Challenges in Predicting Weather & Climate over India: Developments and Improvements

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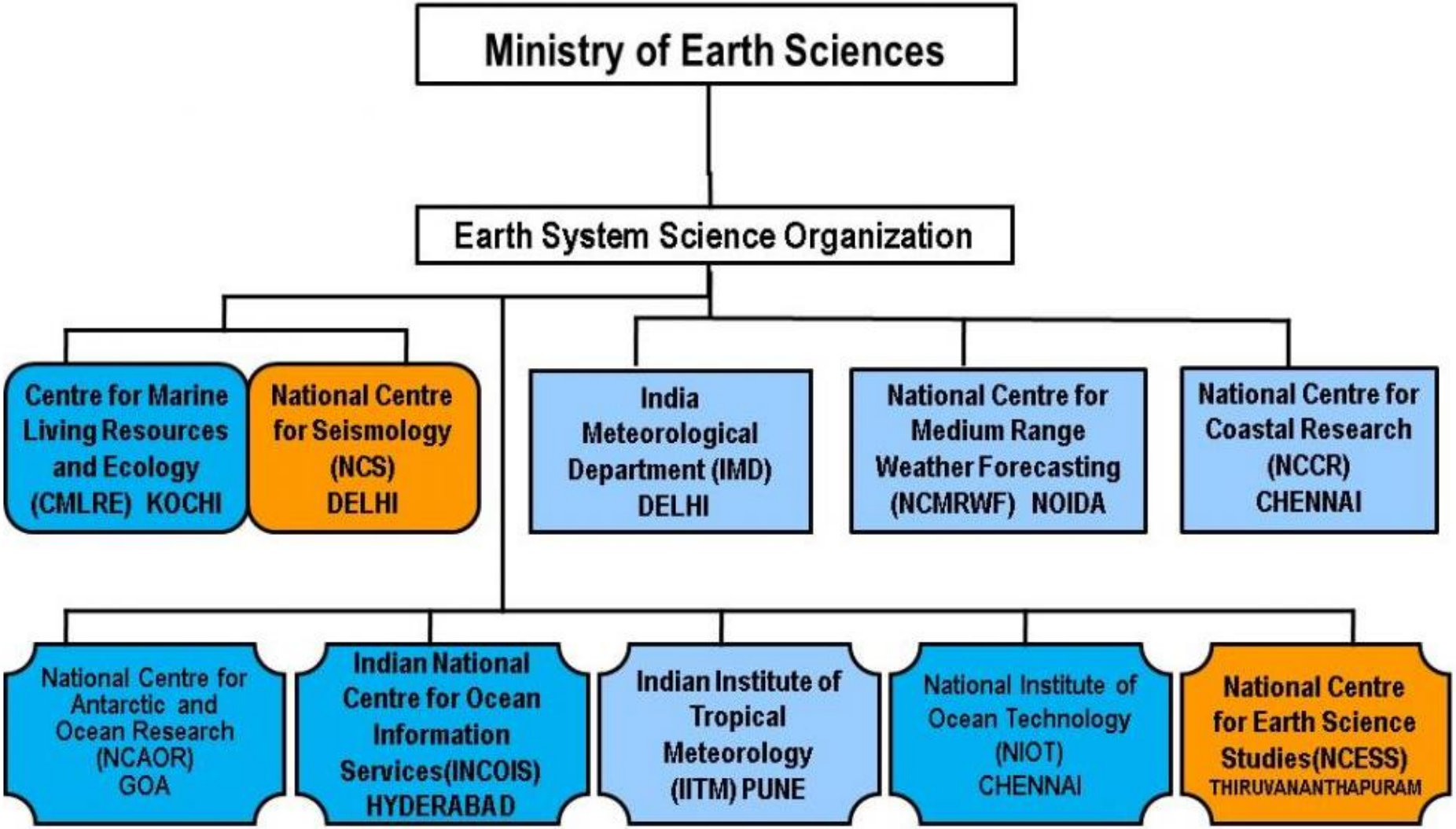
Outline

- Background
- Challenges for Weather/Climate Services for India
- What is achieved and ongoing
- Future Areas of Focus – wcssp context


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

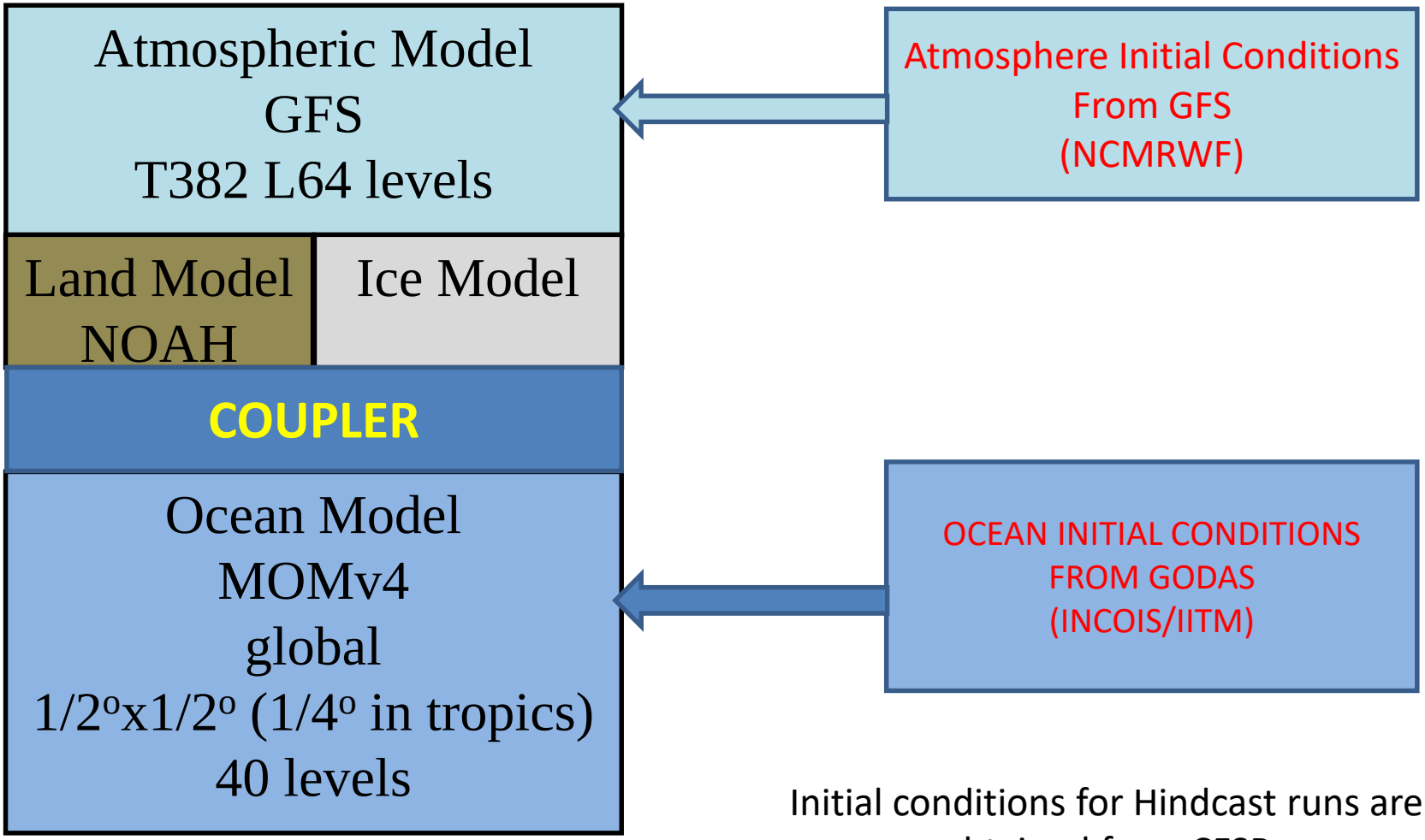
Problems of interest

- Monsoon Weather and Climate Prediction
- Heat/Cold Waves in other seasons
- Cyclones during pre- and post-monsoon seasons
- Monsoon depressions/low pressure systems
- Extreme rainfall events
- Lightening, hailstorms and thunderstorms

New Scientific Developments

- Highest resolution Global NWP (~12 km) and coupled climate models (~38 km) with unprecedent prediction skills (Seasonal, Extended and short & medium range) for prediction of
  - Monsoon weather and climate
  - Heat and Cold waves (short/medium, extended and seasonal)
  - Depressions abd depressions during the monsoon season
  - Cyclones in pre- and post-monsoon seasonal
  - Extreme Rainfall events (using both Global NWP and regional models at ~ 3km)
- Non-hydrostatic regional models (~1-1.5 km) for predicting Lightening, hailstorms and thunderstorms
- Very high resolution (330 m) local area model for predicting events such as fog
- All of the above are supported by strong model development in physics, resolution and initialiazation etc.

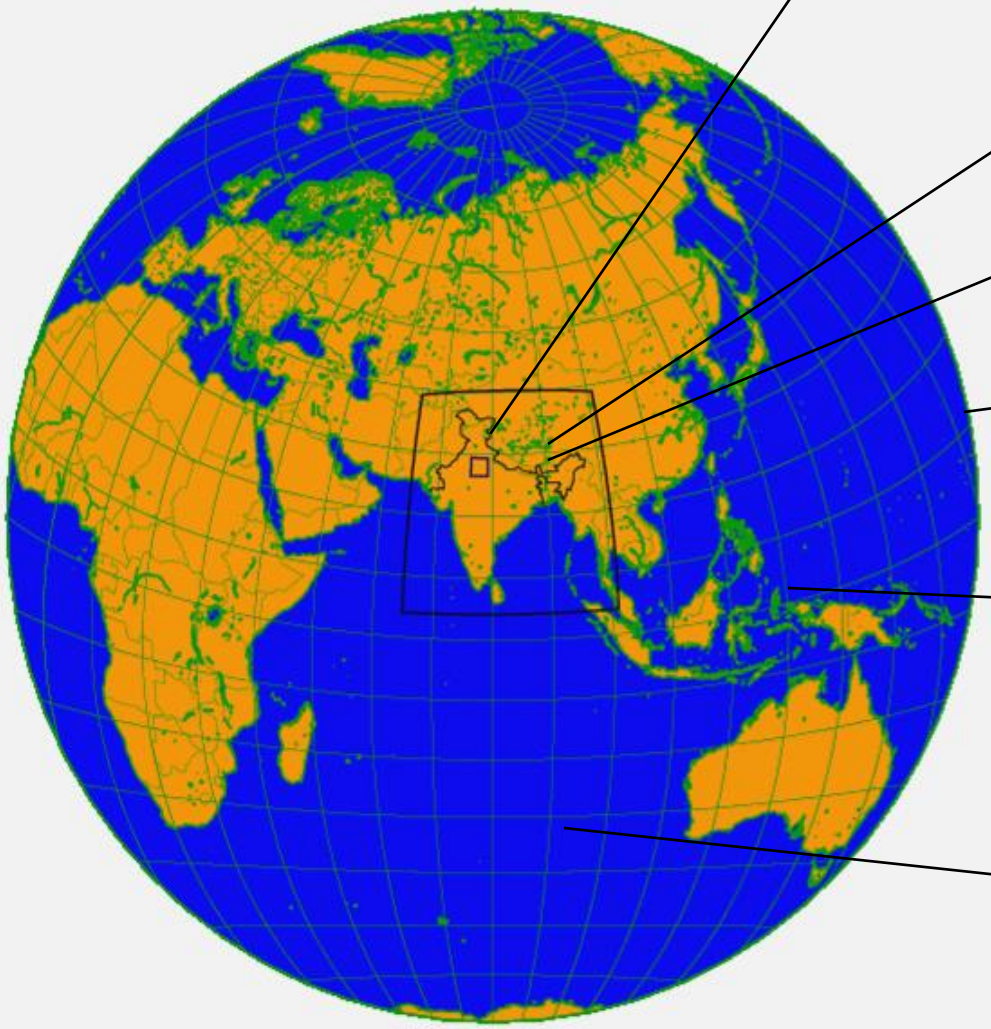
IITM CFS Model: Seasonal/Extended Prediction



Initial conditions for Hindcast runs are obtained from CFSR

(Original model is adopted from NCEP)

Seamless Modelling System: Unified Model at MoES/NCMRWF
Same Model for Global/Regional/Mesoscale/City/ Coupled



330 m Delhi Fog Model

1.5 km regional model
up to 48 hr forecast

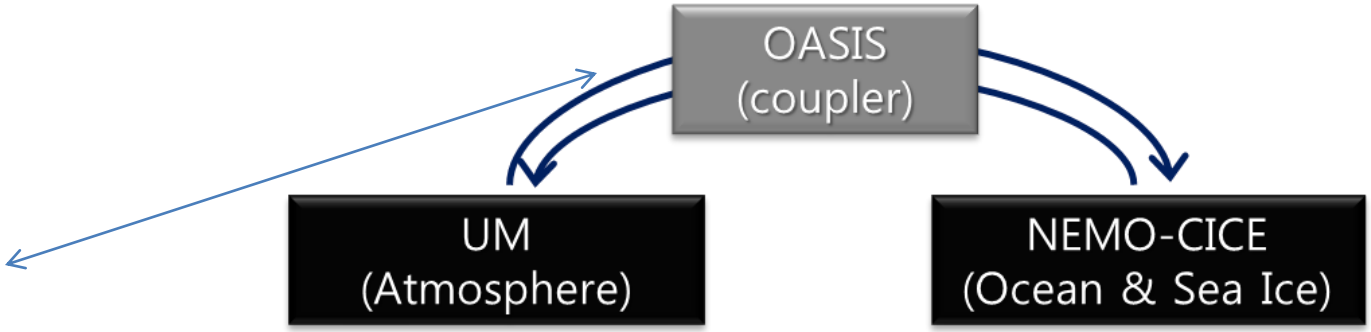
4 km regional model
up to 72 hr forecast

12 km global model
up to 10 Day forecast

Global Ensemble Prediction System – 12 km with 21 members up to 10 Days

Coupled Model N216
(NCUM+JULES+NEMO+CICE)
One Month Real-Time

NCMRWF Coupled Modelling & Ocean Data Assimilation



JULES LS	Atmosphere	Ocean & Sea Ice
Model	UM	NEMO-CICE
Horizontal resolution	N216 (0.83° x 0.56°)	ORCA tri-polar grid at 0.25°
Vertical resolution	85 levels (~85km)	75 levels

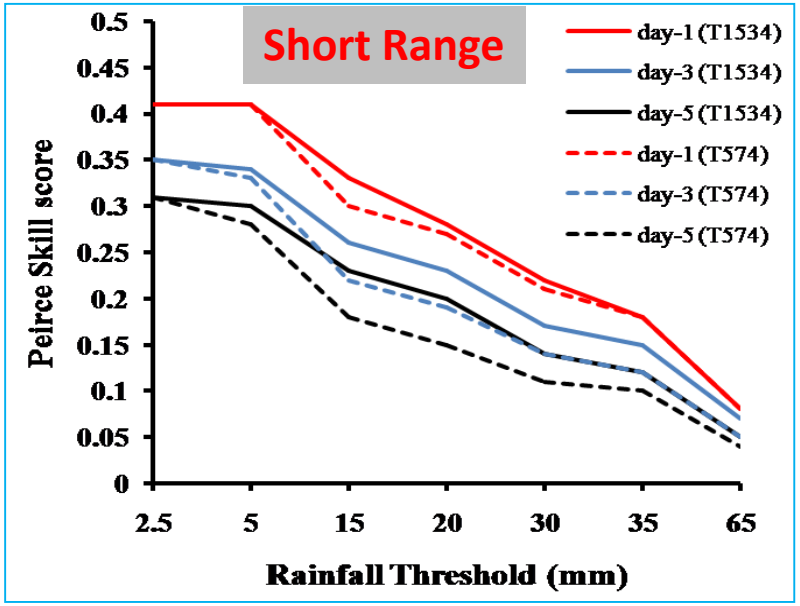
1. NCUM Atmosphere 60 km; L85 (with JULES LS Model)
2. NEMO Global 0.25 deg ; L75 (with CICE)
3. NEMO/CICE ODA(0.25, L75), Real Time
4. Coupled Model GC2: Real Time ERP since July 2018

ERP (up to 4 weeks) to IMD and NCAOR

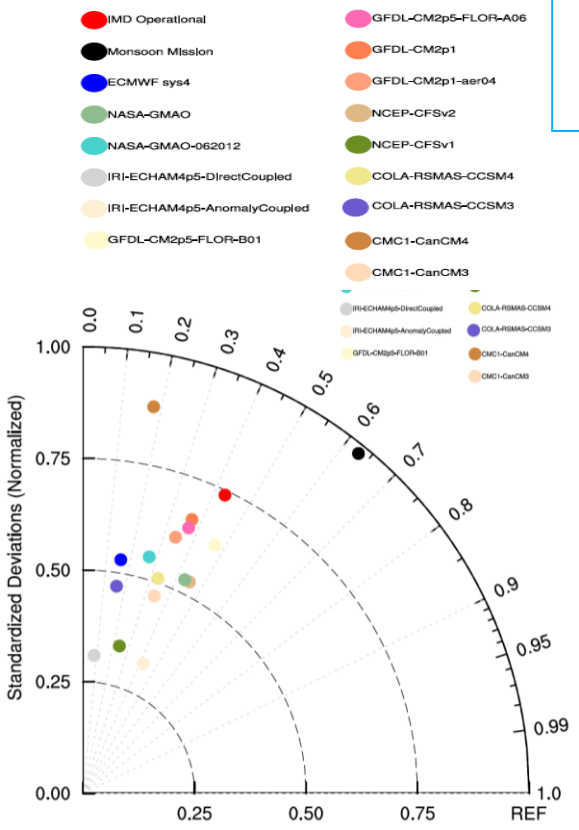
MRF Ocean/Sea-ICE products to INCOIS & NCAOR

Skills of Different Models

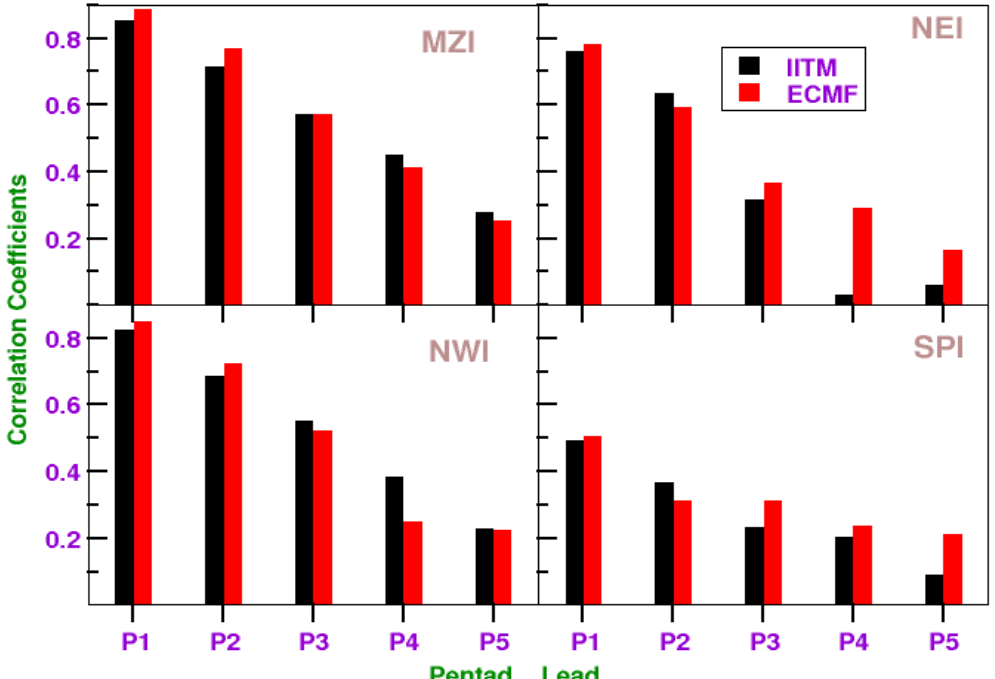
Short Range



Seasonal Prediction



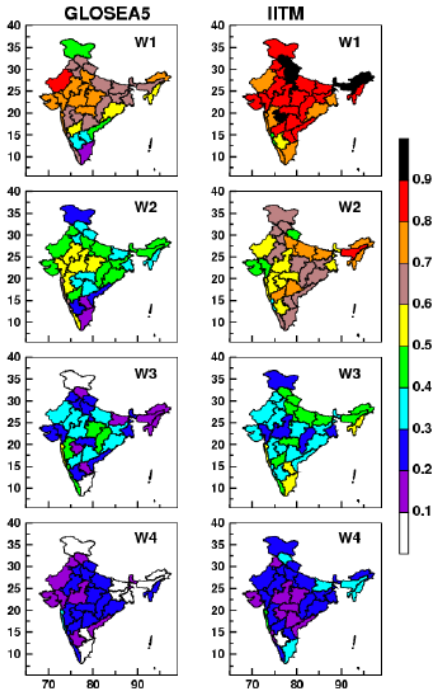
Extended Range



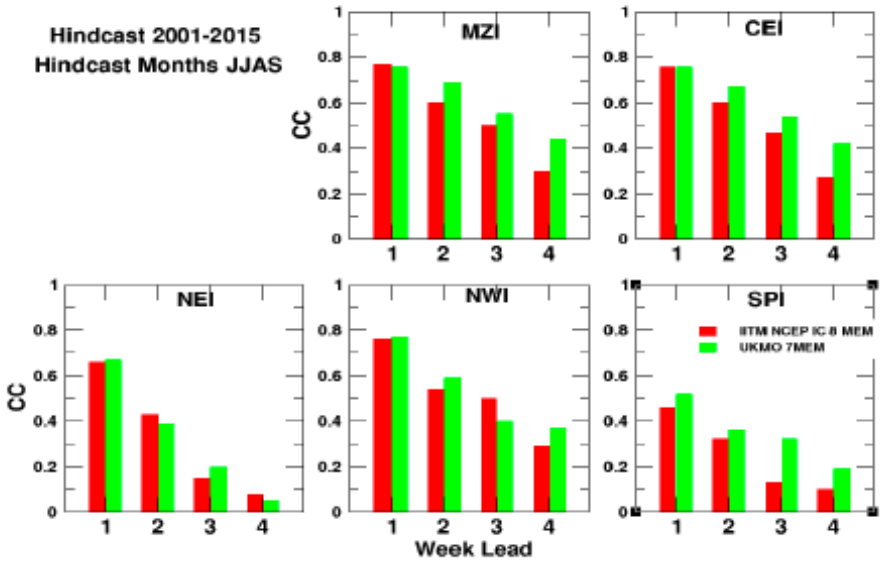
IITM CFS vs UKMO GloSea 5

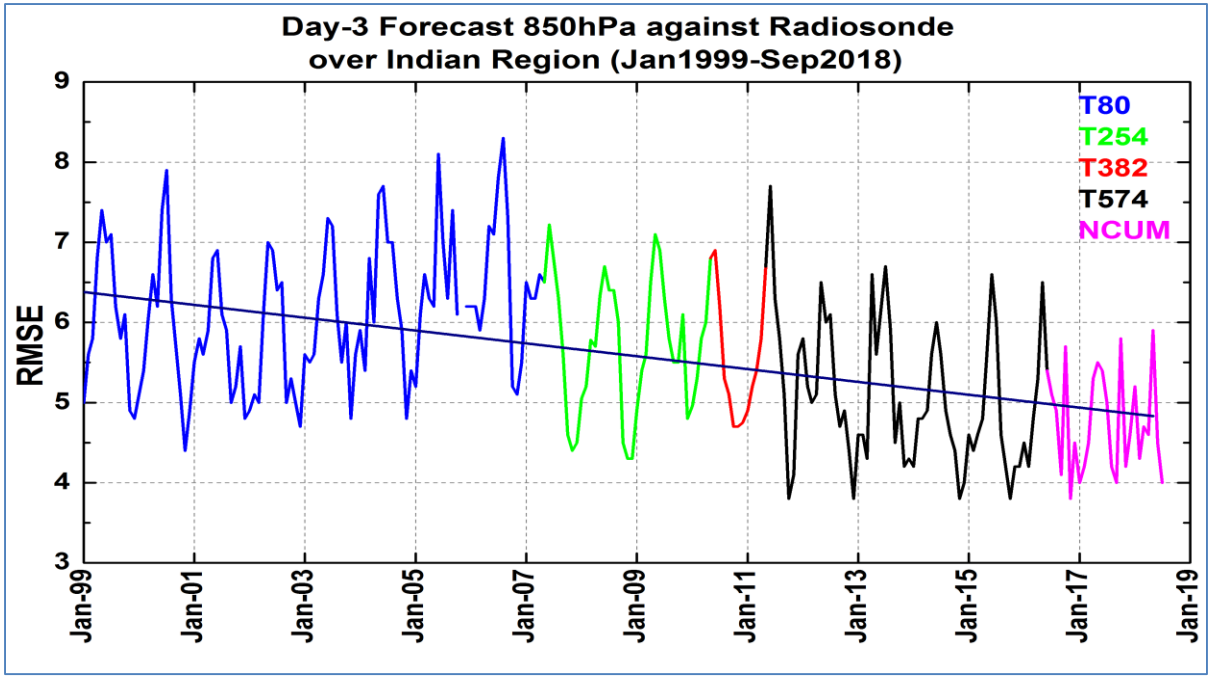
Seasonal Prediction

			Skill			Teleconnections	
	MEAN	SD	ISMR	Nino 3.4	IODE	ISMR vs Nino 3.4	ISMR vs IODE
GPCP	6.91	0.63	-	-	-	-0.42	-0.31
IMD	7.42	0.63	-	-	-	-0.38	-0.30
CFSv2T382	3.51	0.44	0.63 (0.62)	0.80	0.55	-0.83	0.28
UKMO	5.31	0.55	0.42 (0.38)	0.84	0.59	-0.91	-0.06



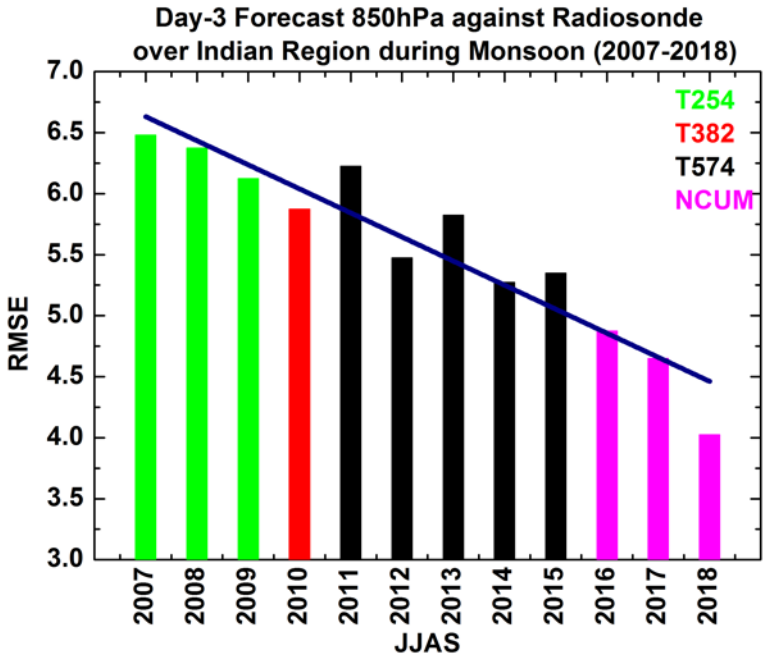
Extended Range

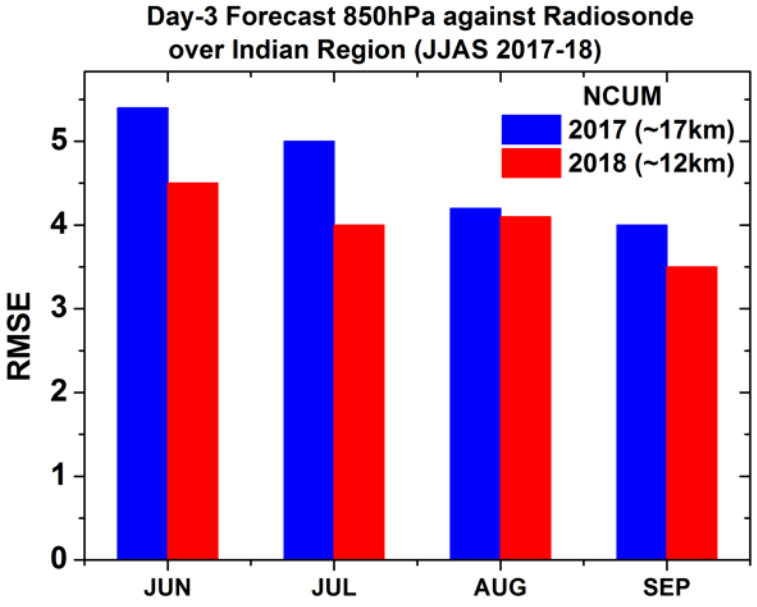




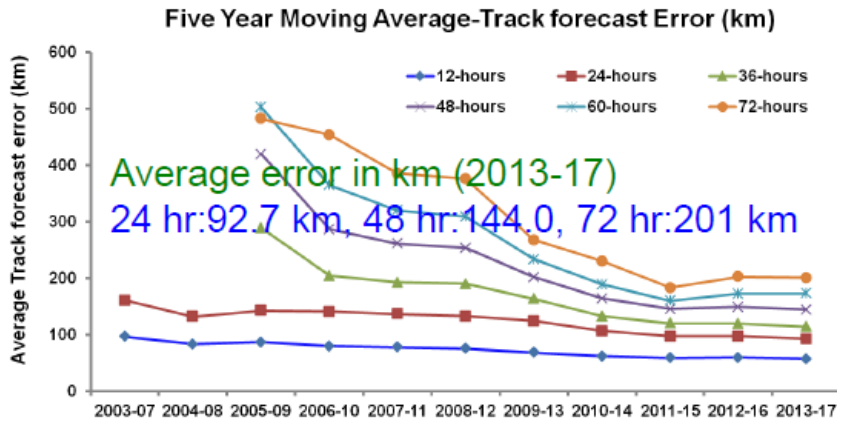
Now we have improved skill from Global Models for Large-Scale aspects of flow

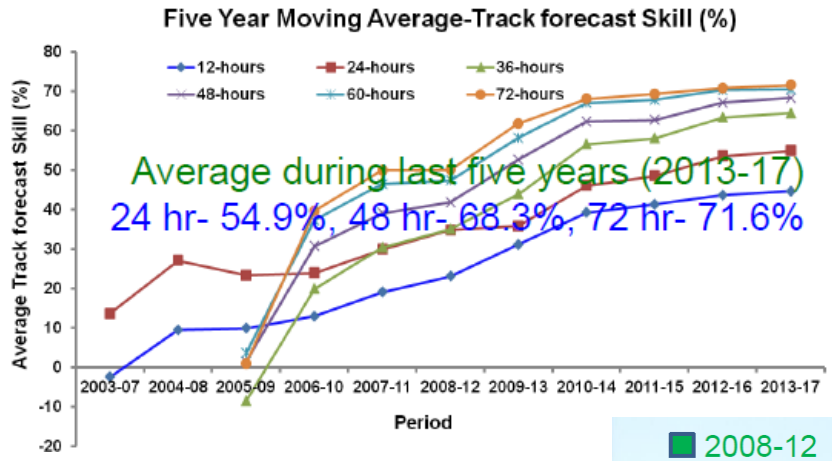
JJAS 2007-2018

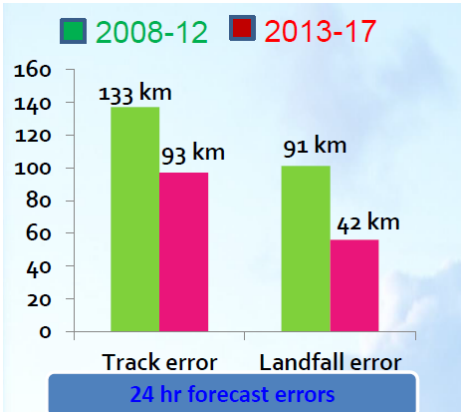


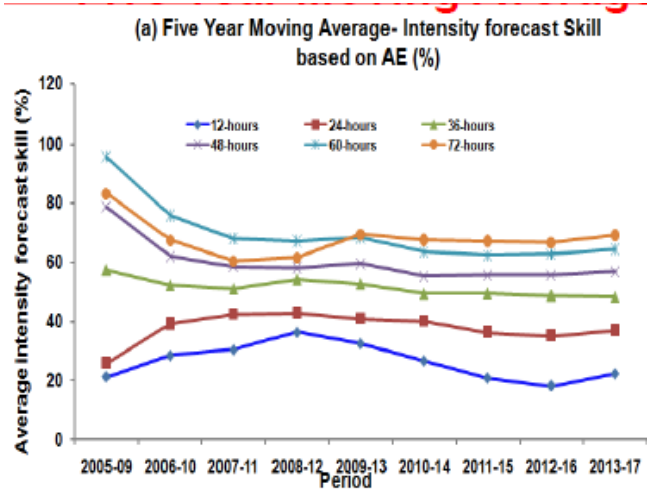


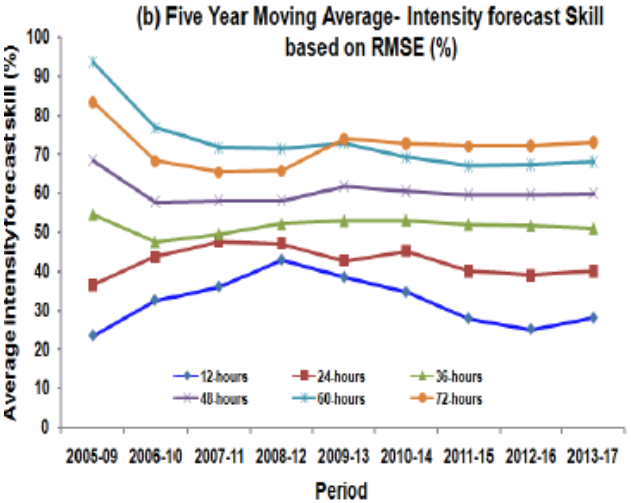
Cyclone Prediction







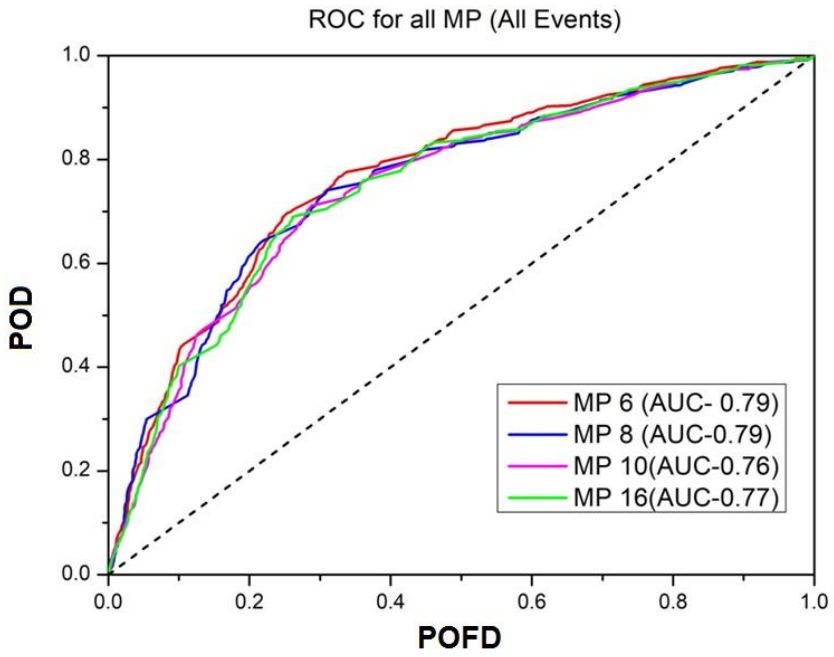




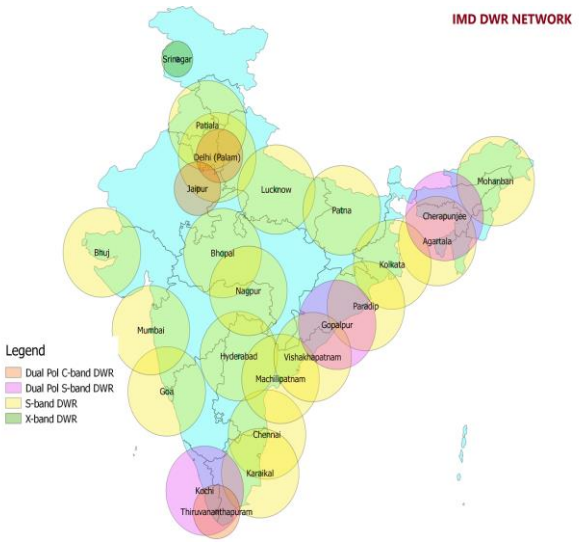
Skill Score (Lightning flash)

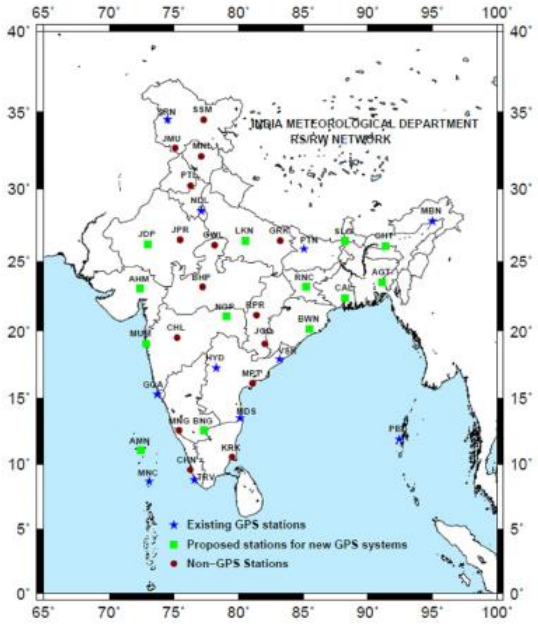
	POD	HR	FAR	POFD	CSI	HSS
MP6 (WSM6)	0.864	0.733	0.283	0.469	0.637	0.395
MP8 (Thompson)	0.822	0.74	0.248	0.399	0.63	0.415
MP10 (Morrison)	0.849	0.72	0.292	0.487	0.624	0.359
MP16 (WDM6)	0.839	0.743	0.261	0.417	0.64	0.417

ROC Curve (Receiver Operating Characteristic)

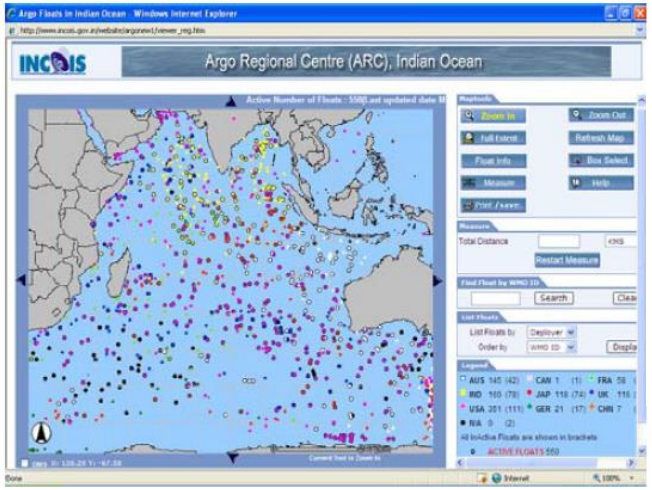


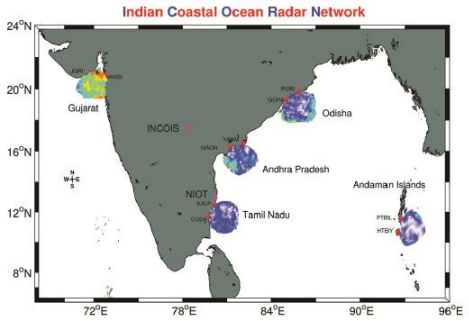
The ROC curve is a probability curve to asses the performance.





- **Extensive observational network has been setup over years.**
- **It has helped in improving forecasts**
- **Continuous Augmentation underway.**
- **Campaigns to improve processes**





Grand Challenges

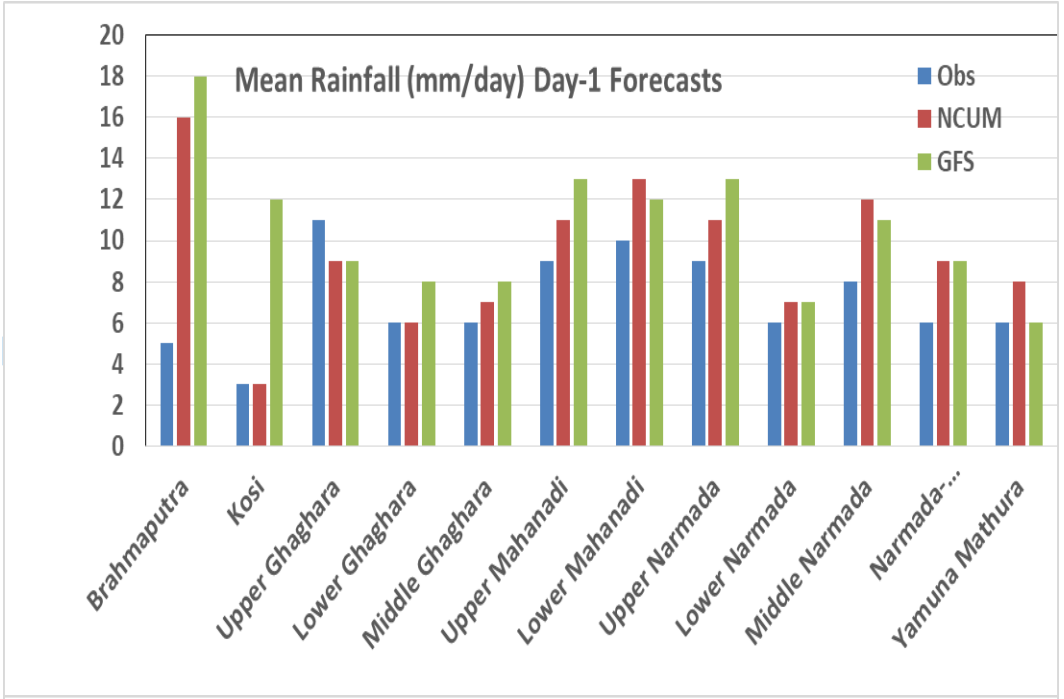
- Getting better skills for smaller spatial scales.
- Predicting extremes (rainfall, heat/cold waves, thunderstorms)
- Improving the lead time.
- Development of applications by using weather and climate forecasts (Flood forecasting, reservoir management, power generation etc.)
- Model development (resolution, dynamics/physics, initialization etc.) – Improvement in description of physical processes such as clouds

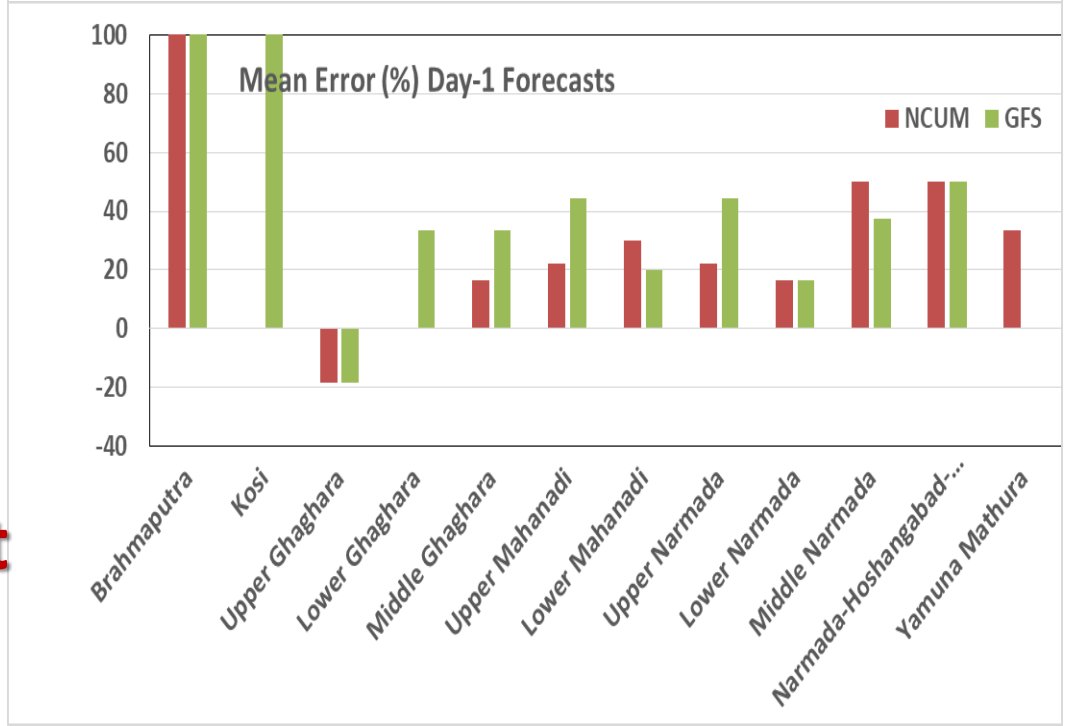
Mean Rainfall (JJAS2018)

For Flood Forecast and Wate Management Basin scale rainfall is important.

- Models have excessive rain over most of the basins
- Highest errors over Brahmaputra and Kosi in NCUM and GFS (>+200% ME)
- For all other sub-basins ME is within the range of (-33% to +83%)

How to improve skill at basin Scale ?





Equal Partnerships

- MoES/NERC sponsored research projects on “Drivers of Variability in the South Asian Monsoon” under Monsoon Mission program of MoES
- MoES/NERC sponsored projects on “Atmospheric Pollution and Human Health in an Indian Megacity” under Newton-Bhabha fund
- MoES/UK Newton Fund sponsored WCSSP
- MoES/NOAA collaboration on Monsoon, RAMA buoys, cyclones etc.
- MoES/UCAR collaboration on airpollution
- MoES/JAMSTEC on Monsoon variability
- MoES/BIMSTEC to support small countries in the region
- Monsoon Mission Programme – GOI provides funding for foreign entities to collaborate and research on Monsoon prediction
- ……

Summary and Challenges

In recent years high resolution global and regional models with advanced data assimilation techniques have been implemented on newer HPCs.

The prediction of large-scale aspects of monsoon in shorter scale (NWP) and tropical cyclone forecasts (track) have improved.

Global/Regional Ensemble prediction systems are able to provide the uncertainty

India is surrounded with data sparse regions, Oceans, Mountains where observations are required. Algorithms for satellite data for cloudy conditions, land-surface processes need development work to provide better initial conditions for rainy areas and Land.

More observations are required for India Ocean to initialise the ocean component better

Validation and in-turn model development for high resolution regional and local models with fine resolution and high frequency observations are required

Algorithms to assimilate affectively radar data, meso-scale observations , lightning data and rainfall information into convective scale coupled models have to be implemented.

Improvement of monsoon rainfall forecasts in S2S scale is a priority

Future Plans

- Looking for a strong partnership to address the grand challenges listed above.
- MoES institutes model developmental activity is now recognized worldwide for their quantum jumps in prediction skills. Interested in collaborating in similar lines with institutions who have similar capabilities to fasten the momentum.
- MoES is planning to issue 1 km forecasts using high resolution models and AI/ML
- Climate Research Test Beds, intensive observation campaigns with focus on addressing model deficiencies and parameterization schemes.

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THANK YOU