Foreword

It is my pleasure to present the Annual Report of the Institute for the year 2004-05. The Institute witnessed a number of scientific, academic and administrative activities and events during the year 2004-05. Visit of Shri Kapil Sibbal, Honourable Minister of State for Science & Technology and Ocean Development, Govt. of India, and the Parliamentary Committee on Official Language, receipt of the Norbert-Gerbier Mum International Award of the WMO by two of our scientists, participation of three scientists in the 24th Indian Scientific Expedition to Antarctica, Institute's identification as Regional Co-ordination Centre for Application of Regional Climate Modelling System for Climate Change Studies in South Asia, organization of GCOS/ WMO International Workshop on Enhancing South and Central Asian Climate Change Monitoring and Indices and a Training Workshop for the Benefit of South Asian Regional Scientists involved in the Regional Climate Modelling and Related Fields, establishment of the permanent ENVIS Information Centre on Acid Rain and Atmospheric Pollution are some of the noteworthy events of the year.

The Institute has taken up several new research projects during the year sponsored by national and international agencies and government departments. A good number of Research Fellows, Research Associates, Consultants and Project Personnel have been inducted to support the new research activities. The Institute continued its academic and research support to various Indian Universities in running their academic courses. A good number of students undergoing post-graduate courses in atmospheric science, space science, environmental science and geography from different universities have been provided facilities such as research guidance, library, laboratories, computer and accommodation for their academic and research programmes.

The year also witnessed a large number of exchange visits of scientists for meetings, seminars, workshops, conferences and specialized research collaborations in the country and abroad. Institute undertook several observational programmes in different environmental conditions at different places in the country and abroad under its own and national/ international collaborative research programmes, and collected valuable data.

The Institute improved its infrastructural facilities by addition of new equipment / computational systems and enhancement of the existing ones. The whole campus of the Institute has received a new look and environmental enrichment by carrying out necessary repairs and improvements.

This Annual Report gives a summary of significant highlights followed by a general overview of the research results including a list of research publications and other activities of the Institute during the year.

I take this opportunity to express my sincere thanks to the Department of Science and Technology, Govt. of India, and Governing Council and Finance Committee of the Institute for continued support and encouragement. I also offer my appreciation and thanks to all my colleagues of the Institute for their co-operation and devotion to work.

G.B. Pant
Director

Highlights

Research

- Coupled climate model simulation results of summer monsoon rainfall during the 20th century were evaluated under the Intergovernmental Panel on Climate Change, Fourth Assessment Report. Outputs of the models have revealed that the gross features of the monsoon rainfall are very well simulated by most of the models under the climate runs.
- The Institute provided climate change scenarios for the preparation of India's Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC).
- Several simulation experiments using the latest version of Hadley Centre Regional Climate Model PRECIS (Providing REgional Climates for Impacts Studies) were performed for the South Asian domain, to generate the regional climate for the baseline (1961-1990) and a future period (2071-2100) under two different socio-economic scenarios.
- Monsoon seasonal prediction experiments were carried out using two atmospheric general circulation models (AGCMs) for the monsoon season of 2004. The two AGCMs used for this purpose were (i) COLA T30L18 (ii) Portable Unified Mode (PUM) Ver.4.5 grid-point GCM from UKMO. The results from the COLA simulation showed deficient monsoon rainfall (-16 % departure from the normal) over the Indian region for 2004. The PUM simulation also showed a decrease in the monsoon rainfall (-3.0 % departure from normal) over the Indian region during 2004.
- Surface and subsurface circulation and temperature of tropical Indian Ocean were simulated using the three dimensional ó coordinate free surface, primitive equation Princeton Ocean Model (POM) with horizontal resolution 1° x 1° and 21 levels from surface to deep ocean (in which 10 levels are from surface to thermocline layer).

Honours and Awards

- Dr. G.B. Pant has been nominated as a Member of the First Board of Governors of Government College of Engineering (Pune Institute of Engineering and Technology), Pune.
- Dr. K. Rupa Kumar has been selected as a Lead Author for the Fourth Assessment Report of the Working Group-I of the IPCC.
- Dr. G.B. Pant has been selected as a Review Editor of Chapter 10 : Global Climate Projections under the Working Group I of the IPCC.
- Dr. G. Beig and Smt. S. S. Fadnavis along with other seventeen authors from around the world have been selected for the Norbert-Gerbier Mumm International Award, instituted by the WMO, for the year 2005 for their paper entitled, 'Review of mesospheric temperature trends' published in Reviews of Geophysics, December 2003.
- Kum. Rohini Bhawar, IITM Research Fellow won the 'Best Paper Award' for her poster presentation entitled "Ground-based radiometric measurements of aerosols and pre-cursor gases over Pune and their comparison with TOMS and MODIS satellite data" at the IASTA Meeting and International Conference on "Aerosols, Clouds and Indian Monsoon", Indian Institute of Technology, Kanpur, 15-17 November, 2004.
- The paper entitled, "Long-term variations in the performance of climate models" by Grimm A.M., **Sahai A.K.,** and Ropelewski C.F., received the Best Paper Award in the 13th Brazilian Congress of Meteorology, Fortaleza, Ceara, Brazil, 30 August – 3 September, 2004.

- Shri B.C. Morwal has been awarded Second Prize for his paper entitled 'Suchana sanchar aur suchi ki pragati' (in Hindi) presented at the 49th Seminar and Hindi Workshop on Official Language, Nainital, 6-8 October, 2004.
- Smt. Shanti P. Iyer, Shri. Y. S. Belgude and Shri. S.M. Jadhav received the Excellent Performance Award for the year 2003 for the Administrative, Technical and Non-Technical Maintenance category of employees respectively.

Events

- Shri Kapil Sibal, Honourable Minister of State for Science and Technology and Ocean Development, Government of India, New Delhi visited the Institute on 7 September, 2004.
- Second Sub-Committee of Parliament on Official Language consisting of five Members visited the Institute on 8 January, 2005.
- The Institute celebrated its 43rd Foundation Day on 17 November, 2004.
- Three scientists of the Institute participated in the 24th Indian Scientific Expedition to Antarctica from 6 December, 2004 to 27 March, 2005 for measurements of aerosols, atmospheric electric and other parameters and trace gases.
- A Training Workshop for the benefit of South Asian regional scientists involved in regional climate modelling and related fields was held at the Institute during 24-28 January, 2005.
- A World Meteorological Organization / Global Climate Observing System (GCOS / WMO) International Workshop on Enhancing South and Central Asian Climate Change Monitoring and Indices was organized at the Institute during 14-19 February, 2005.
- A Meeting of Expert Committee to Study the Effect of Windmills on Rainfall was held at the Institute during 3 - 4 June, 2004 under the Chairmanship of Dr. G.B. Pant, Director.
- A Meeting of the Research Advisory Committee of the Institute under the Chairmanship of Dr. P.C. Pandey was held on 9 -10 June, 2004.
- An in-house Short Term Training Course on Computational Methods for the IITM Research Fellows / Associates / Project Personnel etc. was arranged at the Institute during 14 October - 4 November, 2004.
- First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies was organized at the Institute during 18 – 19 January, 2005.
- Annual Monsoon Workshop – 2004 of the Indian Meteorological Society (Pune Chapter) was jointly organized with the India Meteorological Department on 4 March, 2005.
- First WP/RASS Training Workshop on Meteorology and Atmospheric Science was organized at the Institute during 7-11 March, 2005.

Collaboration

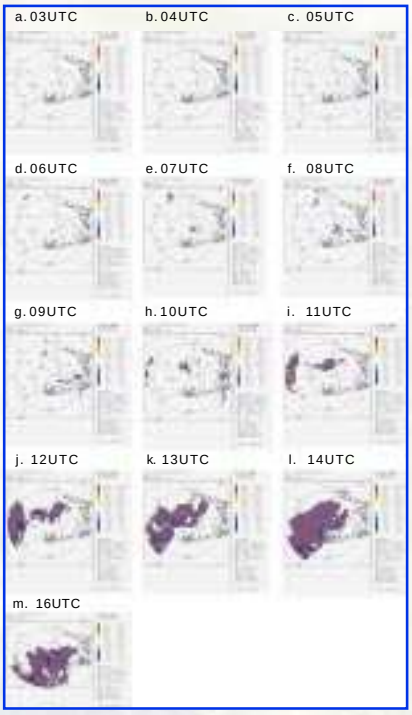
- The Institute has been identified as a Regional Coordination Centre for the application of regional climate modelling system for climate change studies in South Asia, as part of the collaborative framework with the Hadley Centre for Climate Prediction and Research, UK.
- Two Indo-UK projects on development of high-resolution climate change scenarios for India, and impact of climate change on water resources in India, and an Indo-French project on sensitivity of Indian summer monsoon to anthropogenic climate change were successfully completed.

- As a part of the collaborative research between the Institute and the India Meteorological Department, efforts were made to extend the development of seasonal forecasting strategies to northeast monsoon and northwest India winter precipitation.
- Two projects on the design storm studies for the Bhagirathi and Dhauliganga catchments in Uttaranchal State, sponsored by National Thermal Power Corporation (NTPC) were successfully completed.
- An IITM Atmospheric Boundary Layer Field Laboratory at National Centre for Antarctic and Ocean Research (NCAOR), Goa has been modernized and inaugurated by Dr. P.C. Pandey, Director, NCAOR on 10 September, 2004.
- The Institute had provided guidance to Andhra Pradesh State Government in their cloud seeding operations carried out during 2003. A report on 'Cloud seeding operations in Andhra Pradesh during 19 September – 17 November, 2003' was submitted to the Government of Andhra Pradesh.

Field Observational Programmes

- Institute arranged Field Expeditions to Uttaranchal and Chattisgarh during 24 September- 15 October, 2004 and 28 October - 9 November, 2004 respectively for tree-ring sample collection under the collaborative activity on South-Asian Dendroclimatic studies between IITM and Tree-ring Laboratory, Lamont-Doherty Earth Observatory, Columbia University, New York, U.S.A..
- Under the nation- wide land campaign programme organized of the ISRO-GBP/ARBS extensive observations of aerosol physical, chemical and radiative characteristics were carried at the IITM, New Delhi Branch and also at the Dayalbagh Educational Institute (DEI), Agra during 1-31 December, 2004.
- As a part of the IITM-SAC collaborative project entitled Mapping of Aerosol Characteristics from Remote Sensing Data, special field campaign experiments were conducted along the Pune-Daund-Pune sector during April and May 2004 and at a remote place which is about 60 km away from Pune during January-March 2005, in synchronization with the IRS-P4/P6 satellite overhead passes.
- An extensive Field Campaign was arranged with an objective to monitor the levels of ozone and its precursors (NO_X, CO and NMHCs) in the vicinity of the sugar factories during the period 24 January - 6 February, 2005 at the Bhima Patas Co-operative Sugar Factory Ltd., Patas; Yashwant Co-operative Sugar Factory Ltd., Theur and Sant Tukaram Co-operative Sugar Factory Ltd., Kasarsa.
- Institute participated in a Joint Field Campaign with Indira Gandhi Centre for Atomic Research and Bhabha Atomic Research Centre to study the wind and thermal structure of the coastal atmospheric boundary layer at the National Centre for Antarctic and Ocean Research, Goa during 10 - 24 September, 2004.

Forecasting Research



Forecasting Research Division has formulated its research programmes for understanding of tropical weather and prediction of the monsoon rainfall on different time and space scales. Studies are also undertaken to understand and predict the meso-scale systems such as tropical cyclones. Following are the current activities of the Division :

- Study of meso-scale systems and meso-scale modelling.
- Study of Air-Sea Interaction Processes and planetary boundary layer characteristics using ARMEX-2002, ARMEX-2003 and other experimental and routine data.
- Application of satellite data in weather forecasting and tele-connections of monsoon variability over South and East Asia.
- 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.
- Intra-seasonal Madden Julian Oscillations (MJO) and breaks in monsoon.
- 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, A. Bandyopadhyay, J. Sanjay, S. Mahapatra, D.K. Trivedi, P. Mukhopadhyay)

Model simulation of Nor'westers

A Nor'wester of 22 May, 2003, the last in the pre-monsoon season of the year was studied using the Regional Atmospheric Modelling System (RAMS) with two way interactive nested grid of 16 and 4 km resolution. This storm caused a wide spread damage and 73 mm of rainfall was reported over Kolkata in just 90 minutes. The storm struck Kolkata at 1230 UTC (1800h local time). The grids were centered at 22.6°N, 88.4°E which is the location of Alipore observatory of Kolkata. The 16 km domain covers a region from 83.34° - 93.42°E along east-west and 17.78° - 27.28°N in the north-south direction and the inner nested 4 km domain covers a region 87.29° -89.49°E in the east-west and 21.57°-23.59°N in the north-south direction. The number of vertical terrain following levels in both the domains were 36. The height of the top of the model domain was 25 km. Two experiments are carried out, one (exp-1) with the NCEP 6 hourly analyses as the input and the other (exp-2) with the merging radiosonde data of three stations, viz., Ranchi, Patna and Kolkata at 0000 UTC with the gridded analysis of NCEP at the same time. RAMS was initially run in nudging mode for 6 hrs and then in forecast mode for12hrs ending 1800 UTC of 22 May, 2003. Exp-2 showed significant improvement in predicting the temporal and spatial evolution of the Nor'wester. Figure 1 shows the predicted total cloud condensate (gm/kg) at 850hPa in 16km domain by exp-2 and this was compared with the cloud liquid water content (Fig. 2) as estimated by Doppler radar located at Kolkata.

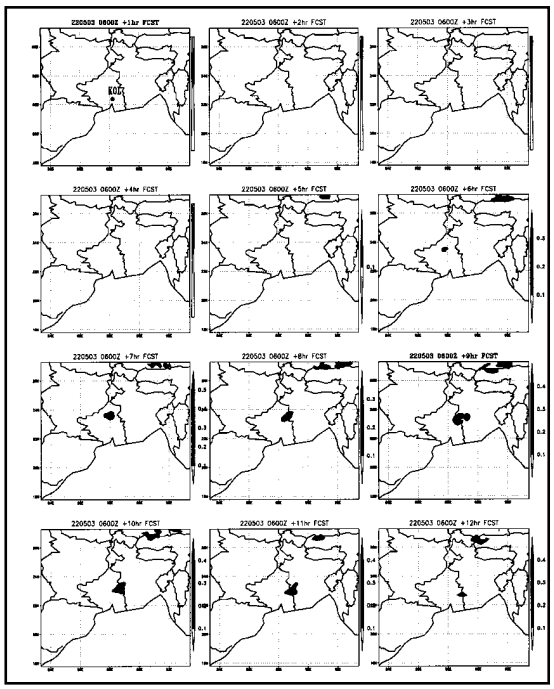


Fig. 1: RAMS hourly prediction of total cloud condensate at 850 hPa in 16 km domain (Exp-2)

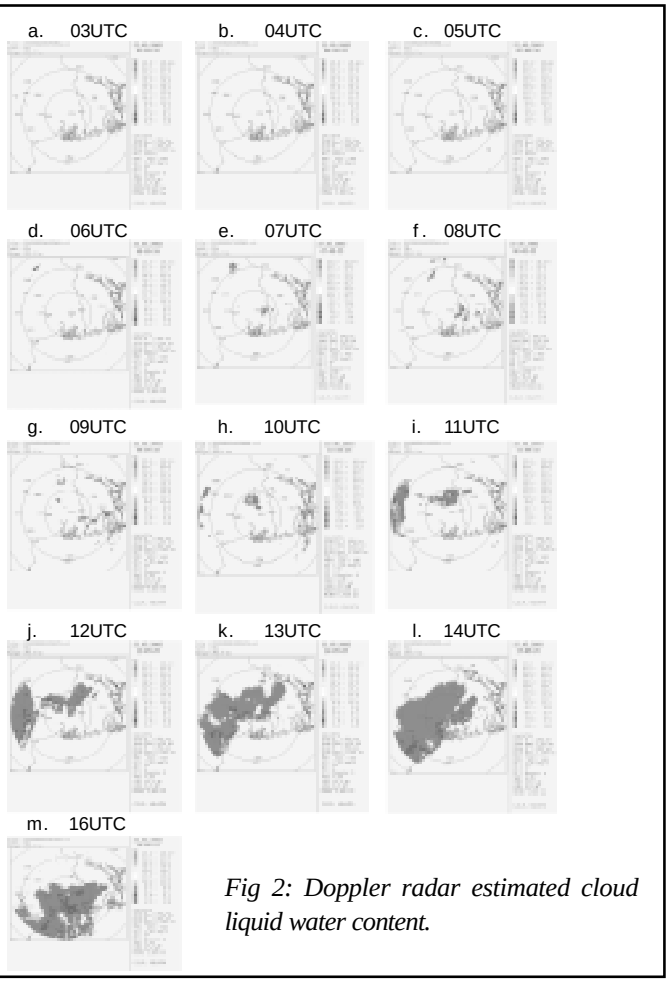


Fig 2: Doppler radar estimated cloud liquid water content.

It is seen from Figure 1 that at 6 hour forecast (1200 UTC) the model predicted formation of the system which was seen to have strengthened in the following hours (7 and 8 hour). Nine hour forecast onwards the simulated system is found to be in dissipating stage. This simulation matched reasonably well with the Doppler radar observation of Kolkata at the respective hours. Fig. 3a shows that the twelve hour accumulated predicted rain (mm) by exp-1, Fig. 3b shows that by exp-2, Fig. 3c depicts the CPC (Climate Prediction Center, NOAA, USA) daily rainfall estimate (mm) and Fig. 3d shows the Doppler radar estimated 12 hour accumulated rain (mm). Exp-2 showed significant improvement in predicting the temporal and spatial evolution of the Nor'wester and the associated rainfall. However, the amount of the forecast precipitation was lesser than the observed one, which may be attributed to the relatively coarser input used for the simulation.

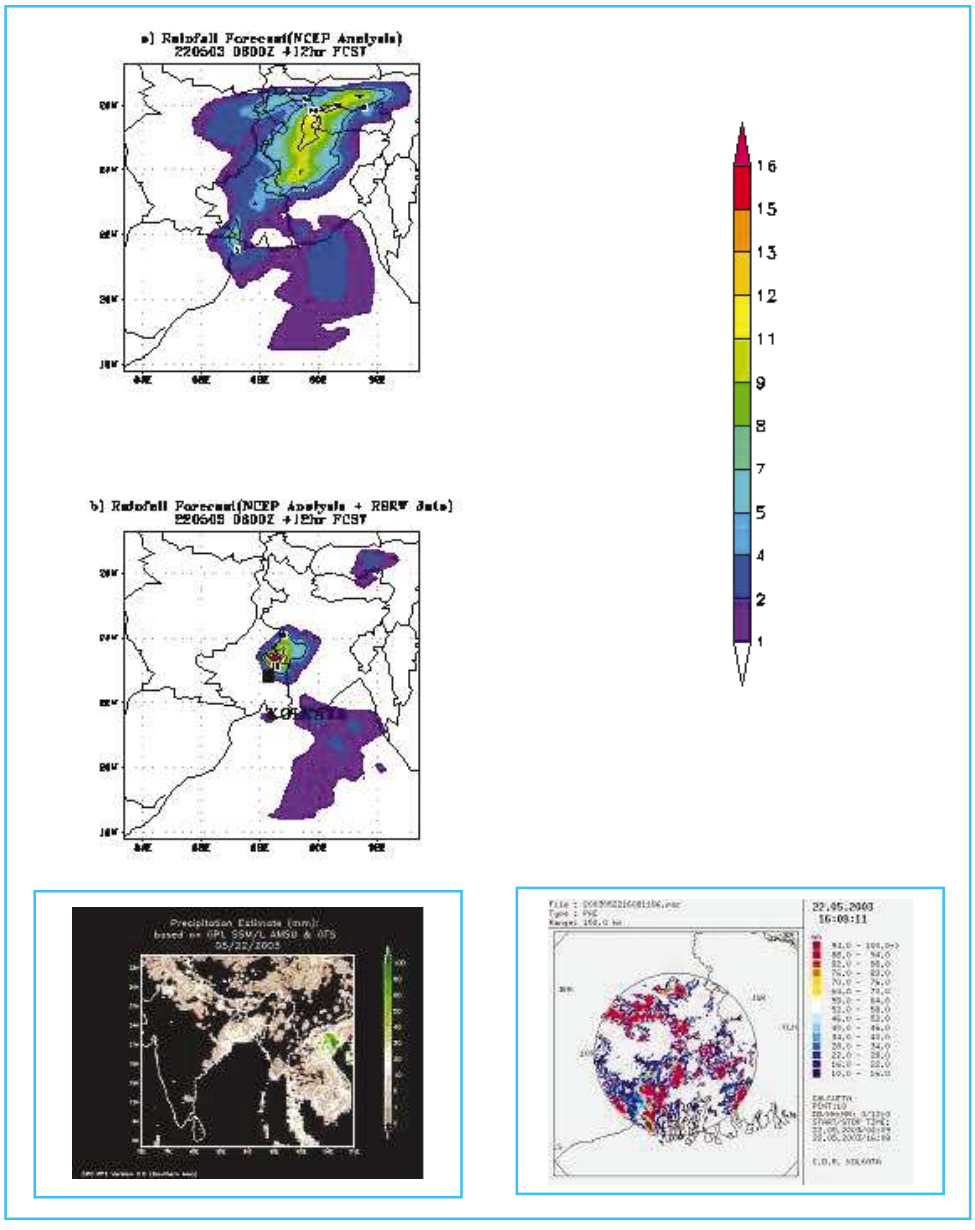


Fig. 3 : 12 hourly accumulated forecast precipitation a) exp-1 b) exp-2 c) daily precipitation estimate by CPC d) 12 hour accumulated Doppler radar rain estimate.

Recent trends of thunderstorms over Gangetic West Bengal

Thunderstorms over Kolkata were studied for a period of 23 years (1980 – 2003) for the months of March, April and May at 0300 and 1200 UTC to examine trend in their occurance. Thunderstorms were classified into different categories such as (a) localized, (b) wide spread, (c) associated with heavy precipitation, (d) associated with less precipitation and (e) with no precipitation. The study revealed a marginal increase in the frequency of thunderstorms taking together both 0300 and 1200 UTC reports. However, the occurrences at 0300 UTC did not show any significant change, but an increase in the frequency was observed at 1200 UTC. Thunderstorms occurring at 0300 UTC were found to be more wide spread in nature and the ones reported at 1200 UTC were found to be mostly localized. A total of 252 thunderstorm events were reported over Kolkata during 1980-2003, out of which only 25% (7% at 0300 and 18% at 1200 UTC) were found to be associated with heavy rain, 51% with light rain and 24% without any rain.

Sensitivity of parameterization schemes on model simulation

Experiments were carried out to see the impact of two planetary boundary layer (PBL) parameterization schemes on the simulation of heavy precipitation associated with a low pressure area during 18 - 20 September, 2000 over Gangetic West Bengal and super-cyclonic storm of Orissa during 26 - 30 October, 1999. For the simulation of heavy precipitation associated with the two selected cases the fifth generation Pennsylvania State University / National Center for Atmospheric Research Mesoscale Model (MM5) wais utilized. The model wais initialized with the data of 0000 UTC of 18 September, 2000 and 0000 UTC of 26 October, 1999 for the low pressure area and the super cyclonic storm respectively. The PBL schemes used were (i) the nonlocal scheme based on Troen- Mahrt representation of counter gradient transports and eddy diffusivity profiles in the well mixed boundary layer used in NCEP Medium Range Forecast Model (MRF scheme) and (ii) the local scheme based on turbulent kinetic energy (TKE) formulation (BT scheme).

In case of low pressure area over Gangetic West Bengal, during first 24 hours of the integration period rainfall amounts predicted by MRF scheme were higher by 6-8 cm as compared to BT scheme. The location and amount of the heavy precipitation with the MRF scheme were closer to the India Meteorological Department's station reports.

In next 24 hours of the model integration MRF scheme produced rainfall closer to observation compared to BT scheme. In case of super cyclone of Orissa, 1999, the results showed that a more intense system is predicted by MRF scheme compared to BT scheme. At the time of landfall, MRF scheme shows decrease in intensity which was in good agreement with the observations. However, BT scheme produced intense system during this period. Although the circulation features were well predicted by both the schemes, the characteristic wind structure like eye and strong gradients to the right to the centre was well brought out by MRF scheme on 3rd day. On the 4th day BT scheme showed much stronger winds than 3rd day that was against the observations in which the intensity of the system hook like structure of rainy area which was a special feature of the tropical cyclone. Associated with this cyclone very heavy rainfall was reported over the coastal stations of Orissa on 30 October. Both the schemes under-predicted rainfall on 4th day, however, MRF showed a better inland shift of the rainy area.

The sensitivity to two cumulus parameterization schemes viz., Kain-Fritsch scheme and Betts-Miller-Janjic scheme were studied using Advanced Regional Prediction System (ARPS) model. Two sets of forecast fields were obtained using input data of a low pressure area, monsoon depression and two tropical cyclones during 1998 over Indian region. The model produced fields of MSLP, wind, rainfall, temperature, moisture etc. were examined. Both the schemes produced well the explicit rainfall at and around the disturbance location, and convective rainfall at and around the disturbance and also away from the disturbance. Inland shift of rainy area was well produced by both the schemes but location and amounts were better produced by Betts-Miller-Janjic scheme. In case of simulation of May cyclone over Bay of Bengal, Kain-Fritsch scheme convincingly produced better rainfall structure compared to Betts-Miller-Janjic scheme. It was found that temporal variations of equivalent potential temperature (θ_e) and cloud water mixing ratio (q_c) values at the three locations, produced by both the schemes are consistent with the known thermo dynamical behaviour of these parameters during the rainfall production.

Extended Range Weather Prediction Research

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

Evaluation of coupled climate model simulations under IPCC, AR4

Climate Modelling groups around the world have been performing an unprecedented set of coordinated 20th through 22nd century climate change experiments designed under the Intergovernmental Panel on Climate Change, Fourth Assessment Report (IPCC AR4). In order to assess the ability of the global models in simulating 20th century climate the coupled model outputs were examined in simulating the summer monsoon rainfall over India vis-à-vis the annual cycle, spatial rainfall patterns

and the inter-annual variability. Simulations were evaluated against observations. Analysis of outputs of 20 models revealed that the gross features of the monsoon rainfall are well captured by the climate models.

Relationship between MJO and monsoon breaks

Relationship between monthly MJO index and duration of the break days in July and August was carried out for 22 years (1979-1997). From the analysis, it was seen that MJO activity in the month of August and duration of the break period showed an inverse association and the relationship was significant at 1% level i.e. when the MJO activity is less than normal then the duration of "break" is large and subsequently the Indian summer monsoon rainfall is less during that period over the central parts of India. The study wais found to be useful for understanding the break monsoon condition, and for the intra-seasonal prediction of monsoon rainfall.

The correlation analysis between the pentad NAO index and the number of break days in July and August (as this period is more prone for the break monsoon condition) was carried out for the period of 48 years (1950-97) (Fig. 4).

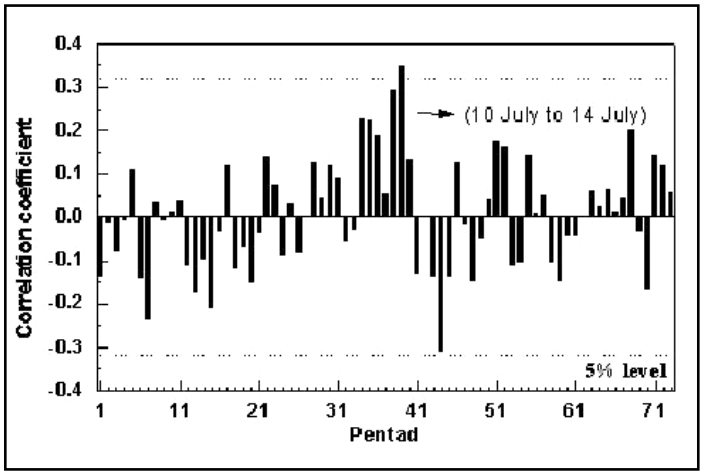


Fig. 4: Relationship of NAO pentad with number of break days in July for 1950-97.

The 39th pentad NAO (10 July to 14 July) showed a significant direct relationship with the number of break days in July. This suggested that during the positive phase of NAO the number of break days are more, and vice versa. The pentad values of NAO index were correlated with the 500-hPa pentad height anomalies at each grid point over the region 20° -40°N and 60° -90°E. The analysis for drought years 1987 and flood year of 1988 is depicted in (Fig. 5).

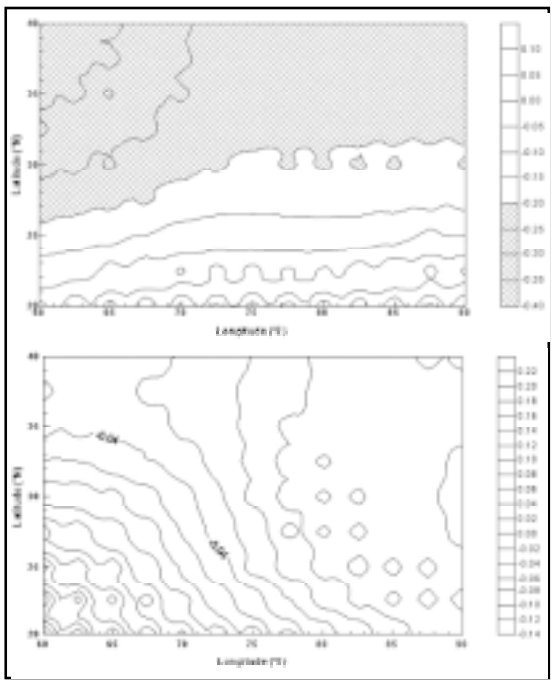


Fig. 5: Correlation coefficients of NAO and 500hPa geo-potential height anomaly for 73 pentads for 1987 and 1988.

It is seen that during the drought year (1987), there was a significant inverse association between them, and the relationship was extended up to 20°N and sometimes even beyond that latitude. Due to this, intrusions of extra-tropical westerlies are seen resulting in the prevailing break monsoon condition over Indian subcontinent. In excess monsoon year (1988), no significant relationship was seen.

Use of OLR in forecasting of summer monsoon rainfall

The interannual variability of satellite derived outgoing longwave radiation (OLR) over the tropical Pacific and Atlantic regions was examined in relation to the Indian summer monsoon rainfall using 25 years (1974–2001) of data. A strong and significant north–south dipole structure in the correlation pattern was found between the Indian Summer Monsoon Rainfall (ISMR) and the OLR field over the west Pacific region with highly significant negative (positive) correlations over the South China Sea and over the north-east Australia during January. During the month of May,

the OLR over the central Atlantic Ocean showed a significant positive relationship with the ISMR. These relationships were found to be consistent and robust during the period of analysis and hence can be used in the prediction of the ISMR. Using these results a multiple regression equation was developed for prediction of the ISMR and the empirical relationships were verified using an independent data set. The results were encouraging.. The composite annual cycle of the OLR, over the west Pacific region during extreme ISMR was found to be useful in the prediction of extreme summer monsoon rainfall conditions over the Indian subcontinent.

Using two OLR predictors, one located over south Indian Ocean during April, and the other over Head Bay during May, a multiple regression model was developed for the prediction of ISMR for 2004 model was developed with training period 1974-1994 and test period 1995-2004. The forecast of monsoon rainfall of India for 2004, using this model was 832.40 mm (about 2.3 % below normal).

Low pressure systems during monsoon

Transient disturbances like low pressure areas, monsoon depressions and cyclonic storms which formed over Bay of Bengal and moved across the monsoon trough region over India were studied for six southwest monsoon seasons of 1997 to 2002. Out of the total 52 low pressure areas which formed over Bay of Bengal 18 intensified into depressions or storms. Out of these, six depressions and two storms were observed to have a very long life period and very long tracks. Five of these depressions merged with the monsoon trough over different subdivisions of northwest India. A well marked low pressure area which formed on 21 June, 2002 also had a very long life and track. These systems caused very heavy rainfall over different sub-divisions of the northwest India. Such rainfall activity is likely to develop intense secondary heat sources due to latent heat release in association with organized cumulus convection due to the synoptic scale disturbances. Hence an analysis of the wind field was carried out using daily NCEP data at 850, 500 and 200 hPa levels for selected systems to study the regional circulation over India in relation to the synoptic scale disturbances which caused weekly excess rainfall over subdivisions of northwest India. The results show that the regional scale monsoon circulation over India was disturbed subsequent to the events of anomalous heavy rainfall activity over northwest India. Systems which have moved from the Bay of Bengal across the monsoon trough, keeping a more southward track caused such anomalous heavy rainfall events.

Studies on monsoon and Tropical weather Systems

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

Intraseasonal variability of southwest monsoon

Estimation of daily apparent heat source and apparent moisture sink over Indian region for four southwest monsoon seasons of 1997, 1998, 1999 and 2002 was completed. Analysis of the synoptic conditions and rainfall distribution over India showed a large intraseasonal and interannual variability of circulation and rainfall in these four seasons. Events of development of secondary diabatic heat sources over northwest India were observed in these seasons due to latent heat released in association with cumulus clouds organized by synoptic systems of active monsoon phases. This caused a reversal of the east-west heating gradient across the monsoon trough. The diabatic heat source and adiabatic warming in its surrounding region due to increased subsidence together led to development of an anticyclone over monsoon trough region at 500 hPa. Following such incidences monsoon evolved into weak or break phases over India.

Regional scale circulations over India were studied during three normal monsoon seasons of 1997, 1998 and 1999 and the deficient monsoon season of 2002. It was observed that during these years the low pressure systems intensified into a depression in presence of strong low level cyclonic vorticity and deep moist layers of atmosphere over Bay of Bengal only when the middle tropopsheric atmosphere of western India was relatively dry and had deep layers of subsidence. For 1997, in presence of such an in-phase relationship five depressions and one cyclonic storm

were formed over the Bay of Bengal while in absence of such circulation features none of the low pressure systems intensified in to a depression during monsoon 2002. It was also noted that during monsoon 1999 due to frequent passage of extra-tropical eastward moving systems, across northern latitudes of the country, the tracks of the depressions were obstructed and the systems were mostly confined to the east of 80°E. However, during monsoon 2002, abnormally large number of such systems passed across the western Himalayan-Tibetan region and as a result, monsoon low pressure systems which formed over Bay of Bengal took more southerly tracks without intensification over Bay of Bengal.

The characteristic features of two depressions, having dominant westward and northward component of movement over central India formed during July and August, 1989 respectively, were compared through the analysis of their wind field, associated rainfall and kinematic parameters such as relative vorticity, divergence and moisture flux based on NCEP/NCAR reanalysis data at 850 hPa. The analysis showed that the zone of maximum rainfall and positive rainfall tendency lie in the southwest quadrant of the July system while these zones lie in the northwest quadrant for the August system. It was also observed that the significant difference in the behaviour of the two systems was mainly in respect of their strength of the wind field, track of movement and moisture supply.

Analysis of BOBMEX-1999 data

Time-series Vaisala mini-radio sonde observations of vertical temperature profiles taken during stationary periods (Phase I and II) of ORV Sagar Kanya ship at 17.5°N and 89.0°E during BOBMEX-99 were analysed. The results showed that the lower and middle troposphere was warm and humid during active Phase (Phase I) while it was relatively cool and dry during weak monsoon Phase (Phase II) of the experiment. Daily Grid-point NCEP data over the Bay of Bengal were used to compute vertical velocity (ω) at 850 and 500 hPa levels during these two Phases. The analysis of y-t sections of ω along the longitude of stationary location of Sagar Kanya showed two prominent zones of upward motion, one associated with induced eastward moving cyclonic circulation / lows due to mid-latitude troughs in westerlies and the second belt associated with westward moving monsoon systems in the continental TCZ extending over the Bay of Bengal. These two belts are separated by a zone of descending motion or subsidence. It was observed that, in general, at 500 hPa, the belt of strong upward motion in the continental TCZ is located at Sagar Kanya latitude during the active period (Phase I) of BOBMEX -1999. This zone was observed to shift southward in the weak monsoon situation (Phase II) due to increased descending motion over the trough region in response to intense upward motion of the eastward moving systems across Nepal and adjoining Himalayas.

An alternative method was developed to estimate latent heat flux (Q_E) under unstable atmospheric conditions, in absence of moisture measurement. Based on the surface marine meteorological observations taken during the stationary periods of BOBMEX-99 at ORV Sagar Kanya ship, a regression relationship is developed between the Bowen Ratio (B) as a dependent variable and the sea-air temperature difference (ΔT) as an independent variable. The relationship was found to be significant at 0.1% level over the region of Bay of Bengal. Using this relationship, the latent heat flux Q_E was estimated with the known values of Q_H and the estimated values of B through the regression equation. A good agreement was seen in the observed and the estimated fluxes of Q_E at Sagar Kanya. The developed regression equation was then used to compute the fluxes using independent data of a moored buoy deployed by the National Institute of Ocean Ttechnology, Chennai, near the ship in the north Bay of Bengal during the same period where the humidity observations were not available. The estimated fluxes at the buoy were in good agreement with the observed fluxes at Sagar Kanya in prevailing synoptic weather conditions. This method is found to be very useful to estimate Q_E in absence of moisture measurements, which is an important parameter for the air-sea interaction studies.

Energetics of global circulation

Based on NCEP/NCAR reanalysis data, kinetic energy and momentum transport of waves 0 to10 at 850 hPa level were computed from monthly mean zonal (u) and meridional (v) components of wind from equator to 90°N. The analysis was carried out for the period from 1958 to 1997 (forty years) and for the winter

months January and February. Fourier technique was used to resolve the wind field into spectrum of waves. Correlation analysis between All India Summer Monsoon Rainfall (AISMR) and energetics of waves indicated that the effective kinetic energy of waves 1, 3 and 4 around 40°N in February has significant correlation (.1%) with AISMR. A simple linear regression equation between the effective kinetic energy of these three waves and AISMR was developed and tested on an independent data of next seven years (1998-2004). Predicted AISMR was found to be in close agreement with observed AISMR. The extreme year 2002 was very well predicted. The regression equation based on the dynamics of the planetary waves was thus found to be useful for Long Range Forecasting (LRF) of the AISMR.

Fig. 6 shows the stream function charts for composite of good monsoon years (1961, 1975, 1983 and 1988) and composite of drought years (1972, 1979, 1982 and 1987) for the month of February. A feeble trough in westerly encored over the region between longitudes 40°-120°E and latitudes 65°-70°N for composite of good monsoon years is seen. Contrary to this, a deep trough in westerly is seen over the same region for composite of drought years. The intense trough causes southward transport of cold air over the Indian region. This results into large accumulation of snow over Himalaya during winter which affects the performance of subsequent monsoon.

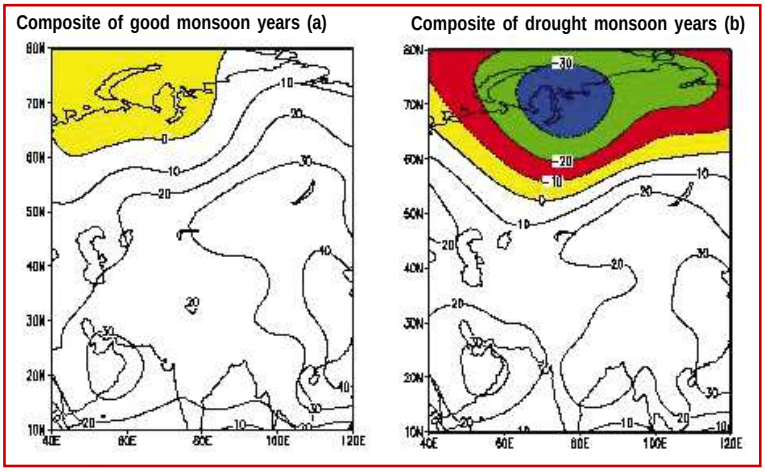


Fig. 6: Stream function field at 850 hPa (February) for (a) Good Monsoon and (b) Drought year

Secondary Satellite Data Utilization Centre

The satellite cloud imageries received daily at the Secondary Data Utilization Centre (SDUC) were displayed and archived for weather updates. The onset, advance and established phase, as well as withdrawal of monsoon 2004 were monitored. The pictures were utilized for the in-house "Current Weather Discussions" of Monsoon 2004. Post monsoon systems, viz., a cyclonic storm formed in north Arabian Sea (1-3 October, 2004) and a depression formed in Bay of Bengal (2 October, 2004) were monitored. The western disturbances that moved over Western Himalayan and Tibetan region with the associated deep southward penetration of troughs in the westerlies which caused rainfall and cold weather conditions over Indian region were observed using the satellite imageries.

Satellite Meteorology and Applications of Satellite Data in Weather Forecasting

(P.N. Mahajan, P.L. Kulkarni, D.R. Talwalkar, S.K. Sinha, R.M. Khaladkar, S. Nair, S.G. Narkhedkar, M. Mahakur)

Monsoon studies using satellite data

Southwest monsoon 2004 was unusual and erratic in nature during its initial phase i.e. from 1 June to 7 July, 2004. It was seen that there was overall simultaneous occurrence of lows, well mark lows, depressions and deep depressions over the Arabian Sea and the Bay of Bengal (Fig. 7). It gave rise to persistent convective activity along the west and the east coasts of India during initial phase of monsoon. This caused subsidence of air mostly in the central

Fig.7 : Homoller Diagram of Sat-Imagery during 01 - 18 June, 2004

part of peninsular India generating a swath, which was not favorable for rainfall activity. In the similar way, occurrence of quasi-stationary major convective activity over northeast India and development of blocking high off northwest India created a swath of deficient rainfall over central and north India. In support of these major convective activities mean vertical velocity computed utilizing NOAA-CIRES.

Climate Diagnostics Center data in the domain 60° - 100°E and 5°S - 35°N for the period 1 June to 7 July, 2004 showed maximum mean omega values of the order of - 0.08 Pascal/s off west coast and central Bay. In a similar manner, deep convection with vertical velocity - 0.12 Pascal/s persisted in northeast India. In response to maximum vertical velocity in the convective region, minimum vertical velocity due to subsidence was generated in the region of swath by Walker circulation and even relative humidity (Fig.8) in this region was minimum as compared to the surrounding region over the country vide a tongue of humidity minimum along 80°E and between 10°-25°N. This was exactly matching with the swath of deficient rainfall over the Indian region during 1 June to 7 July, 2004.

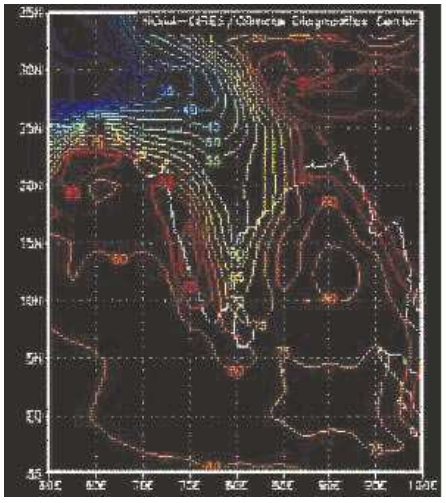


Fig.8: Mean Relative Humidity during 01-07 July, 2004

Simultaneous existence of well organized cloud clusters off west and east coasts of India associated with the development of offshore trough and low pressure systems created major swath of deficient rainfall, leading to the longitudinal bifurcation of clouds over India during initial advancement of monsoon 2004. Vertical velocity computed based on NOAA-CIRES Climate Diagnostic Center data in the domain (5°S-35°N, 60°-100°E) for June, 2004 highlighted maximum vertical velocity -0.08 Pascal/S in the region of major convective activity off east and west coast of India. In response to maximum vertical velocity due to subsidence was generated in the region of swath by Walker circulation and it was found to be exactly matching with deficient rainfall region.

Dynamics of monsoon onset phase

Dynamics of early onset of monsoon in 1997 and 2004 (16 May, 1997 and 14 May, 2004 over Andaman Sea and on 8 June, 1997 and 18 May, 2004 over Kerala) were studied using NOAA OLR data and NCEP/NCAR reanalysis data for u-, v- fields at 200 and 850 hPa and also the temperature data at 200 hPa. Results revealed that the rainfall (release of latent heat) over Indian region during early May has lead to strengthening of circulation both in the lower and upper troposphere indicating an increase in KE. A deep convection between 25°-30°N, 80°-100°E at the same period has lead to the upper tropospheric warming over Tibet, resulting in the temperature pattern at 200 hPa in May becoming similar to that of the August pattern in both the cases. This became favourable for the equatorial convection to move northward. Three to four days before the onset, the intense equatorial convection became the major source of energy leading to readjustment of meridional pressure gradient, and the formation of a low pressure system at the surface over Bay leading to onset over Andaman Sea. In 1997 shifting of the warmest core and convection to the east of 100°E after the onset caused a delay in the advancement of monsoon over Kerala, whereas in 2004 the shifting of warm core to 60°E caused the monsoon advancement and onset over Kerala on 18th May.

Objective analysis scheme for rainfall

An objective analysis scheme of daily rainfall over Maharashtra by distance weighting method on a mesoscale grid was developed. Barnes Scheme was applied to interpolate irregularly distributed daily rainfall data on a regular grid. Spatial resolution of the interpolated arrays is 0.25° latitude x 0.25° longitude. A case of typical westward moving monsoon depression during 1994 monsoon season was chosen for this

study. The objectively determined constraints employed in the study were (i) weights are determined as a function of data spacing (ii) in order to achieve convergence of the analysed values, the number of passes through the data is fixed and (iii) grid spacing is objectively determined from the data spacing. Root mean square errors and mean absolute errors were computed and found to be reasonably low.

The wind and height fields produced by a 2-Dimensional numerical variational analysis scheme and a 3-dimensional numerical variational analysis scheme were examined to study the energetics of a monsoon depression which formed over the Head Bay of Bengal during July, 1991. Different energy and conversion terms were computed. The analyses of these terms showed that they are well in accordance with the prevailing synoptic situation over Indian region. The influence the of the analysed upper and lower tropospheric temperature fields on the energy terms in generation of the kinetic energy and maintaining the circulation patterns were studied critically. It was observed that during the period of depression the north-south temperature gradient was prominent at upper levels. Association of these energy terms with the intensity of convection was examined through OLR data. Results indicated that there exists a process of conversion from available eddy potential energy to eddy kinetic energy with the intensification of the system.

Air-Sea Interactions in Tropical Monsoons

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

Comparison of air-sea interface processes over the East Central Arabian Sea at Onset phases of monsoons MONEX-79 and ARMEX-2003

Special Field Experiments were conducted over the East Central Arabian Sea (ECAS) during two contrasting monsoon years 1979 and 2003. Percentage departure of All India Summer Monsoon Rainfall (AISMR) was -13% in 1979 and +2% in 2003. During these two years the onset of monsoon over Kerala delayed by 13 days in 1979 and 8 days in 2003 from its normal date i.e. 1 June. Further, an onset vortex was formed on 14 June, 1979, whereas, it was not formed during 2003. It was observed that a Mini Warm Pool (MWP >SST ≥30.5°C) formed over an area 10-12°N, 68-72°E and 12-14°N, 62-66°E in the ECAS in 1979 and 2003 respectively (Fig. 9a and 9b). This MWP was stronger in 2003 (SST=31.5 °C) but far away from the west coast than in 1979 (SST=30.8°C) which was very close to the west coast of India. Analyses of the low level (850 hPa) circulation and the ship born meteorological observations showed that there exists a predominant and steady northerly flow over the ECAS during the first week of June during both the years. This flow dominated the southerly and southwesterly winds and prevented the occurrence of onset process for many days. Hence, a delay in monsoon

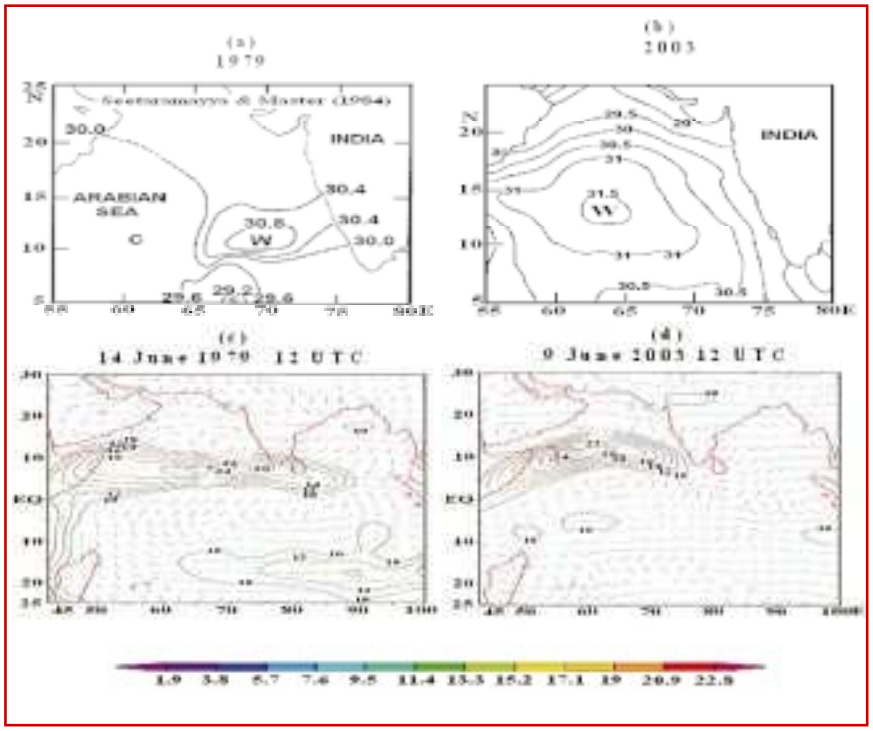


Fig. 9 : Comparison of air-sea interface processes over the East Central Arabian Sea at onset phases of monsoons MONEX-79 and ARMEX-2003

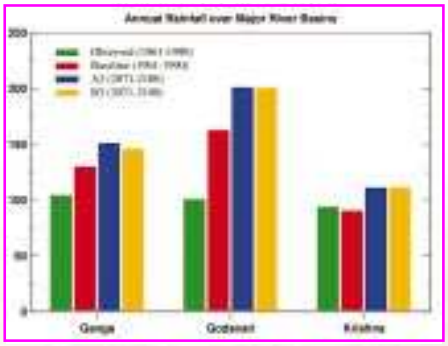
in these years was seen. The low level jet (LLJ) was stronger in 2003 (20 m/s) than in 1979 (18 m/s) on the respective dates of onset. An east-west cyclonic shear line was noticed on the northern flank of LLJ in both the years in coherence with the MWP but along 12°N and between 65° and 70°E during 1979 (conducive for development of onset vortex). This east-west cyclonic shear line was along 15°N and between 45° E and 60°E during 2003 which was not conducive for the development of the onset vortex in spite the existence of the MWP (Fig. 9c and 9d). The fluxes of heat and moisture computed from the ships' observations revealed that the transfer of heat energy from the ocean to the atmosphere during the above period was remarkably low and steady during 2003 which inhibited the local convection development over the warm pool.

Characteristics of marine atmosphere over the southeast Arabian Sea during ARMEX-2003

A very high resolution radiosonde data collected on board ORV Sagar Kanya during ARMEX-2003 (Phase II) during 1-10 June, 2003 was used to study the evolutionary changes in the marine atmosphere i.e. boundary layer at the time of onset of monsoon over Kerala. SST (Sea Surface Temperature) was nearly constant at 30°C throughout the study period. At the time of onset though significant change in SST was not seen, the atmospheric response was seen in other surface meteorological parameters such as reduction in air temperature by 3°C, increase in RH (relative humidity) by 20%, increase in mean wind speed from 6 m/s to 12 m/s backing of winds from westerly - northwesterly to southwesterly after the onset. The significant changes were also noticed in the upper atmospheric conditions at the time of onset. Multiple cloud layers were observed up to 7 June and the atmosphere was found to be well mixed with increase in moisture at lower levels on 8 June. The increase in moisture at the higher levels was attributed to the penetration of the deepest clouds through the inversion. The height of LCL (Lifting Condensation Level) is reduced from 443 m on 7 June to 176 m on 8 June. Reduction in CAPE (Convective Available Potential Energy) after onset was attributed to the moist convection. Zero value of CINE (Convective Inhibition Energy) from 8 June onwards has indicated the existence of super adiabatic layer near the surface with positive buoyancy at the LCL.

A case study of the prevailing marine meteorological conditions in relation to a moving tropical cyclone during 19-30 September, 1997 formed over the Bay of Bengal was made using three hourly marine meteorological data from three buoys DS4, DS5, SW7 (deployed in the Bay of Bengal), satellite imageries and the surface synoptic meteorological charts during the period from 19 September, to 30 September, 1997. The track of this cyclonic storm was found to be quite rare and it moved north east ward parallel to east coast of India (within 1° from the coast line). This study brought out the changes in both the atmospheric as well as the oceanographic parameters. All the three buoys responded when the system approached close to their locations. The salient features at the buoy sites noted were (i) during intensifying phase SST at DS4, DS5 and SW7 had fallen by 1.5°C, 1°C and 2°C from their initial values 31°C, 30.5°C and 31°C respectively, (ii) the air temperature was reduced by 3.5°C, 3°C and 4.4°C respectively following the convective activity, (iii) mean sea level pressure attained the lowest value of 995 hPa, (iv) during the initial stages the wind speed was 6 m/s, increased to 10 m/s during the developing stage and showed a steep rise to 19 m/s with the intensification of the system, (v) the OLR showed high values in the initial stages (240-280 W/m^2), systematic fall (140-180 W/m^2) and drastic fall to a minimum of 120 W/m^2 in cloudy conditions, (vi) the RH was > 80 % (< 60 %) at 850 and 700 hPa (500 hPa) on 23, 24, and 25 September respectively, (vii) the steering current at 500-200 hPa with the formation of troughs and ridges maintained an eastward movement and made the track parallel to the Andhra coast and the system did not cross the Andhra-Orissa coast at any place between Machallipatnam and Paradip.

Climatology and Hydrometeorology



Climatology and Hydrometeorology Division has formulated its research programmes with broadly addressing the following targeted objectives :

- To construct long homogenous time series of regional climatic elements from observed meteorological data, and to study their interannual and decadal variability on different space scales.
- To extend the observed climatic record back to the pre-instrumental era, using high-resolution proxy sources such as historical documents, tree rings, etc. and study the regional climate variability on centennial scales.
- To bring out the regional aspects of global climatic change, in terms of seasonal / annual mean climatic patterns as well as the severe climatic and weather events.
- To assess the numerical simulations of global climate with particular reference to the simulation of the Indian summer monsoon by means of model output diagnostics and to apply appropriate empirical/dynamical downscaling techniques to develop high-resolution future climate scenarios for the Indian region.
- To bring out regional/global teleconnections and develop empirical techniques for the prediction of seasonal / monthly climatic anomalies over the country as a whole and homogenous subdivisions of the country.
- To assess the impact of climate variability in various socioeconomic sectors like agriculture, water resources, human health, etc. and to develop methodologies for an optimal utilization of climatic information in these sectors.
- To carry out hydrometeorological analysis of short-duration rainfall data over various river basins of the country for application in water resources management.
- To carry out estimation of probable maximum precipitation analysis of the depth-area-duration of severe rainstorms and to provide inputs for the estimation of design parameters of hydrological projects.
- To understand the changes in rainfall patterns and hydrologic regimes and their possible association with global warming.

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, S. Ram, K. Kamala, K. Jagdeesh)

Development of high-resolution regional climate change scenarios using PRECIS

Several simulation experiments using the latest version of Hadley Centre Regional Climate Model PRECIS (**P**roviding **RE**gional **C**limates for **I**mpacts **S**tudies) were performed for the South Asian domain, to generate the regional climate for the baseline (1961-1990) and a future period (2071-2100) under two different socio-economic scenarios. A total of ten model simulations with a resolution of 50 km x 50 km were performed, including three ensembles of baseline simulations. The model was run both with and without including the regional sulfur cycle, to understand the role of regional patterns of sulfate aerosols in climate change. High-resolution regional climate change scenarios were developed for various surface and upper air parameters of critical importance to the impact assessments, for smaller spatial units (Fig. 10a and 10b) both on monthly and daily time scales, and also for intermediate time slices by pattern scaling. The scenario data products were distributed to several impact assessment groups in the country. This activity helped the Institute to develop expertise in regional climate modelling, and also emerge as a national and South Asian resource base for regional climate change scenarios. The Institute has been identified as a regional coordinating centre for the application of PRECIS in South Asia.

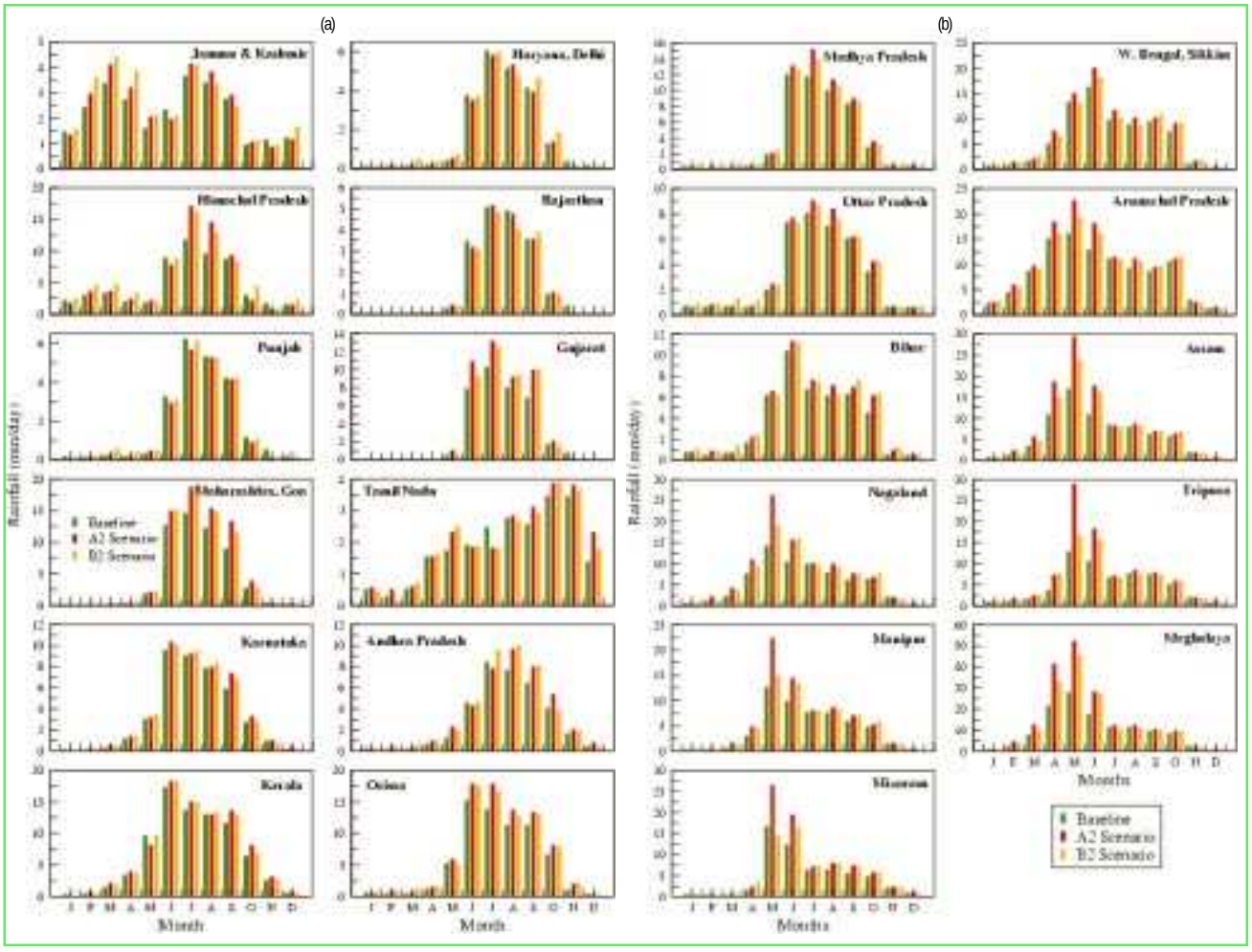


Fig. 10: Baseline and future projections (2071 – 2100) of the mean annual cycles of precipitation for different states of India, as simulated by PRECIS

Sensitivity of the Indian summer monsoon to anthropogenic climate change

The sensitivity of the Indian summer monsoon has been studied using the CNRM coupled atmosphere-ocean model. A range of time slice experiments was performed to bring out the role of the experimental design as well as model formulations such as sea-ice treatment, soil moisture feedback, radiative forcing, interannual variability, etc. The studies indicated that the experimental design can be a potential source for errors/biases in the model-based estimates of sensitivity on regional scale.

Seasonal forecasting of northeast monsoon rainfall and northwest India winter precipitation

As part of collaborative research between the Institute and the India Meteorological Department, concerted efforts were made to extend the development of seasonal forecasting strategies to northeast monsoon and northwest India winter precipitation. Teleconnections of northeast monsoon rainfall and northwest-India winter precipitation variability were studied to identify suitable predictors. Secular variations in the teleconnections were also analyzed.

The interannual variability of northeast monsoon rainfall (NEMR) over South Asia and its relationship with ENSO were studied using data for the period 1951-2000, with special focus on its secular variations. The concurrent correlations between NEMR and SST (OND) indicatd that the correlation coefficients (CCs) are almost zero over the central and east Pacific during 1951-76, whereas the CCs for the period 1976-2000 are statistically significant over the same region. This secular variation of the ENSO-NEMR relationship can be clearly seen in the 21-year sliding correlations of NEMR with Niño-3 index for the two seasons JJA and OND for the period 1901-2000 (Fig. 11).

Fig 11: Twenty one –year sliding correlation of NEM rainfall with NINO – 3 SSTs and SWM rainfall and of SWM rainfall with NINO – 3 SSTs

The composite circulation anomalies during the El Niño years of the period 1976-2000 were strikingly similar to those associated with typical excess NEMR years, and also suggesed anomalously higher levels of moisture convergence in the region. However, the El Niño composite of NEM circulation during the earlier period 1950-1975, has considerably weaker wind anomalies and also relatively weaker low-level moisture convergence over the region, and therefore the conditions did not seem to be favorable for good NEMR activity. Thus, while it has been conjectured by some recent studies that the relationship between ENSO and the Indian summer monsoon has been weakening over the past couple of decades, the present study indicates that the ENSO-NEM relationship has strengthened during the same period.

The northwestern parts of India receive considerable amount of precipitation during the winter months of December to March, mainly associated with western disturbances. Time series of the mean winter precipitation for Northwest India were prepared and for understanding the dominant modes of variability, SST, SAT, and upper tropospheric (200 hPa) zonal wind composite anomalies and correlation patterns were studied for India and neighborhood. It was found that the interannual variability of North-West India Winter Precipitation (NWIWP) is closely associated with the variability of sea surface temperature (SST), surface air temperature (SAT) and upper tropospheric (200 hPa) wind patterns over India and the surrounding regions. During the years of excess NWIWP, the SST was above normal over the equatorial Indian Ocean, SAT was below normal over east Mediterranean Sea and over the Himalayan region (Fig. 12a and 12b) and upper tropospheric westerlies strengthen and shift southwards. Upper tropospheric

westerlies over north and central India are found to be related with the SST anomalies over the equatorial Indian Ocean.

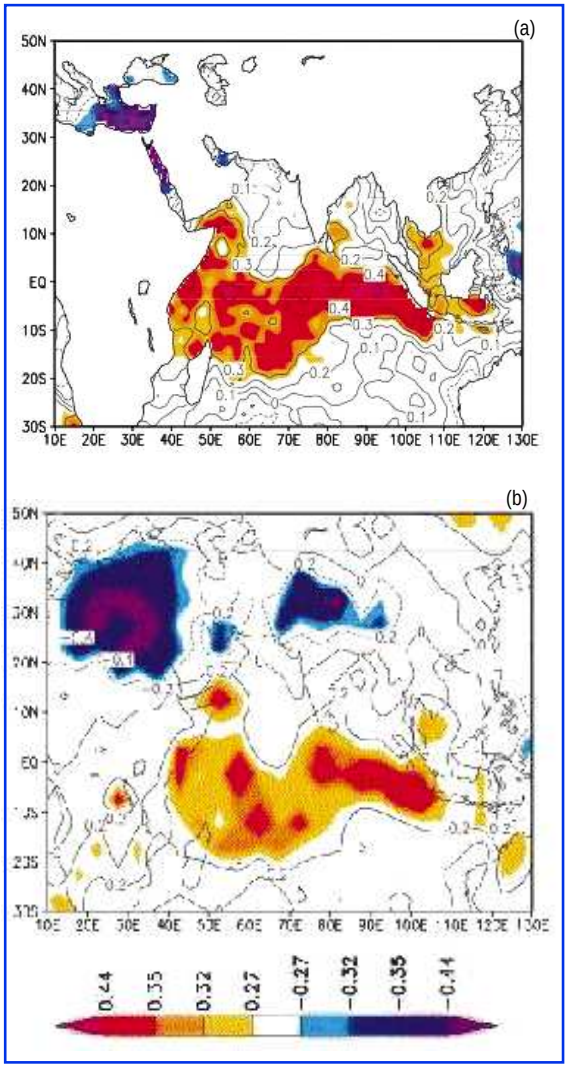


Fig. 12: Correlation of SST during December, January, February and March.

Changes in extreme climatic events

Historical trends in daily extremes of temperatures and precipitation over Indian region were studied for the period of 54 years during 1950-2003. For this purpose, daily maximum and minimum temperature data at 40 stations and precipitation data at 150 stations well-distributed over the country were analyzed. Globally standardized software called CLIMDEX, developed by the WMO Expert Team on Climate Change Detection Monitoring and Indices (ETCCDMI), was used. Using CLIMDEX, in-depth quality control was applied to all the stations, and the data awere tested and corrected for erroneous values, outliers and inhomogeneities. Seventeen extreme indices for temperatures and eleven extreme indices for precipitations were calculated and their long-term changes were examined. Similar analyses were also done on the simulations of the regional climate model PRECIS, to evaluate the model's representation of the extremes and to bring out the future scenarios of extremes in temperature and precipitation.

Recent changes in surface temperature trends over India

To identify the regional patterns of temperature variation within country, annual and seasonal temperature series for the period 1901-2002 were constructed for all-India and seven homogeneous regions. The trend analysis revealed that there is a marked turn-around in the trends in minimum temperatures, indicating that the recent accelerated warming over India is manifest equally in daytime and nighttime temperatures (Fig. 13).

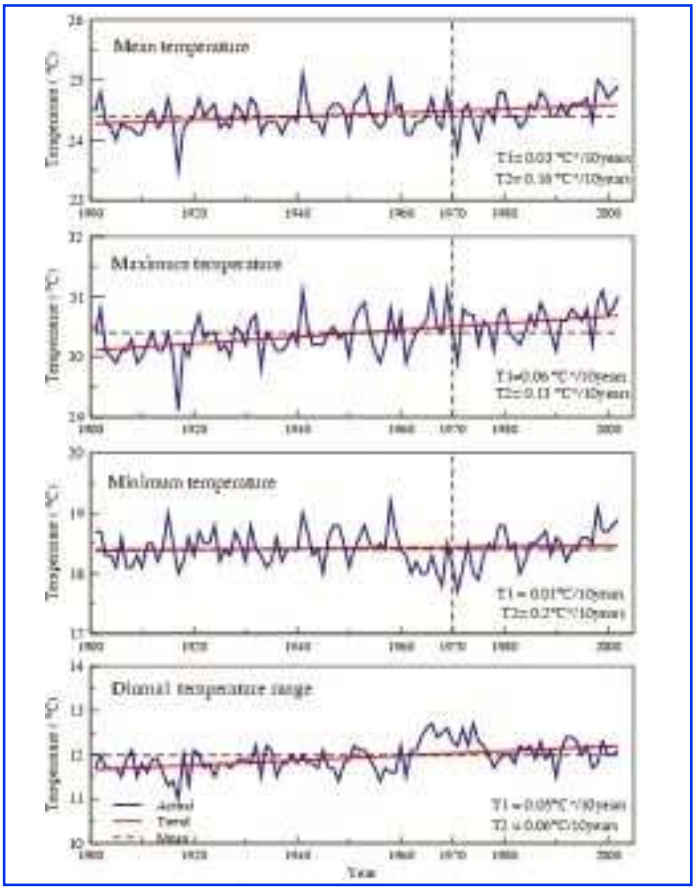


*Fig. 13: Variation of all-India surface air temperature (T1 –trend for 1901 - 2002, T2 - trend for 1971 - 2002, * significant at 5% level).*

Further, in a major shift, the recent period was marked by rising temperatures during the monsoon season, resulting in a weakened seasonal asymmetry of temperature trends noted earlier. During the recent period 1971-2002, for maximum temperature, the area under significant warming trend in all the seasons was notably reduced to that of the period 1901-2002, it was maintained or even increased in the case of minimum temperature (Figure 14a and 14b). The area under significant warming trend for monsoon minimum temperature was significantly increased during the recent period as compared with 1901-2002.

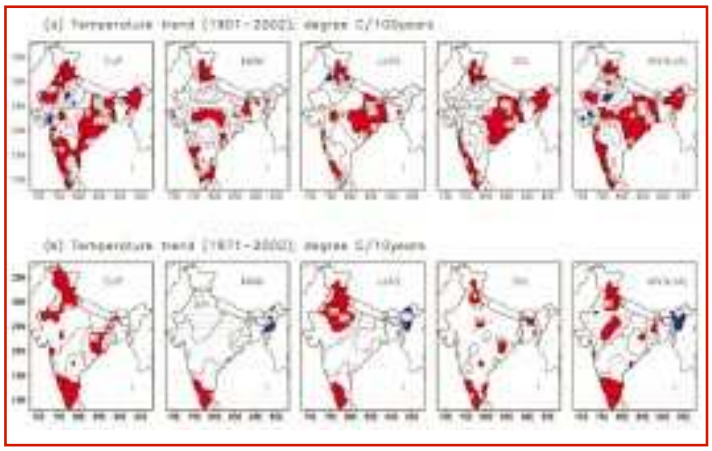


Fig. 14a : Spatial patterns of trend in seasonal maximum temperature (shaded areas indicate trends significant at 5 % level, red for warming and blue for cooling)

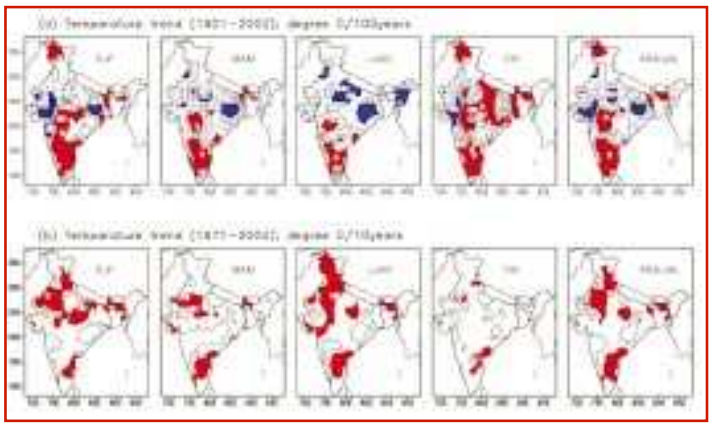


Fig. 14b : Spatial patterns of trend in seasonal maximum temperature (shaded areas indicate trends significant at 5 % level, red for warming and blue for cooling)

Dendroclimatological studies

Tree-ring data from Central India (Madhya Pradesh and Maharashtra State) were subjected to cross-matching and dating process followed by standardization of individual tree-ring series. Four tree-ring index chronologies have been developed. Preliminary dendroclimatic analysis indicated significant association of tree growth with pre-monsoon temperature and summer season rainfall. Tree-ring samples of teak (*Tectona grandis*) collected from Parambiculam, Kerala in January, 2004 were cross-matched and dated. The chronology goes back to AD 1494. Initial results indicated significant correlation with pre-monsoon (March-May) precipitation (Fig. 15).

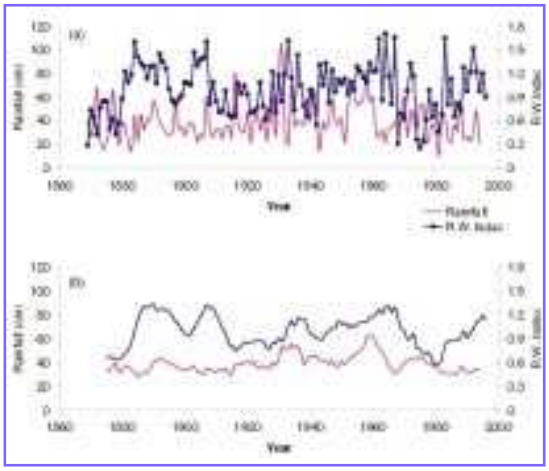


Fig. 15 : (a) Tree-ring variations in teak chronology at Parambiculam, Kerala and March - May rainfall of Kerala (b) low frequency variations.

Tree-ring chronologies from Himachal Pradesh and Uttaranchal analyzed so far showed moderately high dendroclimatic potential. The higher values of various statistics of these chronologies, such as mean sensitivity, common variance and signal to noise ratio indicated significant common signal, mainly due to climate, is available. Most of these high-altitude near-glacier tree-ring chronologies from Western Himalaya showed unprecedented surge in growth since 1930s. These did not show any other such significant episode of higher growth prior to 1930s (Fig. 16). This may be

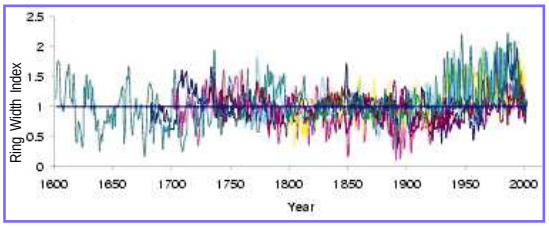


Fig. 16 : High altitude, near-glacier Tree-ring Index chronologies of Himalayan conifers from Himachal Pradesh, Western Himalaya, India

explained as an effect of winter warmth; over the Western Himalaya, winter (December - February) temperature showed increasing trend. Particularly after 1940, significant increasing trend was observed with more positive anomalies. A simple correlation between each of the chronologies with winter temperature of Western Himalaya was found to be statistically significant.

Tree-rings collection at Himachal Pradesh and Uttaranchal

Climate Applications Agriculture, Water Resources and Public Health

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

El Niño and the Indian summer monsoon

The relation between Indian summer monsoon rainfall and El Niño events was examined involving more than 130 years of observations. El Niño events with the warmest SST anomalies in the central Pacific closer to the dateline were found to lead to an enhanced subsidence over the Indian subcontinent resulting in droughts. On the other hand, the events with warmest SST in the Eastern tropical Pacific, alter the subsidence limb of the Walker circulation in a manner to circumscribe its reach over the Indian subcontinent, thereby having lesser impact on the monsoon rainfall. This hypothesis was corroborated using atmospheric general circulation model (AGCM) experiments forced with idealized tropical Pacific warmings representing the above two El Niño flavors.

Evaluation of coupled model forecasts of Indian summer monsoon

Performance of seven fully coupled models in simulating Indian monsoon climatology as well as the interannual variability was assessed using more than 2 decade long multi-member one-month lead hindcasts. These hindcasts were made by several European climate groups under the program called 'DEMETER'. It was found that the skills of monsoon predictions in these hindcasts are generally positive though they are very modest. It appears that large biases in the predicted SSTs in the ENSO region and the not so perfect ENSO-monsoon teleconnections are some of the possible reasons for such lower than expected skills in these coupled models.

Changes in the frequency of cyclonic systems during the summer monsoon

Analysis of sub-divisional monsoon rainfall during 1871-2003 indicated significant decreasing trend over the region comprising of eastern Madhya Pradesh/Chattisgarh and increasing trend over Andhra Pradesh (Fig. 17a). Yearly and decadal variations of the mean position of formation and landfall of monsoon depressions over the Bay of Bengal were a shift towards the southern latitudes, especially in the recent decades (Fig. 17b). Analysis also shows that there is considerable decrease in the frequency of cyclonic disturbances, that formed (or had landfall) north of 19.5°N (Fig. 17c). Hence, the decreasing trend in rainfall over eastern Madhya Pradesh and adjoining regions appeared to be due to decreasing trend in the frequency of occurrence of cyclonic disturbances over the Bay of Bengal. However, no significant increase was noted in the frequency of cyclonic disturbances over the region south of 19.5°N to explain increasing trend in rainfall over Andhra Pradesh.

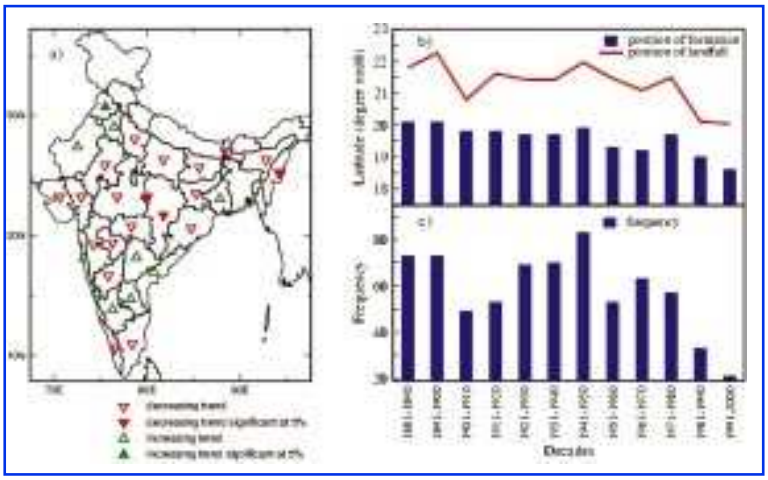


Fig. 17: (a) Trend in subdivisional monsoon rainfall (1871-2003) (b) Position of formation and landfall of cyclonic disturbances (c) Frequency of cyclonic disturbances.

Trends in the Indian summer monsoon rainfall

It is well known that the Indian summer monsoon rainfall is quite robust without any long-term trend during the last 120 years of observed record. However, in view of the importance of climate change in the recent decades, the all-India and macro-regional monthly rainfall data sets are subjected to trend analysis over the past five decades. Trend analysis revealed that after 1950, the June rainfall of all-India as well as northwest India, west central India, central northeast India and peninsular India showed an increasing tendency, whereas it is significantly decreasing over northeast India (Fig. 18). On the other hand, the July rainfall is significantly decreasing over all-India as well as over west central and peninsular India. Rainfall of August and September shows decreasing tendency over all-India as well as over northwest, west central and central northeast India. However, September rainfall is significantly increasing over northeast India.

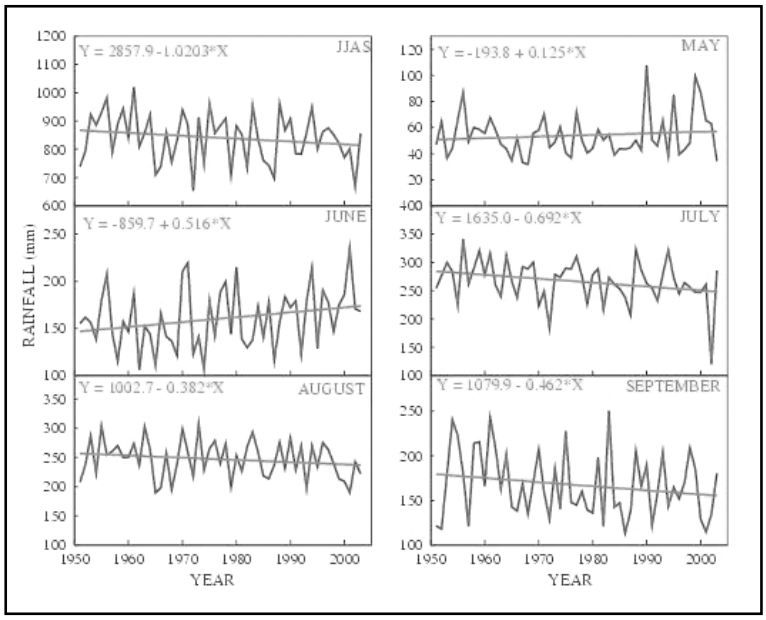


Fig. 18 : Trends in monthly all India rainfall from May to September and JJAS season.

Empirical approaches to seasonal forecasting of summer monsoon rainfall

Using monthly NCEP/NCAR reanalysis data on zonal wind, mean sea level pressure and surface temperature, a set of 73 predictors which are strongly correlated with Indian summer monsoon rainfall were identified. A regression model based on the best subset of these predictors explained 87% of the observed variability, and is able to hindcast the recent drought years successfully in an independent verification mode. It was observed that, with only six predictors, the prediction equation showed a multiple correlation coefficient of 0.93. The estimated rainfall in the El-Niño year of 1997 was -1.7% as against actual of 4.4%. The estimated rainfall deficiency in both the recent drought years of 2002 and 2004 was -19.5% and -8.5% as against observed -20.4% and -11.5% respectively. Prediction schemes were also developed for summer monsoon rainfall of the two meteorological subdivisions of Gujarat State.

Cloud radiative forcing and monsoon activity

Association between the monsoon rainfall activity and the cloud radiative forcing was studied using ERBE (Earth Radiation Budget Experiment) and ISCCP (International Satellite Cloud Climatology Project) data during the period 1985-1989 for the peak monsoon month of July over the Indian region. The changes noted in the cloud radiative forcing are found to be linked with the large-scale subsidence and enhanced convection associated with 1987 El Niño/ 1988 La Niña events respectively.

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

(B.N. Mandal, R.B. Sangam, B.D. Kulkarni, N.R. Deshpande, J.S. Pethkar, S.S. Nandargi, S.S. Mulye, S. Bhandare)

Hydrometeorological analysis over the Krishna river basin

Daily rainfall data for about 570 stations, for the period 1901-2002, in and near the Krishna river basin were compiled from different sources, for carrying out the Central Water Commission (CWC) sponsored project work on "*Preparation of*

generalized PMP Atlases for the Krishna and the Indus river basins". These data were subjected to various quality control checks and processed for their hydrometeorological analyses. Spatial patterns of mean seasonal, annual, highest 1, 2 and 3-day rainfall maps were analyzed for the Krishna basin as a whole (Fig. 19).

Using statistical techniques, estimates of point PMP (Fig. 20) and maximum rainfall of 25, 100, 500 and 1000-year return periods (Fig. 21) were made for each of the 570 stations for durations of 1, 2 and 3-day and generalized maps were also prepared.

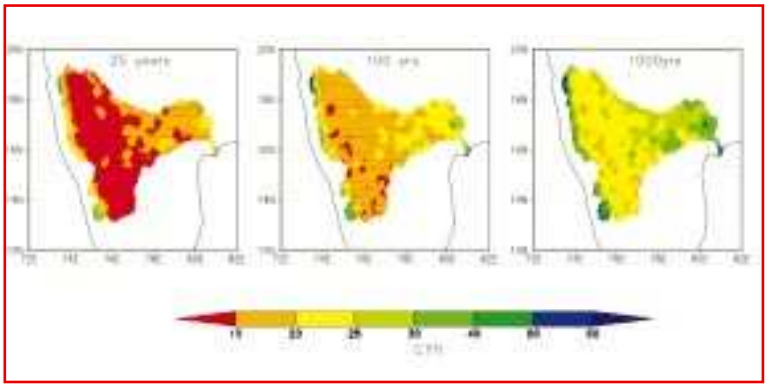


Fig. 19 : Extreme rainfall (cm) in the Krishna river basin

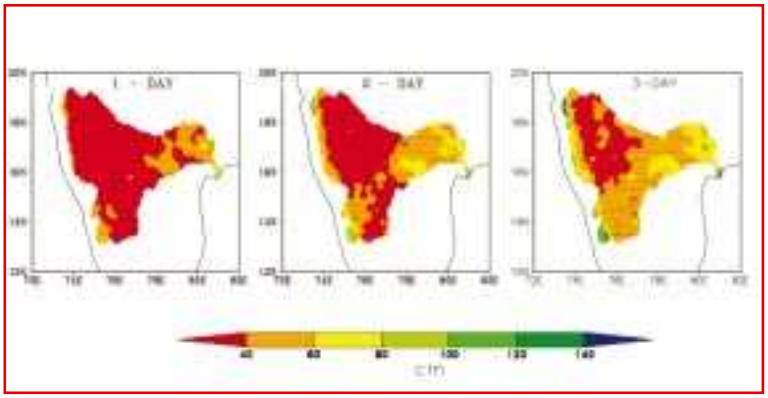


Fig. 20 : PMP (cm) over the Krishna river basin

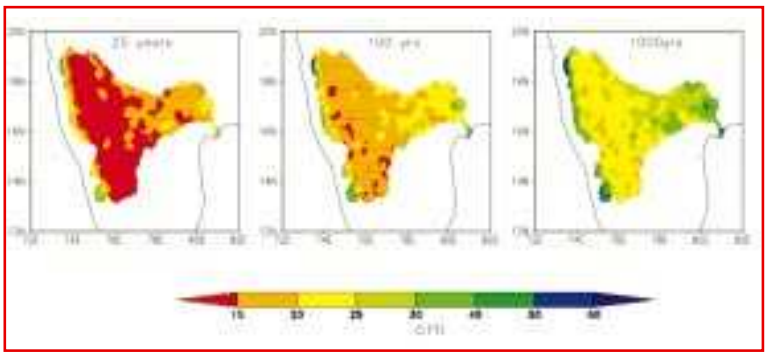


Fig. 21 : Estimates of maximum rainfall for 25, 100 and 1000 year return periods for 1-day over the Krishna basin

Application of hydrological routing algorithm to estimate river water discharges

A global hydrological routing algorithm (HYDRA) that simulates monthly river discharge and changes in surface water level, based on spatial patterns of monthly mean or daily runoff, precipitation, and evaporation, was applied over the Indian river basins. The IBIS (Integrated Biosphere Simulator) simulations of runoff were used as input to the HYDRA. Both HYDRA and IBIS were developed by the Centre for Sustainability and Global Environment (SAGE), University of Wisconsin, USA. The discharge data simulated by HYDRA using observed climate inputs from IBIS were evaluated with the observed discharge data at three sites, viz., Vijayawada in the Krishna basin for the period 1901-1994, Polavaram in the Godavari basin for the period 1901-1979, and Farakka in the Ganga basin for the period 1949-1973. The simulated and observed discharges were generally found to be in good agreement (Fig. 22).

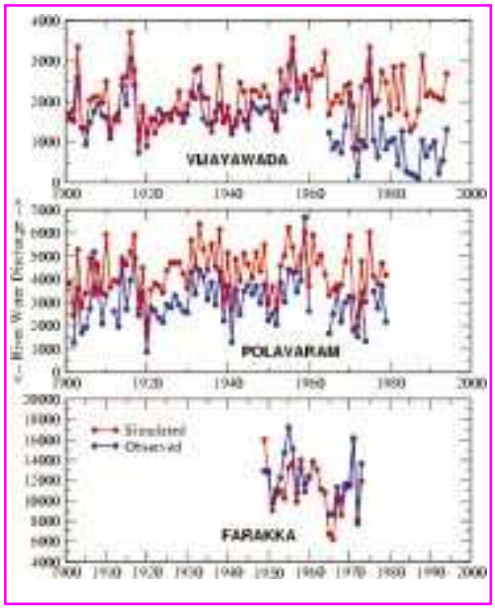


Fig. 22 : Comparison of observed and HYDRA simulated annual river water discharges (in m^3/sec.) at selected sites in three river basins (Krishna, Godavari and Ganga)

Hydrometeorological analyses of PRECIS simulations

To assess the impacts of climate change over three major river basins, viz., the Ganga, the Krishna and the Godavari, daily simulations data from the regional model PRECIS for the baseline (1960-1990) as well as the A2 and B2 scenarios for the future period 2070-2100 were used in hydrometeorological analyses. The regional model simulations of precipitation were evaluated in terms of seasonal/annual rainfall patterns as well as for generating extreme rainfall patterns over the above three major river basins (Fig. 23).

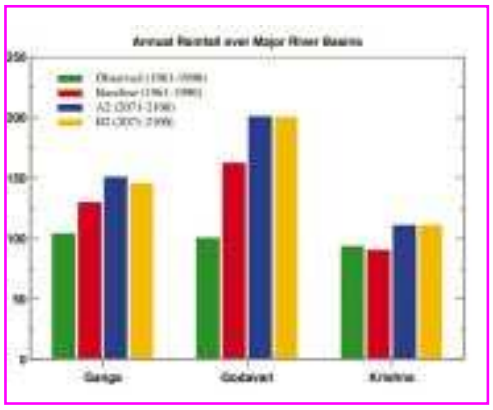


Fig. 23 : PRECIS simulation of present and future precipitation

Future changes in the spatial patterns in number of rainy days and intensity per rainy day under different scenarios have also been estimated (Fig. 24a and 24b). Future scenarios in the number of rainy days over the three basins indicated that over the Ganga basin, there is likely decrease in the number of rainy days in western side of the basin and increasing along the foothills and southeastern portions of the basin. In case of Godavari basin, decreasing tendency in the number of rainy days was noticed in the central part whereas increasing tendency was observed over western and eastern parts of the basin. In the Krishna basin portion falling over the Tungabhadra and Vedavathi sub-catchments located in the southwest portion of the basin showed decreasing tendency in the number of rainy days while rest of the area of this basin showed increasing trend. Rainfall intensity per rainy day is also likely to be changed towards the end of 21st century over the 3 river basins as projected by PRECIS model simulated data, indicating that all the 3 basins are likely to have an increasing tendency in rainfall intensity up to about 5 cm/day. Case studies on the occurrence of severe rainstorms in the future period (2071-2100) from the PRECIS simulated data revealed that rainstorms that would occur in future years over these 3 basins may have larger areal extent as well as higher intensity (Fig. 25).

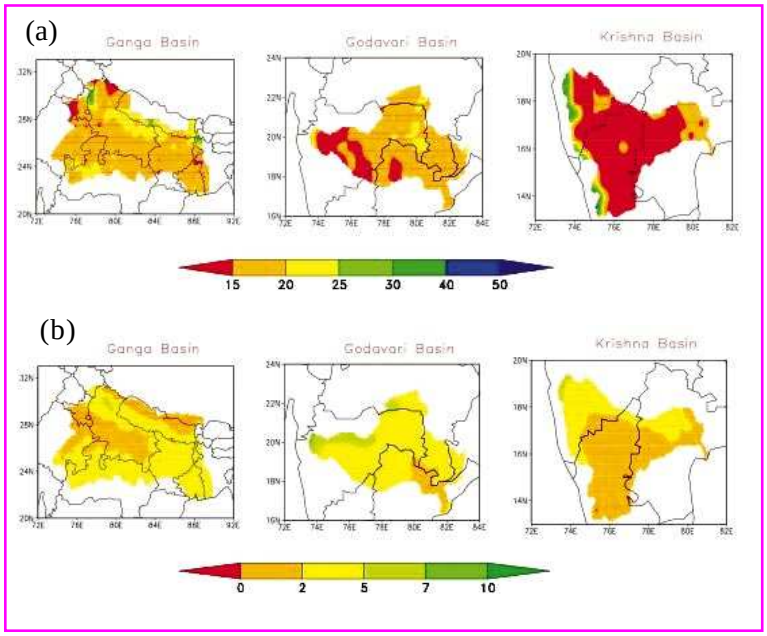


Fig. 24 : a) Observed intensity (mm/day) of rainfall on rainy days over three river basins. b) Future scenarios of change in intensity (mm/day) of rainfall on rainy days over three river basins

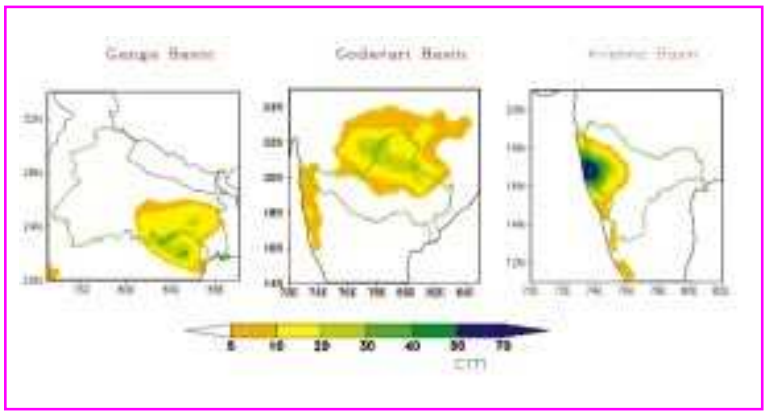


Fig. 25 : Future scenarios of rainstorms in three river basins (rainfall values are in cm)

Low flow estimation over the Krishna basin

Successful management of river water requires knowing how much water flows in a river and the factors that control the flow amount. The Krishna river is a rainfed river which dries up in the summer season facing to water scarcity. Keeping this in view, a case study of water availability in the lean period was carried out. Monthly Discharge data at 17 selected gauging sites in the Krishna basin were considered for the available period. Monthly and seasonal mean discharge values at various sites were estimated to study the temporal and spatial changes in the water availability. Year to year variations were considered to see the existence of any trend in the data series. Series of minimum monthly discharge data per year were constructed for all the sites considered in the study. These series were fitted with suitable statistical distribution to study the water availability in the dry season.

Hydrometeorological aspects of southwest and northeast monsoons of 2004

A catalogue of heavy rainfall amounts at 44 representative observatory stations and a few selected stations data from different sources was made for the year 2004 and compared with past similar data. A few notable rainstorms that affected over various regions of the country in 2004 monsoon were identified. Based on available data, a 2-day rainstorm of 3-4 August, 2004 over Gujarat and adjoining region was analyzed by DAD method. A few notable floods which affected the Indian region were also catalogued. A tentative estimate of water availability in 2004 over India was made and compared with last 10 years average based on discharge data.

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

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

Longest instrumental rainfall series over different river basins and physiographic divisions

Involving data from well spread 316 rainguage stations, the longest available instrumental monthly, seasonal and annual rainfall series were prepared for 11 major river basins, 31 minor river basins and 35 physiographic divisions of the country. For the individual basins areally representative rainfall series for the period 1901-2003 were prepared by averaging point measurements at all the raingauge stations of the selected network in the particular basin, and for the period prior to 1901 the series was extended backward by applying a theoretically vindicated objective technique on lesser available observations. For major basins the periods for which reliable rainfall series could be developed were: *Indus* 1844-2003; *Ganga* 1829-2003; *Brahmaputra* 1848-2003; *Godavari* 1826-2003; *Krishna* 1826-2003; *Sabarmati* 1843-2003; *Mahi* 1857-2003; *Narmada* 1844-2003; *Tapi* 1844-2003; *Mahanadi* 1848-2003; and *Cauvery* 1929-2003. The annual rainfall series of the full period is shown in Fig. 26 and some basic precipitation characteristics of

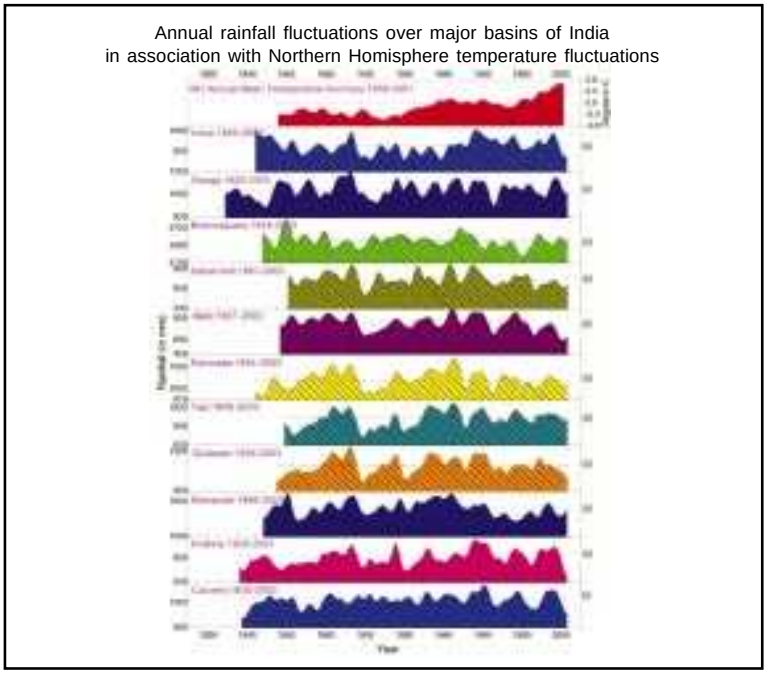


Fig.26 : Low frequency mode fluctuation (9 point Gaussian low pass filtered values) of annual rainfall over 11 major basins of the country during the longest period of instrumental records

the river basins are summarized in Table. Generally, in the recent period, the rainfall shows decreasing trend over Sabarmati, Mahi, Narmada, Godavari and Mahanadi, increasing trend over Indus, Brahmaputra, Tapi, Krishna and Cauvery and stationary over Ganga. A variety of graphical representations of the annual, seasonal and monthly rainfall series have also been prepared for the DST project on *"Atlas of spatial features of moisture regions and rainfall of India during 19th and 20th centuries"*.

Precipitation characteristics of major river basins in India

River Basin	Area (km^2)	PE (mm)	Annual Precip (mm)	Contribution to Annual (%)				Annual Rainy Days	Rainy Season		Wet Epochs	Dry Epochs
				Winter	Summer	Monsoon	Post-Monsoon		Dates	Duration (days)		
Indus	2,91,749	1390	860	10	12	72	6	42	26/6-17/9	84	1844-1894 1954-2003	1895-1953
Ganga	8,60,884	1455	1084	3	6	85	6	52	13/6-22/9	102	1854-1894 1914-1964 1993-2003	1829-1853 1895-1913 1965-1992
Brahmaputra	1,86,732	1147	2239	2	25	65	8	105	26/3-19/10	212	1848-1881 1910-1921 1946-1960 1988-2003	1882-1909 1922-1945 1961-1987
Godavari	3.30,628	1610	1068	2	5	84	9	57	10/6-7/10	120	1861-1895 1931-1963	1896-1930 1964-2003
Krishna	2,95,650	1670	826	1	10	70	19	51	14/6-17/10	126	1874-1903 1953-2003	1836-1873 1904-1952
Sabarmati	36,688	1677	743	1	1	95	3	35	18/6-18/9	93	1861-1898 1926-1959	1899-1925 1960-2003
Mahi	41,179	1653	836	1	2	93	4	40	15/6-19/9	97	1857-1898 1941-1963	1899-1940 1964-2003
Narmada	94,562	1467	1107	2	2	90	6	54	11/6-22/9	84	1869-1894 1914-1949	1844-1868 1895-1913 1950-2003
Tapi	65,041	1665	894	2	3	87	8	49	11/6-20/9	102	1882-1894 1931-1964	1859-1881 1895-1930 1965-2003
Mahanadi	145,040	1519	1410	3	5	84	8	70	8/6-13/10	124	1879-1961	1848-1878 1962-2003
Cauvery	91,691	1499	1266	1	14	61	24	64	15/5-15/11	185	1929-2003	1837-1928

Global sea-level pressure variations and the Indian summer monsoon

To understand underlying mechanism of influence of the global atmospheric thermal conditions on the Indian summer monsoon temporal variation of important climatic parameters like mean sea level pressure (MSLP), geo-potential height, wind, temperature etc. of selected isobaric levels across the globe were examined. Linear approximation of interannual fluctuation of the area-averaged annual and seasonal MSLP for the whole globe, the two hemispheres, different climatic zones (polar, temperate, subtropical, tropical and equatorial) and over different '*Centres of Action*' were examined. The magnitude and direction of linear trend in the MSLP variation for the location of different '*Centres of Action*' were consistent with the trends the corresponding zonal mean sea level pressure values. Further observed changes in the MSLP related to the Indian summer monsoon are, (i) the gradient in the summer MSLP between Mascarene High and northwest India is decreasing at the rate of -2.7 mb/100-yr, between Mascarene High and Bay of Bengal at the rate of -0.4 mb/100-yr and between Mascarene High and head Bay of Bengal -0.6 mb/100-yr. The geopotential height of the Tibetan anticyclone is rising at the rate of 36.7 m/100-yr. Over the global area between 60°N and 40°S, both the MSLP and the surface air temperature show rising trend, but north of 60°N and south of 40°S, the MSLP shows decreasing trend and the temperature shows sharp rising trend. Declining trend in rainfall is reported over the tropics and rising trend over the extra-tropics, both in the northern and the southern hemispheres. Hence, decreasing trend in the Indian monsoon rainfall with inflated variability since 1962 is consistent with the declining trend in rainfall over the tropical belts. While rising temperature trend is favourable for higher rate of evaporation, and eventually enhanced rainfall activities, increasing trend in the MSLP and declining trend in upper tropospheric temperature do not seem to be conducive for efficient condensation and the cloud-rainfall processes. Outgoing longwave radiation (OLR) over the Indian region shows declining trend (and supposedly increasing trend in clouding).

Association between global tropospheric temperature variation and monsoon clouds and rainfall over India

A long period monthly, seasonal and annual mean NOAA-OLR data (1974-2002) was subjected to time series analysis for the whole country as well as 11 regions of the country. Most of the OLR series showed decreasing tendency irrespective of whether rainfall showed increasing, decreasing or stationary fluctuation. To know the possible cause of OLR changes over India during monsoon season correlation of winter, spring, summer and autumn temperature of surface air (surface-850 hPa), the troposphere (850-300 hPa) and the tropopause (300-200 hPa) over the whole globe, the two hemispheres and the different climatic zones with the NOAA-OLR over the whole country was examined. The correlation was examined for the static condition as well as the regional, seasonal and level differences and the favourable conditions for good clouding were identified.

Rainfall Spatial Distribution Index (RSDI)

To understand large-scale temporal variation of monthly and seasonal rainfall over the country a rainfall index, named as *Rainfall Spatial Distribution Index (RSDI)*, has been developed considering rainfall and its horizontal distribution. The RSDI for the particular period and year is calculated as :

$$RSDI = \frac{1.a_{VD} + 2.a_{D} + 3.a_{W} + 4.a_{VW}}{A}$$

Where a_{VD} denotes area of the country under very dry condition, a_{D} under dry, a_{W} under wet and a_{VW} under very wet condition, and A is the total geographical area of the country. These areas were determined based on the appropriate rainfall thresholds. High RSDI value is indicative of enhanced rainfall over large areas, including dry areas and vice versa. Overall, the winter and monsoon rainfall showed decreasing trend from about 1940s and summer and post-monsoon increasing trend. On a monthly scale January, February, March, July, August and September rainfall showed decreasing trend and the remaining six months increasing trend. RSDI has also been found to be useful to understand the teleconnections of the Indian monsoons.

Physical Meteorology and Aerology


CIMEL polarized Sun and Sky Radiometer


Automatic UV/visible Spectrometer

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, Asha Nath, M.I.R. Tinmaker)

Lightning activity using a storm tracker

The Boltek Storm Tracker with Lightning 2000 software has been installed for online recording and mapping of lightning up to a distance 2000 km. The storm tracker detects lightning strikes by sensing the radio signals produced by lightning, which uses the direction finding antenna to determine the direction of the lightning signal. The lightning counter gives count of lightning flashes of different types on real time basis. The concurrent observation of potential gradient carried out at the experimental sites was used to confirm and quantify the lightning activity recorded by the storm tracker. After installation, the observations were started from 6 April, 2004. During the year 2004, 11 to 12 thunderstorms were occurred in each of the pre-monsoon and post-monsoon seasons. Sample record of one of the thunderstorms during the post monsoon is shown in Fig. 27.

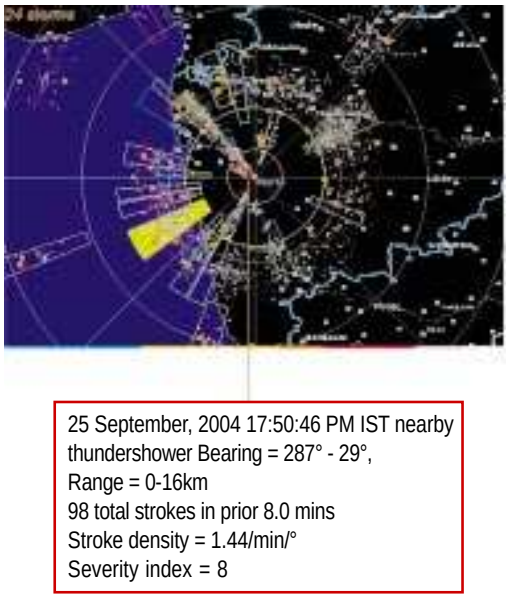


Fig. 27 : Sample record depicting thunderstorm and associated lightning strokes occurred on the evening of September, 25, 2004

Atmospheric boundary layer studies over the eastern Arabian Sea and western coast of India

Aerological observations were collected for six west coastal stations of India and one island station Amini Divi during the phase - I of Arabian Sea Monsoon Experiment (ARMEX) - 2002 during 15 June - 15 August, 2002. The west coastal stations were Ahmedabad, Mumbai, Panjim, Goa, Mangalore and Cochin. Utilizing these observations the vertical stability of the Atmospheric Boundary Layer was investigated. A monograph on CD containing the vertical profiles of thermodynamic parameters (pictorial form and data form) computed utilizing the whole data (over land) collected during the Phase-I of the ARMEX - 2002 was prepared and disseminated to different scientists working in different Scientific and Academic Institutions / organizations to facilitate their scientists to undertake related research studies.

Variation in thermo-dynamical parameters at the surface in atmospheric boundary layer over the eastern Arabian Sea and western coastal stations of India

A study was carried out to examine the surface characteristics of the Atmospheric Boundary Layer (ABL) over the eastern Arabian Sea regions and the western coastal land stations during the summer monsoon season of 2002. For this purpose surface meteorological observations collected onboard ORV Sagar Kanya (interval :10 minute) and over the land stations (interval: 3 hour) along the west coast of India (Mumbai, Ratnagiri, Goa, Cannanore and Harnai) during the Phase-I of ARMEX-2002 during 24 June-15 August were considered. The different thermodynamical parameters viz. lifting condensation level (LCL), potential temperature (θ) and equivalent potential temperature (θ_e) were computed utilizing the surface parameters temperature, dew point temperature and pressure over these regions. The period included different convective events viz. heavy rainfall (26-28 June and 7-12 August, 2002), moderate rainfall (2 - 4 August, 2002) and weak phase of convection (17-20 July, 2002). Therefore, the temporal variations in the thermo-dynamical parameters were also considered with respect to prevailing convective conditions. The results of the study indicated semi- diurnal variations in the surface pressure and diurnal variations in the LCL, θ and θ_e during the period of observations over all the regions oceanic as well as coastal stations (Fig. 28).

However, the variations in the surface parameters were less over the oceanic regions as compared to coastal stations. The semi-diurnal / diurnal pattern of variation in different parameters was not very clearly evident during the passage of convective events. The surface pressure was lowest during moderate monsoon conditions and highest during weak phase of monsoon. The LCL was found at higher levels during weak phase of monsoon and at lower levels for moderate/high convective events. The LCL was observed at lower levels at Ratnagiri and at higher levels over oceanic regions. The moist convective activity (indicated by q_e) was highest during heavy rainfall events over oceanic regions. The moist convective activity (indicated by q_e) was highest during heavy rainfall events over oceanic as well as coastal stations. The variations were of the order of 1 - 7°K among different convective events.

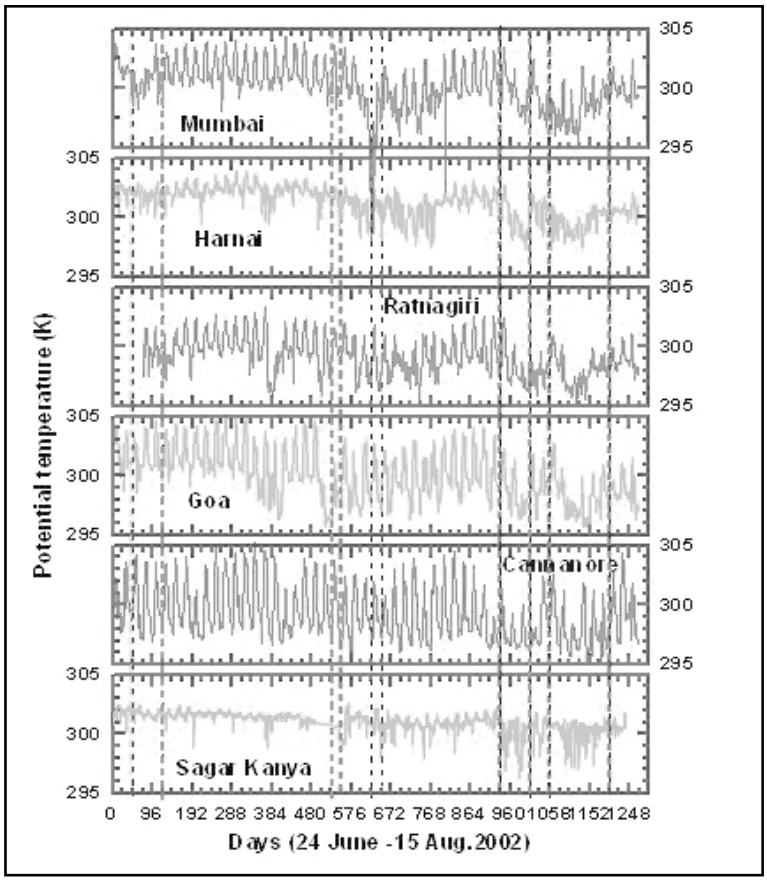


Fig. 28: Variation in the surface potential temperature over Sagar Kanya and the five coastal stations during ARMEX-2002 observational period from 24 June - 15 August, 2002

Space-time variability of convection over the semi-arid region of the north peninsular India

Information on distribution of convection is the key factor not only in the weather modification research for rain augmentation but also to understand the space-time variability in precipitation. These aspects were studied by utilizing the radar data acquired from the rain enhancement experiments performed by the Government of Maharashtra over the sub-divisions of Madhya Maharashtra, Marathwada and Vidarbha during the south-west monsoon season of 2004. For these experiments, two C-band radars, one at Baramati and the other at Shegaon were installed. The radar reflectivity data recorded for every 5 minutes over Baramati during 20 June - 15 September, 2004 were utilized for the study. Anew software, namely, "TITAN (Thunderstorm Identification Tracking Analysis and Now-casting)" was used to delineate the individual convective cells and systems of meso-scale nature, cloud life cycle, convective storms based on the radar reflectivity signatures. The daily rainfall data were analyzed to examine the association between radar reflectivity and precipitation intensity (Z-R relationship) over the experimental region.

Cloud seeding operations in the states of Maharashtra, Karnataka and Andhra Pradesh

The Maharashtra, Karnataka and Andhra Pradesh Governments undertook Cloud Seeding Operations for enhancing rainfall in their drought prone areas during the year 2003 and 2004. IITM was the consultant for these states. The cloud physical data collected during the seeding flights were archived. The analysis work of liquid water content, temperature and updraft along with other cloud parameters has been taken up. For these operations 5 cm radars were installed at Baramati, Shegaon (in Maharashtra state), Jakkur (Karnataka state) and Nandiyal and Karimnagar (Andhra Pradesh) and used for identifying the suitability of the clouds for seeding purpose. The data were archived using TITAN software. Radar cloud reflectivity, aircraft, cloud heights,

precipitation and VIL for 61 days by the radar installed at Baramati for 2003, 90 days of data during 2003 from the radar at Jakkur and about 60 days of data from Baramati and Shegaon radars were archived for 2004. The aircraft data and radar data are used for studying the effect of seeding and also for other meteorological phenomena. Rainfall data collected by over 600 raingauge stations in the Maharashtra state for 2003 and 2004 were archived for analyzing and studying the meteorological phenomena in conjunction with the radar data. The software TITAN was used for analyzing the radar data. The software was also loaded in the computer of Water Resource Division, Nashik.

Remote Sensing of the Atmosphere Using Lidar and Other Ground Based Techniques

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

Lidar-radar study of stratosphere-troposphere exchange phenomenon

The lidar derived back scattering coefficient and optical depth were used to study their variability in the vicinity of tropical tropopause during both clear and during presence of Cirrus clouds. Results clearly showed considerable variability associated with these parameters in the vicinity of tropopause, suggesting possible vertical transport of aerosols across the tropopause, there by leading to Stratosphere Troposphere Exchange (STE) (Fig. 29). The backward trajectories of wind were examined to study influence of wind on the observed STE.

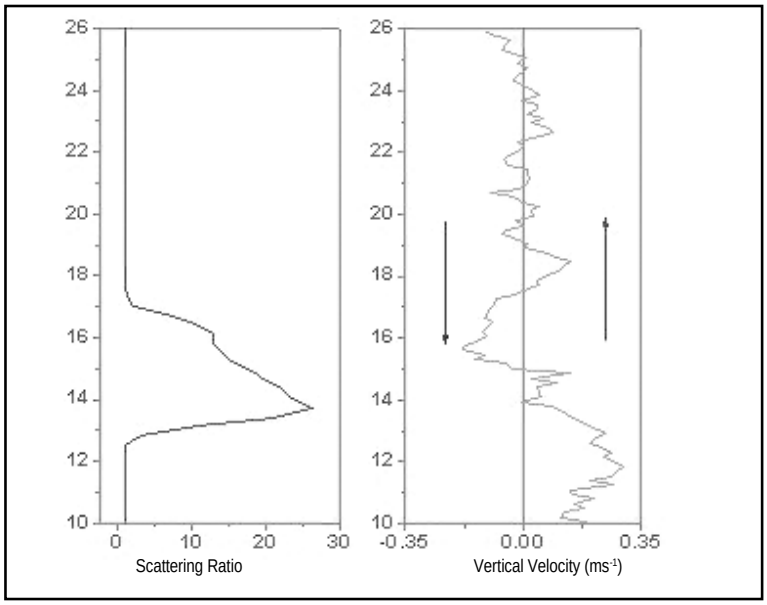


Fig. 29 : Height profiles of lidar observed scattering ratio showing thick cirrus cloud and near simultaneous MST radar observations of vertical velocity. Arrows indicate upward and downward movement of vertical wind

Vertical velocity measurements from MST radar observations were used to study its variability during passage of (a) ITCZ and (b) Tropical Easterly Jet (TEJ). Significant variations including wind reversal were noticed in vertical velocity during the passage of TEJ (Fig. 30). These data were utilized to study the mass flux and diabatic heating rates in the vicinity of tropical tropopause. Results showed considerable enhancement in mass flux across tropopause suggesting enhanced Stratosphere Troposphere Exchange activity during severe weather conditions.

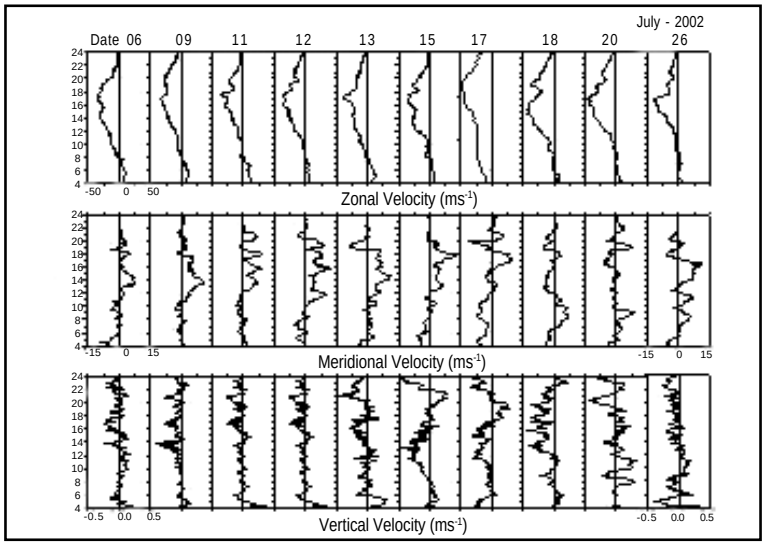


Fig. 30 : Height profiles of zonal, meridional and vertical velocities observed for different days during July, 2002. Larger magnitude of zonal velocity in the height region 10 -20 km represents the winds associated with tropical easterly jet

Variations in vertical velocity and heating rates in the upper troposphere

High resolution measurements of vertical velocity measurements from MST radar were analyzed to study the vertical wind variability in the vicinity of tropical tropopause for the year 2002. Height of the tropical tropopause was derived from temperature profiles for Chennai, which is about 150 km from MST radar location. In the present study, height of the "cold point tropopause" was obtained by defining the height at which temperature attained minimum. Results clearly showed considerable day - to - day variation of vertical velocity across the tropopause. Reversal of vertical velocity was observed during presence of Tropical Easterly Jet associated with monsoon. Mean vertical velocity for monsoon period of 2002 showed downward in the height region 4 -18 km indicating the net downward mass flux across the tropopause.

Height profiles of diabatic heating rates were also derived from vertical velocity measurements for the year 2002. Heating rates in the troposphere were observed to be about 2°/day. Magnitudes of heating rates as high as ~ 8°/day were observed in the upper troposphere during the monsoon period. In the vicinity of tropopause, net positive heating rates during pre-monsoon and net negative rates in the monsoon season with large magnitude as compared to that of pre-monsoon and winter periods were noticed (Fig. 31).

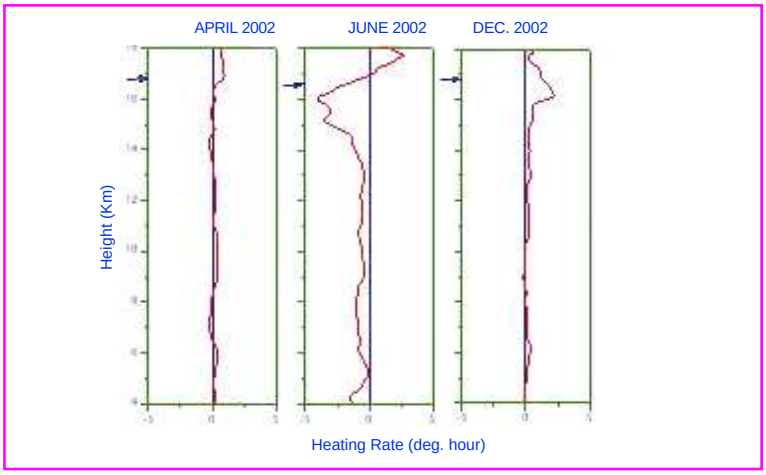


Fig.31: Height profiles of heating rates derived from MST radar observed vertical velocity during different months. Arrow represents the height of the tropopause and each profile represents the mean for the respective months

Lidar and radiometric observations of aerosols and precursor gases

Vertical distributions of atmospheric aerosol number density up to 7 km amsl were obtained on 8 days using the bistatic Argon ion lidar, and column aerosol optical depth, ozone and water vapour were obtained on 29 days from multi-wavelength solar radiometer at the Institute.

Comparison of radiometric measurements with satellite data of aerosols and precursor gases over Pune

Observations of aerosols and precursor gases carried out over Pune using Microtops-II multi-wavelength radiometers during the period 1999-2003 were compared with concurrently measured data from Total Ozone Mapping Spectroradiometer (TOMS) and Moderate Resolution Imaging Spectroradiometer (MODIS) satellites. Daily, monthly and seasonal averages of Aerosol Optical Depth (AOD), Total Column Ozone (TCO) and Precipitable Water Content (PWC) were computed and compared (Fig. 32). AODs at 380 and 500 nm obtained from Microtops agree very well with TOMS observations while MODIS derived AOD appears to be more closely associated with the 675 nm channel of Microtops. TCO

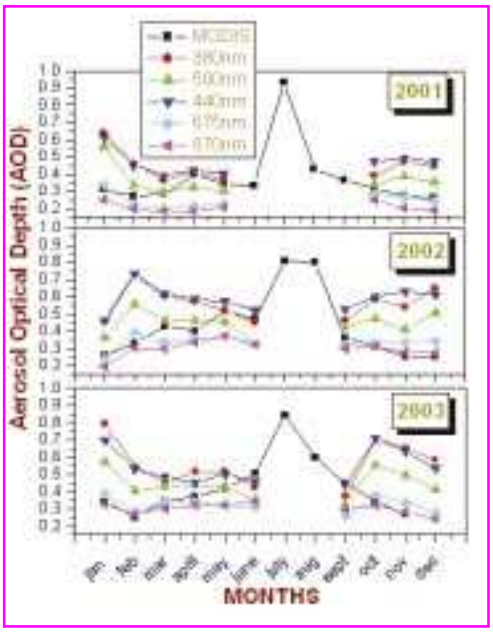


Fig. 32: Comparison between AODs derived from MTP and MODIS during the years 2001-2003

observations of TOMS and Microtops showed good agreement while PWC obtained from Microtops showed good comparison with MODIS observations.

Lidar-radiometer study of planetary boundary layer characteristics over Sofia, Bulgaria

Under the bilateral Indo-Bulgarian Cooperative Research Program joint experiments were performed during the visit of Institute's scientist Dr. P.C.S. Devara, Indian Principal Investigator to the Institute of Electronics (IE), Bulgarian Academy of Sciences, Sofia, Bulgaria during 3-23 October, 2004. In these experiments the Nd:YAG lidar of the IE and the Solar Radiometer (MICROTOPS) of the IITM were operated simultaneously on some selected clear-sky days. The preliminary results of these first-of-its-kind experiments indicated that (i) the time evolution of the planetary boundary layer captured by the lidar indicated a strong relationship with the changes in the local meteorology modulated by the complex terrain conditions, (ii) the residual and capping inversion layers observed by the lidar depicted close association with the vertical gradients in potential temperature and the radiometer-estimated columnar precipitable water content (Fig. 33)and (iii) the height-integrated lidar-derived extinction coefficients exhibited a reasonably good agreement (Fig. 34) with the simultaneously measured columnar aerosol optical depths by the radiometer at 500 nm wavelength close to the lidar wavelength (532 nm).

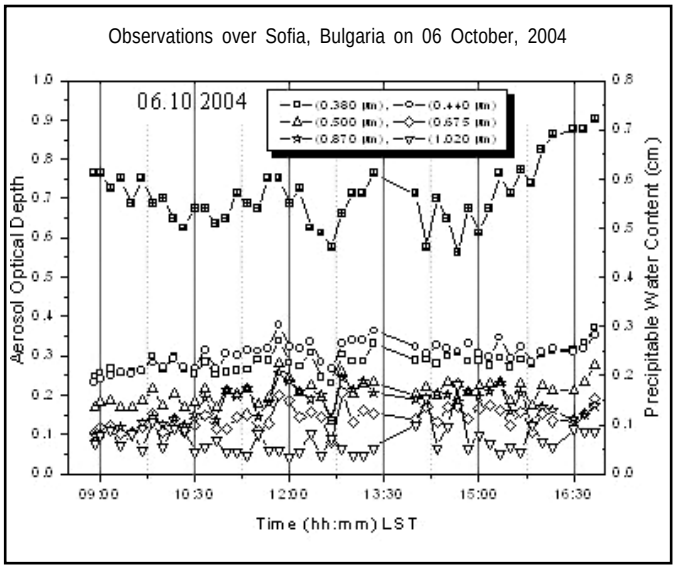


Fig. 33 : Time variation of aerosol optical depth and precipitable water content obtained with MICROTOPS II

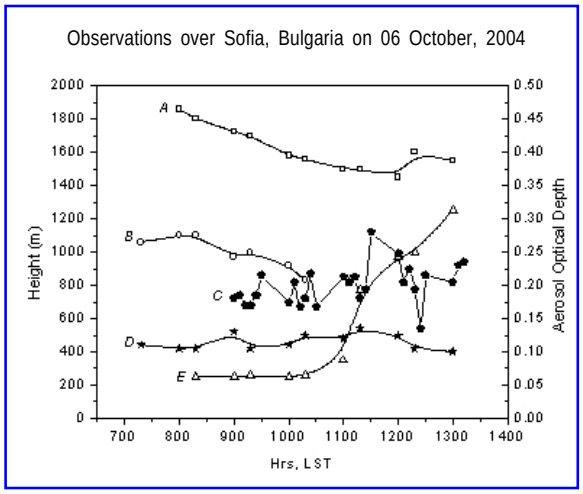


Fig. 34 :Temporal variations in the height of capping inversion layer (A), residual layer (B), mixed layer (E), radiometer-observed AOD (C) and lidar-derived AOD (D)

The Solar Radiometer of the IITM was also used to calibrate an in-house developed spectroradiometer at the Institute of Solar-Terrestrial Influences Laboratory (ISTL), Bulgarian Academy of Sciences, Sofia, Bulgaria.

Seasonal asymmetry in diurnal variation of aerosol optical properties

Aerosol optical depth measurements acquired through a sun/sky radiometer (Prede Model POM-01L) at Pune for a period of two years (December, 2000 - April, 2002) were analysed. Aerosol optical depth (AOD) and Angstrom exponent (a) were expressed as percentage departures from their respective daily averages. Computed percentages were averaged hourly (0900-1000 IST, 1000-1100 IST etc.) for each measurement period. Diurnal variation of AOD and Angstrom exponent showed a variability of about 25% and 15% respectively. But detailed analysis of aerosol optical depth and Angstrom exponent showed higher AOD and lower values of a in the forenoon and vice-versa in the afternoon hours during winter and pre-monsoon months, respectively. Concurrent 3 hourly meteorological parameters from the India Meteorological Department (IMD) for the same period showed elevated temperature inversions and higher humidity values (up to ~80 %) in

the morning hours and resultant haze led to greater AODs in the forenoon hours. Higher AODs in the afternoon hours during pre-monsoon months were considered mainly due to higher air temperatures and wind speeds in those months (Fig. 35).

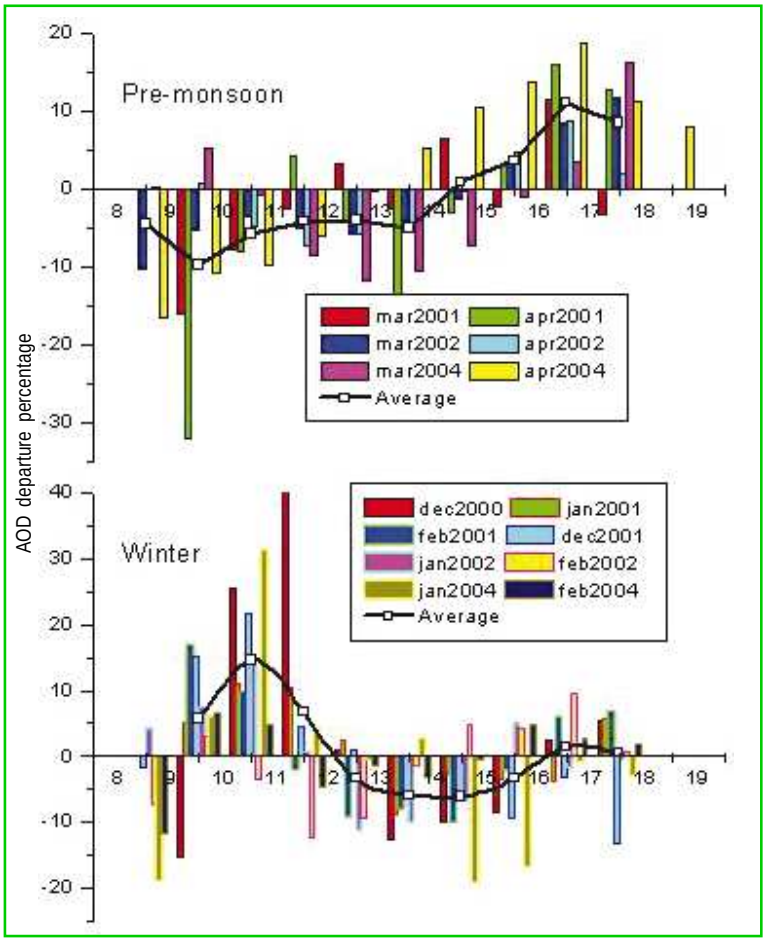


Fig. 35 : Seasonal reversal of diurnal asymmetry in aerosol optical depth

Land-based precipitable water measurements and their association with satellite observations over a mid-latitude station

Precipitable water (PW) observations obtained by the optical technique (sun photometer - Microtops II) at a midlatitude station (Diekirch, Luxemburg, 49.848°N, 6.332°E) over a six-year period (1998-2003) were analyzed. Seasonal variations were examined and compared with the PW estimations made from surface meteorological parameters (temperature and R.H.) and satellite (MODIS) derived data. The results showed an identical seasonal variation in both the data sets, but sun photometer values were higher by almost 1.5 cm during the summer months (Fig. 36 a). On daily scale also there was a very good agreement with a correlation coefficient of 0.85 (Fig. 36 b).

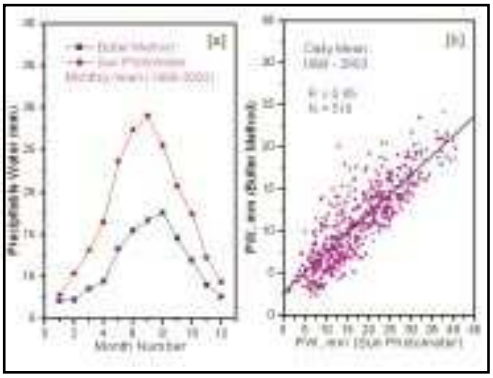


Fig. 36 : Comparison of precipitable water (a) observed with sun photometer and (b) that estimated from surface meteorological parameters

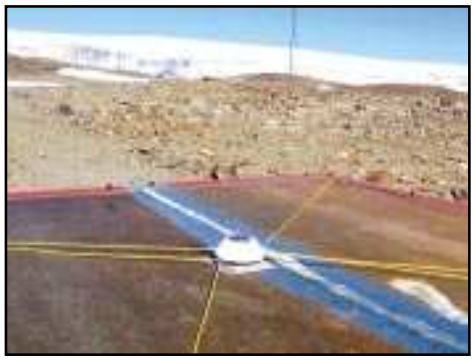
On 75% of the days the agreement was within ± 1.0 cm. The deviations in PW during the summer season were attributed to the difference in the methodologies adopted for deriving PW from photometric and meteorological observations. MODIS satellite derived PW estimations by clear-sky NIR and IR methods for the same experimental station were compared with the above observations and estimations. Temporal variations on monthly mean scale were found to be very consistent.

Atmospheric aerosols : optical, physical and radiative characteristics over Antarctic region

Extensive observations of aerosol optical depth, size distribution, ozone, precipitable water content and down-welling short-wave radiation flux have been carried out on total of 31 cloud-free days during 21 January, - 5 February 2005 during the 24th Indian Scientific Expedition to Antarctica. The concurrent surface and profiles of atmospheric state parameters including ozone at the Indian Antarctic station (Maitri) were archived. Solar radiometric measurements were made over Indian Ocean from ship (MV Emerald Sea) during the Expedition. Pyranometric measurements of the radiative flux and MICROTOPS measurements of aerosol and precursor gases were also taken over Maitri.

Measurements during the 24th Indian Scientific Expedition to Antarctica

Solar radiometric (MICROTOPS - II) measurements of aerosol optical depth and precursor gases made over Indian Ocean from ship (MV Emerald Sea)



Wideband shortwave pyranometer for radiative flux measurements over Maitri (Indian Antarctica Station)

Multichannel sunphotometric and ozonometric measurements of aerosols and gases over Maitri

Atmospheric layer structures around tropical and sub-tropical tropopause region

Thermal structure of the tropopause region over Taipei, a sub tropical station, was studied using radiosonde observed temperature profiles for the year 1999. Multiple layers of temperature inversion were noticed in the height region 14 -18 km. Such inversion layers were observed both above and below the height at which coldest temperature occurred, i.e. cold point tropopause. Frequency of such inversion layers was observed to be more during winter and associated with the sub-tropical jet stream.

Height variation tropical tropopause over Hyderabad, Chennai and Bangalore representing different environments was studied. Cold point tropopause defined as the height at which temperature attains its minimum, was adopted for this study. Results showed enhanced variation of cold point tropopause over Hyderabad as compared to Madras and Bangalore, Analysis of wind clearly showed enhanced height variation of wind over Hyderabad as compared to other two stations. Such enhanced wind variation may be the possible source for enhanced tropopause variability over Hyderabad.

Joint lidar-WP/RASS experiments

Special LIDAR experiments were conducted throughout the night of 11-12 March, 2005 and about 10 aerosol vertical profiles have been collected at one hour interval using the newly installed 'lidar scanning and data acquisition system' to study the nighttime temporal evolution in the vertical aerosol structure and associated air pollution aspects. Simultaneously, the WP-RASS system at IMD (Pashan Campus) was operated near synchronously to study the influence of vertical structure of wind (u, v and w components) and temperature on aerosol distributions.

Active and passive remote sensing of aerosols and pre-cursor gases

Vertical profiles of aerosol number density were obtained on about 45 days using the continuous wave, bistatic Argon ion lidar system equipped with the PC-based on-line control and data acquisition facility. Multi-wavelengths (514.5, 496.5, 488.0 and 476.5 nm) lidar experiments were also conducted on 17 and 30 December, 2004 to investigate the spectral-height distributions of aerosol number density and size distribution over Pune. The results showed good agreement with the in-situ measurements.

The sunphotometer and ozonomteter versions of MICROTOPS-II were operated and acquired total column aerosol optical depth at 6 wavelengths ranging from UV to NIRT, and ozone and precipitable water content data on about 132 days. These data sets, individually and also in conjunction with similar data collected in the previous years, were utilized to investigate the various studies focusing on aerosol characterization and radiative forcing estimations.

Installation of sun sky radiometer

The CIMEL-make polarized sun-sky radiometer which was acquired under the ISRO-ARBS sponsored project has been installed at the Institute on 25-26 October, 2004. The radiometer has been integrated into the global Aerosol Robot Network (AERONET). The aerosol optical, physical and radiative parameters such as spectral distribution of aerosol optical depth, Angstrom Parameter, size distribution, water vapour, asymmetry parameter, polarized phase function and single scattering albedo are archived daily. This instrument was also used for the study of the characterization of aerosols over Delhi (industrial urban station) as a part of the nation-wide land campaign experiments - II during the month of December, 2004.

CIMEL polarized Sun and Sky Radiometer installed at the IITM, Pune for atmospheric aerosol characterization experiments. Solar panel for auto power to the instrument and control unit is seen in a box below the Radiometer

Air Pollution and Precipitation Chemistry

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

Variations in the concentration of ionic species in rain events at Pune

Evolutions of the concentrations of major neutralizing agents (Ca^{2+} and NH_4^+) and acidic species (SO_4^{2-} and NO_3^-) were computed with Slinn's model using the initial number concentrations of particle size distributions measured at Pune during 1998-1999. Predicted ionic concentrations were compared with observed ionic concentrations in the sequential samples collected in the rain events at Pune. Also, equivalent ratios $[(SO_4^{2-} + NO_3^-) / (Ca^{2+} + NH_4^+)]$ were computed theoretically to study the neutralizing capacity of the atmosphere during precipitation events and compared them with observed ones. The variation of observed equivalent ratios with accumulated rain (mm) indicated that acidic components are always neutralized with neutralizing species. These results are found to be useful in better understanding of the scavenging of acidic aerosols by precipitation in the acid rain problem.

Parametric study of scavenging processes during thunderstorm and non-thunderstorm rain

Study of relative dominance of various scavenging mechanisms in their respective airborne particle size regimes including all the collection mechanisms at different rainfall intensities is essential to improve the accuracy of estimation of scavenging rates. Overall collision efficiencies between falling raindrops and

particles of selected chemical species were computed by including the contributions of collection mechanisms due to Brownian diffusion, directional interception, inertial impaction and phoretic effects caused by thermal and concentration gradient for the rainfall associated with thunderstorm and non-thunderstorm. Computations of collision efficiencies were performed for the particles in the diameter range of 0.02 - 0.2 μm (in 0.02 μm steps), 0.2 - 2 μm (in 0.2 μm steps) and 2 -10 μm (in 1 mm steps) and for raindrops in a size range of 200 - 5800 μm (in 200 μm steps). The effect of rain associated with thunderstorm and non-thunderstorm on scavenging rates for the particles of $CaCO_3$, KNO_3, $(NH_4)_2 SO_4$ and aerodynamic size was evaluated in terms of mean mass scavenging coefficients for poly-dispersed aerosols in size regimes 0.02 -0.2 μm, 0.2 - 2 μm and 2 - 10 μm. Mean mass scavenging coefficients were found to exhibit maximum scavenging potential for the particles of $CaCO_3$ as compared to those of KNO_3, $(NH_4)_2SO_4$ and aerodynamic size.

Studies under Indo-Swedish collaborative project "Composition of Asian Deposition (CAD)"

Monitoring of aerosols, trace gases and precipitation chemistry, at a background high-altitude rural location, Sinhagad (about 15 km away from the Pune city) were carried out since 2002. The studies revealed that (i) fine aerosols were acidic at Sinhagad due to the dominance of SO_4 while coarse aerosols were alkaline due to the dominance of soil originated element Ca, (ii) the total aerosols were acidic in winter and alkaline in summer, (iii) The concentrations of gaseous pollutants SO_2 and HNO3 were higher in winter than in summer whereas, it was vice-versa in the case of NH_3 and (iv) on comparison, although the acidic and neutralizing potentials of aerosols at Pune and Sinhagad showed significant variations, Ca was found to be the principal neutralizing constituent of aerosols at both the places even after two decades.

Physical and chemical properties of aerosols in urban and semi urban environments in India

Analysis of the data obtained during the field observations of TSP, mass size distribution of aerosols, Aitken Nuclei, surface ozone and precipitation chemistry were carried out at Delhi (New Rajender Nagar-Residential and Okhla-Industrial), Darjeeling (high-altitude) and Pune (urban) during the winter of 2001 revealed that (i) aerosols showed bimodal distribution with a peak in fine (0.43-0.65μm) range and another in coarse range (4.7-5.4 μm) at all the experimental locations, (ii) Potassium was noticed to be dominant in coarse-mode at Darjeeling while it was significant in fine mode at other locations, (iii) Concentrations of SO_4 and NO_3 showed profound association with local meteorology, particularly temperature, over different locations during the study period, (iv) Aerosols in the fine mode showed acidic for New Rajendernagar, Okhla and Pune, while coarse mode aerosols exhibited acidic nature at Darjeeling. Size distribution of trace metals showed dependence on observational site.

Precipitation chemistry at Pune and Sinhagad

The study of chemical composition of rain water collected at Sinhagad (rural) site and Pune (urban) during 2002 - 03 revealed that (i) at both the locations the rain water was alkaline, (ii) the major neutralising component was associated with Ca, (iii) the major anions were Cl and SO_4 and the major cations were Ca and Na, (iv) local sources did not influence the Sinhagad samples significantly. Back trajectory analyses showed that the significant high concentrations of Ca and SO_4 at Sinhagad were due to the long range transport of pollutants from Gulf countries. This rural site has been useful for obtaining regionally representative precipitation chemistry data.

Deposition chemistry studies in NCR of Delhi

Chemical composition of wet and dry deposition samples collected at eight locations in the National Capital Region (NCR) of Delhi revealed that the rain water was alkaline at all the locations except at one location (Sardhana) where the pH was nearly equal to neutral (5.6). The lower pH at Sardhana was not due to the high concentrations acidic components but due to the low concentrations of the soil oriented components.

Special field observations at Agra (Land Campaign - II)

Extensive observations of physical, chemical and radiative characteristics of aerosols using MICROTOPS-II, Andersen sampler, high volume sampler, aethalometer, $PM_{2.5}$ sampler, dry and wet deposition and fog water collector were carried at the Dayalbagh Educational Institute (DEI), Agra, during 1-31 December, 2004 as a part of the Nation-wide Land Campaign programme, organized under the ISRO-GBP/ARBS project. Preliminary results of the analysis of observations of TSP, mass size distribution, black carbon (BC) and fog water revealed that i) the TSP levels varied between 261 and 685 $\mu g/m^3$ with an average of 361 $\mu g/m^3$, the average TSP during day-time was about 1.7 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, ii) mass size distribution of aerosols showed bimodal distribution and the fine size particles contributed 45-55% to the total TSP, iii) the pH of fog water varied between 6.25 and 6.63 indicating the alkaline nature and iv) BC concentrations varied between 7.1 $\mu g/m^3$ and 48.0 $\mu g/m^3$ with an average of 18.6 $\mu g/m^3$ (v) diurnal variation of BC showed two peaks one in the morning and the other in the night, (vi) low values were observed during the afternoon hours.

Aerosol samplers, fog water collector and MICROTOPS II operated by IITM at Agra during the Nation-wide Land Campaign II

Atmospheric Chemistry Modelling, and Dynamics

(G. Beig, I. Joshi, S.S. Fadnavis, Sompriti Roy, A.C. Saritha, S. Gunthe, V. Singh)

On the temporal and seasonal patterns of surface ozone and its precursors

Baseline data of surface ozone (O_3) and its precursors viz., NO_X, CO and hydrocarbons (HC) from a tropical semi-urban site at IITM, Pune (18°N, 73°E) were analyzed to study the spatial distribution of these tracers and their diurnal and seasonal variations. Observations were made round the clock with a resolution of one hour. The inter-correlation of ozone with its precursors on hourly scale, daily and monthly averages were made. Experimental results were compared with the results obtained using 3-D chemical-transport. Model simulations were made using the assimilated winds with the revised Indian inventory for the emissions of ozone precursor gases. Model reproduced the diurnal and seasonal patterns of ozone reasonably well excepting those few occasions, especially during the monsoon season where local factors abruptly played a significant role.

Measurements at Pune showed high levels of ozone, exceeding 90 ppb on a few occasions. Ozone concentration was found to be highest during noontime, mainly because of photochemical production. Diurnal variations in NO_X and CO were a manifestation of combined effects of local emission effects, boundary layer processes, local wind patterns and chemistry. These variations were higher during morning (after sunrise) and late evening hours. The solar radiations at Pune were maximum during the summer season. However, the maximum ozone was found during the winter season. Ozone showed the maxima during summer when separated on seasonal level, but individually on monthly scale showed maxima during February (winter). This seasonal concentration was not supported by similar variations in NO_X, CO and NMHCs where maximum was found during winter season, unlike that of ozone. Observations and modelled monthly variations showed similarities to a great extent except on some abrupt changes in some parameters due to which there was some difference, which could not be noted in the model.

Ozone weekend effect

Ozone and its precursors have been monitored round-the-clock since last one year. The observed ozone and its precursors measured at IITM during the past one year revealed an interesting phenomenon called as "Ozone Weekend Effect". On the normal scale it is expected that concentration of ozone is less on weekends, because there is considerable reduction on the road traffic, which is major source for the emission of ozone precursors. However, it was observed that even though there was reduction in ozone precursors, mainly NO_X and NMHCs by 10 to 2.5 percent respectively, an increase in ozone concentration by an amount of ~ 9% on weekends was observed since last May. The possible and primary cause of this effect was detected as "reduction in NO_x" concentration. As NO_X is said to be a catalyst in ozone formation reaction in the presence of VOCs and sunlight, under some chemical conditions decided by the VOC/NO_X ratio, sometimes NO_X may inhibit the ozone production. This particular regime (where decrease in NO_x) causes increase in ozone is called as VOC (NMHCs in this case) limited regime. The chemistry of this particular phenomenon is very complex with the involvement of high degree of variation and non-linearity with each other.

Relationship between temperature variations and Sudden Ionospheric Disturbances (SIDs)

Temperature data at 500 hPa and daily data of Sudden Ionospheric Disturbances (SID) for 17-year period (1986-2002) were collected for 20 Indian stations from the available published archives. Monthly mean values of tropospheric temperatures and monthly total frequency of ionospheric disturbances were calculated for each month and for each station. Constructed time series were examined to study the relationship between SIDs and 500 hPa temperatures (Fig. 37). The study indicated that increase in tropospheric temperature accompanies increase in the frequency of occurrence of sudden ionospheric disturbances up to a period of about one month and in-phase relation between tropospheric temperatures and sudden ionospheric disturbances over high-altitude stations.

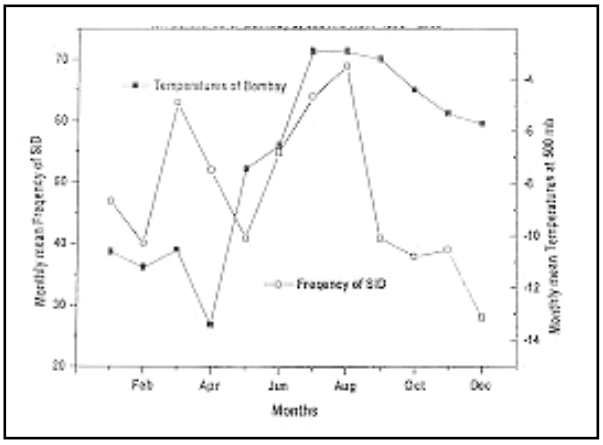


Fig. 37 : Monthly mean frequency of sudden ionospheric disturbances and monthly mean temperature of Bombay at 500 hPa during 1986 -2002

Seasonal variation in the diurnal pattern of ozone over Pune

Surface ozone data archived at the Institute for the past more than a year have been analyzed to the seasonal pattern on diurnal scale. It was observed that minimum in the ozone value occurred at the same time on the diurnal scale for all the seasons. However, the time period and duration for which maximum ozone is observed changed significantly with the season since there was a difference between time of sunrise, sunset and the length of the day that played important role in deciding the net level of ozone concentration. The maximum in ozone level for monsoon season at Pune was found to be ~ 22.56 ppb and lowest rate of increase in ozone ~1.49 ppb / hr.

Solar cycle modulation of ozone and temperature over tropical stratosphere

In order to study the influence of solar activity on the vertical structure of temperature and ozone, Halogen Occultation Experiment (HALOE) aboard Upper Atmospheric Research Satellite (UARS) data of zonally averaged monthly temperature and ozone volume mixing ratio (VMR) were retrieved over the tropical belt of 0-30°N for the period 1991-2004. A multi-functional regression model was used for studying the solar cycle responses to temperature and ozone variations, and

separating them from other natural signals. The annual mean solar response profiles, thus constructed for temperature and ozone during the sunrise and sunset were examined. Results indicated that the stratospheric temperature and ozone have intrinsic relationship with the 11-year solar cycle. Results also indicated positive solar response of ~0.5-1.0K/ 100sfu in the lower stratosphere and ~0.5K/100sfu in the upper stratosphere in the case of temperature while ozone showed a response of 2 - 4% / decade in the lower - and ~0.5 - 2 % / 100sfu in the upper-stratosphere, respectively.

3-D model simulations of the influence of anthropogenic emissions on tropospheric ozone and its precursors over Indian tropical region

An emission inventory of ozone precursors developed for the year 1991 and 2001 were used in three dimensional Chemistry-Transport Model (MOZART) with assimilated winds to examine the tropospheric long term trends in ozone and its major precursors (NOx and CO) over the Indian Geographical region. MOZART model was run with assimilated meteorological data from the European Center for Medium Range Weather Forecasts (ECMWF). The model considered surface emissions of several chemical compounds (N_2O, CH_4, NMHCs, CO, NO_x, CH_2O, and acetone). The emissions due to fossil fuel combustion, agricultural burning, bio-fuel, etc for the Indian region were taken from the Indian national inventory. Model results indicate that the variation in ozone is of the order of 6-10% per decade near the surface, which decreases with height and becomes around 5-7% in the lower troposphere and 3-5% in the upper troposphere. The maximum decadal increase in CO and NOx was found to be around 10-18% and 20-30% respectively near the boundary layer for the latitude range 20-30°N. However in most of the troposphere, magnitude of increase reduced with height and became less than 5% above 10 km. A few hot spots were found where the percentage change shoots up many fold reflecting the high emission regions. The variation was found to be significantly dependent on seasons thereby indicating the role of convection and long-range transport.

GIS based gridded emission inventory of carbon-monoxide over the Indian region

Chemical simulations in most of the atmospheric chemistry models require surface emissions in a specific form (gridded), which are often not available. Simple interpolation of broader level emissions to obtain gridded data may lead to erroneous results. Given the importance of CO emissions in ozone pollution chemistry over India, an attempt was made to develop a Geographical Information System (GIS) based methodology for distributing the CO emissions from a broader (national) level inventory to finely gridded emission values, considering micro level details and activity data. The total CO emission over India for 2001 estimated to be around 69.0 Tg/year was gridded to 1° x 1° resolutions. The final results provided detailed information with "hot spots" and the relative contributions of various sectors in India were differentiated.

Fig. 38 shows the gridded CO emissions for the year 2001 over Indian geographical region from two major sources viz., bio-fuel and vehicular traffic (liquid fossil fuel). The CO emission from bio-fuel sources was around 34,282 Gg, which was almost

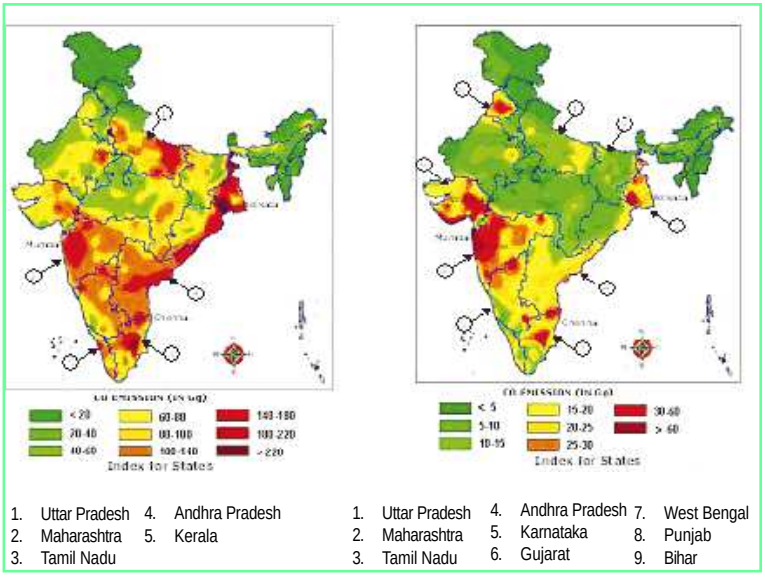


Fig. 38 : Distribution of CO emissions (2001) obtained after gridding (a) combined for rural and urban sectors from biofuel source (b) for vehicular traffic (liquid fossil fuels) source

50% of total CO emissions, thus signifying that the bio-fuel specially from the rural sector is the most important and major contributor for CO emission over Indian region. The highest contribution was found to be from the Southern Indian states where several high emission areas are noticed. The total contribution in CO emission from fossil-fuel sector was around 6,285 Gg and was relatively low as compared to bio-fuel emissions.

Measurement and Monitoring of Atmospheric Minor Constituents

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

Intra-seasonal variability in total column ozone variations

Intra-seasonal variability of daily total column ozone (TCO) over 13 Indian stations was studied. TOMS (Total Ozone Mapping Spectrometer) daily data from June to September for the periods 1979-1992 and 1997-2000 were utilized in the study. Using the daily data, monthly time series of TCO was prepared. The technique of Singular Spectrum Analysis (SSA) used to obtain the TCO variability on the seasonal scale suggested that the variance associated with the seasonal cycle varies from 1.67% to 7.86% over Indian region. The association between filtered monthly TCO and monthly rainfall during extreme monsoon years (deficient and excess) was examined. The relation between two was found statistically significant. It is observed that during excess monsoon years ozone values were found to be decreased and opposite happens in the deficient monsoon years. The power spectrum analysis of daily TCO data showed three dominant modes of periods 3-7 days (synoptic), 15-20 days (quasi bi-weekly, qbw), 30-60 days (Madden Julian oscillation, MJO) similar to that found in the Indian Summer Monsoon rainfall (ISMR). The Synoptic mode was found significant over central and northern part of India, qbw mode was found significant over northwest and northern India, while MJO over southern and eastern part of India.

Twilight photometer observations

The automatic and manual twilight photometers were operated simultaneously and the data were analyzed. It was observed that the profile derived by manual operation looks very smooth while the profile derived by automatic photometer exhibited fine-scale features due to increase in height resolution.

The variability of stratospheric aerosol layer was studied by using the vertical profiles obtained with the twilight photometer at Pune during 2001-2003. The stratospheric aerosol loading was computed by integrating the logarithmic gradient of intensity profiles from the tropopause to ~30 km. The time variation of monthly mean stratospheric aerosol loading showed the annual cycle with a maximum in winter months and minimum in spring and summer months. No significant trend was observed in the background aerosol.

Twilight photometry observations were carried out in the month of April, 2004 and again from November, 2004 to March, 2005 manually. In order to observe the effect of Germinid meteor shower, the morning twilight (starting at 5.30 a.m.) observations were carried out on 14 and 15 December, 2004.

Energetics in the middle atmosphere in association with monsoon and ozone variability

The global grid point monthly data (2.5° x 2.5°) of temperature, zonal and meridional wind for 200, 100, 50, 30, 10 hPa levels during June-September were analysed for the two contrasting monsoon years 1987 and 1988. The mean kinetic energy for the tropopause level (200-100 hPa) and at the stratospheric levels (100-10 hPa) was obtained for the monsoon months (June-September). The total kinetic energy at tropopause level (200-100 hPa) in the equatorial belt 0-30°N, was more in 1988 than in 1987. In mid latitudes of northern hemisphere, it was nearly same during summer of 1987 and 1988. In the southern hemisphere, the mean kinetic energy was more in 1987 than in 1988 during the summer period (June-September) in the region between 15°S and 75°S.

The mean kinetic energy at the stratospheric levels from 100-10 hPa was found increasing from 15°S, peaking at 5°N

and decreasing thereafter up to 60°N in the year 1988. In the stratosphere of southern hemisphere, it was increasing from 15°S, peaking at 55°S and decreasing thereafter for the summer of 1988. Similar variations were found in 1987 as observed in 1988. The mean kinetic energy was more in 1988 summer months in the region 15°S-60°N than in 1987 while in southern hemisphere it was less during 1988 than in 1987 in the region 15°-75°S.

Vertical profiles of NO_2 and O_3

Vertical profiles of O_3 and NO_2 were retrieved from their slant column density measured over a range of 87º-91.5º SZA by the Chahine iteration method for the period 2002-2003. From these profiles, the stratospheric and tropospheric column densities of O_3 and NO_2 were derived and were found to be maximum in summer and minimum in winter.

Ozone variability over Indian region during El Nino and La Nino events

Monthly mean total column ozone (TCO) over the Indian region for the years 1982, 1983, 1987, 1988 and 1997 for 13 Indian stations wasutilized to study the TCO distribution during El Nino and La Nina years. Comparison of TCO distribution during El Nino and La Nina years suggested that ozone values are higher during El Nino years than those in La Nina years, which is considered to be due to suppressed convection. The difference in TCO during monsoon months of El Nino and La Nina years was found statistically significant at 5% level of confidence for all stations except Dumdum. The monthly outgoing long-wave radiation (OLR) data were considered as measure of convection and association between seasonal mean OLR and seasonal mean TCO was examined. It was noticed that this relationship holds good only during the Indian summer monsoon months as convection is stronger during these months than remaining months of the year.

Study of diurnal and seasonal variation of NO_2, O_3, H_2O and O_4

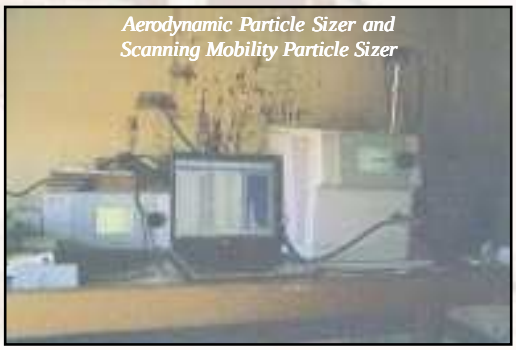
Daily twilight zenith scattered light observations were made for the study of atmospheric minor species by UV-visible spectrometer. Data for the period 2000-2004 were analyzed with Differential Optical Absorption Spectroscopy (DOAS) method. With this method vertical column density (VCDs) of NO_2, O_3, H_2O and O_4 were derived simultaneously. Diurnal and seasonal variations of NO_2 and O_3 were studied. For comparison of O_3, Dobson spectrophotometer observation and satellite born Total Ozone Mapping Spectrometer (TOMS) observations were compared with spectroscopic observations and good correlation was observed between them. The VCDs of NO_2 were found to have strong seasonal and diurnal variation with maxima in summer months (May and June) at sunset and minima in winter months (December and January) at sunrise.

The NO_2 density in the evening was observed more compared to morning. It was also noticed that evening NO_2 values were almost double of morning NO_2 values in the month of October. The high values of NO_2 in the evening appeared to be related to NO-NO_2 conversion that occurred in evening twilight period. Increase in NO_2 density was found to be possible due to increased pollution during day time, which was reflected in the evening twilight hours. In summer, the duration of sunlight hours leads to further photolysis of N_2O_5, which causes higher density of NO_2 as compared to winter values.

Instruments and Observational Techniques

Ion Counter

Plate antenna for Air-Earth current



Aerodynamic Particle Sizer and Scanning Mobility Particle Sizer

Instruments and Observational Techniques Division designs and develops instruments and techniques for observations 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, R. V. Bhalwankar, M. N. Kulkarni and C B. Sailaja)

Experiments to study the effect of electrical forces on the shape of water drops freely suspended in a small vertical wind tunnel were carried out. The suspended drops were photographed with a movie camera. The data obtained on distortion of water drops of different size, in absence and presence of horizontal / vertical electric field were analyzed and compared with the previous results obtained from both theoretical models and experiments. The results showed that with increasing drop diameter the axis ratio of the drop decreases in all ambient electric field conditions. The extreme positions of oscillating drop in electric field were determined from the movie photographs to study the effect of field direction on drop oscillations.

An experiment was conducted in wind tunnel to study the effect of chemical impurities in rain water on different microphysical processes such as distortion, evaporation and corona discharge from water drops in strong horizontal electric fields. Another laboratory experiment to study the effect of turbulence on break-up characteristics of water drops falling at their terminal velocities below the vertical fall tube was also performed.

Surface observations of atmospheric electricity and electrical properties of clouds

(A. K. Kamra, S. D. Pawar, V. Gopalakrishnan, R. Latha, P. Murugavel, Deen Mani Lal, Devendraa Siingh, K. P. Johare, V. Pant and Ramesh Kumar)

Participation in Antarctic Expedition

Measurements of size distribution of aerosols in the size range 5 - 20,000 nm and various atmospheric electric parameters such as concentration of ions in different categories, air-earth current, atmospheric electric field and Maxwell current were made during the 24th Indian Summer Expedition to Antarctica from 6 December, 2004 to 27 March, 2005. An ion counter was designed and fabricated in the institute for the ion measurements. Two state-of-art instruments, namely, Aerosol Particle Analyzer and Scanning Mobility Particle Sizer were used for measurement of full size ranges of atmospheric aerosols. Measurements of aerosols were also made near ice-shelf onboard MV Emerald Sea for a period of ten days during the return cruise from Antarctic to Cape Town, South Africa.

Analysis of ARMEX Data

a. Shipborne measurements

Measurements of the atmospheric electric conductivity and small-, intermediate-, and large-ion concentrations made at four locations over the Arabian Sea onboard ORV Sagar Kanya in the pre-monsoon and monsoon seasons during the Arabian Sea Monsoon Experiment (ARMEX) in 2002-03 were analyzed. The results showed a threefold increase in the daily average value of conductivity over a period of ~10 days preceding the onset of southwest monsoon (Fig. 39). The enhanced values of conductivity were accompanied with higher concentration of large ions (Fig. 40). Although ion concentrations in all categories exhibited large fluctuations, the average concentration levels of small ions decreased and of large ions increased during the monsoon period. The enhancement in conductivity associated with the onset of monsoon may be due to the highly charged large ions produced by the bubble bursting process at the air-sea interface caused by the breaking waves during the high wind speed periods over the Arabian Sea. The correlation coefficient between the large ion concentration and wind speed measured at ORV Sagar Kanya increased to 0.56 during the monsoon onset period from 0.41, 0.16 and 0.23 found during the pre-monsoon and two monsoon periods respectively. Enhanced value and the large variability of large ion concentration observed during monsoon season were found to be associated with the spatial and temporal heterogeneity in not only their production but also their dissipation by the cloud scavenging processes over the Arabian Sea.

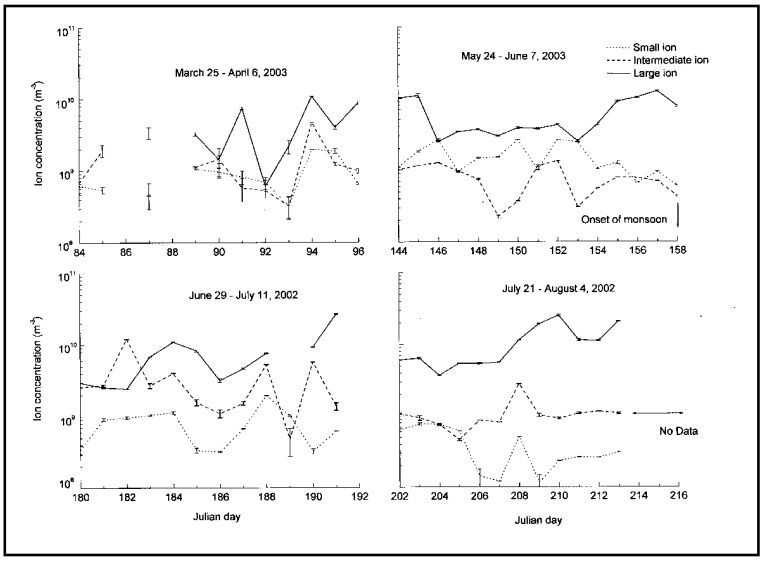


Fig. 39 : The daily average values of the polar and total atmospheric electric conductivity in the pre-monsoon, monsoon-onset and the two monsoon periods of the ARMEX

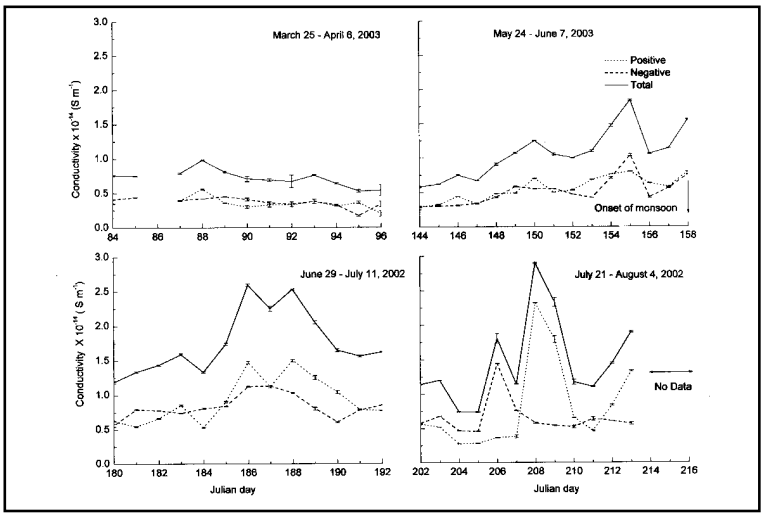


Fig. 40 : The daily average concentrations of the small-, intermediate-, and large- ions in the in the pre-monsoon, monsoon-onset and the two monsoon periods of the ARMEX

The ion concentration in all categories was of same order in the pre-monsoon season whereas the difference in different categories of ions was found to increases as the monsoon sets in and the season progresses. In monsoon season, the large ion concentration becomes 1 to 2 orders higher than that of small ions. Also, the conductivity and ion concentration values showed large fluctuations during the monsoon season. Addition of a new source of large ion production by breaking waves at the sea surface and the destruction of ions and aerosols due to the cloud scavenging processes during the monsoon season may be responsible for the observed large fluctuations and differences in ion concentrations of different categories.

Data on ion concentration and atmospheric electric conductivity obtained over sea onboard Sagar Kanya during the ARMEX period were analyzed to study the climatology of ions over sea near the western coastline of India. Seasonally averaged values of the total as well as polar conductivity were found much higher during the monsoon than during the pre-monsoon season. Surprisingly, however, the concentration of small ions was less and that of large and intermediate ions was more during the monsoon than during the pre-monsoon season. The diurnal variations observed during the pre-monsoon season showed that nighttime small ion concentrations were about an order of magnitude higher than their daytime values. On the contrary the daytime concentration of intermediate and large ions was much higher than that of nighttime values. No such diurnal variations in ion concentration were observed in monsoon season. Variations in ion concentration of different categories with distance from the coastline in different seasons were interpreted in terms of the ion aerosol attachment process in pre-monsoon observations. However, such variations of intermediate and large ion concentration were 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. Ion concentrations of different categories were observed to undergo different types of changes following different types of rainy periods such as drizzle, shower and continuous rain. These changes can be interpreted if one considers the changes in collection efficiency with the sizes of ions and/or drops and the ion production due to splashing of drops on the sea surface.

b. Airborne Measurements

Size distributions of sub-micron sized aerosol particles measured on a cloudy day during the ARMEX period were examined to understand the effect

of cloud processes on the aerosol size evolution. Results showed very high aerosol concentration of particles in the size range 240 - 750 nm whenever the aircraft encountered cloud or precipitation. Concentration of particles less than 240 nm diameter was similar to that of observed on other fair-weather days.

Analysis of Pilot Expedition to the Southern Ocean (PESO) Data

Measurements of aerosol size distribution were made onboard ORV Sagar Kanya using Aerosol Particle Sizer and Scanning Mobility Particle Sizer Systems in the southern Indian Ocean in the region 20°S, 57°E to 56°S, 45°E during Phase - II and in the region from 20°S, 5°E to 11°N, 73°E during Phase-III of PESO from 23 January, 2004 to 31March, 2004. The data were analyzed with respect to the prevailing wind conditions.

Thunderstorm electrification studies

Measurements of electric field, Maxwell current and point discharge - current were made below thunderstorms occurring in the pre-monsoon and post-monsoon seasons for the study of the evolution of lightning and other aspects of the cloud electrification

Two fast-field antennas were fabricated and installed at the Institute's Atmospheric Electricity Observatory for the study of field-changes during lightning discharges.

Method to determine eddy diffusion coefficient

A theoretical method was developed to find eddy diffusion coefficient from ion-aerosol balance equations. The method was improved to include the effect of coagulation of particles. Vertical profiles for different values of mixing parameter were computed.

Visit of Hon. Minister of Science and Technology Govt. of India to Maitri, Antatctica

Minister of Science and Technology with IITM's instruments during his visit to Maitri. (From left to Right: Shri R. K. Seth, Joint Secretary, DOD; Dr. P. C. Pandey, Director, NCAOR, Goa; Dr. Harsh Gupta, Secretary DOD; Shri Kapil Sibal, Minister for Science and Technology; Shri Rajesh Asthana, Expedition Leader, Shri Sunil M. Sonbawne, Dr. Devendraa Siingh and Shri Vimlesh Pant)

Instruments installed at Maitri, Antarctica

Ion Counter

Plate antenna for Air-Earth current

Aerodynamic Particle Sizer and Scanning Mobility Particle Sizer

Boundary Layer and Land Surface Processes Studies

Micrometeorological Tower

Sonic Anemometer and CO_2 / H_2O analysers

The Micrometeorology Laboratory at the IITM Field Laboratory at NCAOR, Goa

Boundary Layer and Land Surface Processes Studies Division carries out field and laboratory experiments relating to the atmospheric boundary layer and land surface processes. Following are the research programmes undertaken by this Division :

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

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

(S.Sinha, M.N.Patil, S.P.Nikam)

Studies on LASPEX

The wind and temperature observations collected during LASPEX at Anand (22°35'N, 72°55'E) were utilized to study the turbulent parameters such as drag coefficient (C_D), sensible heat flux (H) and aerodynamic roughness length (Z_O). The analysis was carried out for the data representing summer, monsoon and winter seasons. Z_O from wind profile measurements showed that it was greater when the wind speed was low in December, 1997 (Fig. 41). During convective conditions Z_O reduced drastically. The resulting values of Z_O and C_D for the monsoon period agreed well with values reported in literature over Indian subcontinent for homogeneous grass covered surfaces. For winds less than 2 m/s, Z_O variation was much more ranging from few mms to few tens of cm. But for wind speeds greater than 2 m/s, Z_O becomes nearly constant and of the order of few mms. This behavior of Z_O was well depicted in summ++er and winter period. In monsoon conditions, Z_O was low of the order of few mms compared to that of summer and winter conditions.

Fig. 42 shows the friction velocity (u_*) and temperature scale (T_*) variation with stability. u_* was high in near neutral conditions (z/L = 0) and it decreasedwhen static stability increased. T_* was high in the unstable conditions (z/L = - ve). The wind speed decreased in highly stable conditions. It was maximum at z/L = -0.25. T_* was nearly zero in stable conditions which indicated that transfer of heat and momentum in stable condition was dominated by the surface wind stress as evidenced by the variation of u_* in stable conditions. The sensible heat flux was high in summer about 150 W/m^2 in the noon hours, while in monsoon and winter climate, sensible heat flux reduced to about 100 W/m^2.

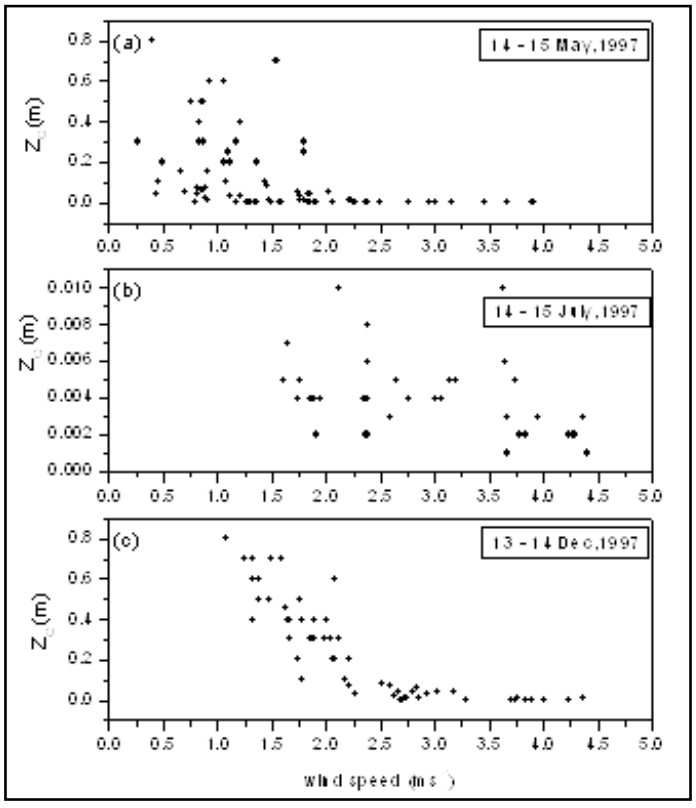


Fig.41 : Dependency of Surface roughness length (Zo) on wind speed in different months (a) 14-15 May (b)14-15 July, and (c) 13-14 December, 1997

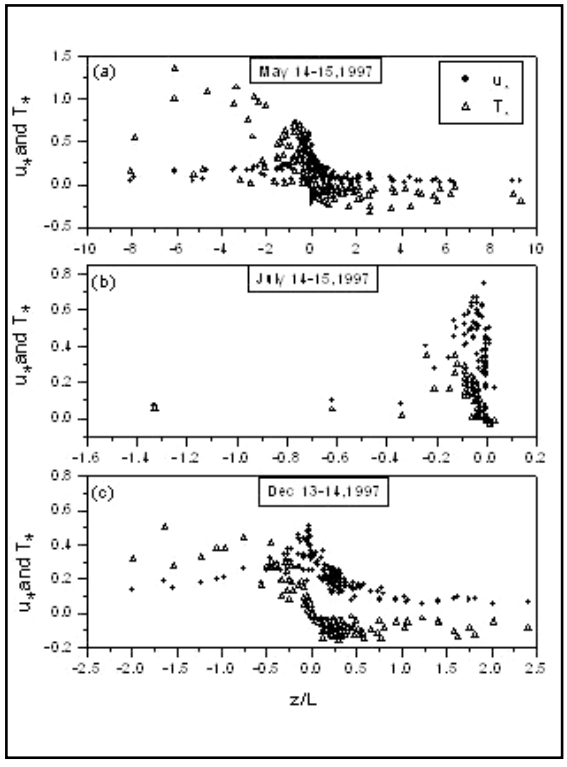


Fig. 42 : The behaviour of frictional velocity with time for (a) 14-15 May (b) 14-15 July and (c) 13-14 December, 1997

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, Cini Sukumaran)

Boundary layer characteristics at west coast station, Goa

Doppler mini-sodar of Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam was used at the National Centre for National Centre for Antarctica and Ocean Research (NCAOR), Goa to measure all the three components of wind up to a height of 500 m AGL with a height resolution of 10 m. Initial scan of the data during 10-24September, 2004 showed down drafts of ~ 2-3 m/s in the convective boundary layer in the height range 200-500 m (Fig. 43) AGL during the same period sonic anemometer at 5 m AGL also showed down drafts of 0.3 m/s when the sensible heat flux was about 200 W/m^2. This was unexpected during convective, clear sky conditions. Similar feature was also observed at SHAR where sonic anemometer measurements were done at 10 m AGL. Similarly at IGCAR also sodar measured vertical velocity showed down drafts of 2-3 m/s in ABL during convective conditions. LASPEX sonic anemometer data at 9.5 m AGL at Anand showed updrafts during clear, convective day time conditions which was obvious because of thermal plumes rising from the heated surface. The inference that can be drawn from these observations is that there is some local circulation at coastal sites (NCAOR, Goa; SHAR; IGCAR, Kalpakkam) that gives strong downdrafts at times which is not occurring at inland sites (like Anand).

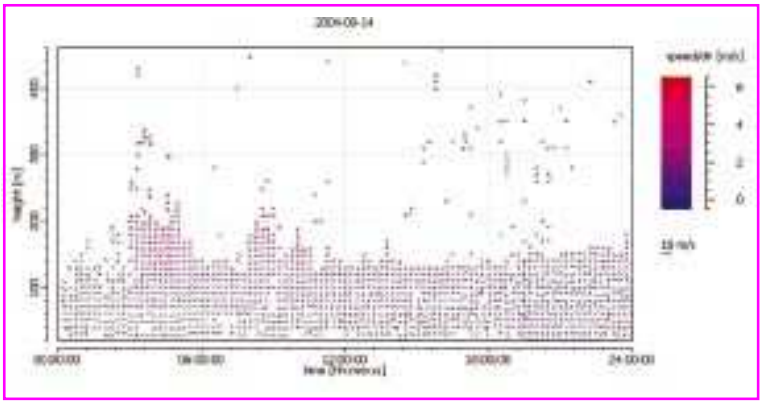


Fig. 43: Sodar wind vector profiles in ABL on September, 14, 2004 at NCAOR, Goa

Scintillometer was set up by Bhabha Atomic Research Centre (BARC), Mumbai, at NCAOR, Goa and path-averaged sensible and momentum fluxes were measured. Surface fluxes of momentum and sensible heat as measured by sonic anemometer (at 5 m AGL) and scintillometer (at 1.5 m AGL, path-length = 50 m) were compared.

Turbulence structure of the surface layer at NCAOR, Goa

Variation of the magnitude of sensible heat and momentum flux as a function of averaging time was investigated to find the appropriate averaging time required for statistically consistent flux and vertical velocity. The shape of the spectra of wind components in the atmospheric surface layer and related dynamical processes as a function of static stability was investigated. The extent of plateau (-1 slope) in the spectrum 'S(f) Vs f' of along wind component (u-component) was observed to increase with instability.

Frequency weighted spectra of wind (u, v and w) during unstable, near-neutral and stable conditions on 24July, 2002 showed -2/3 slope in the inertial sub-range, zero slope at intermediate frequency range (only for u-component) and +1 slope at low-frequency range (Fig. 44). The frequency range of the zero-slope in u-spectrum was found to increase from stable to near-neutral/ unstable condition.

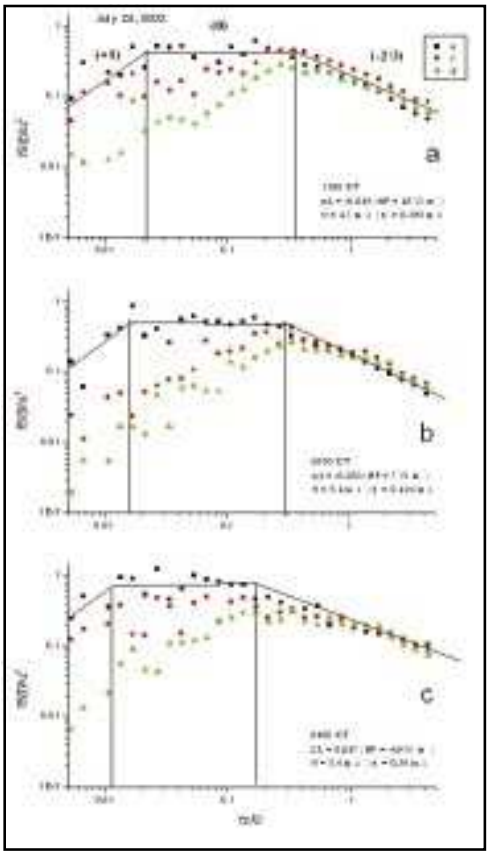


Fig. 44 : Spectra of wind for (a) unstable (b) near neutral and (c) stable conditions on 24 July, 2002 at Goa. The inertial subrange (-2/3 slope), intermediate range (0 slope) and low-frequency range (+ slope) are shown. The vertical lines indicate the lower and higher endes of the intermediate frequency range

Analysis of LASPEX Data

Power spectrum of mean wind from Land Surface Processes Experiment (LASPEX) at Anand (22° 35' N, 72° 55' E) and relative humidity at Khandha (22° 02' N, 73° 11' E) revealed the planetary scale (40 day period) Madden-Julian oscillation in the 1-2 m AGL of the surface layer (SL). Oscillations of period: 21, 6-9 day, the diurnal (24 hr.) and the semi-diurnal (12 hr.) were prominent in the spectrum of all the variables. Low frequency peaks (15 and 21 days) showed that the spectral energy in wind was 2-3 times higher at Khandha than at Anand whereas in the case of temperature the 21 day mode showed spectral energy 3 times higher at Anand than at Khandha. The diurnal peak for spectral energy of temperature was comparable at these stations showing large heat exchange taking place in the surface layer. The humidity spectrum (1 m) at Khandha showed prominent peaks of period 43 day corroborating large scale transport of maritime humid air to the site from the Arabian Sea.

Studies on CO_2 and water vapour at Goa

Study of the variation of CO_2 and water vapor in the surface layer (5m AGL) at Goa during the Indian summer monsoon shows an inverse relation in the diurnal variation of CO_2 (decrease) and water vapour (increase) due to sea/land breeze effects exists in August, September and October, 2002. This relationship wais not clear in the variation of daily averaged values of CO_2 and water vapor. Large/ synoptic scale oscillations of period 5, 8 days for CO_2 and 5, 11 days for water vapour occurred with the 1 day period equally prominent in spectral energy content. Spectral gap existed at the frequency band of about 1-2 cycles per hour where the power spectral energy dropped for CO_2 and water vapour. Small scale micrometeorological spectra of CO_2 and water vapor obey the Kolmogorov's -5/3 power law in the inertial sub range.

Studies on surface Ozone

Continuous measurements of ozone, incoming solar radiation and relative humidity were being carried out at the institute campus, Pune. The study revealed that the incoming solar radiation is positively related to ozone concentration, whereas relative humidity is negatively related. Fig. 45 shows that seasonal diurnal variation of surface ozone observed at IITM campus, suggesting that photochemical production and destruction of ozone.

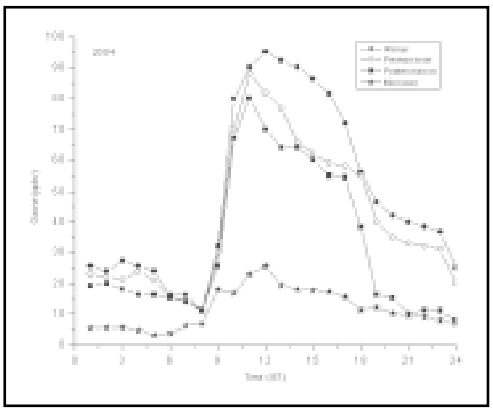


Fig. 45 : Seasonal diurnal variation of maximum surface ozone concentration observed at IITM campus, Pune, suggesting photochemical production and destruction of ozone

Measurements on ground-level ozone (O_3) were carried out over three tropical rural sites (Poombuhar, Tranquebar and TR Pattinam) along and across Coromandal coast of Tamilnadu, India, for 6 days each in December (2000 and 2002) and in April (2001 and 2003) (Fig. 46).

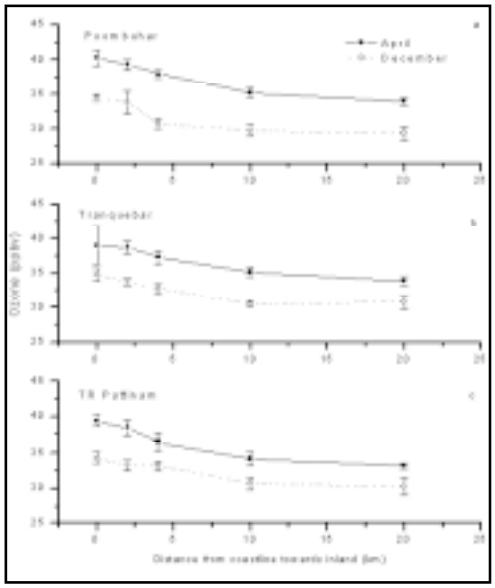


Fig. 46 : Variations of average ozone concentrations in April (solid line) and December (dotted line) observed at Poombuhar, Tranquebar and TR Pattinam. Vertical bars are 1 ó variations.

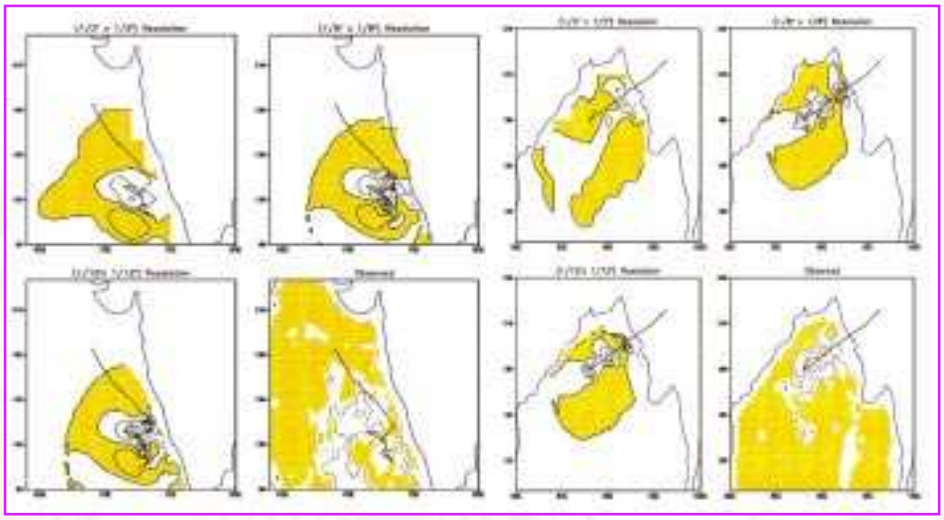
The analysis showed that the average maximum O_3 concentration is 40.3 ± 1.13 ppbv (parts per billion by volume) (34.8 ± 0.90 ppbv) in the afternoon and minimum 15.8 ± 0.63 ppbv (12.7 ± 0.47 ppbv) with 1 ó variations during early morning hours in April (December) at the coastline. The corresponding maximum and minimum O_3 concentration was 33.9 ± 0.49 ppbv (29 ± 1.04 ppbv) and 12.3 ± 1.31 ppbv (8.7 ± 0.74 ppbv) at 20 km inland which indicated that O_3 enhancement by 6 ppbv or 19% at the coastline as compared inland. Further, the higher O_3 about 5 ppbv or 16% in April (summer) as compared to that in December (monsoon) was due to relatively warmer air temperature and less cloud cover. The increase in O_3 in April was also attributed to the higher emission of its precursor gases (NOx, VOC, CO and CH_4) by different sources (such as biomass burning) from February to April in the proximity of these rural coastal sites. The daily average O_3 (high) appeared to vary between 26.3 ± 0.41 ppbv and 22.7 ± 0.16 ppbv, whereas O_3 (low) between 20.9 ± 0.15 ppbv and 18.3 ± 0.23 ppbv respectively at the coastline and at 20 km inland with 1 ó variations. The measurements of O_3 showed that average east to west gradients in O_3 was about 0.7 ppbv/km which was highest between coastline to 2 km inland and then it decreased towards 20 km inland. The north to south gradients in O_3 concentration along the coastline was observed nearly equal to zero.

IITM Atmospheric Boundary Layer (ABL) Field Laboratory at the National Centre for Antarctica and Ocean Research (NCAOR), Goa

From L to R: Mini-Sodar of Indira Gandhi Centre for Atomic Research Laboratory and Tower with Meteorological Sensors of the IITM

The Micrometeorology Laboratory at the IITM Field Laboratory at NCAOR, Goa

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, D.W. Ganer, P.R.C. Reddy, B. Thompson, J.S. Chowdary, B.H. Vaid, Medha Deshpande)

Three dimensional multilevel ocean model studies

Sigma (σ) coordinate ocean model POM

The three dimensional σ coordinate free surface, primitive equation Princeton Ocean Model (POM) with horizontal resolution 1° x 1° and 21 levels from surface to deep ocean (in which 10 levels are from surface to thermocline layer) was used to simulate surface and subsurface circulation and temperature of tropical Indian Ocean (25°S - 25°N, 35° -115°E).

For simulation of thermodynamic features the model was forced by QuickSCAT surface winds and OLR derived heat fluxes during 1999 to 2004 to understand the Arabian Sea warm pool. It was found that the surface water in the warm pool area is less saline, and so favours the accumulation of heat in the upper mixed layer. The warmer and less saline water acts as a thin stable stratified surface layer that inhibits the mixing with deeper, cooler and high saline water. This strong haline stratification leads to the formation of subsurface temperature inversions through the formation of a stable Barrier Layer. The model was able to simulate successfully the temperature inversions observed in the South East Arabian Sea (Fig.47). The westward propagation of these inversions with the propagation of annual Rossby waves is also well simulated by the model. Temperature inversions in the north Indian Ocean is found to be a permanent feature except in April month. The inversions form in the seas, head Bay and East equatorial Indian Ocean all move along with the Rossby and coastal Kelvin waves.

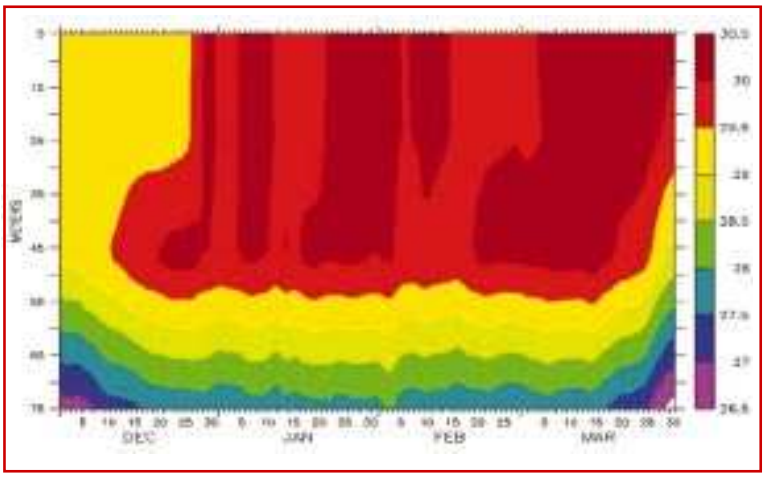


Fig. 47 :Time-depth plot of temperature inversions (2000-2001) at 10° N, 75° E

For simulation of intraseasonally varying circulation the model was spun up for 20 years to reach the quasi steady state using ECMWF monthly mean climatological surface forcings and Levitus Climatology for internal forcings. The model simulated surface currents for all the 12 months after spin up time is shown in figure 48. The model successfully simulated surface circulation for all the months. The westward flowing south equatorial currents (SEC) between 10° and 20°S were found almost throughout the year. During boreal winter the winds were northeasterly in the north Indian Ocean but the Somali current along the Somali coast flew southward as simulated in the January circulation. An eastward equatorial counter current existed in the Southern Hemisphere between 2°S and 8°S. The southward flowing Somali Current in the winter months (November, December, and January) disappeared in March. During the spring season (prior to SW monsoon) the surface current along Somali coast started flowing northward. The model results suggested northward flow north of 5°N in March and northward along the coast in April. Further, in April the establishment of strong eastward jet within a few degrees of equator in the central and eastern part of the Indian Ocean was found. As in the case of Somali Current the East India Coastal Current (EICC) also reversed direction twice a year flowing North Eastward from February until September with a strong peak in March-April and southwestward from October to January with strongest flow in November. Large basin wide anticyclonic gyre in winter and spring i.e. December to April was seen in the Bay, which agreed very well with available literature.

Fig. 48 : Model simulation of surface circulation for all the months after spun up for 20 years

Z-coordinate ocean general circulation model MOM4

The Modular Ocean Model version 4 (MOM4) with the horizontal resolution of 1° x 1° and 25 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 the National Center for Atmospheric Research (NCAR) which consists of monthly climatological precipitation, daily climatological radiative fluxes of downwelling shortwave and longwave radiations and 6 hourly climatologies of 10-m zonal and meridional winds, air temperature, humidity and sea level pressure. After spin up, the model was integrated for a period of 43 years from 1958-2000 with inter-annually varying all the above mentioned forcing from NCAR. The model simulated Sea Surface Temperature Anomaly (SSTA) showed good agreements with the Observed (HADISST) anomalies during peak phase of Dipole mode years (e.g. October, 1994, October, 1996 and November, 1997). The model simulation showed a maximum cooling of 2° C on the eastern side during November, 1997, which was well comparable with the observations. The model simulated subsurface temperature was well comparable with Simple Ocean Data Assimilation (SODA) subsurface temperature in the dipole years. Subsurface cooling in the eastern equatorial Indian Ocean of about 5°C at 80m depth was found in the model during October, 1994 and November, 1997. The model could simulate the currents in the Indian Ocean very well. The strong currents associated with the peak phase of negative dipole mode year and absence of Wyrtki jets in the positive dipole mode year were well simulated. During November, 1997 the eastward equatorial jets were replaced by westward current. Associated with the reversal of surface currents, subsurface also showed a strong eastward flow (Fig. 49). The westward flow in surface and eastward flow in the subsurface can lead to a zonal circulation pattern. The vertical velocity analysis showed that western equatorial Indian Ocean is characterized by strong down welling and strong upwelling in the eastern region. These features were well evident in the model simulations. Strong variability in the circulation of Bay of Bengal especially during the dipole mode years was also seen in the model.

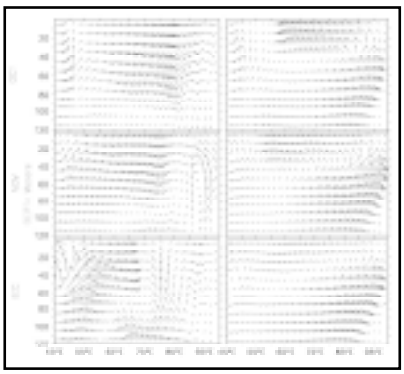


Fig. 49 : Zonal – vertical current vectors for 1996 (left) and 1997 (right)

Basin scale reduced gravity model study

Ocean response to moving tropical cyclones using 1 ½ layer IRG model

The IRG (IITM Reduced Gravity) Ocean model was suitably modified to investigate the ocean response to observed cyclones in May 2004, one in the Arabian Sea (TC 01A) and the other in Bay of Bengal (TC 02B). The control experiments for the observed tracks of TC 01A and TC 02B were performed with ½° x ½° resolution model. The model upwelling and cooling indicated unusual left bias for the TC 01A due to the erratic motion in the initial stage. In the case of TC 02B the model fields showed right bias. The model cooling is 3° C and 3.5° C during the passage of TC 01A and TC 02B. The sensitivity study with fine model resolutions (up to 9km x 9km), indicated the stronger model output for both the cyclones. Further, the numerical experiments with varying vertical temperature gradient in the mixed layer were carried out and the model cooling thus obtained for fine resolutions was found comparable with the observed cooling of 2.5°C on the left of the TC 01A track and that of 3.5°C on the right of the TC 02B track (Fig. 50).

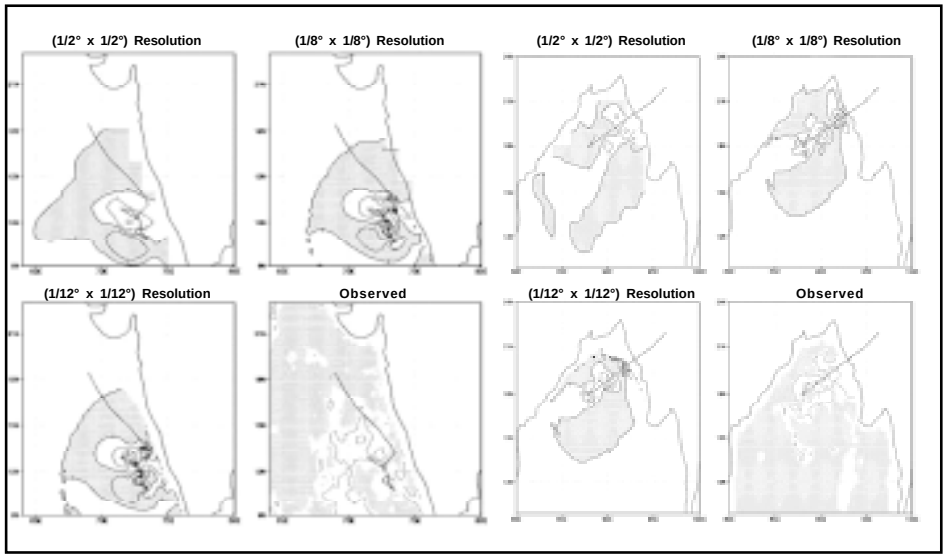


Fig. 50: Temperature change (°C) on the third day of TC 01A for the different resolutions compared with the observed one. Positive values are shaded

Study using 2 ½ layer thermodynamic ocean model

A 2½ layer thermodynamic ocean model was used to simulate inter-annual variability in the circulation and SST anomaly (SSTA) fluctuations in the tropical Indian Ocean using daily NCEP surface forcings for the period 1992-2000. The warm SSTA in the western equatorial Indian Ocean and cold SSTA in the eastern equatorial Indian Ocean during the years 1994 and 1997 (positive dipole years) and, opposite SSTA during the years 1992 and 1996 (negative dipole years), were well simulated by the model. The model sub-surface temperature also showed both positive and negative dipole structure. The model circulation showed that the equatorial jet was absent in the year 1994 and weak in the year 1997, whereas, during negative dipole years 1992 and 1996, the equatorial jet was found similar to the Climatology of the model. The absence of equatorial jet in the positive dipole years might be due to the weak westerly winds in the equatorial region. The model lower layer currents reversed in the direction and the magnitude of the currents reduced to half of the surface currents in both the positive and negative dipole years.

Diagnostic studies using in situ and satellite observations

Role of intra-seasonal oscillations in modulating storm frequencies

The modulation of the frequency of tropical storms over the southern tropical Indian Ocean by the intra-seasonal low frequency oscillations was investigated using data for the period 1981-1995 in the months November to April, since the frequency of the storms was higher in these months. The strength of the low frequency oscillations was estimated by using pentad OLR data over the region (55° -105° E; 5°-10°S). Band pass filter was applied to this OLR series and the variances in the low frequency bands (10-20, 20-30, 20-40) were computed. Preliminary results showed that the strength of these low frequency modes is inversely related with the frequency of the tropical storms.

Wind driven transport in the Arabian Sea

Mean monthly meridional Ekman and Sverdrup transports along the Arabian Sea at 8.5° N were estimated using QuikSCAT winds for the period 2000 to 2003. There was strong southward transport in summer monsoon and northward transport during winter monsoon. Seasonally reversing winds contributed to the reversing currents and resultant mass transport. For the 2000-2003 June and September, mean meridional Ekman transport along 8.5° N in the Arabian Sea were -17.4 Sv and -6.1 Sv, respectively. Four year mean values from January, 2000 to December, 2003 of meridional Ekman transport and Sverdrup transport at southern boundary of AS at 8.5° N were -3.4 Sv and -4.0 Sv, respectively, where as for the summer monsoon period (June to September) mean meridional Ekman transport for four years was -13 Sv and Sverdrup transport was -16.3 Sv. The maximum meridional Ekman transport was substantially greater in the month of June than JJAS and annual mean in most of the years (3 of 4 years) and the maximum Sverdrup transport was in July.

Biannual Rossby waves in the Indian Ocean

Anomalous downwelling biannual Rossby waves (filtered from TOPEX / POSEIDON SSHA) started propagating westward from the eastern boundary in July/August, of 1993 and 1996, more than one year prior to the formation of the Indian Ocean Dipole (IOD) events in 1994 and 1997 (Fig. 51). The biannual downwelling Rossby wave signals observed in the east during July, 1995, 1998 and 2001 did not show any westward propagation. This strong downwelling signals reaches the western equatorial Indian Ocean during the peak dipole time.

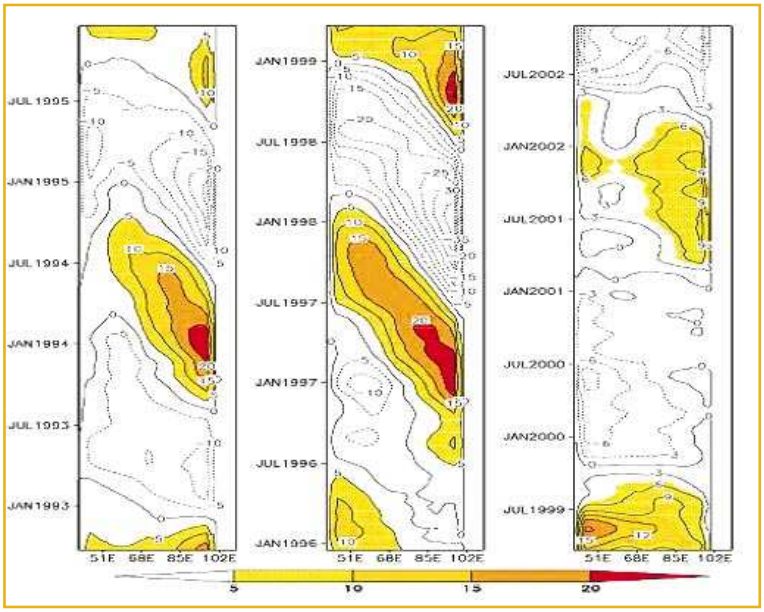


Fig. 51 : Propagation of biennial Rossby waves (mm) over 1.5° N to 3.5° S

Following the downwelling signals, upwelling biannual Rossby waves were formed in July, 1994 and 1997 in the east giving a sea saw gradient to the thermocline in the equatorial Indian Ocean. These biannual Rossby wave signals are triggered by the wind stress curl in the eastern boundary, however strengthened by the arrival of semi annual Kelvin waves. Based on this relatively short record, the westward propagating downwelling biannual Rossby wave signal is hypothesized as a predictor for the Indian Ocean Dipole. These biannual Rossby waves were also seen in the SODA (Simple Ocean Data Assimilation) thermocline depth.

Trimestral Kelvin waves in the Indian Ocean

The anomalous downwelling trimestral Kelvin wave propagation during October, 1994 to November/December, 1994 terminated the basin-wide coupled process by warming the eastern Indian Ocean. Moreover, such downwelling trimestral Kelvin Waves were found to be absent during the IOD events concurrent with the El Nino (e.g. 1997). This strengthened the role of surface heat fluxes in terminating the IOD events. To study the role of surface heat fluxes in the termination of IOD, latent heat fluxes and rate of change of SST in the eastern IOD box were analysed. It was observed that reduction in the latent heat loss led to the elimination of the coastal SST anomalies in the east, which was observed to be the cause for termination of the IOD events especially during the IOD years concurrent with the El Nino.

Empirical Orthogonal Function analysis

The Complex Empirical Orthogonal Function (CEOF) analysis of Topex/ Poseidon (T/P) sea surface height anomalies (SSHA) and heat storage

anomalies (HSA) were carried out during 1993 to 2002 in the tropical Indian Ocean (TIO). The first CEOF mode of T/P SSHA and HSA explained 30.13% and 43.12% respectively of the total variance and also showed existence of dipole like structure. The second CEOF mode of T/P SSHA and HSA explained 21.66% and 22.48% respectively of the total sea-level variance in the TIO, of which spatial pattern clearly showed dipole structure. Moreover, phase also showed westward propagation of signals in the TIO. The study revealed that the significant amount of interannual variability is confined to the north of 15°S.

Studies on Atmospheric Energetics in Wave Number and Frequency Domain

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

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

In order to find out the possible explanation for the locations of the error variance maxima in the geographical distributions of the systematic and random error of NCEP (MRF) model using the 850 hPa wind forecast up to 7-days for winter (DJF, 2000-01) and summer (JJA, 2001) season with respect to the places of maxima of the actual wind variances, the relationship between the error and the analysed flow were examined. The systematic and random error variances were normalized by the analysed wind variances at each grid point for each day of forecast. Almost similar qualitative features of the error variance and its respective normalized version establish the nonlinear relation of the systematic and random error to the analysed flow. This implies that there may be the physical and dynamical causes other than the large wind variances for the locations of the error maxima shown in the geographical distributions of respective error variance.

The statistical aspect of the forecasts were studied by calculating the predictability score (i.e. the ratio of root mean square error and the standard deviation of analysed field of wind at each grid point) and thereby estimating the predictability limit of certain geographical regions over the tropical belt (30°S-30°N) and the global tropics as a whole. Results indicated that the root mean square error covers the tropical region after being generated in the Southern Hemisphere during the boreal winter whereas the same spreads the global tropics after being appeared in the Northern Hemisphere during the boreal summer period for both the zonal (fig. 52) and meridional winds (fig. 53). During the boreal winter, the limit of predictability of the Indian region was found to be up to 2-day forecasts but the South African region and the northern Australia showed the predictability limit of 1-day only. In the boreal summer the tropical Africa, the Indian and the Indonesian regions showed the predictability limit of 1-day for both the zonal (fig.52) and meridional winds (fig. 53). As far as the whole tropical region is concerned, the limit of

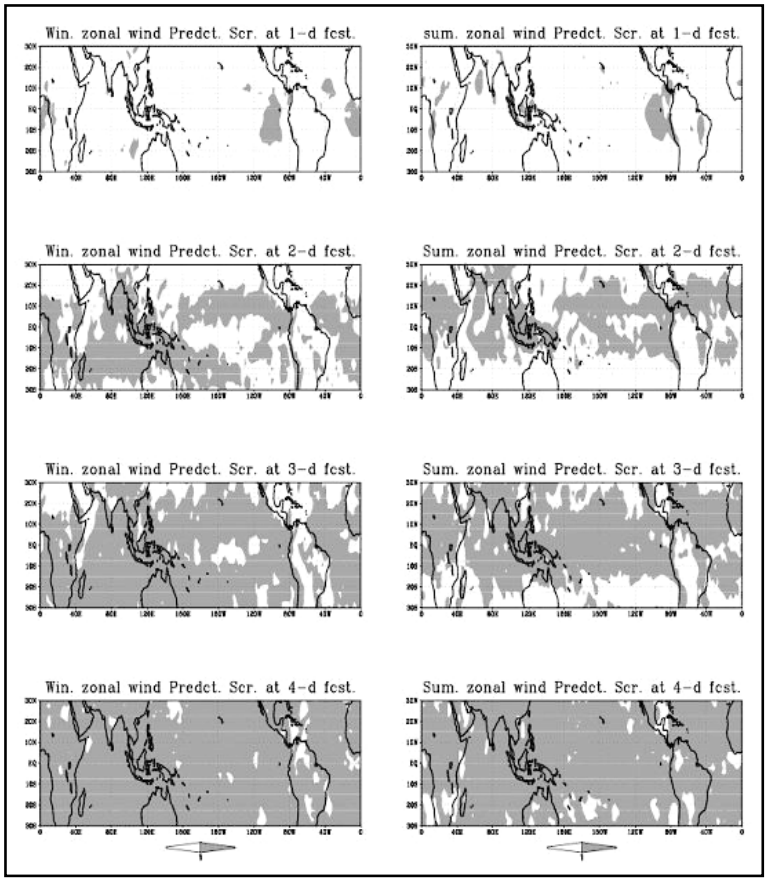


Fig. 52 : Predictability score in zonal 850 hPa wind for winter (DJF, 2000-01) and summer (JJA, 2001) of NCEP (MRF) model. Score greater than 1 is shaded

predictability was found to be 2-day and 1-day in the zonal (fig.52) and meridional (fig.53) wind respectively during both the seasons.

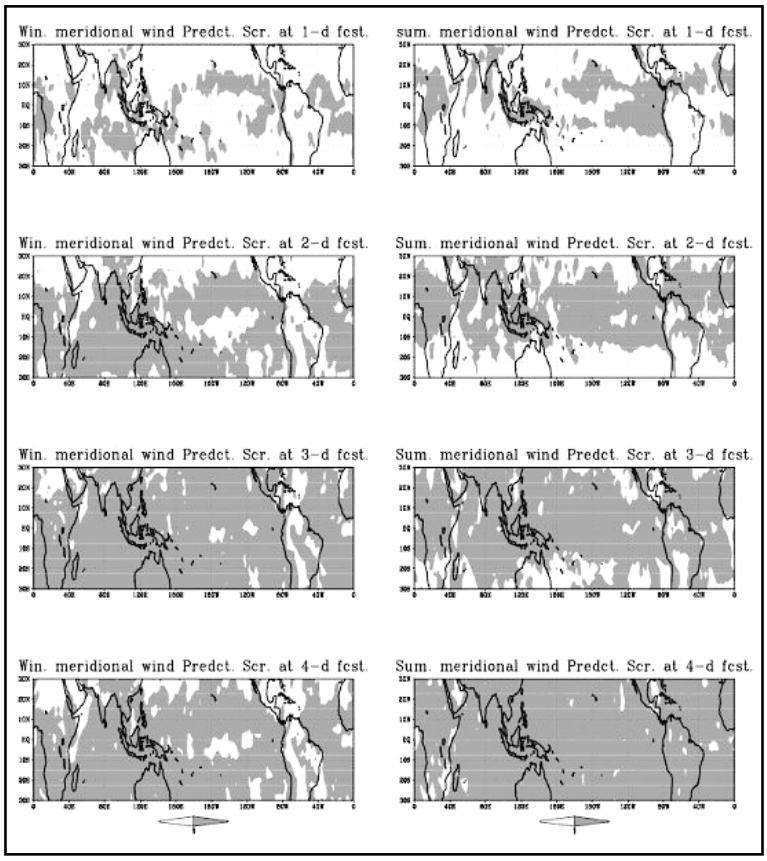


Fig. 53 : Predictability score in meridional 850 hPa wind for winter (DJF, 2000-01) and summer (JJA, 2001) of NCEP (MRF) model. Score greater than 1 is shaded.

Intraseasonal transients in energy exchanges

Many low frequency phenomena such as the Madden Julian Oscillation (MJO) or the El Nino – Southern Oscillations (ENSO) exhibit rapid growth where they appear to be undergoing a phase locking with other time scales such as the annual cycle. Using ECMWF reanalysis (ERA 40) data sets for the year 2001 an example of phase locking of different time scale was studied and it was found that during the epochs of phase locking a large increase in nonlinear energy exchanges occurs from one time scale to the other.

The preliminary study of nonlinear APE (available potential energy) exchanges in the frequency domain to examine the baroclinic mechanism for the maintenance of transient disturbances during Indian Summer Monsoon 2004 showed that MJO on 30-60 day time scale looses APE by inter time scale interactions at the upper troposphere and there exists a temporal down scale cascade of APE in the upper troposphere. However, APE spectra showed its maximum on 60 day period.

Diagnostic study for understanding the onset phase of southwest monsoon over the Indian region

Onset phase of the southwest monsoon over Kerala coast and subsequently its impact on atmospheric circulation pattern was examined during the unusual onset phenomena of the drought year 2002 and abnormal monsoon year 2004, by using NCEP reanalysed daily wind, temperature and humidity data over the region EQ-25°N and 50°-90°E for the period 15 May – 15 June throughout in the troposphere.

For the case of very early onset of 2004 (18 May), computations showed a very strong upward motion in the southeast Arabian Sea throughout in the lower and mid-troposphere indicating the existence of intense mesoscale circulation. Upward velocity (ω) drastically increased up to 20 May with a max. $\omega = -19 \times 10^{-3}$ mb s^{-1} at 700 hPa in the southeast coast of India which supported the existence of very severe cyclonic storm during 17-20 May over North Bay of Bengal. However, the strong magnitude of vertical velocity gets reduced when averaged over synoptic scale region. It seems that the onset over Kerala coast on 18 May was due to strong systems in the Arabian Sea and in the Bay of Bengal. The abnormal intensity in the upward motion, particularly in the eastern half of India and Bay of Bengal region was found since third week of May. But the overall large scale monsoon development throughout in the north of equator was noticed only from 1 June. In view of this it was concluded that large scale development of monsoon circulation is

required to finalise the monsoon onset because the occurrence of convective activity can be due to pre-monsoon systems.

For the year 2002, the horizontal extent of dynamical parameters was found to be of mesoscale nature till 8 June. Thereafter, from 9 June onwards, all the parameters showed increase in the horizontal extent i.e. synoptic scale. Strong cyclonic circulation was found in the northwest to southeast belt from north Arabian Sea to southwest Bay of Bengal with max. $\zeta = 5 \times 10^{-5}\ s^{-1}$ at 850 to 700 hPa on 12th June. Atmospheric circulation on southern Indian Ocean was found to be favourable for large scale monsoon system. All the significant features for the onset phenomena were noticed from 9-15 June. The time series of area averaged vorticity at 850 hPa over the horizontal region surrounding Kerala coast i.e. 5°-15°N, 65°-85°E were also obtained for different years as shown in the (Fig. 54). For the year 2002, the vorticity magnitude was found to be oscillating from 1- 8 June and then it gradually increased with a maximum vorticity, ($\zeta = 2 \times 10^{-5}\ s^{-1}$) on 12 June, 2002. This computation gave indication that though the onset of southwest monsoon for the year 2002 was declared on 29 May based on the rainfall criteria over Kerala coast, the circulation in the lower level was not favourable till 12 June over the region EQ-25°N & 50°-90°E. During the abnormal year 2004, maximum vorticity was seen on 1 June in the small region. It was seen that enhancement in the vorticity took place near the onset date. The area averaged vorticity from surface to 700 hPa is found to be suitable to decide the onset of southwest monsoon for India. In other words, the rainfall criteria at Kerala coast alone is not sufficient to finalise the onset date.

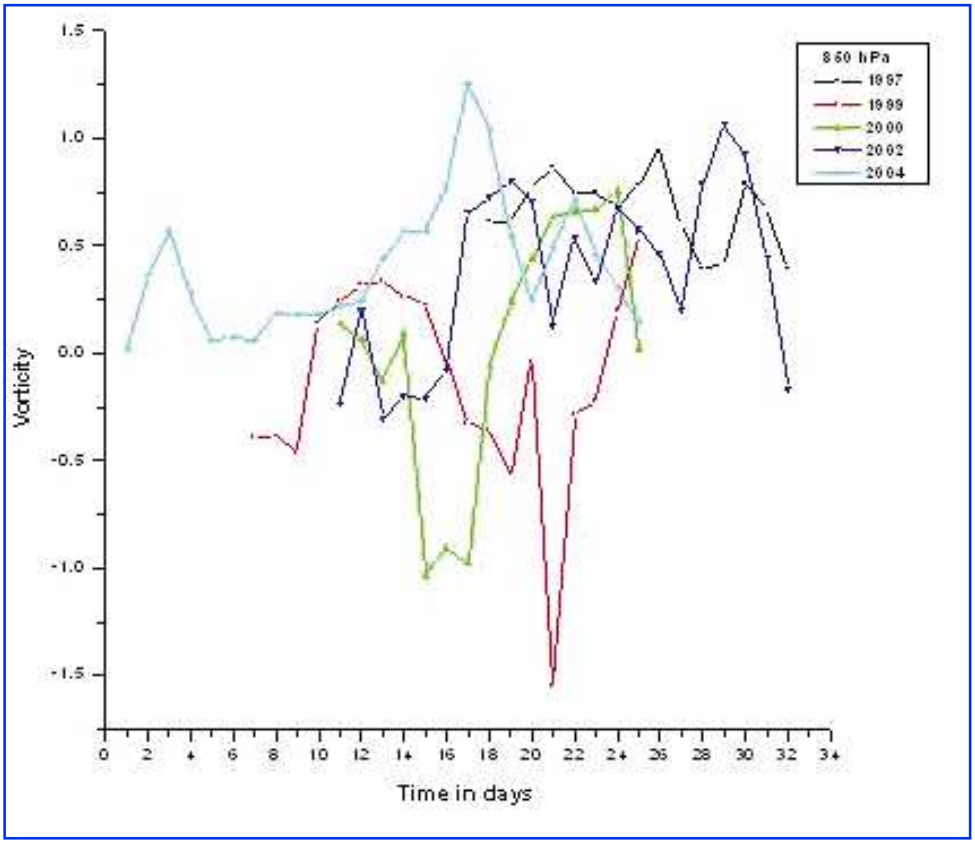
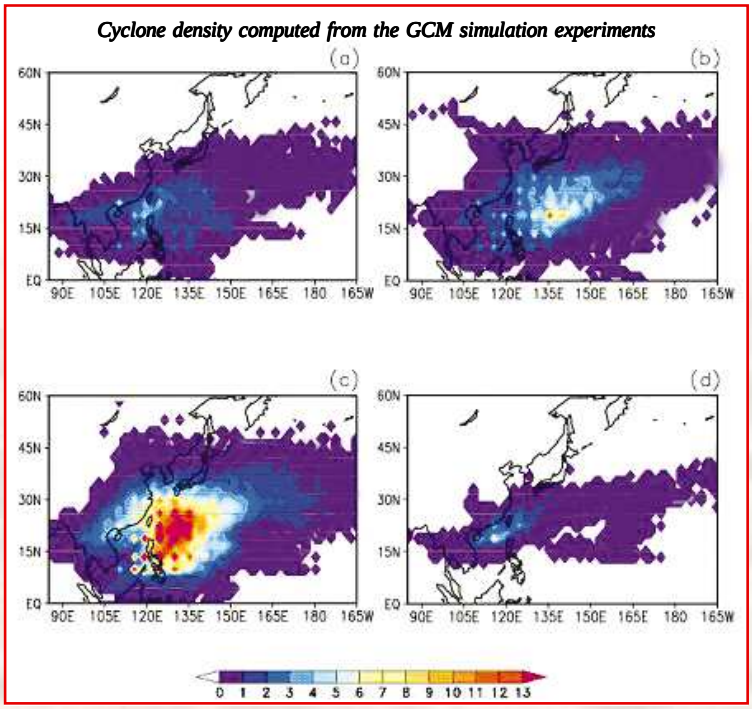


Fig. 54 : Time series of the vorticity for all the small regions at 850 hPa

Climate and Global Modelling



Cyclone density computed from the GCM simulation experiments

Climate and Global Modelling Division conducts global modelling studies to understand the physical and dynamical processes in the climate system. The current research programmes are focused at the following objectives :

- Comprehensive study of the physical and dynamical processes relating to global and monsoon climate and their variabilities 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 or the Indian - Asia Pacific Regions

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

Numerical simulation of Indian Ocean Dipole / Zonal Mode events using Ocean GCM.

Studies in the recent past have drawn attention to an ocean-atmosphere coupled instability in the tropical Indian Ocean, which is analogous to the El Nino/Southern Oscillation (ENSO) phenomenon in the Pacific Ocean, which is being referred to as the Indian Ocean Dipole/Zonal Mode (IODZM). It is now recognized that the ocean-atmosphere coupling associated with the IODZM involves the well-known Bjerknes feedback mechanism through which ocean temperature gradients induce changes in the zonal winds and precipitation; so that the zonal wind anomalies in turn influence the ocean temperatures by altering the thermocline movements through upwelling/ downwelling variations. In this study, the evolution of subsurface features associated with the IODZM was investigated using observed datasets and numerical simulations from ocean general circulation model (OGCM). Three sets of 43-year (1958-2000) simulation experiments were carried out. In the first experiment (EXP1), the OGCM was forced with monthly observed wind-stress and heat fluxes. In the second experiment (EXP2), the OGCM was forced with interannually varying wind-stress and climatological heat fluxes. In the third experiment (EXP3), the OGCM was forced with climatological wind-stress and interannually varying heat fluxes.

The EXP1 and EXP2 simulations, which were forced with interannually varying wind-stress, showed many features of the observed subsurface variability associated with the IODZM evolution (Fig. 55). On the other hand, the subsurface variability was found negligible in EXP3 due to the lack of ocean dynamical changes resulting from the absence of interannually varying wind-stress forcing. Analysis of subsurface variations from the OGCM simulations indicated that the development of IODZM events can be traced back almost one year prior to its mature phase. Eastward propagation of heat content anomalies, in the equatorial region, can be noticed during the autumn months of Year (-1) which leads to accumulation of heat in the eastern Indian Ocean. The accumulation of warm waters in the eastern

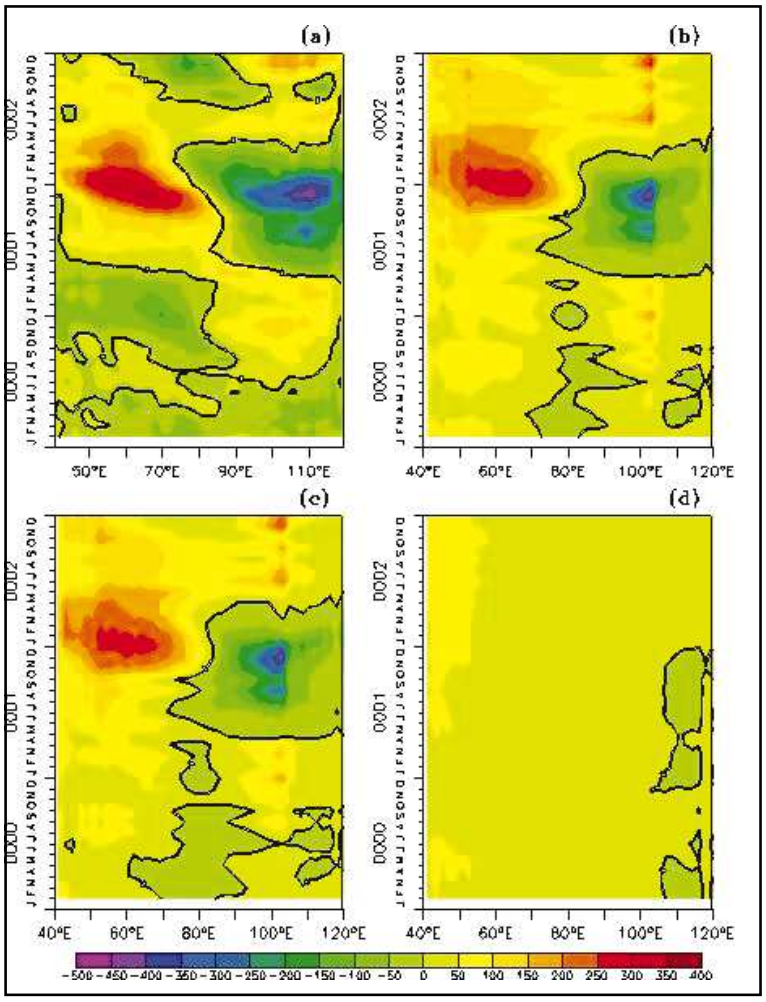


Fig.55 :Longitude-time section of ocean heat content anomalies in the upper 300 meters during IODZM events. The anomalies were latitudinally averaged between 10°S and equator (a) SODA dataset (b) EXP1 (c) EXP2 (d) EXP3. The time-axis (0000, 0001, 0002) correspond to Years (-1, 0, +1) respectively with respect to the IODZM event in Year (0)

Indian Ocean is followed by gradual westward propagation of heat content anomalies from the spring season March-April-May [MAM (0)] onward. The westward propagating heat content anomalies are related to off-equatorial Rossby waves forced by anomalous easterly winds. Around May-June months, the seasonal upwelling enhances the cooling in the eastern Indian Ocean. The dipole pattern of cold anomalies in the east and warm anomalies in the west can be seen from June-July-August [JJA (0)] onward. The dipole pattern in the SST anomalies and the easterly wind anomalies intensify during September-October-November [SON (0)]. Further, it was seen that the dipole pattern in the subsurface temperature anomalies continue beyond SON(0) and the anomalies are found to be very strong during the winter months December-January-February [DJF(0)]. Termination of the IODZM was characterized by eastward propagation of heat content anomalies from the western Indian Ocean. By MAM (+1), the cold anomalies in the eastern Indian Ocean were dramatically reduced. The findings further suggested that interactions between the Pacific Walker cell and the regional east-west circulations over the equatorial Indian Ocean play an important role in determining the evolution of the IODZM.

Additionally, a suite of simulation experiments was carried out using a regional Indian Ocean General Circulation Model in order to understand the influence of the Southwest monsoon circulation on the evolution of oceanic anomalies associated with the IODZM events. The results indicated that an enhancement of easterly winds, associated with strong monsoon cross-equatorial flow, plays a crucial role in inducing upwelling cold waters in the eastern Indian Ocean. The intensified upwelling elevates the thermocline, so that the cold anomalies in the eastern Indian Ocean are maintained by ocean dynamical processes. The study highlighted that the forcing from the Southwest monsoon is an important factor in the evolution of the oceanic sub-surface anomalies during IODZM events.

Feasibility of extended range monsoon prediction using dynamical models

Numerical experiments were conducted using a global atmospheric model to investigate the feasibility of extended range monsoon prediction. The basis for seasonal scale predictability of the atmosphere is that bottom boundary forcings like sea surface temperature (SST), soil moisture, etc. vary slowly as compared to the atmospheric anomalies. However, the problem of the extended range prediction (timescale ~ 2-3 weeks) involves not only the effect of slowly varying boundary conditions on the atmosphere, but also the impact from the atmospheric initial conditions. Numerical integrations of atmospheric model, with the same boundary forcing, starting from different initial conditions tend to diverge after a few days. Such variability due to internal dynamics is known to be substantial over the Indian monsoon region. Several sets of experiments were carried out with a global atmospheric model in order to understand the role of internal dynamics in affecting the extended range monsoon prediction. Preliminary results of this study indicated that the variance among the different ensemble members tends to be small when the model integrations are initiated from a set of states corresponding to a weak monsoon situation. On the other hand, the spread among the members is found to be higher when the integrations are started from initial states that correspond to active monsoon condition.

Dynamical prediction of summer Monsoon 2004 using AGCM

Monsoon seasonal prediction experiments were carried out using two atmospheric general circulation models (AGCMs) for the monsoon season of 2004. The two AGCMs used for this purpose were (1) COLA T30L18 (2) Portable Unified Mode (PUM) Ver.4.5 grid-point GCM from UKMO. The latest observed SST anomalies of May 2004 were superposed on the monthly climatological SST and used as boundary condition for the GCM experiments. In the case of the COLA AGCM, four member ensemble runs were carried out starting from different observed initial conditions. In case of the PUM AGCM, six member ensemble runs were carried out. The results from the COLA simulation showed deficient monsoon rainfall (-16 % departure from the normal) over the Indian region for 2004. The PUM simulation also showed a decrease in the monsoon rainfall (-3.0 % departure from normal) over the Indian region during 2004.

Tropical cyclones over Northwest Pacific and its linkage with the Southwest monsoon circulation

Several studies in the past have examined the variability of the Indian summer monsoon in relation to typhoon activity over the Northwest Pacific. It has been known that "breaks" (dry periods) in the monsoon rainfall over India are generally associated with northward moving tropical cyclones over the Northwest Pacific. The recent monsoon drought during 2002 is an excellent example to illustrate this point. The fig. 56 and 57 show that as many as 7 tropical storms formed during July, 2002 and most of them moved northward causing heavy rainfall over the Philippines-Taiwan region (Fig.56). During this period, the Indian subcontinent experienced an intense and prolonged monsoon break. An investigation of the dynamical association between the southwest monsoon circulation and the tropical cyclone activity over Pacific was carried out using long-term data of the observed typhoon tracks and daily global winds for 55-years (1948-2003). The findings from this study revealed that large-scale circulation anomalies associated with the interannual variability of the Indian monsoon play an important role in influencing the tropical cyclone activity over the west Pacific. The cyclogenesis over the tropical west-central Pacific was found to be about 1.33 times higher during weak monsoon years as compared to strong monsoon years. Also, there was greater tendency for the Pacific cyclones to move northward and recurve (to the north of 20°N) during weak monsoon years. The enhanced cyclogenesis during weak monsoon years is found to be associated with enrichment of low-level cyclonic vorticity anomalies over a wide-region of the sub-tropical Pacific extending from the China Sea, Taiwan and Philippines region to the central Pacific; while the movement of the tropical cyclones is associated with anomalies of upper-tropospheric steering currents.

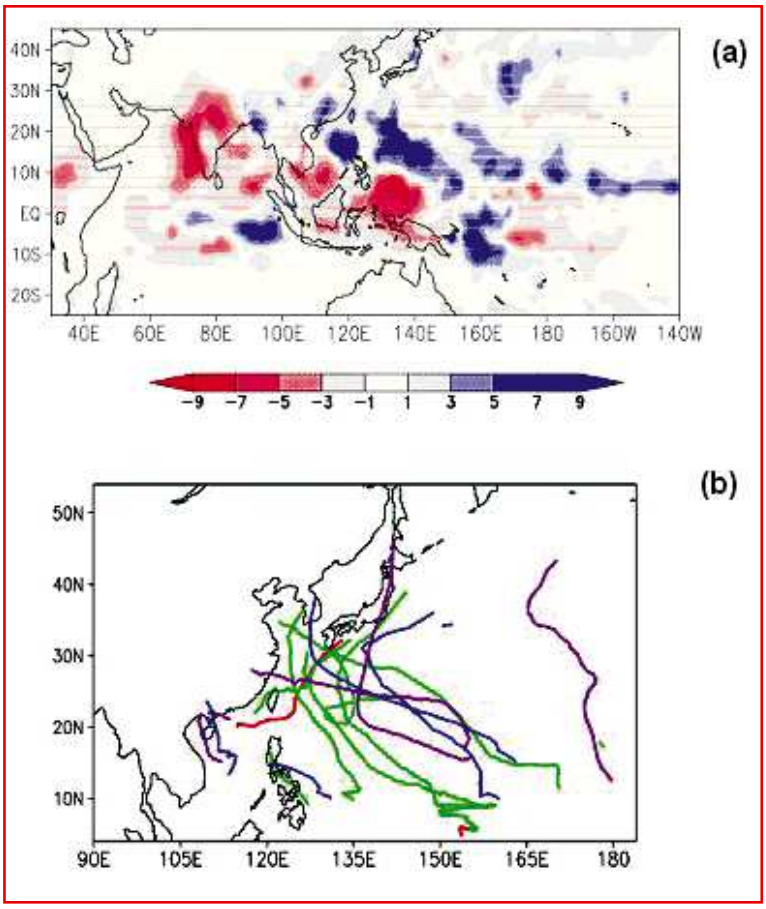


Fig. 56 : (a) Spatial distribution of rainfall anomaly (mm per day) during July, 2002. The gridded rainfall data are from the Climate Prediction Center Merged Analysis of Precipitation, which is a product of merging rain gauge observations and precipitation estimates from satellites (b) Observed cyclone tracks over tropical Pacific during 2002. Different colours indicate the tracks during the monsoon months [June (Red); July (Green); August (Blue); September (Purple)]

Additionally, several sets of numerical simulation experiments were conducted using an atmospheric GCM in order to study the monsoon drought of 2002. The moderate El Nino conditions prevailed during the summer of 2002. Model experiments that were forced with the Pacific sea-surface temperature (SST) anomalies of 2002 indicated weakening of the Southwest monsoon circulation and decrease in rainfall over the Indian region. In addition, the anomalous response of the large-scale circulation to the El Nino forcing in the model was found to alter the tropical cyclone activity over the Northwest Pacific. The GCM simulations showed a general increase in the tropical cyclones over Northwest Pacific when forced with the warm SST anomalies in the Pacific associated with the El Nino (Fig. 57)

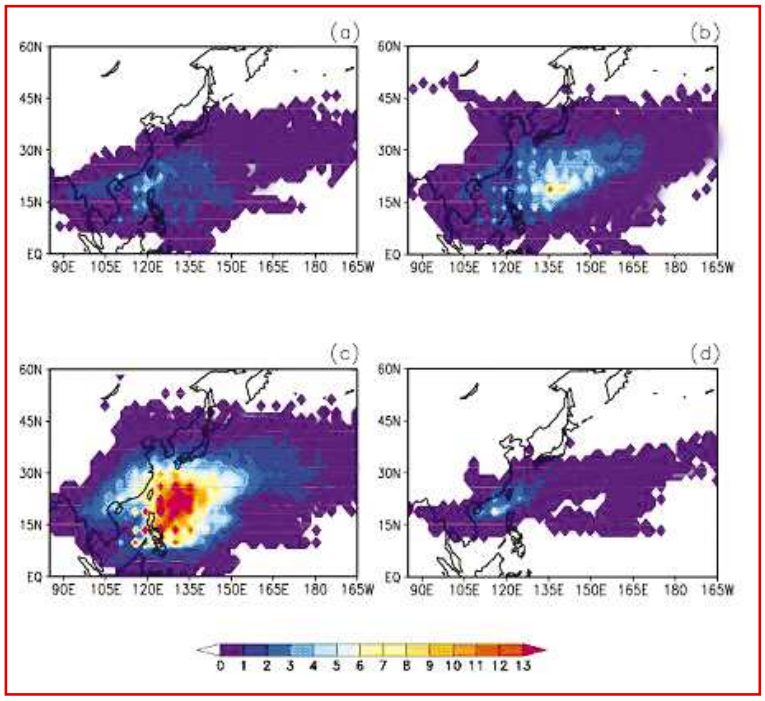


Fig. 57: Cyclone density computed from the GCM simulation experiments (a) Experiment forced by climatological SST (b) Experiment forced by SST of 2002 (c) Experiment forced by SST of 2002 only for the Pacific Ocean; elsewhere by climatological SST (d) Experiment forced by SST of 2002 only for the Indian Ocean; elsewhere by climatological SST. The results are based on 10-member ensemble integrations carried out for each of the four experiments

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

(A. K. Sahai, J. R. Kulkarni)

Dynamical seasonal prediction of recent monsoons using weighted ensemble mean method

An assessment of experimental dynamical ensemble seasonal prediction of recent six Indian summer monsoons was made with weighted ensemble mean method. Twelve-member ensemble integrations for six-monsoon seasons (1999-2004) were made with Portable Unified Model (PUM) version 4.5 AGCM specified with May SST anomaly persistent as boundary forcing. The Indian summer monsoon precipitation simulation by models is sensitive to small changes in initial conditions causing large intraensemble spread. The standardised spread among 12 members ensemble of the model for summer monsoon precipitation over India is shown in (fig. 58). It is seen that the ensemble spread varies among six monsoon seasons with minimum (maximum) in monsoon 2000 (2003).

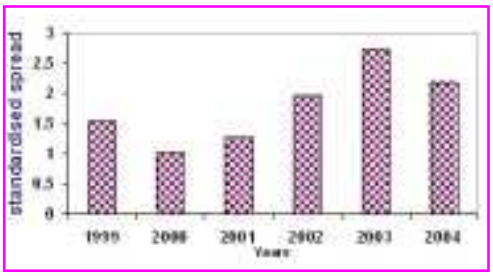


Fig. 58 : Standardized spread among 12 ensemble members for Indian summer monsoon precipitation simulated by model with May SST anomaly persistent

The weighted ensemble mean (WEM) method gives more (less) weight to ensemble members for which the sum of the distance between daily anomalies from rest of the ensemble members is less (more). The WEM may capture the signal resulting from boundary forcing of SST by reducing the noise from unpredictable internal dynamics.

Comparison of percentage departure of summer monsoon precipitation averaged over Indian land region simulated by the model in twelve-member ensemble mean (EM) and WEM with corresponding CMAP observations is shown in (fig. 59). It is clearly seen from the figure that WEM improves the precipitation forecast except that for the year 2000.

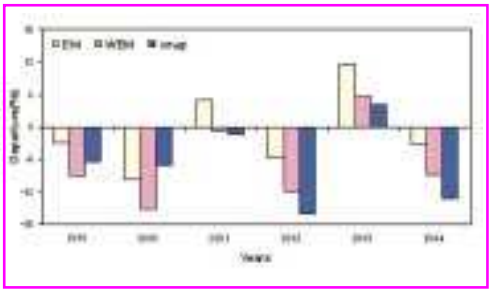


Fig.59 : Percentage departure of summer monsoon precipitation over India in 12 member ensemble mean (EM), weighted ensemble mean (WEM), Observations (CMAP)

Spatial distribution of precipitation anomalies over 30°-150°E; 20°S-40°N in EM and WEM were also compared with corresponding CMAP anomalies for all the six monsoons. Results showed that the precipitation anomalies from WEM are closer to the observations than the EM. The precipitation anomalies for summer monsoon of 2002 and 2003 for EM and WEM are shown in (fig. 60) (a, b and d, e respectively). The corresponding observed precipitation anomalies from CMAP (CDC merged analysis of precipitation) are also shown in (fig. 60) (c and f for 2002 and 2003 respectively). Improvement with weighted ensemble mean method is seen clear from the figure.

The percentage departure monsoon of precipitation over India in 2003 (2004) in majority of ensemble members is positive (negative) in spite of presence of La Nina in the month of May of both years, implying that the SST's of ocean basins other than Nino3, play a role in the monsoon interannual variability.

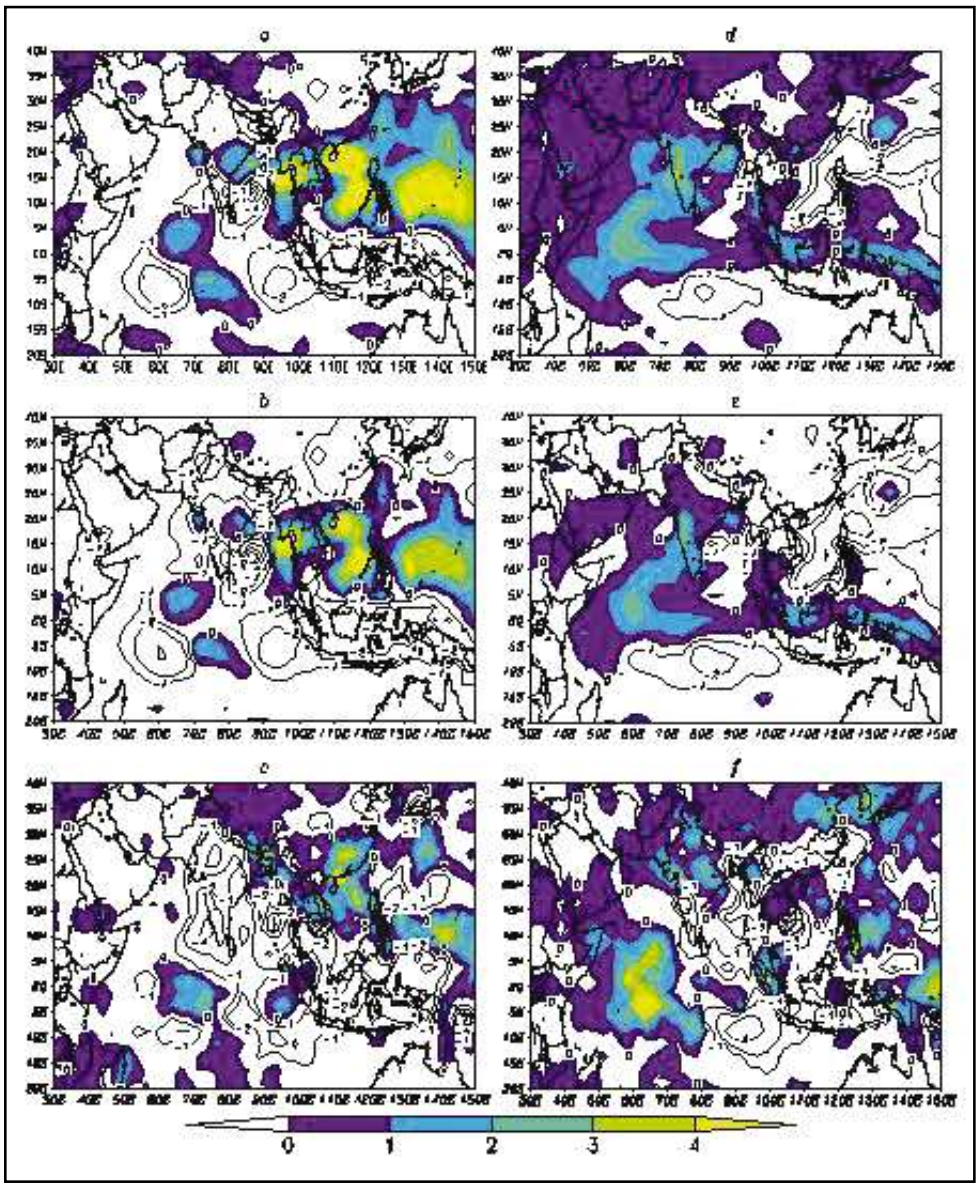


Fig. 60 : Precipitation anomalies (a) 12-member ensemble mean (b) weighted ensemble mean (c) CMAP observations for summer monsoon 2002 (d)12-member ensemble mean (e) weighted ensemble mean (f) CMAP observations for summer monsoon 2003

ENVIS-Center

(Acid Rain and Atmospheric Pollution)

The broad objective of the center is to furnish and disseminate information on the subject area "Acid rain and Atmospheric Pollutants" and to enrich the available database for India with the following goals :

- 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 (NO_X), 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 to provide 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 fulfil the need of the bottom end user.

Establishment of the ENVIS Centre

(G.B. Pant, G. Beig, and S. Gunthe)

The ENVIS center on the subject area "Acid Rain and Atmospheric Pollution" at the Indian Institute of Tropical Meteorology, Pune has been established in February, 2005 to build up repositories and dissemination center in the subject areas of acid rain and atmospheric pollutants. The storage, retrieval and dissemination capabilities, with the ultimate objective of disseminating information speedily to the users have been made. The ENVIS Center has developed and maintaining an information base that includes both descriptive information as well as numerical data. Descriptive information in the form of publications, reports, reprints and abstracts on Atmospheric Pollution is stored for dissemination. Numerical data on the subject are collected, compiled, processed and analysed for the purpose of dissemination. Documentation in the form of publications and reports are periodically issued. The whole information thus compiled is made available on the website launched. The ENVIS web site was launched on 10th February, 2003 when it was a node. The current ENVIS website at IITM has a public domain IP address. It comprises the interlinking with other ENVIS nodes and center resources, sustainable operation and management on system reliability and availability, adequate fail-safe operations, backup, recovery provisions etc. It includes some initial basic information containing the various narrative sub-topics and diversified fundamental aspects related to subject. Web site has been designed in such a way that all the links will appear on a same domain frame while surfing. To provide information about the topics covered in the website, it has been registered with popular web search engines like *google.com*, altavista.com and *khoj.com* where the link of ENVIS web site appears as a first option when used with 'Acid Rain and Pollutant Modelling' as a key word. The animated VCDs with the related subject areas are available for the visualization. In addition, Kids corner, Bibliography and a feedback query session is set-up.

Atmospheric Pollutants and Emission Inventories: Information and Database

Creating and disseminating the database for various pollutants for India is a major objective of the center. To fulfil this objective the database related with following pollutants have been developed:

- Sulfur Dioxide (SO_2) : Mainly due to fossil fuel and industries.
- Carbon Mono-oxide (CO) : Emitted from combustion process.
- Nitrogen Dioxide (NO_2) : From the fossil fuel combustion.
- Ozone (O_3) : A secondary pollutant.

Data related with the above pollutants have been created and maintained for the various major cities in India. The database developed is normalized to eliminate maximum amount of redundant data to ensure that data are logically correct. However, guidelines for the data normalization may differ for different aspects. The online database comprises a visual interface with the measurements of atmospheric pollutants (viz. ozone, NOx, CO, Volatile organic compounds), which is an ongoing activity of the Institute. A reliable Data Acquisition System (DAS) have been developed to acquire data on a real time for Pune city. The value of minimum and maximum ozone at the Institute premises in Pune has been found to be around 10 ppb and 105 ppb respectively over the year which varies within the above limit. The link given to this database enables the online visualization of this database in graphical format. The secondary data have been included either by web links or directly form the generating agencies like CPCB, NEERI and other institutes.

The database generated for the geographical distribution of pollutant emissions from various sources in several layers using the GIS software are displayed offline in website. A record of the estimated amount of pollutants (commonly in lbs or tons) emitted from mobile and stationary sources into the atmosphere over a specific period such as a day or a year for a particular location forms the basis of emission inventories. Further development of database for emission inventories in India has

been undertaken. For this purpose, data related with NO_X, CO, CH_4 and black carbon emitted from various sectors like Transport, Energy and Bio-mass burning etc. has been maintained. This database has been categorized in three categories (i) emissions for India, (ii) for different states and (iii) for different locations having particular emission source within the states. From the database emission of CO from fossil fuel over Maharashtra has been found to be of the order of 2857.3 Gg. Further database has been downscaled for emissions from power plants. In Maharashtra the emissions of CO_2, SO_2 and NO are found to be 0.956, 0.006 and 0.007 mass/KWH respectively for Parali Power Plant. This entire database has an interface/link for the online visualization.

Data Bank for Acid Rain

The amount of data available in India related to acid rain parameters are limited. Effort is being made to compile maximum information available on this subject area for dissemination through IITM-ENVIS web link. The rainwater has been classified on the basis of pH scale either into acidic or basic categories. Seven is considered neutral and measurements below seven are acidic while those above it are basic or alkaline. Rain is naturally acidic because carbon dioxide, found normally in the earth's atmosphere, reacts with water to form carbonic acid. While "pure" rain's acidity is pH 5.6-5.7, actual pH readings vary from place to place depending upon the type and amount of other gases present in the air, such as sulphur oxide and nitrogen oxides. Sulphur dioxide and nitrogen oxides are the main pollutants that cause acid rain. These pollutants are emitted largely by the combustion of fossil fuels. It can be stated from the available database for the acid rain that for the two major cities like Mumbai and Kolkata it does not show any sign of acidification of rainwater. The pH values of rainwater found to be of the range of 6.2 to 6.8 and 6.68 to 7.21 for Mumbai and Kolkata respectively. It has been concluded from the observations taken, that (a) monsoon rainwater is neutral under local condition and (b) rain water dissolves little carbon dioxide and the dissolved gas is not in equilibrium with atmospheric carbon dioxide. Acid rain has a variety of effects including damage to forests and soils, fish and other living things and human health. In some part of the world an effect called "Visibility Reduction" due to acid rain has been reported. However, such acid rain episodes in India are found to be very low and sparse.

Carbon – Monoxide Emission from Bio-fuel Sources over the Indian Region

The issues related to emissions of atmospheric pollutants are the key to understand the air pollution problems. To address the emission related issues United Nations Framework Convention on Climate Change (UNFCCC) has also initiated an effort. The immediate requirement was to prepare national inventories of Greenhouse Gases (GHG) emissions and sink using comparable methodologies. National level inventories not only improve global emission estimates and consequent impacts but also provide a base line from which nation may develop their future emission strategies to streamline the anthropogenic activities. The Indian subcontinent is a rich source for ozone precursors. The predominant circulation pattern can carry the pollutants from one place to other regions depending on the direction of the flow. The concerned world scientific community is focusing attention to explore chemical weather related to pollution which is mostly influenced by local or regional factors rather than global where Indian subcontinent is going to play a major role. Bio-fuels are the main source of energy for cooking and other household use in rural areas and even many urban/ semi-urban areas. The consumption and composition of bio-fuels differs from region to region in India. The combustion efficiency and hence emission of CO will also differ based on composition of the bio-fuel and the stoves/ *chullahs* (open stoves) used for cooking. There will thus be a marked difference between contribution to (bio-fuel) CO from rural and urban areas. To relate the CO emissions to the rural or urban population, it was necessary to first determine the relative contribution by the rural and urban sectors. An estimate of the relative bio-fuel consumption by rural and urban population can be obtained from the Census of India (2001). The household data released till date gives the number of rural as well as urban households utilizing various fuels as a main energy source for cooking.

The energy sources considered for Census survey were firewood, crop residue, cow-dung cake, coal (including lignite, charcoal), kerosene, LPG, electricity, biogas and others. Households using firewood, crop residue and cow dung should be considered as those consuming bio-fuels. As per the Census figures, out of the 192 million households in India, nearly 139 million use bio-fuel as main source of cooking, and nearly 90% of these are from the rural area. Based on the number of (rural/ urban) households using bio-fuels in a given state, the number of rural and urban persons depending upon bio-fuels can be determined. The proportion of this rural/ urban population is applied to the state-level bio-fuel CO value to determine the contribution from rural and urban sector to CO emission from that state. Based on the respective population and CO contribution, the per capita emission of CO (separately for rural and urban) is determined for each state. The interstate difference in per capita CO emission thus obtained can be said to represent the differences in proportion of population using bio-fuels, composition of bio-fuels used, types of stoves / combustion efficiency, etc. between the states. These per capita emission figures are then applied to the district-level population from the respective states, thus allocating the bio-fuel CO emissions from state to district level. Total CO emission from all the sources over the Indian geographical region for 2001 was estimated to be around 69,376 Gg. The CO emission from bio-fuel sources was around 34,282 Gg for the same year, which is almost 50% of total CO emissions, thus signifying that the bio-fuel from the rural sector is the most important and major contributor for CO emission over Indian region. Figure 61 shows the distribution of bio-fuel CO-emission from the rural, urban and sum of both rural and urban sectors respectively for 2001 over the Indian region.

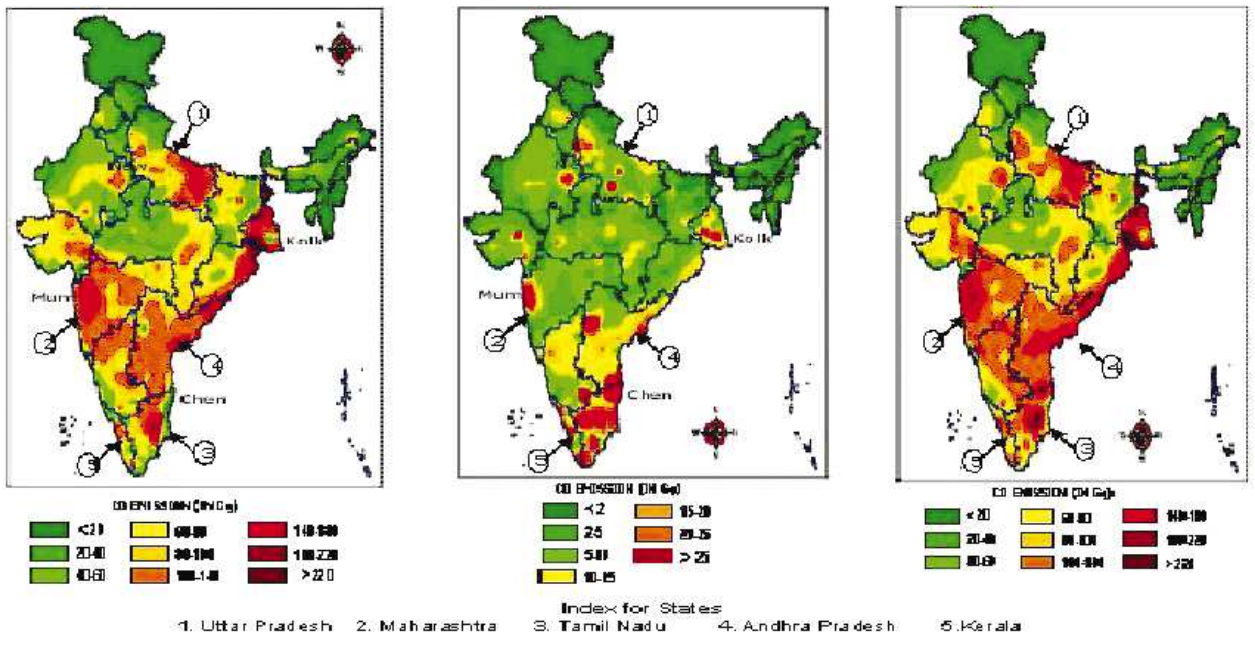


Fig.61 : Geographical distribution of CO emissions (Gg/year) from bio-fuel sources in 2001 over India (a) Rural Sector, (b) Urban Sector and (c) Sum of rural and urban sectors

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	2000-2005	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	2001-2004	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	2001-2004	9.50	Ministry of Environment & Forests, Govt. of India/ Dept. of Environment, Food and Rural Affairs, Govt. of U.K.
5.	Indian Climate Change Scenario for Impact Assessment	Dr. K. Rupa Kumar	2001- 2004	48.50	Ministry of Environment & Forests, Govt. of India/ Dept. of Environment, Food and Rural Affairs, Govt. of U.K.
6.	Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change	Dr. K. Rupa Kumar	2001-2004	6.20	Indo French Centre
7.	Non-linear Scale Interactions in the Energetics of Monsoon in Wavenumber / Frequency Domain	Shri D. R. Chakraborty	2001-2004	7.85	Department of Science and Technology, Govt. of India
8.	Observational Study of Aerosol Radiative Forcings on the Surface Reaching Solar Flux (Fast Track Scheme for Young Scientists)	Dr. R. S. Maheskumar	2001-2004	9.36	Department of Science and Technology, Govt. of India
9.	Studies of Atmospheric Aerosols, Trace Gases and Precipitation Chemistry in Different Environments	Dr. P. S. P. Rao	2001-2004	16.57	Department of Science and Technology, Govt. of India

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
10.	Surface Climatology of Western Himalaya	Dr. K. Rupa Kumar	2001-2005	9.90	Snow and Avalanche Study Establishment, Defence Research & Development Organisation, Govt. of India
11.	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
12.	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
13.	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
14.	Climate Change Projection for India and Assessment of the Associated Agricultural and Human Health Impact	Dr. K. Rupa Kumar	2002-2004	18.00	National Communication (NATCOM), Ministry of Environment and Forests, Govt. of India
15.	Composition of Acid Deposition (CAD)	Dr. P. S. P. Rao	2002-2004	0.90	Department of Meteorology, Stockholm University, Sweden
16.	Dendroglaciological Studies of High Altitude Glacier Sites of Western Himalaya	Dr. H. P. Borgaonkar	2002- 2005	4.92	Snow and Avalanche Study Establishment, Defence Research & Development Organisation, Govt. of India
17.	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
18.	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
19.	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
20.	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

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
21.	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
22.	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
23.	Environmental Information System (ENVIS) Node on Acid Rain and Atmospheric Pollutants Modelling	Dr. G. Beig	2003-2004	11.46	Ministry of Environment and Forest, Govt. of India.
24.	Estimation of Standard Project Storm (SPS), Probable Maximum Precipitation (PMP) and Time Distribution over the Bhagirathi Catchment up to Loharinagpala & Dhauliganga Catchment up to Tapovan	Shri B. N. Mandal	2003-2004	6.00	National Thermal Power Corporation (NTPC), Noida
25.	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
26.	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
27.	Application of Satellite Data to Climate Research	Dr. G. B. Pant	2003-2005	15.50	Indian Space Research Organisation (ISRO), Govt. of India
28.	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)
29.	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
30.	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

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
31.	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
32.	Acid Rain and Atmospheric Pollution	Dr. G. Beig	July, 2004-March, 2005	5.27	Ministry of Environment and Forests, Govt. of India
33.	Science of Climate Change	Dr. K. Rupa Kumar	2004-2005	5.50	British High Commission, New Delhi
34.	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
35.	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
36.	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
37.	Atmospheric Pollutants and Chemical Weather under Different Environments	Dr. G. Beig	2005-2008	31.98	Department of Science and Technology, Govt. of India
38.	Impact of Long Term Solar Variability on the Middle Atmosphere Chemical Climate using Satellite Data and Model Simulation	Dr. G. Beig	March, 2005-March, 2008	6.73	Climate and Weather of the Sun Earth System (CAWSES), Indian Space Research Organisation

Other Special Events and Activities

Visit of Minister of State for Science and Technology and Ocean Development

Shri Kapil Sibal, Honourable Minister of State for Science and Technology and Ocean Development, Government of India, New Delhi visited the Institute on 7 September, 2004.

Visit of Parliamentary Committee

Second Sub-Committee of Committee of Parliament on Official Language consisting of five Members viz., Dr. Laxmi Narayan Pandey, Dr. Prasanna Kumar Patsani, Shri Vidya Nivas Mishra, Shri Uday Pratap Singh and Shri Laxmi Narayan Sharma visited the Institute on 8 January, 2005 along with four officials for inspection of use of Hindi. While expressing the overall satisfaction of the work of Official Language at the Institute, Committee suggested that some additional work as per the target fixed by the Government of India in this behalf could be undertaken by the Institute and for this the additional staff, as laid down in the norms of Government of India, could be asked for.

Honours

Dr. G.B. Pant has been nominated as a Member of the First Board of Governors of Government College of Engineering (Pune Institute of Engineering and Technology), Pune.

Dr. A.K. Kamra has been nominated by the Director General, Council for Scientific and Industrial Research (CSIR) as a Member of the Physical Sciences Research Committee of the CSIR. Dr. Kamra has also been nominated by the Council of Indian National Science Academy as a member of the Sectional Committee-V. He has also been nominated a member of the Scientific Team for Coherent Radar Imaging (CRI)/Spatial Domain Interferometery (SDI) project of National MST Radar Facility from 2004 and a Member of the Multidisciplinary Committee for Engineering and Applied Sciences (M2) of Indian National Science Academy for the year 2005.

Dr. P.C.S. Devara has been elected as Vice-President of the 'Indian Aerosol Science and Technology Association (IASTA)'. He has been nominated as Member, Technical Program Committee of the 7th International Aerosol Conference (IAC-2006). Dr. Devara, has also been nominated as Member, Editorial Board of the Indian Journal of Radio and Space Physics for the period January, 2005 - December, 2007 and a Member of the National Organizing Committee of the Asian Aerosol Conference (AAC-2005). He has been re-elected as Member, Governing Council of the Instrument Society of India (ISOI), Bangalore for the period 2004-2006.

Dr. K. Rupa Kumar has been invited to act as the Co-Chair of Asian-Australian Monsoon Panel (AAMP) (2005-2008) of the Scientific Steering Group for the Climate Variability and Predictability (CLIVAR) project of the World Climate Research Programme (WCRP). He has been invited by the Co-Chairs of the Intergovernmental Panel on Climate Change (IPCC) Working Group I, to act as a Lead Author for the IPCC Working Group I Fourth Assessment Report (WG1-AR4), for Chapter 11 on "Regional Climate Projections". WG1-AR4 is expected to be completed in early 2007.

Dr. G. Beig has been nominated as Member, Scientific Committee of the Working Group 4.4, on Ionosphere and Upper-Atmosphere Variability. He has also been nominated as a Convener of the Symposium on Short-term Variability and Long-term Changes in the Lower and Middle Atmosphere to be held at Toulouse, France.

Dr. G.B. Pant, Dr. A.K. Kamra, Dr. P.C.S. Devara, Dr. K. Rupa Kumar, Dr. (Smt.) P.S. Salvekar, Shri J.R. Kulkarni, Dr. P.N. Mahajan, Dr. G. Beig, Dr. (Smt.) A.A. Kulkarni and Smt. A.A. Deo were bestowed with the title 'Adjunct Professor' of the Department of Physics, University of Pune, Pune for the Academic Year 2004-2005.

Awards

International Award

Dr. G. Beig and Smt. S. S. Fadnavis along with other seventeen authors from around the world have been selected for the Nobert-Gerbier Mumm International Award for the year 2005 for their paper entitled, 'Review of Mesospheric Temperature Trends' published in Reviews of Geophysics, December, 2003. The Award has been instituted by the World Meteorological Organisation.

The paper entitled, "Long-term Variations in the Performance of Climate Models" by Grimm A. M., **Sahai A. K.** and Ropelewski C. F., presented at the 3rd Brazilian Symposium of Atmospheric Modelling received the Best Paper Award in the 13th Brazilian Congress of Meteorology, held at Fortaleza, Ceara, Brazil during 30 August - 3 September, 2004.

National Award

Kum. Rohini Bhawar, IITM Research Fellow won the 'Best Paper Award' for her poster presentation entitled "Ground-based Radiometric Measurements of Aerosols and Pre-cursor Gases over Pune and Their Comparison with TOMS and MODIS Satellite Data", delivered at the IASTA Meeting and International Conference on "Aerosols, Clouds and Indian Monsoon", held at Indian Institute of Technology, Kanpur during 15-17 November, 2004.

Shri B.C. Morwal has been awarded Second Prize for his paper entitled 'Suchana sanchar aur suchi ki pragati' (in Hindi) presented at the 49th Seminar and Hindi Workshop on Official Language Management, Policy Implementation, Conducting Workshops, Information Technology and Computerization, held at Nainital, 6-8 October, 2004.

Excellent Performance Awards

Smt. Shanti P. Iyer, Shri Y.S. Belgude and Shri S.M. Jadhav received the Excellent Performance Award for the year 2003 for the Administrative, Technical and Non-Technical Maintenance category of Employees respectively. The Awards were presented on Institute's 43rd Foundation Day function on 17 November, 2004.

Participation in International Programmes

Scientific Expedition to Antarctica

Dr. Devendraa Siingh, Shri S.M. Sonbawne and Shri V. Pant participated in the 24th Indian Scientific Expedition to Antarctica from 6 December, 2004 to 27 March, 2005 for measurements of aerosols, atmospheric electric and other parameters and trace gases at Maitri, Indian Station in Antarctic and onboard ship during the journey. Extensive observations of aerosol optical depth, size distribution, ozone, precipitable water content and down-dwelling short wave radiation flux were carried out on 31 cloud-free days during 21 January - 5 February,, 2005. The surface-level and height profiles of atmospheric state parameters including ozone at the Indian Antarctic station (Maitri) were archived. En-route observations over marine and ice-shelf environments were also carried out.

Regional Coordination Centre

The Institute has been identified as a Regional Coordination Centre for the application of regional climate modelling system for climate change studies in South Asia, as part of the collaborative framework with the Hadley Centre for Climate Prediction and Research, UK. Dr. David Griggs, Director, Hadley Centre along with officials of British Council paid a visit to the Institute.

27th JSC / WCRP Meeting to be held at IITM : March, 2006

Dr. G.B.Pant, Director has been a Member of the Joint Scientific Committee (JSC) of the World Climate Research Programme (WCRP). He participated in the 26th Session of JSC of the WCRP held at Guayaquil, Ecuador during 14-18 March, 2005. Next Meeting of the JSC along with IGBP Scientific Steering Committee Meeting will be held in India at the Indian Institute of Tropical Meteorology, Pune.

Atmospheric Boundary Layer Field Laboratory of the IITM

An IITM Atmospheric Boundary Layer Field Laboratory at National Centre for Antarctic and Ocean Research (NCAOR), Goa has been modernized and inaugurated by Dr. P.C. Pandey, Director, NCAOR on 10 September, 2004.

Organisation of Workshops / Meetings / Seminars etc.

International

A World Meteorological Organization / Global Climate Observing System (GCOS / WMO) International Workshop on Enhancing South and Central Asian Climate Change Monitoring and Indices was organized at the Institute during 14-19 February, 2005. About 30 scientists from various Asian countries like China, Pakistan, Bhutan, Bangladesh, Nepal, Sri Lanka, Mongolia, Kyrgyz Republic, Tajikistan, Uzbekistan, Afghanistan, Kazakhstan, Turkmenistan and India participated in the Workshop. Senior scientists from USA, UK, The Netherlands and India delivered lectures on the theme of the Workshop.

A Training Workshop for the benefit of South Asian Regional Scientists involved in the Regional Climate Modelling and Related Fields was organized at the Institute during 24-28 January, 2005. About 20 participants from South Asian countries and two experts from Hadley Centre, U.K. participated in the Workshop.

National

First Technical Advisory and Review Committee (TARC) Meeting for a Central Water Commission (CWC) sponsored project entitled 'Preparation of generalized PMP atlas for the Krishna and the Indus river basins', was held at the Institute on 29 May, 2004. About 15 persons including TARC members, principal investigator and special invitees participated in the Meeting.

First Meeting of Expert Committee to Study the Effect of Windmills on Rainfall was held at the Institute during 3-4 June, 2004 under the Chairmanship of Dr. G.B. Pant, Director.

First Meeting of the Research Advisory Committee of the Institute under the Chairmanship of Dr. P.C. Pandey was held on 9-10 June, 2004.

Sixth Meeting of the Programme Advisory and Monitoring Committee (PAMC) on World Climate Research Programme and a Sub-group Meeting for a sponsored project entitled 'Atlas of Spatial Features of Moisture Regions and Rainfall of India during 19th and 20th Centuries' were held at the Institute during 9-11 September, 2004. About 15 scientists participated in the Meeting.

An in-house Short Term Training Course on Computational Methods for the IITM Research Fellows / Associates / Project Personnel etc. was arranged at the Institute during 14 October - 4 November, 2004. Participants were provided full fledged knowledge to start research in meteorology through the well organized lectures on different topics of the numerical, statistical and computational methods. Lectures were delivered by the faculties from the Institute, University of Pune and National Centre for Medium Range Weather Forecasting.

First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies was organized at the Institute during 18 - 19 January, 2005. The Conference was organized exclusively by the students and for the students. Dr. K. K. Padaiyya, Director, Deccan College Post Graduate Research Institute, Pune inaugurated the Conference. On this occasion, an Extended Abstracts Volume was released at the hands of Prof. G.C. Asnani. About 100 delegates comprising scientists, post-graduate and post-doctoral students, Research Fellows / Associates and many Project Personnel from various universities participated in the Conference and presented their research papers. Prizes to the students for Best Oral and Poster Presentations were awarded in the form of books.

Annual Monsoon Workshop - 2004 of the Indian Meteorological Society (Pune Chapter) was jointly organized with the India Meteorological Department on 4 March, 2005.

First WP/RASS Training / Workshop on Meteorology and Atmospheric Science was organized at the Institute during

7-11 March, 2005 under the DST sponsored project "Establishment of wind profiler data archival and utilization centre at IITM for Wind Profiler/Radio Acoustic Sounding System". The Workshop was inaugurated by Shri D.R. Sikka, Former Director, IITM and Chairman, Indian Climate Research Programme of the Department of Science and Technology, New Delhi. Dr. Shravan Kumar, Additional Director General of Meteorology (LACD), Pune was the Chief Guest. About 31 participants from various Institutes and Universities participated in the workshop. Volume of Lecture Notes was released at the hands of Shri Sikka.

Collaborative Programmes

As a part of the IITM-SAC collaborative project entitled Mapping of aerosol characteristics from remote sensing data, Special field campaign experiments were conducted along the Pune-Daund-Pune sector during April and May, 2004 and at a remote place which is about 60 km away from Pune during January-March, 2005, in synchronization with the IRS-P4/P6 satellite overhead passes, employing the multi-channel solar radiometer (MICROTOPS-II) and weather monitor. Observations of columnar aerosol optical depth, ozone and precipitable water vapour, near-surface by meteorological parameters were carried out. Near-similar MICROTOPS-II was also operated at the Institute, representing the urban environment. The aerosol and precursor gaseous optical depths were obtained for comparison with those obtained over the satellite overhead pass regions.

The Institute provided assistance to Andhra Pradesh State Government in their cloud seeding operations carried out during 2003. A report on 'Cloud seeding operations in Andhra Pradesh during 19 September - 17 November, 2003', delineating the scientific, technical , operational and administrative aspects related to the cloud seeding activities that have been carried out over some selected regions of Andhra Pradesh State during September - November, 2003 was submitted to the Government of Andhra Pradesh.

A monograph on CD containing the vertical profiles of thermodynamic parameters (pictorial form and data form) computed utilizing the whole data (over land) collected during the Phase-I of the Arabian Sea Monsoon Experiment-2002 was prepared and disseminated to different scientists working in different Scientific and Academic Institutions / organizations to facilitate their scientists to undertake related research studies.

Special Field Observational Programmes

In collaboration with Indira Gandhi Centre for Atomic Research and Bhabha Atomic Research Centre, a Joint Field Campaign was arranged to study the wind and thermal structure of the coastal atmospheric boundary layer at the National Centre for Antarctic and Ocean Research, Goa during 10-24 September, 2004.

Field Expeditions were arranged to Uttaranchal during 24 September-15 October, 2004 for tree-ring sample collection under the Dendroglaciological project of Snow and Avalanche Study Establishment, Chandigarh and to Chattisgarh during 28 October - 9 November, 2004 for teak and tree-ring sample collection under the collaborative activity on South - Asian Dendroclimatic studies between IITM and Tree - ring Laboratory, Lamont-Doherty Earth Observatory, Columbia University, New York, U.S.A.

Extensive observations of physical, chemical and radiative characteristics of aerosols using CIMEL Sun-sky radiometer, MICROTOPS-II, Andersen sampler, High-volume sampler, Aethalometer, $PM_{2.5}$ sampler, Dry and Wet deposition and Fog water collectors were carried out at New Delhi and also at the Dayalbagh Educational Institute (DEI), Agra, as a part of the Nation-wide Land Campaign Program, organized by the ISRO-GBP/ARBS during 1-31 December, 2004, in conjunction with such observations carried out simultaneously by other organizations, in a network mode, along the Indo - Gangetic Plain, to investigate aerosol transport and transformation processes during the study period. Before the Campaign, inter-comparison of the performance of various instruments pertaining to IITM with similar instruments of other Institutes was carried out at the National Physical Laboratory (NPL), New Delhi on 28 and 29 November, 2004 in order to remove the bias between functioning of similar instruments deployed in the major experiments of the Campaign.

An extensive Field Campaign was arranged with an objective to monitor the levels of ozone and its precursors (NO_X, CO and NMHCs) in the vicinity of the sugar factories during the period 24 January - 6 February, 2005 at the Bhima Patas Co-operative Sugar Factory Ltd., Patas; Yashwant Co-operative Sugar Factory Ltd., Theur and Sant Tukaram Co-operative Sugar Factory Ltd., Kasarsai.

Foundation Day Celebration

The Institute celebrated its 43rd Foundation Day on 17 November, 2004 at its premises at Pashan. Dr. N.K. Dadhich, Director, Inter-University Centre for Astronomy and Astrophysics (IUCAA) Pune was the Chief Guest of the function. Dr. R.R. Kelkar, Ex. Director General of Meteorology was the Chairman of the function. Dr. O.N. Dhar, Emeritus Scientist of the Institute was the Guest of Honour. The function included presentation of the Excellent Performance Award specially established by the Institute for its Administrative, Technical and Non-Technical Maintenance staff, and Annual Sports Awards to the employees. A scientific lecture on 'Earth Climate: Past, Present and Future' by Dr. R.R. Kelkar was also arranged. On this occasion, the renovated Canteen building of the Institute was inaugurated at the hands of Dr. N.K. Dadhich. In addition to the main function, an exhibition on scientific activities of the Institute and important events in the Institute was arranged. Heads of various Institutions, important dignitaries and ex-employees of the Institute participated in the function. The function was concluded in the evening with a cultural programme.

Science Popularisation Programmes

The Institute celebrated National Science Day on 28 February, 2005 and World Meteorological Day on 23 March, 2005 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., 'Role of Teachers in Science Education' by Prof. V.K. Wagh, Principal, Fergusson College, Pune and 'Climate Change Issues for Sustainable Development' by Dr. K. Rupa Kumar, scientist 'F', IITM were arranged on the occasion of National Science Day and World Meteorological Day respectively.

As a part of the science promotion activities of the Government of India for nurturing scientific talent and promoting scientific research attitude in the young students Navodaya Vidyalaya Samiti organized Children's Science Congress in Pune during 14-19 November, 2004. Dr. G.B. Pant, Director, IITM inaugurated the Congress and delivered the inaugural address. The participating students visited the Institute on 18 November, 2004, seen its laboratories, computers, satellite pictures and data receiving centre, library, etc.

Vigilance Awareness Week Celebration

The Institute observed Vigilance Awareness Week during 1-6 November, 2004. The programme began with the pledge. On this occasion a lecture on "Vigilance of mind for better efficiency" by Dr. Ulhas Luktuke was arranged in the Institute on 5 November, 2004. An essay competition was also organized for the employees of the Institute on the topic "Impact of corrupt practices on day to day life of citizens" and prizes to the winners were given away at the hands of Dr. Luktuke.

Computer and Data Division

Computing Facilities

Most of the research projects and other supporting functions of the Institute are computer based and realizing this, the Institute has been enhancing its computer power from time to time by acquiring a number of PCs, high end workstations and accessories.

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 Division arranges acquisition of PCs, workstations and accessories such as printers, scanners, data storage systems etc. and provides to different Divisions as per the requirement. The Division also arranges regular maintenance of all these equipment. The present computational facilities available in the Institute are 165 PCs with requisite softwares and accessories, 18 servers/workstations, a few laptops, a terrestrial leased line internet connectivity of 512 KBPs bandwidth and intranet in the Institute's office campus.

The Division has installed a Web-based e-mail facility so that e-mails of the Institute can be accessed from anywhere in the world by logging-in through Internet, by opening the website *'mail.tropmet.res.in'*.

Web Server of the Institute has been upgraded with latest operating system and web-pages for different scientific activities and events were created. The latest information like advertisements for recruitments of Institute's various posts and Research Fellowships, tender notices etc. were uploaded on the website from time to time.

Security of the network has been increased by upgrading all the Window based PCs to the latest available security updates and the anti-virus software. The Internet access has continuously been monitored to ensure its smooth operation. Mail/DNS server and Web server were upgraded to RH Linux 9.0 and were configured with services and security restrictions.

Website of the Institute has been upgraded and updated periodically. A few bi-lingual web-pages have also been created.

Training on installation and working with Linux and on GrADS was provided to the Research Fellows and project personnel of the Institute.

Hindi word processing software 'Akshar' has been procured for the Institute and installed on PCs of various Divisions and a suitable training for its use was also arranged.

State of art well equipped Pisharoty Conference Hall and Varahamihira Seminar Hall of the Institute have been well maintained and kept ready for organization of meetings, lectures, Seminars, symposia, workshops etc.

Data Archival

Different data sets were procured from the India Meteorological Department and provided to the users by changing their formats as per user's request using FORTRAN programs.

Under the project, Establishment of Wind Profiler data archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System, observations for wind and temperature were generated from the wind profiler from May, 2003. Data were processed through offline software to calculate u, v, ws and wd from raw data, and stored on 40 x 6 GB DAT as well as on CDs.

Software Development

Computer programmes were made for preparation of various forms in Accounts Section for pay-roll, Income -Tax, GPF/ EPF/ reimbursement of tuitions fees, TA and medical claims of the Institute's employees. Assistance was provided to Purchase and Stores for updating databases for technical items, dead stock items and written off items.

Library, Information and Publications

The Institute has developed a comprehensive Information System in Meteorology and Atmospheric Sciences. The Institute's Library, Information and Publications Division serves as the Information System with the following objectives :

- Collection, organisation and dissemination of information pertinent to the present and anticipated research needs of the Institute.
- Providing technical services like library, documentation, information, publications, drawing, drafting, micrography and photography to scientists of the Institute.
- Providing facilities for the retrieval and use of information resources.
- Preparing, publishing and presenting various scientific research reports and allied material on the activities of the Institute and keeping liaison with other scientific organisations and universities in India and abroad.
- Development of resource sharing network with libraries in India and abroad.

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 181 books and reports in Meteorology and allied subjects were added. 92 Periodicals of national/ international origin were subscribed to. Reprints of 68 papers authored by the Institute's scientists were also acquired. Several scientific and technical reports were received from the other National and the International Organisations on complimentary and exchange basis.

The scientists of the Institute are kept abreast of the latest development in their research areas by rendering Information Dissemination Services through the Selective Dissemination of Information on different ongoing research projects of the Institute. On request, supply of photocopies of articles of interest from the publications of the Institute library were arranged to scientists, academicians and students of other organizations.

The library has been listed in the Directory of Special and Research Libraries in India, World Guide to Libraries and the Union Catalogue of Serials and Periodicals. The Library has also been an active member- participant of the Resource Sharing Group and Network of Libraries in Pune Metropolitan area (PUNE-NET).

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, micrography, photography, drafting, drawing, printing and binding were provided.

Programmes for popularisation of meteorology among students and public by organising open day 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. were arranged. 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.

Science Popularization Programmes

Academic Cell

Keeping in view the highly specialized nature of atmospheric research, the Institute has signed a Memorandum of Understanding (MoU) with the University of Pune, for the development of human resources. Under this MoU the Institute has been conducting M.Tech. (Atmospheric Physics) degree course of the University of Pune in collaboration with the Department of Physics. Courses for 17th batch have been started and facilities for internship and research guidance are being provided to the students of 16th batch. The Institute has also been providing research facilities to M.Sc. and M.Tech. students of other Universities. Academic Cell of the Institute coordinates the academic activities of the Post-graduate, Ph.D. and Post-Doctoral students from various Indian Universities. All the activities and formalities related to admissions for M.Tech. (Atmospheric Physics) and registration of Institute's Research Fellows and scientists for Ph. D. are dealt with by the Academic Cell. Dr. (Smt.) P.S. Salvekar has been the coordinator of the Academic Cell.

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 G.C. are nominated by the DST. The Director General of Meteorology is the Ex-officio Chairman of the Council. The Governing Council held its meeting on 2 August, 2004. 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, 2005 the Institute had its staff under different categories as shown below :

Research I	79
Research I- A	50
Technical	34
Administrative	46
Non-Technical Maintenance	42
Total	251

Staff changes

Six employees under different categories left the Institute during the year as shown below:

Retirement on Superannuation

Shri N.S. Ramakrishnan Section Officer	30 April, 2004
Smt. A.H.Mullan Scientist C	31 October, 2004
Shri D.R.Talwalkar Scientist C	31 October, 2004
Kum. J.S. Pethkar Scientist B	31 December, 2004
Shri K.V. Ramachandran Assistant	31 December, 2004

Resignation

Shri S.Rana Junior Technical Officer	18 March, 2005

Status of SC / ST / OBC Reservations

The status of filled positions for SC / ST / OBC as on 31 March, 2005 is as follows :

	SC	ST	OBC	Total
Research I	12	5	5	22
Research I-A	9	4	3	16
Technical	6	2	1	9
Administrative	6	6	-	12
Non-Technical Maintenance	12	2	2	16
Total	**45**	**19**	**11**	**75**

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.

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. Eight meetings of the council were held during the year.

Advisory Committee

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

Armed Force Flag Day

Armed Forces Flag Day was celebrated on 7 December, 2004.

Finance

The Finance Committee of the Institute constituted by Governing Council met on 12 October, 2004 and 28 February, 2005.

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 2004 - 05 are as follows :

(Rs. in Lakhs)

	Opening Balance	Other Income	Grant Received	Total	Actual Expenditure
Plan	129.00	24.00	550.00	703.00	766.00
Non-Plan	-	-	248.00	248.00	248.00
Sponsored Projects	115.00	-	130.00	245.00	172.00
Total	**244.00**	**24.00**	**928.00**	**1196.00**	**1186.00**

The Auditors appointed by the Governing Council M/s M.S. Godbole and Associates, Chartered Accountants, Pune conducted the audit for the year 2004-05. The abstract of the report is enclosed at the end of this report.

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. 125.02 lakhs
- Dead Stock : Rs. 2.17 lakhs
- Consumables : Rs. 14.23 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. Five employees were nominated for "prabodh" and "Pragnya" course held by Hindi Teaching Scheme during the year. All the five 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 25-30 September, 2004. On this occasion, competitions in Hindi were organised. Major General S.S. Sharma was the Chief Guest. A lecture by Dr. Malati Sharma, a renowned writer, was also arranged. The prizes to the winners of the competitions were given away by the Chief Guest. On this occasion, second issue of the 'Indradhanush' a Hindi Magazine of the Institute was also released at the hands of 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 2004-2005 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 43rd Foundation Day Celebration of the Institute held on 17 November, 2005. Employees retiring from the service were felicitated with a silver coin on behalf of the recreation club.

Garden Committee

The Garden Committee took special efforts in maintaining ecological balance, cleanliness, upkeep and modernization of the garden. Various seasonal, annual and perennial plants were planted throughout the year. Special Tree Plantation Programmes by the Hon'ble Minister Shri Kapil Sibal on 7 September and by other dignitaries on 17 November, 2004 were also organized. Beautiful gardens, landscaped surroundings, manicured lawns and a plethora of flowering shrubs and enticing trees make up an ideal setting for serious study and well rounded research for the employees and the researchers of the institute. The sprawling campus with its amazing flora makes the ambience very pleasant.

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Rupa Kumar K., Application of regional models - High resolution climate change scenarios for India using PRECIS, Workshop on Climate Change Impacts, Vulnerability and Adaptation, Buenos Aires, Argentina, 7 - 8 December, 2004.

Rupa Kumar K., Climate change and monsoon, International Conference on MONEX and its Legacy, Habitat Centre, New Delhi, 3 - 7 February, 2005 (Invited Talk).

Rupa Kumar K., Climate of the future, GCOS / WMO International Workshop on Enhancing South and Central Asian Climate Change Monitoring and Indices, Indian Institute of Tropical Meteorology, Pune, 14 - 19 February, 2005.

Safai P.D., Preliminary results of Land Campaign Project under ISRO-GBP, ISRO-GBP Working Group (WG-II) Meeting, Physical Research Laboratory, Ahmedabad, 1 - 2 March, 2005.

Safai P.D., Role of aerosols and black carbon in atmospheric radiation budget studies, ISRO-GBP Working Group (WG-II) Meeting, Physical Research Laboratory, Ahmedabad, 3 March, 2005.

Safai P.D., Praveen P.S., Rao P.S. P., Momin G.A., Ali K. and **Chate D.M.,** Variation in acidic and neutralizing potentials of aerosols at Pune and Sinhagad after two decades, IASTA Meeting and International Conference on Aerosols, Clouds and Indian Monsoon, Indian Institute of Technology, Kanpur, 15 - 17 November, 2004.

Sahai A.K., Mandke S.K. and **Shinde M.A.,** Assessment of ensemble dynamical seasonal prediction of recent monsoons by an AGCM, International Conference on MONEX and its Legacy, Habitat Centre, New Delhi, 3 - 7 February, 2005.

Shaiju A., Singh D. and **Tiwari S.,** Chemical composition of rainwater at Panipat inside NCR of Delhi, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 - 19 January, 2005.

Shirsat S.V. and **Devara P.C.S.,** Study of aerosol size distribution from remote sensing technique, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 - 19 January, 2005.

Singh N. and **Joshi R.R.,** Estimation of turbulence parameters using Uhf wind profiler radar, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 - 19 January, 2005.

Singh V. and **Beig G.,** Long term changes in ozone pollutants over India: 3-D model simulations, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 - 19 January, 2005.

Sontakke N.A. and **Singh N.,** Climatological time series : construction, analysis and extrapolation, International Conference on Industrial and Applied Mathematics, New Delhi, 4 - 6 December, 2004 (Invited Talk).

Sukumaran C. and **Sivaramakrishnan S.,** Variation of advective fluxes of CO_2 and water vapour over Vasco-da-Gama, Goa during monsoon 2002, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 - 19 January, 2005.

Tarafdar S. and **Salvekar P.S.,** Understanding the tropical Indian Ocean surface wind stress in the behaviour of Indian southwest monsoon, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 - 19 January, 2005.

Thompson B., Gnanaseelan C., Chowdary J.S. and **Salvekar P.S.,** Dynamical response of Indian Ocean to interannually varying surface forcing in an OGCM, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 - 19 January, 2005.

Tiwari S., Momin G.A., Rao P.S.P., Safai P.D., Chate D.M., Ali K., Rodhe H. and Granat L., Rainwater chemistry around national capital region of Delhi, IASTA Meeting and International Conference on Aerosols, Clouds and Indian Monsoon, Indian Institute of Technology, Kanpur, 15 - 17 November, 2004.

Trivedi D.K., Impact of initial conditions and physical processes on tropical cyclone, International Conference on Tropical Cyclone, Observations, Understanding and Prediction, Department of Mathematics, Behrampur University, Bhubaneshwar, 5-6 January, 2005 (Invited Talk).

Vaid B.H., Gnanaseelan C. and **Thompson B.,** Statistical analysis of Topex / Poseidon altimetry data with emphasis on Indian Ocean dipoles, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 -19 January, 2005.

Vaid B.H., Gnanaseelan C., Thompson B. and **Salvekar P.S.,** Indian Ocean dipoles observed in the TOPEX/ POSEIDON altimetry data, 41st IGU Annual Convention and Meeting on Inter and Intraplate Seismicity in India - Present Knowledge and Future Strategy, National Geophysical Research Institute, Hyderabad, 29 - 31 December, 2004.

Vijayakumar R., Kulkarni J.R., Kolawale H.Y. and **Pant G.B.,** Monsoon 2004 over Maharashtra as rendered by cloud seeding radars, Annual Monsoon Workshop – 2004, Indian Meteorological Society (Pune Chapter), India Meteorological Department, Pune, 4 March, 2005.

Vinay Kumar and **Krishnan R.,** On the association between Indian summer monsoon and the tropical cyclone activity over the northwest Pacific, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 -19 January, 2005.

Yadav R.K. and **Patil S.D.,** Upper tropospheric circulation features during extreme monsoon years, First Prof. R. Ananthakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 - 19 January, 2005.

Yamagata T., Ohba R., Sakuma H., Behera S., **Mujumdar M.** and Chakraborty A., Refinement of numerical modelling and technology of global and regional water cycle, 85th American Meteorological Society Annual Meeting , San Diego, U.S.A., 9 -13 January, 2005.

PAPERS PUBLISHED		
Journals	:	70
Proceedings, Books, Reports etc.	:	73
PAPERS PRESENTED	**:**	**133**

Participation in Symposia, Seminars etc.

International Meeting on Tree-ring and Climate : Sharpening the Focus, University of Arizona, Tucson, U.S.A., 6 - 9 April, 2004
(Dr. H.P. Borgaonkar)

Brain Storming Session for the forthcoming Indian Children's Science Congress, Ratnagiri, 10 - 11 April, 2004
(Dr. C.G. Deshpande)

International Symposium on Snow Monitoring and Avalanche Study, Snow and Avalanche Study Establishment, Manali, 12 - 16 April, 2004
(Dr. G.B. Pant, Shri C.M. Mohile)

Workshop on Climate Variability in 20th Century, Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, 19 - 30 April, 2004
(Smt. S.K. Mandke)

Workshop on Climate Change Adaptation in India, Indo-German Bilateral project, New Delhi, 12 May, 2004
(Dr. G.B. Pant)

Quadrennial Ozone Symposium, Kos, Greece, 1 - 8 June, 2004
(Dr. G. Beig)

3rd International Workshop on Long Term Changes and Trends in the Atmosphere, Sozopol, Bulgaria, 10 -14 June, 2004
(Dr. G. Beig)

7th International Winds Workshop, Helsinki, Finland, 14 -17 June, 2004
(Dr. P.N. Mahajan)

CLIVAR Workshop on Ocean Model Development, Geophysical Fluid Dynamics Laboratory, Princeton, U.S.A., 16 - 18 June, 2004
(Dr. R. Krishnan)

First International CLIVAR Science Conference on Understanding and Predicting our Climate System, Baltimore, U.S.A., 21 - 25 June, 2004
(Dr. R. Krishnan)

Indo US Conference on Space Science, Applications and Commerce - Strengthening and Expanding Cooperation, Indian Space Research Organisation, Bangalore, 21 - 25 June, 2004
(Dr. A.K. Kamra, Dr. P.C.S. Devara and Dr. P.N. Mahajan)

DST Sponsored Foundation Training Programme for Scientists, Indian Institute of Public Administration (IIPA), New Delhi, 4 July - 3 October, 2004
(Dr. C. Gnanaseelan)

Brain Storming Session on Environment Monitoring in India, India Habitat Centre, New Delhi, 6 - 7 July, 2004
(Dr. K. Rupa Kumar)

22nd International Laser Radar Conference (ILRC XXII), Matera, Italy, 12 - 16 July, 2004
(Dr. P.C.S. Devara)

14th International Conference on Clouds and Precipitation (ICCP), Bologna, Italy, 18 - 23 July, 2004
(Dr. P.C.S. Devara) (Chaired a Session on Warm Cloud Microphysics)

PRECIS Training Workshop, Thimpu, Bhutan, 20 - 24 July, 2004
(Dr. K. Rupa Kumar)

Workshop on Indian Antarctica Research Programme: Achievements of 23rd and Planning for the 24th Antarctic Expedition, National Centre for Antarctica and Ocean Research, Goa, 19 - 20 July, 2004
(Dr. A.K. Kamra and Shri S.M. Sonbawne)

INDO-US Climate Change Science Workshop, New Delhi, 26 - 28 July, 2004
(Dr. P.C.S. Devara and Dr. K. Rupa Kumar)

3rd SPARC General Assembly, Victoria, British Columbia, Canada, 1 - 6 August, 2004
(Dr. Y. Jaya Rao)

International 2nd ESA Summer School on Earth System Monitoring and Modelling, ESA-ESRIN, (Frascati), Rome, Italy, 16 - 26 August, 2004
(Shri J.S. Chowdary)

Seminar on Aerosols and Environmental Pollution, Sona College of Technology, Salem, 30 August, 2004
(Shri V. Gopalkrishnan)

Pre-Antarctic Snow Ice Acclimatization Training for the 24th Antarctic Expedition, ITBT Camp, Auli, 5 - 20 September, 2004
(Dr. D.K. Siingh and Shri V. Pant)

Indo-EU Workshop on Climate Change and Natural Disasters, University of Hyderabad, Hyderabad, 6-10 September, 2004
(Dr. G.B. Pant and Dr. K. Rupa Kumar)

Workshop on Lightning Protection for Floating Roof Tanks, Indian Oil Corporation, New Delhi, 10 September, 2004
(Dr. A.K. Kamra)

Brainstorming Session on Receding Glaciers in Indian Himalayan Region (HIR) – Environmental and Social Implications, G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora, 11 September, 2004
(Dr. P.C.S. Devara)

One-day Workshop on Discover the Power and Flexibility of 64-bit Computing, Pune, 13 September, 2004
(Smt. J.V. Revadekar)

Global Ocean Data Assimilation Experiment (GODAE) International Summer School, La Londe - Les Maures, France, 20 September - 1 October, 2004
(Dr. C. Gnanaseelan)

National Workshop on Strategies and Technologies for Weather Modification and Cloud Seeding, S. V. University, Tirupati, 29 - 30 September, 2004
(Dr. A.K. Kamra)

ADCOS Brain Storming Meeting on Chemical Modelling for Climate Change and Air Pollution Studies, ISRO Head Quarters, Bangalore, 30 September, 2004
(Dr. G. Beig)

Group Monitoring Workshop (GMW) on Atmospheric Science, Physical Research Laboratory, Ahmedabad, 5 October, 2004
(Dr. G. Beig and Shri D.R. Chakraborty)

49th Seminar and Hindi Workshop on Official Language Management, Policy Implementation, Conducting Workshops, Information Technology and Computerization, Nainital, 6-8 October, 2004
(Shri B.C. Morwal)

Workshop on Cirrus Clouds and Their Supersaturated Environment, Institute of Physics and Atmosphere, German Space Operations Centre, Oberpfaffenhofen, Germany, 11 - 12 October, 2004
(Dr. Y. Jaya Rao)

Global Climate Observing System (GCOS) Regional Workshop for South and Southwest Asia and the IPCC Lead Authors Meeting, New Delhi, 11 - 13 October, 2004
(Dr. K. Rupa Kumar)

Third International Workshop on Monsoon (IWM III), Hangzhou, China, 2 - 6 November, 2004
(Shri D.R. Chakraborty)

Final Workshop of the Joint Indo-UK Programme on Impacts of Climate Change in India, New Delhi, 5 November, 2004
(Dr. G.B. Pant, Dr. K. Rupa Kumar and Shri B.N. Mandal)

Indo-UK workshop on Impact of Climate Change in India New Delhi, 5 - 6 November, 2004
(Dr. G.B. Pant)

IASTA Meeting and International Conference on Aerosols, Clouds and Indian Monsoon, Indian Institute of Technology, Kanpur, 15 - 17 November, 2004
(Dr. P.C.S. Devara, Dr. G. Beig, Dr. (Smt.) I. Joshi, Dr. P.D. Safai, Dr. S. Tiwari, Shri V. Gopalkrishnan, Shri S.D. Patil, Smt. B. Padmakumari and Kum. R. Bhawar)

(Dr. P.C.S. Devera delivered Welcome Address and Chaired a Session on Bio and Radioactive Aerosols, Nano Particles)

First NIAS Course on Multi-disciplinary Perspectives on Science and Technology, National Institute of Advance Studies, Bangalore, 15 - 27 November, 2004
(Dr. N. Singh)

11th National Symposium on Hydrology with Focal Theme on Water Quality, National Institute of Hydrology, Roorkee, 22 - 23 November, 2004
(Dr. B.D. Kulkarni and Smt. N.R. Deshpande)

Indian Ocean Modelling Workshop, International Pacific Research Center, University of Hawaii, Honolulu, Hawaii, USA, 29 November, - 3 December, 2004
(Dr. R. Krishnan, Dr. C. Gnanaseelan and Dr. P. R. C. Reddy)

Annual Convention of the Computer Society of India, Mumbai, 30 November – 3 December, 2004
(Shri O.Abraham)

Group Monitoring Workshop (GMW-2004) on Monsoon and Tropical Climate (MONTCLIM), Agrometeorology and Indian Climate Research Program (ICRP), Birbal Sahni Institute of Palaeobotany (BSIP), Lucknow, 1 - 3 December, 2004
(Dr. G.B. Pant, Dr. P.C.S. Devara, Dr. (Smt.) P.S. Salvekar, Dr. S. Sivaramakrishnan, Smt. S.S. Vaidya, Dr. N. Singh, Dr. P.S.P. Rao, Smt. U.V. Bhide, Dr. M.N. Patil, Shri S.S. Dugam, Dr. (Smt.) S.B. Morwal, Dr. S. Tiwari, Smt. A.A. Shiralkar and Dr. (Smt.) R.R. Joshi)

International Conference on Industrial and Applied Mathematics, New Delhi, 4 - 6 December, 2004
(Dr. (Smt.) N.A. Sontakke, Shri S.S. Dugam and Shri S.B. Kakade)

International Conference on Better Air Quality, Agra, 6 - 9 December, 2004
(Dr. G. Beig)

UNFCCA/SBSTA Workshop on Climate Change Impacts, Vulnerability and Adaptation, Buenos Aires, Argentina, 7 - 8 December, 2004
(Dr. K. Rupa Kumar)

Workshop on Economic Reforms: Canadian and Indian Perspective, New Delhi, 9 -11 December, 2004
(Dr. G.B. Pant)

International Conference on Instrumentation (INCON 2004), Instrument Society of India, Pune Institute of Engineering and Technology (PIET), Pune, 19 - 21 December, 2004
(Dr. P.C.S. Devara and Dr. D.B. Jadhav)

Workshop on the New ICAR National Project 'Impact, Adaptation and Vulnerability of Indian Agriculture to Global Climate Change', Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, 20 - 21 December, 2004.
(Dr. K. Rupa Kumar)

Workshop on Advanced Ocean State forecast and Ocean Modelling, Space Applications Center, Ahmedabad, 20 - 21 December, 2004
(Dr. C. Gnanaseelan)

National Symposium on Half a Century Progress in Oceanographic Studies of North Indian Ocean since Prof. La Fond's Contributions (HAC PO), Department of Meteorology and Oceanography, Andhra University, Visakhapatnam, 23 - 24 December, 2004
(Dr. K. Rupa Kumar, Smt. S.G. Nagar, Shri V.R. Mujumdar, Shri S.P. Ghanekar, Shri G.R. Chinthalu, Shri M.D. Chipade, Shri J.S. Chowdary and Kum. R. Deepa)

41st IGU Annual Convention and Meeting on Inter and Intraplate seismicity in India- Present Knowledge and Future Strategy, National Geophysical Research Institute, Hyderabad, 29 - 31 December, 2004
(Dr. P.N. Mahajan, Shri S.S. Dugam, Shri S. Mahapatra, Smt. A.A. Deo, Shri D.W. Ganer and Shri B.H. Vaid)

International Conference on Tropical Cyclone, Observations, Understanding and Prediction, Department of Mathematics, Behrampur University, Bhubaneshwar, 5-6 Janaury 2005
(Shri D.K. Trivedi)

Pre-Workshop on Weather Modification and Cloud Seeding Technologies for Rain Water Enhancement -2005, Jawaharlal Nehru Technology University, Hyderabad, 7 January, 2005
(Dr. R. Vijayakumar)

First Prof. R. Ananathakrishnan Memorial Conference on Atmospheric Science, Climate Change and Environmental Studies, Indian Institute of Tropical Meteorology, Pune, 18 -19 January, 2005
(Shri R. Chattopadhyay, Shri R. K. Yadav, Shri A. K. Verma, Shri B. H. Vaid, Shri B.K. Samala, Shri B. Thompson, Shri D. P. Prajapati, Shri J. S. Chowdary, Shri K. Jagdeesh, Shri S. H. Kulkarni, Shri M. Muhsin, Shri N. Singh, Shri Pankaj Kumar, Shri P. K. Rathore, Shri S. Deshpande, Shri S. Bhandare, Shri S. Gunthe, Shri S.K. Sahu, Shri S. Kewat, Shri S. Taraphdar, Shri S. K. Mishra, Shri U. Singh, Shri V.Singh, Shri Vinay Kumar, Smt. A. A. Prabhu, Smt. A. A. Ranade, Kum. M. S. Deshpande, Kum. S. Joshi, Kum. A. Dey, Kum.C. Sukumaran, Kum. K. Kamala, Kum. P. Bhaskar, Kum. R. Dutta, Kum.R. Bhawar, Kum. S. V. Shirsat, Kum. S. John, Kum. S.Joseph, Shri S. Augustine, Shri U. Shinde, Dr. R.P.C. Reddy)

Colloquium on International Network on Tropical Atmosphere Radars (INTAR 2005), National MST Radar Facility and Shri Venkateswara University, Tirupati, 20 - 22 January, 2005
(Dr. P.C.S. Devara)

International Workshop on Weather Modification and Cloud Seeding Technologies for Rain Water Enhancement – 2005, Jawaharlal Nehru Technology University, Hyderabad, 27 - 28 January, 2005
(Dr. R. Vijayakumar)

Brain Storming Meeting on Modelling and Prediction over Indian Monsoon Region – Vision 2005, National Centre for Medium Range Weather Forecasting, New Delhi, 1 - 2 February, 2005
(Dr. K. Rupa Kumar, Dr. R. Krishnan and Dr. K. Krishna Kumar)

International Conference on MONEX and its Legacy, Habitat Centre, New Delhi, 3 - 7 February, 2005
(Dr. K. Rupa Kumar, Dr. R. Krishnan, Dr. P.N. Mahajan, Dr. K. Krishna Kumar, Dr. (Smt.)S.G. Nagar, Shri S.S. Dugam, Shri S.M. Bawiskar and Smt. S.K. Mandke)

Indian Ocean Marine Environment Conference, Perth, Australia, 14 -18 February, 2005
(Dr. R. Krishnan)

International Workshop on Enhancing South Central Asian Climate Change Monitoring and Indices, Indian Institute of Tropical Meteorology, Pune, 14 - 19 February, 2005
(Shri A.B. Sikder, Smt. N.R. Deshpande and Smt. J.V. Revdekar)

National Academy of Agricultural Science : 7th Agricultural Science Congress, College of Agriculture, Pune, 16 -18 February, 2005
(Dr. G.B. Pant)

SHARP /CS Workshop on Sustainable Environmental Management and Livelihood Issues: Indian and Canadian Perspective, Kolkata, 19 - 21 February, 2005
(Dr. G.B. Pant)

Workshop on Women in Scientific Careers, SNDT University, Mumbai, 24 February, 2005
(Dr.(Smt.) P.S. Salvekar and Smt. A.A. Shiralkar)

Symposium in Mathematics, S. P. College, Pune, 27 February, 2005
(Dr. (Smt.) P.S. Salvekar)

Workshop on Land Campaign Results, Physical Research Laboratory, Ahmedabad, 1 - 2 March, 2004
(Dr. P.E. Raj, Dr. G. Pandithurai, Dr. P.D. Safai)

IPCC Model Analysis Workshop, Honolulu, Hawaii, U.S.A., 1 - 4 March, 2005
(Dr. K. Rupa Kumar)

Brain Storming Seminar on the High Performance Computing for Weather and Climate Modelling, Indian Institute of Technology, New Delhi, 2 - 4 March, 2005
(Dr. G.B. Pant, Dr. R. Krishnan, Dr. G. Beig and Smt. S.U. Athale)

First WP / RASS Training/Workshop on Meteorology and Atmospheric Science, Indian Institute of Tropical Meteorology, Pune, 7 - 11 March, 2005
(Shri S.D. Pawar, Shri S.S. Saha, Kum. S.P. Nikam, Shri A.R.Dhakate and Smt. A. Prabhu)

Seminar on Global Climate Change and the Oceans - How India is Responding, Indian Maritime Foundation, Pune, 9 March, 2005
(Dr. (Smt.) P.S. Salvekar, Dr. C. Gnanaseelan and Smt. A.A. Deo)

Brain Storming on Seasonal Forecasting of Summer Monsoon - 2005, India Meteorological Department, New Delhi, 11 March, 2005
(Dr. K. Rupa Kumar)

Workshop on Air Modelling, Centre for Development of Advanced Computing, Pune, 14 - 17 March, 2005
(Dr. G. Beig, Kum. S. Roy, Shri Vikas Singh and Shri S. Gunthe)

Brain Storming Session on Modelling Tropical Cyclones with Emphasis on Super Cyclone 1999, India Meteorological Department, New Delhi, 21 - 22 March, 2005
(Shri P. Mukhopadhyay)

Participation in Meetings

Dr. G.B. Pant

- Selection Committee Meeting of CSIR for Senior Research Fellows and Research Associates, New Delhi, 5 April, 2004.
- Meeting of Augmentation of Ocean Observing Network In the Indian Ocean Region, Department of Ocean Development, New Delhi, 28 April, 2004.
- Advisory Committee Meeting, Environmental Information System (ENVIS), Ministry of Environment, New Delhi, 13 May, 2004.
- 7th Meeting of Ocean Environment Panel, Naval Research Board, National Institute of Ocean Technology, Chennai, 22 May, 2004.
- 1st Meeting of the Committee for the Establishment of Marine Meteorological Forecasting Centre (MMFC), India Meteorological Department, New Delhi, 24 May, 2004.
- NNRMS Meteorology Standing Committee Meeting, Indian Space Research Organisation, Bangalore, 31 May, 2004.
- INSAT 3-D Retrieval and Application Review Board Meeting, Space Applications Centre, Ahmedabad, 1 June,, 2004.
- Scooping Meeting of the IPCC's 4th Assessment Report, World Meteorological Organisation, Geneva, Switzerland, 6 - 8 July, 2004.
- Advisory Committee Meeting for developing the Centre for Advanced Research on Astrophysics and Space Science, Bose Institute, Kolkata, 29 July, 2004.
- Meeting with the Minister of Science and Technology, Department of Science and Technology, New Delhi, 1 - 2 August, 2004.
- 103rd SERC Meeting, Department of Science and Technology, New Delhi, 6 August, 2004.
- Organising Committee Meeting of India European Community Workshop, University of Hyderabad, Hyderabad, 16 August, 2004.
- Final Meeting for the Establishment of National Marine Meteorological Forecasting Centre, India Meteorological Department, New Delhi, 16-17 August, 2004.
- Meeting convened by the Secretary, DST for setting up of the proposed BIMST-EC Centre on Weather and Climate in India, Department of Science and Technology, New Delhi, 18 August, 2004.
- Meeting of the Heads of Institutions under the DST convened by the Secretary on Vigilance Matters, Department of Science and Technology, New Delhi, 30 August, 2004.
- Meeting in the British High Commission with Mrs. Beckett, Hon. Secretary of State, Govt. of U.K. regarding Indo - UK collaborative research work on Climate Change, New Delhi, 5 October, 2004.
- Programme Advisory Committee Meeting for SHARP Environmental Projects, New Delhi, 6 October and 9 December, 2004.
- Meeting for Round Table Consultation of Resource Panelist on Climate Change, British Council, New Delhi, 9 October, 2004.
- Eighth Research and Development Council Meeting, Centre for Wind Energy Technology, Chennai, 11 October, 2004.
- Meeting of Fourth Assessment Report of the IPCC, New Delhi, 15 October, 2004.
- Selection Committee Meeting, Indian Institute of Technology, New Delhi, 19 October, 2004
- Meeting with the Chinese Delegation, New Delhi, 5-6 November, 2004.
- First meeting of the National Coordinate Committee on Forecasting Monsoon (NCCFM) , New Delhi,10 November, 2004.
- Meeting of Project Advisory Committee in the area of Oceanography, New Delhi, 24 November, 2004.
- Meeting of the Advisory Committee for SHARP project, New Delhi, 9 December, 2004.

- Meeting of the Expert Committee of Interviews, Council for Scientific and Industrial Research, New Delhi, 22 January, 2005.
- Ninth Research and Development Council Meeting, Centre for Wind Energy Technology, Bangalore, 12 February, 2005.
- Discussion Meeting called by Prof. J. Shukla, India International Centre, New Delhi, 17 February, 2005.
- Programme Advisory and Monitoring Committee Meeting, Department of Science and Technology, New Delhi, 25 February, 2005.
- Finance Committee Meeting of the Indian Institute of Tropical Meteorology, Indian Institute of Tropical Meteorology, Delhi Branch, New Delhi, 28 February, 2005.
- 26th Session of the Joint Scientific Committee (JSC) Meeting of the World Climate Research Programme (WCRP), Guayaquil, Ecuador, 14 - 18 March, 2005.

Dr. A.K. Kamra

- Meeting of the Technical Committee for the Establishment of National Lightning Information System, India Meteorological Department, New Delhi, 12 April, 2004.
- 70th Annual Meeting of the Indian Academy of Science, Banaras Hindu University, Varanasi, 15 - 17 November, 2004.
- 70th Anniversary General Meeting of the Indian National Science Academy, National Institute of Ocean Technology (NIOT), Chennai, 27-28 December, 2004.
- First Meeting of the Physical Sciences Research Committee and Project Monitoring Session of EMR Schemes of CSIR, Council of Scientific and Industrial Research, New Delhi, 24 January, 2005.
- Meeting of the Joint Science Working Group on Megha Tropique, Indian Space Research Organisation, Bangalore, 28 January, 2005.
- Meeting of the ISRO – Geosphere Biosphere Programme (I-GBP) Working Group for 2004-2005, Physical Research Laboratory, Ahmedabad, 1-2 March, 2005.
- Second Expert Committee Meeting towards preparing a Science plan for Severe Thunderstorms - Observational and Regional Modelling (STORM), Indian Statistical Institute, Kolkata, 14 March, 2005.

Dr. P.C.S. Devara

- Meeting of the Instrument Society of India, Pune Chapter (ISOI-P) in connection with Organisation of the forthcoming International Conference (INCON 2004), Pune Institute of Engineering and Technology, Pune, 2, 9 and 16 April, 2004.
- ICCP Commission Meetings, Bologna, Italy, 18 and 19 July, 2004.
- Meeting on Land Campaign – Results under the ISRO-GBP Program, Bangalore, 9-12 August, 2004.
- First Meeting on Scientific Studies on Space Based Navigation Systems, Indian Space Research Organisation, Bangalore, 18 August, 2004.
- Annual General Body Meeting of the Indian Aerosol Science and Technology Association (IASTA), Bhabha Atomic Research Centre, Mumbai, 23 August, 2004.
- Planning Meeting on Land Campaign-II under ISRO- Geosphere Biosphere Programme (I-GBP), Physical Research Laboratory, Ahmedabad, 28-29 October, 2004.
- First Project Monitoring Board Meeting on the Development of High-Power Lidar for Atmospheric Studies over Nainital, Aryabhatta Research Institute for Observational Sciences (ARIES), Nainital, 5 November, 2004.
- Coordinating Committee Meeting for organization of Inter-comparison experiments in connection with the Land Campaign Program, National Physical Laboratory, New Delhi, 28-29 November, 2004.
- Governing Council and Annual General Body Meetings of the Indian Society of Instrumentation (ISOI), Pune Institute of Engineering and Technology, Pune, 19 December, 2004.

Dr. D.B. Jadhav

- Meeting of the Instrument Society of India, Pune Chapter (ISOI-P) in connection with Organisation of the forthcoming International Conference (INCON 2004), Pune Institute of Engineering and Technology, Pune, 2, 9 and 16 April, 2004.
- Annual General Body Meetings of the Indian Society of Instrumentation (ISOI), Pune Institute of Engineering and Technology, Pune, 19 December, 2004.
- Selection Committee Meeting for the Post of Scientific Officer, Shivaji University, Kolhapur, 2 - 4 January, 2005.

Dr. K. Rupa Kumar

- US-India Meeting on Climate Change Science, Department of Science and Technology, New Delhi, 26 - 28 July, 2004.
- Second Meeting of the TARC for the project on Preparation of Generalised PMP Atlases for the Krishna and the Indus River Basins, Central Water Commission, New Delhi, 24 August, 2004.
- IPCC Workshop Group I Fourth Assessment Report First Lead Authors Meeting, Trieste, Italy, 26 - 29 September, 2004.
- Meeting in the British High Commission with Mrs. Beckett, Hon. Secretary of State, Govt. of U.K. regarding Indo - UK collaborative research work on Climate Change, New Delhi, 5 October, 2004.
- Intergovernmental Panel on Climate Change (IPCC) Lead Authors Meeting, Tata Energy Research Institute (TERI), New Delhi, 15 October, 2004.
- Indo French Scientific Council Meeting, Kolkata, 28 November, 2004.

Dr. R. Vijayakumar

- State Level Task Force Committee Meeting on Cloud Seeding constituted by the Govt. of Andhra Pradesh, Hyderabad, 30 August, 2004.

Dr. R. Krishnan

- Working Group Meeting on Extended Range Monsoon Prediction (ERMP) - Models and Diagnostics, Space Application Centre, Ahmedabad, 14-16 October, 2004.
- Extended Range Monsoon Prediction (ERMP) Meeting, Indian Institute of Technology, New Delhi, 4 March, 2005.

Dr. P.E. Raj

- Meeting on Land Campaign-II Results, Physical Research Laboratory, Ahmedabad, 1-2 March, 2005.
- ISRO-GBP Working Group (WG-II) Meeting, Physical Research Laboratory, Ahmedabad, 3 March, 2005.

Dr. P.N. Mahajan

- Fifth Meeting of Advisory Committee on Space Sciences (ADCOS -1), Indian Space Research Organisation, Bangalore, 19 August, 2004.

Shri J.R. Kulkarni

- Cloud Seeding Experiment - 2004 Meeting of Government of Maharashtra, Jal Vigyan Bhavan, Dindori, Nasik, 7-9 May, 2004.
- Meeting to Monitor the Cloud Seeding Operations, Government of Maharashtra, Directorate of Ground Water, Pune, 15 June, 29 July and 7 September, 2004.

Smt. S.S. Vaidya

- Monitoring Committee Meeting of CSIR sponsored New Millennium Indian Technology Leadership Initiative (NMITLI) Project on Mesoscale Modelling, National Aeronautical Laboratory, Bangalore, 4 August, 2004.

Shri B.N. Mandal

- Second Meeting of the TARC for the project on Preparation of Generalised PMP Atlases for the Krishna and the Indus River Basins, Central Water Commission, New Delhi, 24 August, 2004.

- Expert Committee Meeting for a DST funded project proposal presentation on Spatial and temporal fingerprinting of waters of India using stable isotopes to study seasonal evaluation interacting geographic controls and climate forcing, Indian Institute of Tropical Meteorology, Pune, 8 December, 2004.

Dr. G. Beig

- VI Meeting of the PAMC on Weather and Climate Research Program (WCRP), Indian Institute of Tropical Meteorology, Pune, 10-11 September, 2004.
- ADCOS Brain Storming Meeting on Chemical Modelling for Climate Change and Air Pollution Studies, Indian Space Research Organisation, Bangalore, 30 September, 2004.
- Project Advisory Committee on Atmospheric Sciences Meeting, Physical Research Laboratory, Ahmedabad, 5 October, 2004.

Dr. A.K. Sahai

- Extended Range Monsoon Prediction (ERMP) Meeting, Indian Institute of Technology, New Delhi, 4 March, 2005.

Dr. P.S.P. Rao

- Meeting on Land Campaign – Results under ISRO-GBP Program, Bangalore, 9-12 August, 2004.
- International CAD (Composition of Asian Deposition) Planning Meeting, National Physical Laboratory, New Delhi, 7-9 October, 2004.
- Planning Meeting on Land Campaign-II under ISRO-GBP, Physical Research Laboratory, Ahmedabad, 28-29 October, 2004.
- Coordinating Committee Meeting for organization of Inter-comparison experiments in connection with the Land Campaign Program, National Physical Laboratory, New Delhi, 28-29 November, 2004.

Shri D.R. Chakraborty

- International Committee Review Meeting of the 3rd International Workshop on Monsoon (IWM-III), Hangzhou, China, 4 November, 2004.

Dr. H.P. Borgaonkar

- International Meeting on Tree-Ring and Climate: Sharpening the Focus, University of Arizona, Tucson, U.S.A., 4 -12 April, 2004.

Dr. M. N. Patil

- Selection Committee Meeting for Apprentice and Technical Evaluation Committee, India Meteorological Department, Pune, 16 - 20 August, 2004.

Shri J. Sanjay

- Meeting of the Subprojects under India Meteorological Department, New Delhi (INDO - USAID Programme), 10 August, 2004
- RCM/ISRO-GBP meeting, Space Applications Centre (SAC), Ahmedabad, 28 October, 2004.

Dr. G. Pandithurai

- Meeting on Land Campaign-II Results, Physical Research Laboratory, Ahmedabad, 1-2 March, 2005.
- ISRO-Geosphere Biosphere Programme (I-GBP) Working Group (WG-II) Meeting, Physical Research Laboratory, Ahmedabad, 3 March, 2005.

Shri S.D. Patil

- Departmental Promotion Committee Meeting, India Meteorological Department, Pune, 25 October, 8 December, 2004 and 18 January, 2005.

Dr. P.D. Safai

- Meeting on Land Campaign-II Results, Physical Research Laboratory, Ahmedabad, 1 - 2 March, 2005.
- ISRO- Geosphere Biosphere Programme (I-GBP) Working Group (WG-II) Meeting, 3 March, 2005.

Dr. M. Mujumdar

- General Body Meeting of Indian Academy of Industrial and Applicable Mathematics, Pune, 18 December, 2004.

Seminars

By Visitors

Ms. Rajshree Rege, Space Applications Centre, Ahmedabad.

- Mapping of aerosol properties over land using OCM-land data, 5 April, 2004.

Dr. D.K.Prashar, Snow and Avalanche Study Establishment, Chandigarh.

- Mitigation of avalanches, 18 May, 2004.

Dr. V. Ghole, Dept. of Environment Studies, University of Pune, Pune.

- Impact of environmental toxicity on human health, 1 June, 2004.

Dr. P. Satyamurty, Center for Weather Forecasts and Climate Studies, INPE, Brazil.

- Operational and research activities at CPTEC, Brazil 15 June, 2004.

Dr. (Ms) Sushma Prasad, Climate Dynamics and Sediments Group, Germany.

- VARVES as high resolution palaeoclimate archieves: examples from near East and Europe, 2 July, 2004.

Shri S. Kulkarni, India Soft Technologies (P) Ltd., Pune.

- Presentation of MATLAB - a mathematical modeling and simulation package, 28 July, 2004.

Prof. A.H. Siddiqi, Department of Mathematical Sciences, King Fahd University of Petroleum and Minerals, Saudi Arabia.

- Application of wavelet and Fractal formalism of time series representing meteorological data- Part I and II, 9 and 10 August, 2004.

Dr. S. Someshwar, University of Colombia, USA.

- Climate application activities at IRI for climate prediction, 12 August, 2004.

- **Dr. M. I. Bhat,** Department of Geology and Geophysics, University of Kashmir, Srinagar.
  - Monitoring microseismicity and microgravity fluctuations for climate prediction, 10 September, 2004.

Dr. Andrew Roberston, International Research Institute (IRI) for Climate Prediction, USA.

- Downscaling monsoon rainfall variability over Brazil and Australia using a hidden Markov model, 18 November, 2004.

Dr. Murali Shashtri, National Chemical Laboratory, Pune.

- Introduction to nano-technology, 25 November, 2004.

Dr. Vasubandhu Mishra, Center for Ocean Land Atmosphere Studies, USA.

- Seasonal simulation of the South American summer monsoon, 31 January, 2005.

- Development of COLA AGCM V3 for coupled climate integrations, 1 February, 2005.

Dr. A.K. Gosain, Deptt. of Civil Engineering, Indian Institute of Technology, New Delhi.

- Climate change impacts over different river basins of the Indian rivers, 4 February, 2005.

Dr. David Griggs, Hadley Centre for Climate Prediction and Research, UK.

- Climate change this century, 9 February, 2005.

Dr. Thomas C. Peterson, Climate Analysis Branch, National Climate Data Center, USA.

- Recent developments at the US National Climate Data Center, 17 February, 2005.

Dr. Philip D. Jones, Climate Research Unit, University of East Anglia, UK.

- Instrumental temperature change since 1850 and long-term palaeoclimatic data, 18 February, 2005.

Prof. V.K. Wagh, Fergusson College, Pune.

- Role of teachers in science education, 28 February, 2005.

  (National Science Day Lecture)

Dr. S. T. Rao, Atmospheric Sciences Modeling Division, NOAA, USA.

- Linking air pollution and health, 16 March, 2005.

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

- Turbulent transport of passive tracer in the indoor environment, 23 March, 2005.

By Institute Scientists

Dr. H.P. Borgaonkar

- Tree-ring data networks of *Tectona grandis* (Teak) from Central and Peninsular India and its dendroclimatic potential, 1 April, 2004.
- Climatic response of Himalayan conifers growing at upper tree-line and near glaciers, 1 April, 2004.

Shri C.M. Mohile

- Climate variability over western Himalaya, 1 April, 2004.

Dr. G. Beig

- 3-D ozone pollution modelling and emission inventories, 7 April, 2004.

Dr. C.G. Deshpande and **Shri V. Pant**

- Pilot expedition to Southern Ocean-Overview, 7 April, 2004.

Dr. M. Mujumdar

- Dynamics of rainfall events over the Arabian region, 30 April, 2004.

Dr. P.N. Mahajan

- Signal of dissipation of very severe tropical cyclone through AMVs over the Indian region, 18 May, 2004.

Shri B.N. Mandal

- Preparation of generalized PMP Atlas for the Krishna and the Indus river basins in India, 21 May, and 24 August, 2004.

Dr. R. Krishnan

- Mixed layer and thermocline interactions associated with the monsoonal flow over the Arabian Sea, 8 June, 2004.
- Evolution of subsurface anomalies associated with the tropical Indian ocean dipole/zonal mode, 5 January, 2005.

Dr. P. C. S. Devara

- Excimer-Raman DIAL probing of atmospheric ozone over an urban station: First results, 30 June, 2004.
- Wavelet analysis of 14 years' aerosol lidar observations over Pune, India, 30 June, 2004.
- Polarization-lidar probing of clear and cloudy atmosphere over Gadanki, a remote continental station in India, 30 June, 2004.
- Microtops observations of columnar aerosol optical depth, ozone and water vapour over Gadanki (13.5°N, 79.2°E) , 30 June, 2004.
- Combined ground-based and satellite borne study of aerosol characteristics during successive contrasting monsoon season, 11 November, 2004.
- LIRAD remote sensing of industry and environment monitoring, 15 December, 2004.

Dr. Y. Jaya Rao

- Combined lidar and MST radar observations of stratospheric tropospheric exchanges, 1 July, 2004.
- Radar and lidar study of cirrus clouds, stable layers and vertical velocity in UT/LS region, 20 October, 2004.
- Dynamics of UT/LS region : lidar and radiosonde observations over tropical and sub-tropical stations, 7 January, 2005.

Dr. C. Gnanaseelan

- Numerical simulation of pre-monsoon warming in the southeast Arabian Sea, 2 July, 2004.
- Developments in ocean observations, modelling and data assimilation, 27 October, 2004.

- Evolution and collapse of Arabian Sea warm pool and its sensitivity to interannually varying surface forcing, 7 January, 2005.

Dr. T. Venugopal

- Atmospheric boundary layer studies, 2 August, 2004.

Shri D.R. Chakraborty

- On the dynamics of phase locking, 22 September, 2004.
- Current state of research of monsoons, 24 January, 2005.

Shri S.D. Patil

- Large-scale changes in the cloud radiative forcing averaged over the Indian region, 11 October, 2004.

Shri B.D. Kulkarni

- Estimation of areal probable maximum precipitation (PMP) over Saurashtra and Kutch by grid point transposition, 11 October, 2004.

Smt. N.R. Deshpande

- Low flow estimation over the Krishna river basin in India, 11 October, 2004.

Dr. R. Vijayakumar

- Indo-Russian collaboration - visit to Main Geophysical Observatory, Saint Petersburg, 2-10 August, 2004, 15 October, 2004.

Shri H.N. Singh

- Investigations into relationship between extreme wet/dry conditions over India and space-based OLR observation over global tropics, 19 October, 2004.

Dr. (Smt.) I. Joshi

- Association between first southern hemisphere stratospheric warming and volcanic aerosols, 8 November, 2004.

Smt. B. Padmakumari

- Twilight probing of dust particles in the middle atmosphere during Leonid meteor shower 2003, 8 November, 2004.

Dr. G. Pandithurai

- Aerosol radiative forcing and heating rates during winter and pre-monsoon seasons over Pune, 9 November, 2004.

Dr. P. D. Safai

- Variation in acidic and neutralizing potentials of aerosols at Pune and Sinhagad after two decades, 9 November, 2004.

Shri V. Gopalakrishnan

- Airborne measurements of aerosol size-distributions on a cloudy day, 9 November, 2004.

Dr. K. Rupa Kumar

- Application of regional models – high resolution climate change scenarios for India using PRECIS, 3 December, 2004
- Climate of the future, 14 February, 2005
- Climate Change issues for sustainable development, 23 March, 2005.
  (World Meteorological Day Lecture)

Dr. D.B. Jadhav

- Thunderstorm warning system using vector electric field mill, 15 December, 2004.

Smt. J.V. Revadekar

- Climate trends in daily weather extremes over India, 17 December, 2004.

Shri. K. Madhu Chandra Reddy

- Radar studies on atmospheric boundary layer and precipitation over a tropical station, 13 January, 2005.

Shri D. R. Kothawale

- Surface and Upper air temperature variability over India and its influence on the summer monsoon rainfall, 9 March, 2005.

Dr. (Smt.) N. A. Sontakke

- Indian monsoon in the changing global environment, 31 March, 2005.

By Research Fellows / Project Personnel

Shri A. K. Shrivastava

- MICROTOPS and LIDAR observations of aerosols over a remote sensing in India, 7 May, 2004.
- Diabatic heating rate derived from vertical velocity observed by Indian MST radar, 1 July, 2004.

Shri K. Jagadeesh

- Dendroclimatic analysis of Teak (Tectona grandis) from Bori, Madhya Pradesh, 7 May, 2004.

Shri P. S. Praveen

- Aerosol properties in different environments, 7 May, 2004.

Shri S. Gunthe

- ENVIS-node of IITM, acid rain and atmospheric pollutant modeling, 21 June, 2004.

Shri V. Prasanna

- Climate change projections for India and assessment of the associated agricultural and human health impacts, 21 June, 2004.

Shri R. K. Yadav

- Role of Indian Ocean sea surface temperature in modulating northwest Indian winter precipitation variability, 6 August, 2004.

Shri J. S. Chowdary

- Report on 2nd ENVISAT summer school, 20 October, 2004.

Kum. R. Bhawar

- Ground-based radiometric measurements of aerosols and pre-cursor gases over Pune and their comparison with TOMS and MODIS satellite data, 8 November, 2004.

Kum.C. Sukumaran

- Variation of advective fluxes of CO_2 and water vapour over Vasco-da-Gama, Goa during monsoon 2002, 13 January, 2005.

Shri U. K. Singh

- Role of orography and mesoscale atmospheric disturbances on rainfall over Indian region, 10 March, 2005.

By M.Sc. / M. Tech. Students

Kum. R. Deepa

- Role of air-sea interaction processes in the evolution of southeast Arabian Sea warm pool, 16 April, 2004.

Shri K. Mathur

- A study of winds and turbulence in the vicinity of tropopause using Indian MST radar, 17 May, 2004.

Shri S.S.S. Chauhan

- Study of aerosol size distribution over Pune, as retrieved from sky radiometer observations, 25 May, 2004.

Academic Activities

Guidance to Students for Research Projects

Dr. P. C. S. Devara

- Kum. S. Shirsat, M. Tech. (Atmospheric Physics), University of Pune, Pune.
- Shri M. Muhsin, M. Tech.(Atmospheric Science), Cochin University of Science and Technology, Kochi.

Dr. (Smt.) P. S. Salvekar

- Shri S. Taraphadar, M. Tech. (Atmospheric Physics), University of Pune, Pune.

Dr. R. Krishnan

- Shri S. Banerjee, M. Tech. (Atmospheric Science), Cochin University of Science and Technology, Kochi.

Shri P. Seetaramayya

- Shri P. Desai, M. Sc.(Physics), Nowrosjee Wadia College, Pune.

Smt S. S. Vaidya

- Kum. S. John, M.Tech (Atmopsheric Physics), University of Pune, Pune.

Dr. G. Beig

- Smt. S. S. Fadanvis, M. Tech.(Atmospheric Physics), University of Pune, Pune.

Dr. A. K. Sahai

- Shri R.Chattopadhyay, M. Tech.(Atmospheric Physics), University of Pune, Pune.

Dr. P. S. P. Rao

- Kum. C. Manimegalai, M.Phil. (Energy and Environment), Devi Ahilya Vishwavidhyalaya, Indore.
- Shri S. K. Mishra, M. Tech.(Atmospheric Physics), University of Pune, Pune.
- Shri A. K. Singh, M.Sc. (Space Science), University of Pune, Pune.

Dr. (Smt.) I. S. Joshi

- Shri V. P. Rao, M. Sc. (Space Physics), Andhra University, Visakhapatnam.
- Shri S. A. Kurkute, M.Sc. (Space Science), University of Pune, Pune.
- Kum. N.N. Jadhav, M.Sc. (Physics), Fergusson College, Pune.
- Kum. A.G. Landge, M.Sc. (Physics), University of Pune, Pune.

Dr. (Smt.) N. A. Sontakke

- Kum. P.T. Sumeja, M.Sc. (Physics), Nowrosjee Wadia College, Pune.

Dr. A. L. Londhe

- Kum. R. L. Sonone, B.Sc. (Physics), Sir Parshurambhau College, Pune.

Dr. A. A. Munot

- Shri Y. V. Kumkar, M. Sc. (Physics), Nowrosjee Wadia College, Pune.

Dr. H. P. Borgaonkar

- Shri A.B. Dhule, M. Sc. (Space Science), University of Pune, Pune.
- Shri K.R. Phulsundar, M. Sc. (Space Science), University of Pune, Pune.
- Shri N.D. Sabale, M. Sc. (Space Science), University of Pune, Pune.

Dr. Y. Jaya Rao

- Kum. R. Datta, M. Tech.(Atmospheric Physics), University of Pune, Pune.

Shri S. D. Pawar

- Kum. S. J. Wakchaure, M. Sc.(Physics), Nowrosjee Wadia College, Pune.
- Kum. J. R. Pawar, M. Sc.(Physics), Nowrosjee Wadia College, Pune.

Dr. (Smt.) S. B. Morwal

- Kum. S. A. Kumbhar, M. Sc. (Space Science), University of Pune, Pune.

Shri S. S. Dugam

- Kum. Y. B. Dumbre, M. Sc.(Physics), Nowrosjee Wadia College, Pune.
- Kum. M. V. Gawande, M.Sc.(Physics), Nowrosjee Wadia College, Pune.

Shri V. Gopalakrishnan

- Kum. A. Nitave, B.E., D.Y. Patil College of Engineering and Technology, Pune.
- Kum. D. Mane, B.E., D.Y. Patil College of Engineering and Technology, Pune.
- Kum. P. Rane, B.E., D.Y. Patil College of Engineering and Technology, Pune.

Dr. C. Gnanaseelan

- Kum. A. De, M. Tech.(Atmospheric Physics), University of Pune, Pune.

Dr. S. B. Debaje

- Kum. N. A. Chavan, M. Sc.(Physics), Nowrosjee Wadia College, Pune.
- Kum. V. Vaishnavi, M. Sc.(Physics), Abasaheb Garware College, Pune.
- Kum. S. R. Gholap, M. Sc.(Physics), Abasaheb Garware College, Pune.
- Kum. M. S. Kobule, M. Sc.(Physics), Abasaheb Garware College, Pune.
- Shri H. L. Mohol, M. Sc.(Physics), Abasaheb Garware College, Pune.

Shri S. Mahapatra

- Shri Rahul Hiwale, M.Sc. (Space Science), University of Pune, Pune.
- Kum.P.Pandey, M.Sc.(Tech.), Banaras Hindu University, Varanasi.

Smt. R. Latha

- Kum. T. Bhatia, B.E., Vishwakarma Institute of Technology, Pune.
- Kum. S. Raina, B.E., Vishwakarma Institute of Technology, Pune.
- Shri V. A. Deshpande, B.E., Vishwakarma Institute of Technology, Pune.

Dr. P. D. Safai

- Shri S. Kewat, M.Phil. (Energy and Environment), Devi Ahilya Vishwavidhyalaya, Indore.

Smt. B. Padma Kumari

- Kum. S. D. Shirasker, B.Sc. (Physics), Sir Parshurambhau College, Pune.

Shri P. Mukhopadhyay

- Kum. P. Pandey, M.Sc.(Tech.), Banaras Hindu University, Varanasi.

Smt. R. Bhalawankar

- Kum. R. Dixit, M. Sc.(Physics), Abasaheb Garware College, Pune.
- Shri A. Lale, M. Sc.(Physics), Abasaheb Garware College, Pune.

Dr. (Smt.) R.R. Joshi

- Shri M. Das, M. Sc.(Physics), University of Hyderabad, Hyderabad.
- Shri Pramod Kumar, M. Sc.(Physics), University of Hyderabad, Hyderabad.

Expertise Provided

Dr. P.C.S. Devara and Shri J. R. Kulkarni

- Advance Refresher Course on Environmental Meteorology, India Meteorological Department, Pune, April - May, 2004.

Dr. P.C.S. Devara, Shri B. N. Mandal, Dr.H.P.Borgaonkar and Smt.S.K.Patwardhan

- Met. Gr.II Training Course, Batch No. 17, India Meteorological Department, Pune, May - June, 2004.

Dr. P. C. S. Devara, Shri J. R. Kulkarni, Shri M. C. Reddy, Shri P. Mukhopadhyay, Dr. (Smt.) R. R. Joshi

- First WP / RASS Training / Workshop on Meteorology and Atmospheric Science, Indian Institute of Tropical Meteorology, Pune, 7 - 11 March, 2005.

Dr. K. Rupa Kumar, Smt. N. R. Deshpande, Smt. J. V. Revadekar

- WMO/GCOS Workshop on Enhancing South and Central Asian Climate Change Monitoring and Indices, Indian Institute of Tropical Meteorology, Pune, 14 -19 February, 2005.

Dr. N. Singh

- Training course on Application of RS-GIS in Water Sector, National Water Academy, Pune, 1 February, 2005.

Dr. R. Krishnan, Shri J. R. Kulkarni, Dr. A. K. Sahai, Shri M. K. Tandon, Shri. M. Y. Totagi, Shri A. Bandyopadhyay, Dr. C. Gnanaseelan, Dr. (Smt.) A. A. Kulkarni, Shri S. Mahapatra, Smt. S. K. Mandke, Dr. M. Mujumdar, Smt. S. S. Fadnavis, Smt. S. U. Athale and Smt. V. V. Sapre

- Short Training Course on Computational Methods for IITM Research Fellows / Associates / Personnel, Indian Institute of Tropical Meteorology, Pune, 14 October - 4 November, 2004.

Dr. R. H. Kripalani

- UN-Affiliated course on Satellite Meteorology and Global Climate, Space Application Center, Ahmedabad, 23 - 27 August, 2004.

Dr. A. K. Sahai

- Training Course on Artificial Neural Networks to students of K. Banerjee Centre of Atmosphere and Ocean Studies, University of Allahabad, Indian Institute of Tropical Meteorology, Pune, 1-9 June, 2004.
- Practical Training on Artificial Neural Network, K. Banerjee Centre of Atmospheric and Ocean Studies, Allahabad, 8 -19 December, 2004.

Shri B. N. Mandal, Dr. H.P. Borgaonkar, Smt. S.K. Patawardhan

- Met. Gr.II Training Course Batch No. 118 and 119, India Meteorological Department, Pune, January, 2005.

Dr. A. L. Londhe, Shri S. S. Dugam

- Refresher Course for the Lecturers of Physics, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, 19 - 20 March, 2005.

Shri J. Sanjay

- Advanced Training School on Tropical Cyclones, Department of Meteorology and Oceanography, Andhra University, Visakhapatnam, 29 November, - 24 December, 2004.

Dr. M. Mujumdar

- Training Workshop on Systems Approach for Climatic Risk Management, Department of Agricultural Meteorology, Tamil Nadu Agricultural University, Coimbatore, 30 August - 8 September, 2004.

Lectures Delivered Outside

Dr. G. B. Pant

- Global and regional climate change, G.B. Pant Institute of Himalayan Environment, Almora, 5 May, 2004.
- Wind and wind energy, Vasundhara Trust sponsored programme on Children's Science Movement, Indian Institute of Tropical Meteorology, Pune, 28 January, 2005.

Dr. A. K. Kamra

- Salient features of lightning flashes and lightning protection for floating roof tanks, Indian Oil Corporation, New Delhi, 10 September, 2004.
- Contemporary chaos in the cloud seeding practices for the rain enhancement efforts, S.V. University, Tirupati, 20 September, 2004.
- Technology in lightning research, Automotive Research Association of India, Pune, 11 May, 2004.

Dr. P.C.S. Devara

- Lidar sounding of aerosols and pre-cursor gases at Pune, a tropical urban station in India, Institute of Electronics, Bulgarian Academy of Sciences, Sofia, Bulgaria, 20 October, 2004.

Dr. K. Rupa Kumar

- Monsoon variability implication on drought, College of Agriculture, Pune, 23 March, 2005.

Dr. S. Sivaramakrishnan

- Some aspects of wind profiles in the atmospheric boundary layer over coastal and inland stations, Centre for Wind Energy Technology, Chennai, 25 August, 2004.

Dr. N. Singh

- Utility of satellite remote sensing for better monitoring of monsoon system over the Indian regions, National Water Academy, Pune, 14 October, 2004 and 1 February, 2005.
- GIS supported spatial analysis of rainfall variations over India –an assessment of role of meteorological factors caused river channel changes over the Great Indo-Gangetic plains from mythology to modern, Indian Institute of Remote Sensing, Dehradun, 22 July, 2004.

Dr. R. Krishnan

- Mixed layer and thermohaline interactions associated with the monsoonal flow over the Arabian Sea, International Pacific Research Centre, Hawaii, Honolulu, U.S.A., 30 June, 2004.
- Extended range monsoon prediction (ERMP) - models and diagnostics, Space Applications Centre, Ahmedabad, 16 October, 2004.

Dr. R. H. Kripalani

- Monsoon variability during 2002 and 2003: role of intra-seasonal oscillations, Space Application Centre, Ahmedabad, 24 August, 2004.

Dr. G. Beig

- Global change signals in the middle atmosphere, Institute for Chemistry and Dynamics of the Geosphere I (ICG-I), Research Center Jülich, Germany, 2 July, 2004.
- Global change signals in the mesospheric temperature: model versus observations, Max Plank Institute of Meteorology, Hamburg, Germany, 21 July, 2004.
- Greenhouse cooling of the atmosphere, Indian Meteorological Society, Pune Chapter (IMS-P), Pune, 2 November, 2004.

Dr. C. Gnanaseelan

- Interannual variability in the surface and subsurface temperature over the tropical Indian Ocean, National Institute of Oceanography, Goa, 11 May, 2004.
- Response of Arabian Sea to two contrasting monsoons 2002 and 2003, Indian Institute of Science, Bangalore, 14 May, 2004.

Training Undergone

Shri D. M. Chate and Shri S. Saha

- Advance Refresher Course on Environmental Meteorology, India Meteorological Department, Pune, 17 - 21 May, 2004.

Shri S. Bhandare

- Introduction to Geographic Information System (GIS) and its Application, National Remote Sensing Agency, Hyderabad, 24 May - 18 June, 2004.

Dr. C. Gnanaseelan and Dr. G. Pandithurai

- Foundation Training Programme for Scientists and Technologists sponsored by Department of Science and Technology conducted by Indian Institute of Public Administration, New Delhi, 5 July - 24 September, 2004.

Smt. S. U. Athale

- Training Course on Linux System Administration, Centre for Development of Advanced Computing, (C-DAC), Pune, 9 -13 August, 2004.

Shri S. Sonbawne, Dr. Devendraa Siingh and Shri V. Pant

- Pre-Antarctica Training: Ice Acclimatization and Medical Examination, New Delhi and Auli, 1 - 22 September, 2004.

Smt. S. R. Inamdar

- Advanced Meteorological Training, India Meteorological Department, Pune, October, 2004 - September, 2005.

Shri S. P. Gharge and Shri B. Thompson

- Intensive Training cum Workshop on Large Scale Ocean Modelling, Centre for Mathematical Modelling and Computer Simulation, Bangalore, 4 -14 October, 2004.

Smt. V. V. Sapre

- Advanced Diploma in Web Multimedia, Keerti Computers, Pune 1 November, 2004 - 31 January, 2005.

Smt. M. S. Deshpande and Kum. K. Kamala

- Advanced Training School on Tropical Cyclones, Andhra University, Visakhapatnam, 29 November - 24 December, 2004.

Shri J. S. Chowdary, Kum. K. Kamala, Kum. P. Bhaskar and Shri R. K. Yadav

- Short Course on Fluid Dynamics, Remote Sensing, Atmosphere and Ocean Modelling, University of Hyderabad, Hyderabad, 7-12 February, 2005.

Shri H. N. Singh

- Four Week Course on Introduction to GIS and its Application, National Remote Sensing Agency, Hyderabad, 14 February – 12 March, 2005.

Membership of Scientific Committees

Dr. A. K. Kamra

- Physical Sciences Research Committee of the Council of Scientific and Industrial Research.
- Scientific Team for Coherent Radar Imaging (CRI)/Spatial Domain Interferometry (SDI) Project of National MST Radar Facility.
- Multi-disciplinary Committee for Engineering and Applied Sciences (M2) of Indian National Science Association (INSA) for 2005-2007.
- Sectional Committee-V of INSA 2005 -2008.

Dr. K. Rupa Kumar

- Intergovernmental Panel on Climate Change (IPCC) Working Group-I.
- Lead Author, IPCC Working Group-I Fourth Assessment Report (WGI – AR4) for Chapter 11 on Regional Climate Projections.
- Co-Chair, CLIVAR Asian Australian Monsoon Panel (International Panel of Monsoon Experts).

Dr. (Smt.) P. S. Salvekar

- Committee for Women Scientists (WOS) A., Department of Science and Technology.

Ph.D. and Post-Graduate Programme

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

Shri D. R. Kothawale

- Surface and upper air temperature variability over India and its influence on the summer monsoon rainfall

  (Guide : Dr. K. Rupa Kumar)

Shri P. R. C. Reddy

- Role of satellite data in understanding the circulation and the SST field over the Indian seas

  (Guide : Dr. (Smt.) P.S. Salvekar)

Award of M.Tech. (Atmospheric Physics) by the University of Pune, Pune

Smt. S. S. Fadanvis

- Study on middle atmospheric long term temperature and ozone trends

  (Guide : Dr. G. Beig)

Award of M.Tech. by the Andhra University, Visakhapatnam

Shri H. N. Singh

- Investigations into relationship between wet/dry conditions over India and space-based OLR observation over global tropics

  (Guides : Dr. N. Singh, IITM and Dr. C. M. Kishtawal, Space Applications Centre, Ahmedabad)

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

Shri P. Mukhopadhyay

- Prediction of thunderstorms and heavy precipitation events over Indian region

  (Guide : Dr. S.S. Singh)

Shri. K. V. Ramesh

- Numerical modelling of air-sea interactions in the Indo-Pacific region

  (Guide: Dr. R. Krishnan)

Smt. B. Padmakumari

- Study of stratospheric aerosols by passive remote sensing technique

  (Guide: Dr. D. B. Jadhav)

Shri G. S. Meena

- Study of atmospheric constituents by visible spectroscopy (Guide: Dr. D.B. Jadhav)

Recognition as Research Guide

- Dr. S. Sivaramakrishnan, Dr. P. S. P. Rao, Dr. K. Krishna Kumar Dr. A. L. Londhe and Dr. Y. Jaya Rao have been recognized as guides for Ph.D. and Post-Graduate degrees in Space Science by the University of Pune, Pune.

Teaching and Research Support to Universities

Lectures delivered for M.Sc./M.Tech. Students.

Dr. P. C. S. Devara

- Modern observational techniques, M. Tech. (Atmospheric Physics), University of Pune, Pune
- Lidars and their application to environmental pollution, M.Tech. (Lasers and Electro-optics), Institute of Armament Technology, Pune

Dr. K. Rupa Kumar

- Climate modelling, M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. (Smt.) P. S. Salvekar

- Advanced dynamic meteorology, M. Tech. (Atmospheric Physics), University of Pune, Pune
- Monsoon meteorology, M. Tech. (Atmospheric Physics), University of Pune, Pune

Shri J. R. Kulkarni

- Fluid mechanics, M. Tech. (Atmospheric Physics), University of Pune, Pune
- Advanced dynamic meteorology, M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. P. N. Mahajan

- Satellite meteorology, M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. G. Beig

- Atmospheric chemistry, M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. (Smt.) I. S. Joshi

- Association between southern ionospheric disturbances and tropospheric temperatures, M. Tech. (Space Physics), Andhra University, Visakhapatnam

Shri Prem Singh

- Numerical methods, M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. (Smt.) A. A. Kulkarni

- Statistical theory, M. Tech. (Atmospheric Physics), University of Pune, Pune

Shri S. Mahapatra

- Spectral methods and spectral models, M. Tech. (Atmospheric Physics), University of Pune, Pune

Smt. A. A. Deo

- Physical and dynamic oceanography, M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. K. Ali

- Aerosol and air pollution, M. Tech. (Atmospheric Physics), University of Pune, Pune

Smt. S. Nair

- Objective analysis, M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. Devendraa Siingh

- Mathematical methods, M. Tech. (Atmospheric Physics), University of Pune, Pune

Nominations as External Examiner / Paper Setter

Dr. G. B. Pant

- Ph.D., Indian Institute of Technology, New Delhi

Dr. A. K. Kamra

- Ph.D.(Physics), Mohanlal Sukhadia University, Udaipur

Dr. P. C. S. Devara

- M. Tech. (Atmospheric Physics), University of Pune, Pune
- M. Tech.(Lasers and Electro-Optics), Institute of Armament Technology, Pune

Dr. (Smt.) P. S. Salvekar

- M. Tech.(Atmospheric Physics), University of Pune, Pune

Dr. S. Sivaramakrishnan

- M.Sc. / M.Tech. (Atmospheric Boundary Layer), Cochin University of Science and Technology, Kochi

Shri J. R. Kulkarni

- M. Sc. (Space Science), University of Pune, Pune
- M. Tech. (Atmospheric Physics), University of Pune, Pune
- M.Tech. (Modelling and Simulation), Institute of Armament Technology, Pune

Dr. P. E. Raj

- M. Sc. (Space Science), University of Pune, Pune

Dr. G. Beig

- M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. P.S.P. Rao

- M. Sc. (Space Science), University of Pune, Pune
- M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. (Smt.) I. S. Joshi

- M. Sc. (Space Science), University of Pune, Pune

Dr. S. K. Sinha

- Ph.D. (Science), Jadavpur University, Kolkata

Dr. G. Pandithurai

- M. Sc. (Space Science), University of Pune, Pune

Dr. Y. Jaya Rao

- M. Sc. (Space Science), University of Pune, Pune

Deputation Abroad

Dr. G.B. Pant

- Participation in the Scoping Meeting of the IPCC's 4th Assessment Report, World Meteorological Organisation, Geneva, **Switzerland**
  (4 -11 July, 2004)
- Participation in the 26th Session of the Joint Scientific Committee (JSC) Meeting of the World Climate Research Programme (WCRP), Guayaquil, **Ecuador**
  (11 - 18 March, 2005)

Dr. P.C.S. Devara

- Participation in the 22nd International Laser Radar Conference (ILRC XXII), Matera and 14th International Conference on Clouds and Precipitation (ICCP), Bologna, **Italy**
  (11 - 26 July, 2004)
- Collaborative research work under the Indo-Bulgarian Cooperative Research Program on the joint project entitled 'Optical Remote Sensing Studies of the Atmospheric Boundary Layer Characteristics using Laser Radar', Laser Research Laboratory, Institute of Electronics, Bulgarian Academy of Sciences, Sofia, **Bulgaria**
  (2 - 24 October, 2004)

Dr. K. Rupa Kumar

- Participation in the PRECIS Training Workshop organized by Hadley Centre for Climate Prediction and Research, Thimpu, **Bhutan**
  (18 - 26 July, 2004)
- Participation in the IPCC Working Group-I Fourth Assessment Report First Lead Author Meeting, Trieste, **Italy**
  (24 September - 1 October, 2004)
- Participation in the UNFCCC/SBSTA Workshop on Climate Change Impacts, Vulnerability and Adaptation, Buenous Aires, **Argentina**
  (6 -11 December, 2004)
- Participation in the IPCC Model Analysis Workshop and IPCC Working Group 1 AR4 Chapter 11 Lead Authors' Meeting, Honolulu, Hawaii, **U.S.A.**
  (26 February - 8 March, 2005)

Dr. R. Vijayakumar

- Visit, on invitation by the Department of Scientific Cooperation, to Main Geophysical Observatory and Vaiikov Research Institute, St. Petersburg, ROSHYDROMET, Moscow, **Russia**
  (29 July - 11 August, 2004)

Dr. R. Krishnan

- Participation in the CLIVAR Workshop on Ocean Model Development, Geophysical Fluid Dynamics Laboratory, Princeton, 16-18 June, 2004 and First International CLIVAR Science Conference on Understanding and Predicting our Climate System, Baltimore, 21-25 June, 2004. Also visit to Center for Ocean Land Atmosphere Studies, Maryland and International Pacific Research Center, Honolulu, Hawaii, **U.S.A.**
  (14 June - 4 July, 2004)
- Participation in the Indian Ocean Modeling Workshop, Internatiponal Pacific Research Center, University of Hawaii, Honolulu, Hawaii, **U.S.A.**
  (28 November - 8 December, 2004)
- Participation in the Indian Ocean Marine Environment Conference, Perth, **Australia**
  (12 - 20 February, 2005)

Dr. P.N. Mahajan

- Participation in the 7th International Winds Workshop, Helsinki, **Finland**
  (14 - 17 June, 2004)

Dr. G. Beig

- Guest Scientist, Max-Plank Institute for Meteorology, Hamburg, **Germany**
  (2 May - 31 July, 2004)
- Participation in Quadrennial Ozone Symposium, Kos, **Greece**
  (1 - 8 June, 2004)
- 3rd International Workshop on Long Term Changes and Trends in the Atmosphere, Sozopol, **Bulgaria**
  (10 - 14 June, 2004)

Shri D.R. Chakraborty

- Participation in the 3rd International Workshop on Monsoons (IWM-III) as a Member of International Organising Committee , Hangzhou, **China**
  (31 October - 8 November, 2004)

Shri G.A. Momin

- In connection with the on-going Indo-Swedish Collaborative Project, Stockholm University, Stockholm, **Sweden**
  (31 August -14 September, 2004

Dr. H.P. Borgaonkar

- Participation in the International Meeting on Tree-Ring and Climate: Sharpening the Focus, University of Arizona, Tucson, **U.S.A.**
  (6 -9 April, 2004).

Dr. C. Gnanaseelan

- Participation in the Global Ocean Data Assimilation Experiment (GODAE) International Summer School, La Londe-Les Maures, **France**
  (18 September - 3 October, 2004)
- Participation in the Indian Ocean Modeling Workshop and visit to the International Pacific Research Centre (IPRC), University of Hawaii, Honolulu, Hawaii, **U.S.A.**
  (27 November - 9 December, 2004)

Smt. S.K. Mandke

- Participation in the Workshop on Climate Variability in 20th Century, Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy**
  (18 April – 2 May, 2004)

Dr. Y. Jaya Rao

- Participation in the 3rd SPARC General Assembly, Victoria, British Columbia, **Canada**
  (30 July - 8 August, 2004)
- Participation in the Workshop on Cirrus Clouds and Their Supersaturated Environment, Institute of Physics, German Space Operations Centre, Oberpfaffenhofen, **Germany**
  (9 - 15 October, 2004)
- Visiting Scientist to work with Prof. J.B. Nee, Department of Physics, National Central University, Chung-Li, **Taiwan**
  (24 October - 29 December, 2004)

Dr. C.G. Deshpande

- To work under the Post-Doctoral Fellowship, Institute of Environmental Engineering, National Chiao Tung University, **Taiwan**
  (2 August, 2004 - 29 July, 2005)

Shri S.M. Sonbawne, Dr. Devendraa Siingh and Shri V. Pant

- Participation in the 24th Indian Scientific Expedition to Antarctica, **Antarctica**
  (5 December, 2004 – 27 March, 2005)

Dr. P. R. C. Reddy

- Participation in the Indian Ocean Modeling Workshop and visit to the International Pacific Research Centre (IPRC), University of Hawaii Honolulu, Hawaii, **U.S.A.**
  (28 November - 17 December, 2004)

Shri J. S. Chowdary

- Participation in the International 2nd ESA Summer School on Earth System Monitoring and Modelling, ESA-ESRIN, (Frascati), Rome, **Italy**
  (14 – 28 August, 2004)

Visitors

International

Dr. Prakki Satyamurty
National Institute of Educational Studies and Research
Climatic Centre for Forecast of Time and Studies
Brazil
12-17 June, 2004

Dr. (Ms) Sushma Prasad
Climate Dynamics and Sediments Group
Geoforschungs Zentrum
Germany
29 June - 2 July, 2004

Prof. A. H. Siddiqi
Department of Mathematical Sciences
King Fahd University of Petroleum and Minerals
Saudi Arabia
9 -11 August, 2004

Dr. S. Someshwar
University of Columbia
U.S.A.
12 August, 2004

Dr. Brendon M. Buckley
Dr. William Wright and
Mr. Benjamin P. Cook
Lamont-Doherty Earth Observatory
U.S.A.
24-28 October, 2004

Dr. Andrew Roberston
International Research Institute for Climate Prediction
U.S.A.
18 November, 2004

Mr. M. Saho
Chief, Fellowship Division
Education and Training Department
World Meteorological Organisation
Switzerland
25 January, 2005

Dr. Vasubandhu Mishra
Centre for Ocean Land Atmosphere Studies
U.S.A.
1 February, 2005

Dr. David Griggs
Hadley Centre for Climate Prediction and Research
U.K.
8-9 February, 2005

Dr. Thomas C. Peterson
Climate Analysis Branch
National Climate Data Centre
U.S.A.
17 February, 2005

Dr. Philp D. Jones
Climate Research Unit
University of East Anglia
U.K.
18 February, 2005

Dr. S.T. Rao
Atmospheric Sciences Modeling Division
National Oceanic and
Atmospheric Administration (NOAA)
U.S.A.
17 March, 2005

National

Naval Met. Observers (I Class) Sailors
School of Naval Oceanology and Meteorology
INS Garuda
Kochi
7 April, 2004

Dr. M.B. Potdar
Scientist SG and
Kum. R. Rege
Space Applications Centre
Ahmedabad
29 April - 1 May, 2004

Dr. Kolawale
Chief Engineer
Hydrology Project
Government of Maharashtra
Nasik
20 May, 2004
Participants of the Advance Refresher Course on Environmental Meteorology
India Meteorological Department
Pune
20 May, 2004
Senior Naval Met. Officers
Advanced Refresher Course
India Meteorological Department
Pune
25 May, 2004

Shri S.M. Khare
Deputy General Manager
National Thermal Power Corporation
Noida
4 June, 2004

Dr. M. Rajendran
Senior Lecturer
Annamalai University
Annamalainagar
14-18 June, 2004

Dr. Vyas Pandey
Professor
Anand Agricultural University
Anand
23-25 June, 2004

Dr. (Smt.) Pammy Manchanda
Department of Mathematics
Guru Nanak Dev University
Amritsar
9-11 August, 2004

Dr. Ashok Kaushal
Dr. Sandeep Srivastava and
Dr. Manoj Khare
Centre for Developing Advanced Computing (C-DAC)
Pune
26 August, 2004 and
6 December, 2004

Shri Rajeev Baboota
Sr. Manager (Hydrology) and
Shri S.D. Shukla
Engineer (Civil)
National Hydroelectric Power Corporation
Faridabad
30 - 31 August, 2004

Dr. M.I. Bhat
Department of Geology and Geophysics
University of Kashmir
Srinagar
10 September, 2004

Postgraduate Doctors (M.D.)
Department of Preventive and Social Medicine
B.J. Medical College
Pune
10 November, 2004

Dr. J.P. Dudeja, **Dr. K.K. Sharma** and
Dr. P. Raghu
Senior Scientists, Laser Science and Technology Centre
Defence Research and Development Organisation
New Delhi
6-8 December, 2004

Dr. P. Pant, Shri A. Tavore
T.S. Kumar and **T. Bangia**
Aryabhatta Research Institute of Observational Sciences
Nainital
19 - 23 December, 2004

Trainees of Agricultural Meteorology for Teaching Graduate Courses
College of Agriculture
Pune
21 December, 2004

Participants of the International Conference on Instrumentation (INCON 2004)
Pune Institute of Engineering and Technology
Pune
21 December, 2004

Trainees of the Training Programme for Non-Technical Staff of the Department of Science & Technology
Indian Institute of Public Administration
New Delhi
6 January, 2005

Dr. Ved Prakash Sandlas
Distinguished Scientist,
Chief Controller, Research and Development, Defence Research and Development Organisation (DRDO), Govt. of India
13 January, 2005

M.Sc. (Tech) Students and Teachers
Banaras Hindu University
Varanasi
17 and 18 January, 2005

M.Sc. Students and Teachers
University of Kashmir
Srinagar
2 February, 2005

Dr. A.K. Gosain
Professor
Department of Civil Engineering
Indian Institute of Technology
New Delhi
4 February, 2005

Trainees of the 40th Junior Forecasters' Course
Air Force Administrative College
Coimbatore
7 March, 2005

Dr. S.V. M. Satyanarayan
Scientist
Indira Gandhi Centre for Atomic Research
Kalpakkam
22 - 24 March, 2005

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	kamra@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. V. Satyan	Climate Modelling	satyan@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. S. Sivaramakrishnan	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 P. Seetaramayya	Oceanography	seetar@tropmet.res.in	M.Sc. (Tech.)
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.
Smt. S.S. Vaidya	Numerical Weather Prediction with Special Emphasis on the Physical Processes	ssvady@tropmet.res.in	M.Sc.

Name	Specialisation	E-mail Address	Academic Qualifications
Dr. R. H. Kripalani	Asian Monsoon and Climate Variability	krip@tropmet.res.in	M.Sc., Ph.D.
Dr. L.S. Hingane	Climate Change Studies	hingane@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. 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.
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.
Dr. S.K. Sinha	Objective Analysis including Satellite Input for NWP	sinha@tropmet.res.in	M.Sc., Ph.D. Ph.D.
Smt. U.V. Bhide	Studies on Monsoon and Tropical Weather System	bhide@tropmet.res.in	M.Sc.
Shri C.M. Mohile	Climate Change, Frequency of Tropical Cyclones, Climate Database Mgmt.	mohile@tropmet.res.in	M.Sc.
Dr. (Kum.) P.L. Kulkarni	Objective Analysis including Satellite Input for NWP	plk@tropmet.res.in	M.Sc., Ph.D.
Shri M.Y. Totagi	Monsoon Energetics	frdmail@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.
Shri D.R. Chakraborty	Atmospheric Energetics in the Wavenumber and Frequency Domain	drc@tropmet.res.in	M.Sc.
Shri A. Bandyopadhyay	NWP Modelling and Model Diagnostics	bandop@tropmet.res.in	M.Sc., DIIT

Name	Specialisation	E-mail Address	Academic Qualifications
Dr. A.L. Londhe	Monitoring of Atmospheric Constituents, Twilight Spectroscopy	londhe@tropmet.res.in	M.Sc., Ph.D.
Shri. C.S. Bhosale	Monitoring of Atmospheric Constituents, Twilight Spectroscopy	bhosale@tropmet.res.in	M.Sc.
Dr. (Smt.) S.S. Kandalgaonkar	Thunderstorm Climatology and Related Meteorological Parameters	sskandal@tropmet.res.in	M.Sc., Ph.D.
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.
Dr. H.P. Borgaonkar	Long-term Climate Variability over Monsoon Asia, Dendroclimatology, Palaeoclimatology	hemant@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.S. Mulye	Hydrometeorological Studies for Different River Basins and Regions	mulye@tropmet.res.in	B.Sc.
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.
Smt. A.A. Kulkarni	Monsoon Studies and Forecasting	aakulkarni@tropmet.res.in	M.Sc.
Shri R.M. Khaladkar	Satellite Meteorology, Weather	khaldkr@tropmet.res.in	M.Sc., M.Tech.,PGD
Smt. S.S. Desai	Forecasting Atmospheric Dynamics, Global Spectral Energetics	ssd@tropmet.res.in	M.Sc.
Shri V.R. Mujumdar	Indian Monsoon	vrmujumdar@hotmail.com	B.Sc.
Shri P.V. Puranik	Studies of Monsoons and Tropical Weather Systems	monsoon@tropmet.res.in	B.Sc.
Dr. S.M. Bawiskar	Studies of Monsoons and Tropical Weather Systems	monsoon@tropmet. res.in	M.Sc., Ph.D.
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 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.

Name	Specialisation	E-mail Address	Academic Qualifications
Dr. K. Ali	Cloud Physics and Radar Meteorology, Air Pollution Studies	kaushar@tropmet.res.in	M.Sc. (Tech.), Ph.D.
Dr. D. R. Kothawale	Climate Change, Monsoon Variability and Prediction	kotha@tropmet.res.in	M.Sc., Ph.D.
Shri S.D. Patil	Climate and Climatic Change, Ozone Variability	patilsd@tropmet.res.in	M.Sc.
Smt. M.K. Kulkarni	Atmospheric Electricity	mkk@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.
Shri M.Mahakur	Applications of Satellite Data in Weather Forecasting	mmahakur@tropkmet.res.in	M.Sc.,
Smt. M.N. Kulkarni	Atmospheric Electricity	mnkulk@tropmet.res.in	M.Sc.
Smt. Padma Kumari	Atmospheric Minor Constituents	padma@tropmet.res.in	M. Sc., M. Tech.
Shri 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.
Shri P. Mukhopadhyay	NWP and Meso-scale Modelling of Thunderstorms, Heavy Precipitation Events	mpartha@tropmet.res.in	M.Sc.

Name	Specialisation	E-mail Address	Academic Qualifications
Smt.J.V. Revdekar	Extreme Weather Events, Climate Change, Monsoon Variability	jvrch@tropmet.res.in	B.Sc., 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.
Smt.S.S.Nandargi	Hydrometeorological Studies for Different River Basins and Regions	nshobha@tropmet.res.in	M.Sc., Ph.D.
Shri K.M.C.Reddy	Remote Sensing of Atmospheric Aerosols and Trace Gases	madhucomcom@rediff. com	M. Sc.
Shri D.M. Lal	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. (Smt.) B.P. Shukla	Regional Climate Modelling, Climate Change Studies	bipasha@tropmet.res.in	M.Sc., Ph.D.

Managerial and Technical Support

Administration, Finance and Purchase & Stores

Shri V.K. Asrani, Administrative Officer
Ms. N.S. Girija, Accounts Officer
Shri A. Girijavallabhan, P.A. to Director
Shri S.R. Nirgude
Shri V.G. Bathija
Shri V.S. Kulkarni
Shri V.R. Mali
Shri S.N. Prasad
Shri M.H. Gangawane
Shri K.B. Gophane

Computer and Data Archival

Smt. S.U. Athale, Head of the Division
Shri S.P. Gharge (Climate and Global Modelling)
Shri O. Abraham
Smt. A.R. Sheshagiri
Dr. (Smt.) R.R. Joshi
Smt. V.V. Sapre
Shri P.W. Dixit (Purchase & Stores)

Library, Information and Publications

Smt. A.A. Shiralkar, Head of the Division
Smt. V.V. Massey
Shri P.G. Bhegade (Forecasting Research)
Shri A.L. Sagar (Physical Meteorology and Aerology)
Shri R.P. Mali
Shri B.C. Morwal (Administration)
Shri T.A. Disale
Shri A. Bhisikar
Shri S.C. Rahalkar
Shri V.V. Deodhar
Shri V.H. Sasane

Workshop

Shri S.B. Jaunjale

Research Fellows and Project Personnel

Name	Project (Funding Agency)
IITM Research Fellows	
Kum. Suchitra Sundaram	Diagnostics and Modelling Studies of Long Term Trends and Variability of Climate over the Indian-Asia Pacific Regions.
Kum. Rohini Bhawar	Aerosol Characterisation using Satellite and in situ measurements.
Shri Vimalesh Pant	Surface Observations of Atmospheric Electricity and Electric Properties of Clouds.
Kum. Cini Sukumaran	Experimental Study of Exchange Processes in the Atmospheric Boundary Layer over Continental and Marine Environment.
Shri B.H. Vaid	Numerical Modelling of the Upper Ocean Mixed Layer over Indian Ocean Region using Satellite Data.
Shri Santosh Kulkarni	Measurements and Monitoring of Atmospheric Minor Constituents.
Shri K. Jagdeesh	Regional Aspects of Global Climate Change and Variability.
Smt. Medha S. Deshpande	Studies on Dynamical Ocean Modelling.
Shri P. Ramesh Kumar	Surface Observations of Atmospheric Electricity and Electric Properties of Clouds.
Shri Vikas Singh	Atmospheric Chemistry Modelling and Dynamics.
Smt. Ashwini A. Ranade	Air Pollution and Precipitation Chemistry.
Kum. K. Kamala	Regional Aspects of Global Climate Change and Variability.
Shri Sachin S. Bhandare	Hydrometeorological Studies of River Basins for Applications in Water and Power Resource Projects.
Shri P. Siva Praveen	Studies in Air Pollution and Precipitation Chemistry.
Shri Umesh Kumar Singh	Changes in Rainfall Pattern and Hydrologic Regimes over India and their Relationship to Global Warming.
Shri Pawan Kumar Rathore	Optical Monitoring of Atmospheric Constituents.
IITM Research Associates	
Dr. P. Rahul Chand Reddy	Studies on Dynamical Ocean Modelling.
Dr. R.S. Maheskumar	Observational Study of Direct Radiative Forcing of Atmospheric Aerosols on the Surface Reaching Solar Flux.
CSIR Research Fellows	
Shri Bijoy Thompson	Numerical Modelling of North Indian Ocean using a Multi-level Ocean General Circulation Model (Council for Scientific and Industrial Research).
Kum. R. Deepa	Study of Evolution of Arabian Sea Warm Pool and Onset Vortex in Relation With Onset of South West Monsoon(Council for Scientific and Industrial Research).
Kum. Susmita Joseph	Monsoon Study using General Circulation Models (Council for Scientific and Industrial Research).
Project Personnel	
Shri S.H. Damale (Consultant)	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).
Major Gen. S. S. Sharma (Consultant)	Preparation of Generalised PMP Atlases over the Krishna and the Indus River Basins (Central Water Commission).
Shri Jasti Sriranga Chowdary	Data Assimilative Sigma Coordinate Numerical Model for the North Indian Ocean (DOD / INDOMOD 10th plan programme) (Department of Ocean Development, Govt. of India).

Name	Project (Funding Agency)
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).
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).
Smt.Amita A. Prabhu	Monsoon variability Studies with Regional Climate Models. (RCM) using Satellite Derived Surface Parameters: Validation and Application (Indian Space Research Organisation (ISRO), Government of India).
Shri Ashok Kumar Verma	Preparation of Generalized PMP Atlases over the Krishna and the Indus River Basins (Central Water Commission, New Delhi).
Shri Dhawal P. Prajapati	Preparation of Generalized PMP Atlases over the Krishna and the Indus River Basins (Central Water Commission, New Delhi).
Shri Vinaykumar	Air-Sea Interactions in the Indian Ocean Region (DOD/ INDOMOD 10th Plan Programme, Department of Ocean Development, Govt. of India).
Shri Rajib Chattopadhyay	Air-sea interactions in the Indian Ocean region, (DOD /INDOMOD 10th Plan Programme Department of Ocean Development, Govt. of India).
Shri Basant Kumar Samala	Air-Sea Interactions in the Indian Ocean Region (DOD/ INDOMOD 10th Plan Programme, Department of Ocean Development, Govt. of India).
Smt. P. Swapna	Air-Sea Interactions in the Indian Ocean Region (DOD/ INDOMOD 10th Plan Programme, Department of Ocean Development, Govt. of India).
Kum. Preethi Bhaskar	Management Perspectives to Seasonal Climate Forecast in Mixed Cropping System of Southern India's Semi Arid Field (Global Change System for Analysis, Research and Training / Asia Pacific Network).
Shri Unmesh P. Shinde	Multi site Characterization of Tropical Aerosol Direct Radiative Forcing using Measurements (ISRO-GBP/ARBS) (Indian Space Research Organisation (ISRO), Government of India).
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).
Shri Pankaj Kumar	India Meteorological Department, New Delhi-IITM Collaborative Scheme on Development of Long-range Forecasting (India Meteorological Department).
Shri Ramesh Kumar Yadav	India Meteorological Department, New Delhi-IITM Collaborative Scheme on Development of Long-range Forecasting (India Meteorological Department).
Shri Sachin Gunthe	Experimental and Theoretical Studies of Secondary Pollutants and Ozone for Chemical Forecasting (Department of Science and Technology, New Delhi).
Shri Sachin S. Deshpande	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).
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).
Shri Saroj Kumar Sahu	Application of Satellite Data to Climate Research (Indian Space Research Organisation (ISRO), Government of India).
Shri V. Prasanna	Climate Change Projection for India and Assessment of the Associated Agricultural and Human Health Impact (National Communication (NATCOM), Ministry of Environment and Forests, Government of India).

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**

M/s M. S. Godbole & Associates

CHARTERED ACCOUNTANTS

67 / 2, 4, Uberoi House, Nal Stop, Karve Road, Pune 411 004
Phone : 2543 35 40, E-mail : mgodbole@vsnl.com

To
The Members,
Indian Institute of Tropical Meteorology,
Homi Bhabha Road,
Pashan,
Pune-411 008.

Sub : Audit Report for the Financial Year ended 31st March 2005

Sirs,

We have audited the attached Balance Sheet of the Indian Institute of Tropical Meteorology as on 31st March 2005 and the Income & Expenditure account as on that date annexed thereto. These financial statements are the responsibility of the management. Our responsibility is to express an opinion on these financial statements based on our audit.

We have concluded our audit in accordance with auditing standards generally accepted in India. These standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statements presentation. We believe that our audit provides reasonable basis for our opinion.

a) We have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit.

b) The Balance Sheet and Income & Expenditure Account dealt with by the report are in agreement with the books of accounts.

c) We invite your attention to the following:

   i) In respect of funds received for earmarked projects, no separate investment / bank accounts are made. As informed this is due to large number of projects. Hence interest income earned on these funds are not credited to respective projects but is shown as consolidated figure in Income & Expenditure Account.

d) In our opinion and to the best our information and according to the explanations given to us, the said Balance Sheet and Income & Expenditure Account read together with significant Accounting Policies followed and other observations give a True and Fair view:

   i) In the case of Balance Sheet, of the state of affairs as at 31st March 2005.

   ii) In the case of Income & Expenditure Account, of the deficit for the year ended on that date.

For **M. S. Godbole & Associates**
Chartered Accountants

sd/-

Date : 11 .07.2005
Place : Pune

(Mohan S. Godbole)
Partner

Auditor's Report

Following are our observations based on books, records, and documents produced before us and information and explanation given by the officials of the Institute:

A. **Maintenance of Fixed Assets 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 store records.

B. **Physical Verification Report 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 2005 is still in progress.

C. **Claims Receivable:** (Schedule 6 to Balance Sheet) Claims receivable amounting to Rs. 4,64,709.63 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.

D. **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 the land belonging to IITM. It has been explained that NCL is getting the land surveyed. However efforts are in progress to get the land in question from NCL as per the demarcation of land shown by the city survey office.

E. **Arbitration Case:** As per the request letter from CPWD, the Institute has deposited Rs. 3,45,000/- with CPWD to settle the case with M/s. Naidu & Co. which has given up the work of construction of A, B, C type quarters including water supply and sanitary provisions half way. The case went against CPWD and the amount of deposit is still recoverable from CPWD.

This amount is due since 1992 and in spite of follow-up for recovery by the Institute, no recovery has been possible till date. We are of the opinion that, given the nature of advance and the time since which it is outstanding, the advance seems to be irrecoverable.

F. **Assets Written Off:** During the year fixed assets to the extent of Rs. 635/- have been written off as per the resolution passed by the governing council.

Acknowledgement : We express our sincere thanks to Dr. G.B. Pant, Director, and his officers Mr. V.K. Asrani, Mrs. N.S. Girija, Mr. V.G. Bathija and all 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 : 11.07.2005
Place : Pune

Compliance to Audit Observations

A. Maintenance of Fixed Assets Register.	The Assets acquired fully (Equipments) are entered in Dead 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 concerned 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 entries book keeping system.
B. Physical Verification Report of Dead Stock.	A committee has been constituted for physical verification for the financial year 2004-05. The physical verification work is under progress and as soon as the report is ready the same will be produced to auditors.
C. Claims Receivable	It may be mentioned here that most of the outstanding claims receivable for the financial year 2004-05 have been received and settled. The same will be produced to the audit.
D. Land Dispute with National Chemical Laboratory (NCL), Pune	The survey of NCL land completed by the City Surveyor Department and as per their report the land belong to IITM. The matter is being presently persuaded by IITM with NCL to settle the land dispute as early as possible.
E. Arbitration Case	Since the CPWD, Pune have not responded to our letters regarding settlement of arbitration case with M/s. Naidu & Co. The matter was taken up with the Chief Engineer (Civil), West Zone, CPWD, Nagpur and it is being again pursued to settle the arbitration case for construction of A, B, C types quarters.
F. Assets Written Off	No comments.

SIGNIFICANT ACCOUNTING POLICIES

A. 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.

B. FIXED ASSETS

Fixed assets stated in the Balance Sheet are at their cost of acquisition inclusive of freight, octroi and other direct and indirect costs in respect thereof less depreciation. Assets acquired for sponsored projects are written off as project cost.

C. Depreciation

Depreciation is provided on the straight line method at the following rates.

Sr. No.	Particulars	Rate
1.	Building, Tube wells & Overhead Water Tank	1.63%
2.	Furniture & Fixtures	6.33%
3.	Plant & Machinery, Scientific Equipment Office Equipment	4.75%
4.	Computers, Workstations	16.21%
5.	Vehicle	9.5%
6.	Books	100%

D. GOVERNMENT GRANTS :

a. Government grants of the nature of contribution 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 of the related assets.

c. Government grants are accounted on realization basis.

E. RETIREMENT BENEFITS :

1. Retirement benefits to the employees comprise of payments 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 same is provided on cash basis.

F. CONTINGENT LIABILITY :

Commitments given towards purchase of Scientific Equipments
Institute Fund - Rs. 4,87,063.00
Project Fund - Rs. 9,39,696.00

G. Previous year figures have been regrouped wherever necessary.

For **M. S. Godbole & Associates**
Chartered Accountants
sd/-
(Mohan S. Godbole)
Partner

Date : 11.07. 2005
Place : Pune

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31.03.2004

	Schedule	Current Year	Previous Year
INCOME			
Income from Sales / Services			
Grants / Subsidies	7	7,36,92,189.17	6,76,40,634.03
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.	8	0.00	0.00
Interest Earned	9	14,06,368.48	16,76,672.00
Other Income	10	10,12,141.70	9,42,332.16
Increase / (decrease) in stock of Finished goods and works-in-progress	—	0.00	0.00
TOTAL (A)		**7,61,10,699.35**	**7,02,59,638.19**
EXPENDITURE			
Establishment Expenses	11	7,02,31,041.69	5,16,77,069.32
Other Administrative Expenses etc.	12	1,56,50,969.46	1,41,76,518.54
Expenditure on Grants Subsidies etc.	13	0.00	0.00
Interest	—	0.00	0.00
Depreciation during the year	15	36,53,735.76	40,23,518.00
TOTAL (B)		**89535746.91**	**6,98,77,105.86**
Balance being excess of Income over Expenditure (A-B)	—	0.00	3,82,532.33
Transfer to Special Reserve (Specify each)	—	0.00	0.00
Transfer to / from General Reserve	—	0.00	0.00
Previous years depreciation	—	0.00	28,708.00
BALANCE BEING SURPLUS / (DEFICIT) CARRIED TO CORPUS / CAPITAL FUND	—	1,34,25,047.56	3,53,824.33
Significant Accounting Policies contingent Liabilities and Notes on Accounts	14		

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

BALANCE SHEET AS AT 31.03.2004

CORPUS / CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year
CORPUS / CAPITAL FUND	1	7,48,74,268.23	8,21,91,504.96
RESERVES AND SURPLUS	2	2,27,88,792.06	2,11,68,677.25
EARMARKED / ENDOWMENT FUNDS	3	72,49,065.06	1,14,58,024.74
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	18,72,008.63	24,09,724.95
TOTAL		**10,67,84,133.98**	**11,72,27,931.90**
ASSETS			
FIXED ASSETS	5	7,55,61,379.41	7,32,72,453.52
INVESTMENTS - FROM EARMARKED / ENDOWMENT FUNDS	—	0.00	0.00
INVESTMENTS - OTHERS	—	0.00	0.00
CURRENT ASSETS LOANS ADVANCES ETC.	6	3,12,22,754.57	4,39,55,478.38
MISCELLANEOUS EXPENDITURE (TO THE EXTENT NOT WRITTEN OFF OR ADJUSTED)	—	—	—
TOTAL		**10,67,84,133.98**	**11,72,27,931.90**
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