Centre update
Indian Institute of Tropical Meteorology
Pune, India
Ministry of Earth Sciences, Govt. of India

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Monsoon Mission

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With inputs from colleagues in MoES

WGNE Session 1, Tuesday, November 5, 2024

Under Monsoon Mission, IITM is tasked with developing a state-of-the-art dynamical prediction systems for different time scales developed by IITM with active collaboration with NCMRWF and INCOIS

IITM

Research to Operations

India Meteorological Department

Ministry of Earth Sciences

Ministry of Earth Sciences

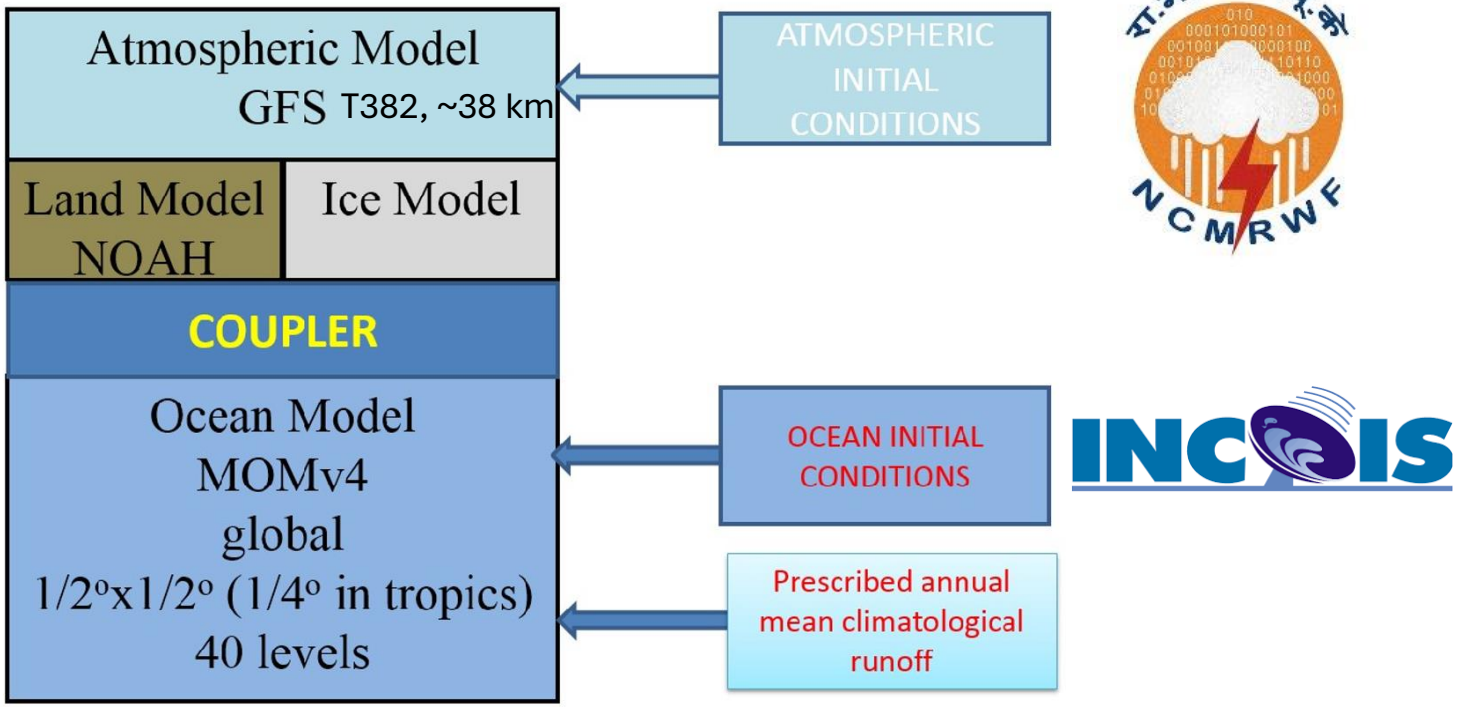
Earth System Science Organization

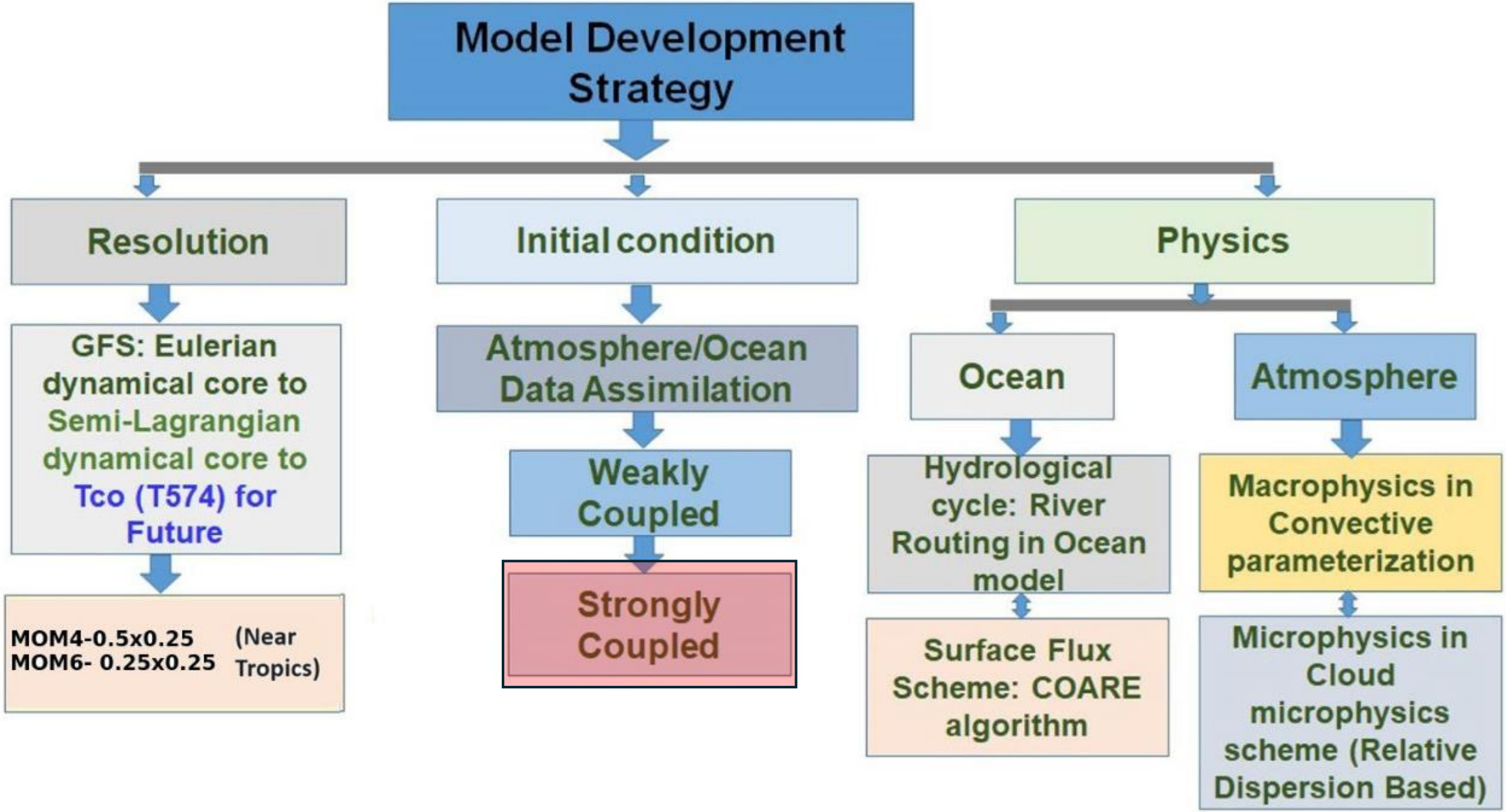
- India Meteorological Department (IMD) DELHI
- National Center for Medium Range Weather Forecasting (NCMRWF) NOIDA
- Centre for Marine Living Resources and Ecology (CMLRE) KOCHI
- National Center for Seismology (NCS) DELHI
- National Center for Coastal Research (NCCR) CHENNAI
- National Center for Polar and Ocean Research (NCPOR) GOA
- Indian National Center for Ocean Information Services (INCOIS) HYDERABAD
- Indian Institute of Tropical Meteorology (IITM) PUNE
- National Institute of Ocean Technology (NIOT) CHENNAI
- National Center for Earth Science Studies (NCESS) THIRUVANANTHAPURAM

Monsoon Mission

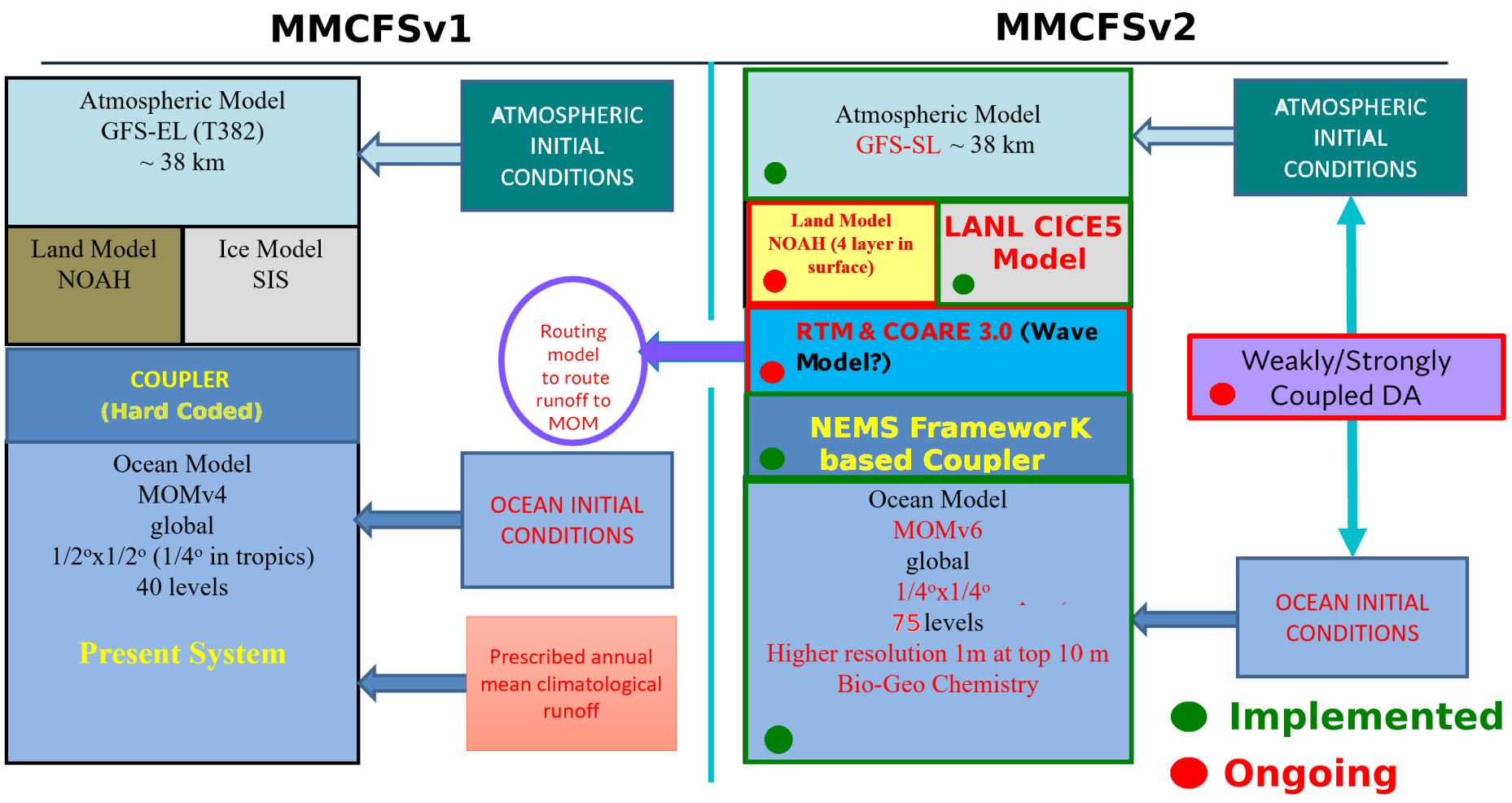
A mission mode program started in 2012 - to improve quality of Monsoon forecasts at:

- ✓ **Seasonal scale (9 months) – original model (CFS) was adopted from NCEP**
- ✓ **Extended range (4 weeks) – CFS based**
- ✓ **Short (3-5 days) and Medium (5-15 days) ranges – GFS/GEFS based**




Model Development Strategy
Resolution
Initial condition
Physics
GFS: Eulerian dynamical core to Semi-Lagrangian dynamical core to Tco (T574) for Future
Atmosphere/Ocean Data Assimilation
Ocean
Atmosphere
MOM4-0.5x0.25 (Near Tropics)
MOM6- 0.25x0.25
Weakly Coupled
Strongly Coupled
Hydrological cycle: River Routing in Ocean model
Surface Flux Scheme: COARE algorithm
Macrophysics in Convective parameterization
Microphysics in Cloud microphysics scheme (Relative Dispersion Based)

MMCFS: Next Generation Seasonal Prediction System



Deepesh et al (2024), Ankur et al. (2022), Pradhan et al. (2022), Gade et al. (2022)

Please look-out for my presentation on Thursday, November 7, 2024 in the Joint plenary S4 - Model processes improvements for details on

river-routing and COARE 3.0 implementation in CFS and impacts on S2S variability.

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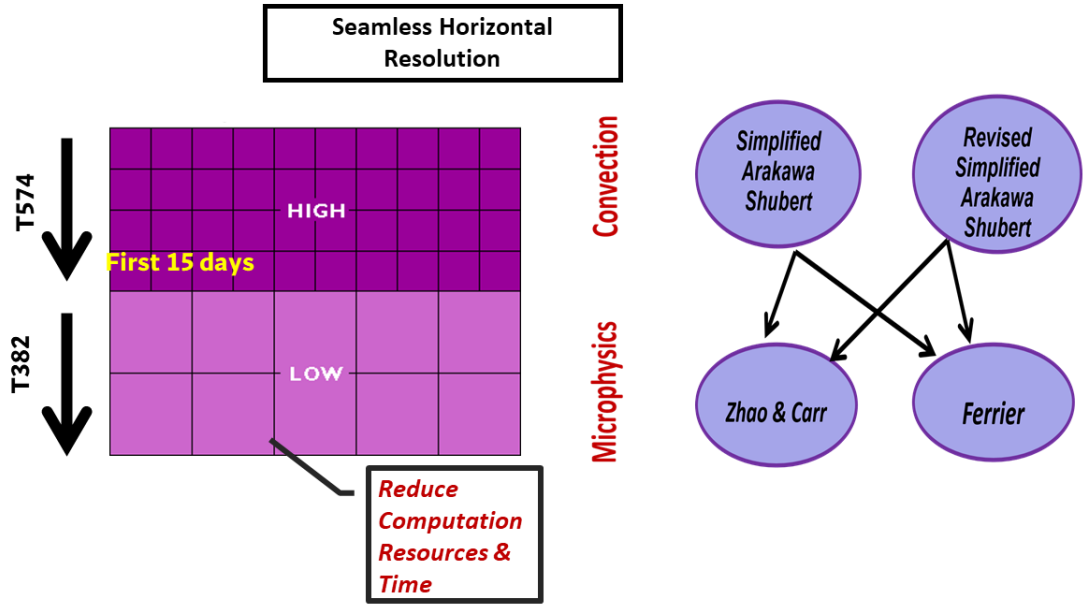
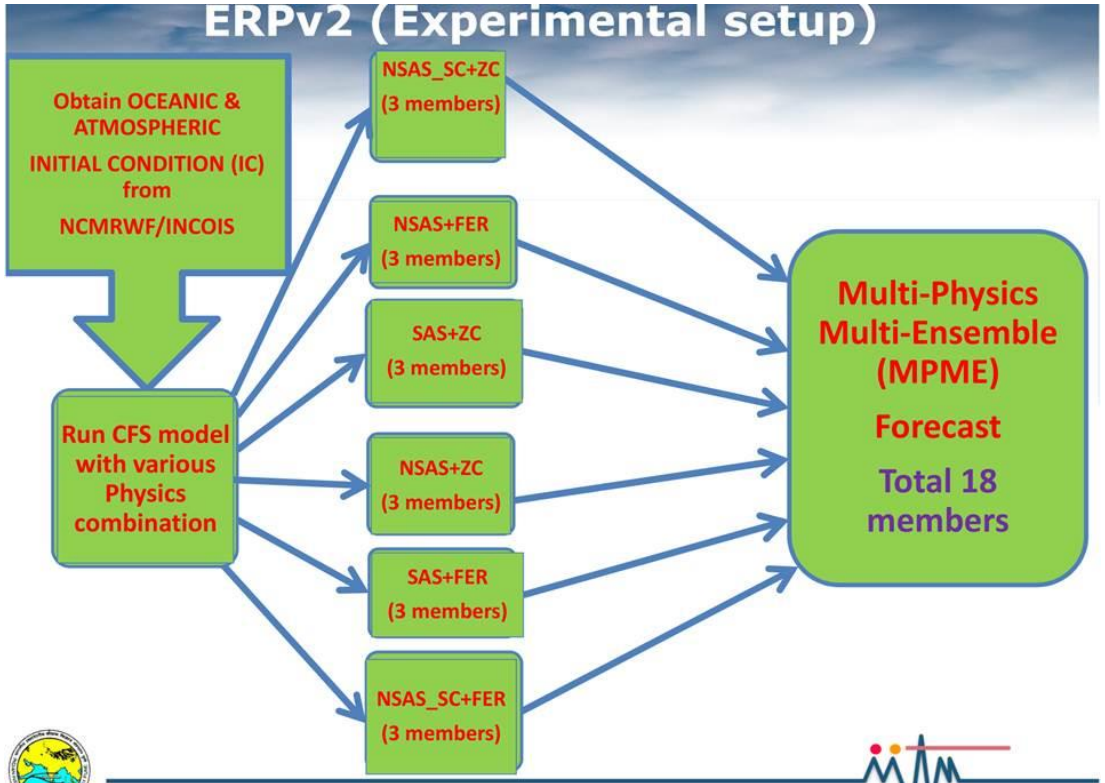
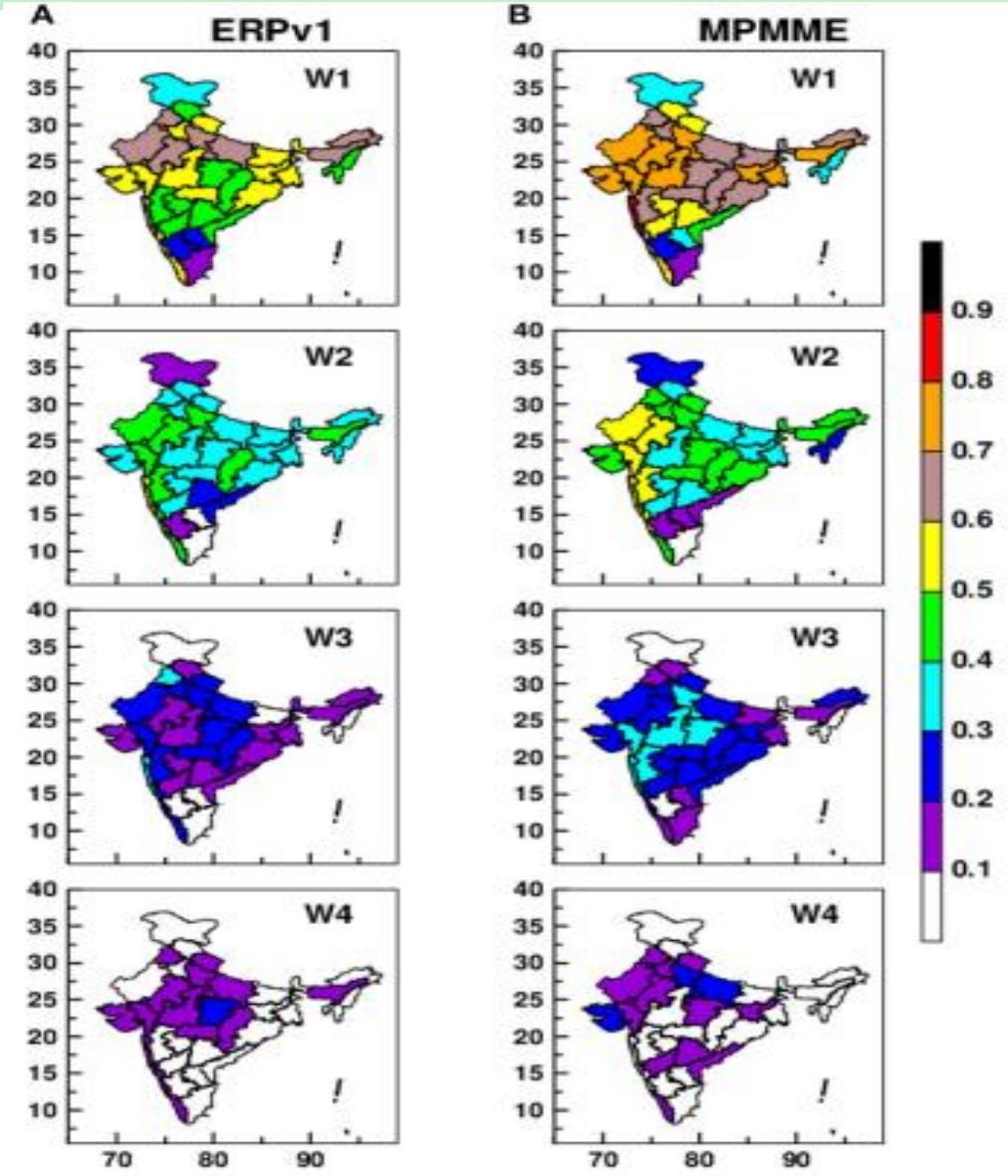
IITM Extended Range Prediction System Version 2



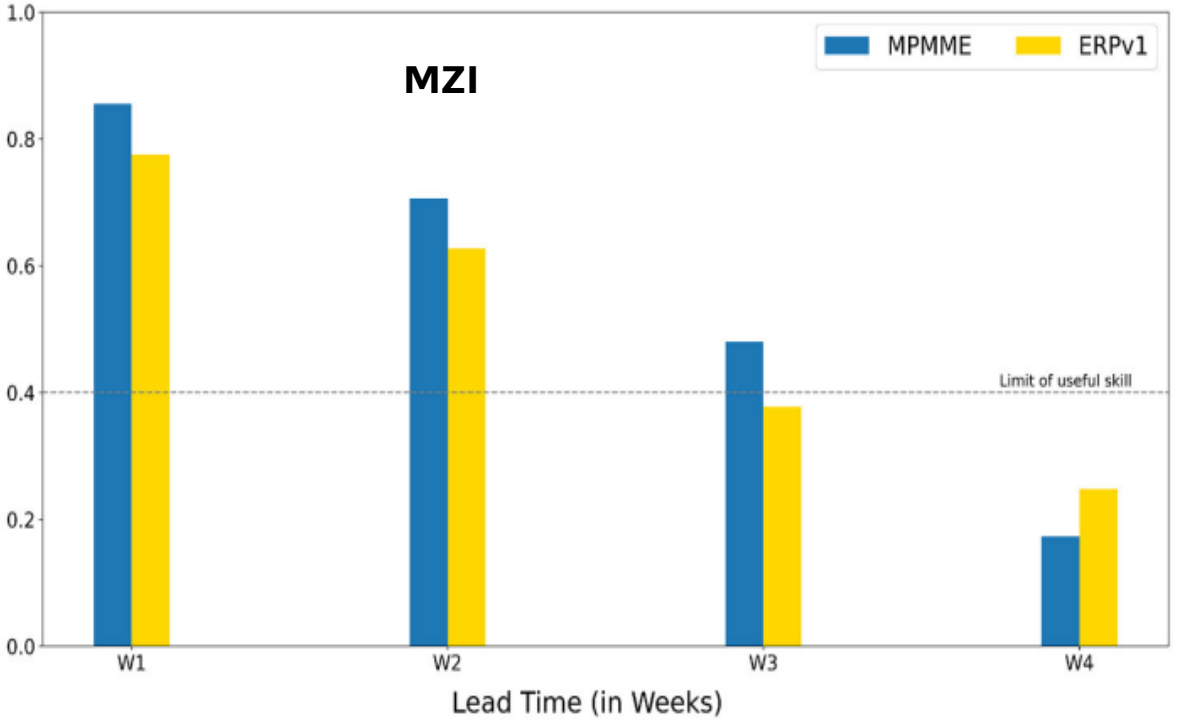


Sahai et al., 2021, Frontiers; Manpreet et al. 2021, ClimDyn

Summer Monsoon Rainfall Prediction Skill



Anomaly Correlation



Sahai et al., 2021, Frontiers; Manpreet et al. 2021, ClimDyn

Plan: Increasing the Vertical Resolution

64 Levels	91 Levels	127 Levels
14 Levels Below 850hPa	**15 Levels below 850hPa**	**30 levels below 850hPa (More levels within PBL) (temp inversion/ low clouds)**
16 Levels below 2KM	**17 Levels below 2KM**	**33 Levels below 2KM**
15 levels between 700hPa to 200hPa	**21 levels between 700hPa to 200hPa**	**33 levels between 700hPa to 200hPa**
24 Levels above 15KM	**40 Levels above 15KM**	**46 Levels above 15KM**
		extending the model top from the upper stratosphere (~55 km height) to the mesopause (~80 km height).

Increasing the vertical resolution would aid a better stratosphere interaction in the extended range.

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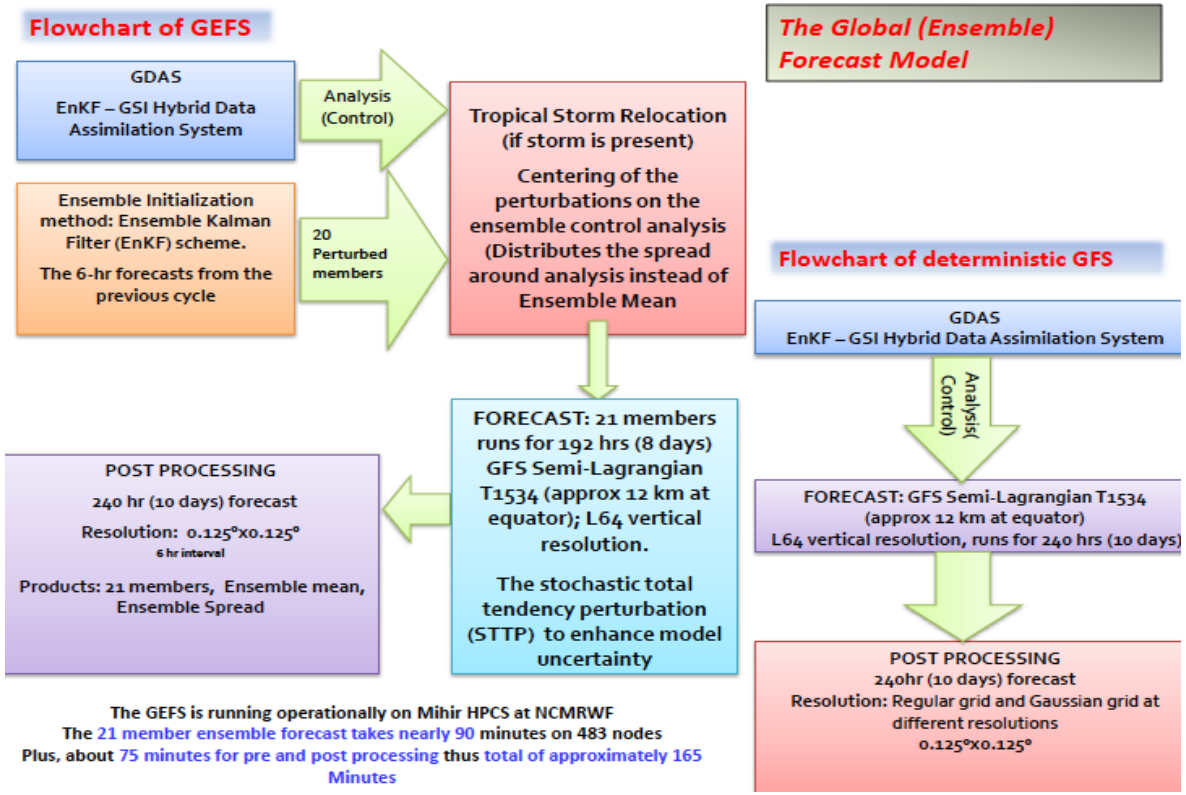
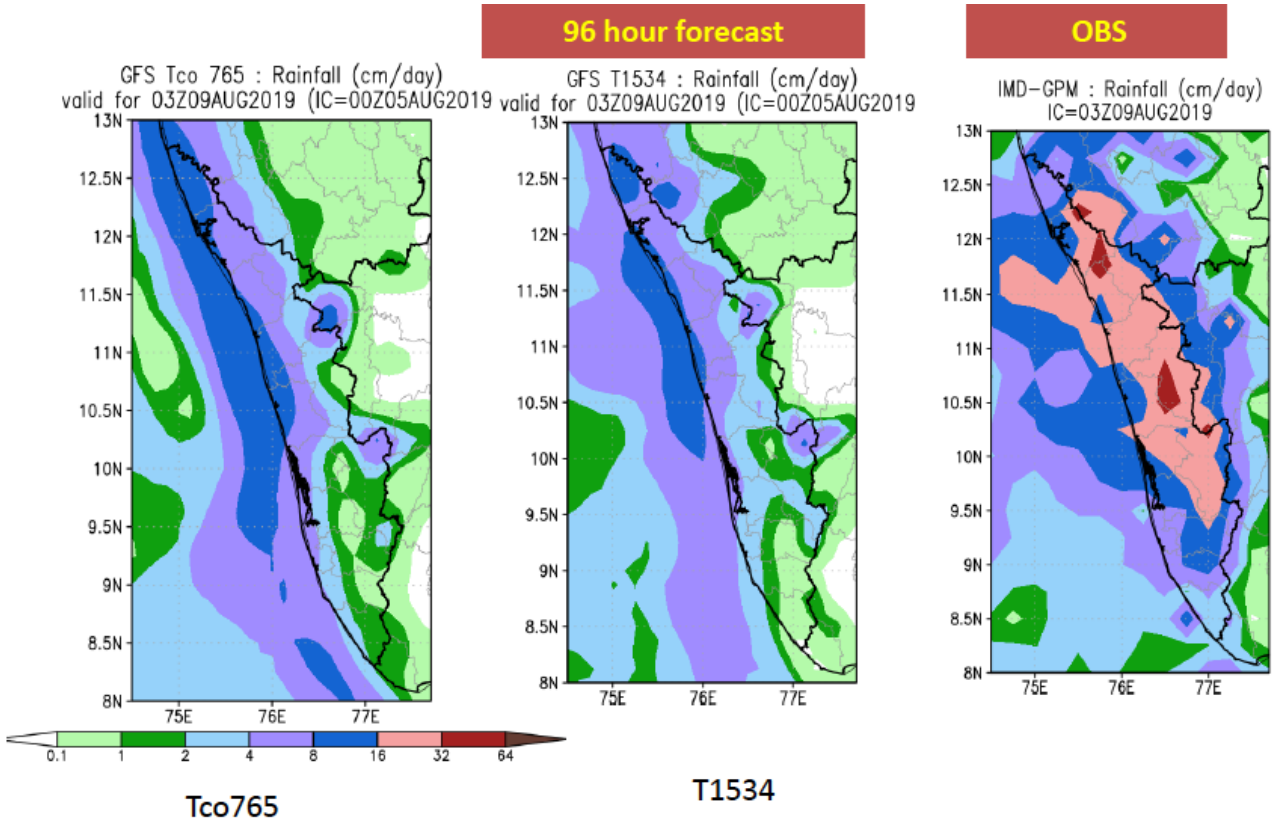


Geoscientific Model Development

IITM High-Resolution Global Forecast Model Version 1: An attempt to resolve monsoon prediction deadlock

https://doi.org/10.5194/gmd-2024-89



GFS-TCO

- Doubling the resolution to 6/7 km using Spectral Cubic Octahedral Grid.
- Deterministic HGFM (TCO 1534, ~ 6km) implemented and running in experimental mode at IITM since June 2022.

Future Plans:

- Improved Parametrization Schemes may be based on AI/ML and scale aware Parametrization schemes.
- Improved Ensemble Generation Scheme

New HPC Infrastructure

- The IITM system is equipped with a capacity of **11.77 Peta FLOPS** and 33 petabytes of storage
- NCMRWF facility features **8.24 Peta FLOPS** with 24 petabytes of storage.
- Additionally, there is a dedicated standalone system for Artificial Intelligence and Machine Learning applications with a capacity of **1.9 Peta FLOPS**.
- With this augmentation, the Ministry of Earth Sciences will enhance its total computing power to **22 Peta FLOPS**, a substantial increase from the previous capacity of 6.8 Peta FLOPS

In 2013, two HPC systems have been successfully procured:

✓ **790 TF "Aaditya" HPC at ESSO-IITM**

✓ **350 TF at ESSO-NCMRWF**

Next upgrade took place in February 2018 with two new HPC systems

✓ **4006 TF "Pratyush" at ESSO-IITM**

✓ **2808 TF "Mihir" at ESSO-NCMRWF**

Way forward

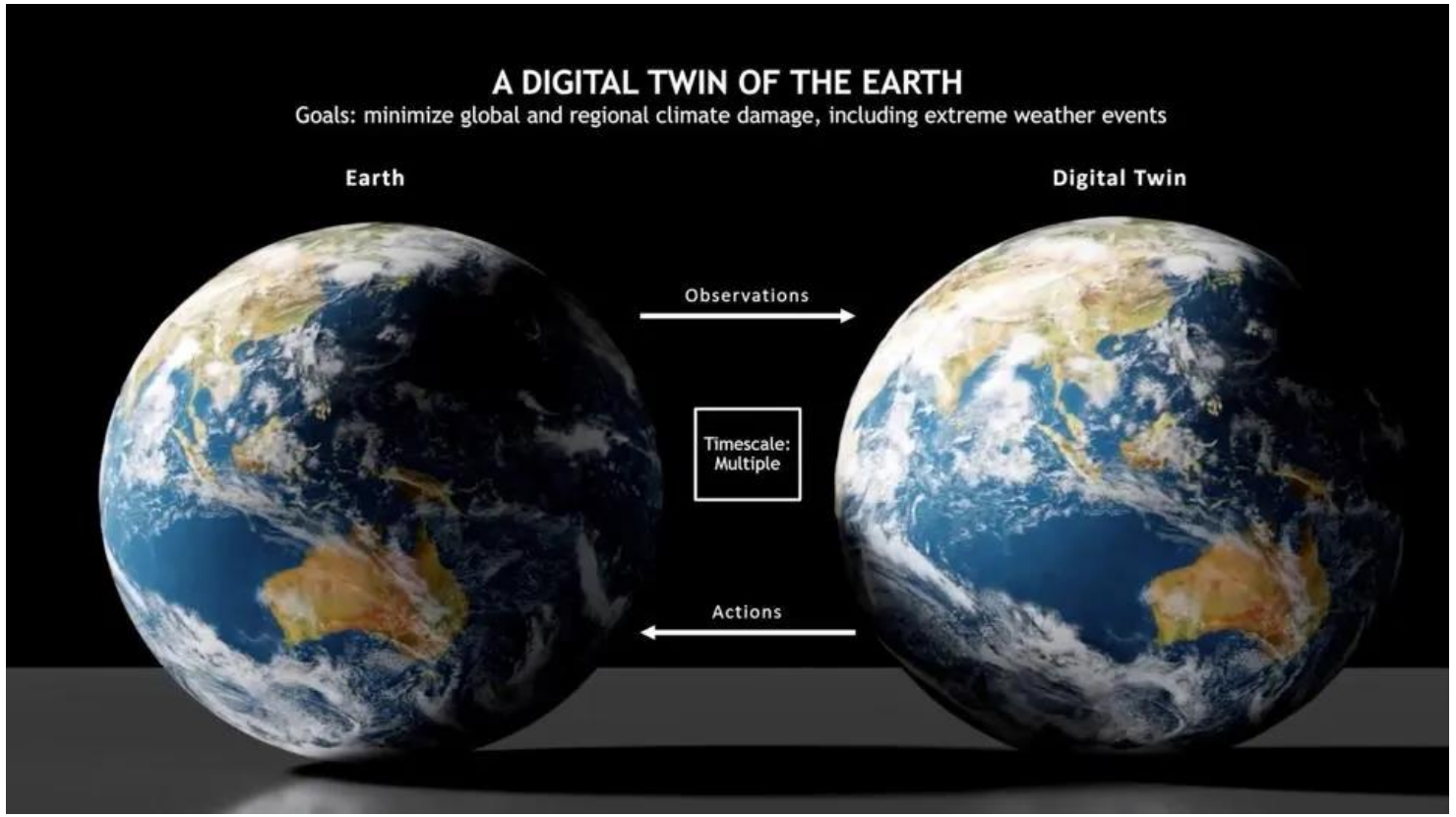
Current NWP models can be modified to take advantages of AI to certain extent

1) **Develop Conventional ML Models**
2) **Research on Physis Informed Neural Network (PINN) models**

Models for Extreme Precipitation events will be developed includes,

a) **Cloud-bursts**
b) **Hyper local forecast**
c) **Urban meteorology**
d) **Thunderstorm / lightning forecast**
e) **Flash flood**
f) **Air pollution forecast**

Requirement of Sub-kilometer Model



Credit: NVIDIA

Develop Digital Twin for Earth System

'Prithvi Pratibimb AI'

To realize the potential of AI
Current Infrastructure is not sufficient

The way forward: Digital twin

Requirement: 1000 GPUs
Target: Forecasting systems (sub-km scale)

Inter ministerial cloud data infrastructure

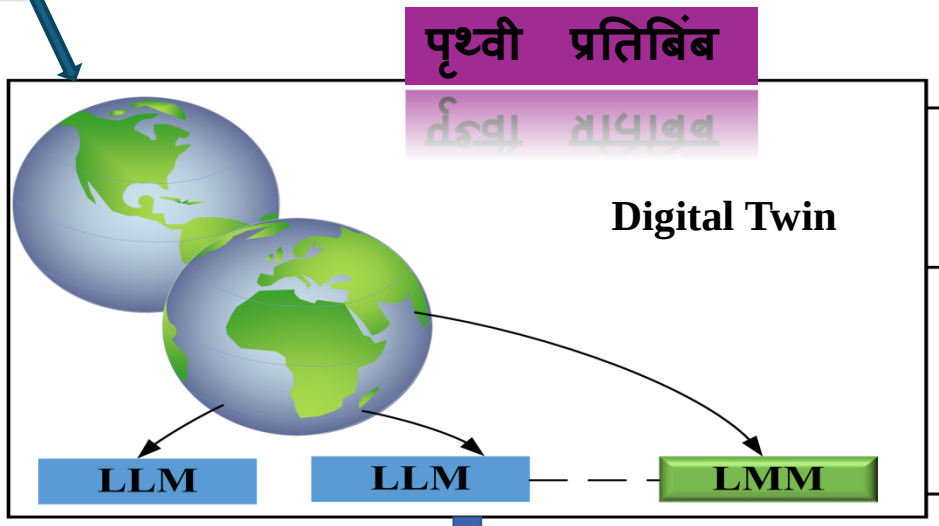
Conventional Machine Learning → Complete data driven approach

Physics Informed NN (PINN) → Data + Physical Laws Requires less data

Non-Disclosure Agreement (NDA) with Nvidia for the LLM Model

Multi models

- Hydrology model
- Ocean model
- Atmospheric model
- Land model
- Greenhouse gases emission model



API: Trained models

API: Digital Twin Data

Cloud API: Inter institutional data access

Large Multimodal Model (LMM)

Mausam GPT

(1st version by 2025)

Thank You!

Eighth WMO International Workshop on Monsoons (IWM-8) 17-21 March 2025, Pune, India

"Advancing the Understanding & Prediction of Monsoons and their Impacts in a Changing Climate"

WORLD METEOROLOGICAL ORGANIZATION