Multiscale ISMR variations in the NCEP-CFS

Exploring possible improvements through experiments with embedded regional modeling at weather and cloud resolving scales

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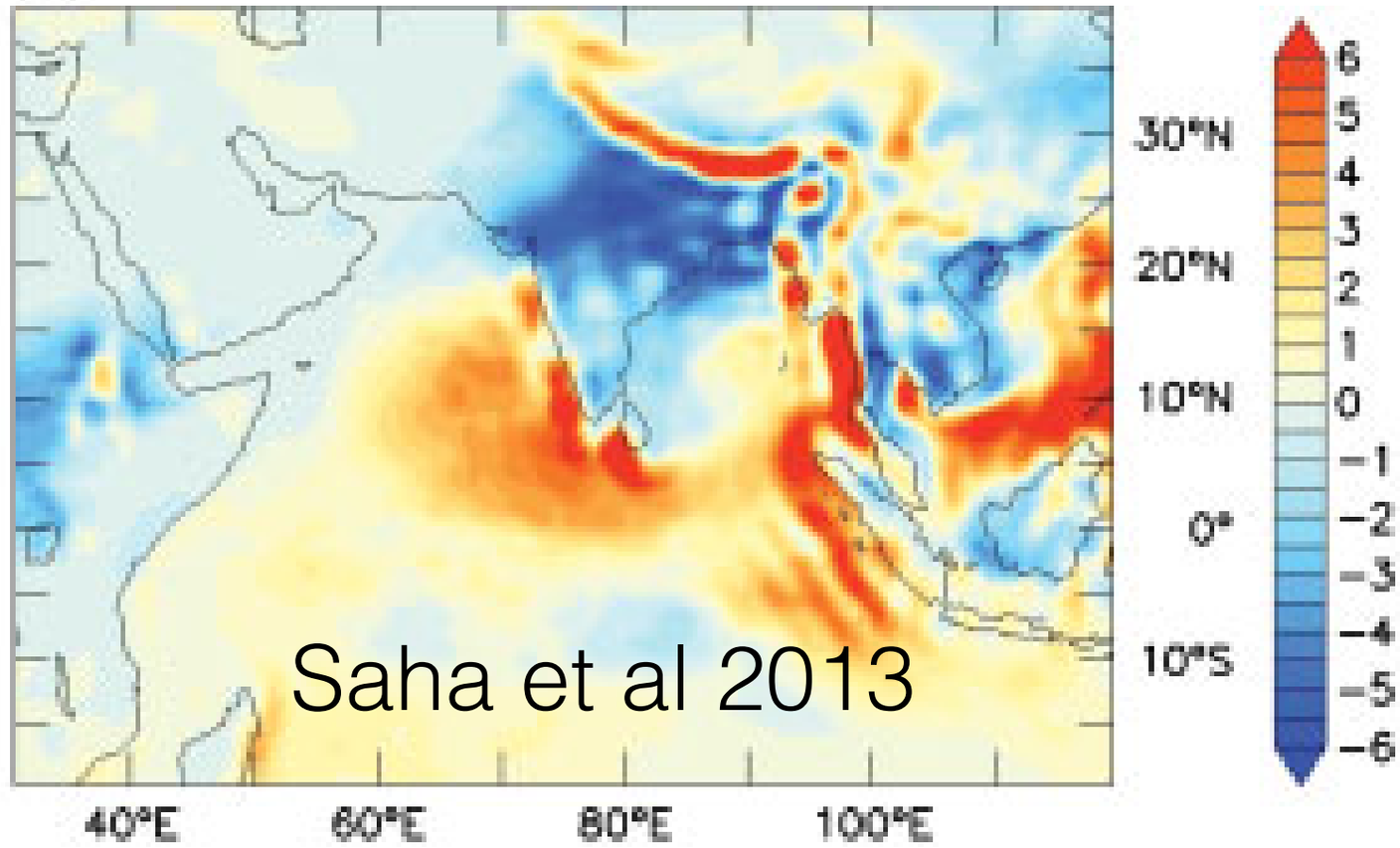
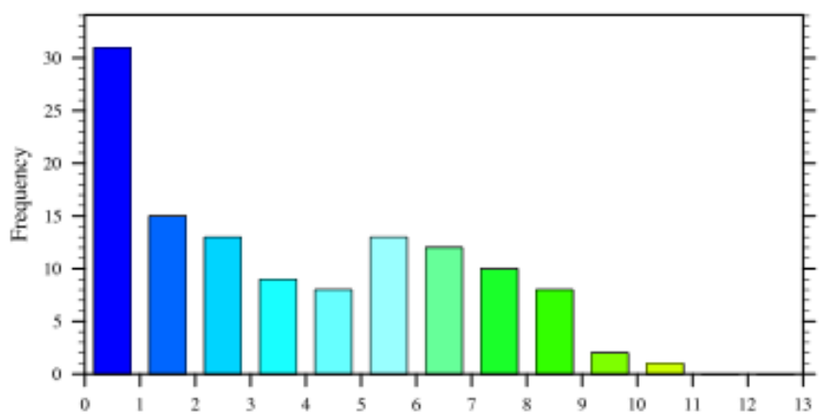
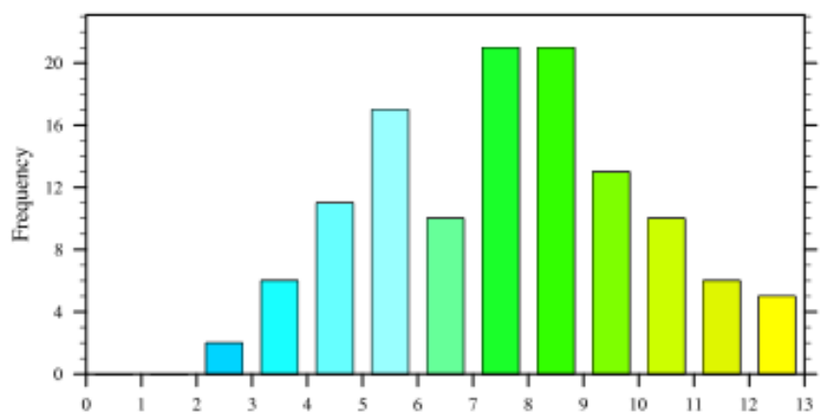


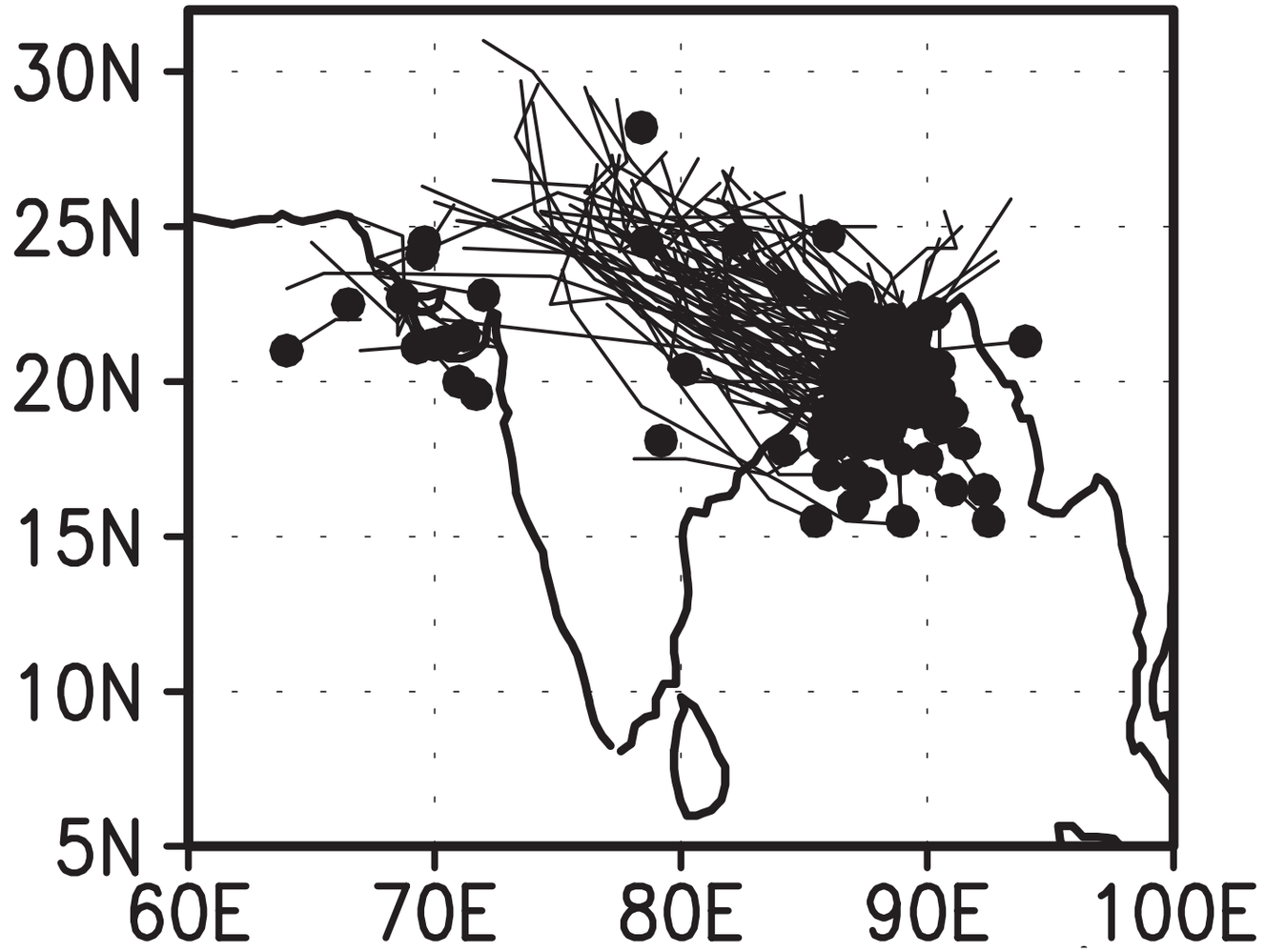
Saha et al 2013



NCEP CFSv2 T382

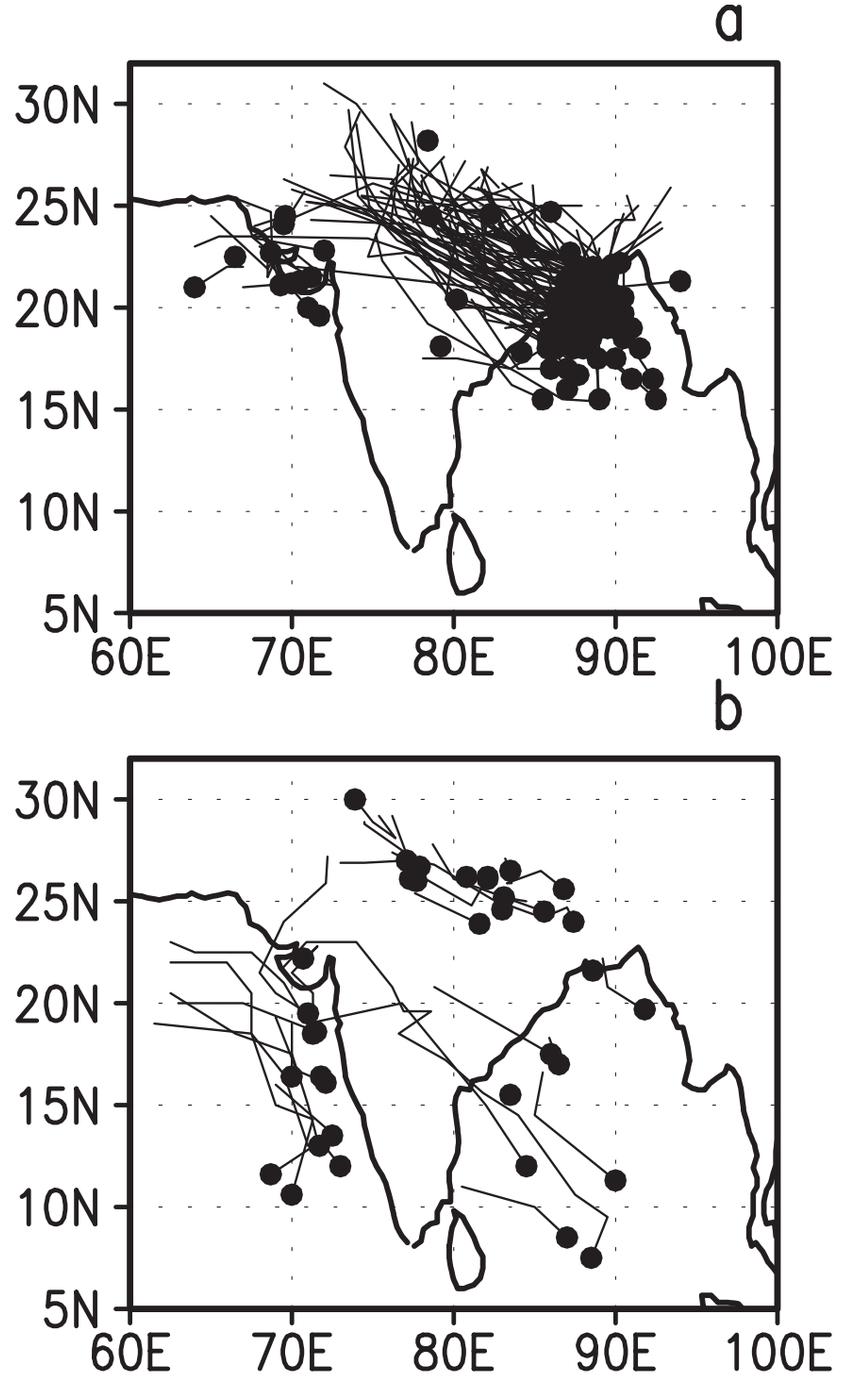


TRMM



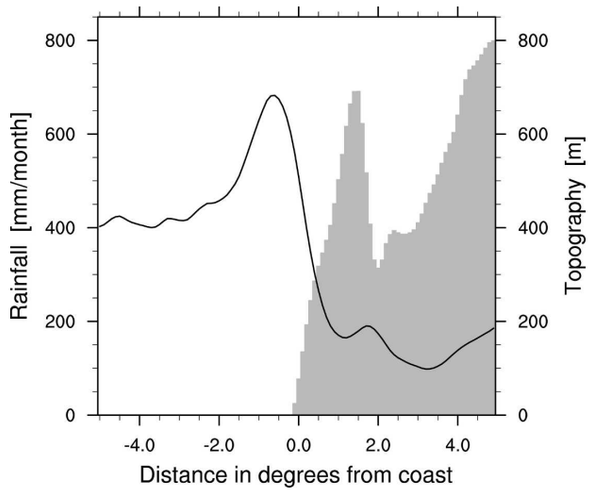
collectively account for 50% of the total ISMR rainfall(Sikka 1977, 2006)

Modulation of synoptic activity by Monsoon ISO

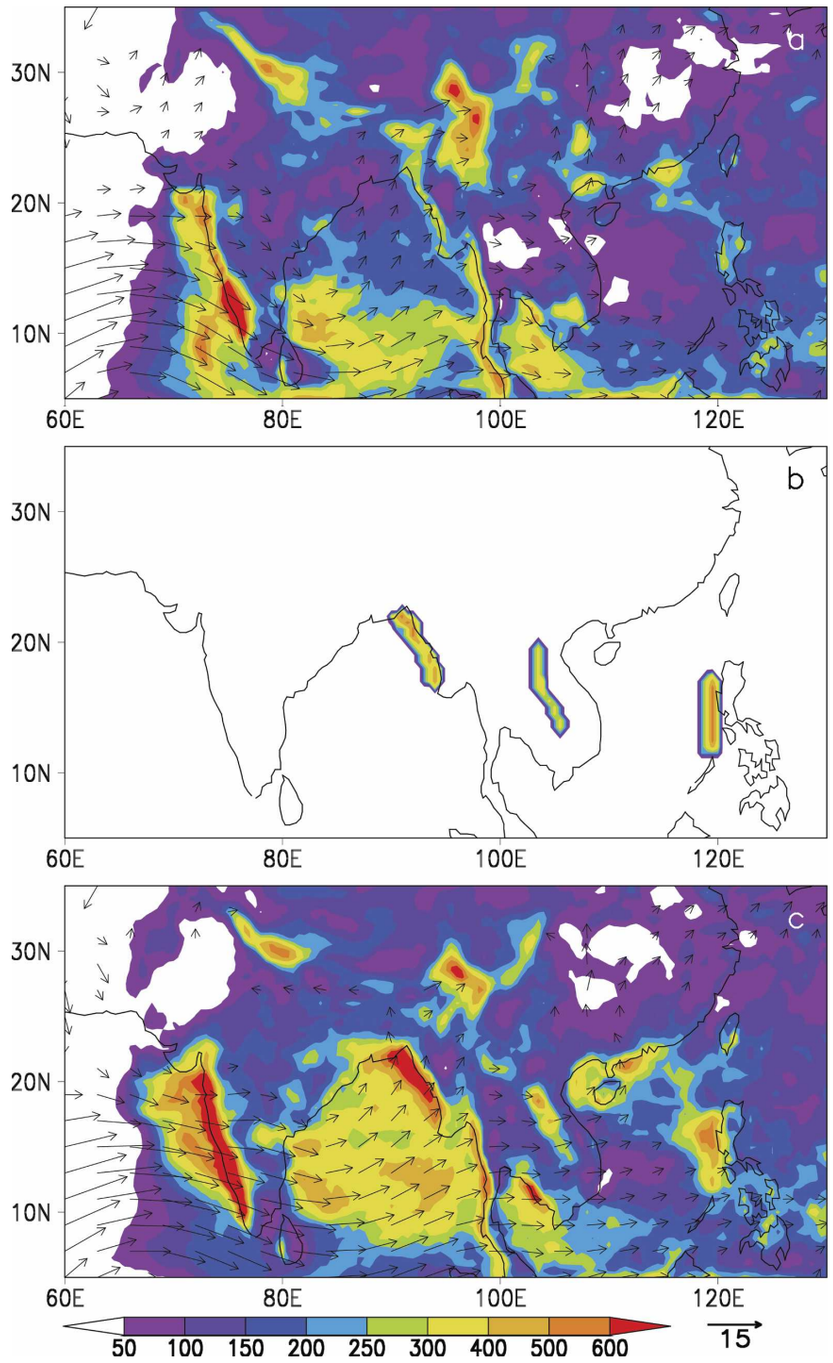


Goswami et al 2003

Mesoscale features as a shaper of mean climate



Xie et al 2006, J. Climate



Background

- Growing recognition of monsoon as a complex system (Sikka and Gadgil, 1980; Suhas et al 2012)
- A framework for understanding monsoon interannual variations as an interacting multi-scale system has been developed (Goswami et al 2006)

A Bottom-Up approach

- Focus on improving weather and ISO statistics
  - Role of high resolution, cloud resolving grids
  - Impact of topography representation
  - Role of regional air-sea interaction
- Problem - How to do all of this on a 1TerraFlops computer?
- Pragmatic approach - Embedded regional simulations

Objectives

- Objective identification of multiple scales and their validation in simulations (evaluation framework)

- Evaluate whether NCEP-CFS captures important scales of monsoon variability correctly.

- Using WRF as an intermediate tool to explore factors relevant to scales of ISMR variations of interest to this project.

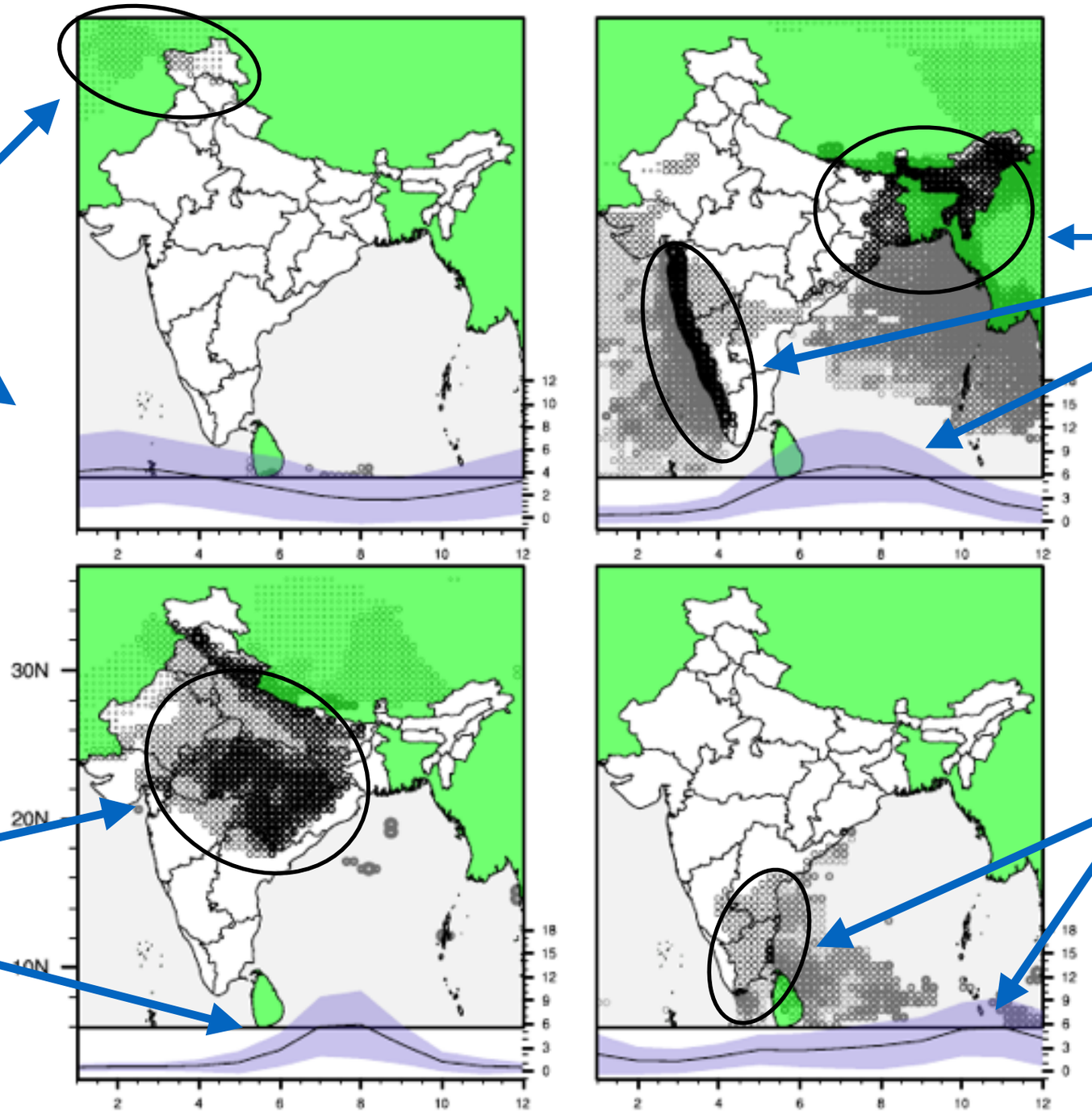
Evaluation Framework centered around Self Organizing Maps

Multiscale IMR rain regimes

annual scale

Late winter/
early spring
Northwest

Follows evolution
of SW Monsoon



Rapid evolution
over Central India
Jul-Aug

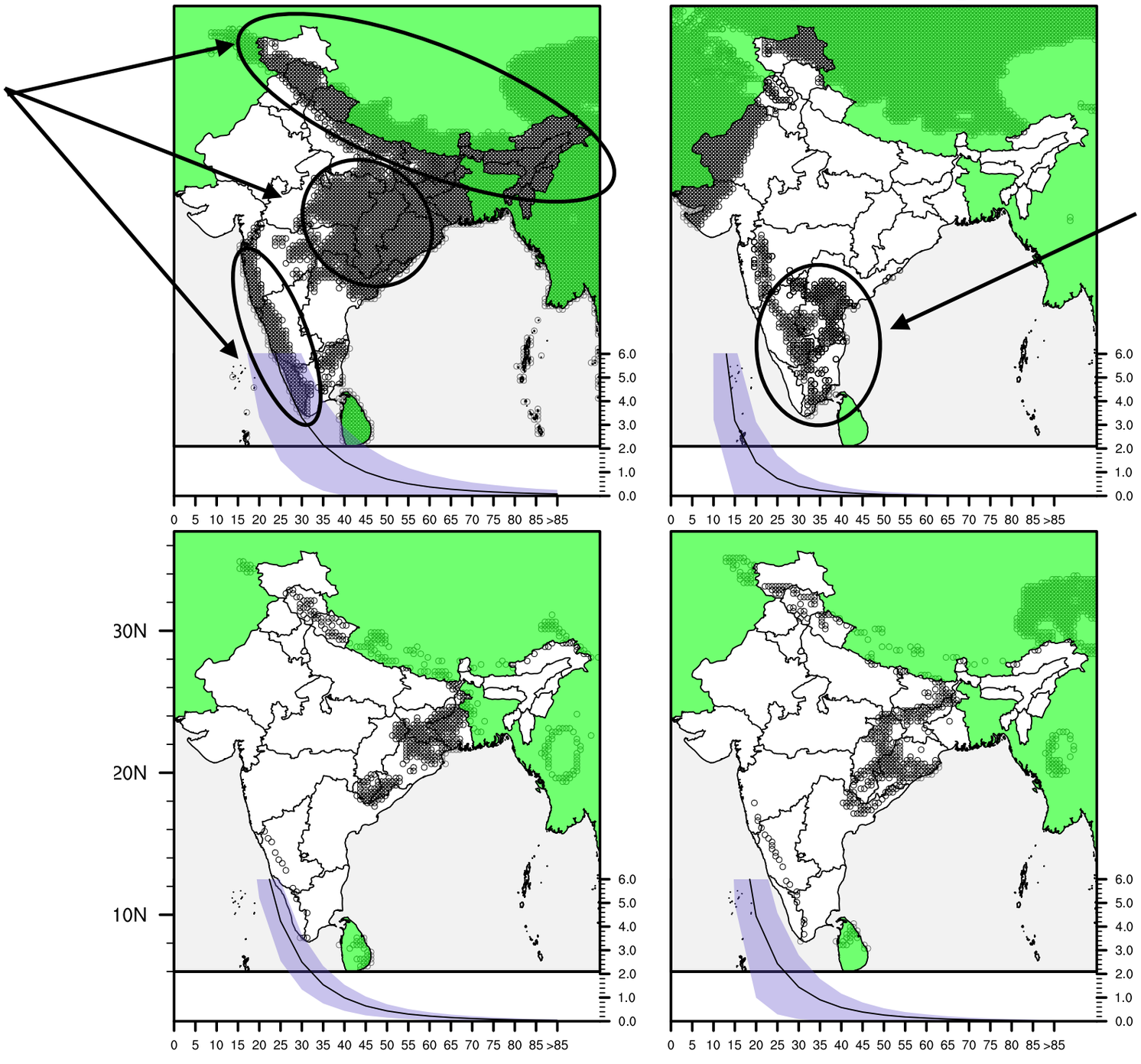
Follows evolution
of NE Monsoon

**source:
Aphrodite+TMI**

Multiscale IMR rain regimes

rainfall intensity

Strong rain intensity

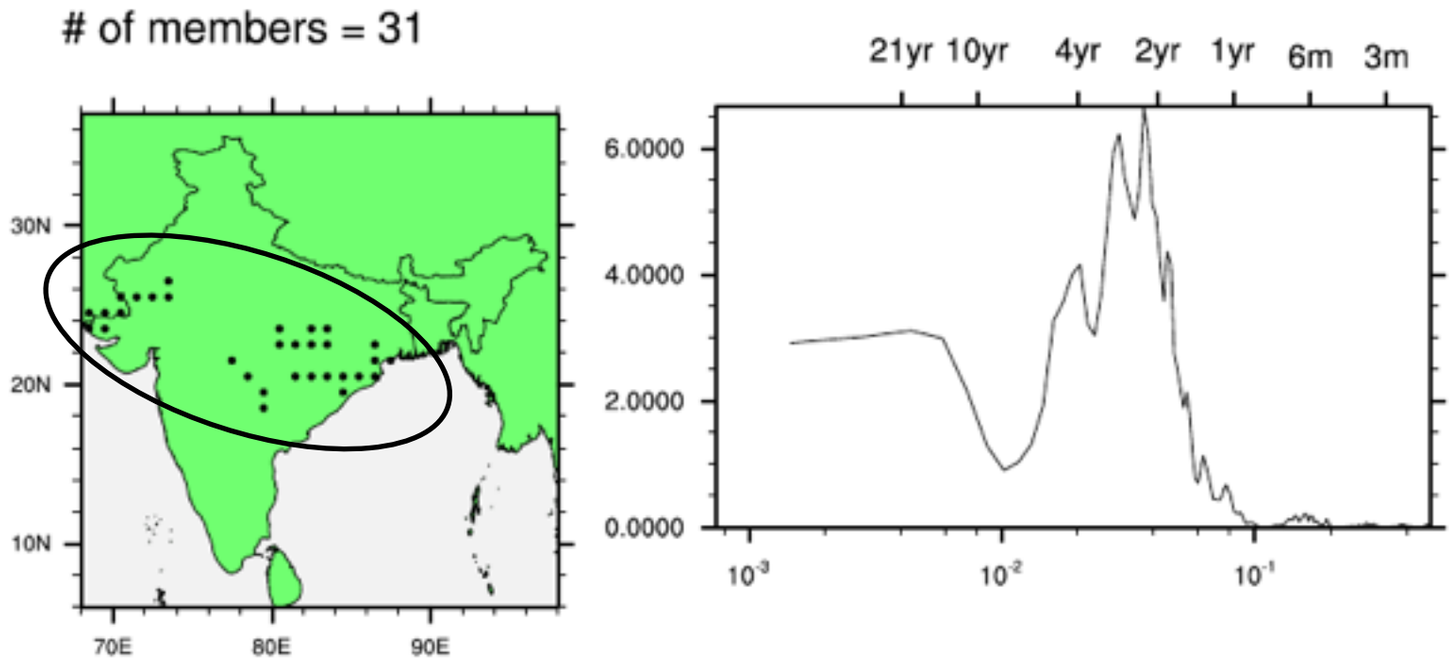


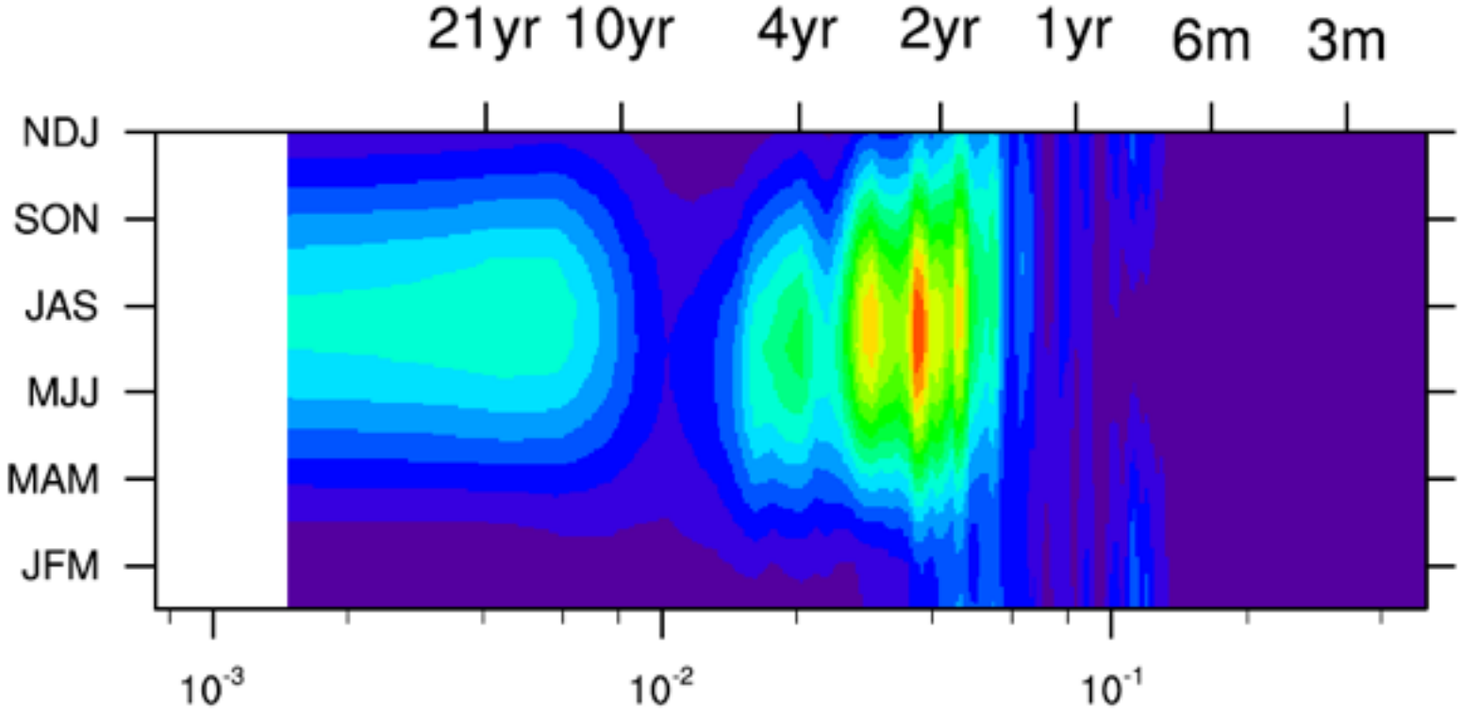
Moderate rain intensity

source: Aphrodite

Multiscale IMR rain regimes

inter annual scale



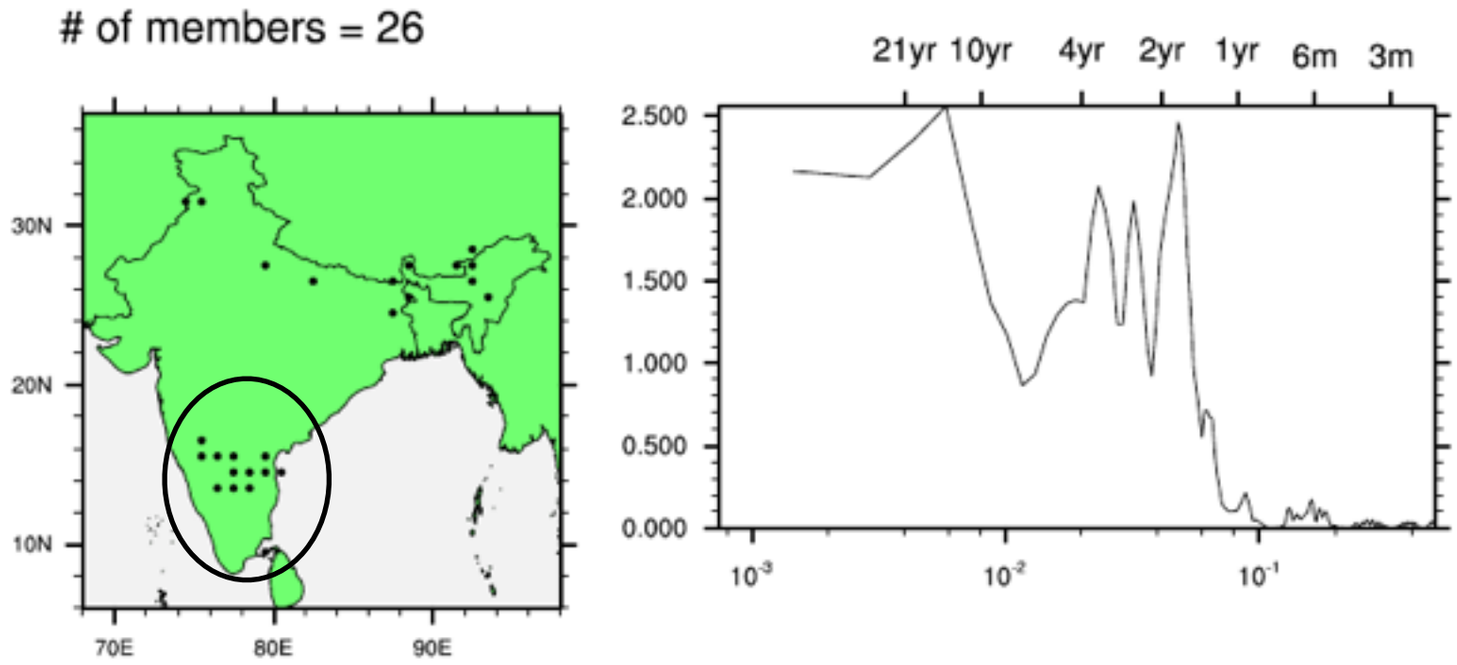


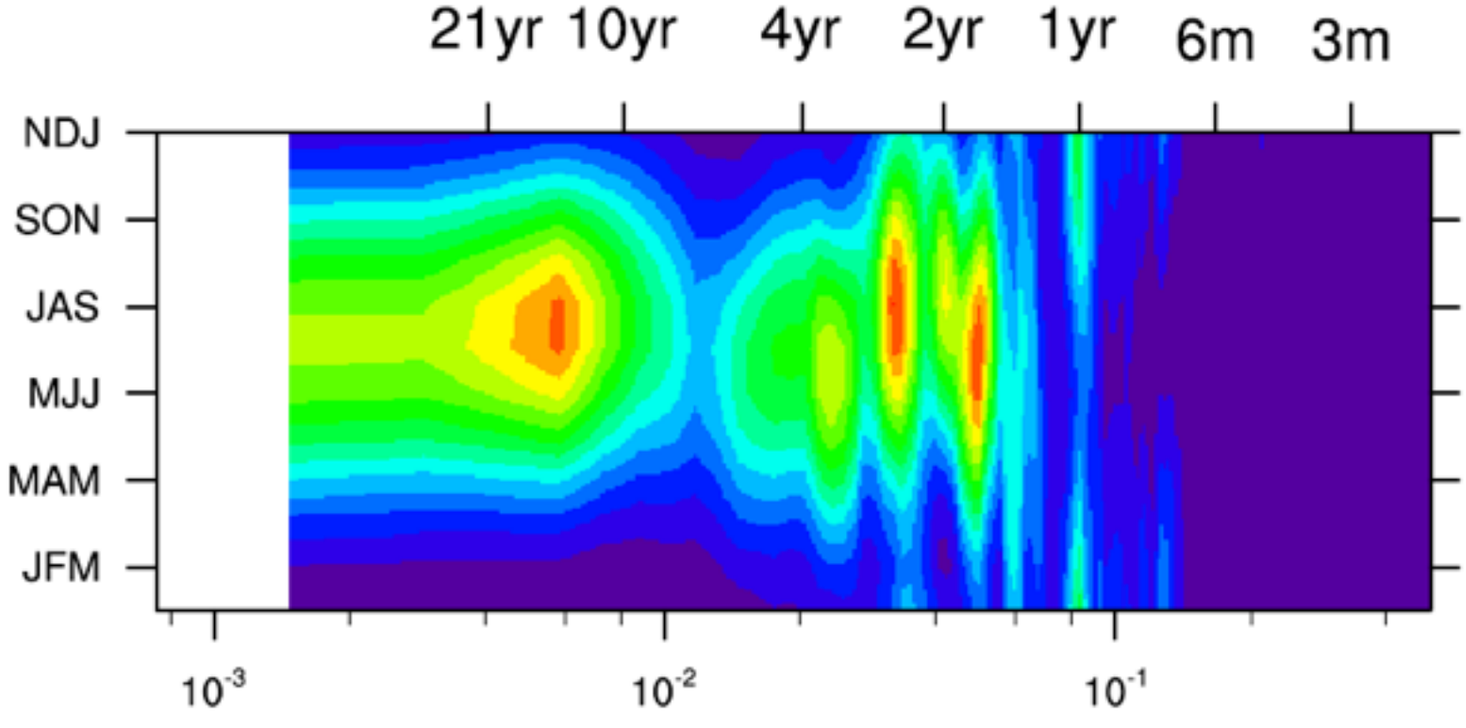
Thank
R. Chatopadyay,
S. Pai
and
M. Rajeevan
for the IMD
data

source: IMD 1º

Multiscale IMR rain regimes

inter annual scale





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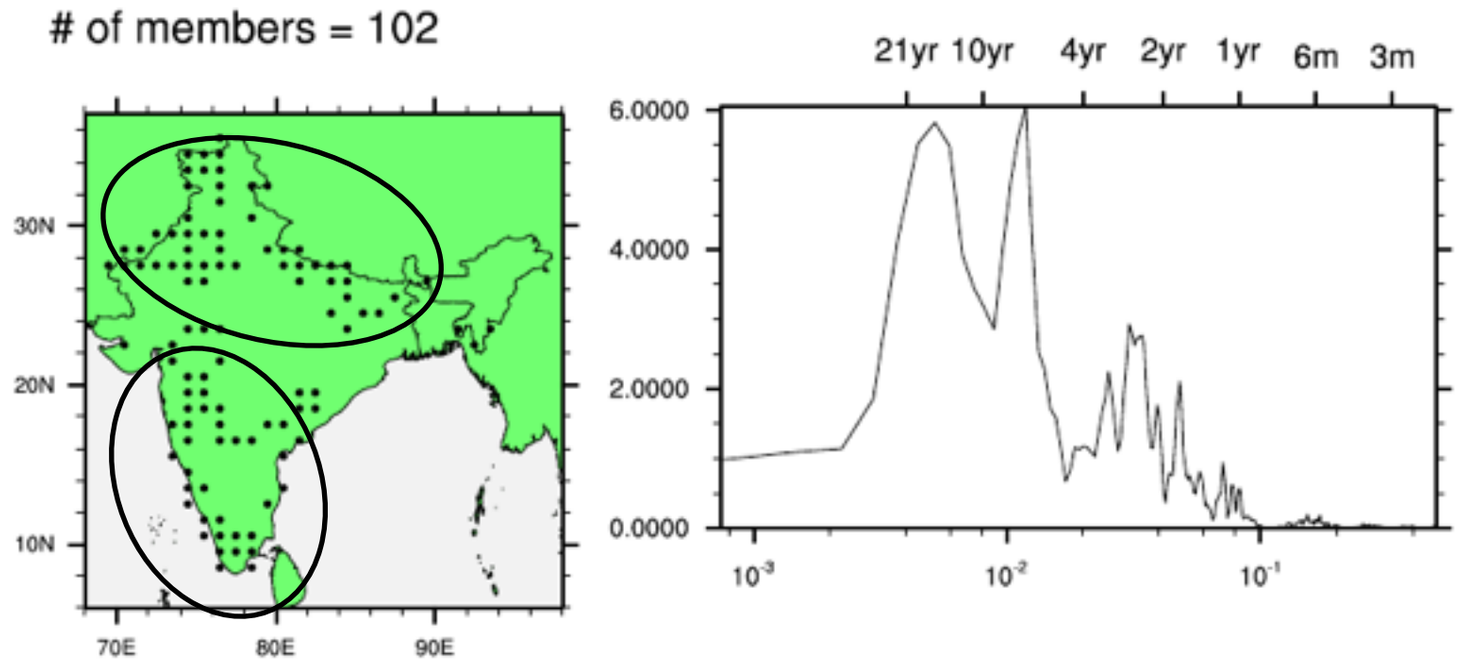
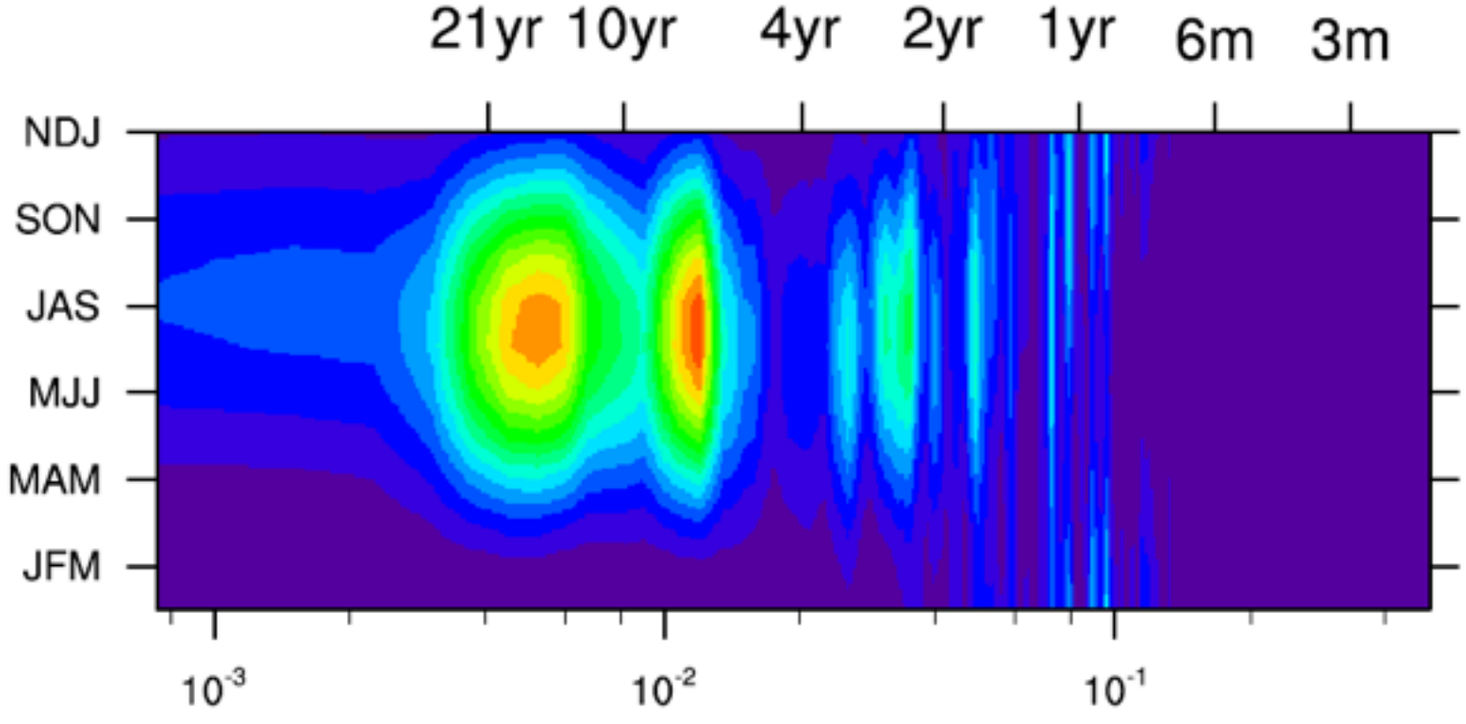
Multiscale IMR rain regimes

decadal scale





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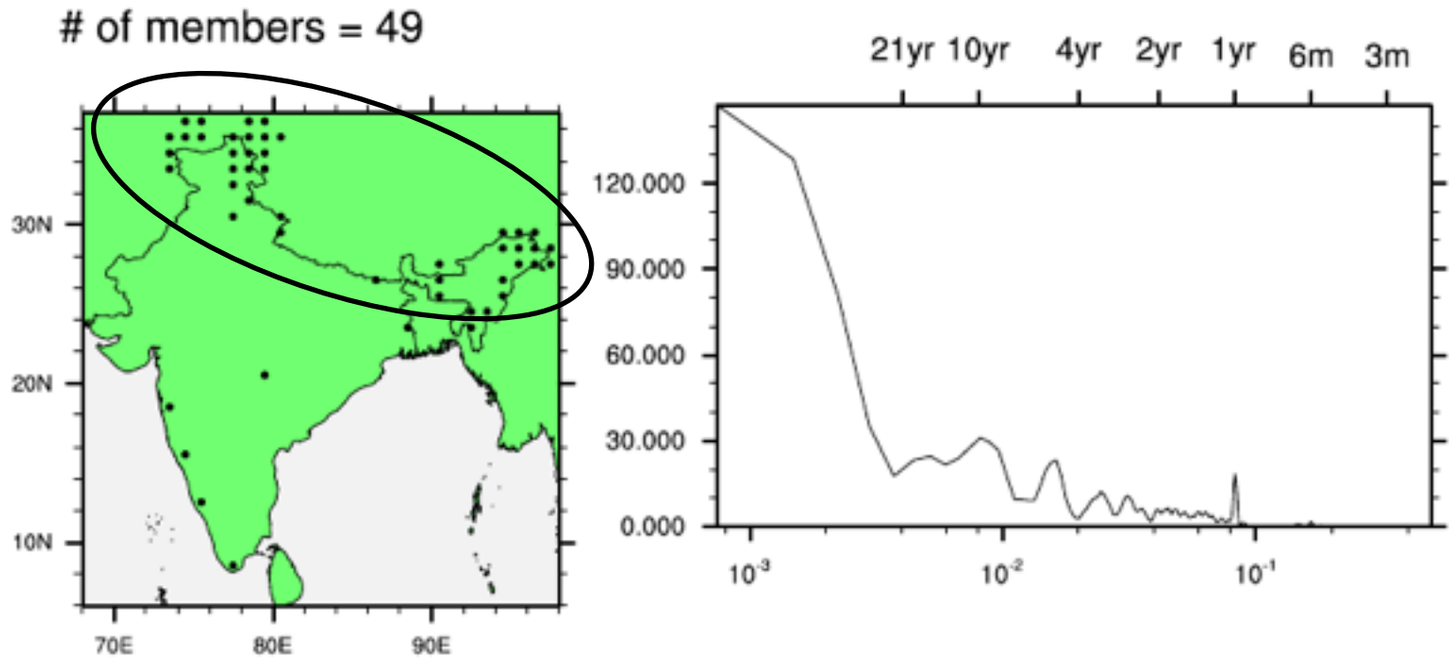
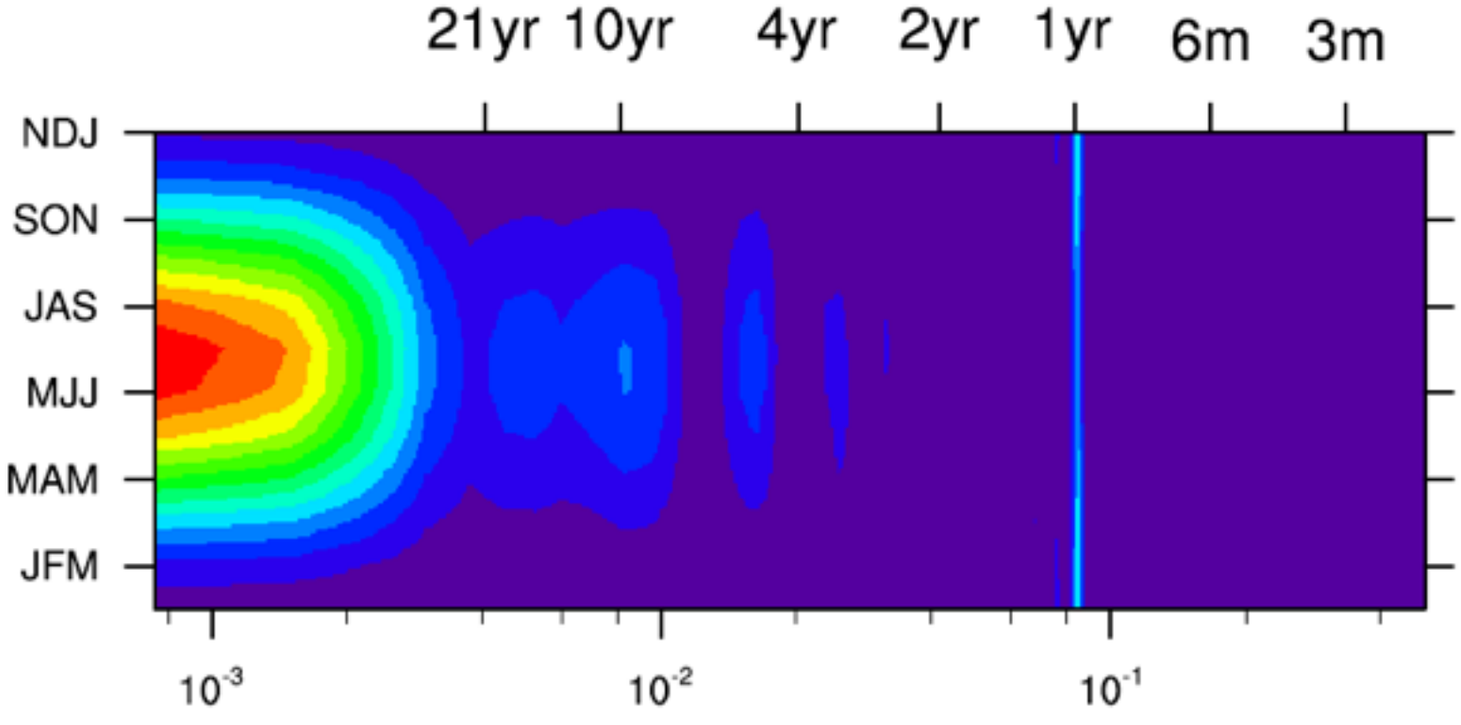
Multiscale IMR rain regimes

multidecadal scale





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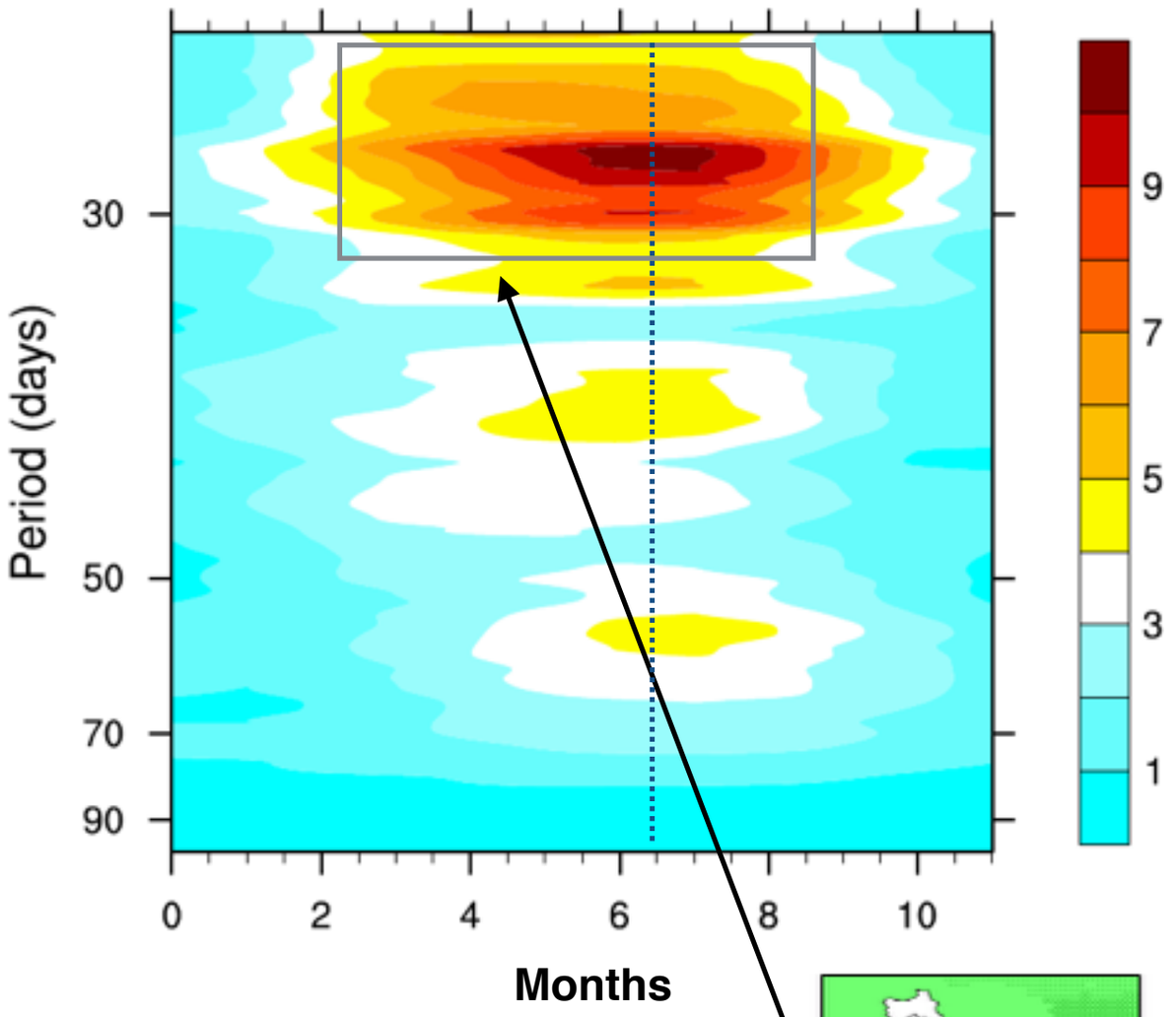
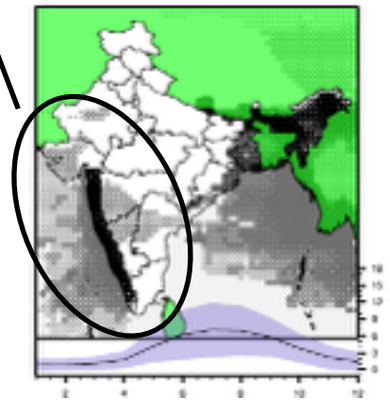
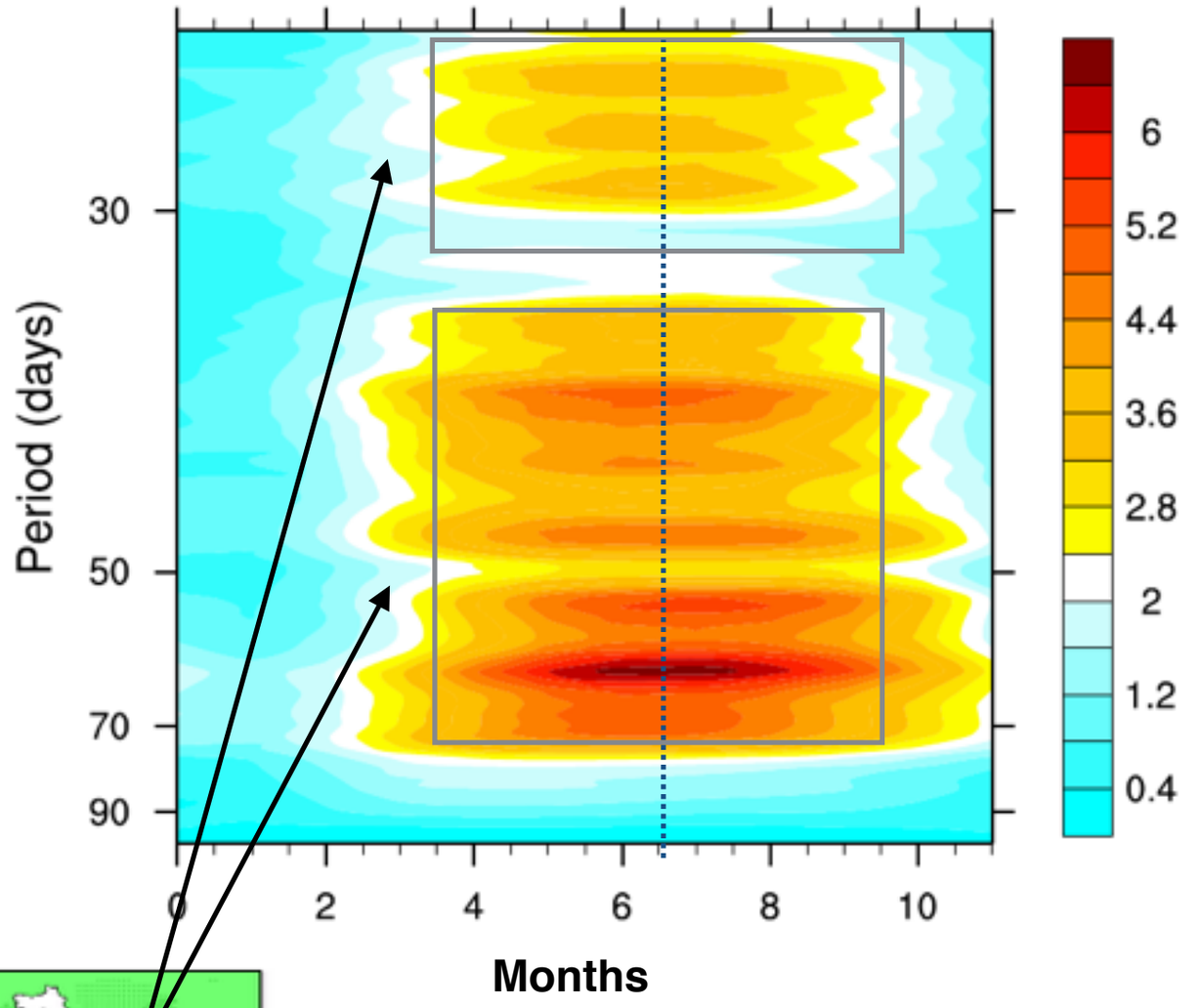
Multiscale ISMR rain regimes

subseasonal scale

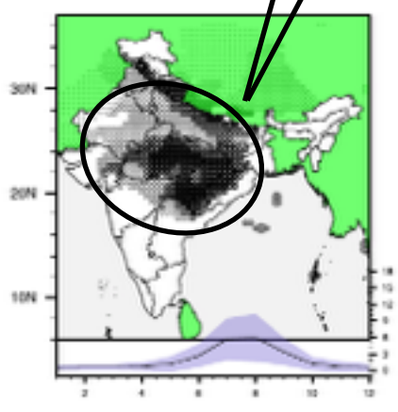


Quasi-biweekly regime





Quasi-biweekly
+
Monsoon ISO



source: Aphrodite

Multiscale IMR rain regimes

- Monsoon rain rich in scales of variability
- Central Indian rain has several unique features
    - sharp evolution during the middle of the summer monsoon
    - intense rainfall events associated with monsoon lows and depressions
    - dominantly interannual
- Western ghat rain
    - Evolution of rain closely related to SW monsoon
    - intense rainfall events
    - dominantly decadal
    - dominantly quasi-biweekly

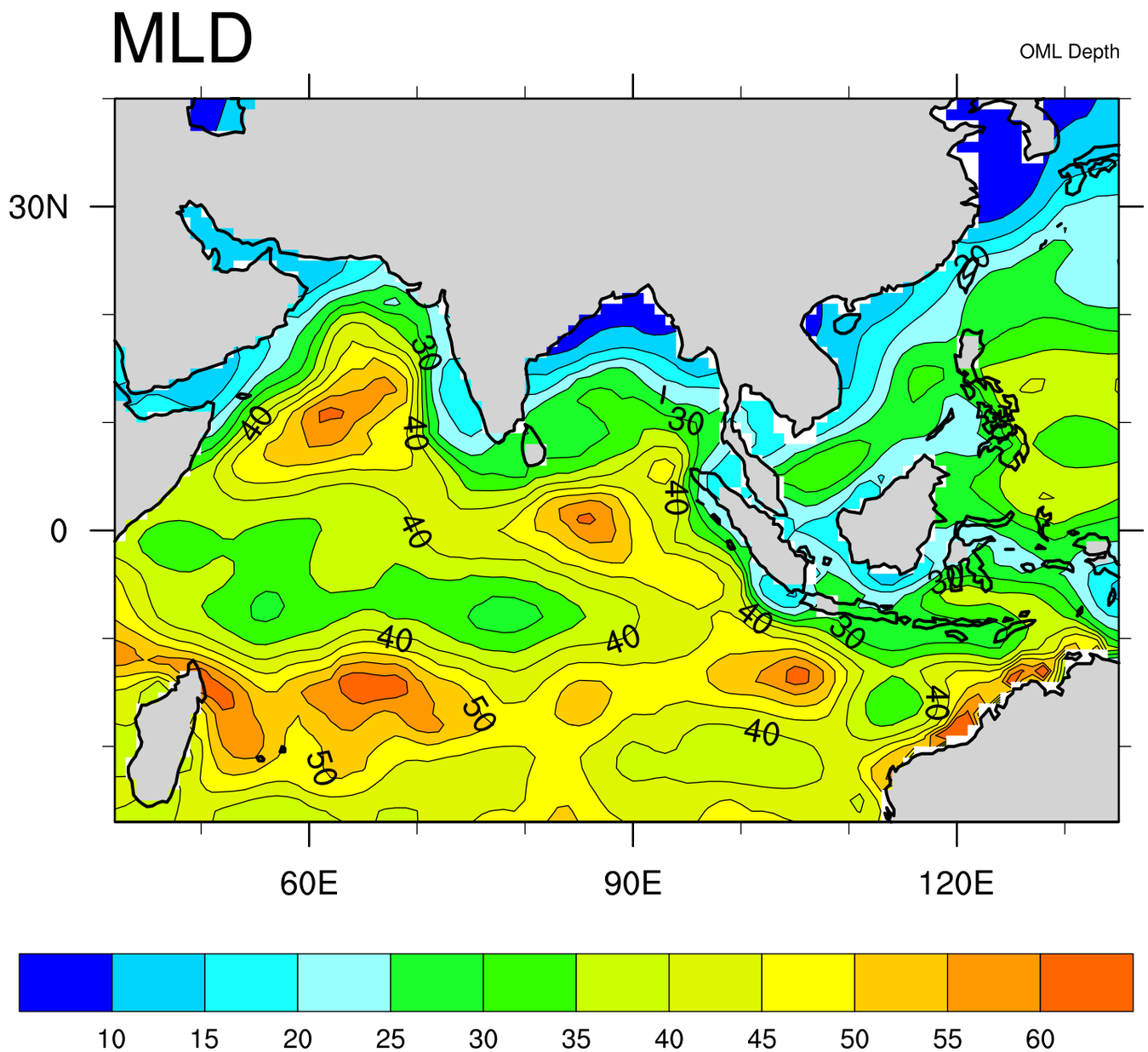
Multiscale ISM variations in the NCEP CFSv2 T382 runs and embedded simulations

Model Data and Embedded experiments

- NCEP CFS v2 T382
    - Coupled (free) runs spanning 20 years
- Embedded WRF simulations (CFS+WRF) with above as LBC
    - 5 Experiments, each for a 7-year period corresponding to model years 1999-2005

1. No SST
2. Daily updated NCEP CFS SST
3. Coupled to 1D mixed layer Pollard, Rhines and Thompson (1972) - spatially uniform, time-invariant depth of 50m
4. Same as above, but MLD from observations and varies on monthly scale
5. WRF run with hydrostatic dynamical core

Mixed layer depth - JJAS

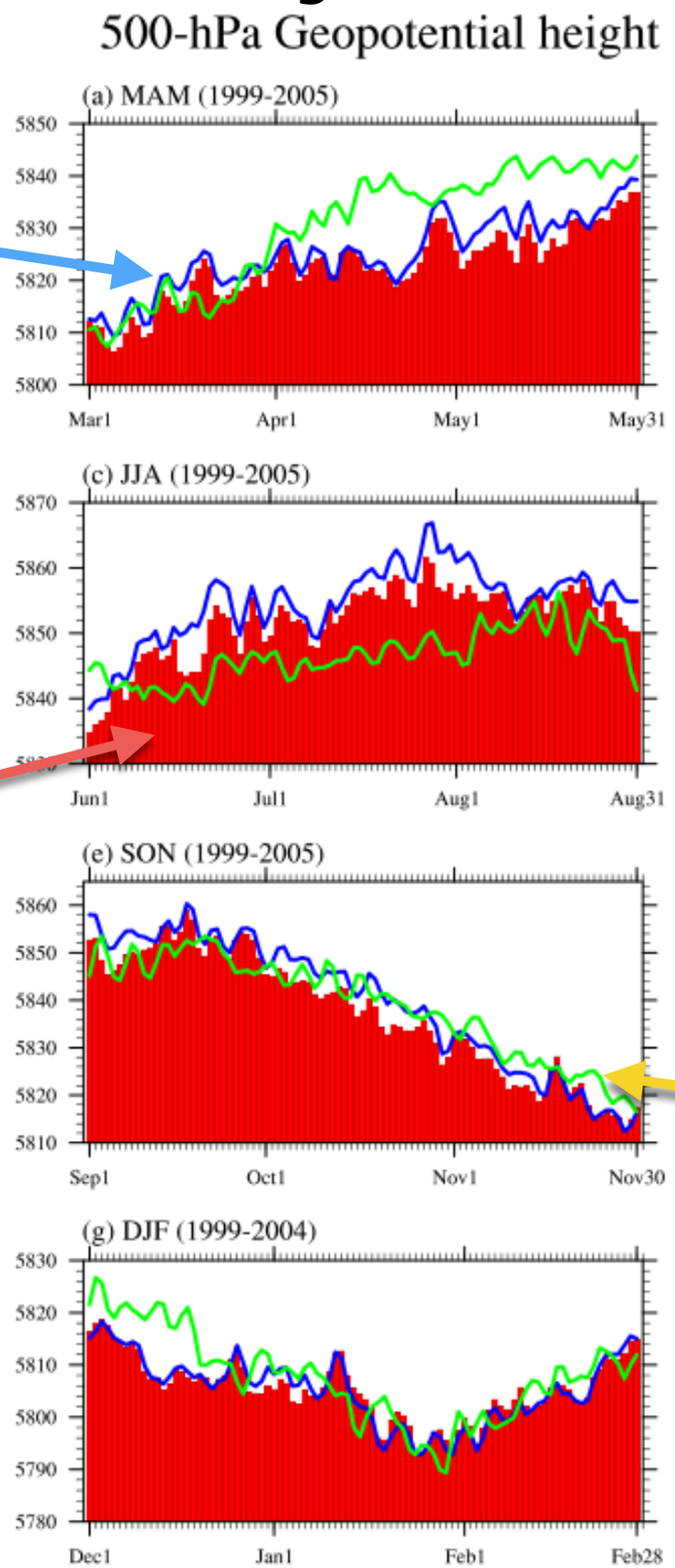


Physical Schemes for the embedded simulations

- Cumulus: Betts-Miller-Janjic scheme
- Longwave Radiation: RRTMG scheme
- Shortwave Radiation: RRTMG shortwave
- Land surface: unified Noah land-surface model
- Surface Layer: Monin-Obukhov (Janjic Eta) scheme
- Boundary layer: Mellor-Yamada-Janjic (Eta) TKE scheme
- Microphysics: WSM 3-class simple ice scheme

Sanity Checks

Embedded simulations (blue line)



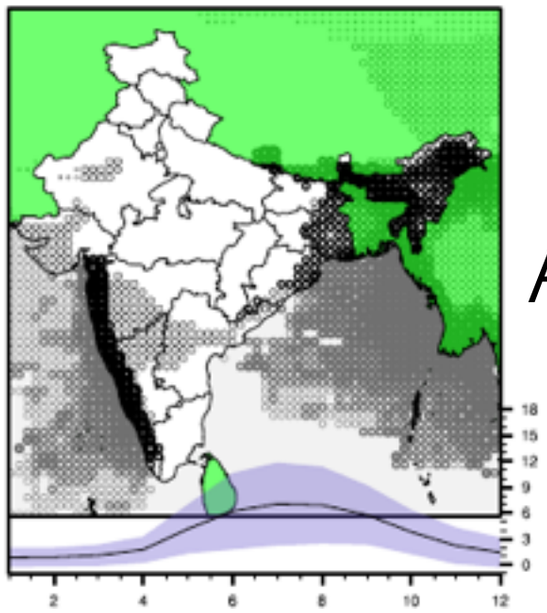
Area averaged 500 hPa Geopotential Height over tropical Indian domain

NCEP CFSv2 T382 (red bars)

NCEP reanalysis1 climatology (green line)

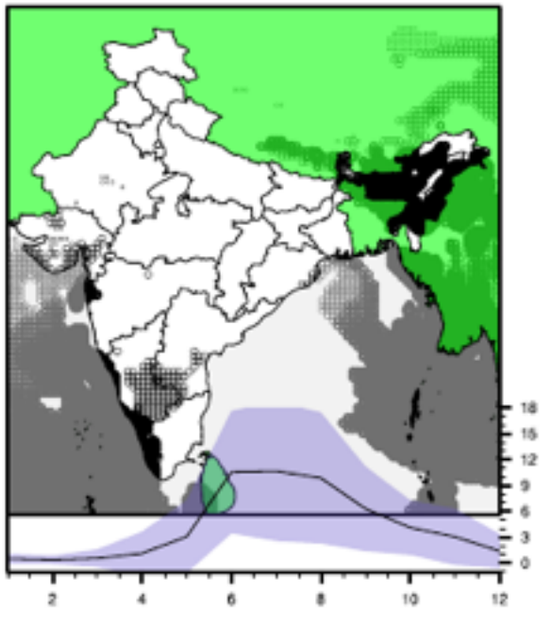
Annual cycle of rainfall

SW monsoon

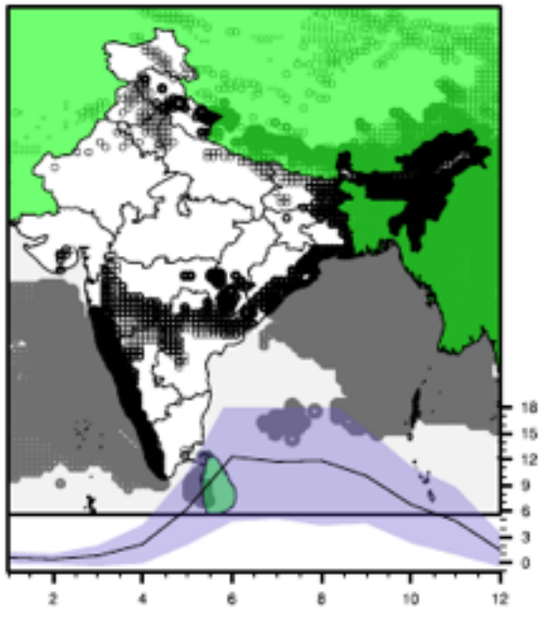


Aphrodite + TMI

NCEP CFSv2

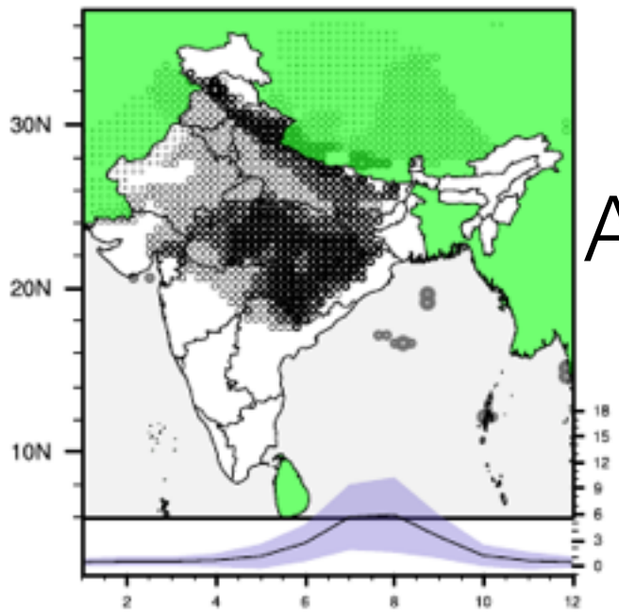


CFS + WRF



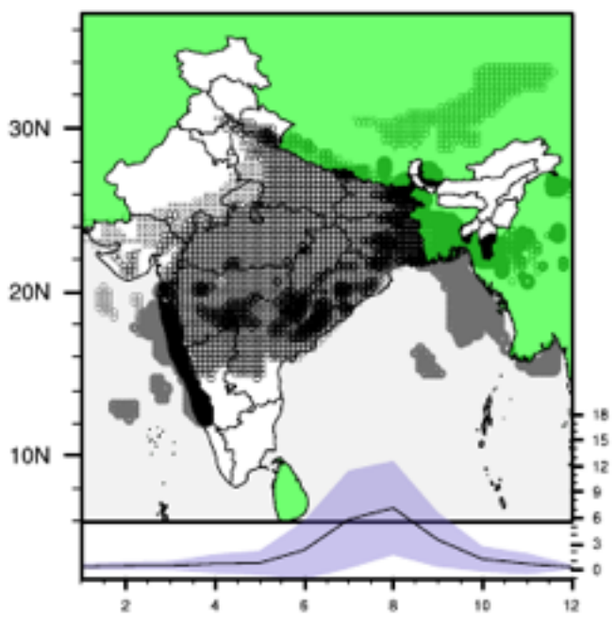
Annual cycle of rainfall

Central India



Aphrodite + TMI

NCEP CFSv2



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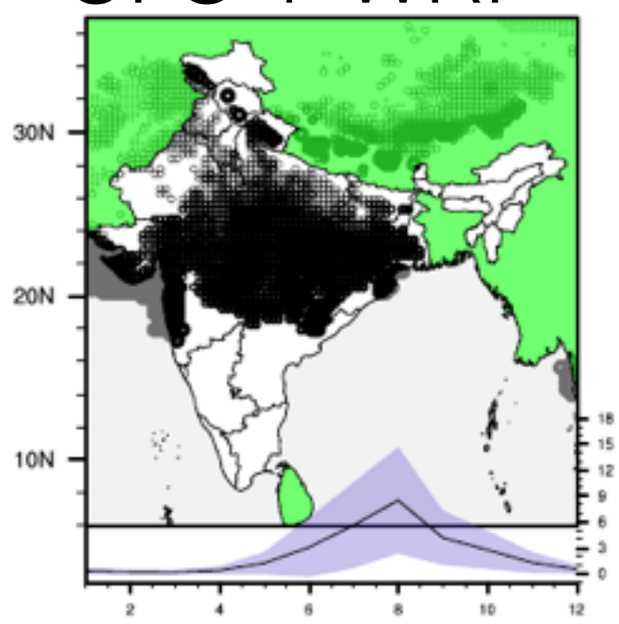
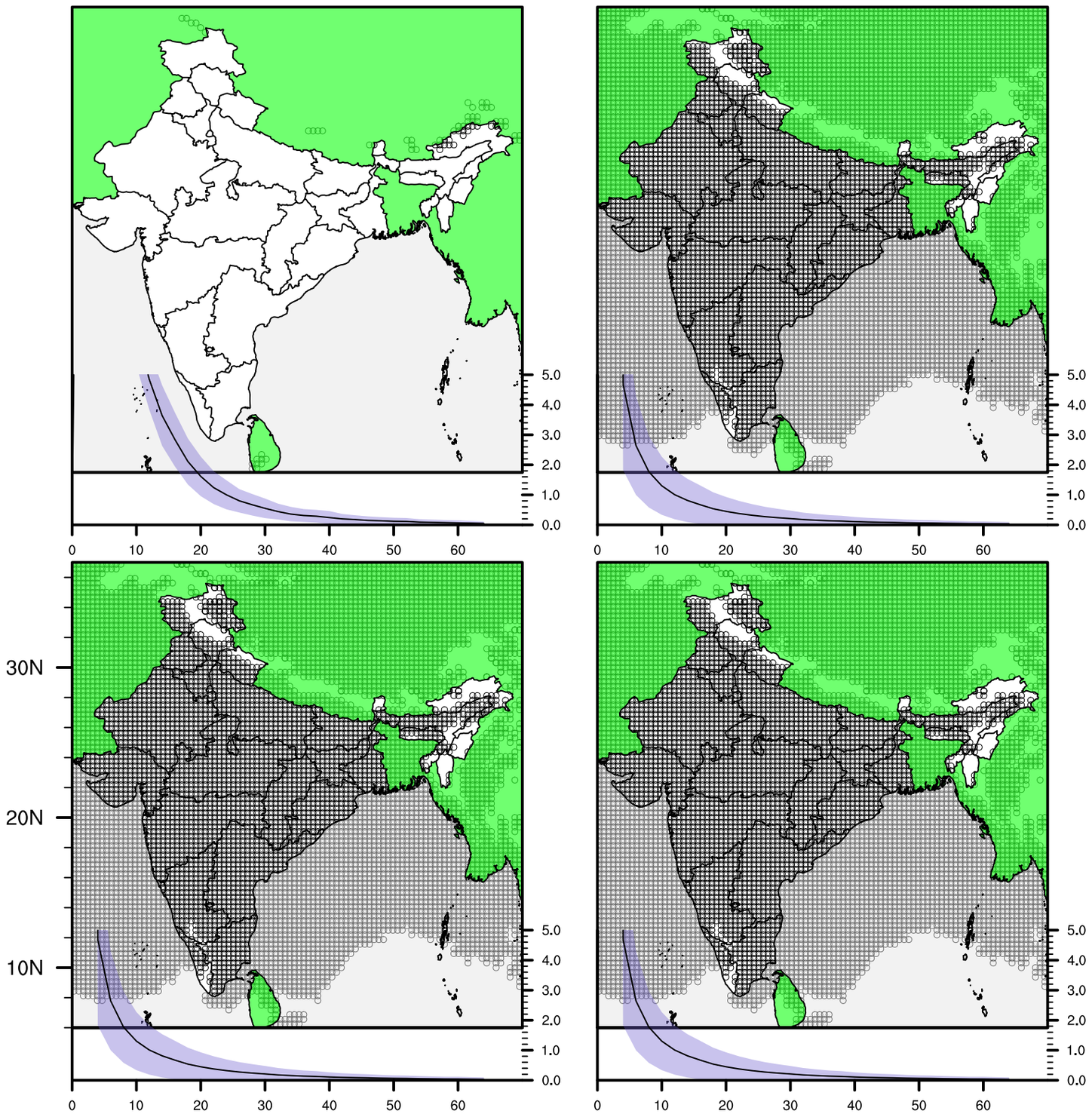
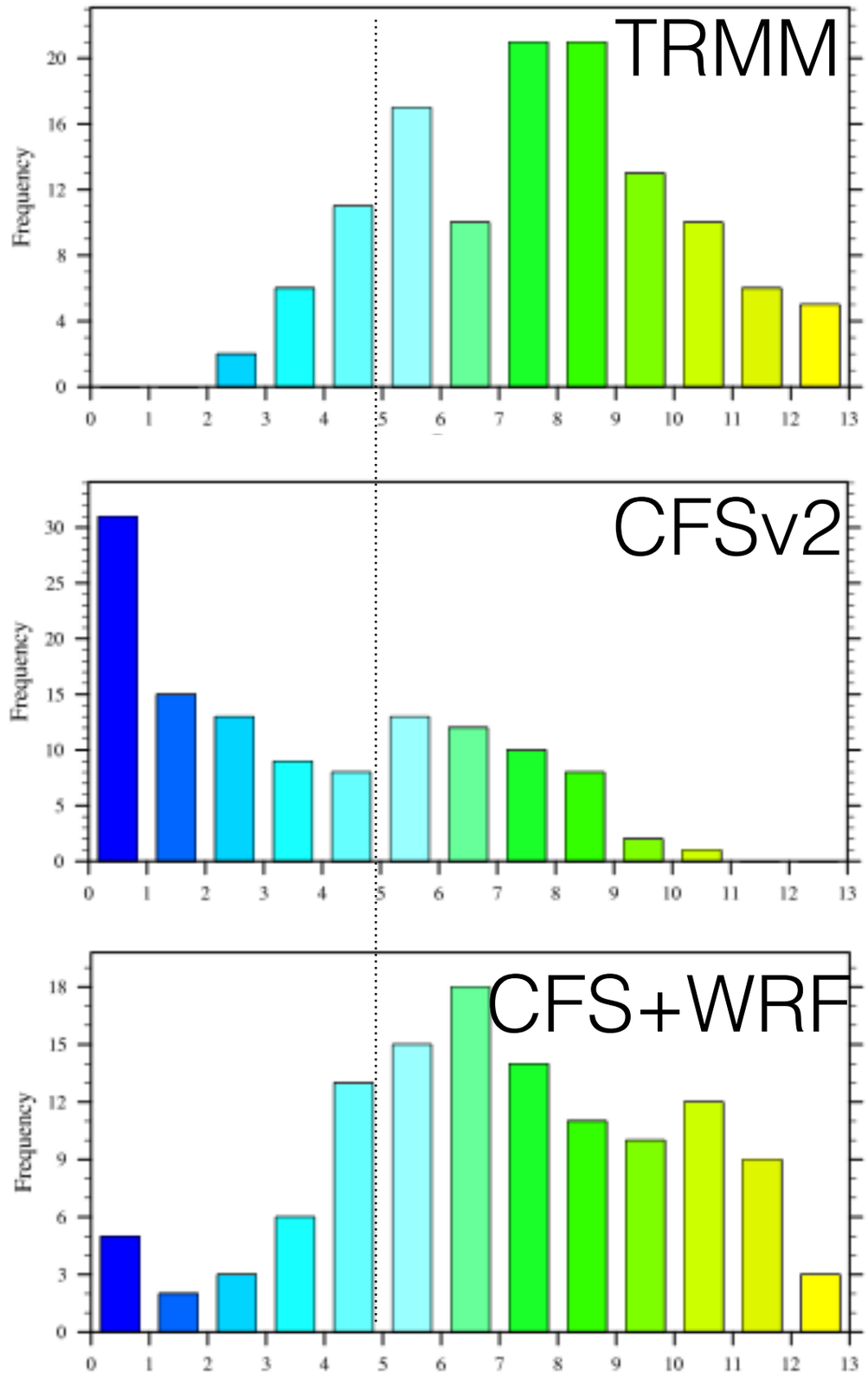


Intensity regimes in CFSv2 T382

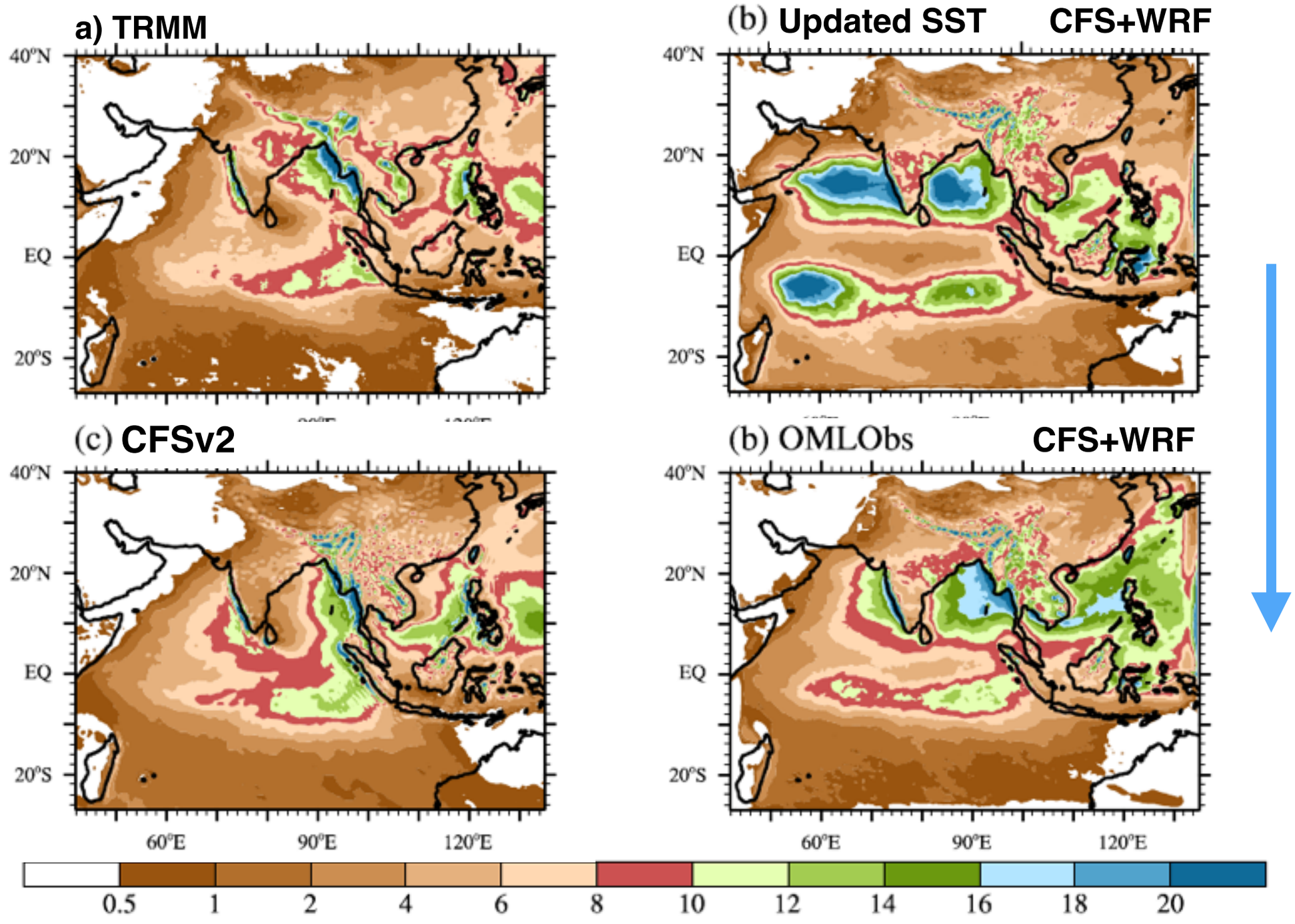


Comparison over CI region

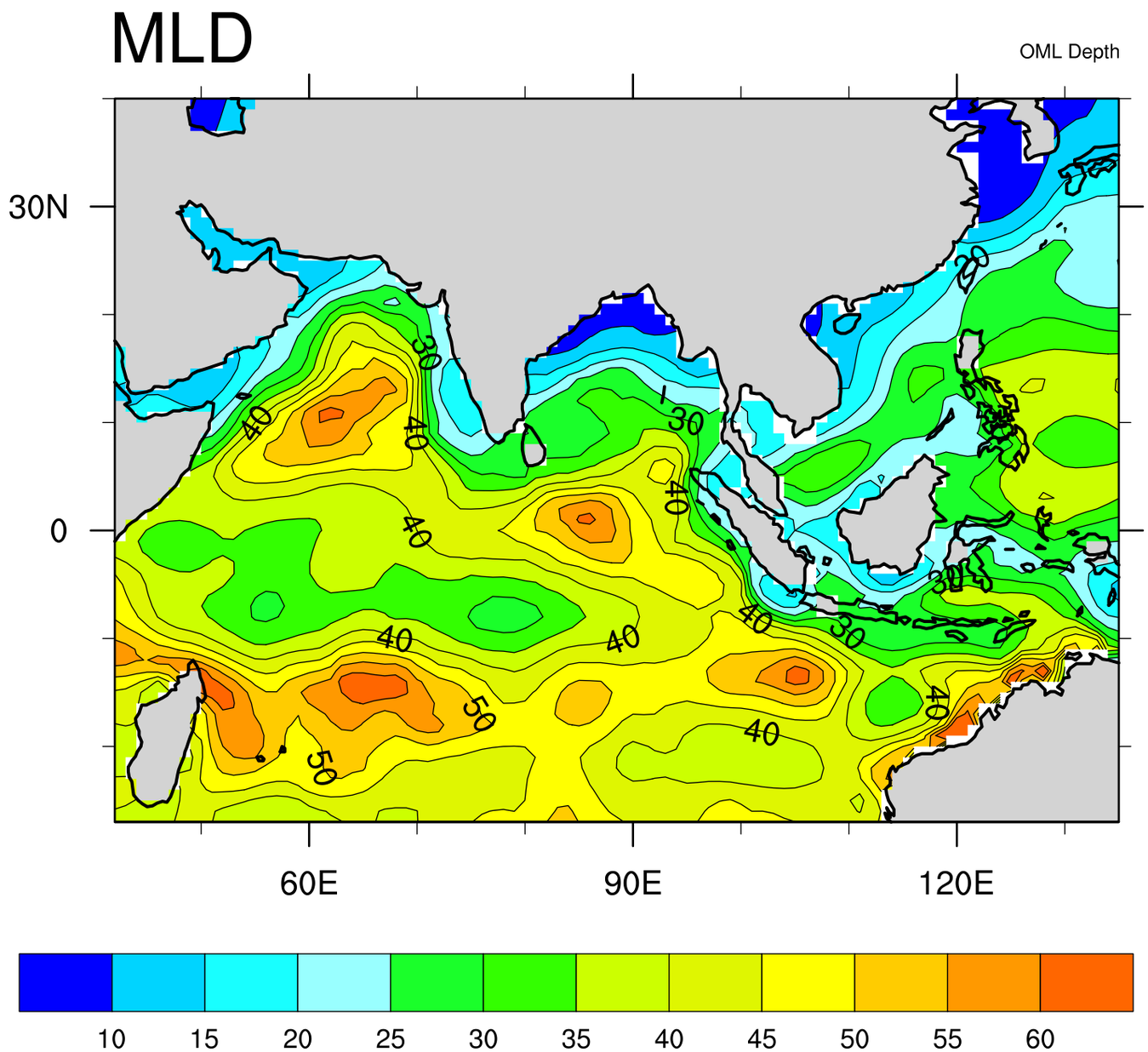
PDF of daily rainfall intensity is shown



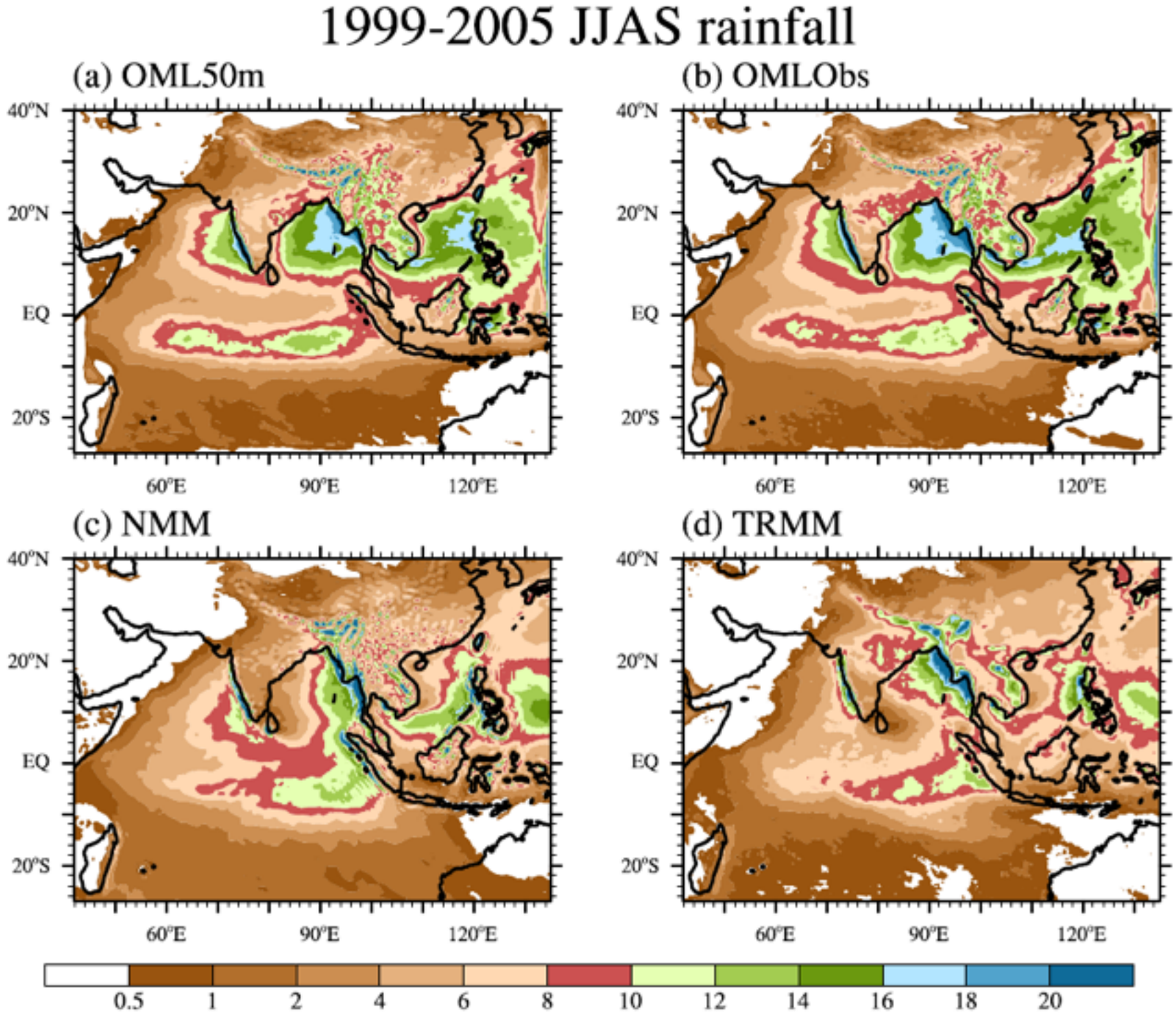
Regional air-sea interactions and mean state



Mixed layer depth - JJAS

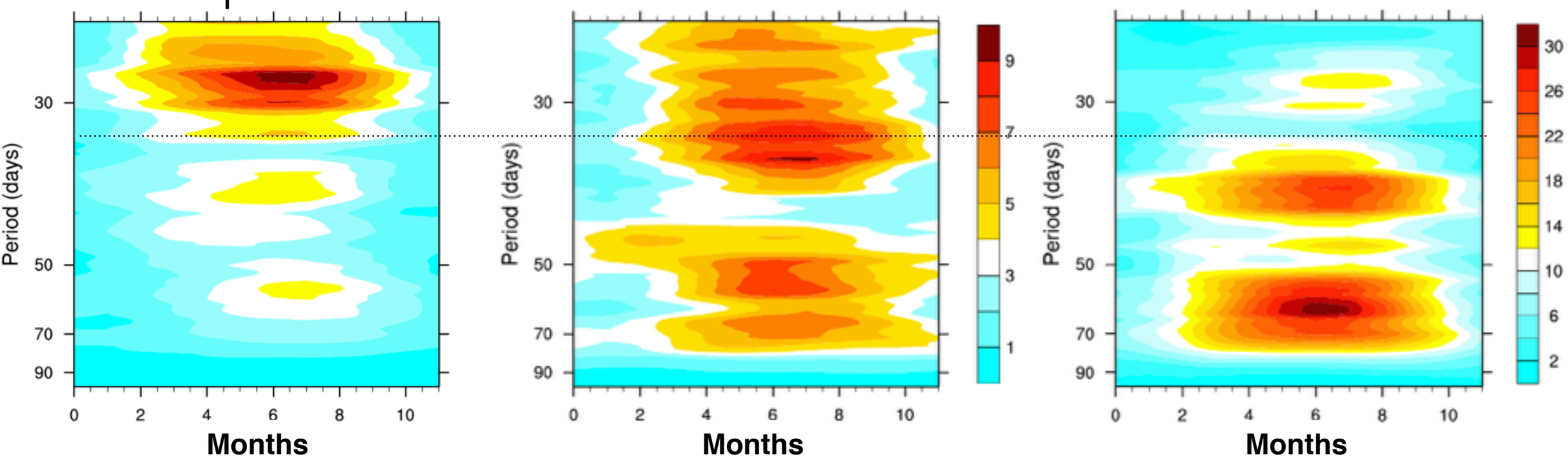


Slab mixed-layer experiments

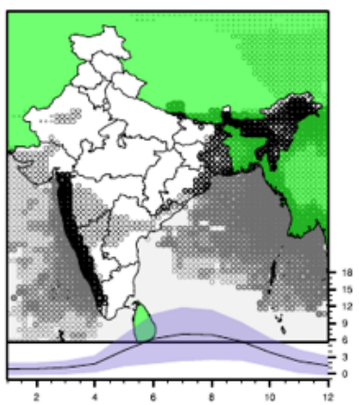


Multiscale ISMR rain regimes

subseasonal scale



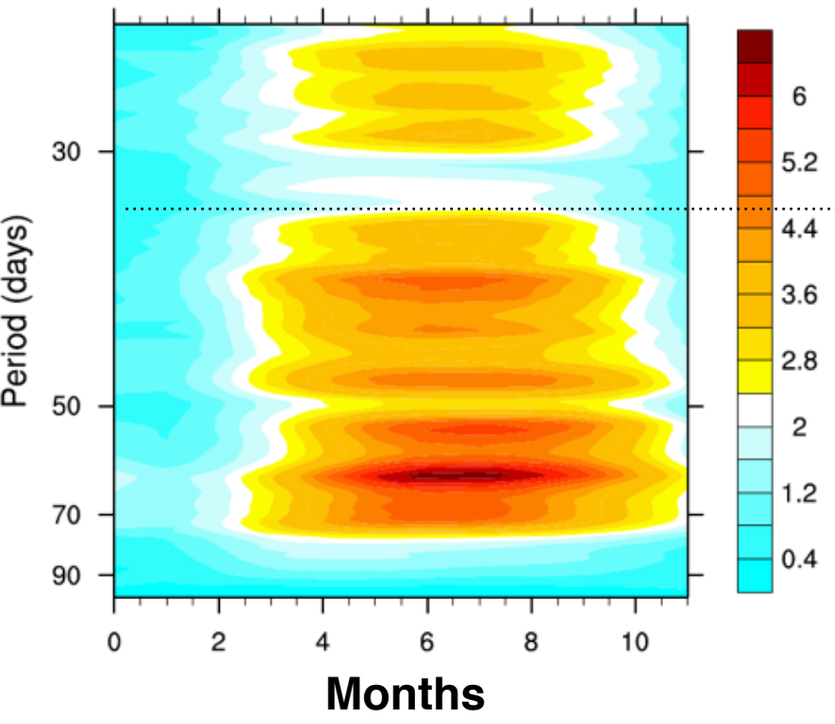
Quasi-biweekly regime



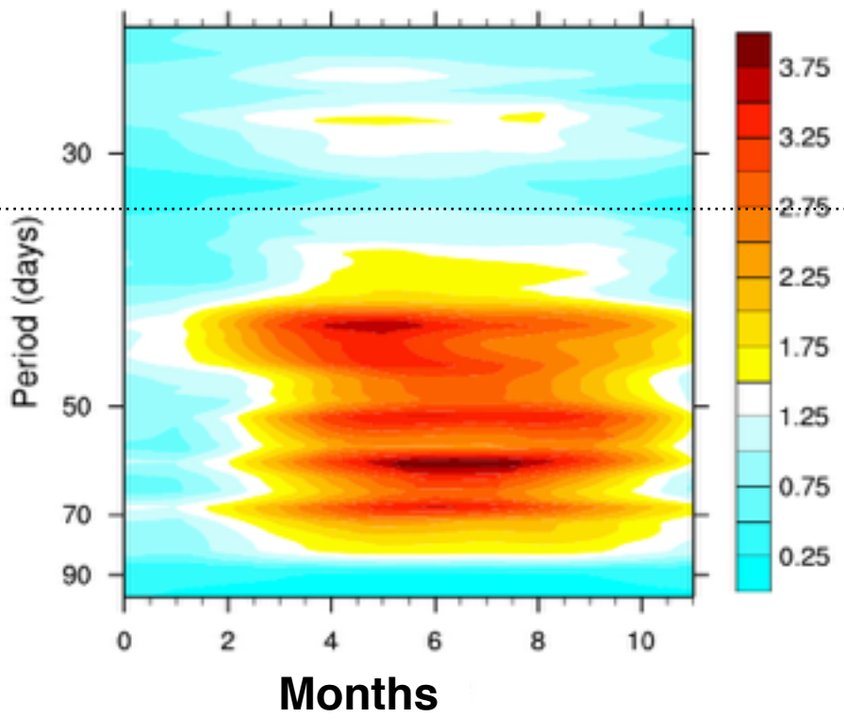
Multiscale ISMR rain regimes

subseasonal scale

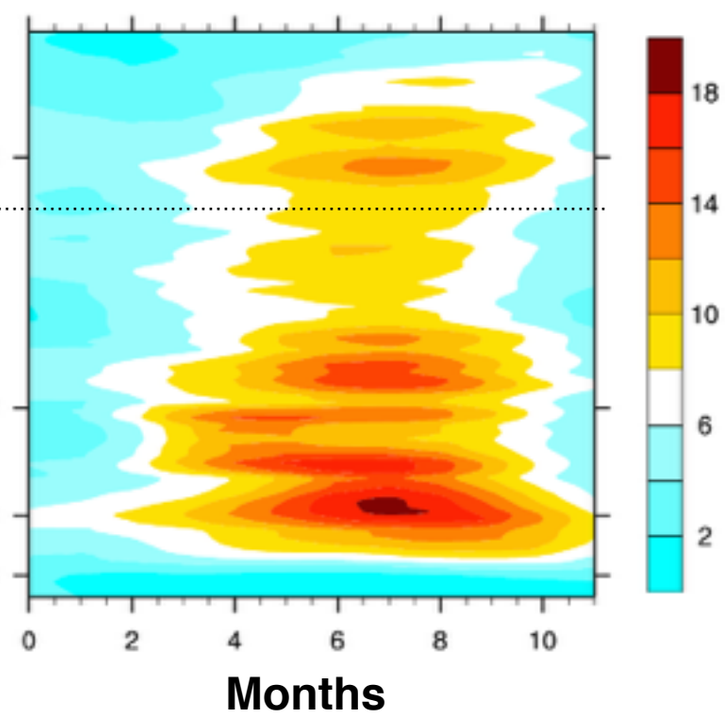
Aphrodite

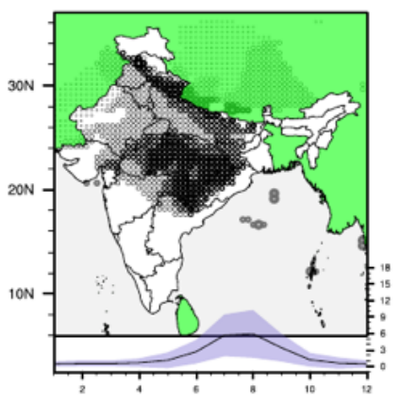


NCEP CFSv2



CFS + WRF





Summary

- Focus on role of resolution, topography, regional air-sea interaction
- A new, SOM based framework for identifying and assessing ISM features
- A series of 7 year-long embedded regional simulations using NCEP CFSv2 T382 free run as LBCs has been carried out
  - Mean structure of rainfall - regional air-sea interaction
    - Improving simulation of oceanic mixed layer (too deep in NCEP CFSv2)
  - Role of non-hydrostatic dynamics in better simulation of synoptic disturbances relevant to CI rainfall (needs further exploration)

Future work plan

- Improving ISO simulation
    - Experiments coupling with better mixed-layer formulation (3D Price-Weller-Pinkel)
- Role of resolution and topography
    - ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer, 30 meter resolution)
- Interannual time scales
- Improvements to ISMR predictability
    - Embedded runs using NCEP CFSv2 hindcasts/forecasts as LBC

Objectives

- Evaluate multi scale variations & interactions
- Impact of dynamical downscaling - through higher resolution, better representation of sea and land surface characteristics
- Representation of topography
- Role of regional air-sea interactions