Biosphere-atmosphere exchanges of carbon , water and energy at natural ecosystems over India (Metflux Project)

Dr. Pramit Kumar Deb Burman, Dr. Dipankar Sarma, Mr. Amey Datye, Mr. Abhijit Bora, Dr. Yogesh Kumar Tiwari, Dr. Milind Mujumdar

Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Pune

Introduction

The interaction between biosphere and atmosphere through the exchanges of mass and energy can significantly modulate the climate. Forest ecosystems play an important role in controlling the global carbon cycle due to its dual ability to act as source and sinks of atmospheric CO_2.

To properly understand the source/sink nature of Indian forest ecosystems, and their spatial and temporal variations IITM has setup flux tower sites over forest ecosystems under Metflux Project. Measurements at these locations include carbon, moisture, heat and momentum fluxes, soil CO_2 flux and surface energy balance components,

The flux towers are equipped with high-frequency Eddy Covariance (EC) sensors containing sonic anemometer and infrared gas analyser, radiation sensors, weather sensors, and soil temperature, moisture, and heat flux sensors at multiple heights (depths) Supporting measurements of photosynthetically active radiation (PAR) and leaf area index (LAI) are carried out for plant physiological studies

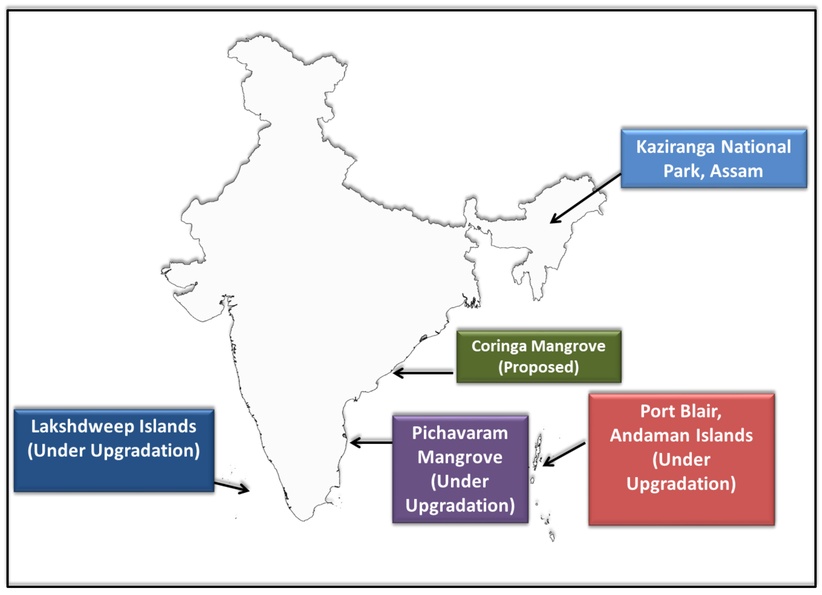


Fig.1 Metflux Project Sites

Key Findings

(A) Kaziranga National Park (KNP), Assam

Quantifying the net ecosystem exchange at a semi-deciduous forest in northeast India from intra-seasonal to the seasonal time scale[1]

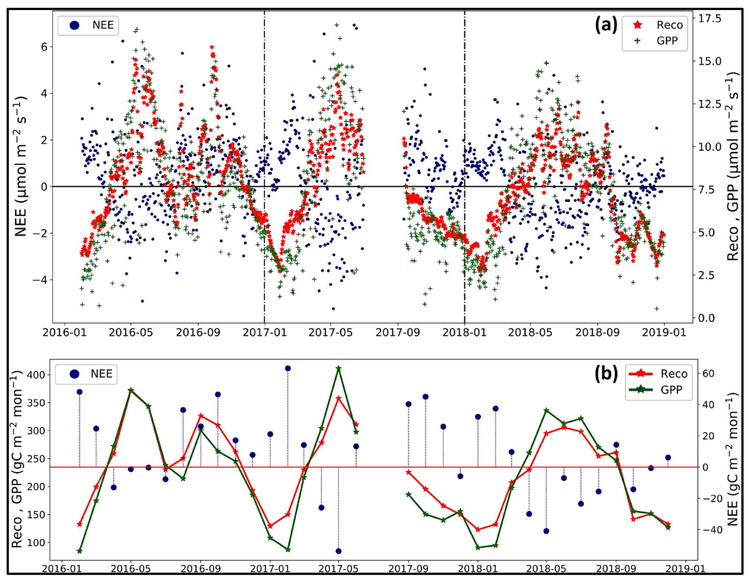


Fig.2 Daily (a) and Monthly (b)averages of NEE, GPP, and R_{eco}

- The maximum carbon sequestration at KNP took place during the pre-monsoon season. Abundant radiation and an adequate amount of rainfall enhanced vegetation growth which transferred the maximum amount of carbon from the atmosphere to the biosphere.
- The respiration by the KNP ecosystem was considerably higher than the other forest ecosystems in India. A high level of soil CO_2 flux caused such high respiration.
- Five months of soil CO_2 flux measurement revealed a sharp increase in soil CO_2 emission with the arrival of the pre-monsoon season; during this time, soil respiration dominated the above-ground canopy respiration.
- The annual flood events and air temperature strongly influence the KNP ecosystem respiration.
- The KNP acted as a net source of carbon in 2016 but a moderate sink in 2018.

Linkage between precipitation isotopes and biosphere-atmosphere interaction observed in northeast India[2]

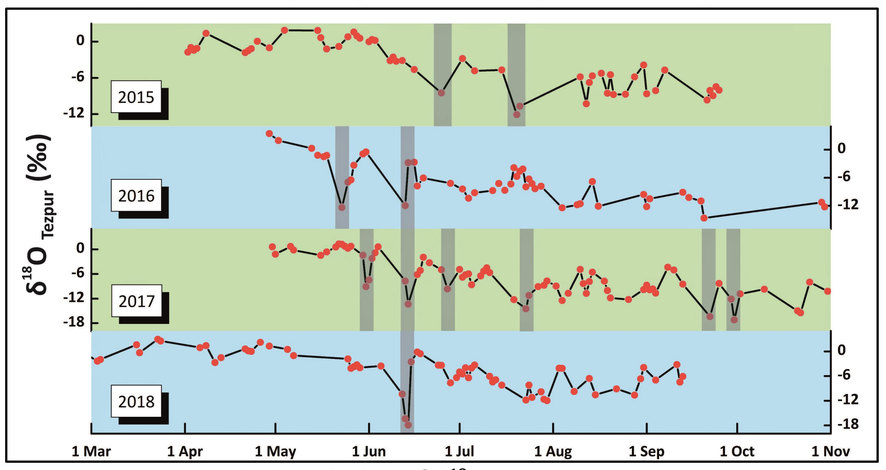


Fig.3 Variation of $\delta^{18}O$ at Tezpur Site

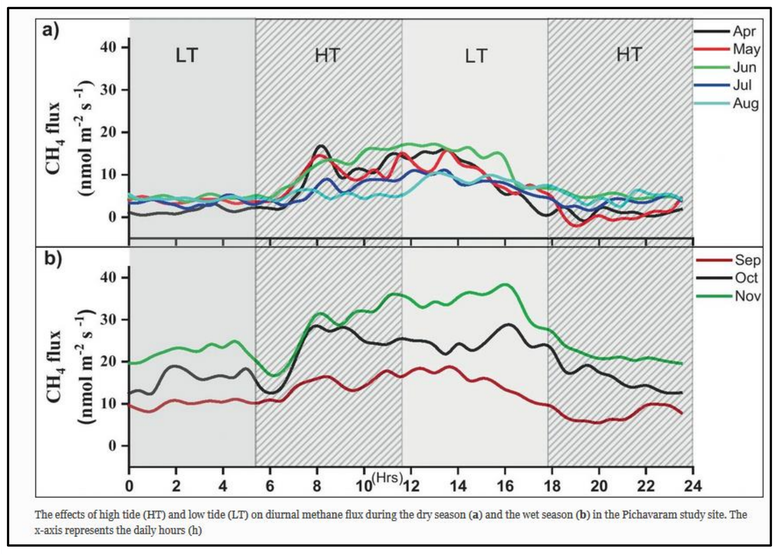
The climate of NEI is distinct compared to the rest of India. This region receives very heavy rainfall, with several places being among the wettest in the world.

Mean annual rainfall in NEI is 151.3 cm; the pre-monsoon time (March–May) witnesses a significant amount of rainfall driven by the thunderstorm activities.

A large portion of NEI is forest-covered (64%), much higher than the national average of India.

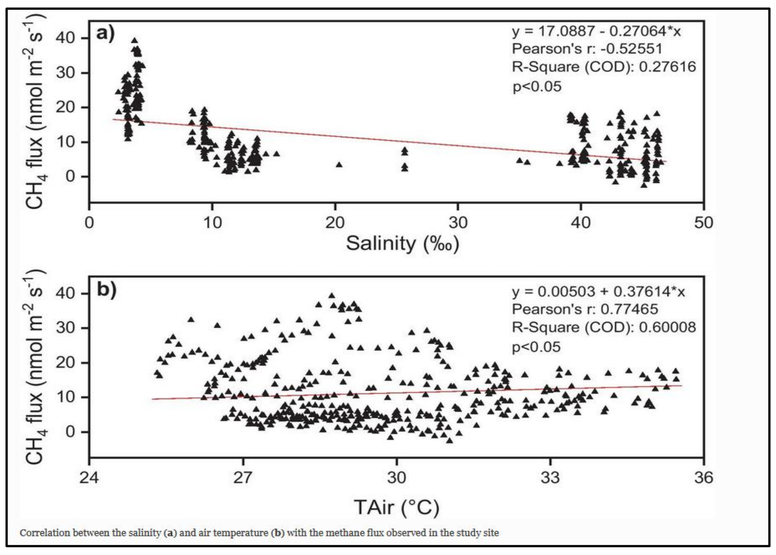
- The intra-seasonal variation in precipitation isotopes shows a characteristic declining trend over northeast India.
- Measurement of Isotopic properties of rainwater along with net ecosystem exchange and latent heat flux (by using Eddy covariance method) was carried out.
- A strong link between the enhanced ecosystem productivity and isotopic enrichment in rainwater during the pre-monsoon season was observed.
- The internal factors, such as the local land-atmosphere interactions, rather than the external influences, play a significant role in governing the precipitation isotopes in northeast India.
- A strong coupling between the hydrological cycle and plant physiological processes during the pre-monsoon season is evident from the results. So, a declining trend in the evapotranspiration generated vapor may indicate the reduction of primary productivity, which may alter the carbon balance of the fragile ecosystems of northeast India.

(B) Pichavaram Mangroves, Tamil Nadu



The effects of high tide (HT) and low tide (LT) on diurnal methane flux during the dry season (**a**) and the wet season (**b**) in the Pichavaram study site. The x-axis represents the daily hours (h)

Fig.4 Effect of High and Low tide on CH_4 flux



Correlation between the salinity (**a**) and air temperature (**b**) with the methane flux observed in the study site

Fig.5 Effect of Salinity and Air Temperature on CH_4 flux

- The atmospheric methane (CH_4) concentration has increased in recent years due to natural and anthropogenic causes
- Coastal wetlands, particularly the mangrove ecosystems in the tropical and subtropical coasts, are significant sources of CH_4
- Pichavaram mangroves acted as a minor source for CH_4 (Daily mean CH_4 flux 12 to 26 nmol m^{-2} s^{-1}) during the wet season when compared with the dry season(Daily mean CH_4 flux 6 to 20 nmol m^{-2} s^{-1}).[3]
- The Pichavaram mangroves are characterised by a lower emission rate than the tropical mangroves of Sundarbans, India and subtropical forest near Hong Kong, China.[3]
- Statistical results indicate that air temperature, tidal inundation patterns, and water salinity were important for describing the variability of CH_4 flux in the site, Pichavaram mangroves may become a larger source of Methane as anthropogenic inputs of organic matter are increased and sea levels rise in the future.

(C) Lakshadweep Islands

- Lakshadweep is known as coral islands of India in the Arabian Sea. Systematic efforts are made to study the physiochemical properties of sea water and CO_2 concentration at the islands.
- The average air-sea pCO_2 levels varied between 388 and 402 ppm during 2014-2018 period. High levels of pCO_2 might have affected the reef-building capacity of the ecosystem since the current level of air-sea pCO_2 is believed to cause substantial damage to coral reefs. [4]
- Seas surface temperature is increasing (26.68–30.36°C) in the Lakshadweep Island ecosystem.[4]
- Lowering pH and reducing the availability of CO_3 ions would synergistically affect this precious ecosystem and denudes its biodiversity. Hence, an integrated management strategy has to be implemented to safeguard the coral reef ecosystem.

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