather forecast	sde@tropmet.res.in	M.Sc., M.Tech.
Dr. S. D. Ghude	Aerosol studies in relation to climate change, Trace gases measurement	sachinghude@tropmet.res.in	M.Sc., Ph. D.
Dr. R.C. Reddy	Ocean Modelling Application of Satellite Data for Ocean Studies	rahul@tropmet.res.in	M.Sc., M.Tech., Ph.D.
Dr. Y.K. Tiwari	Greenhouse Gas Modelling and its measurement	yktiwari@tropmet.res.in	M.Sc.(Tech.), Ph.D.

Administrative and Technical Support

Administration		
Smt. N.S. Girija	Administrative Officer	girija@tropmet.res.in
Accounts		
Shri V.G. Bathija	Accounts Officer	vashi@tropmet.res.in
Purchase and Stores		
Shri S.R. Nirgude	Senior Technical Officer, Gr. II	nirgude@tropmet.res.in
Library, Information and Publication		
Smt. A.A. Shiralkar	Senior Technical Officer, Gr. I	siralkar@tropmet.res.in
Computer and Data Archival		
Smt. S.U. Athale	Senior Technical Officer, Gr.II	swati@tropmet.res.in

IITM Research Fellows/Associates and Project Personnel

IITM Research Fellows

Name	Project	Guide
Kum. Suchitra Sundaram	Diagnostics and Modelling Studies of Long Term Trends and Variability of Climate over the Indian-Asia Pacific Regions	Dr. K. Krishnan
Kum. Rohini Bhawar	Remote Sensing of Atmosphere Using Lidar, Radiometetric and other Ground Based Techniques	Dr. P.C. S. Devara
Shri Vimalesh Pant	Surface Observations of Atmospheric Electricity and Electric Properties of Clouds	Dr. A.K. Kamra
Kum. Cini Sukumaran	Experimental Study of Exchange Processes in the Atmospheric Boundary Layer over Continental and Marine Environment	Dr. S. Sivaramakrishnan
Shri B.H. Vaid	Numerical Modelling of the Upper Ocean Mixed Layer over Indian Ocean Region using Satellite Data	Dr. C. Gnanaseelan
Shri Santosh Kulkarni	Measurements and Monitoring of Atmospheric Minor Constituents	Dr. D.B. Jadhav
Smt. M.S. Deshpande	Studies on Dynamical Ocean Modelling	Dr. P.S. Salvekar
Shri P. Ramesh Kumar	Surface Observations of Atmospheric Electricity and Electric Properties of Clouds	Dr. A.K. Kamr
Shri Vikas Singh	Atmospheric Chemistry Modelling and Dynamics	Dr.G. Beig
Smt.Ashwini A.Ranade	Air Pollution and Precipitation Chemistry	Dr. Suresh Tiwari
Kum. K. Kamala	Regional Aspects of Global Climate Change and Variability	Dr. K. Rupa Kumar
Shri Sachin S. Bhandare	Hydrometeorological Studies of River Basins for Applicationsin Water and Power Resource Projects	Dr. K. Rupa Kumar
Shri Umesh Kumar Singh	Changes in Rainfall Pattern and Hydrologic Regimes over India and their Relationship to Global Warming	Dr. (Smt.) P.S. Salvekar
Shri Sachin S.Gunthe	Atmospheric Chemistry Modelling and Dynamics	Dr.G. Beig
Shri Sachin S. Deshpande	Remote Sensing of Atmosphere Using Lidar, Radiometetric and other Ground Based Techniques	Dr. P.C.S. Devara

Project Personnel

Name	Project (Funding Agency)	Principal Investigator
Major Gen. S. S. Sharma (Consultant)	Preparation of Generalised PMP Atlases over the Krishna and the Indus River Basins (Central Water Commission)	Dr. G.B. Pant
Dr. S.H. Damale (Consultant)	Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Sounding System (Department of Science and Technology, New Delhi)	Dr. G.B. Pant
Shri Narendra Singh	Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System (Department of Science and Technology, New Delhi)	Dr. G.B. Pant
Shri Vinaykumar	Air-Sea Interactions in the Indian Ocean Region (DOD/ INDOMOD10th Plan Programme) (Department of Ocean Development, Govt. of India)	Dr. R. Krishnan
Shri Rajib Chattopadhyay	Air-sea interactions in the Indian Ocean region (DOD / INDOMOD10th Plan Programme) (Department of Ocean Development, Govt. of India)	Dr. R. Krishnan
Kum. Ayankita Dey	Air-sea interactions in the Indian Ocean region (DOD / INDOMOD 10th Plan Programme) (Department of Ocean Development, Govt. of India)	Dr. R. Krishnan
Shri Basant Kumar Samala	Air-Sea Interactions in the Indian Ocean Region (DOD/ INDOMOD 10th Plan Programme) (Department of Ocean Development, Govt. of India)	Dr. R. Krishnan
Smt. P. Swapna	Air-Sea Interactions in the Indian Ocean Region (DOD/ INDOMOD 10th Plan Programme) (Department of Ocean Development, Govt. of India)	Dr. R. Krishnan
Shri Ashok Kumar Verma	Preparation of Generalized PMP Atlases over the Krishna and the Indus River Basins (Central Water Commission, New Delhi)	Dr. G.B. Pant
Shri Dhawal P. Prajapati	Preparation of Generalized PMP Atlases over the Krishna and the Indus River Basins (Central Water Commission, New Delhi)	Dr. G.B. Pant
Smt. Shally Joshi	Monsoon Variability Studies with Regional Climate Models (RCM) using Satellite Derived Surface Parameters: Validation and Application (Indian Space Research Organisation (ISRO), Government of India)	Dr. G.B. Pant

Name	Project (Funding Agency)	Principal Investigator
Shri Sourav Taraphadar	Monsoon Variability Studies with Regional Climate Models (RCM) using Satellite Derived Surface Parameters: Validation and Application (Indian Space Research Organisation (ISRO), Government of India)	Dr. G.B. Pant
Shri Saroj Kumar Sahu	Impact of Long Term Solar variability on Middle Atmosphere Chemical Climate Using Satellite Data and Model Simulation	Dr. G. Beig
Shri Pankaj Kumar	India Meteorological Department, New Delhi-IITM Collaborative Scheme on Development of Long-range Forecasting(India Meteorological Department)	Dr. K. Rupa Kumar
Shri J.S. Chaudari	Data Assimilative Sigma Coordinate Numerical Model for the North Indian Ocean (DOD/INDOMOD 10th Plan Programme)	Dr. C. Gnanaseelan
Shri Shailandra Kewat	Role of Aerosols and Black Carbon in Atmospheric Radiation Budget Studies (ISRO-GBP/ARBS) (Indian Space Research Organisation (ISRO), Government of India)	Dr. P.D. Safai
Kum. Pratima Pandey	Development of a Regional Atmosphere-Ocean Coupled Modelling strategy for Predicting Indian Summer Monsoon	Dr. K. Krishna Kumar
Smt. Shipa Jain (Talekar)	ENVIS Information Centre	Dr. G. Beig
Shri Abhishek Kumar Solanki (I.T. Assistant)	ENVIS Information Centre	Dr. G. Beig
Shri Himanshu Phatak	ENVIS Information Centre	Dr. G. Beig
Shri Raju Pratapbhai Dhanak (I.T. Assistant)	Accounts and Finance	Shri V.G. Bathija

M.S. Godbole & Associates

CHARTERED ACCOUNTANT

67 / 2, 4, Uberio House, Karve Road, Pune 411 004

Phone : 2543 35 40, E-mail : mgodbole@vsnl.com

To,
The Members,
The Indian Institute of Tropical Meteorology,
Homi Bhabha Road,
Pashan,
Pune-411008.

Sub. - Audit Report for the Financial Year ended 31 st March, 2006.

Dear Sirs,

We have audited the attached Balance Sheet of, **THE INDIAN INSTITUTE OF TROPICAL METEOROLOGY,** as on **31st March 2006** and also the Income & Expenditure Account for the year ended on that date, annexed thereto. These financial statements are the responsibility of the Company's Management. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with the auditing standards generally accepted in India. Those standards require that we plan & perform our audit to obtain reasonable assurance about whether the financial statements are free from material misstatements. An audit includes assessing the accounting principles used & significant estimates made by the management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

Further to our Observations annexed herewith and read with the Notes forming Part of the Accounts, we report that:

1. We have obtained all information and explanation, which to the best of our knowledge and belief were necessary for the purpose of our audit.

2. The Balance Sheet and the Profit & Loss Account dealt with by this report, are in agreement with the books of account of the company.

3. We invite your attention to the following :

   i) In respect of funds received for earmarked investments / projects, no separate investment / bank accounts are maintained. As informed to us by the Management, this is due to a large number of projects. Hence, interest income earned on theses funds are not credited to the respective projects but is shown as a consolidated figure in Income & Expenditure account.

4. In our opinion, to the best of our information and according to the explanation given to us, the Balance Sheet and the Income & Expenditure Account read along with the Notes Forming part of Accounts and other observations, give a true and fair view:

   (a) In the case of Balance Sheet, of the state of affairs as at 31st March, 2006, and
   (b) In the case of the Income & Expenditure Account, of the Deficit for the year ended on that date.

For M. S. Godbole & Associates
Chartered Accountants

sd/-

(Mohan S. Godbole)
Partner

Date : 26th June, 2006.

Place: Pune.

AUDITOR'S REPORT

Following are our observations based on books, records and documents produced before us and information and explanations given by the officials of the Institute :

1. **Maintenance of Fixed Asset Register :** To have proper control over the assets, it is recommended that the entries in the said register should be made as soon as the entries are made in the stores record.
2. **Physical Verification of Dead Stock :** Physical Verification report for the year ended 31st March, 2004 is on record. Preparation of the physical report for the year ended 31st March, 2006 is still in progress.
3. **Claims Receivable :** (Schedule 6 to the Balance Sheet) Claims receivable amounting to Rs.7,99,604.63 pertains to excess expenditure on some projects. The above said amount is receivable from the concerned sponsors of the projects and advances given to employees.
4. **Land Dispute with National Chemical Laboratory (NCL), Pune :** We have been informed that a high level discussion with NCL officials had taken place regarding encroachment of land belonging to IITM. It has been explained that NCL is getting the land surveyed. Efforts are in progress to get the land in question from NCL as per the demarcation of the land shown by the city survey office. However, there has been no progress on this front since the last year and the same needs follow up with NCL authorities
5. **Arbitration Case :** The arbitration case between CPWD and M/s. Naidu & Co. was pending with the court, since the said firm left the construction work in halfway. The amount of Rs. 3,48,345.00 deposited with CPWD for construction of ABC type quarters including water supply and sanitary provisions, due to price escalation , because of delay due to arbitration case filed by CPWD against M/s. Naidu & Co. After the settlement of the arbitration case, CPWD awarded the construction work to some other contractor and this process delayed the construction work, and hence additional amount of Rs. 3,48,345.00 was paid to CPWD towards construction of ABC type quarters.

Aknowledgement : We express our sincere thanks to The Director, Prof. B.N. Goswami, his officer, Mr. V. G. Bathija, Mrs. N.S. Girija and the staff members of the Institute for the kind co-operation extended by them during the course of the audit.

For M. S. Godbole & Associates
Chartered Accountants
sd/-
(Mohan S. Godbole)
Partner

Date : 26th June, 2006.
Place: Pune.

Compliance to Audit Observations

A **Maintenance of Fixed Asset Register :** The Assets acquired fully (Equipments) are entered inDead Stock Register maintained by the Purchase and Stores Unit. Also, the same is reflected in the balance sheet of the books of accounts maintained by, the Institute. In addition the fixed assets register is being maintained by the conerned division as per the provision provided under General Financial Rules, which is a part of requirement of Govt. Auditors. And it has no impact on double entry book keeping system. Keeping in view the above facts, the auditors will be persuaded to settle the audit para in question raised by them.

B **Physical Verification of Dead Stock :** A committee has been constituted for physical verification of stores for the financial year 2005-06. The work relating to physical verification for all the furniture, equipments etc. is under progress and soon as the report on physical verification of stores for 2005 2006 is received, the same will be produced to auditors for compliance and settlement of the said audit para.

C **Claims Receivable :** Most of the advances pertain to tour granted during the financial year 2005-06 most of them have been settled during the current financial year. In some cases Institute has advanced TA/DA for foreign deputation, field experiments which are receivable from the sponsorers. Efforts are made to get the refund and settle them during the current financial year

D **Land Dispute with National Chemical Laboratory (NCL), Pune :** On the resurvey conducted by the NCL, it has been ascertained that the land admeasuring 2.5 acres towards the boundary of the two organization belongs to the Institute and settle the issue. A meeting is being fixed with the Director of both the organizations to settle the issue amicably.

E **Arbitration Case :** The matter was discussed with higher authorities of CPWD, Pune, they informed that the additional amount of Rs.348345/-was incurred due to price escalation for construction of ABC quarters including water and sanitary provisions. The delay was inevitable due to Govt, procedures and guide lines for civil works and also the arbitration case against M/s.Naidu & Co. In view of the fact, it is proposed that the additional expenditure amounting to Rs.348345/-incurred against the construction of ABC quarters may be booked under Capital Works of the Institute and settle the long outstanding para.

SIGNIFICANT ACCOUNTING POLICIES

1. BASIS OF ACCOUNTING :

The Financial statements are prepared by the Institute on the basis of historical cost convention, unless otherwise stated and on accrual method of accounting.

2. FIXED ASSETS :

Fixed Assets stated in the Balance Sheet are at their cost of acquisition inclusive of freight, octroi and other direct and indirect cost in respect thereof less depreciation. Assets acquired for sponsored projects are written off as project cost.

3. DEPRECIATION :

Depreciation is provided on Straight Line method at the following rates

Sr. No.	Particulars	Rate
1	Building, Tube Wells and Overhead Water Tank	1.63%
2	Furniture & Fixtures	6.33 %
3	Plant & Machinery, Scientific Equipments and Office Equipment	4.75 %
4	Computers and Workstations	16.21 %
5	Vehicle	9.50 %
6	Books	100.00%

4. GOVERNMENT GRANTS :

a) Government Grants of the nature contributions towards capital cost are shown as capital grants in the Balance Sheet.

b) Grants in respect of specific fixed assets acquired are shown as a deduction from the cost ofrelated asset.

c) Government grants are accounted for on realization basis.

5. RETIREMENT BENEFITS :

Retirement Benefits to the employees comprise of payment to gratuity, superannuation and provident fund under the approved schemes of the society. Contribution to pension fund for payment of gratuity is made on adhoc basis and not on the basis of actuarial valuation. No provision is made for encashment of leave entitlements of employees and the same is provided on cash basis.

6. CONTINGENT LIABILITY :

Commitments given towards purchase of Scientific Equipments
Institute Fund - Rs. 1,54,41,577.00
Project Fund - Rs. 60,150.00

7. Previous year figures have been regrouped wherever necessary.

For M. S. Godbole & Associates
Chartered Accountants

sd/-

(Mohan S. Godbole)
Partner

Date : 26th June, 2006.
Place: Pune.

INCOME & EXPENDITURE ACCOUNT FOR THE PERIOD/YEAR ENDED 31-3-2006

INCOME	Schedule	Current Year	Previous Year
Income from Sales/Services			
Grants/Subsidies	7	89037227.73	73692189.17
Fees/Subscriptions	-	0.00	0.00
Income from Investments (Income on Invest from earmarked /endow. Funds transferred to Funds)	-	0.00	0.00
Income from Royalty Publication etc.		0.00	0.00
Interest Earned	9	1391734.00	1406368.48
Other Income	10	934358.80	1012141.70
Increase/(decrease) in stock of Finished goods and works-in-progress	-		
TOTAL (A)		**91363320.53**	**76110699.35**
EXPENDITURE			
Establishment Expenses	11	71062009.90	70231041.69
Other Administrative Expenses etc.	12	17377765.55	15650969.46
Expenditure on Grants Subsidies etc.	13	0.00	0.00
Interest			
Depreciation during the year	15	6458264.65	3653735.76
TOTAL (B)		**94898040.10**	**89535746.91**
Balance being excess of Income over Expenditure (A-B)			
Transfer to Special Reserve (Specify each)			
Transfer to / from General Reserve			
Previous years depreciation			
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS / CAPITAL FUND		**(3534719.57)**	**(l3425047.56)**
Significant Accounting Policies Contingent Liabilities and Notes on Accounts	14		

For M. S. Godbole & Associates
Chartered Accountants

sd/-
Director
Indian Institute of Tropical Meteorology
Pune- 411 008

sd/-
Accounts Officer
Indian Institute of Tropical Meteorology
Pune- 411 008

sd/-
(Mohan S. Godbole)
Partner

Note : Schedules are not enclosed

BALANCE SHEET AS AT 31.3.2006

CORPUS/ CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year
CORPUS/CAPITAL FUND	1	89302320.93	74874268.23
RESERVES AND SURPLUS	2	23734108.87	22788792.06
EARMARKED/ENDOWMENT FUNDS	3	11556313.76	7249065.06
SECURED LOANS AND BORROWINGS	-	0.00	0.00
UNSECURED LOANS AND BORROWINGS	-	0.00	0.00
DEFERRED CREDIT LIABILITIES	-	0.00	0.00
CURRENT LIABILITIES AND PROVISIONS	4	1477724.26	1872008.63
TOTAL		**126070467.82**	**106784133.98**
ASSETS			
FIXED ASSETS	5	87064317.39	75561379.41
INVESTMENTS - FROM EARMARKED/ ENDOWMENT FUNDS	-	0.00	0.00
INVESTMENTS - OTHERS	-	0.00	0.00
CURRENT ASSETS LOANS ADVANCES ETC.	6	39006150.43	31222754.57
MISCELLANEOUS EXPENDITURE (To the extent not written off or adjusted)			
TOTAL		**126070467.82**	**106784133.98**
SIGNIFICANT ACCOUNTING POLICIES	14		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	-		

Date: 11 July, 2005
Place: Pune

For M. S. Godbole & Associates
Chartered Accountants

sd/-
Director
Indian Institute of Tropical Meteorology
Pune- 411 008

sd/-
Accounts Officer
Indian Institute of Tropical Meteorology
Pune- 411 008

sd/-
(Mohan S. Godbole)
Partner

Note : Schedules are not enclosed