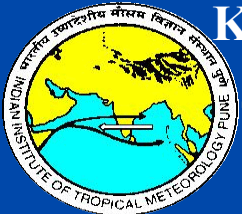# The IITM Earth System Model

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ESM Team: P. Swapna, R. Krishnan, M.K. Roxy, V. Prajeesh, K. Aparna, K. Kulkarni, D.C. Ayantika , V. Ramesh, K. Ashok, B. Preethi, Sandeep, Bhupendra

18th WGCM Session, Germany, 9th-10th October 2014

Science of climate change
Centre for Climate Change Research, IITM, India

Detection, attribution & projection of global climate and regional monsoons, variability and change

## Roadmap for Earth System Model (ESM) development

Start with an atmosphere-ocean coupled model with realistic mean climate

- Fidelity in capturing the global and monsoon climate
- Realistic representation of monsoon interannual variability
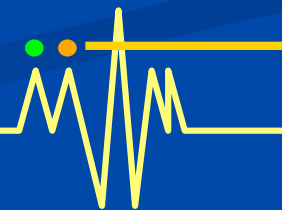- Features of ocean-atmosphere coupled interactions
- …

Include components / modules of the ESM

- Biogeochemistry
- Interactive Sea-ice
- Aerosol and Chemistry Transport
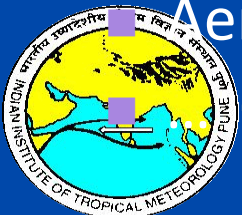
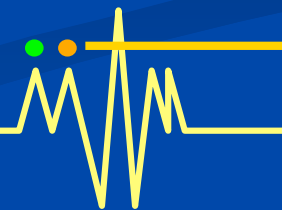# IITM Earth System Model (ESM1.0)

Based on Coupled Forecast System (CFS) T126L64

- The **NCEP CFS** Components

- Atmospheric **GFS (Global Forecast System) model**
  - T126 ~ 110 km; vertical: 64 sigma – pressure hybrid levels
  - Model top 0.2 mb
  - Simplified Arakawa-Schubert convection (Pan)
  - Non-local PBL (Pan & Hong)
  - SW radiation (Chou, modifications by Y. Hou)
  - Prognostic cloud water (Moorthi, Hou & Zhao)
  - LW radiation (GFDL, AER in operational wx model)
  - Land surface processes (Noah land model)

- Interactive Ocean: **GFDL MOM4p1** (Modular Ocean Model-4p1)
  - 0.5 deg poleward of 10^oN and 10^oS; and 0.25 deg near equator ($10^oS – 10^oN$)
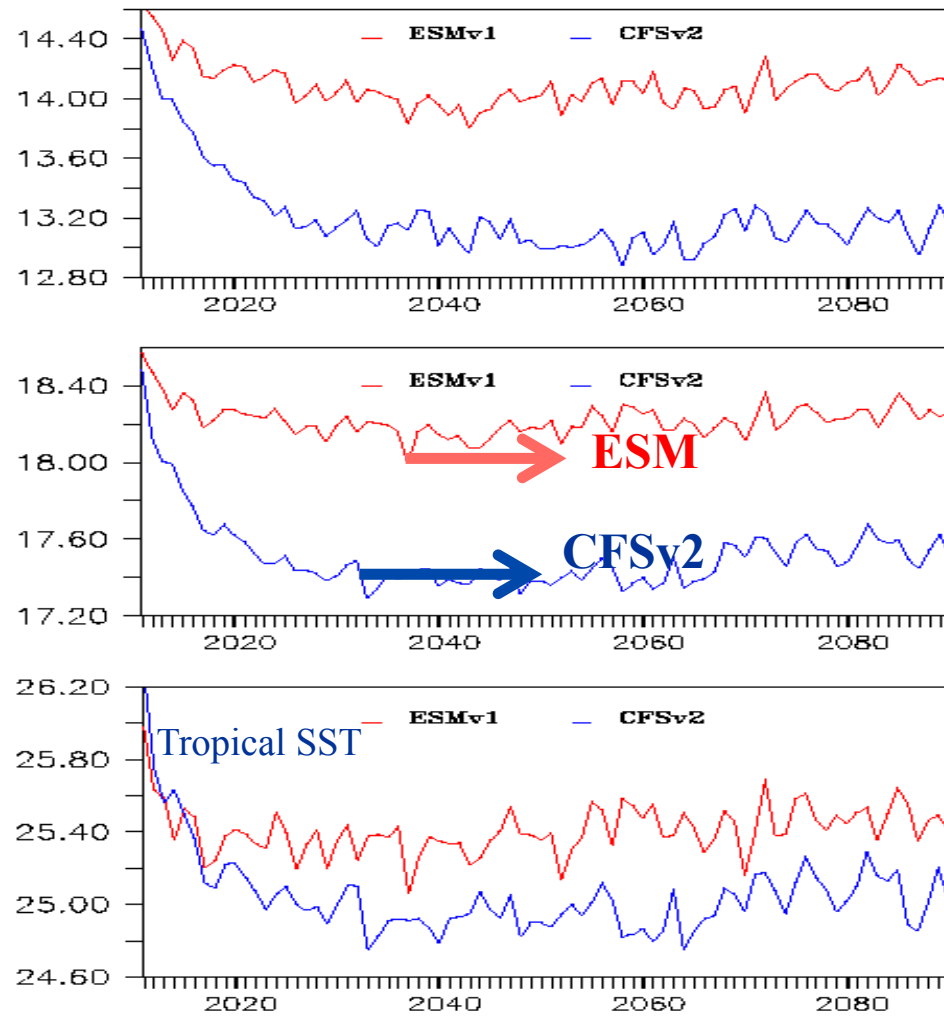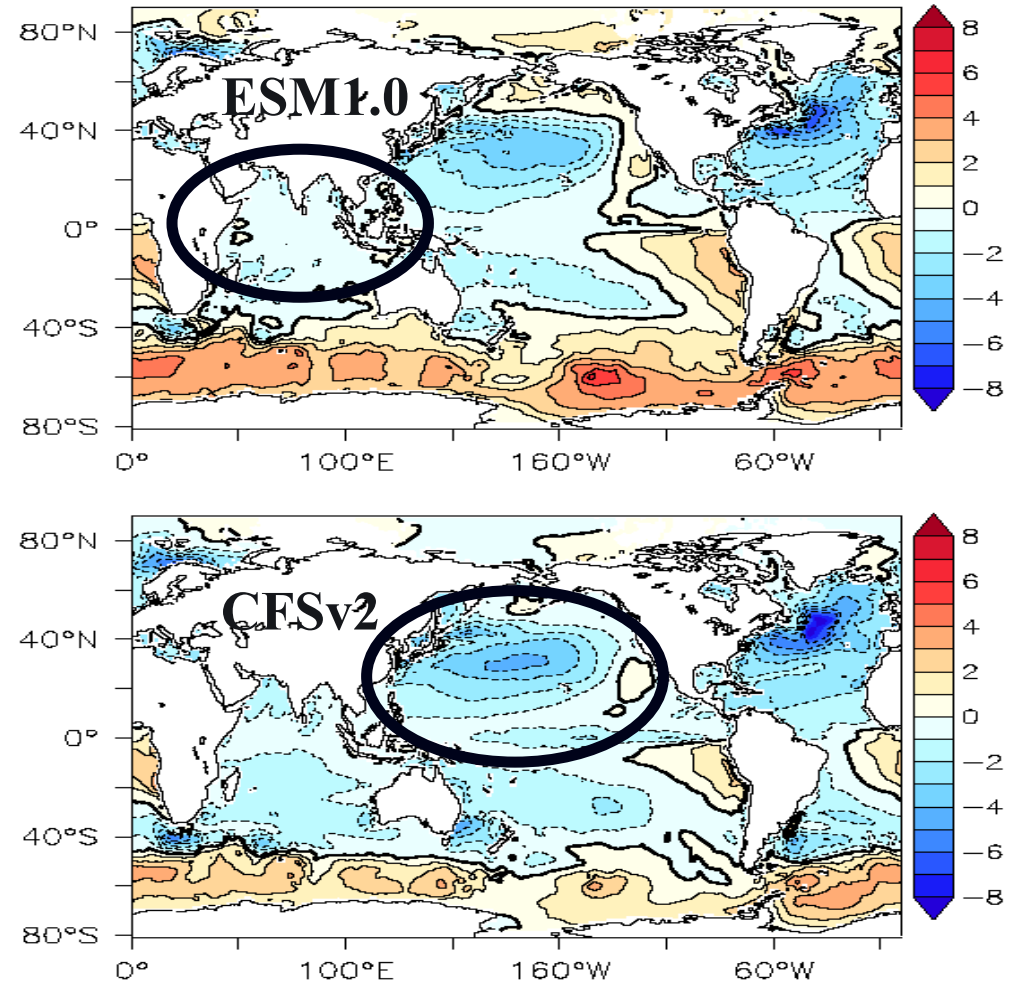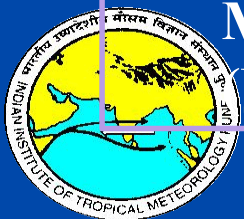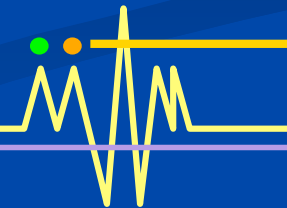 - 40 levels
  - Interactive sea-ice
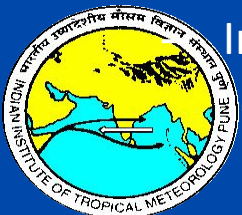
Global mean surface (2m) temperature

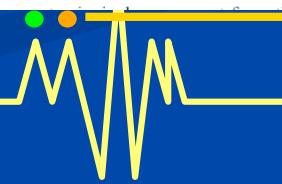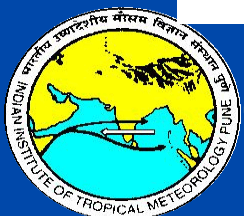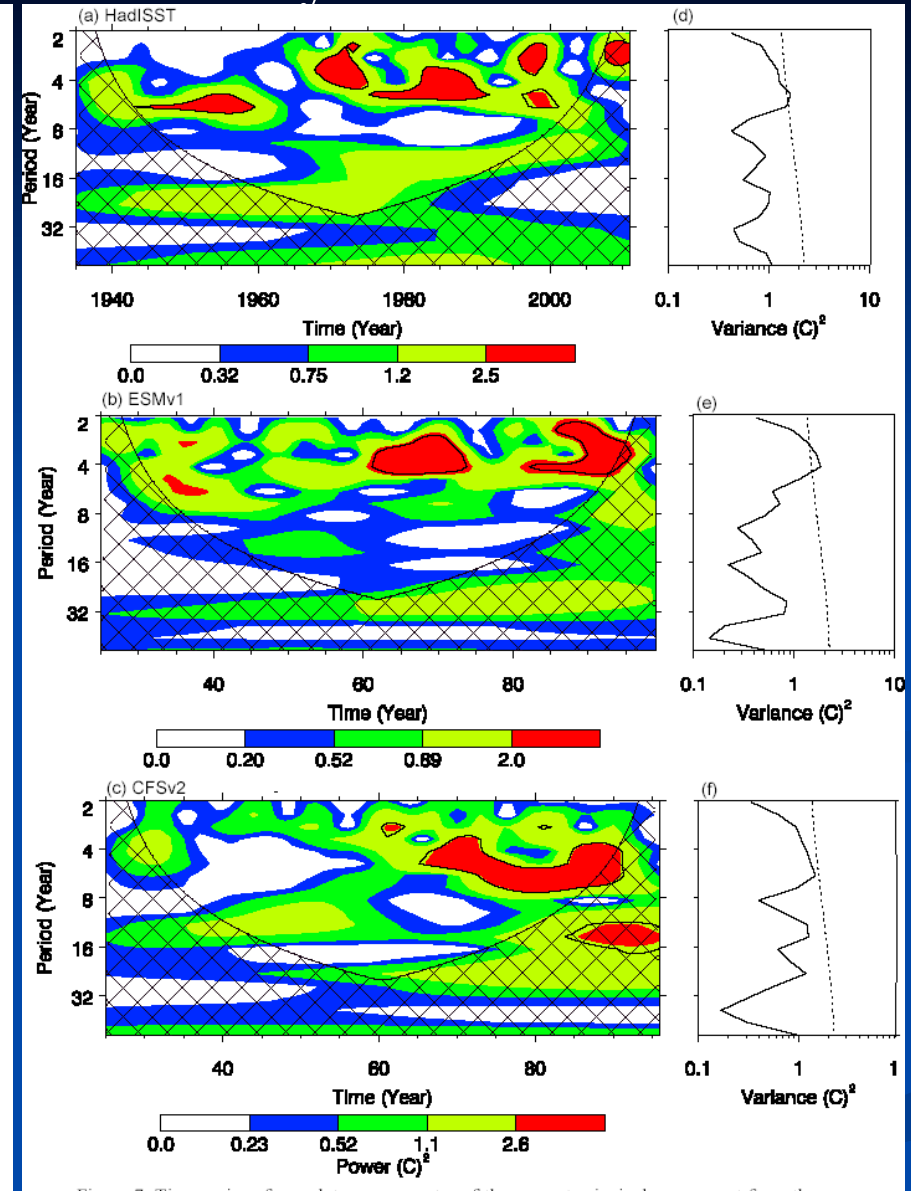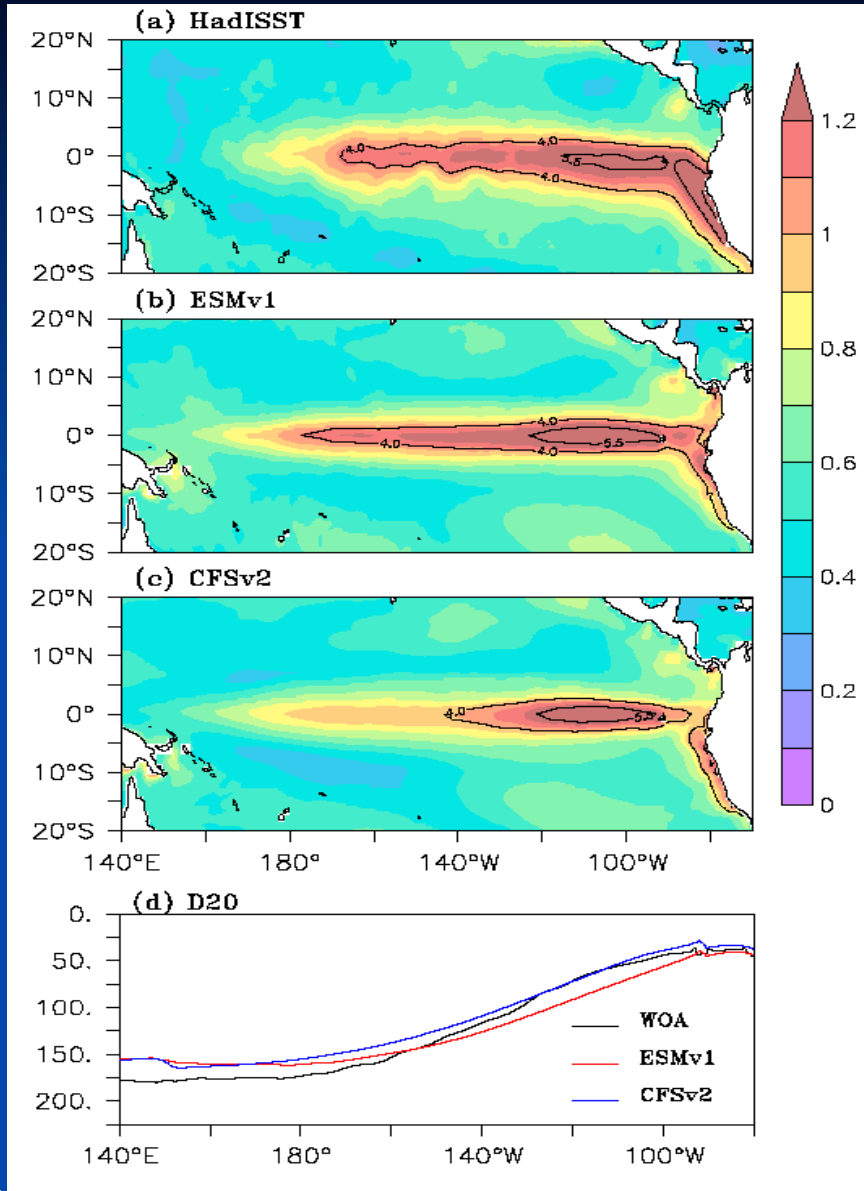# Annual mean SST difference (Model minus WOA)

The IITM Earth System Model: Transformation of a Seasonal Prediction Model to a Long Term Climate Model. Swapna et al. (Under Review, BAMS).

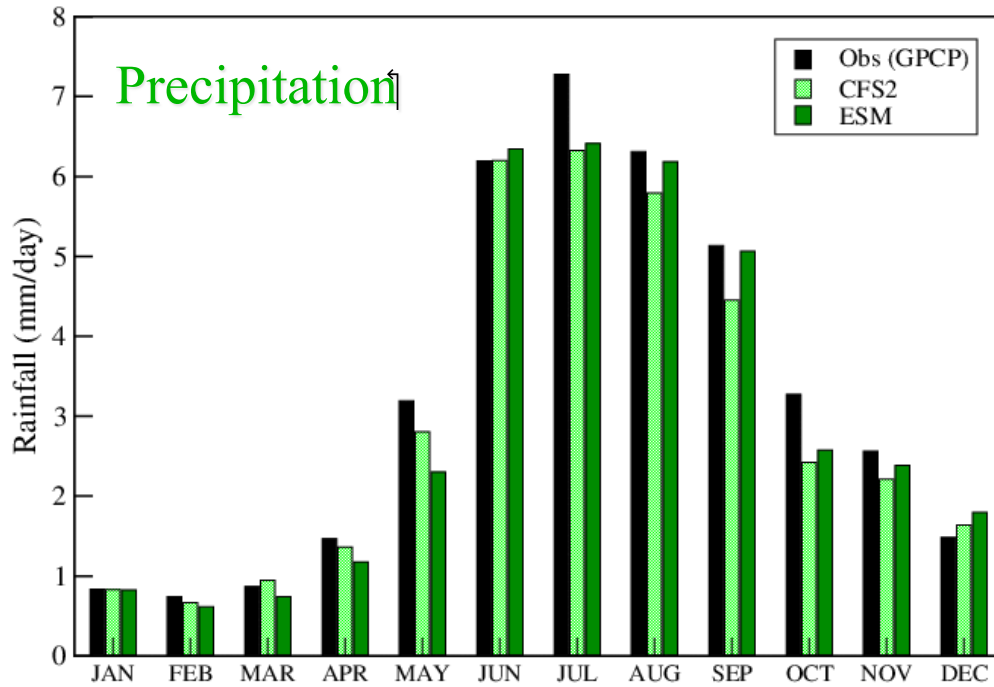18th WGCM Session, Germany, 9th-10th October 2014
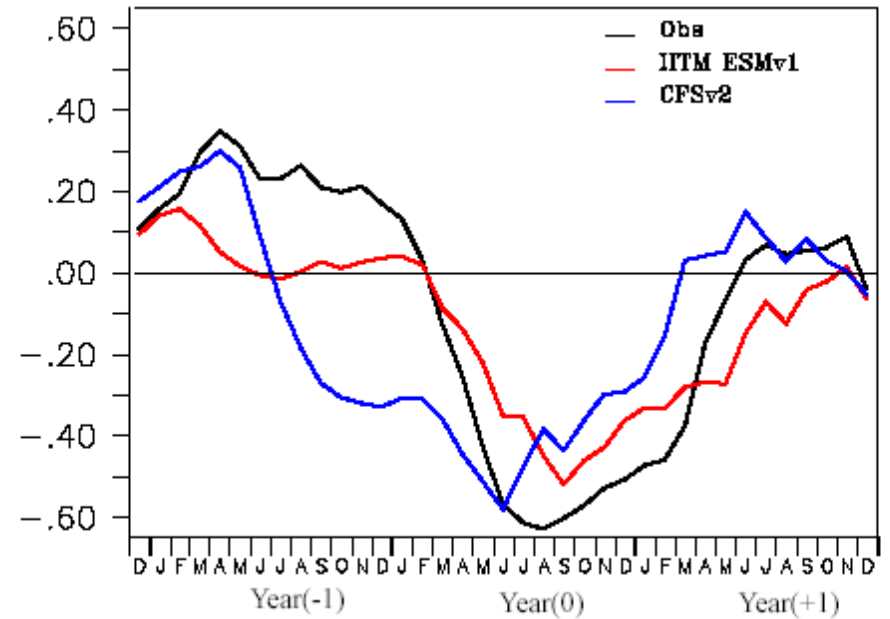
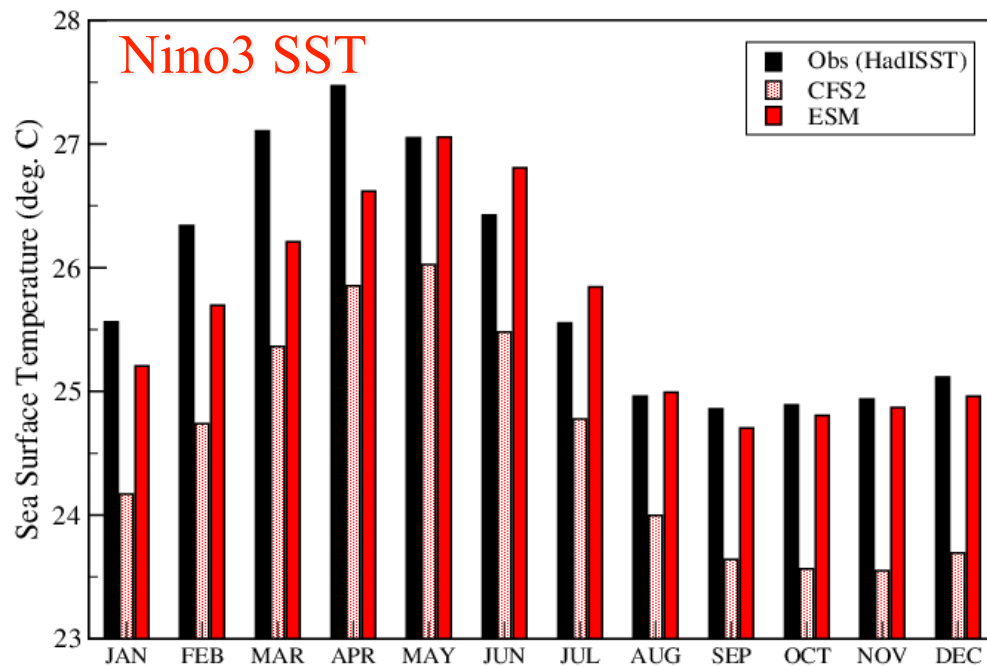# Inter-annual variability

Precipitation

(5N-35N; 65E-95E)

Indian (land + ocean)

Lagged correlation between ISMR and Nino3 SST in the preceding/following months

Improving ESM before launch of CMIP6 DECK expts

- Reduce net radiation imbalance at top-of-atmosphere (TOA) in ESM

- Improve simulation of mean rainfall distribution over the South Asian monsoon region and the tropics in general

  - Modified cumulus convection scheme (new SAS scheme) in CFSv2 significantly improves the Indian monsoon rainfall distribution - Courtesy: Mukhopadhyay et al.

  - Inclusion of new cloud microphysics scheme in CFSv2 reduces the cold tropospheric temperature biases - Courtesy: P. Mukhopadhyay et al.

- Underestimation of sea-ice concentration in Summer Hemisphere

- Prescribe time-varying aerosol fields from CMIP6 for the historical simulation and future projection using ESM1.0

- Incorporating and testing of interactive aerosol and chemistry transport model (HAM) in ESM1.0 - to continue in parallel.

Mean rainfall (JJAS)

Improvement with new convection scheme)
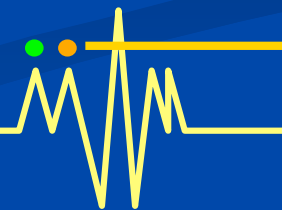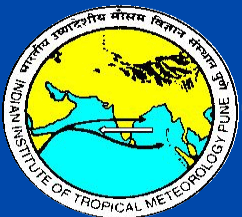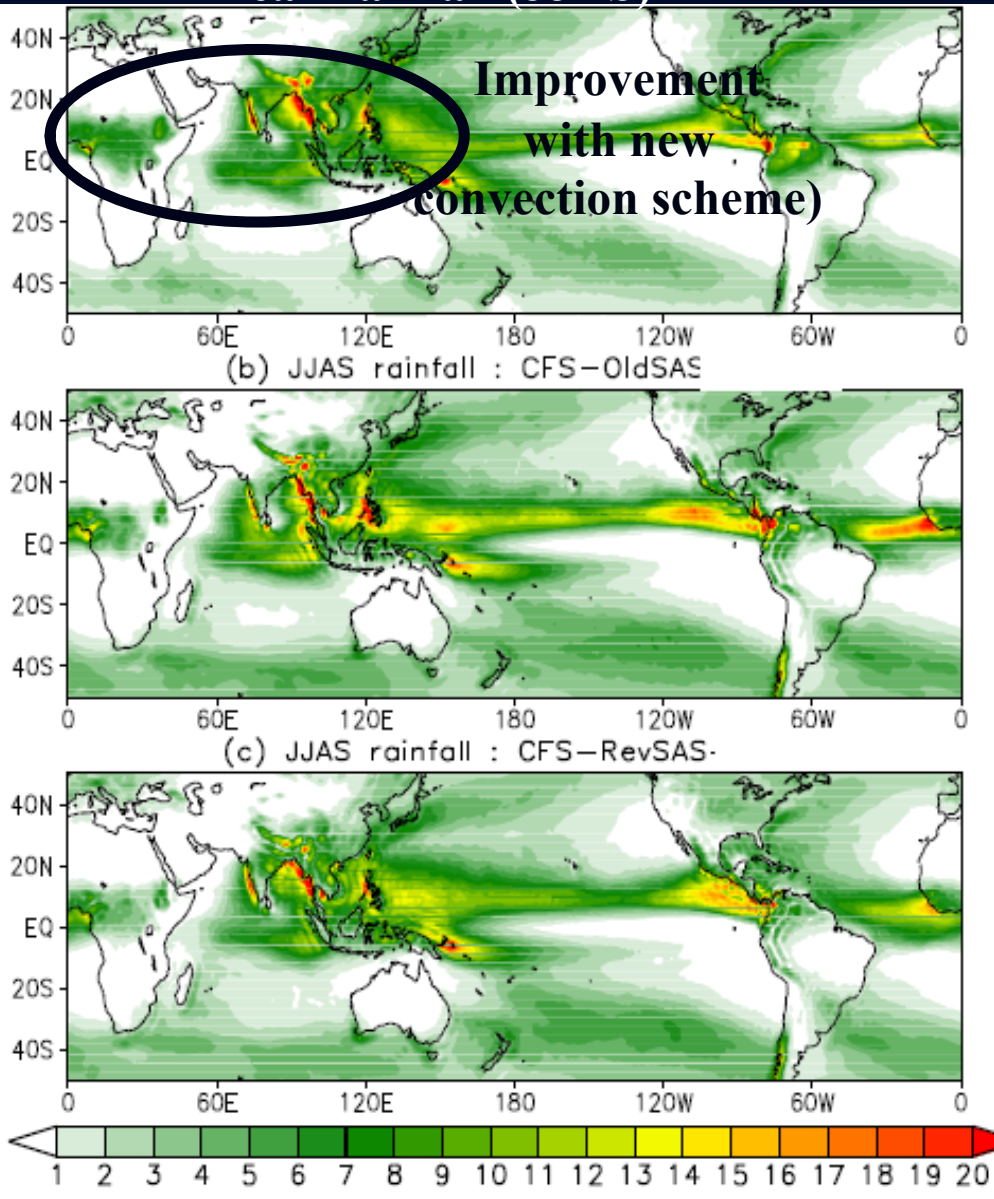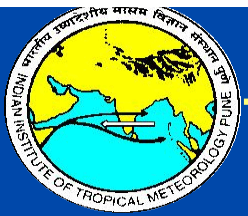
Annual cycle of rainfall over Indian region
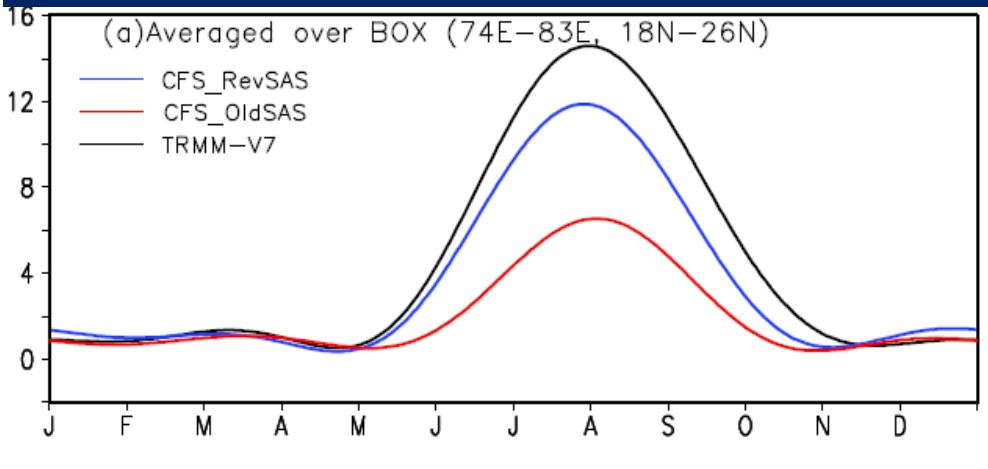
Modified cumulus convection scheme (new SAS scheme) in CFSv2 significantly improves the Indian monsoon rainfall distribution – Malai et al . Climate Dynamics, 2014

CMIP6 Schematic

Initial proposal for the CMIP6 experimental design has been released

Meehl et al., 2014: Climate Model Intercomparisons: Preparing for the Next Phase, Eos Trans. AGU, 95,77-84.
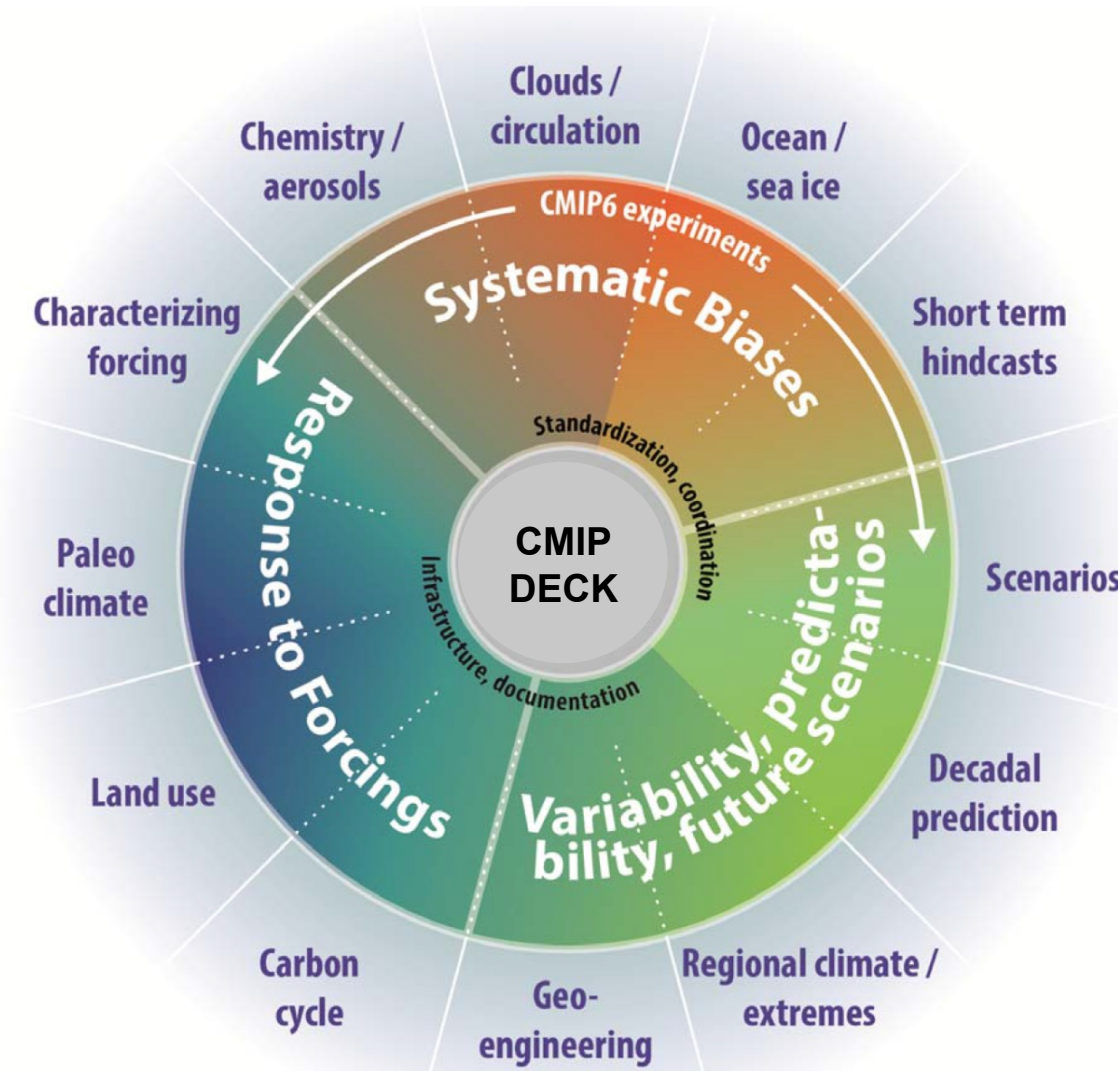
CMIP6 Concept:

A Distributed Organization under the oversight of the CMIP Panel

"DECK":

Development
Evaluation
Characterisation of
Klima (German for 'climate')

Summary

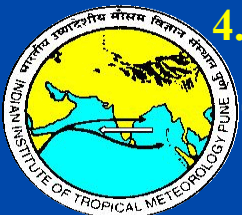- The first version of ESM has been successfully developed at CCCR-IITM by incorporating MOM4P1 (with ocean biogeochemistry) component in CFSv2. Major improvements are seen in the ESM simulation vis-à-vis CFSv2 :

  - Significant reduction of cold bias of global mean SST by ~0.8^{o}C due to better ocean physical processes. The bias reduction is seen in the tropical Indian & Pacific Oceans ; and the north Pacific .
  - ENSO & PDO are robust and spatially more coherent in ESM1.0
  - ENSO and monsoon links are well-captured
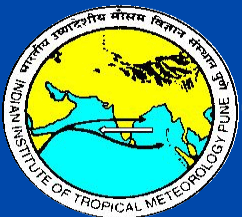 - ESM1.0 includes marine ecosystem & biogochemical processes that were absent in CFS

The IITM Earth System Model: Transformation of a Seasonal Prediction Model to a Long Term Climate Model. Swapna et al. (Under Review, BAMS).

Plan for CMIP6 Exp : IITM will be contributing to the DECK experiments:

1. **a multi-hundred year pre-industrial control simulation;**

2. **a 1%/yr CO2 increase simulation to quadrupling to derive the transient climate response;**

3. **an instantaneous 4xCO2 run to derive the equilibrium climate sensitivity;**

4. **a simulation starting in the 1th century and running through the 21st century using an existing scenario (RCP8.5).**

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