Indian Monsoon 2023 & 2024 in partially coupled regional suite (ATM-KPP)

Session 9: Regional Coupled Modelling

Coupled Model (60 km) (NCUM+JULES+NEMO+CICE)

15-Days forecast/Coupled NWP: Daily

25 Km Global Ocean NEMO/CICI

60Km UM/JULES Atmosphere/Land-Surface

Multi-week/Extended Range: Weekly (every Thursday) -2018 onwards
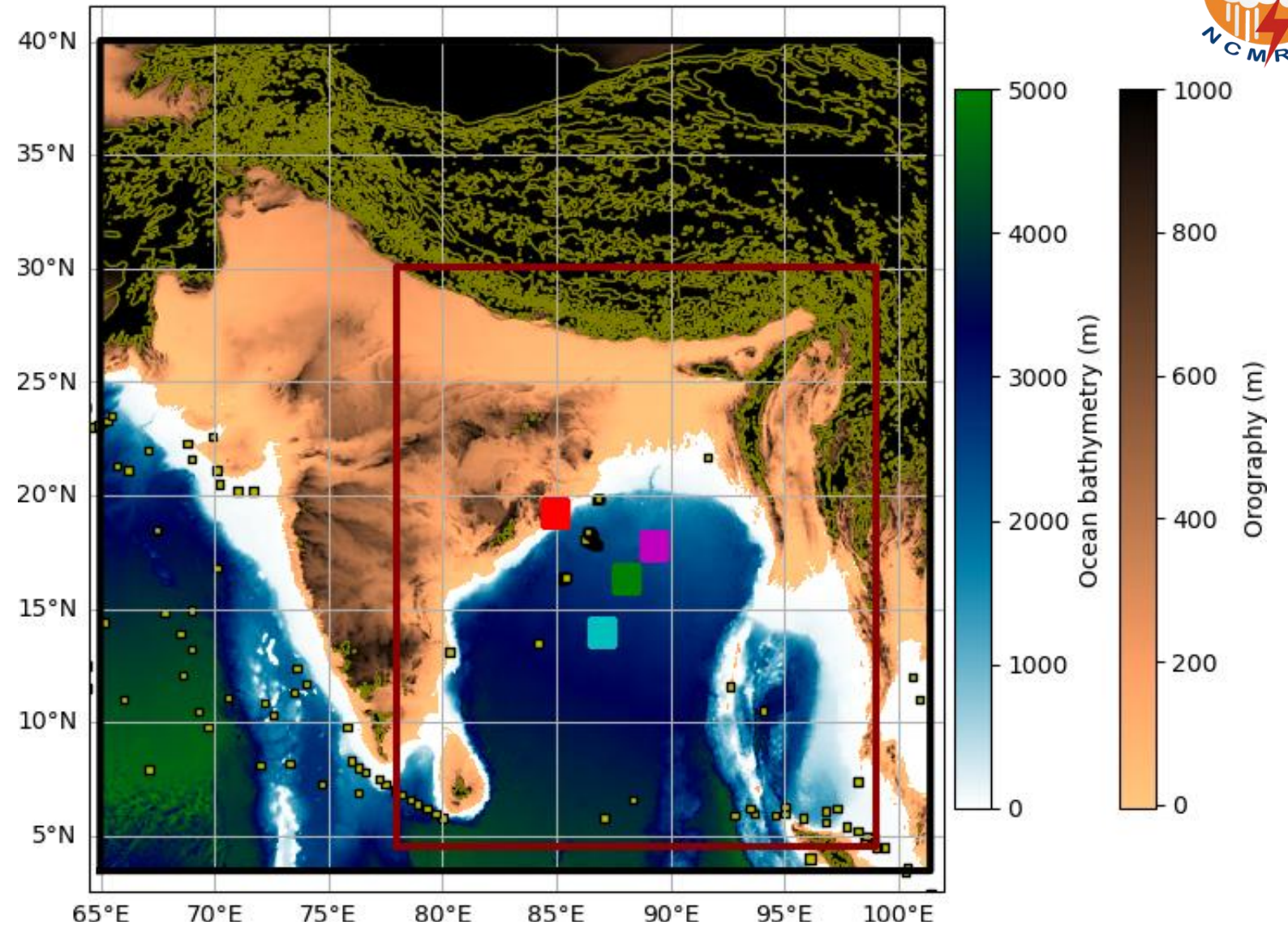
Latest example: Forecast issues on 1st Dec

- Weekly Anomalies during 2nd – 29th December 2022

- Model Climatology 23 years. Hindcast data used (1993-2015) from 6 members

- This Forecast is from 16 ensemble members with IC: 27th – 30th November 2022

- Plots show week-by-week anomalies and full fields and monthly mean anomalies valid for December 2022

Seasonal (Experimental Run): End of each month – started in 2020

Latest example: 24th November

- Number of Forecast members: 55

- Start dates: 12th to 22nd of each month & 5 member per start date

- Number of hindcast members: 23 years*6 per year (1993-2015)

- Hindcasts are used to defined the normal for percentage departures

- Hindcasts are used to define threshold for tercile categories for probabilistic forecasts

Regional Coupled Suite (RCS-Ind) Modelling at NCMRWWF

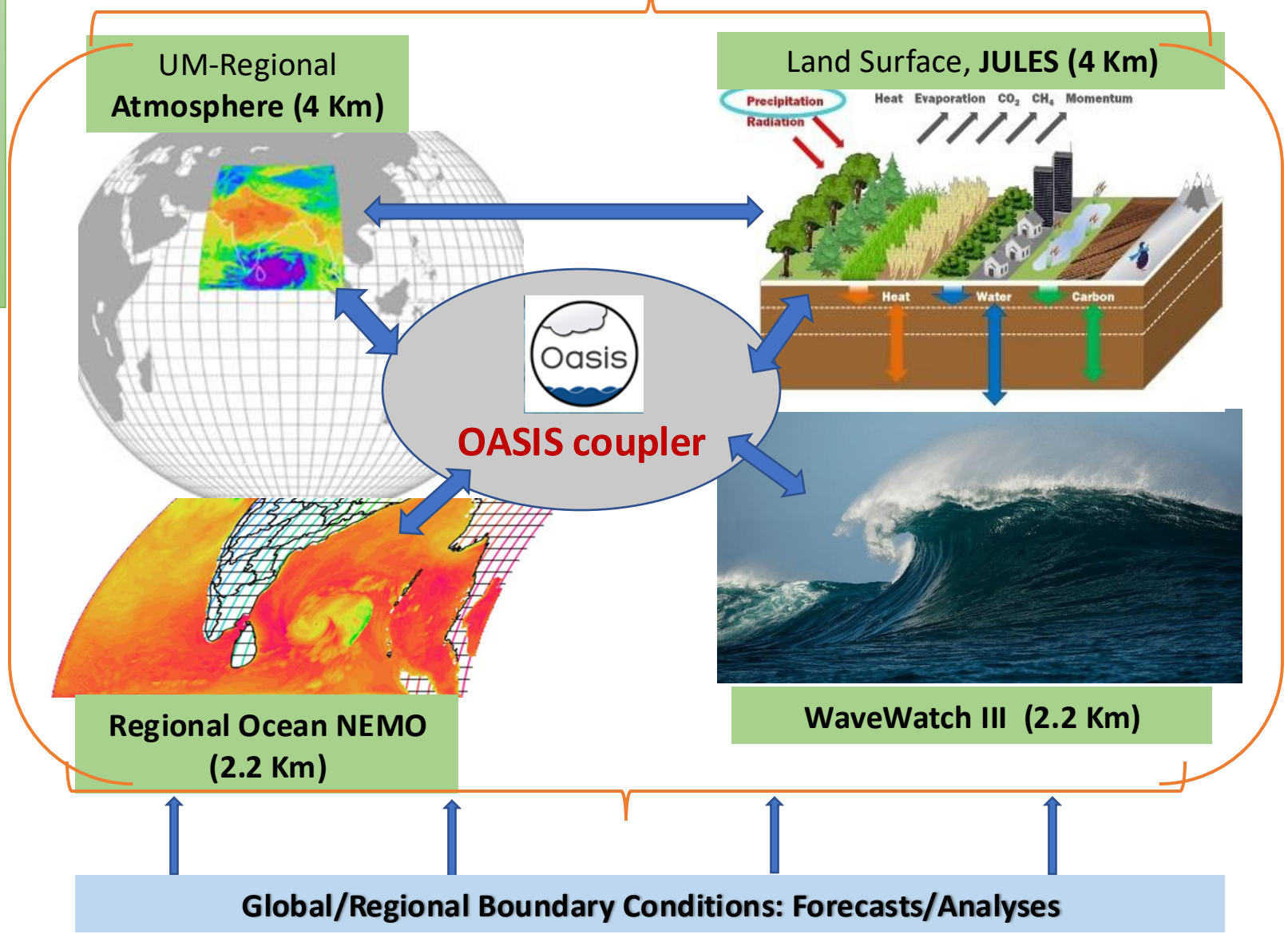Regional coupled environmental model with "Ocean", "Atmosphere" and "Wave" components.

UM+JULES-> **Atmosphere**
NEMO-> **Ocean**
WAVEWATCH III-> **Waves**

ATMOSPHERE & LAND SURFACE

Resolution: **4.05 km x 4.05 km,**
E-W: **64.9835 E - 101.393 E,**
N-S: **3.464 N, 40.0355 N**
Domain Size: **900x904x80 grids**

OCEAN & WAVE

Resolution: **2.2 km x 2.2 km, Wave**
Model: **WaveWatch III**
E-W: **64.9835 E- 101.393,**
N-S: **3.464 N- 26.558 N**
Domain Size: **1100x1760x75 grids**

OFFICIAL
Regional Coupled Model
Convective Scale Coupled Environmental Prediction System

UM-Regional **Atmosphere (4 Km)**

Land Surface, **JULES (4 Km)**

OASIS coupler

Regional Ocean NEMO (2.2 Km)

WaveWatch III (2.2 Km)

Global/Regional Boundary Conditions: Forecasts/Analyses

Experiments: UNCOUPLED → PARTIALLY COUPLED → FULLY COUPLED

Tropical Storm Fani: Model Rain and OLR

Forecasts IC: 00z 28th April 2019

6-hrly forecast up to 108 Hr

FORECAST IC=00Z28April2019, 6 hour Forecast

Outgoing Longwave Radiation (OLR)

MSLP (hPa),Rain (mm/hr)

Tropical Storm Fani:
26th April-4th May 2019
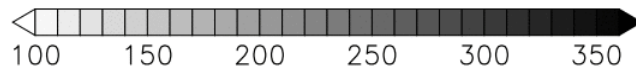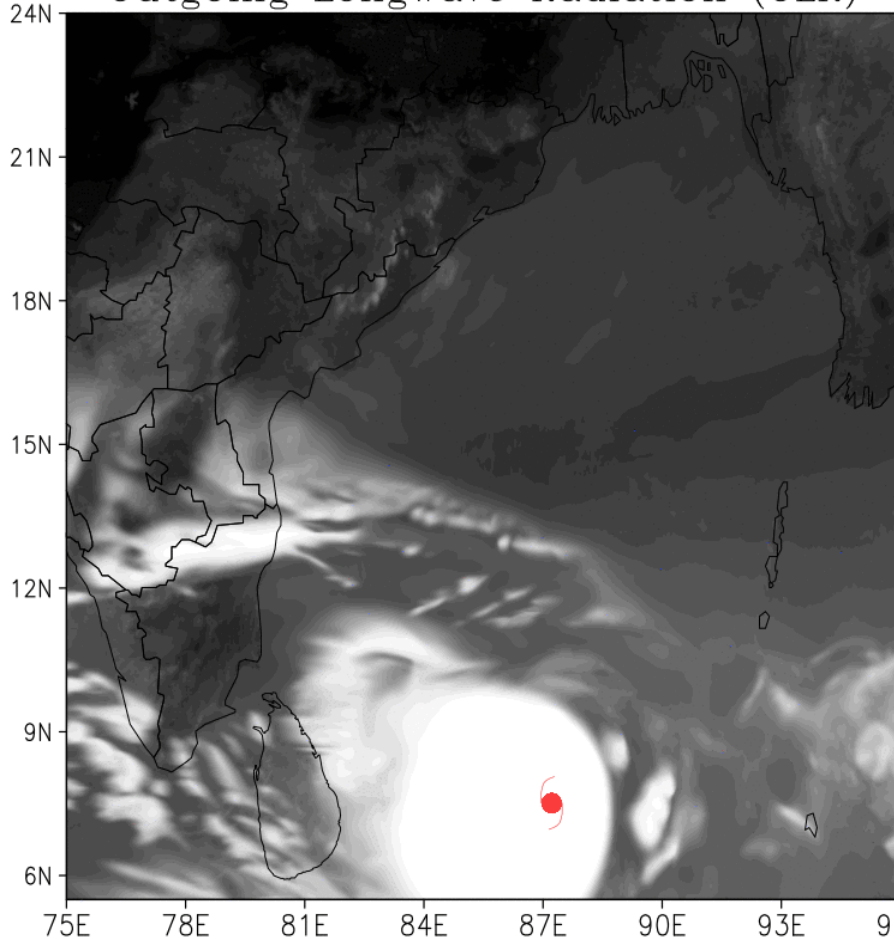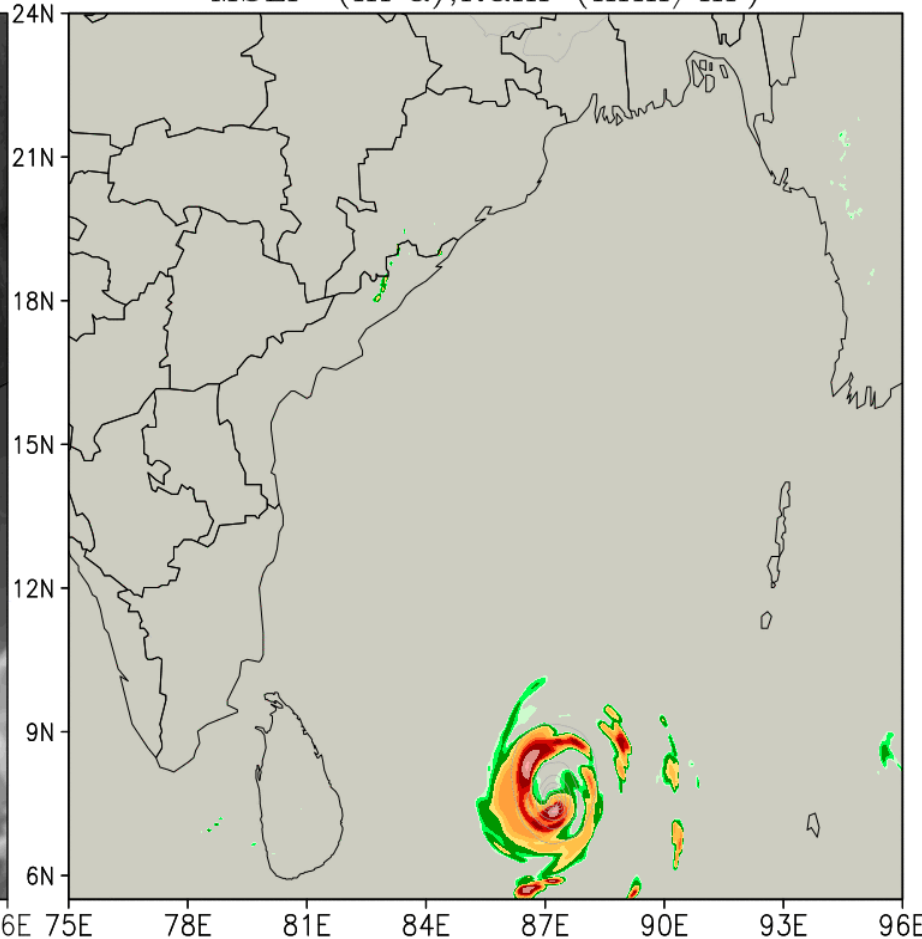
At 8:00 a.m. IST (02:30 UTC) 3 May, Fani made landfall near Puri, Odisha as an extremely severe cyclonic storm, with 3-minute sustained winds of 185 km/h (115 mph) and 1-minute sustained winds of 230 km/h (145 mph) according to IBTrACS record.
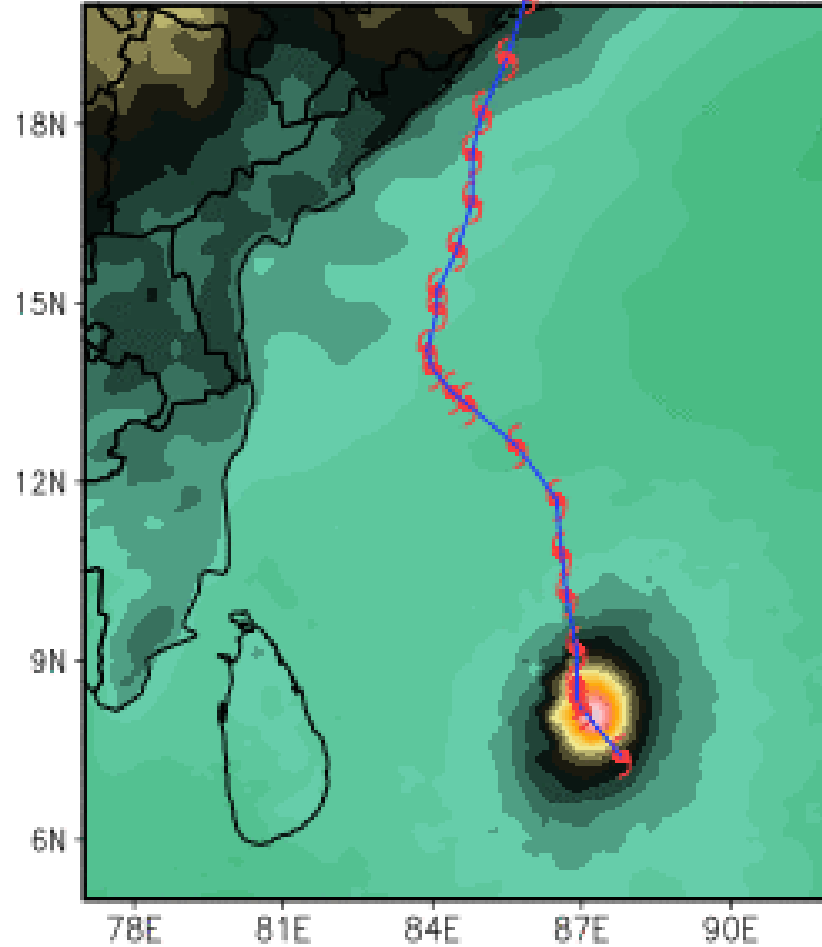
This made Fani the most intense storm to make landfall in India's Odisha state since the 1999 Odisha cyclone.

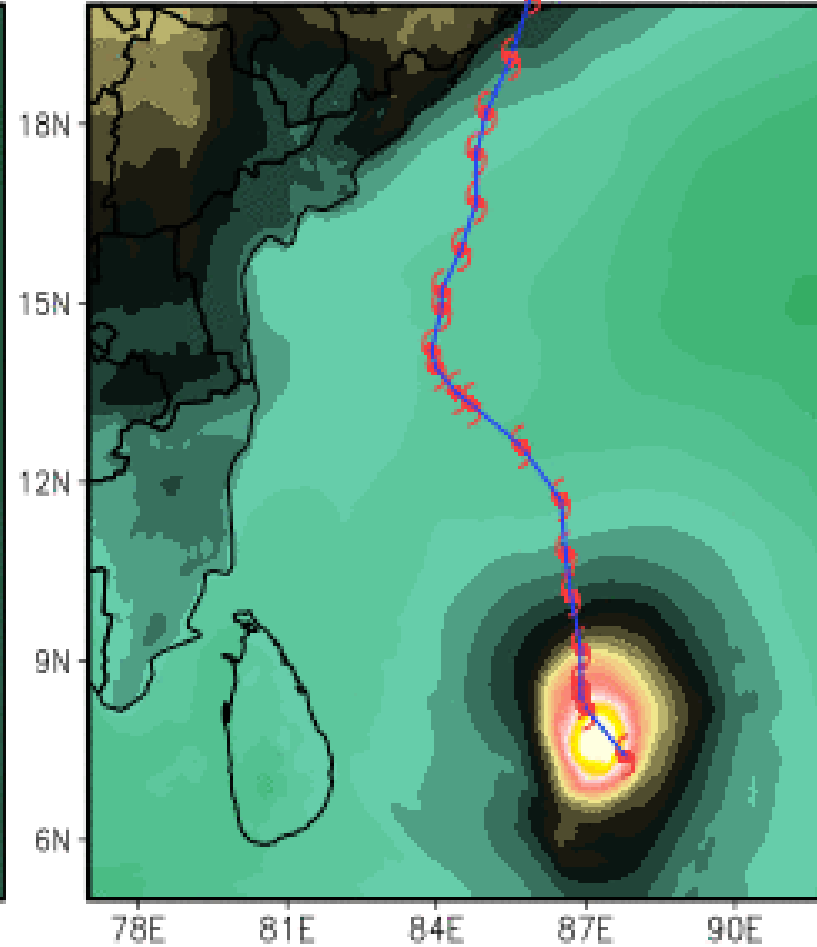# Tropical Storm Fani: Observed Track and Model forecasted MSLP

Forecasts IC: 00z 28th April 2019
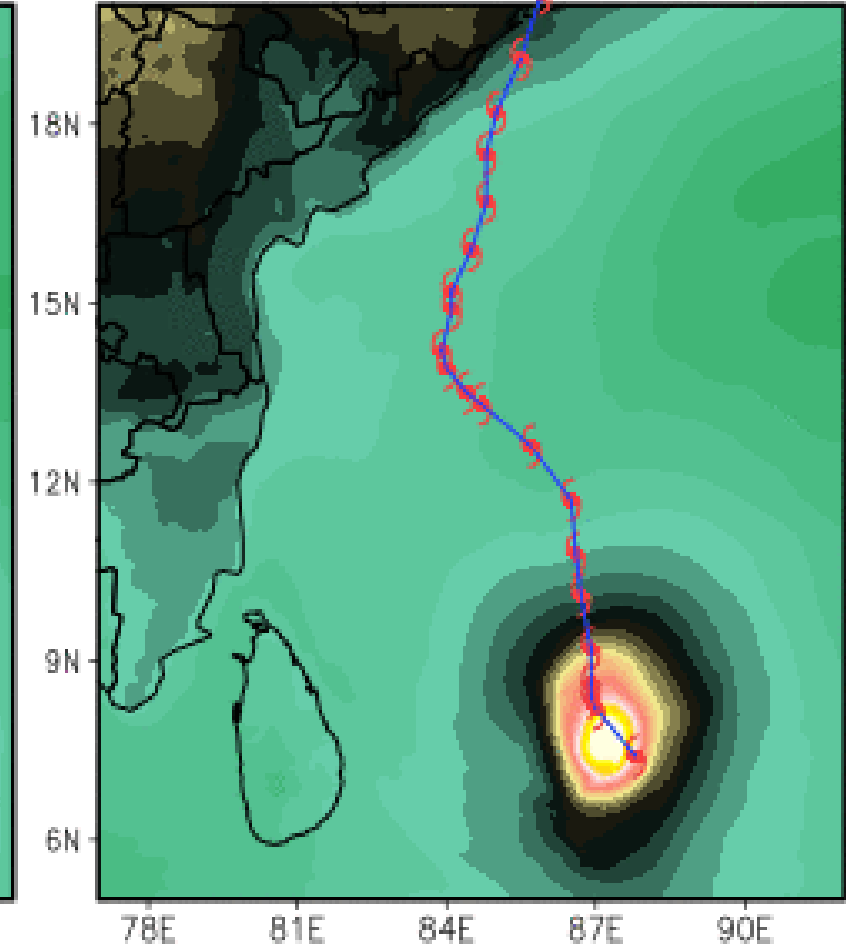
6-hrly forecast up to 108 Hr

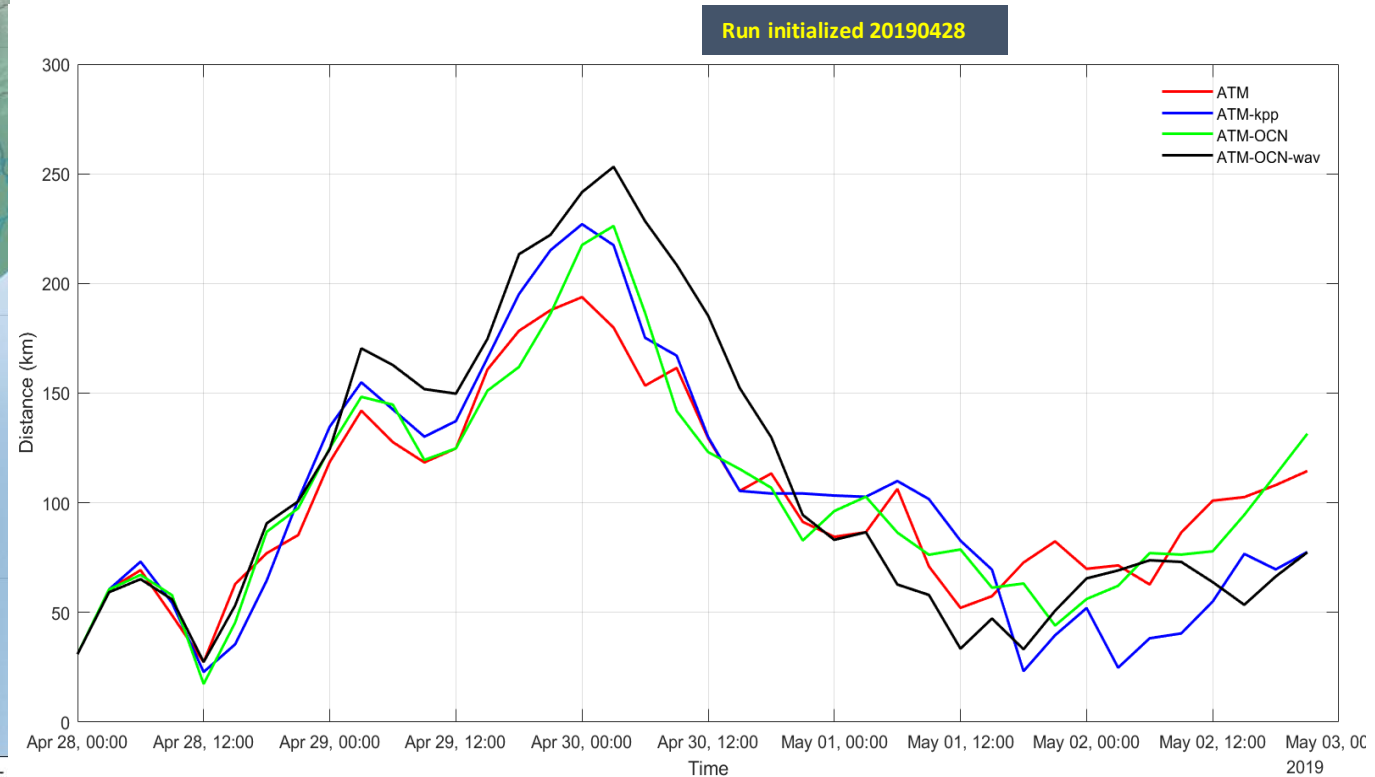(a) Global NCUM MSLP Fcst hr 6   (b) Reg unCpl-A MSLP Fcst hr 6   (c) Reg cpl-OA MSLP Fcst hr 6
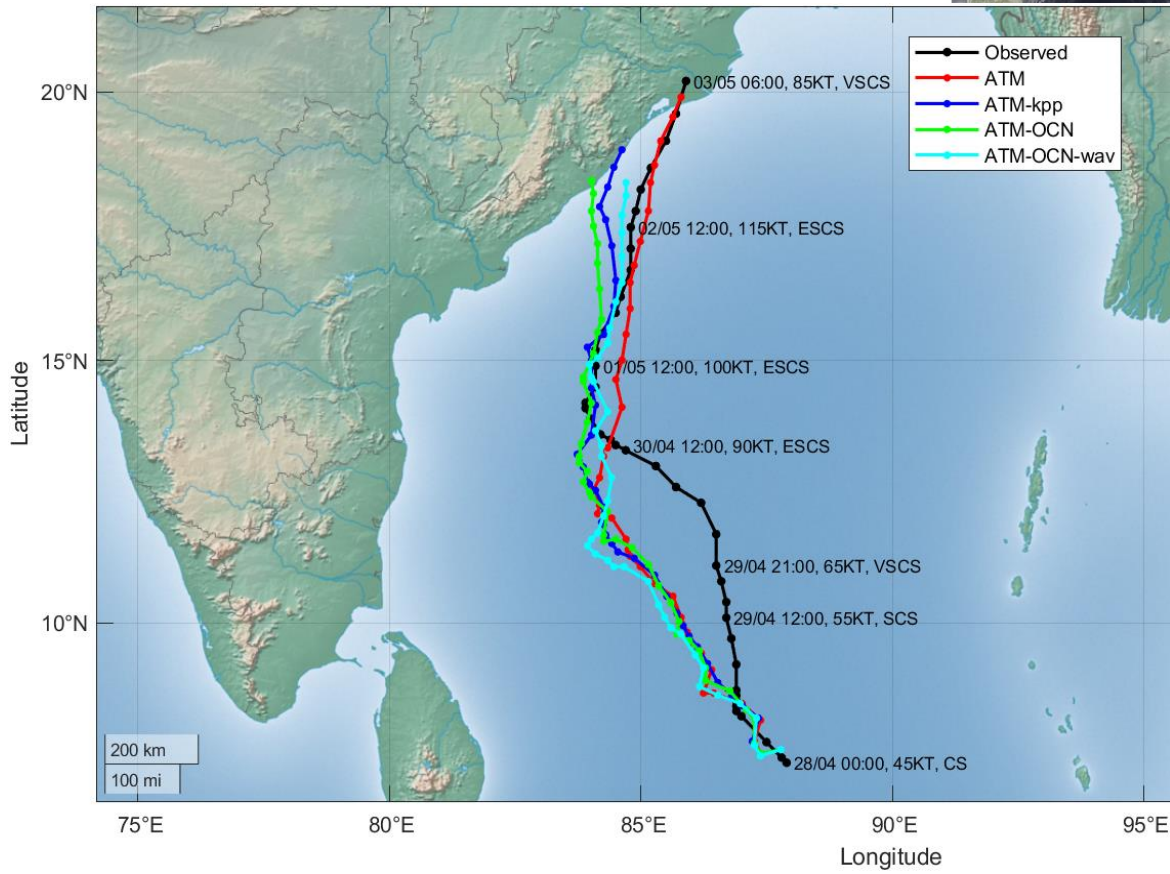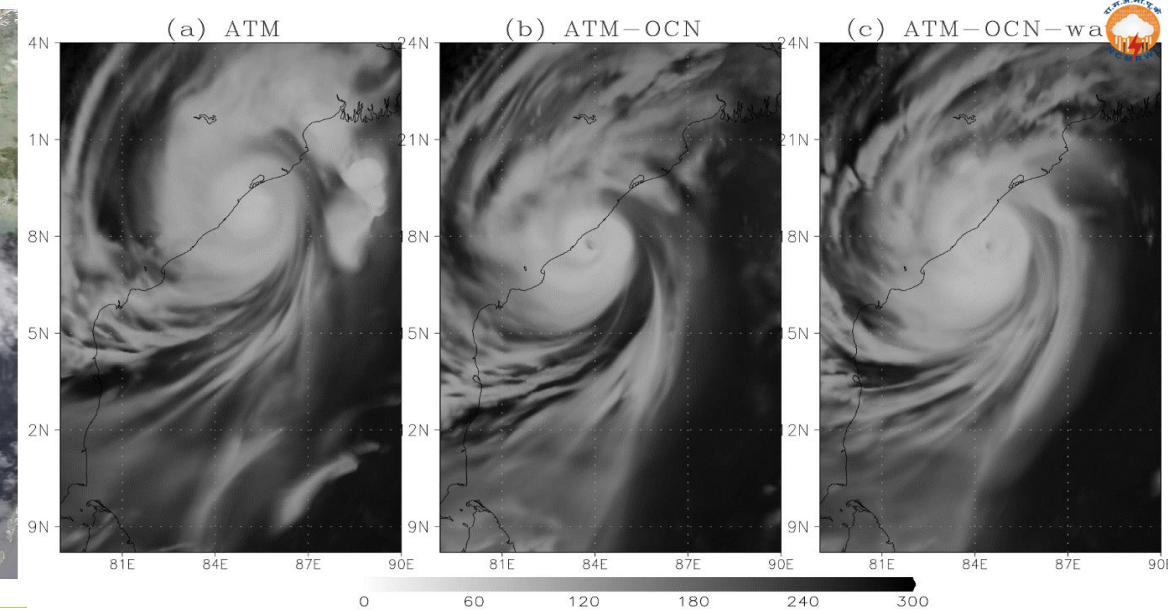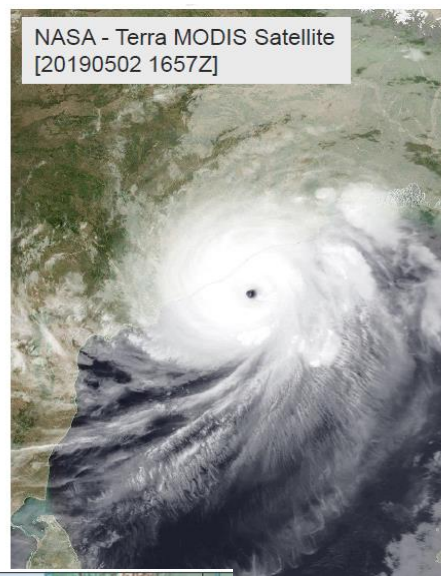
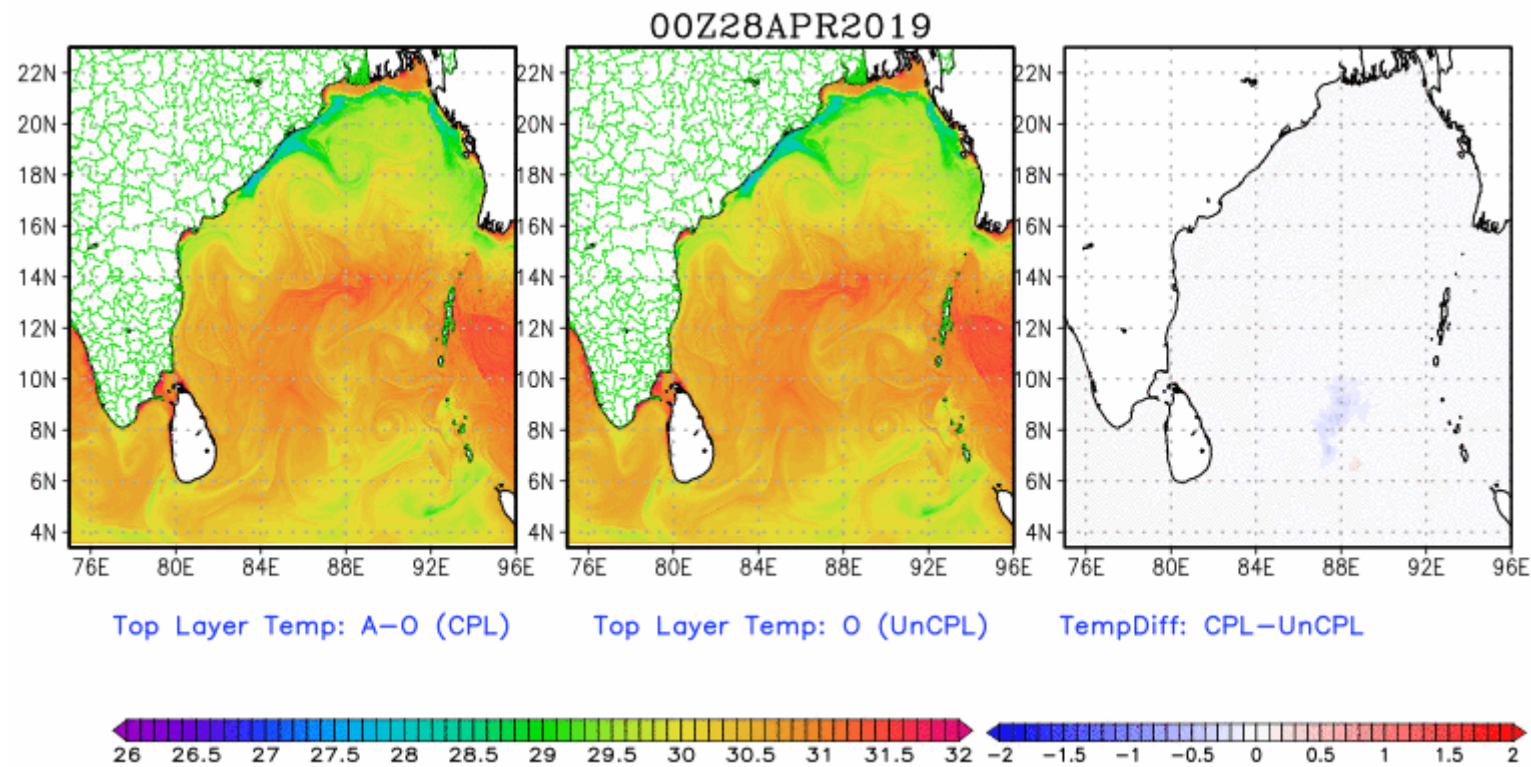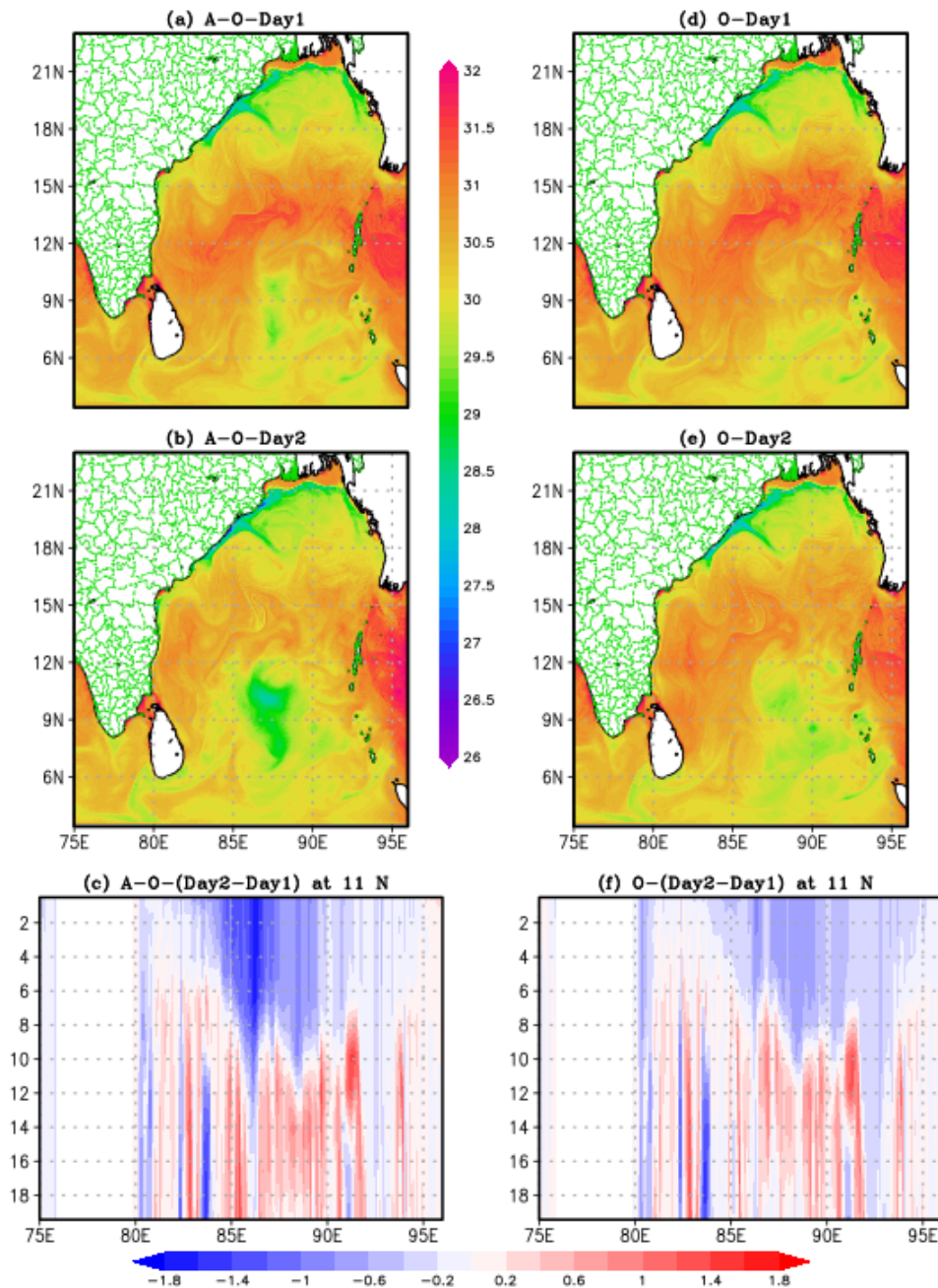**(Outgoing Longwave Radiation (OLR)) Forecast from Model compared against Satellite observation**

NCMRWF HPC

Model was initialized at
00Z28April2019 on NCMRWF HPC,
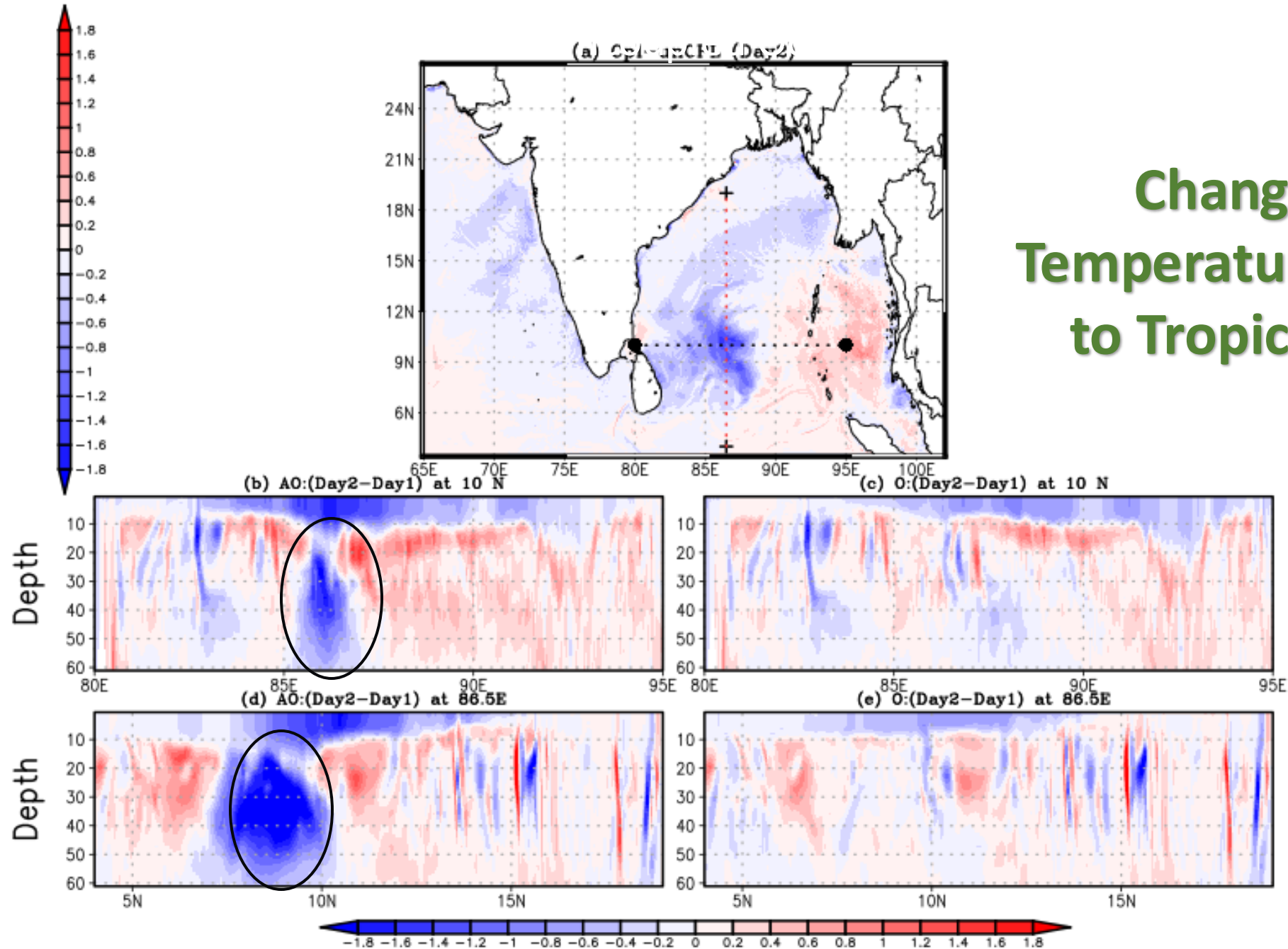OLR forecasts compares are valid at
[20190502 1700]

NASA - Terra MODIS Satellite
[20190502 1657Z]

(a) ATM

(b) ATM−OCN

(c) ATM−OCN−wav

Run initialized 20190428

SST and Ocean Temperature Tendency

(a) A-O-Day1
(b) A-O-Day2
(c) A-O-(Day2-Day1) at 11 N
(d) O-Day1
(e) O-Day2
(f) O-(Day2-Day1) at 11 N

00Z28APR2019

Top Layer Temp: A-O (CPL)
Top Layer Temp: O (UnCPL)
TempDiff: CPL-UnCPL

Change in Ocean Temperature (model) due to Tropical Storm Fani

Configuration	a	o	w	ak	aw	ao	aow
Nodes used	48	15	10	49	58	63	73
Runtime per day[1]	17 min	20 min	5 min	18 min	18 min	20 min	22 min
Runtime per day[2]	16 min	21 min			16 min		24 min	
Output per day[3] (Diagnostic)	20 Gb	25 Gb	2 Gb	25 Gb	22 Gb	45 Gb	47 Gb
Output per day[4] (Coupling)	0 Gb	0 Gb	0 Gb	26 Gb	10 Gb	51 Gb	71 Gb

1 Met Office HPC
2 Mihir (MoES) HPC

Geosci. Model Dev., 15, 4193–4223, 2022

https://doi.org/10.5194/gmd-15-4193-2022

Geoscientific
Model Development

First attempt to install the Regional Coupled Suite (RCS) coupled suite on NCMRWF HPC was done in March 2020. Initial test results were compared with those of UKMO.

MoES-UKMO Joint study was communicated to GMD, work is published in June 2022.

Work continues to further fine-tune the RCS

The Regional Coupled Suite (RCS-IND1): application of a flexible regional coupled modelling framework to the Indian region at kilometre scale

Juan Manuel Castillo[1], Huw W. Lewis[1], Akhilesh Mishra[2], Ashis Mitra[2], Jeff Polton[3], Ashley Brereton[3], Andrew Saulter[1], Alex Arnold[1], Segolene Berthou[1], Douglas Clark[4], Julia Crook[5], Ananda Das[6], John Edwards[1], Xiangbo Feng[7], Ankur Gupta[2], Sudheer Joseph[8], Nicholas Klingaman[7], Imranali Momin[2], Christine Pequignet[1], Claudio Sanchez[1], Jennifer Saxby[5], and Maria Valdivieso da Costa[7]

[1]Met Office, Exeter, EX1 3PB, UK
[2]National Centre for Medium Range Weather Forecasting (NCMRWF), Noida, India
[3]National Oceanography Centre, Liverpool, UK
[4]UK Centre of Ecology & Hydrology (UKCEH), Wallingford, UK
[5]School of Earth and Environment, University of Leeds, Leeds, UK
[6]India Meteorological Department (IMD), Delhi, India
[7]Department of Meteorology, University of Reading, Reading, UK
[8]Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, India

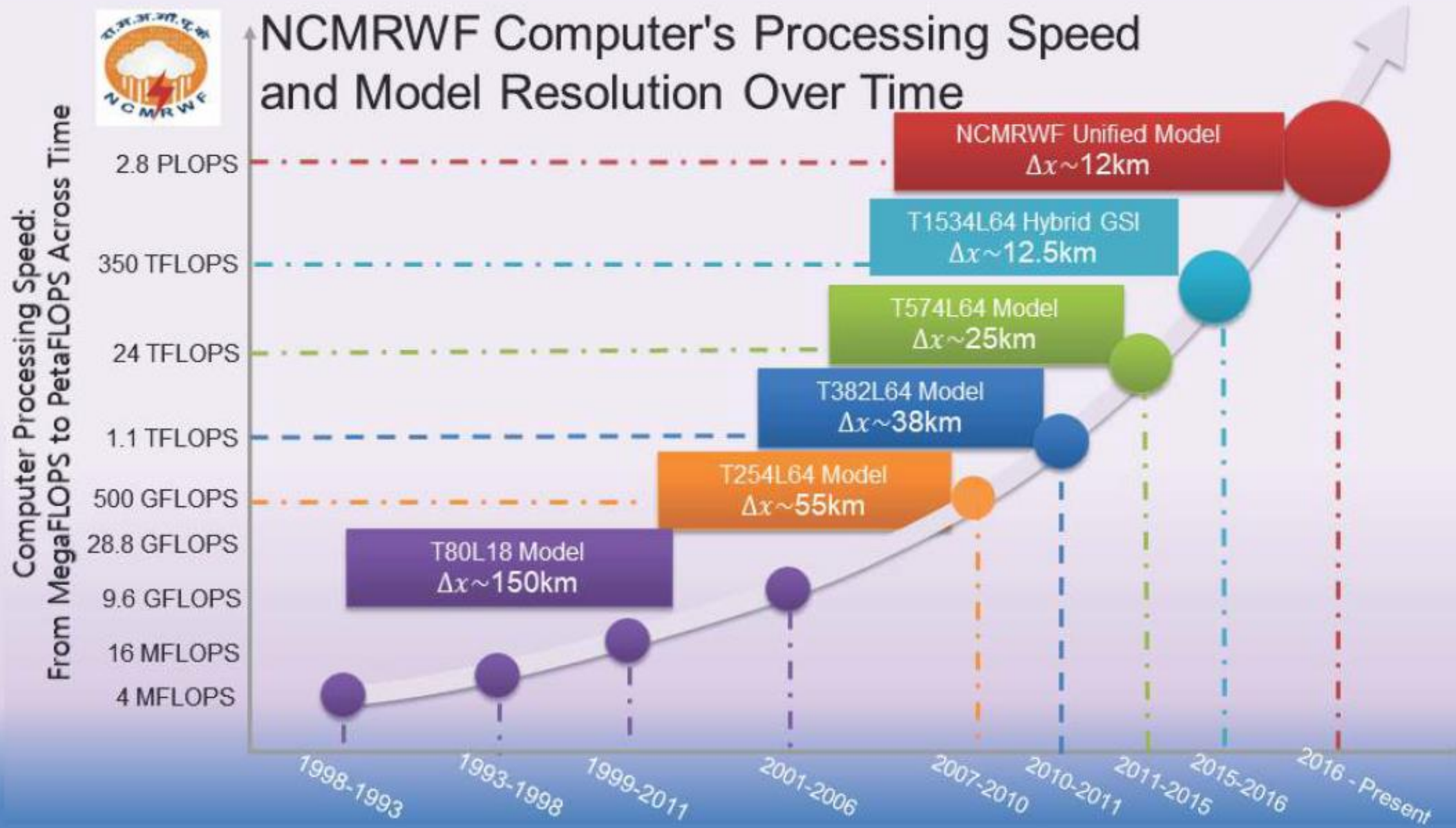Correspondence: Juan Manuel Castillo (juan.m.castillo@metoffice.gov.uk)

Figure 2.27: Schematic showing the time evolution of the computer processing speed along with decreasing spatial resolution of the NWP models at NCMRWF.

ATMOSPHERE/LAND   IND1a
ATM

Experiment options:

Default: fixed global NWP *SST*

o: OSTIA *SST updated daily*

h: INDo *SST updated hourly*

MetUM vn11.1
JULES vn5.2

OCEAN-ONLY   IND1o

Experiment options:

e: ERA5 *core forcing*

g: global NWP *flux forcing*

h: INDa *hourly flux forcing*

NEMO vn4.0.1

WAVE-ONLY   IND1w

Experiment options:

g: global NWP *flux forcing*

h: INDa *hourly flux forcing*

gc or hc: with INDo *currents*

WWIII vn4.18

PARTIALLY COUPLED
AO **IND1ao**

A ↔ O

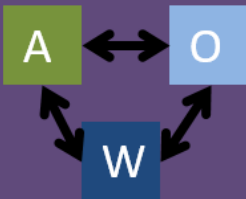**PARTIALLY COUPLED**
IND1aw
[options: o, h, c]

A ↔ W

Source: MetOffice

PARTIALLY COUPLED
OW **IND1ow**
[options g, h]

O ↔ W

PARTIALLY COUPLED (KPP)
KPP **IND1ak**

FULLY COUPLED
AOW **IND1aow**

A ↔ O
W

**Schematic summary of RCS-IND1 modelling framework configuration, experiment options and naming conventions.**

Monsoon & Tropical Cyclone Case Studies 2023/2024

**Near Real Time Forecast using Regional Coupled Suite's ATM & ATM-Kpp**

1. **Experiments with and without KPP Mixed Layer (UM 12.1)**
2. **RA2T Experiments (both)**
3. **Forced with NCUM-G forecast**
4. **Atmospheric Initialization with NCMRWF UM Global Analysis**
5. **KPP Initialized using NCMRWF NEMO-ORCA25 Analysis**
6. **Daily runs with 00Z IC**
7. **RAL3 experiments going on**
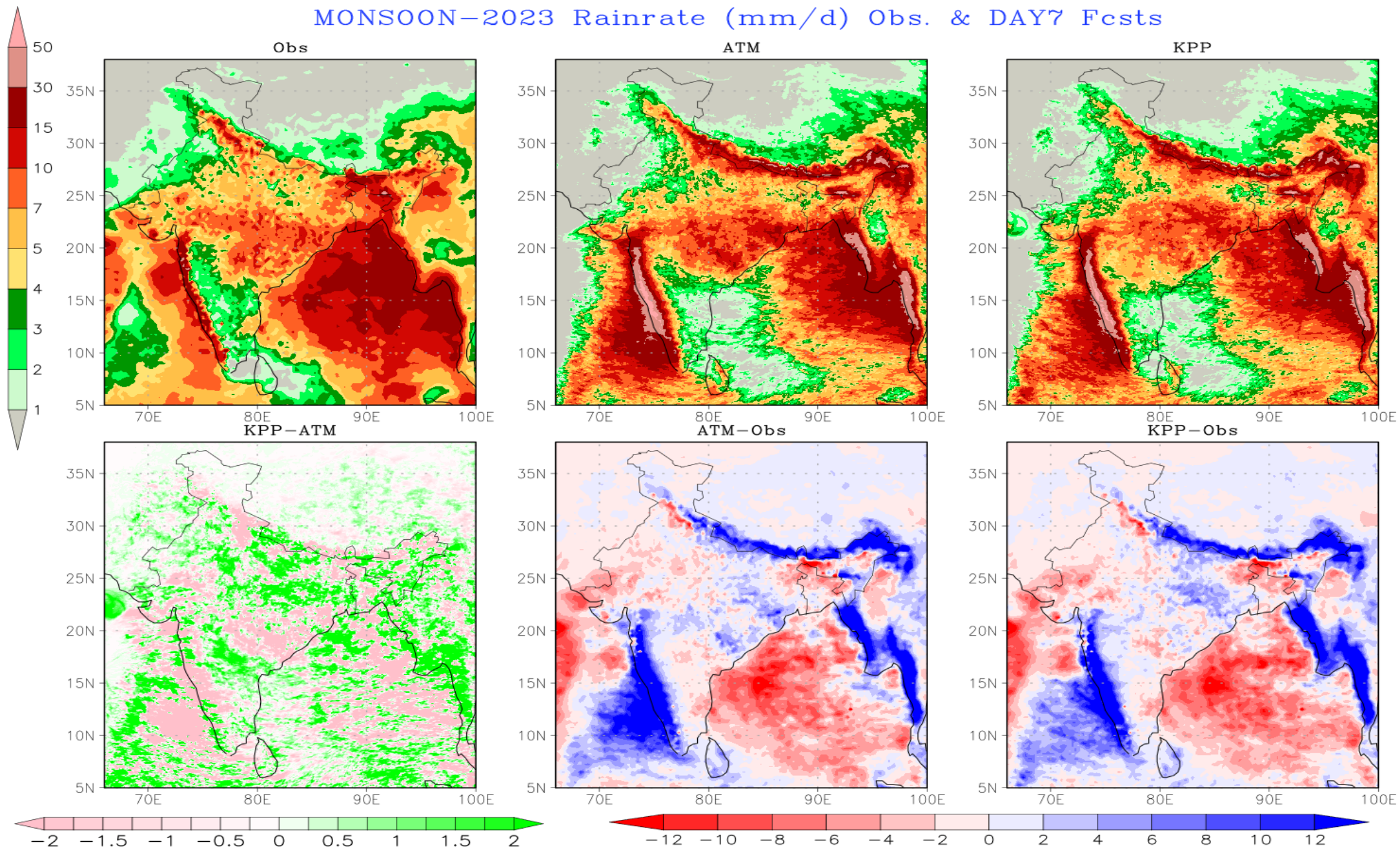
MONSOON-2023 Rainrate (mm/d) Obs. & DAY3 Fcsts
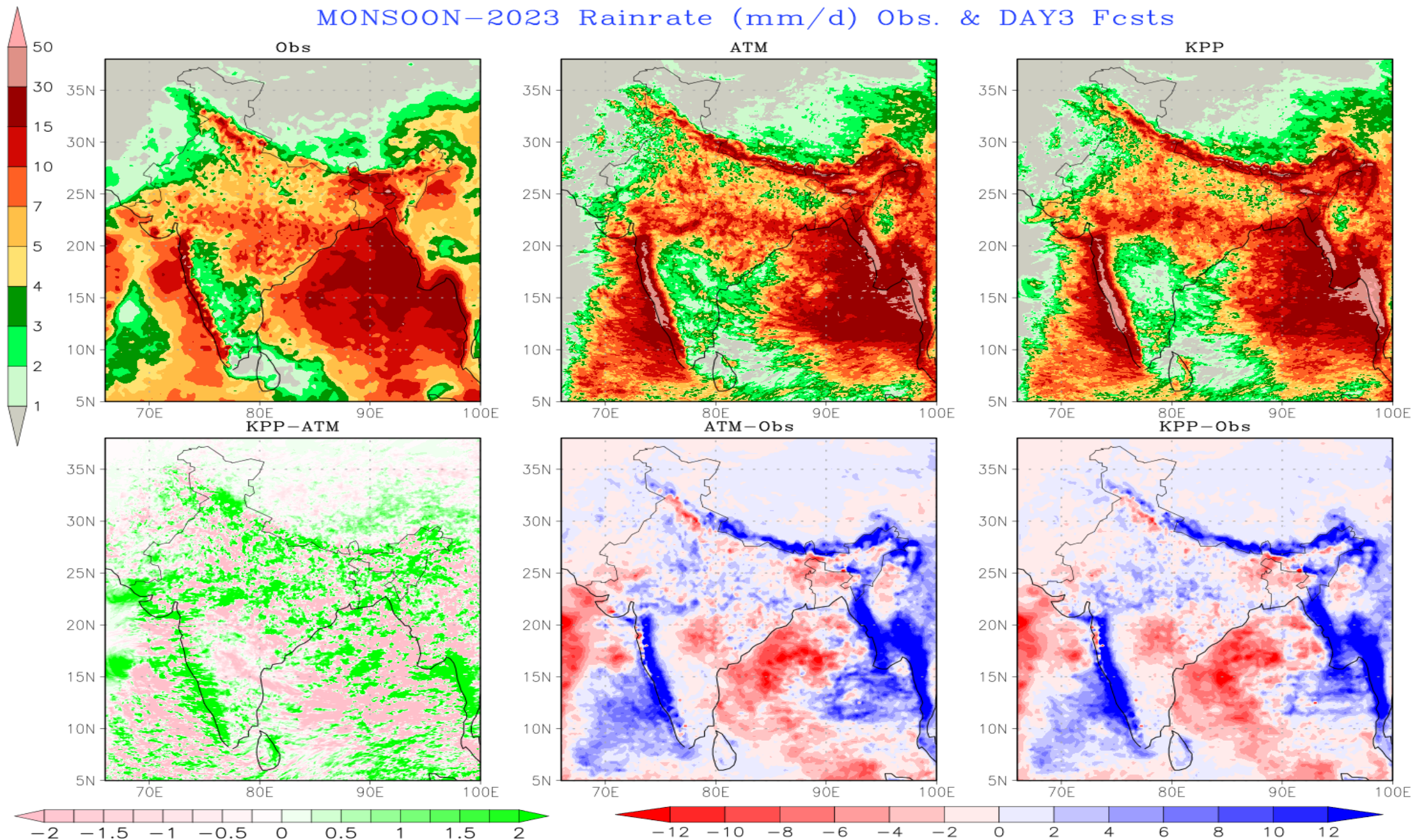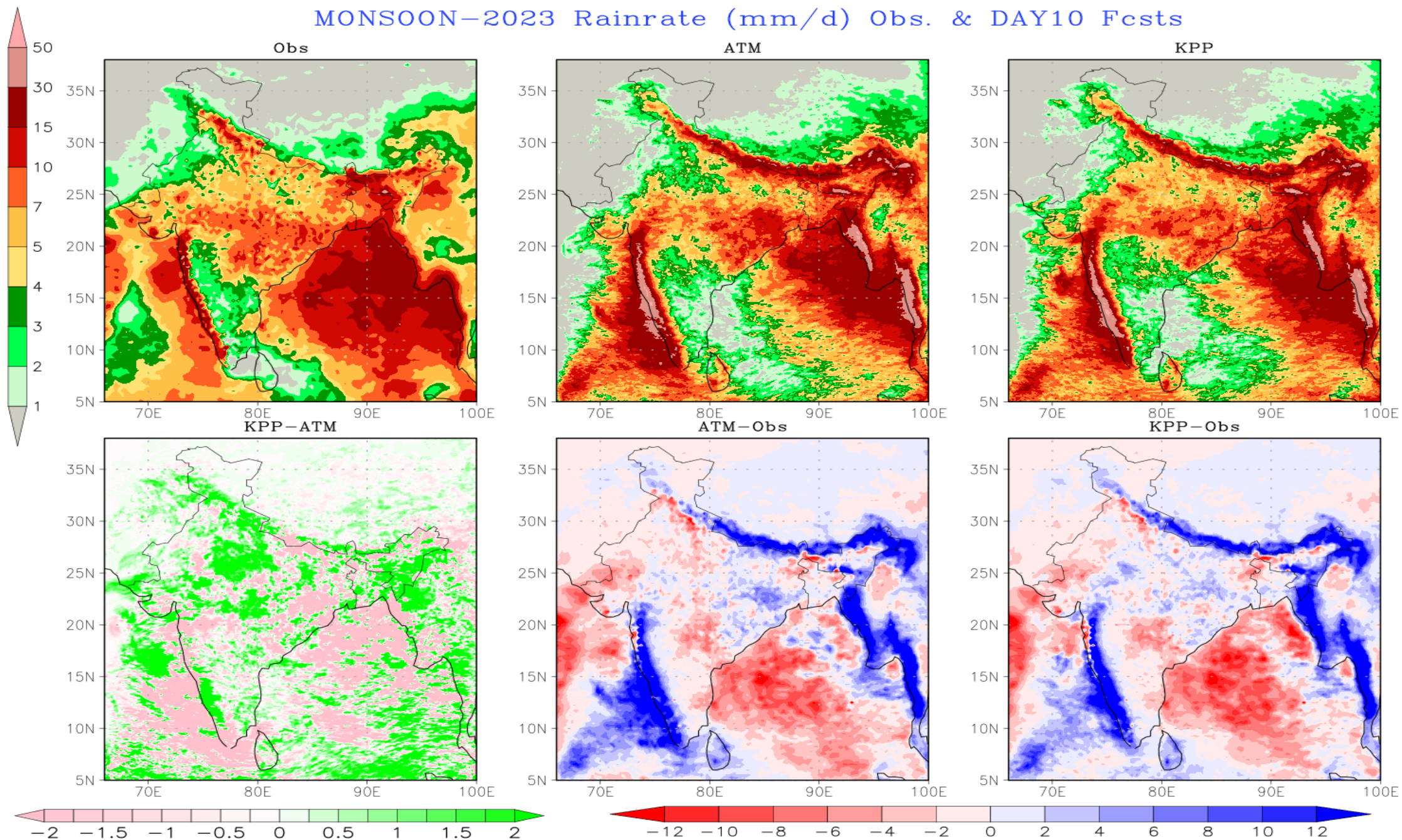
MONSOON−2023 Rainrate (mm/d) Obs. & DAY5 Fcsts
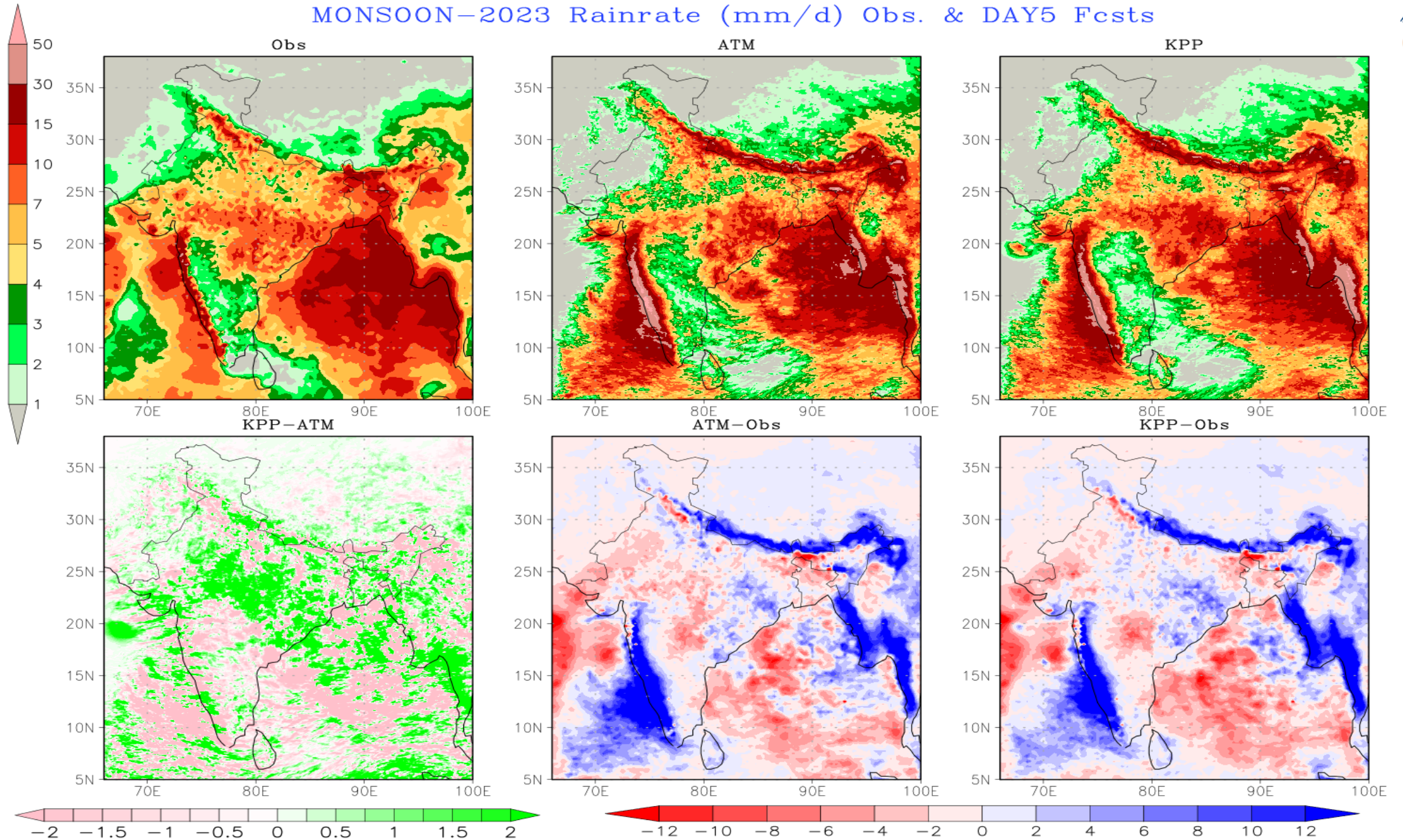
MONSOON-2023 Rainrate (mm/d) Obs. & DAY7 Fcsts
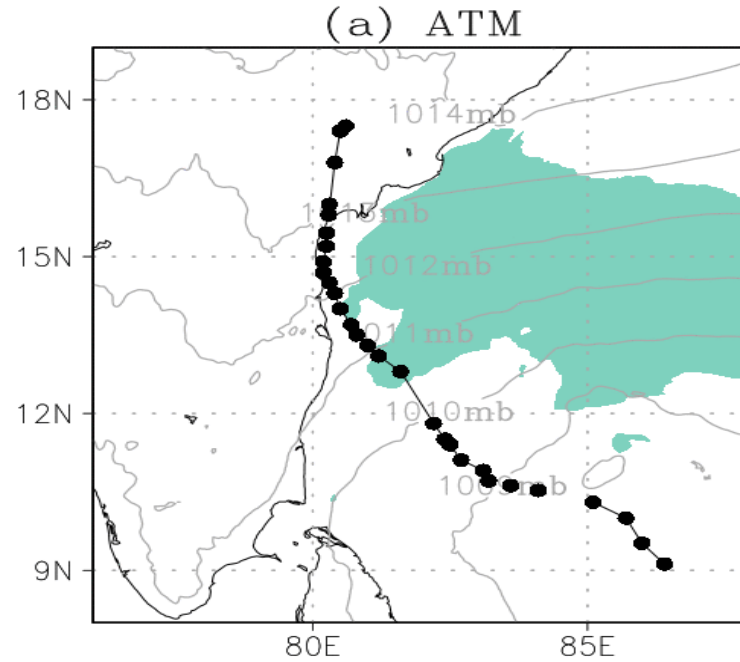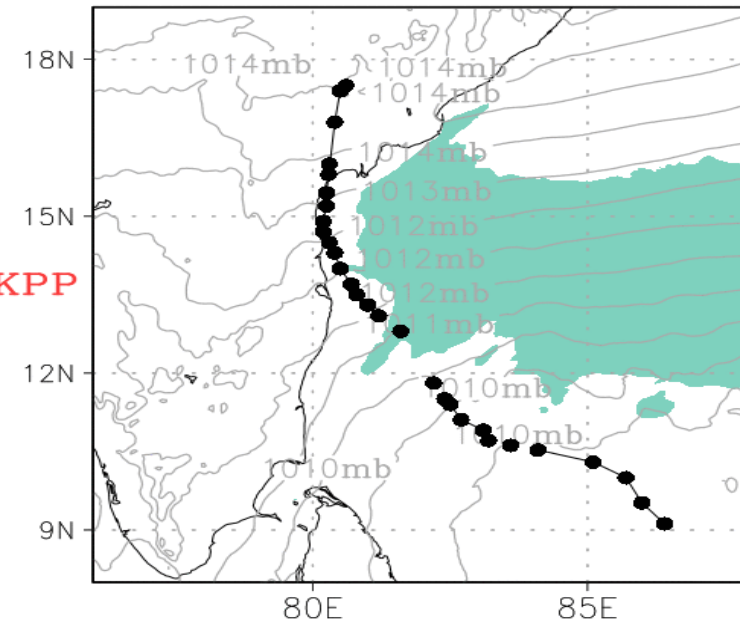
MONSOON−2023 Rainrate (mm/d) Obs. & DAY10 Fcsts

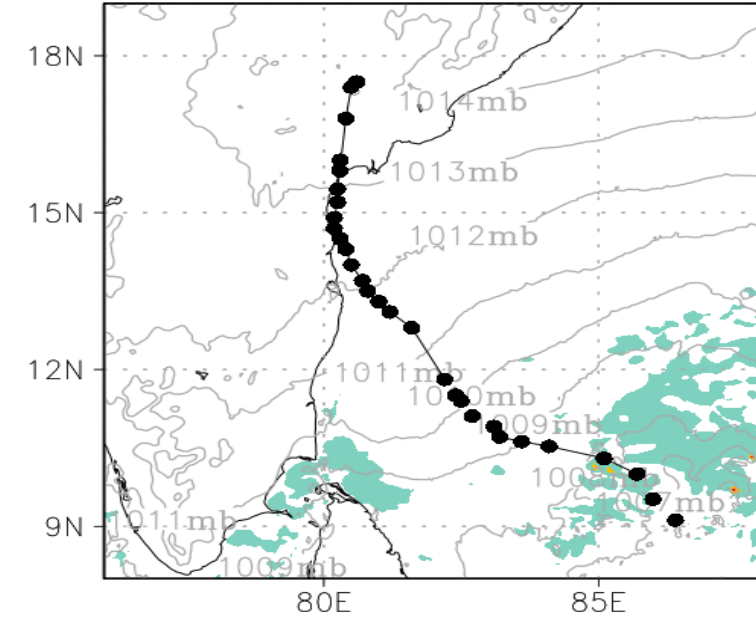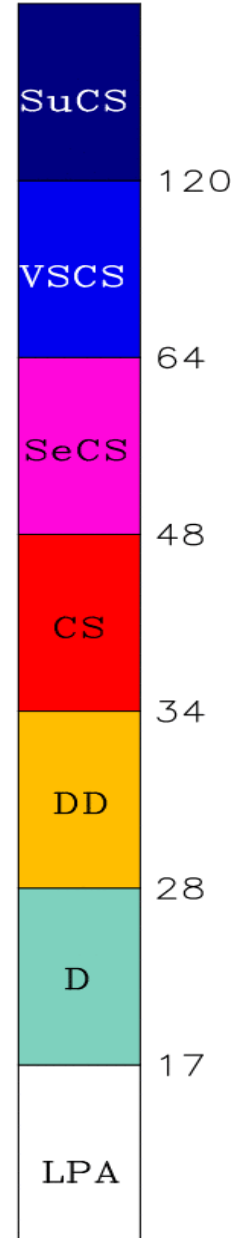Cyclone Michuang: 10m Winds (shaded, knots) & MSLP (contour, hPa) IC=00Z20231129

(a) ATM

(b) RDA-Analysis

(b) ATM-KPP
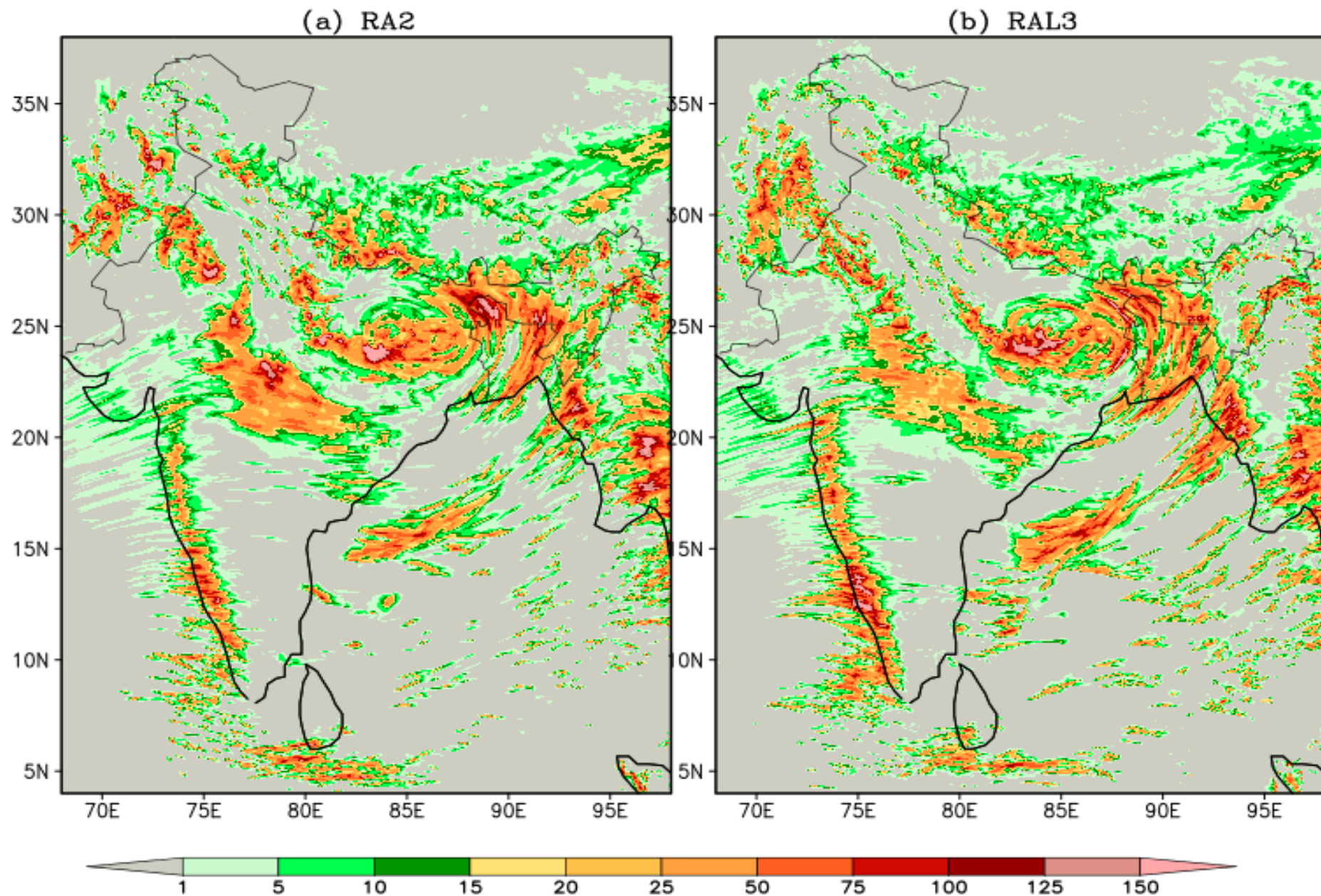
Cyclone Michuang
Dec 2023

Valid at 00Z on 01DEC2023

48 hr. total rain forecast (mm) valid at 00Z on 3 AUG 2024, IC:00Z20240801

(a) RA2 (b) RAL3

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Summary

- ✓ **Regional ocean-atmosphere-wave coupled model with 4 Km atmosphere and 2.2 Km ocean & wave model is installed at NCMRWF.**

- ✓ **Atmosphere in coupled suite is initialized with NCMRWF Analysis.**

- ✓ **Plans are underway to initialize regional NEMO using NEMO/ORCA25 Analysis produced at NCMRWF regularly**

- ✓ **Suite upgradation to RAL3 is done.**

- ✓ **Successfully nested in NCMRWF extended range prediction system.**

On the Cards (Future)
- ➢ Regional Coupled Environmental Forecast System Regional Climate for BIMSTEC Center For Weather and Climate (BCWC)
- ➢ RAL3 experiments with Monsoon

Thank You