



# Proposal for Centre for Earth Systems and Climate Change Research



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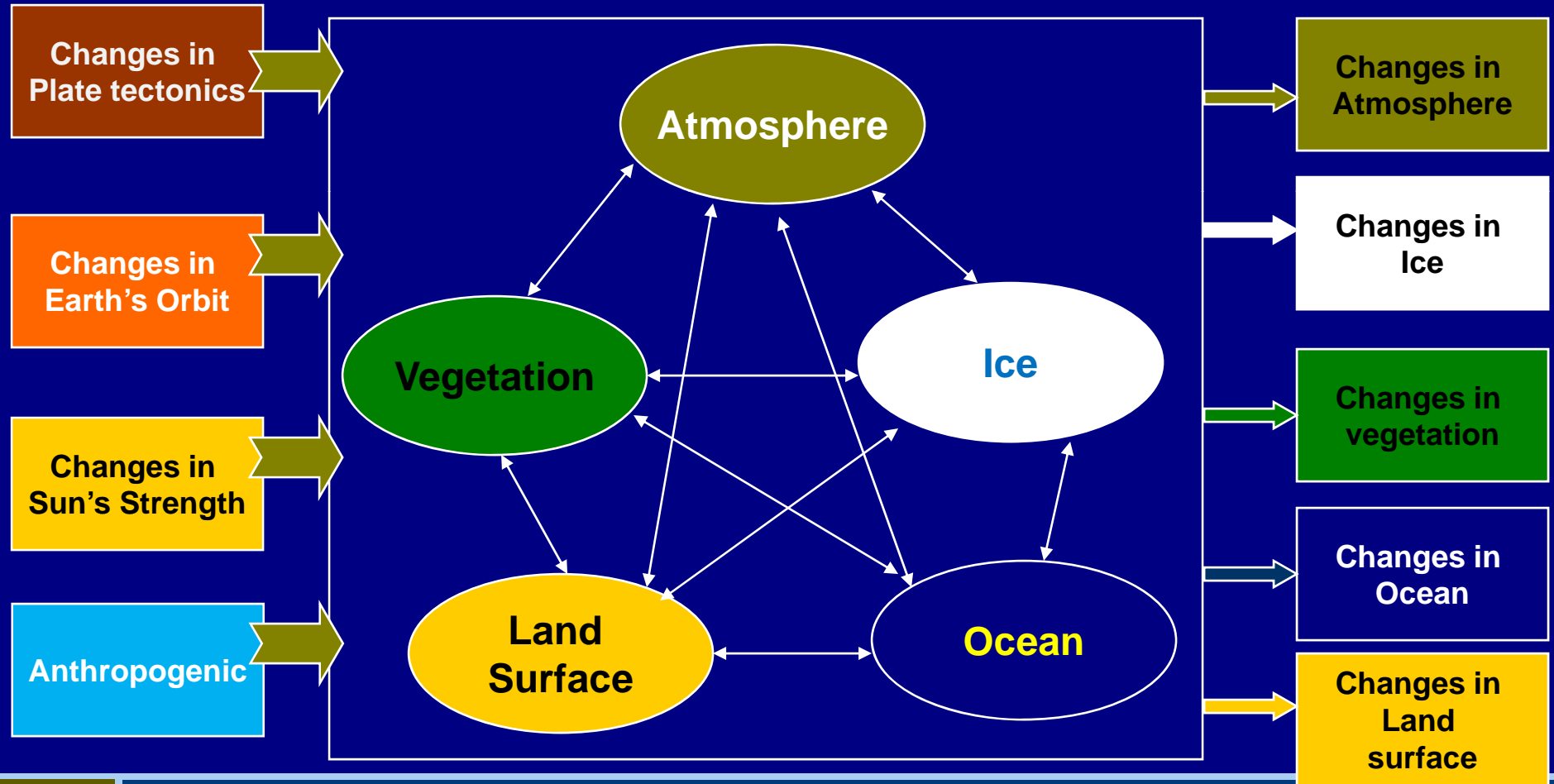
## Indian Institute of Technology Kanpur

# The Climate Machine!

## CAUSES (Forcing)

## EARTH SYSTEM (Internal Interactions)

## VARIATIONS (internal responses)



# 3 Challenges of Climate Change Research

- Scale:
  - “The Earth is faster now”
  - Earth’s process understanding
  - Downscaling of models
- Knowledge base:
  - Mad rush to blame everything to climate change
  - Differential impacts – needs multiple solutions
- Policy issues
  - Mitigation vs Adaptation?
  - Adaptation strategies for whom, for what, how?
  - Trade-offs, Adaptive learning mechanisms?
  - System interventions?
  - Community participation?

What do we need?

I – Information  
I – Initiatives  
I - Implementation



Emphasis on?

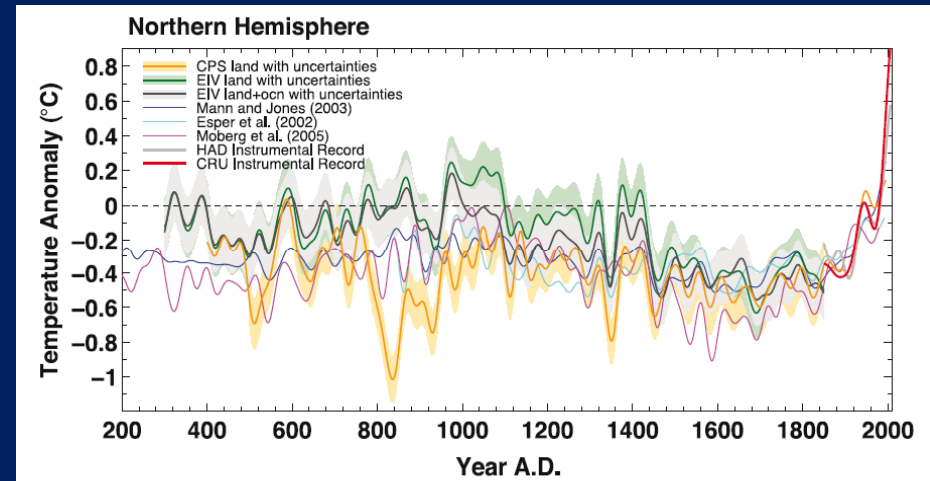
E – Equity  
E – Economy  
E – Environment

**Act Now!**

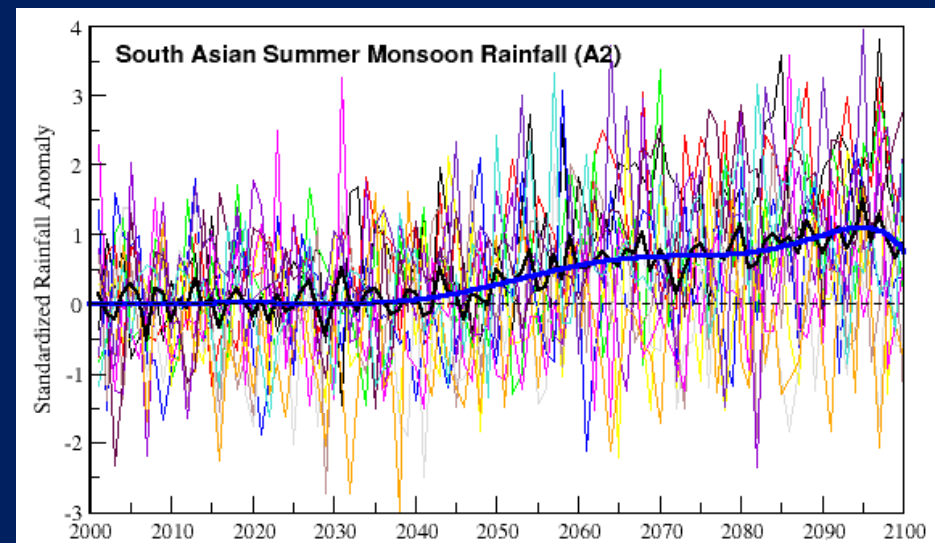
# Major Scientific Questions

- How did the Natural and anthropogenic climate forcing factors vary in the past?
- How sensitive was (and is) the climate system to these forcings?
- What caused the natural greenhouse gas and aerosol variations?
- To what extent can palaeodata constrain climate sensitivity and the carbon cycle-climate feedback?
- In what precise sequence and over what timescales did changes in forcings, climate and ecological systems occur?
- How do we assess the impact of climate change on natural resources e.g. water resources and on ecological systems
- How do we develop strategies to adapt to changing climate – technological solutions, social engineering, public participation?

(PAGES, 2009, IBGP Report no. 57. Stockholm)



(Mann et al., 2008, NAS, USA)



(Goswami et al., 2006, Nature)

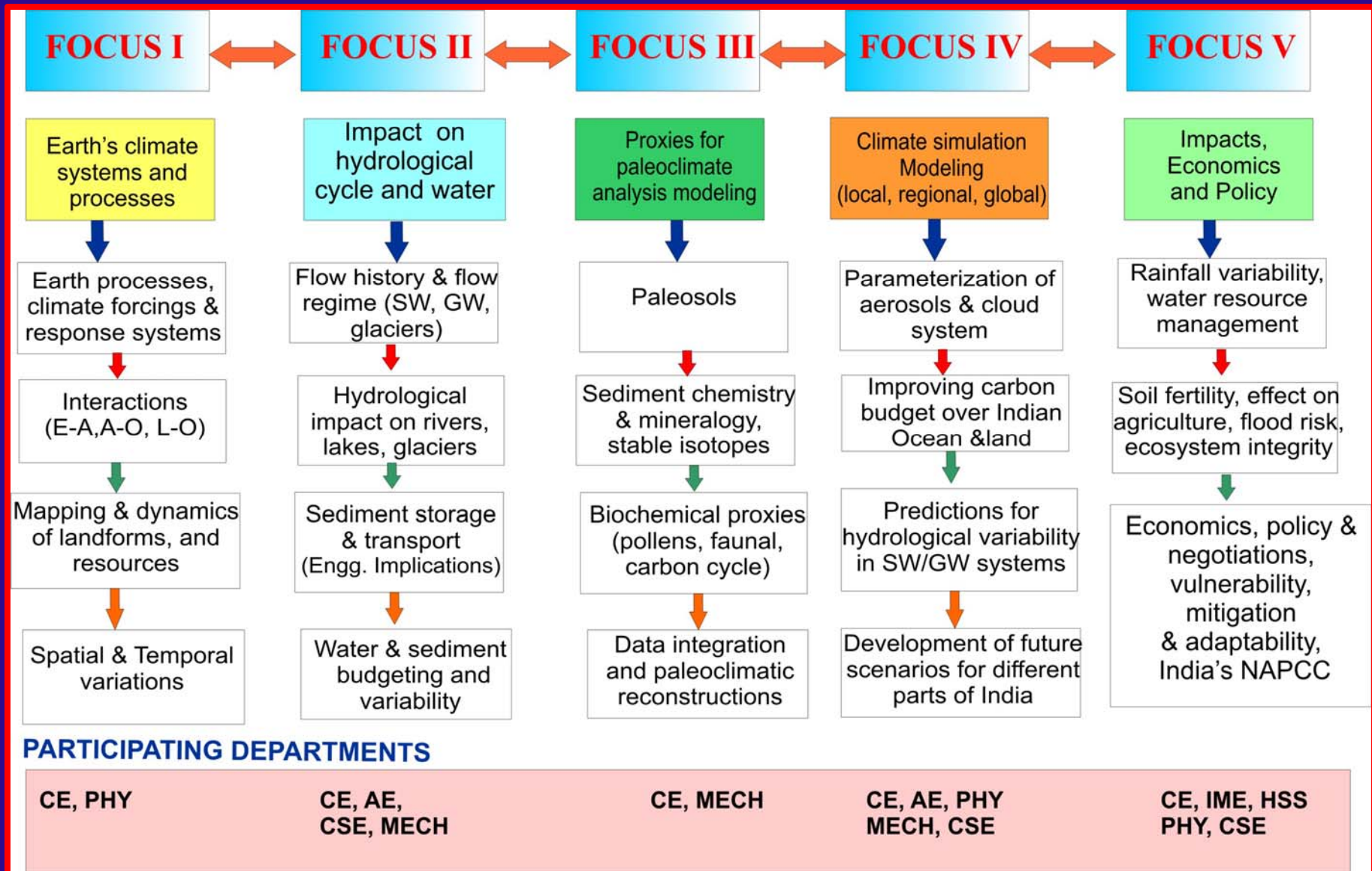
# Centre for Earth Systems and Climate Change Research at IITK: Major Objectives

- To generate new data and knowledge on the climate variability (spatial and temporal) of the Indian sub-continent and its bearing on global scale
- To impart training for capacity building and manpower development in Earth systems and climate studies.
- To develop infrastructural facilities for climate change research related to observational, experimental, analytical and modelling studies.
- To facilitate information, literature and data collection and dissemination related to climate change scenarios in India.
- To make policy makers aware of the key issues related to climate change.



**Climate research needs a fusion!**

# Proposed Structure and Activities



# Participants and Knowledge Partners

## IIT Kanpur

1. Rajiv Sinha, CE
2. S.N. Tripathi, CE
3. D. Paul, CE
4. R. Srivastava, CE
5. Ashu Jain, CE
6. P.K. Mohapatra, CE
7. Tarun Gupta, CE
8. Harish Verma, Phy
9. Sanjay Mittal, AE
10. Pankaj jain, Phy
11. Mahendra Verma, Phy
12. P.M. Prasad, HSS
13. P. Kulshreshtha, HSS
14. Sarani Saha, HSS
15. Anoop Singh, IME
16. R. Gurunath, Chem
17. Ishan Sharma, Mech
18. T.V. Prabhakar, CSE
19. Rajat Moona, CSE

## National Institutions

1. PRL, Ahemedabad
2. NIO, Goa
3. NCOAR, Goa
4. University of Delhi, Delhi
5. JNU, New Delhi
6. IIT Roorkee
7. Dibrugarh University
8. IIT Kharagpur
9. IIT Mumbai
10. BSIP, Lucknow
11. WWF – India
12. NIH, Roorkee
13. IIT Delhi
14. Vishwabharti University
15. TARU, Hyderabad

## International Institutions

1. Columbia University, USA
2. CH2M HILL, Oakland, CA
3. University of Cambridge, UK
4. Imperial College, London
5. University of Durham, UK
6. George Mason University, U.S.A.
7. NASA Goddard Space Flight Center
8. Georgia Institute of Technology
9. University of Reading, UK
10. Oxford University , UK
11. CRPG-CNRS, Nancy, France
12. University of Texas, Austin
13. University of Maringa, Brazil

# Focus I: Earth's Climate System and processes: Key issues

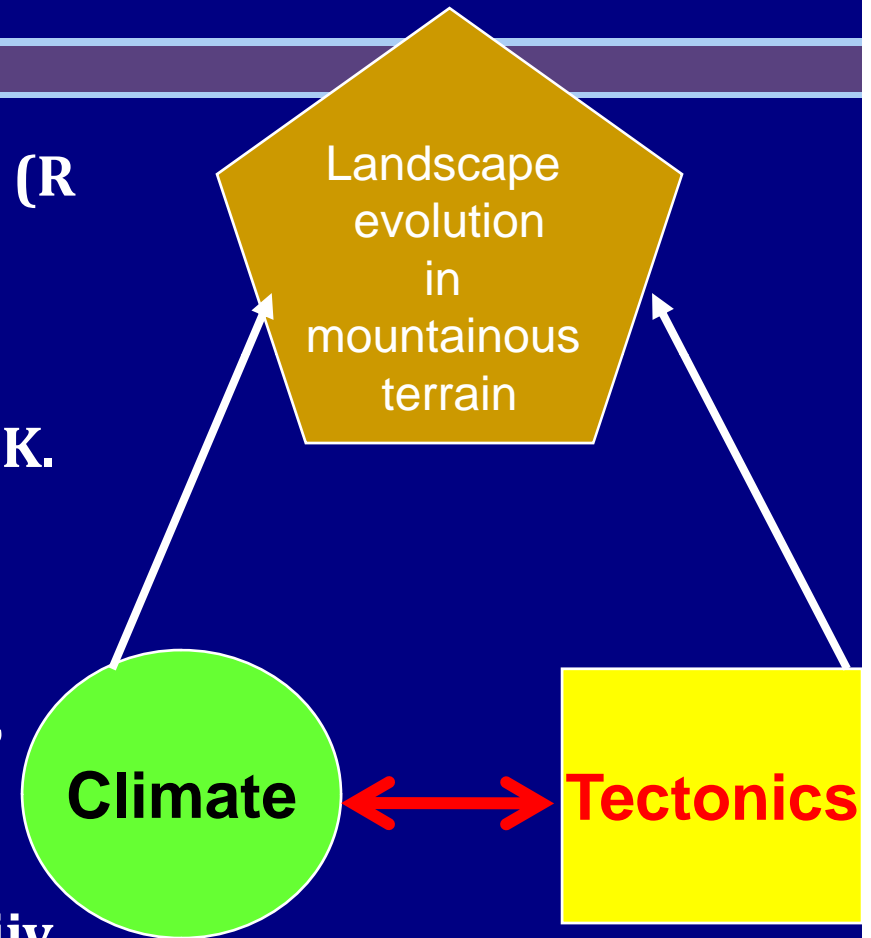
- Land-ocean-atmosphere interactions – inputs for modeling
- Response of earth's systems to climate change – spatial and temporal scales, tectonics-climate coupling
- Natural variability vs anthropogenic effects
- Dynamics of earth's systems – viz. rivers

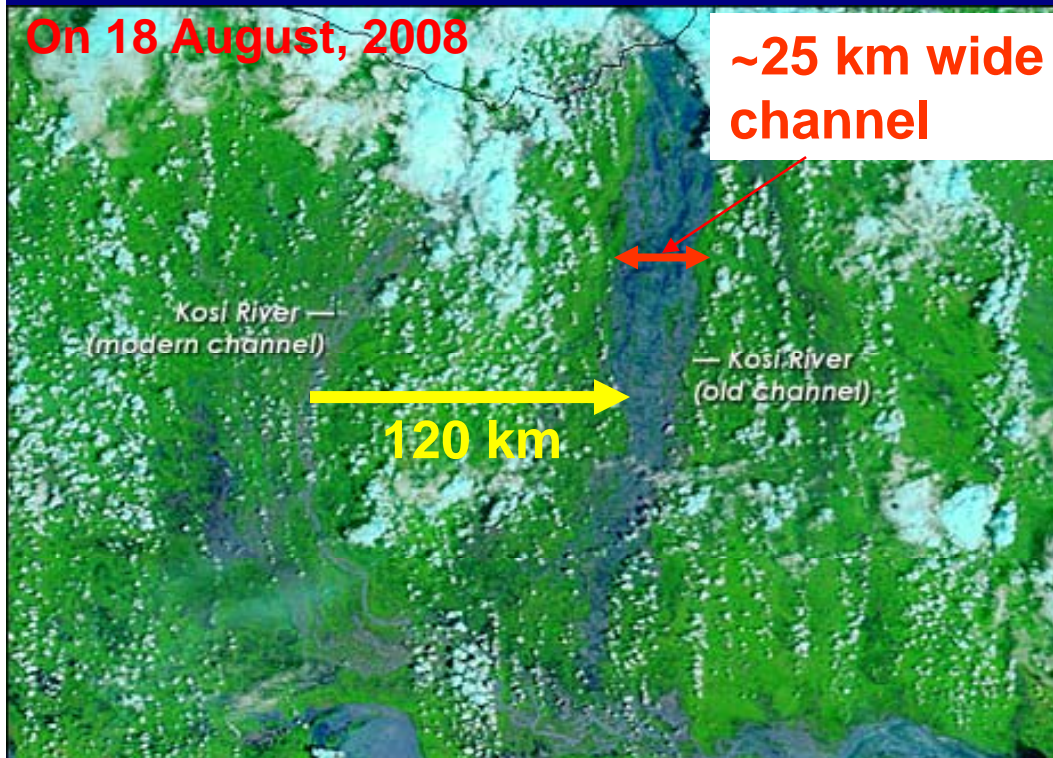




# Focus I: Earth Climate System and Processes: Research Themes

- **Theme 1: Tectonics-climate coupling (R Sinha, Vikrant Jain, Malay Mukul) - Ongoing (DST)**
- **Theme 2: Catchment processes and landscape dynamics (Vikrant Jain, S. K. Tandon, R. Sinha) - New initiative**
- **Theme 3: River dynamics and hydrologic modelling - use of RS and GIS (R. Sinha, V. Jain, P. K. Mohapatra, Malay Mukul) - Ongoing (MOES)**
- **Theme 4: Ocean-atmosphere teleconnections (Devesh K Sinha, Rajiv Nigam) - new initiative**





## The Kosi case: Choice of paths in climate change scenario

- High vulnerability environment
- Structural approaches
  - Sediment loads
  - Extreme event frequency & maximum flows
  - Minimum flows
- Open basin approaches
  - Weather - early warning
  - Broad extent of potential flooded areas
  - Community flood vulnerability

# Focus II: Impact of Climate Change on Water Resources & Hydrologic Cycle

## Key issues

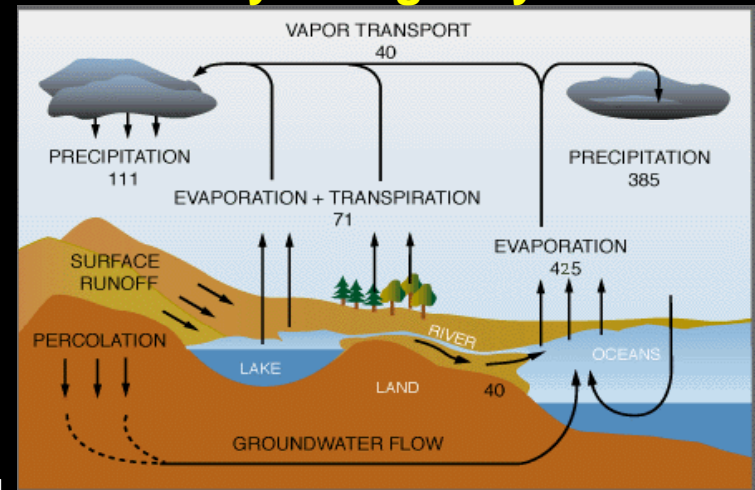
- Increase in atmospheric water vapour content → Increased precipitation
- Change in precipitation patterns → Increased risk of floods and droughts
- Change in soil moisture and runoff → Implications for agriculture and water supply
- Ice melting and reduction in snow cover → Change in runoff pattern
- Sea level rise → Increased seawater intrusion, Coastal population

## Quantification of Impact

Large degree of uncertainty due to:

- Projected socio-economic development
- Emission scenarios in climate models
- Downscaling - global to regional
- Limited observations
- Incomplete understanding

## Hydrologic Cycle



## Research Needs and challenges

- Analysis at higher spatial and temporal resolution
- Probabilistic Analysis
- Appropriate downscaling methods
- Climate-linked watershed models for quick evaluation of impacts
- Coupled climate -land use models
- Socio-economic & ecological impacts

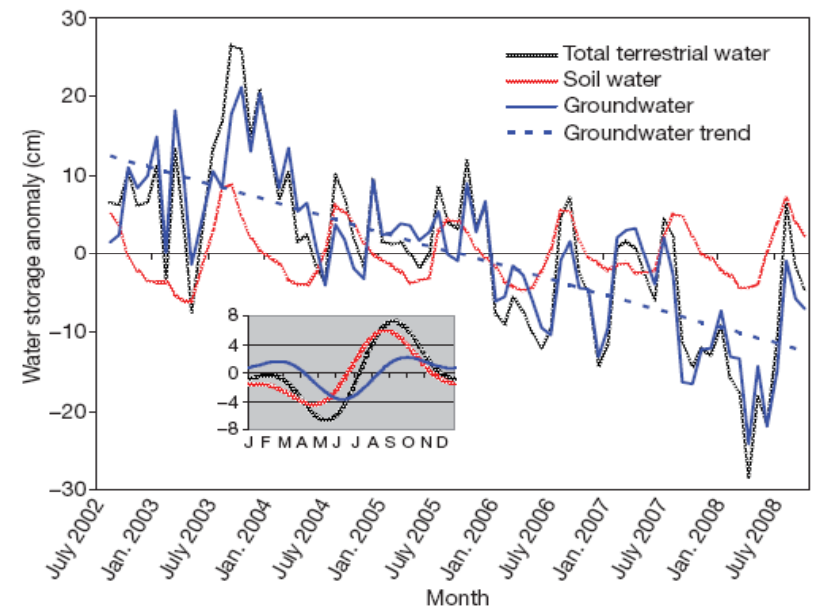
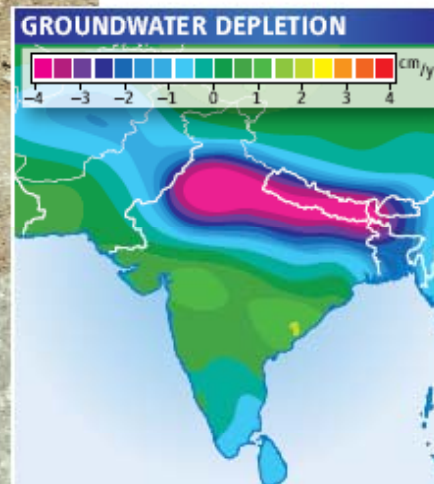
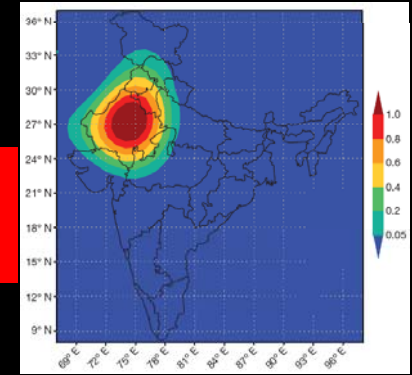
# Northern India's Groundwater Is Going, Going, Going ...

NASA GRACE satellites



**Groundwater loss:  
54 BCM per year  
(since 2002)  
= 10 cm/year fall  
in the water table**

**=>Water stress is  
already here!**



Monthly time series of water storage anomalies in northwestern India

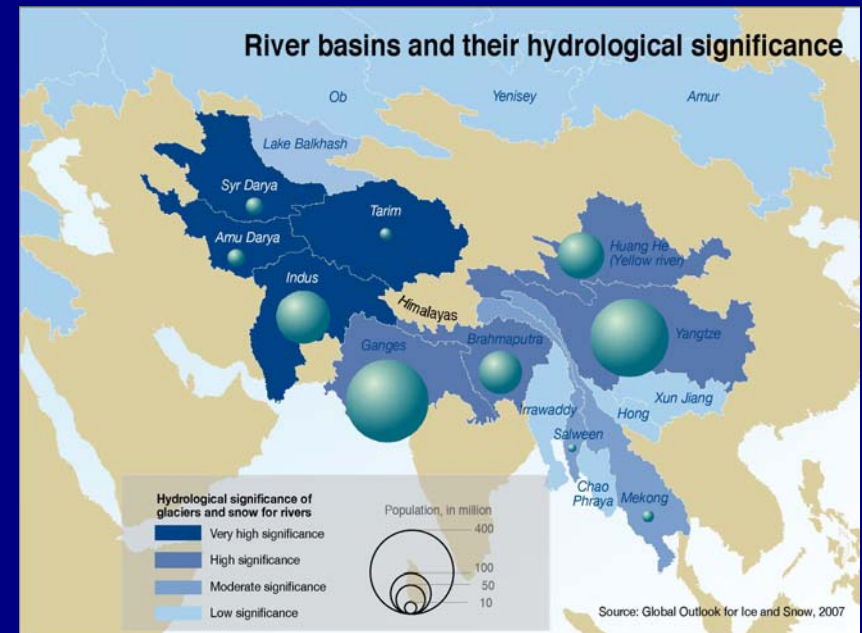
(Rodell et al., Nature, 18 Aug., 2009)

Richard A. Kerr,  
Science, 14<sup>th</sup>  
August, 2009

**“Groundwater is NOT  
bottomless and when we  
hit the bottom, the  
situation could get very  
scary.....”**

# Focus II: Impact of Climate Change on Water Resources & Hydrological Cycle

- Theme 1: Basin-scale assessment of water resources and planning for future (R. Srivastava, Ashu Jain, P.K. Mohapatra) – **new initiative**
- Theme 2: Integrated water resource management for the Ganga basin in a changing climate scenario (Udai P. Singh, U. Lall, U.C. Kothiyari, R. Sinha) – **new initiative**
- Theme 3: Connectivity analysis of a large river- The Ganga dispersal system (S.K. Tandon, V. Jain) - **Ongoing**
- Theme 4: Flow energy and future trajectory of river systems (V. Jain and R. Sinha) – **new initiative**
- Theme 5: River morphology-hydrology linkage (U.C. Kothiyari) – **new initiative**

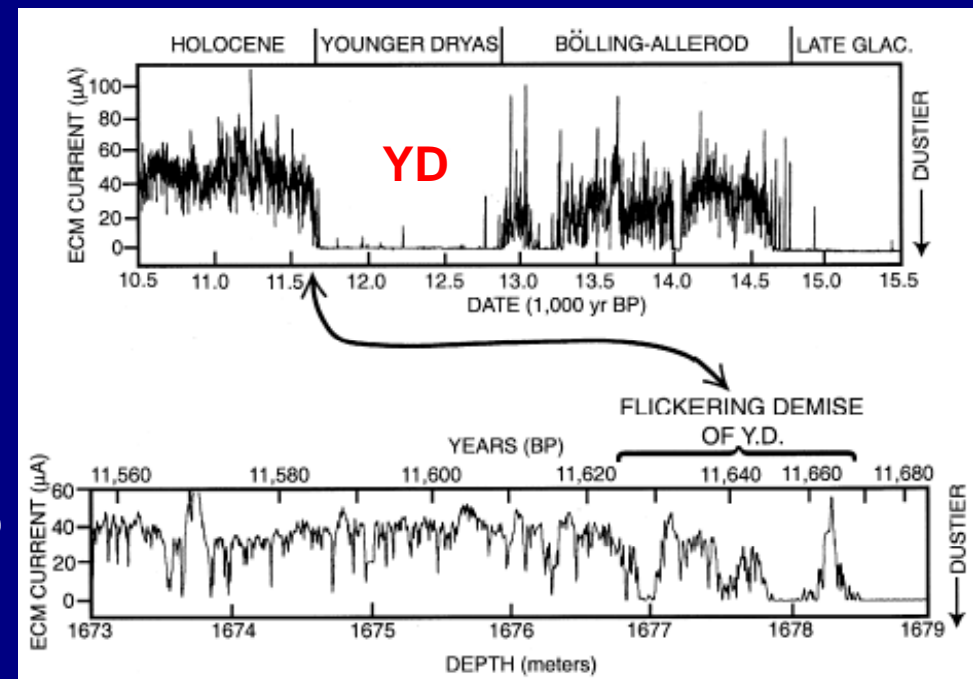


# Focus III: Proxies for paleoclimate analysis

## Key issues

- Secular trends of SW monsoon variability for the past **100 ka** hampered by poor age constraints and often contradictory
- High-resolution data for the entire Holocene time period ( $\leq 10$  Ka) scarce - important to understand human response to climate changes
- Data on **short-term, century scale** variations from continental settings very limited

YD is yet to be properly documented from the Indian sub-continent!



**Abrupt climate change  
in the last 20 ka**

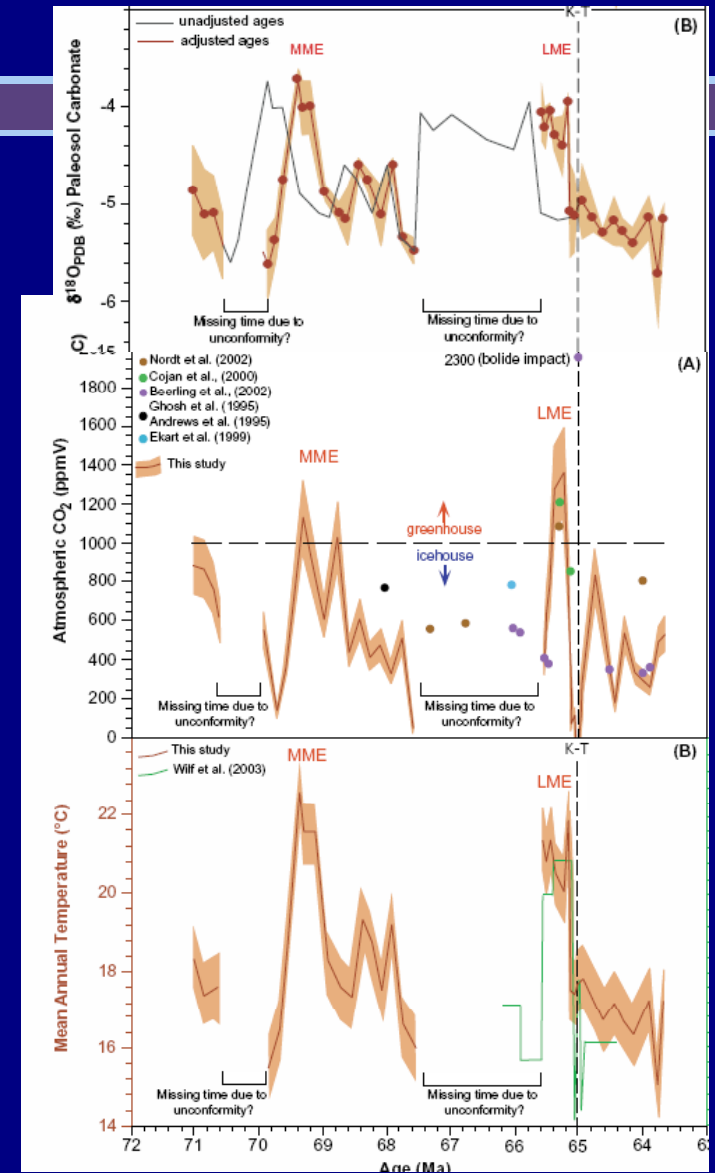
# Focus III: Proxies for Paleoclimate Analysis

- Theme 1: **Paleoclimate and paleovegetation reconstruction** in Northern India for the past 100 Ka (D. Paul, Anindya Sarkar, Vandana Prasad) – **new initiative**
- Theme 2: **Decade-to-Century scale** climate variability reconstructed from sedimentological and archaeological Proxies (D. Paul, R. Sinha, Sheena Panja) – **new initiative**
- Theme 3: Carbon isotope composition of peat bogs in India as a proxy to reconstruct **century-scale** climate fluctuations (D. Paul, A. Sarkar) – **new initiative**
- Theme 4: Geochemistry of sedimentary archives and climate change study (J.K. Tripathi) – **new initiative**



# Realistic Outcome

- Quantitative reconstruction of temp., ppt.,  $p_{CO_2}$  variations for the past 100 Ka, and more specifically for the past 10 Ka –**input for regional-scale models**
- Chronology of abundance of **paleovegetation patterns** ( $C_3$  and  $C_4$  plant distribution) in NW India.
- Linkage between sudden climate change and disappearance of Harappan civilization to understand **adaptation strategies** of humans to climate change.

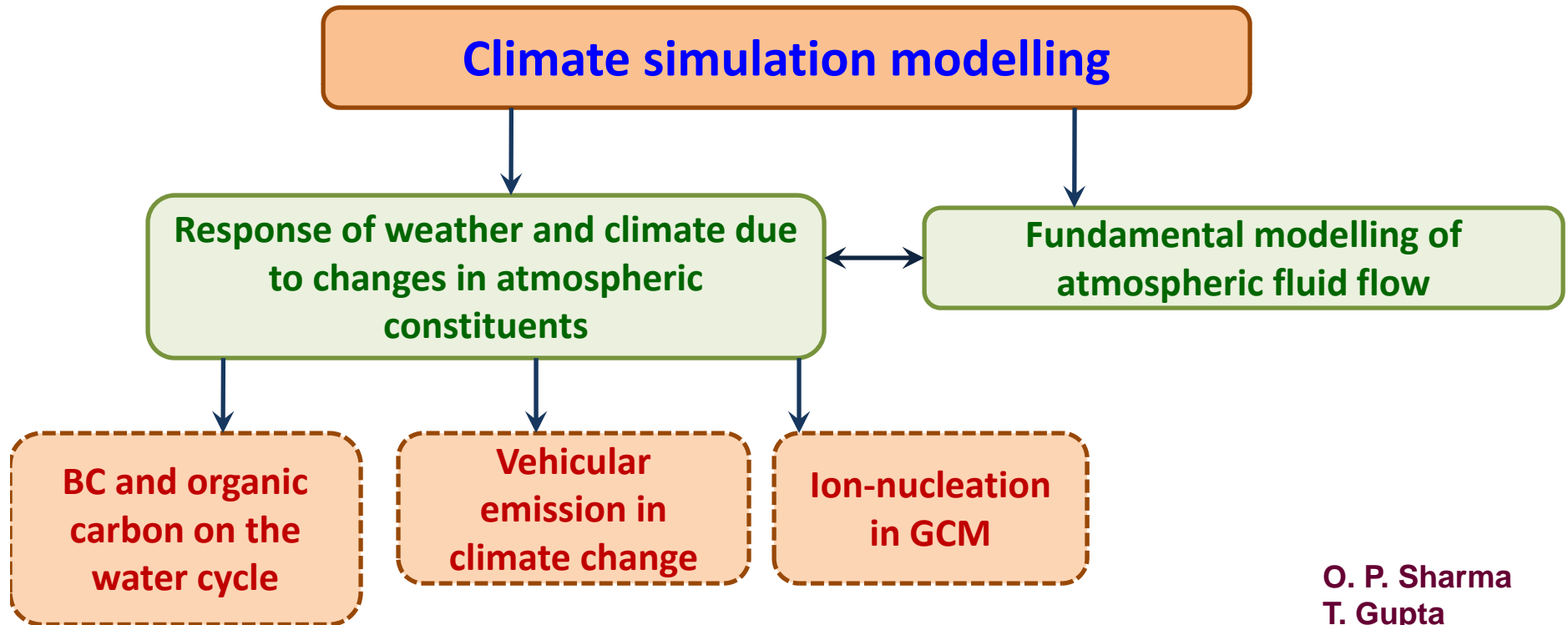




# Focus IV. Climate Simulation Modelling (local, regional, global)

## Goals:

1. Understand the influence of anthropogenic aerosols on weather and climate
2. New Code Development



**Strong Synergism**

O. P. Sharma  
T. Gupta  
I. Sharma  
M. K. Verma  
S. N. Tripathi

# Theme 1: Role of Black Carbon and Organic Aerosols on the Water Cycle and Rainfall over India (SNT, TG) – new initiative

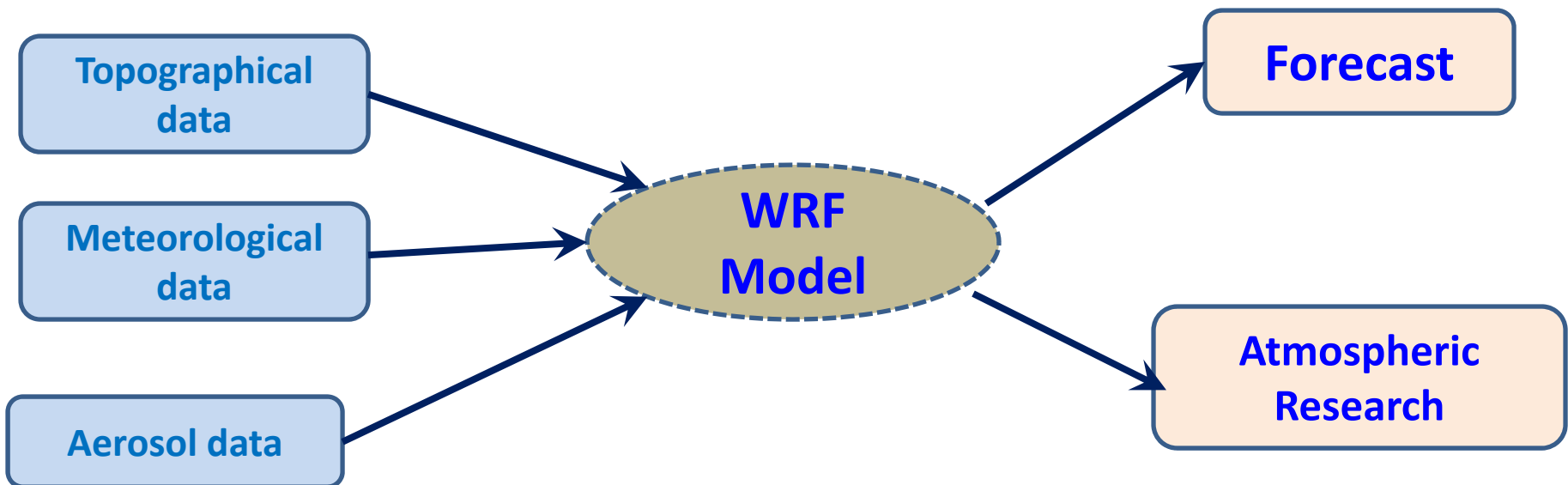
**Goal 1:** Effect of elevated loading of aerosols in the hydrological cycle

**Goal 2:** Role of BC in the monsoonal rainfall

**Goal 3:** Long-term climatological effects of aerosols

## WRF (Weather Research and Forecast) model

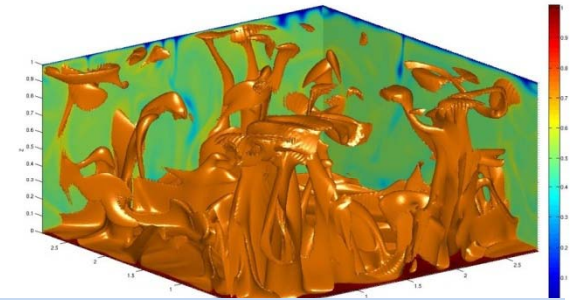
WRF is a mesoscale numerical weather prediction system, which is suitable for a broad spectrum of applications across scales ranging from meters to thousands of kilometers.



## Theme 2: Numerical Simulation of Atmosphere (MKV, IS, SNT) – new initiative

- Solve for the velocity, temperature, moisture etc. using Direct numerical simulations.
- Validate the simulations using past data.
- Predict the future climate using the models.

Convection simulation using the existing pseudospectral code.

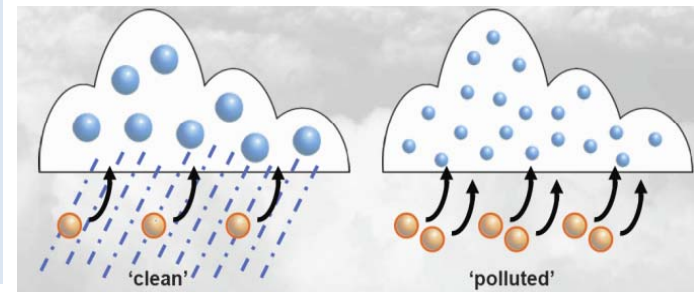


## Theme 3: In Situ Particle Formation in Aerosol Indirect Effect (SNT, OPS) - ongoing

Implement existing nucleation parameterizations for homogeneous and ion- induced nucleation and estimate the ultra fine particle formation, in a Global Circulation Model to understand their contribution to cloud condensation nuclei concentrations globally.

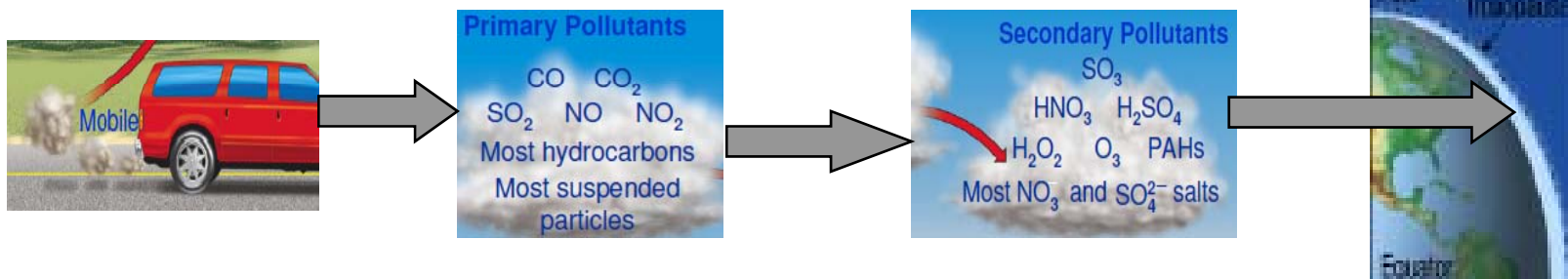
This will help address the aerosol indirect effect

Focus on Monsoons - India and Southeast Asia



## Theme 4: Role of Vehicular Pollution in Climate Modification (TG,SNT) – new initiative

Aerosol indirect effect: Cloud lifetime effect



# Focus V: Impacts, Economics and policy of climate change: Indian scenario

- World's 4<sup>th</sup> largest and Asia's 2<sup>nd</sup> largest economy
- World's 5<sup>th</sup> largest greenhouse gas (GHG) emitter (TERI, 2008; Sengupta, 2007)
- Rapid industrial growth (about 5% a year), costs India an estimated \$9.7 billion a year in environmental damages [USAID]
- India's initiatives towards Climate Change
  - Ratified UN Framework Convention on Climate Change (UNFCCC) in 1993 and Kyoto Protocol in 2002
  - Active participation in Clean Development Mechanism (CDM) and Asia-Pacific Partnership on Clean Development and Climate (APP) - Australia, China, India, Japan, Republic of Korea, and the USA
  - PM released National Action Plan on Climate Change (NAPCC) in 2008
- Copenhagen, November 13, 2009
- Hanoi, January 19-21 2009
- Bamako, February 24-25 2009
- Nairobi, April 16-17 2009
- Kathmandu, 29-30 August, 2009
- Copenhagen 2009 (COP15)

# Towards Copenhagen 2009 (COP15)

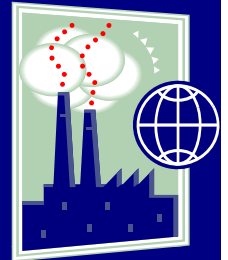
- **Holistic approach** for land and water management systems, adaptation needs
- Need of infrastructure to reduce **water disaster & risk**
- Focus in Kyoto and after was on mitigation- carbon trade, reduced emissions reforestation.....
- New emphasis on **adaptive capacity** and **Knowledge-based** adaptation measures
- Adaptation in a **development context**
- **Financing for adaptation** is a key element in the COP15 negotiations.
- **Resilience**- for ecosystems and livelihoods
- **Partnership** between research, government civil society, media.
- **Spatial scale**: transboundary/regional, national, local governance, community to household



# Focus V: Impacts, Economics and policy of climate change - Indian scenarios

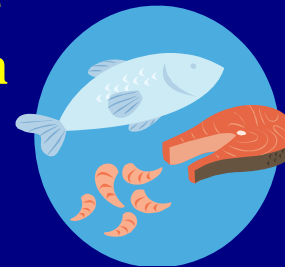
## ➤ **Theme 1: Climate Change: Mitigation/ Adaptation Mechanisms (P. Kulshreshtha, S. Saha, P.M. Prasad) – new initiative**

- Develop a feasible permit trading market for GHG (Carbon trading) and water pollutant
- Subsidies and its Implications on Global Warming



## ➤ **Theme 2: Environmental flow in the Ganga river for sustainable biodiversity (R. Sinha, P.M. Prasad, V. Jain) - ongoing, WWF India**

- Multi-disciplinary approach including: biodiversity, fluvial geomorphology, hydraulics, water quality and socio-economic issues

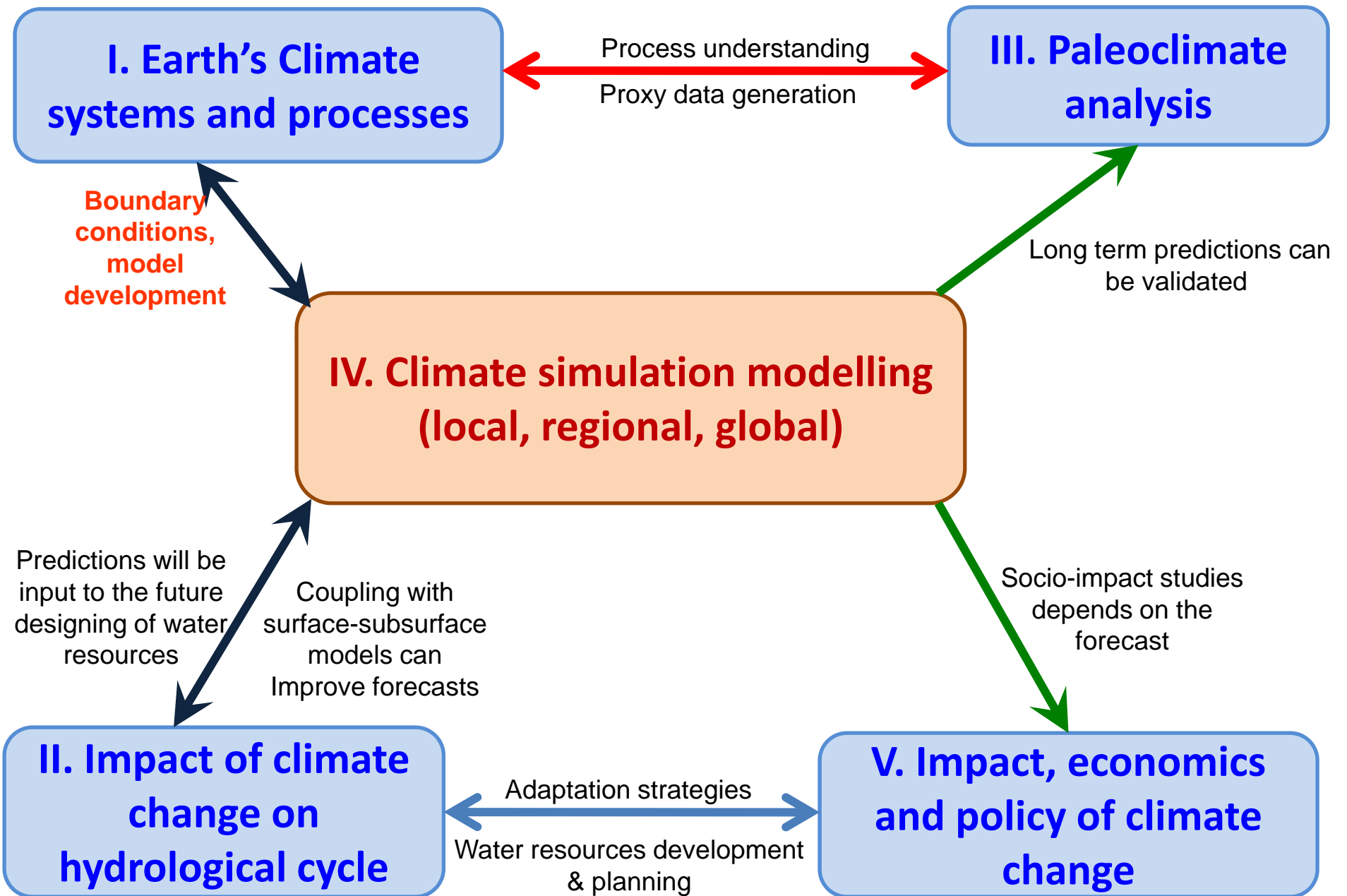


## ➤ **Theme 3: Socio-economics, policy and negotiations of climate change (Anoop Singh, P. Murli Prasad) – new initiative**

- Mitigation vs. adaptation
- Negative Externalities – Voluntary Bargaining, ex-ante and ex-post approaches, Centralized and Decentralized policies

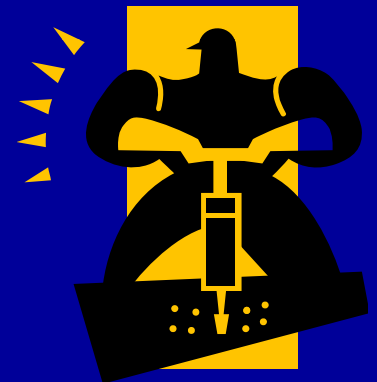


# Linkages



# Deliverables

- **Coordinated research programmes**
  - Quantification of impact of climate change on water resources
  - Development of India-specific GCM
  - Adaptive measures and economic instruments
- **Manpower development**
  - Short term courses
  - Workshops and training programmes
  - Development of a teaching programme (degree programme)
- **Knowledge dissemination**
  - Public participation programmes
  - Invited lectures
  - National/International conference





# Multiplier Effects

- Create 'space' in climate research at IITK
- A multi-disciplinary platform for interaction between scientists, engineers, economists and policy researchers
- Motivation for students
- Should attract new faculty – interested in multi-disciplinary research
- Societal relevance

# Tentative Financial Requirements



Budget head	Description	Budget (Lakhs)
Infrastructure and Instrumentation	Laboratory space, Major analytical facilities, computational facilities and minor equipments	<b>1166</b>
Manpower	Visiting professors, PDF, PhD students, technical and administrative personnel	<b>445</b>
Travel	Advisory committee members for annual meetings, project participants, PDF's and students for attending meetings, seminars and symposia and conferences	<b>125</b>
Contingency and consumables	Chemicals, glassware, spares for major equipments, computer peripherals etc.	<b>140</b>
<b>TOTAL</b>		<b>1816</b>

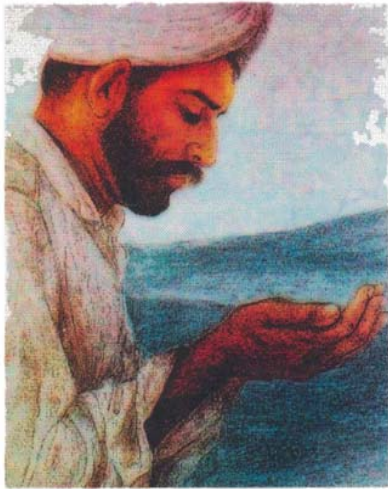
# Possible sources for funding

- Ministry of Earth Sciences – contacted, positive
- Ministry of Human Resources and Development
- ISRO– contacted, positive
- JSW Foundation– contacted, positive
- HSBC-Climate Partnership– contacted, positive
- WWF-India – contacted, positive
- IDRC, Canada/Delhi – contacted, positive
- Ministry of Water Resources
- Ministry of Science and Technology
- Ministry of Environment and Forests
- Ministry of Agriculture
- IITK Alumni

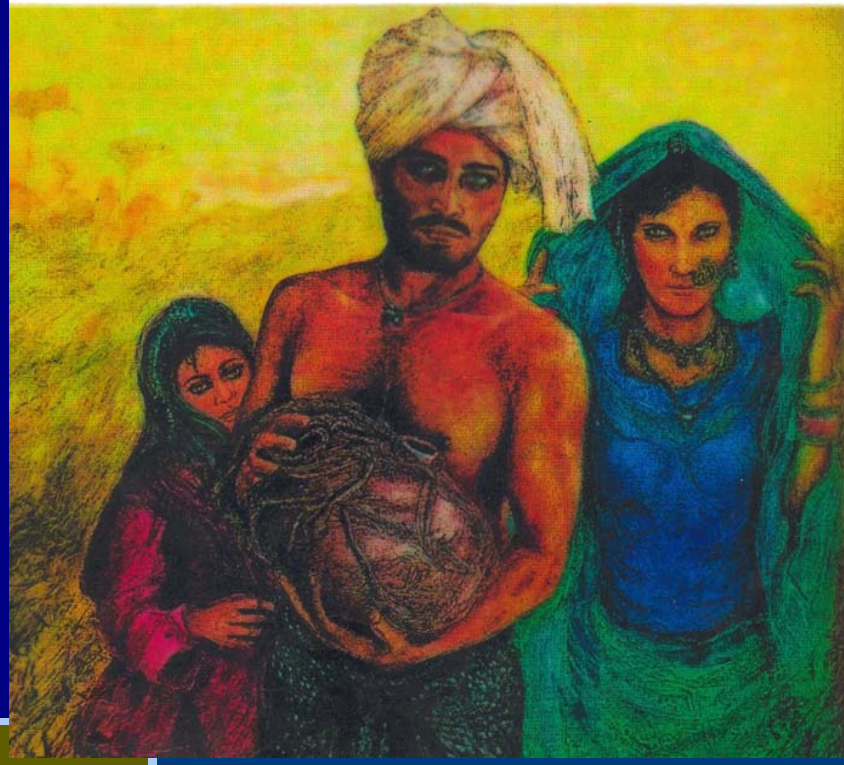


# Project Implementation

- **Advisory Committee**
  - National and international members
  - At least one Full meeting and one National meeting every year
- **Implementation and monitoring committee**
  - DORD
  - Project coordinators
  - Representatives from funding agencies
  - Quarterly review meetings
- **Project participants**
  - Monthly review meetings



*“For the rains to come, the sands thirst a long, long time, for the rains to come, the desert song echoes endlessly, for the rains to come, one more whisper in this silent night.”*



## **Climate Science – People Oriented Science**

**(...those who notice the change  
lead this Science.....)**

***Thank you  
for  
your attention!***