Use of EO inputs for Climate Change studies in India

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Climate Change Research in India

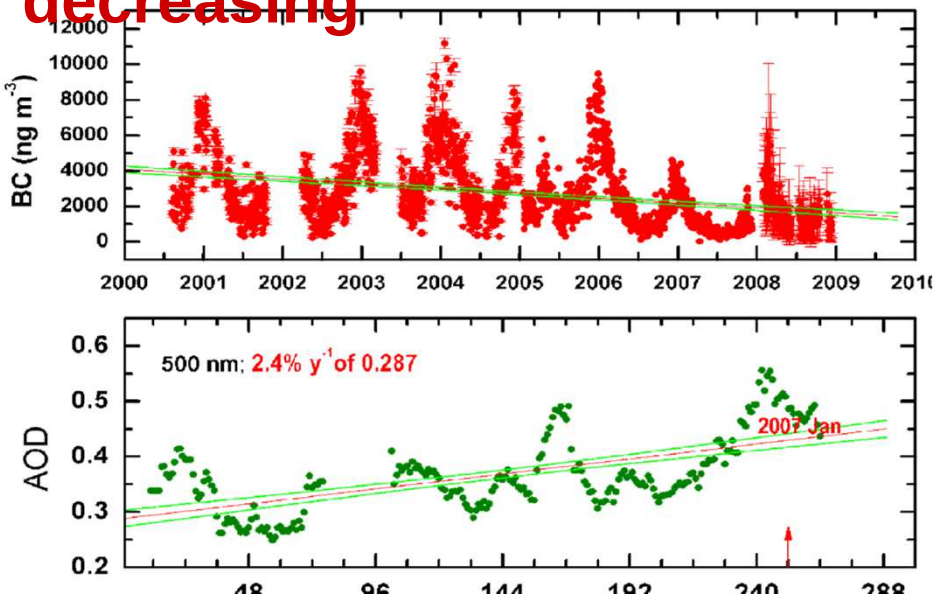
- Ministry of Environment, Forest and Climate Change is responsible for climate change coordination, including policy and international cooperation
  - UNFCCC, IPCC, …
- Ministry of Earth Sciences has established Centre for Climate Change Research in IITM, Pune
  - Earth System Model & a computing facility established at CCCR
- *Universities & Institutions also have a large climate research program*
- ISRO supports climate research program through
  - Space Segment comprising satellites & sensors
  - ISRO Geosphere Biosphere Research Program
  - National Information System of Climate & Environemental Studies
  - Climate Change Research Programs at ISRO (SAC, NRSC, IIRS, SPL/VSSC) as well as DOS centres:
    - PHYSCIAL RESEARCH LABORATORY .
    - NATIONAL ATMOSPHERIC RES. LAB

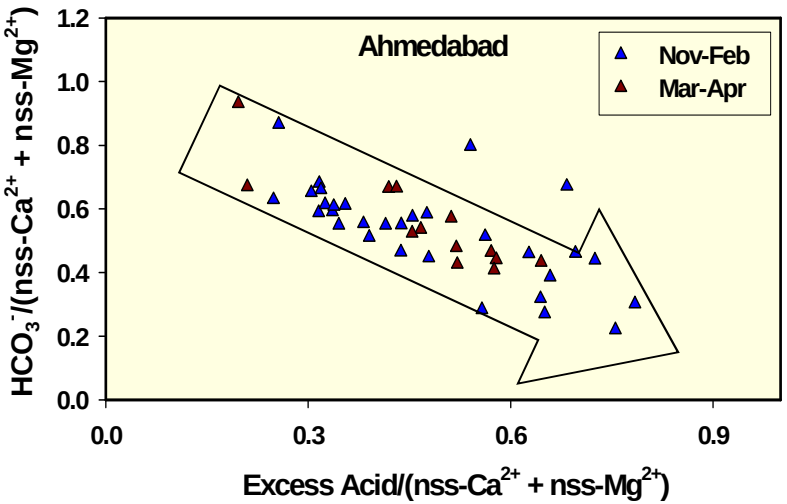
ISRO GEOSPHERE-BIOSPHERE PROGRAM

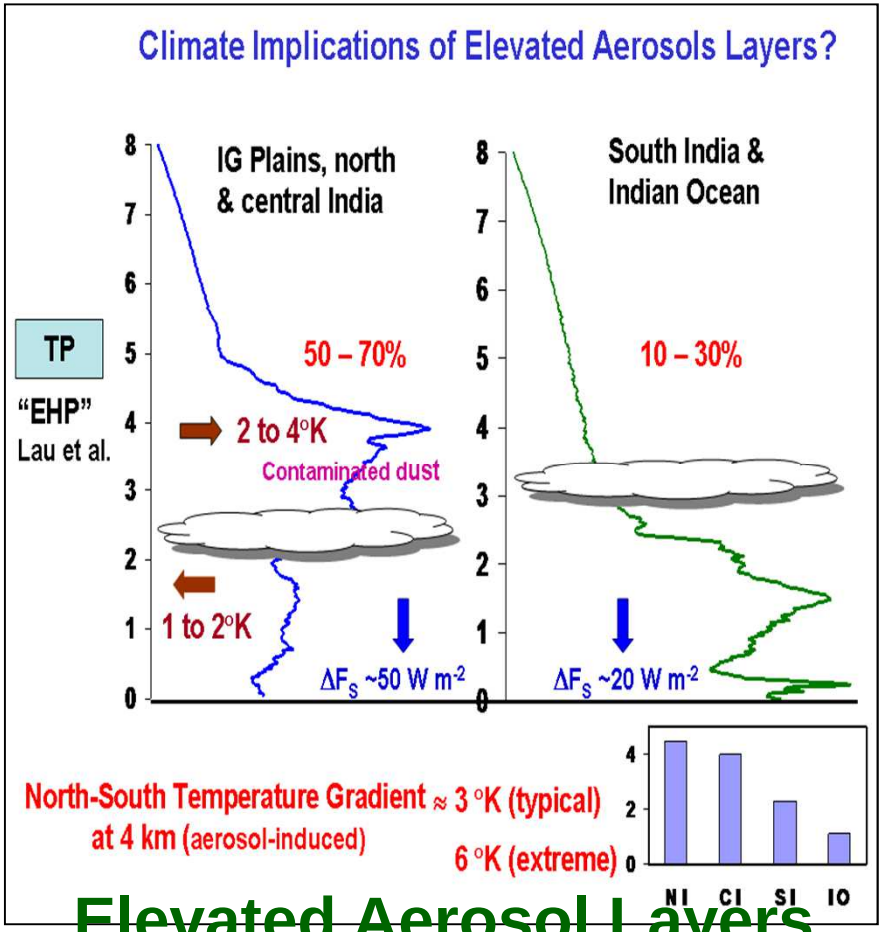
- **Multi-institutional & national scale programs :**
  - National Carbon Project
  - Aerosol Radiative Forcing in India
  - Aerosol Chemistry
  - Trace Gases & dynamics
  - Atmospheric Boundary Layers
  - Energy & Mass Exchange in Vegetation
  - Land Use & Hydrology
  - Multi-proxy paleo-climate studies

Aerosol Research

Black Carbon emissions are decreasing







Elevated Aerosol Layers

No Acid Rains in India (N West)

ISRO Observation Infrastructure for CC

- AEROSOLS
  - Multiwavelength radiometer network, aetholometers
- BOUNDARY LAYER
  - LIDARS, Agromet Towers
- GREEN HOUSE GASES
  - FTIR, GHG Observations
- HIMALAYA GLACIERS
  - Field Campaigns
- OCEAN
  - Ship Cruises for ocean biogeochemistry, air sampling, Aircraft
- TERRESTRIAL BIOSPHERE
  - Eddy-covariance Flux tower netwrok

MWR-MKIII Patented

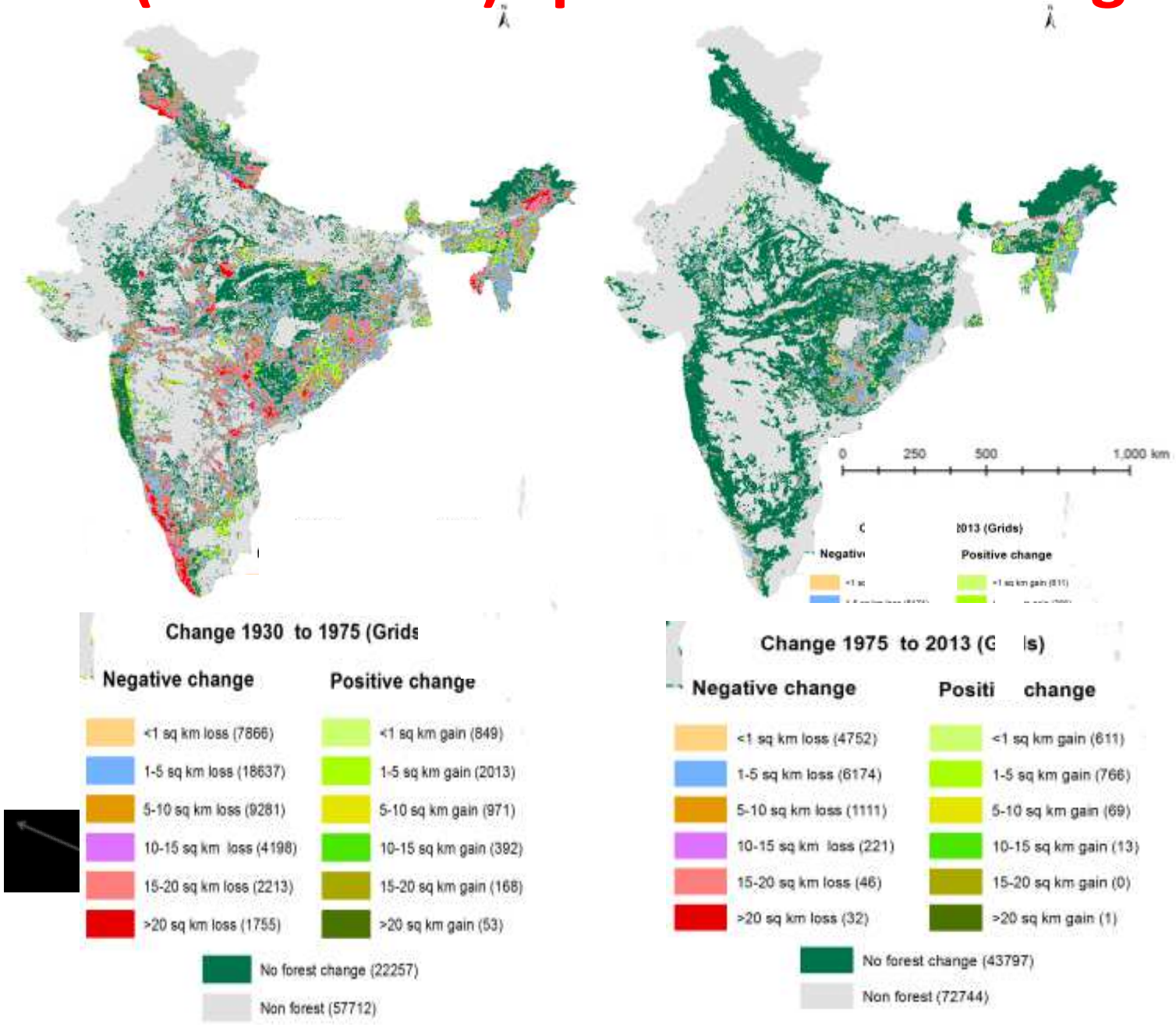
ISRO-Agro-Met Station (AMS)
10m for short canopies

Flux Towers 50Metrs

Carbon Cycle of India

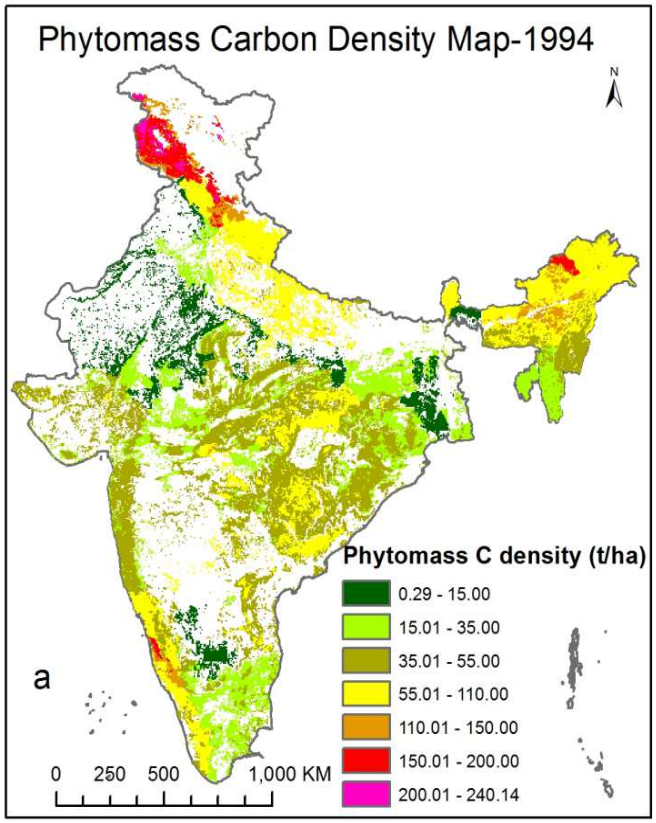
- Scientific Questions for Carbon Cycle are
  - Quantify Carbon pools, fluxes and net C balance
  - Estimate temporal pattern as affected by human activities
  - Predict carbon source-sink in future climate and human influence
  - …
- Challenge is to
  - Capture large spatial variability
  - Detect small differences over large variability & uncertainty
  - ..
- Science Program
  - National Carbon Project under ISRO GEOSPHERE BIOSPHERE PROGRAM
    - FLUX TOWERS FOR NET C EXCHANGE
    - LAND USE CHANGE; DEFORESTATION; FOREST BIOMASS
    - OCEAN & COAST; SOIL POOLS & FLUXES;
    - MODEL NPP ;

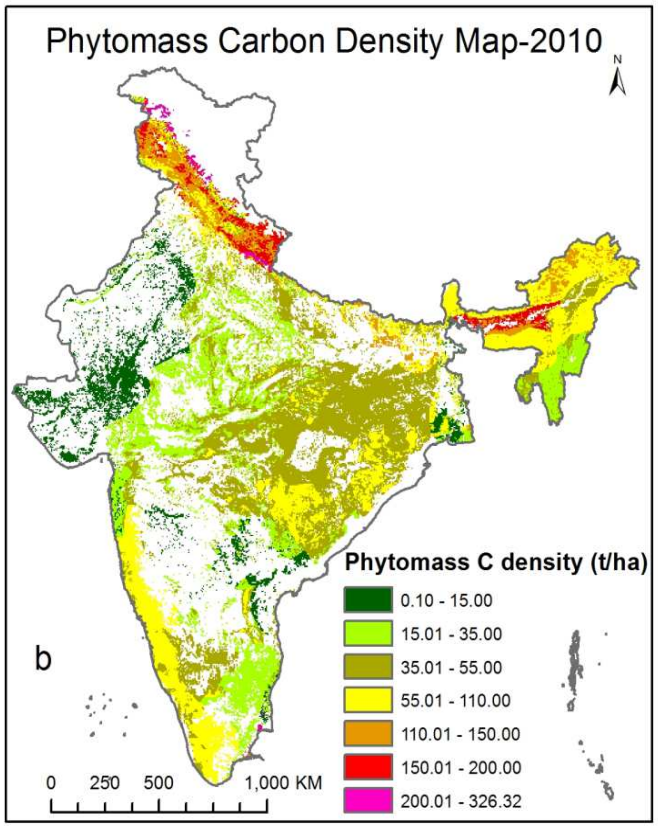
Long-term (1930-2013) spatial forest change

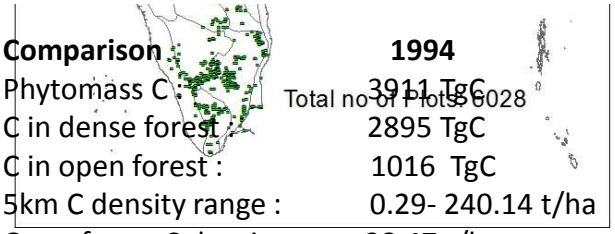


Forest phytomass C pools & trends

Phytomass C density change analysis (1994-2010)



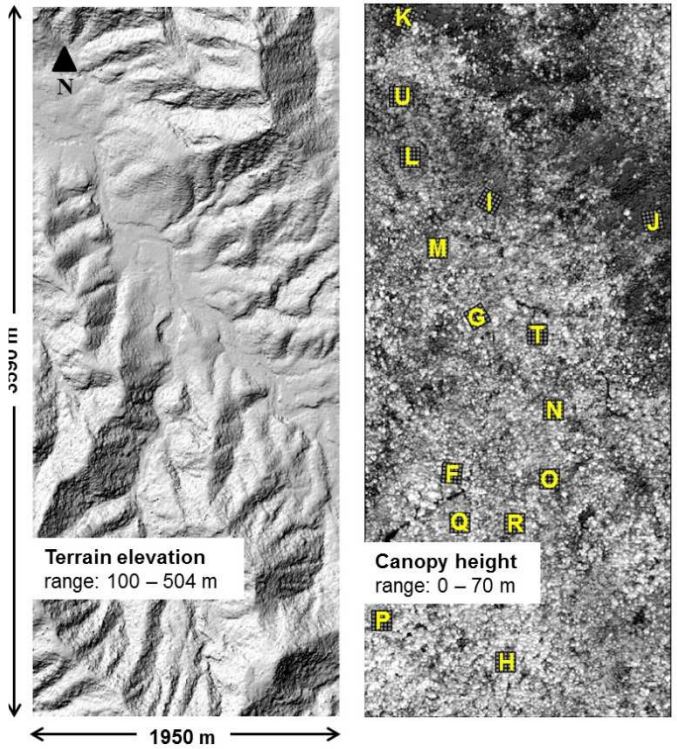


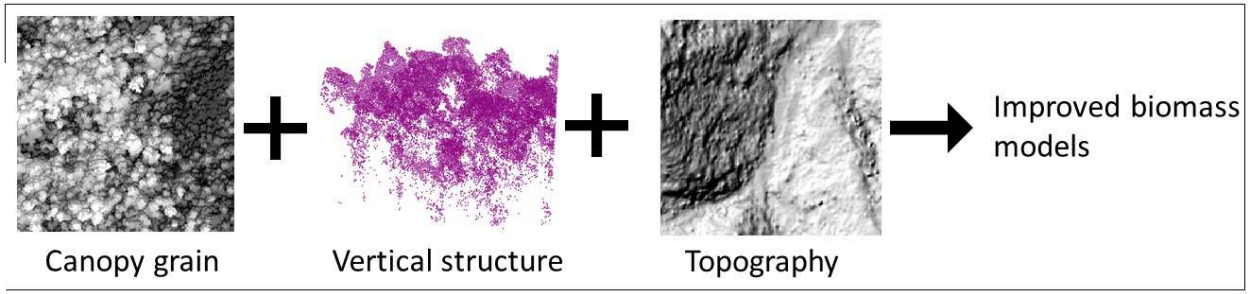


Comparison	1994	2010
Phytomass C :	3911 TgC	4368TgC
C in dense forest :	2895 TgC	3176 TgC
C in open forest :	1016 TgC	1192 TgC
5km C density range :	0.29- 240.14 t/ha	0.10- 326.32 t/ha
Open forest C density :	38.47 t/ha	41.69 t/ha
Dense forest C density :	77.08 t/ha	80.24 t/ha
Forest Cover:	61.14 Mha	64.08 Mha

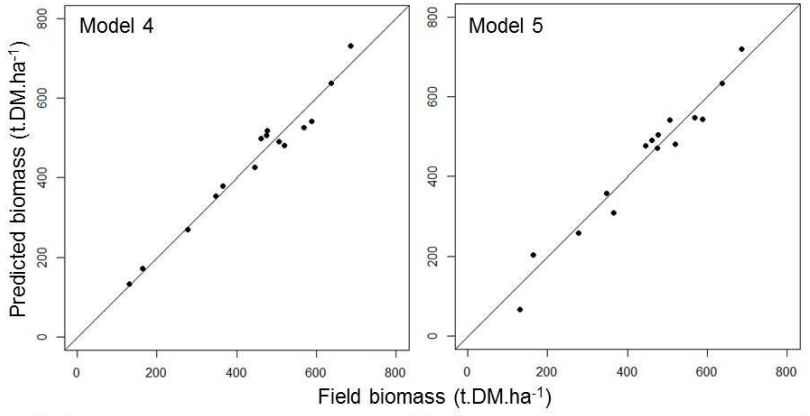
Improving Forest Phytomass estimates

- **Approach I: High Resolution + LIDAR (aerial)**
  - **Uppangla Forest, Very High Biomass, Multi-tier canopy, Western Ghats, INDIA**





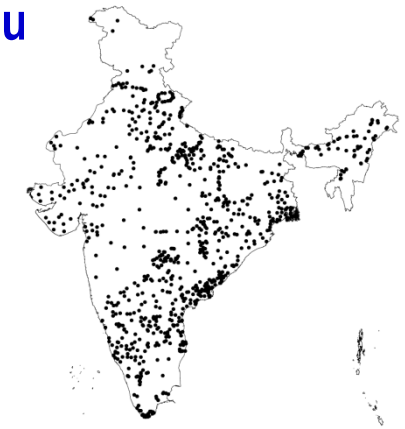
Model Indices : Directional Metrics
FOTO (HR Data)
Terrain Complexity Indices
R2 : 0.95;
RMSE : 28 % (446+ 140 t/ha)

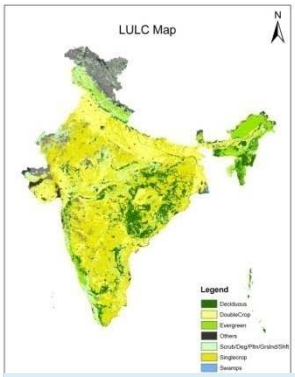


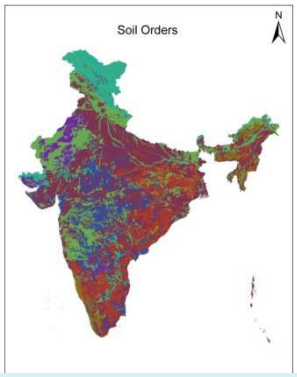
Tree Height – upto 70m
DBH - upto 160 cm
Tree Biomass – 690 t/ha
Pushpagiri Wildlife Sanctuary

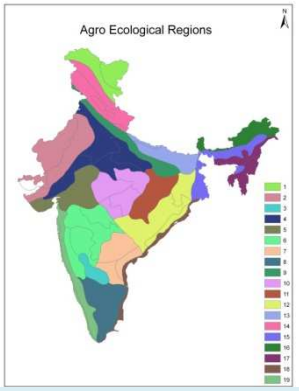
Soil Carbon Pool : Geospatial Modeling

- **Approach**
  - Sampling plan with land use, soil map, slope & AEZ
  - Consistent 1200 samples analysed by CHN
  - Modelling & Prediction by Data Mining (Random Forest) uses additional weather & VI
  - Predicted SOC, SIC & TOC maps at 250m spatial resolu



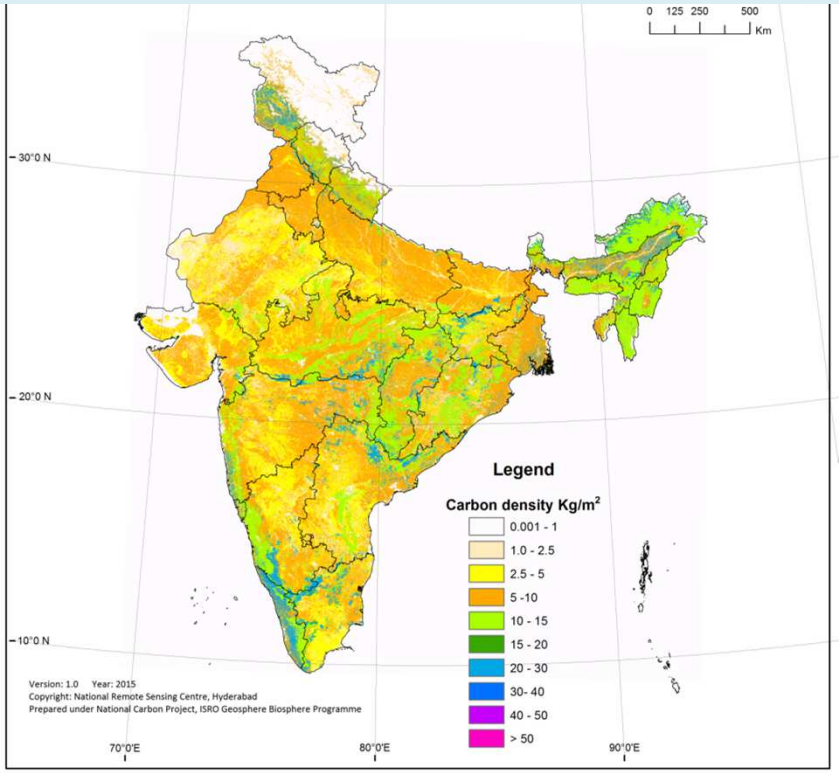




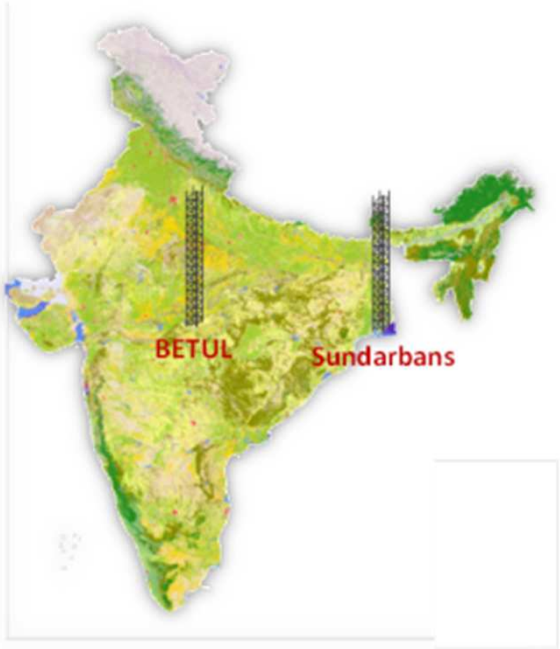


LAND USE SOIL MAP AGROECO ZONE

Soil organic C density



Forest Flux towers – Betul & Sundarbans



Betul Flux tower

Sundarbans

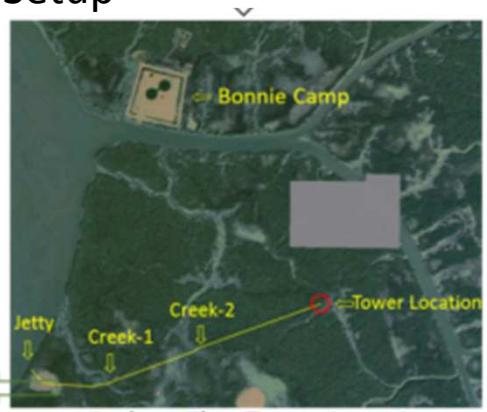
Location

Betul (Dry Deciduous)
21.86 N 77.42 E

Sundarbans (Mangrove)
21.82 N 88.62 E

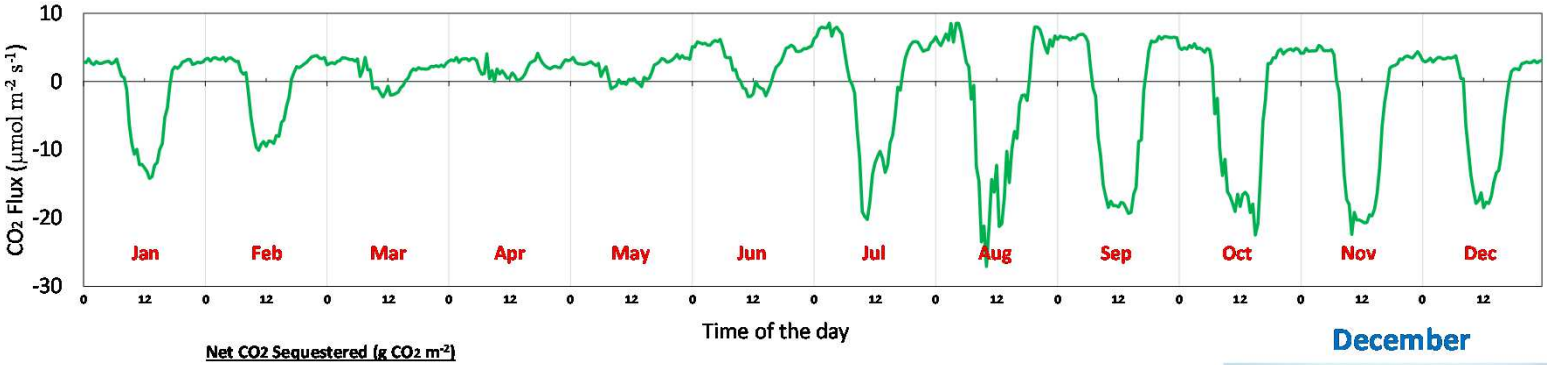
Sundarbans Tower Setup

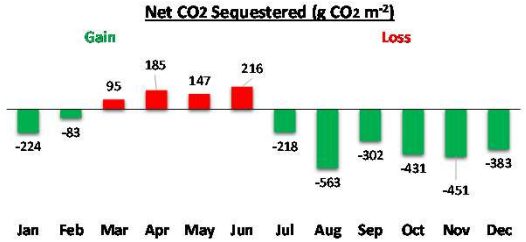
Canopy Walkway



Carbon Flux Tower Location

Diurnal Average variation of CO_2 Flux – Betul, M.P



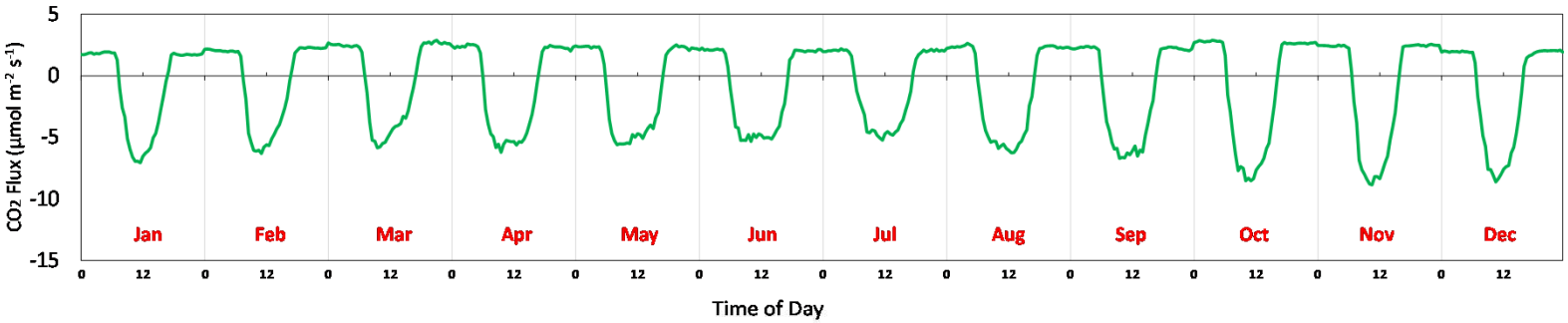


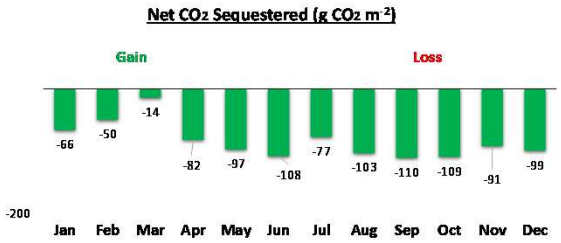
Net Annual Production

2012.87 g CO_2 m^{-2}
(or)
548.46 g C m^{-2}.

December

Diurnal Average variation of CO_2 Flux – Sundarbans, W.B.



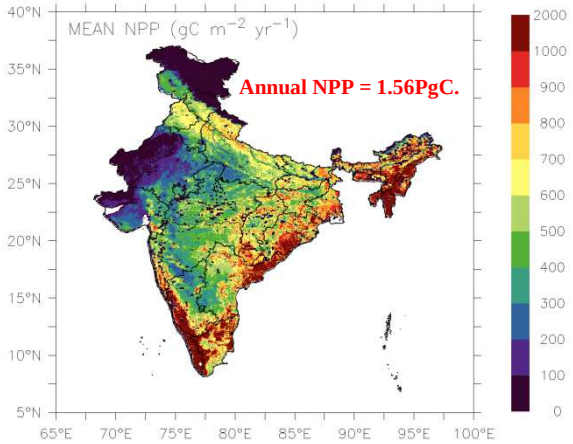


Net Annual Production

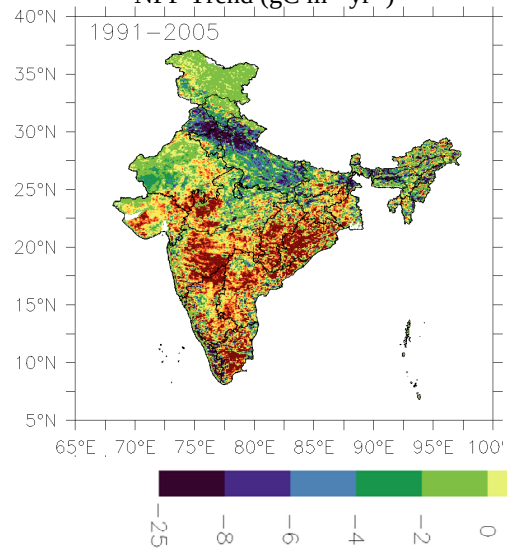
1005.32 g CO_2 m^{-2}
(or)
273.93 g C m^{-2}.

Inter-annual variability of simulated NPP and NEP during 1981-2006

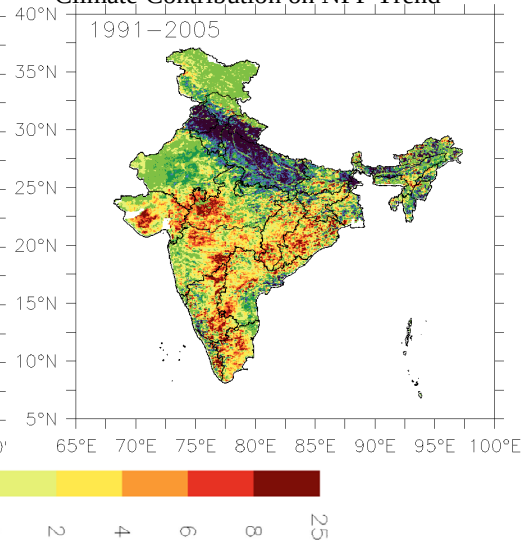
Annual NPP Trend (gC m^{-2} yr^{-1})



NPP Trend (gC m^{-2} yr^{-2})



Climate Contribution on NPP Trend

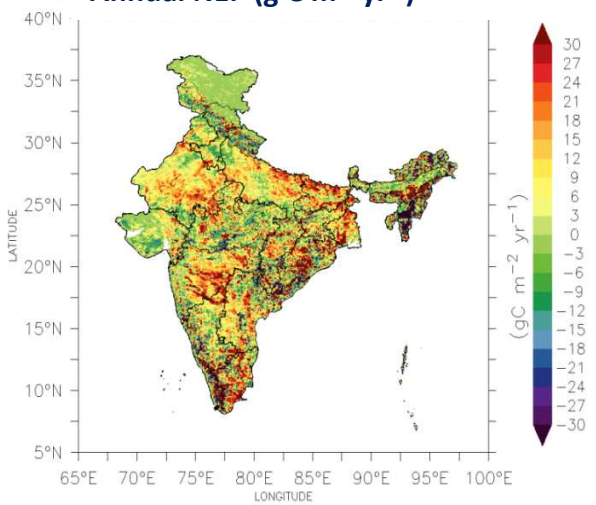


➢**Large decline of NPP over the Indo-Gangetic plains**

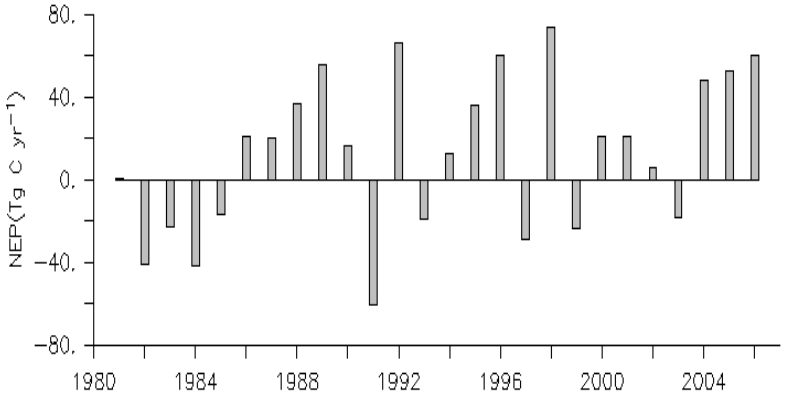
➢**Climate has Significant control**

➢**NPP budget is 1.56 PgCyr^{-1} & is increasing at the rate of 5 Tg C Yr^{-2}**

Annual NEP (g C m^{-2} yr^{-1})



Annual NEP budgets for the country during 1981-2006



➢**India is the region of net sink of atmospheric CO_2 during most of the years after 1985 .**

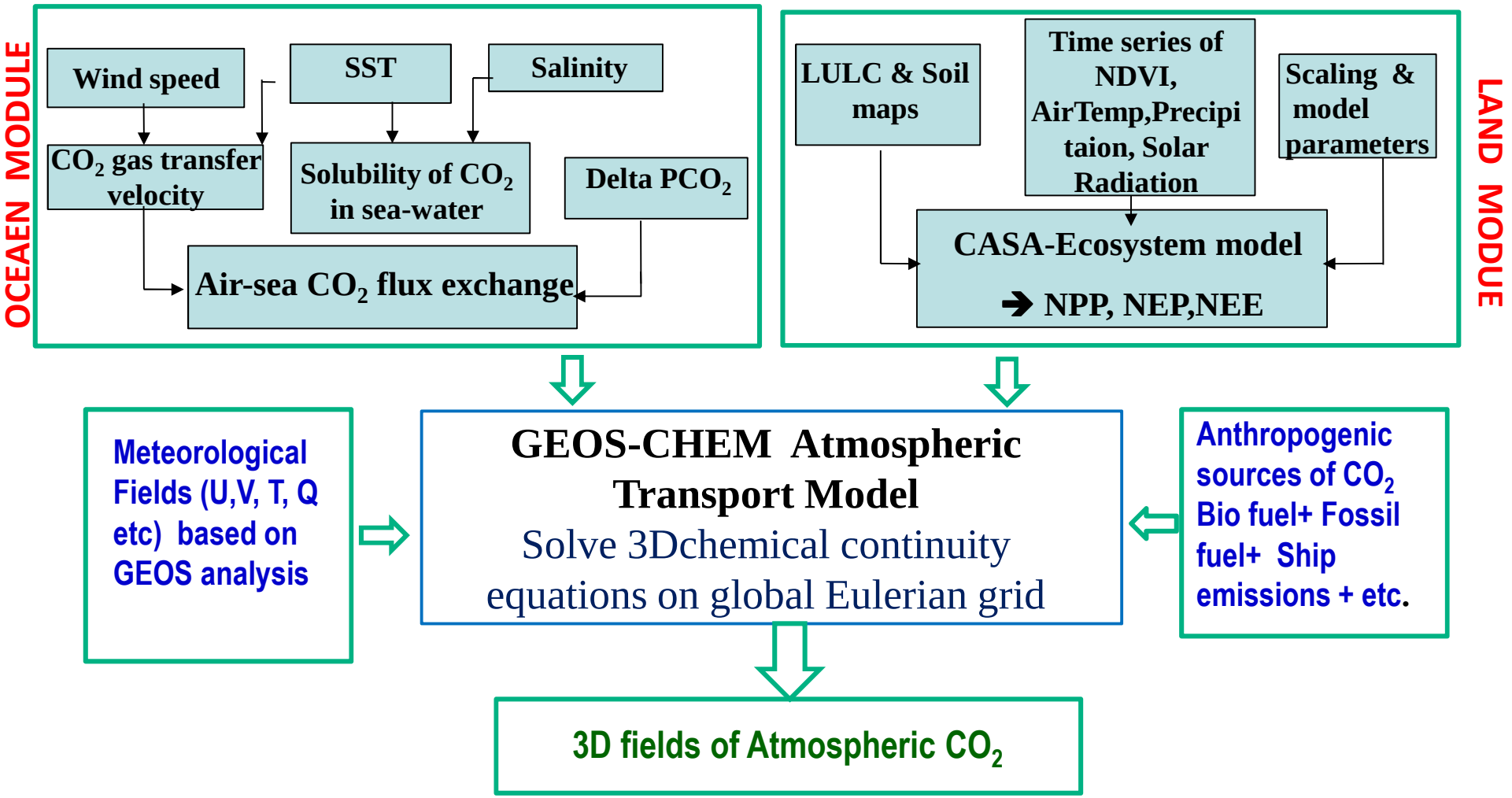
➢**Annual uptake is 9.5 Tg C yr^{-1} during 1981-2006**

➢**& is 19 Tg C yr^{-1} during 1991-2006**

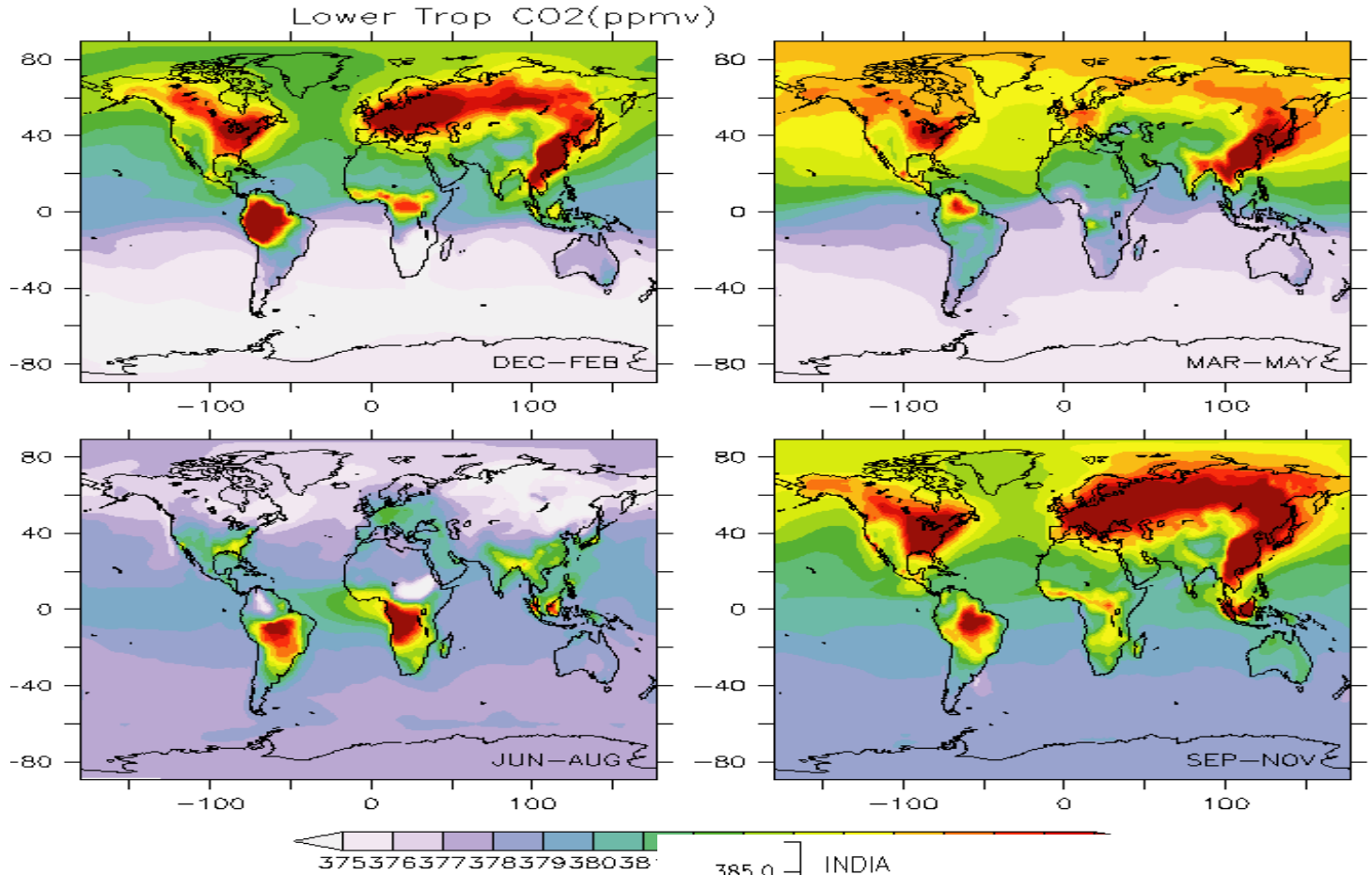
RKN-OSG-ECSA

Integrated CO_2 Model

- **GEOS-CHEM Implementation for Comprehensive Analysis of Carbon Cycle over the Indian Region**
  - **Presently at 20x2.50 for the globe, Years: 2006 and 2013 at 3hourly interval**



GEOS-CHEM: Simulated Atmospheric CO_2



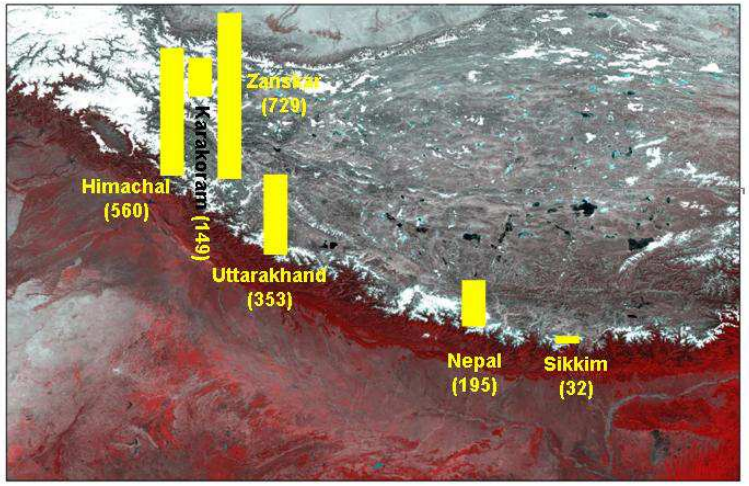
Geos-Chem Surface
Geos-Chem Mid-Trop
AIRS Mid-Trop
Geos-Chem Upper-Trop

Himalayas : Climate Change studies

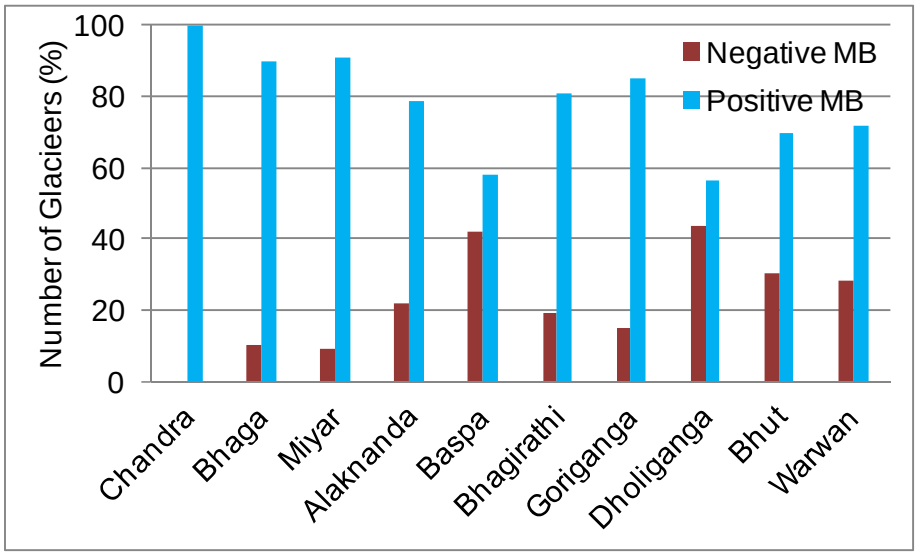
- Himalayas are highly populated hilly region with a significant anthropogenic impacts, respond to climate variability and also have potential to influence regional climate
- Himalayan Cryosphere
- EO inputs is the only approach to characterise large spatio-temporal variability, limited by parameters estimated by EO
- Important parameters of interest are
  - Snow cover, inter-seasonal & interannual variability, trends ?
  - Glaciers, inventory & characteristics
  - Glacier mass balance, snout retreat/advance, ice sheet thickness, glacier velocity, trends/future ?
  - Implications on snowmelt, runoff, long-term societal effects

Glacier Monitoring

- **Glacier Inventory**
  - Total Glaciers: 34, 919 (Indus: 18, 576; Ganga: 6, 237; Brahmaputra: 10, 106)
  - Glaciated area : 75, 779 sq km (Indus: 36, 843; Ganga: 18, 393; Brahmaputra: 20, 543 sq km)



- **Glacier Retreat**
  - Total 2018 glaciers
  - 1752 shows no change,
  - 248 Retreat & 18 Advance
  - [Bahuguna et al. (2014)]



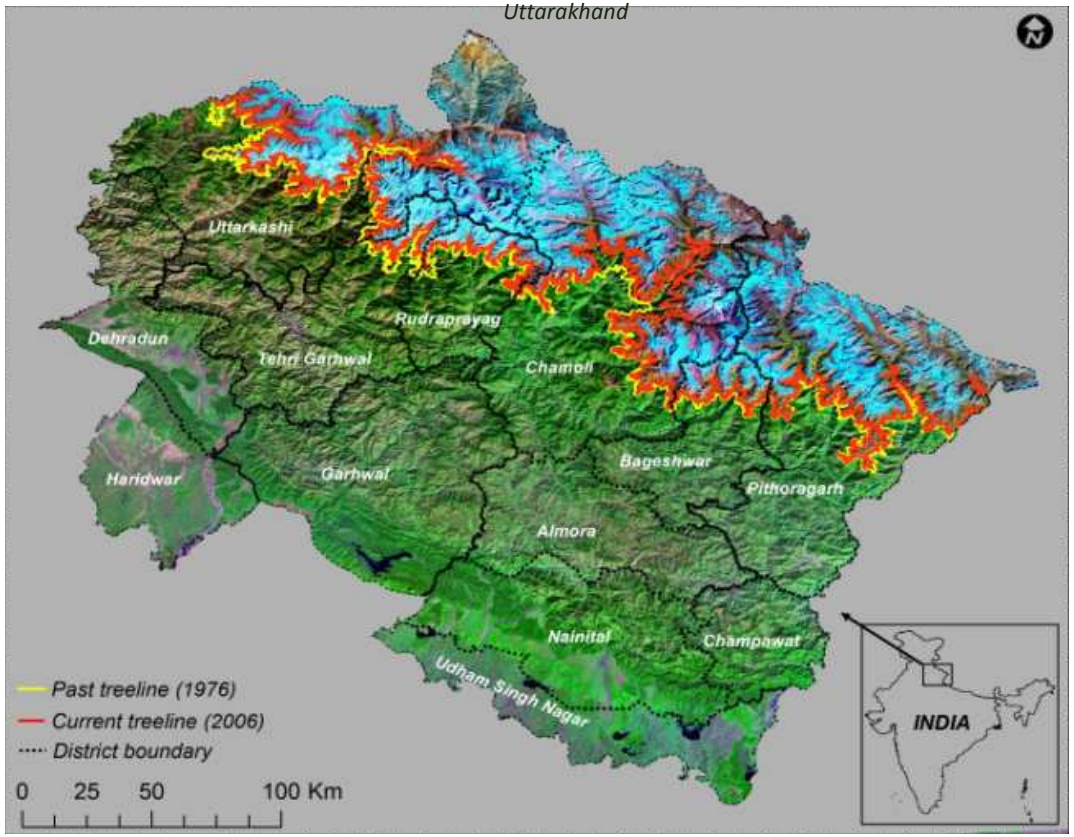
- **Glacier Mass Balance**

- **Glacier Hazard - GLOF**

Treeline Shift in Himalayas

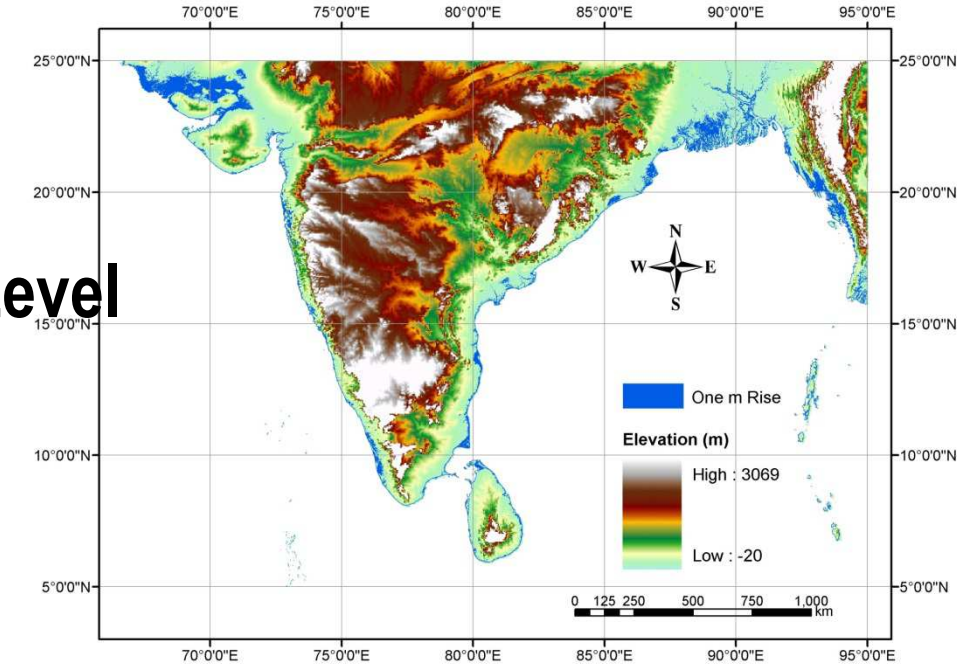
- **Treeline upward shift of 388±80m (~11m/year) in Uttarakhand has been reported during year 1970s–2006 in study conducted for Indian Himalaya using satellite remote sensing technique (Panigrahy et al., 2010; Singh et al., 2012)**

Treeline status map of Uttarakhand

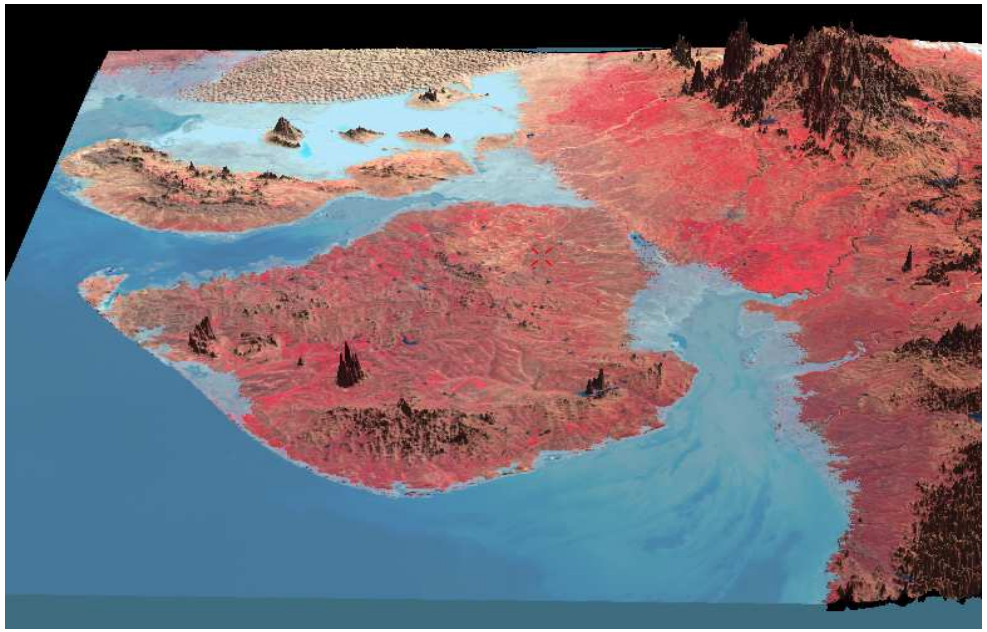


Sea Level : Rise & Coastal Interactions

- **Regional Vulnerability of the Indian Coast due to 1 m Sea Level Rise**

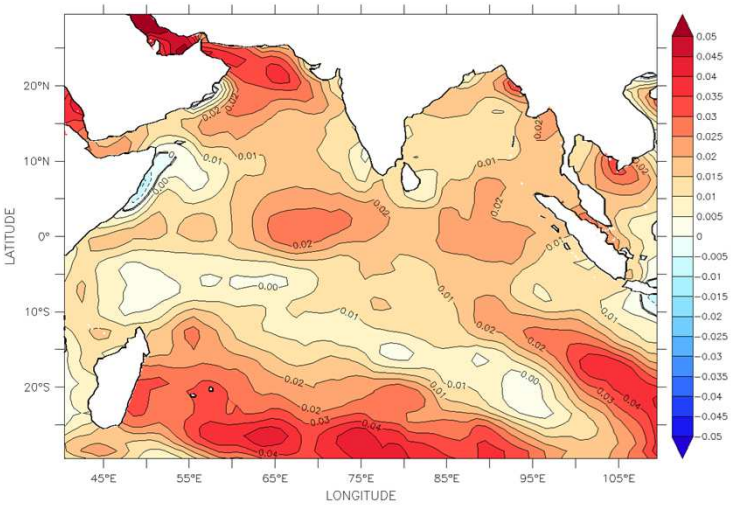


- **Vulnerable low slope regions along Gujarat coast**



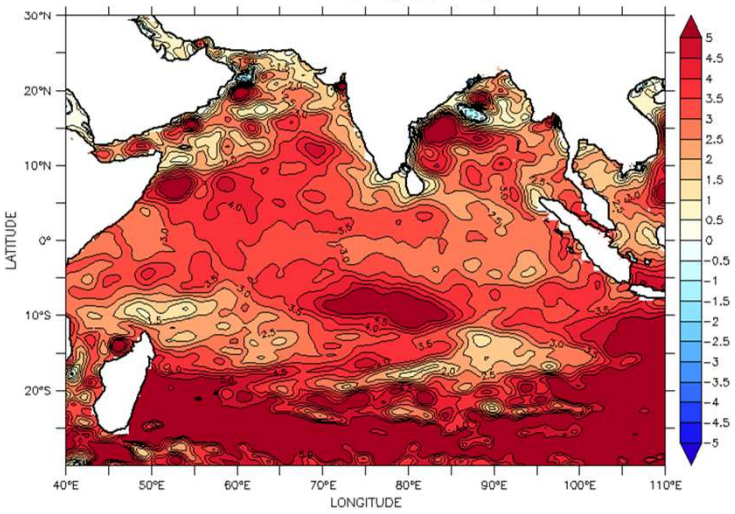
Ocean

- SST Trends (Deg C / year) from NOAA OISST during 1990-July 2014

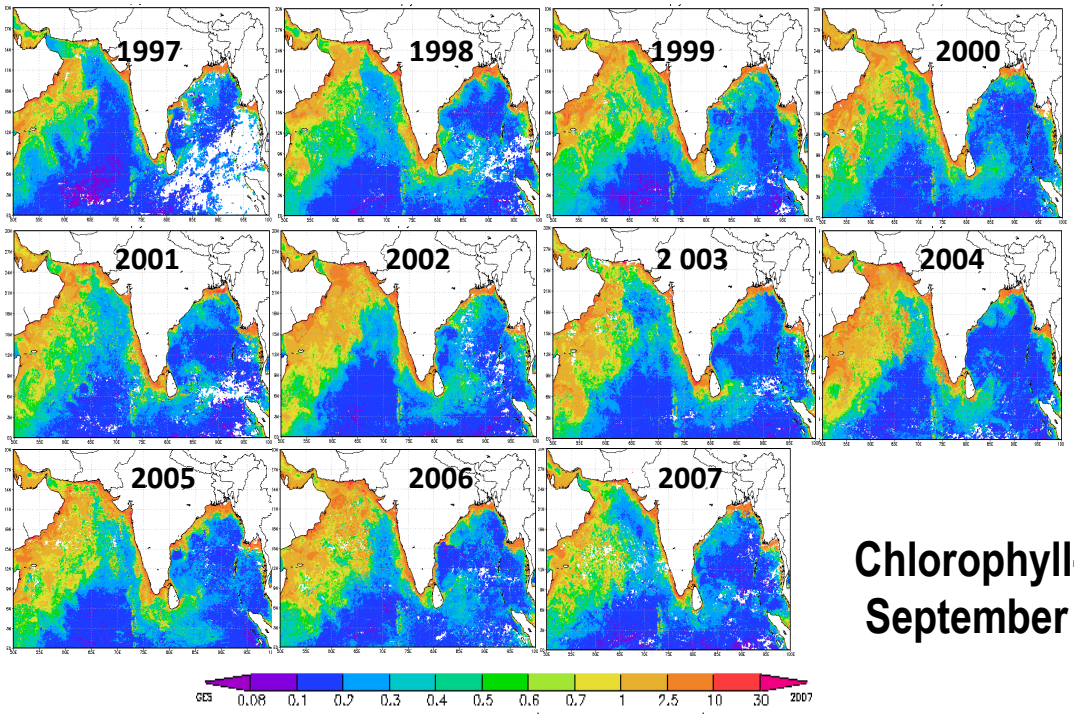


SST trend (DegC/year)

- Sea Level Trends (mm/ year) from Altimeter during 1992-2012



Sea Level Anomaly trend (mm/year)



Chlorophyll-*a* concentration (mg m^{-3})

Chlorophyll-a variability in the Indian Ocean in September month during 1997-2007

Thank You

http://www.isro.org
http://www.isro.gov.in

http://bhuvan.nrsc.gov.in