Assimilation of INSAT AMVs in NCMRWF NWP system: An Evaluation of the Indian Summer Monsoon Onset Features

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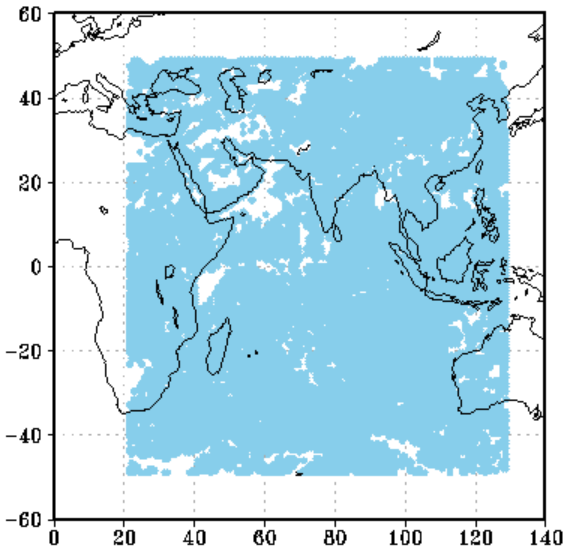
OUTLINE

- **Validation of INSAT AMVs**
  - ✓ first guess
  - ✓ in-situ winds

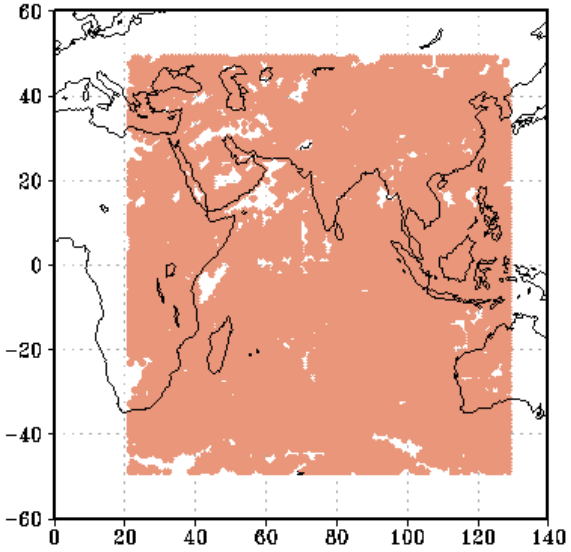
- **OSE with INSAT(3D & 3DR) AMVs**
  - ✓ monsoon onset (Bay of Bengal, Arabian Sea)
  - ✓ verification of analysis and forecast

Spatial Coverage of INSAT(3D & 3DR)

INSAT-3DR (74^0 E)



INSAT-3D (82^{0}E)



- **Located at different longitude**

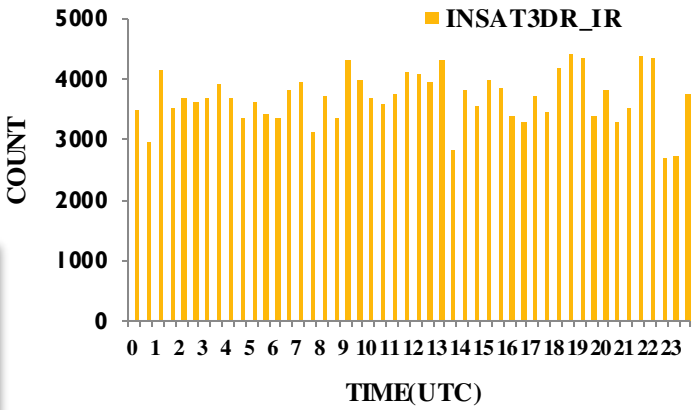
- **Due to sector generated product AMVs from both INSAT-3D & 3DR are available over same geographical area**

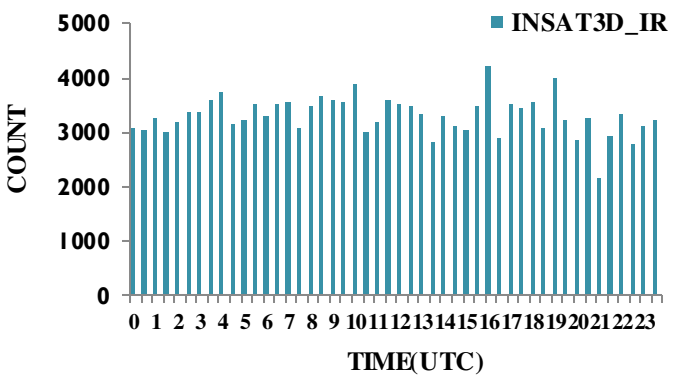
Monthly average reception of INSAT-3D & INSAT-3DR for May 2020

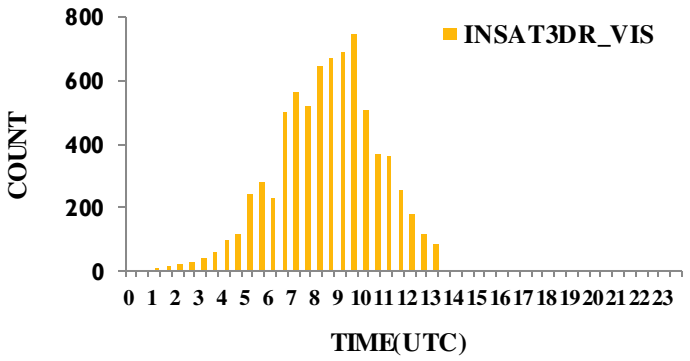
AMVs from each INSAT (3D & 3DR) are available at every 30 minutes interval

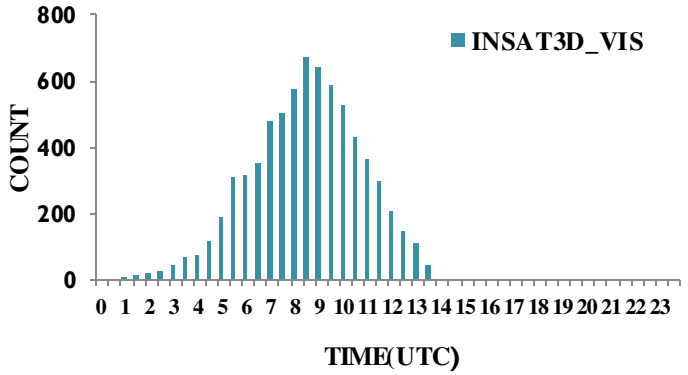
✓INSAT-3D starting at 0000 UTCs (0000,0030 UTC…)

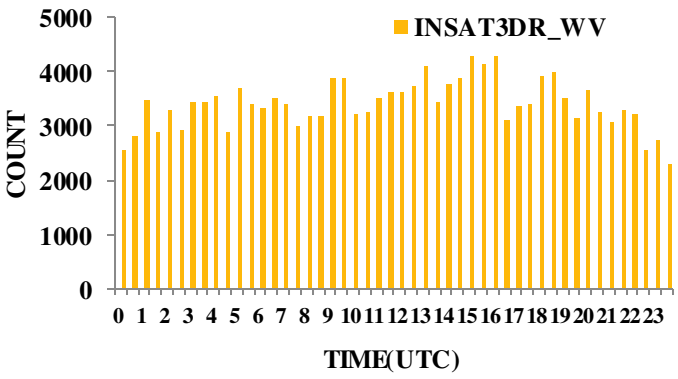
✓ INSAT-3DR starting at 0015 UTCs (0015,0045 UTC…)

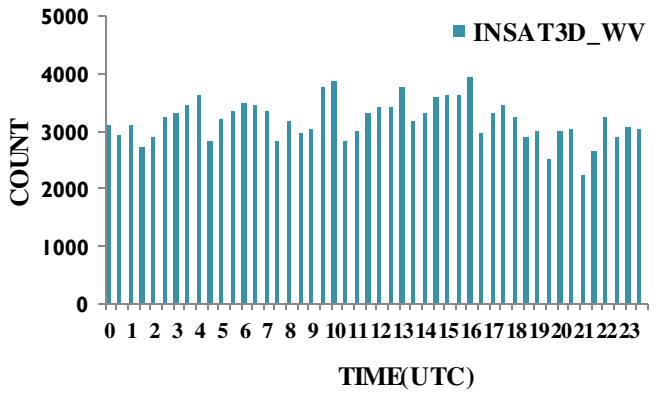








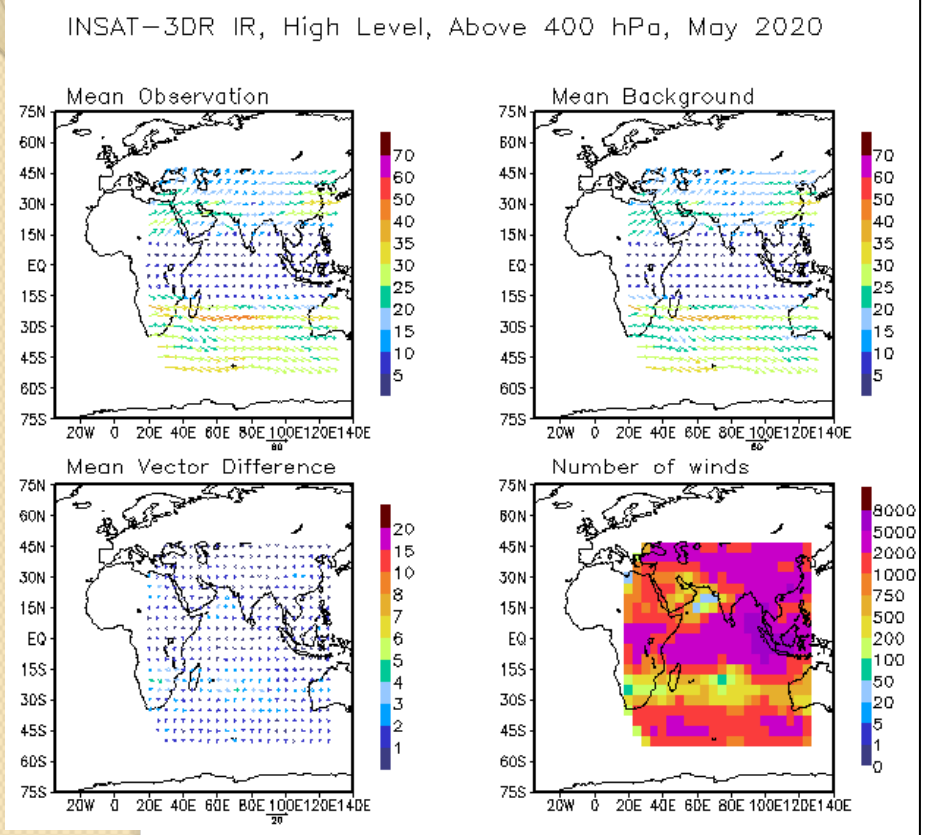




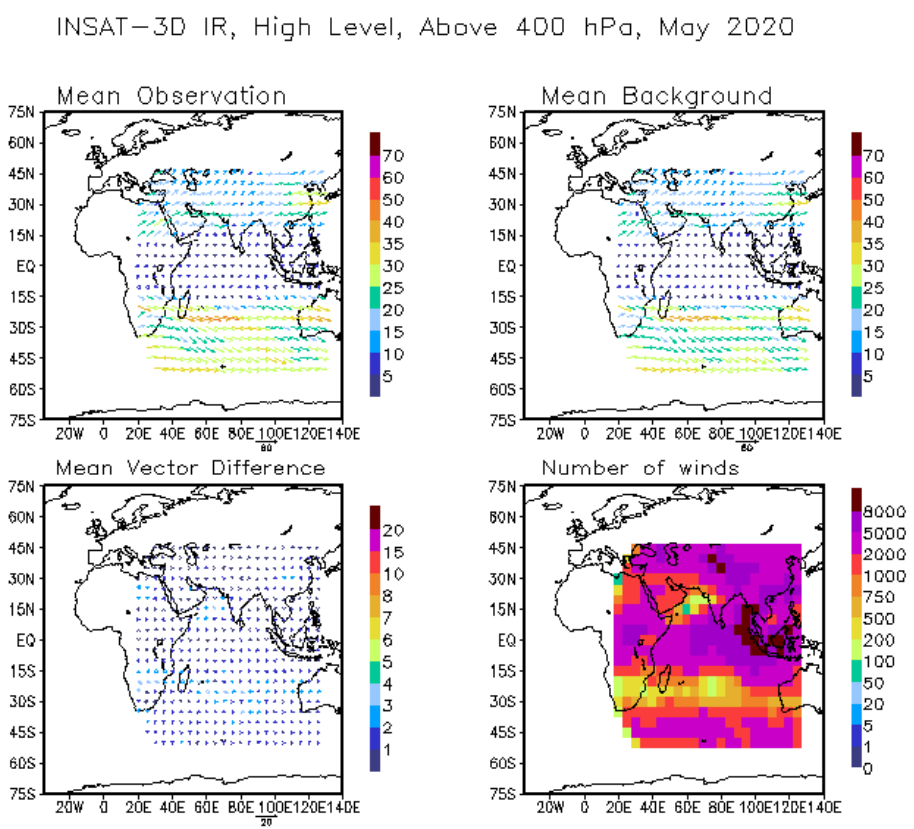
Validation of INSAT-3DR AMVs against NCMRWF First Guess

IR WINDS (High Level)

INSAT-3DR



INSAT-3D

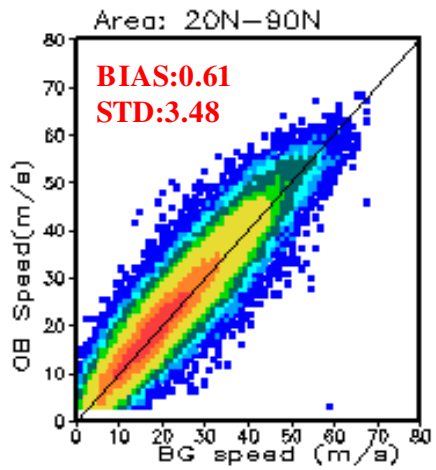


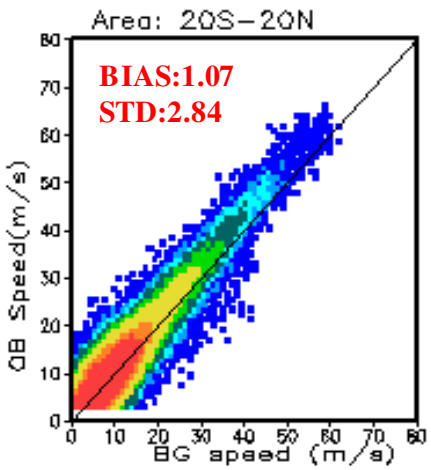
as per NWP–SAF criteria

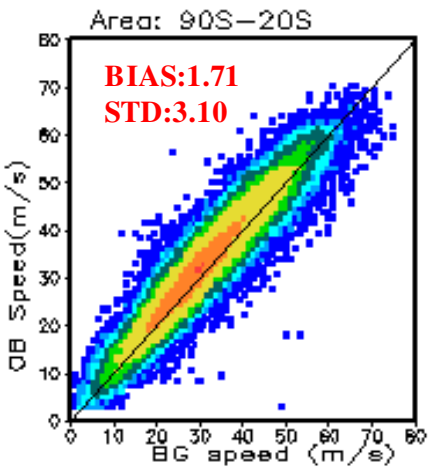
Speed Bias Density Plots

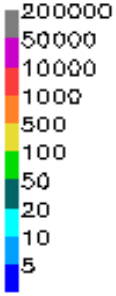
IR WINDS (High Level)

INSAT-3DR

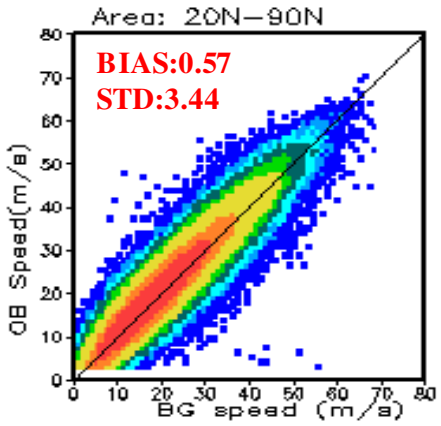


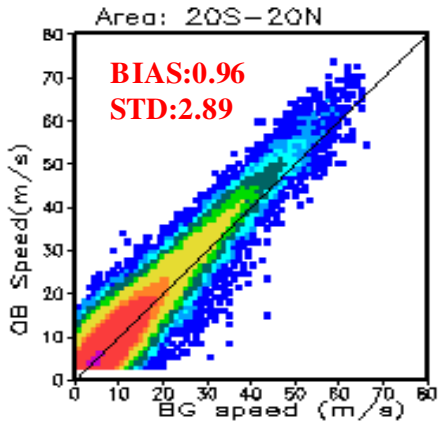


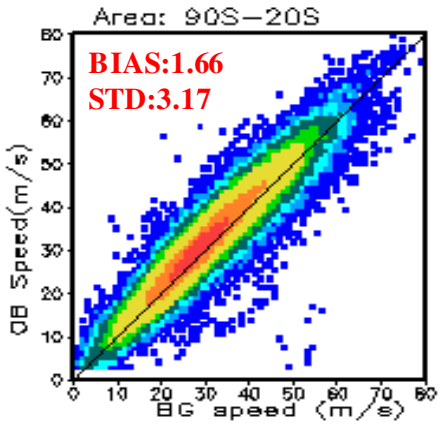


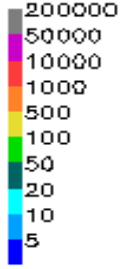


INSAT-3D

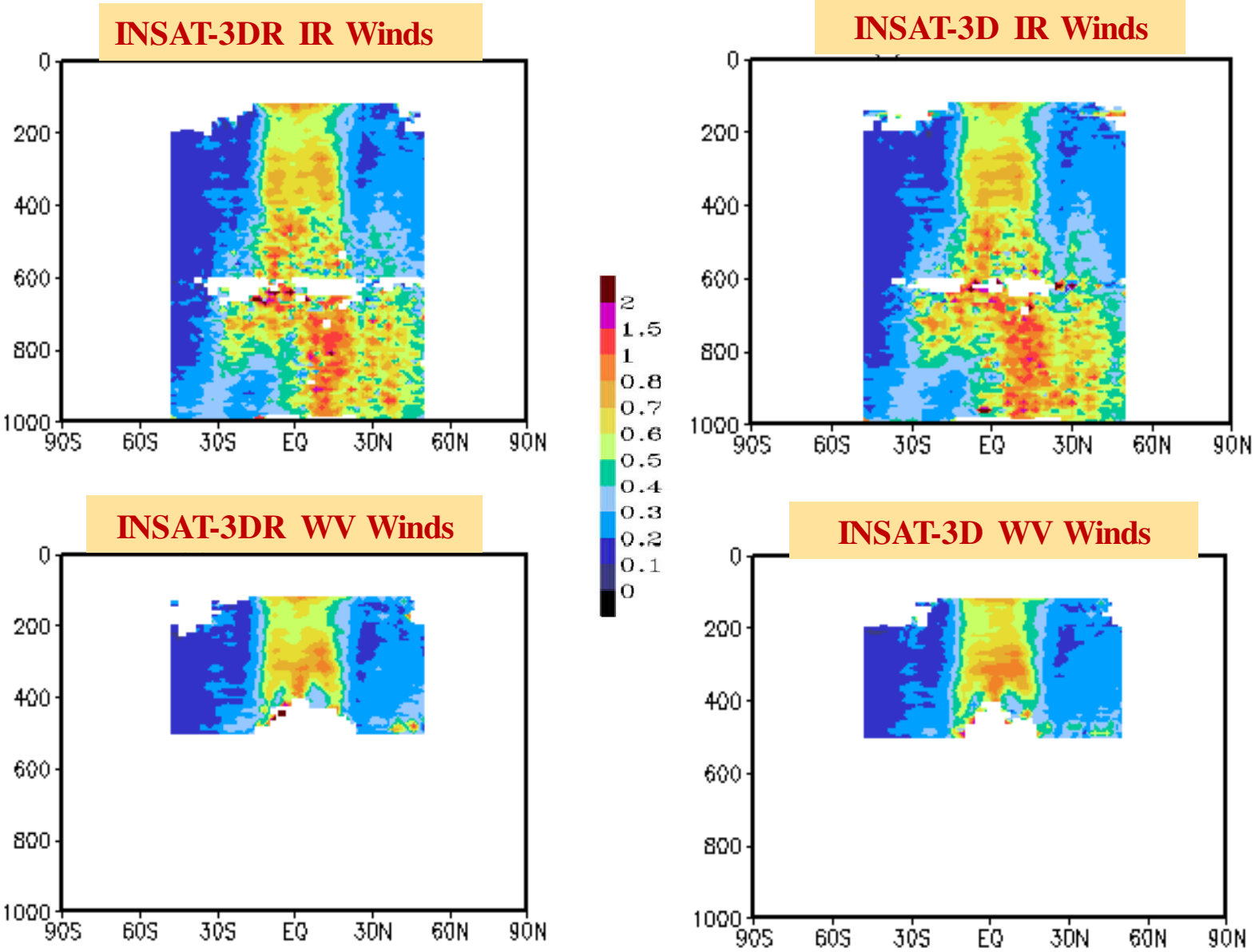








NRMSVD zonal average at different pressure level

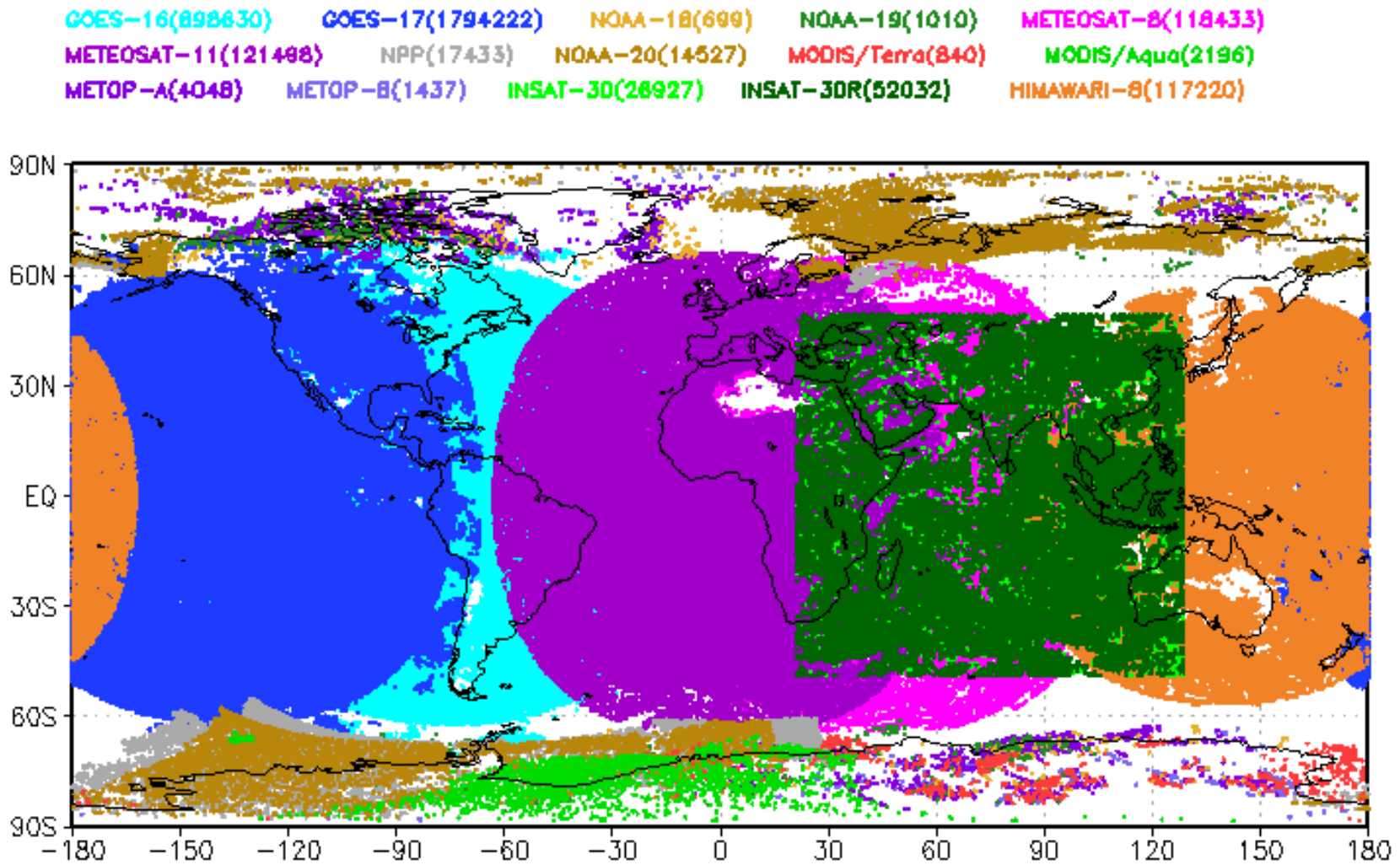


Validation against In-situ Winds

Satellite	Northern Hemisphere			Tropics			Southern Hemisphere		
	Bias	RMSVD	No. of collocations	Bias	RMSVD	No. of collocations	Bias	RMSVD	No. of collocations
	High Level IR Winds								
INSAT-3D	0.36	6.57	9535	0.42	4.73	15447	1.83	5.99	395
INSAT-3DR	0.52	6.57	5314	0.39	4.72	11488	1.61	5.90	374
	Mid Level IR Winds								
INSAT-3D	-0.75	5.16	2989	-0.57	3.93	656	-0.55	4.98	283
INSAT-3DR	-0.97	5.06	1268	0.39	4.72	260	-1.91	5.25	184
	Low Level IR Winds								
INSAT-3D	0.19	4.73	1994	1.15	4.18	2111	-0.68	4.83	918
INSAT-3DR	0.07	4.20	1476	1.09	4.29	1147	-0.10	4.81	484
	WV Winds								
INSAT-3D	0.61	6.89	19633	0.76	5.28	18583	0.80	6.43	1699
INSAT-3DR	0.60	6.73	10457	0.90	5.19	11620	1.30	6.80	699

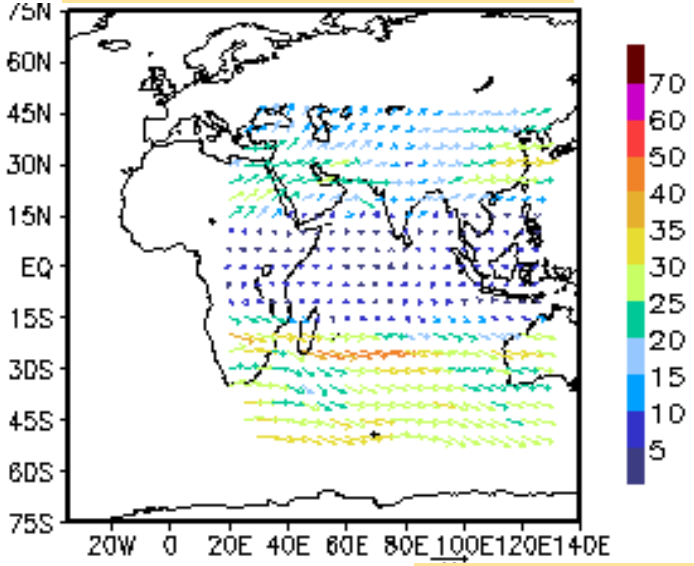
As per CGMS criteria

AMVs received at NCMRWF on a typical day at 00UTC

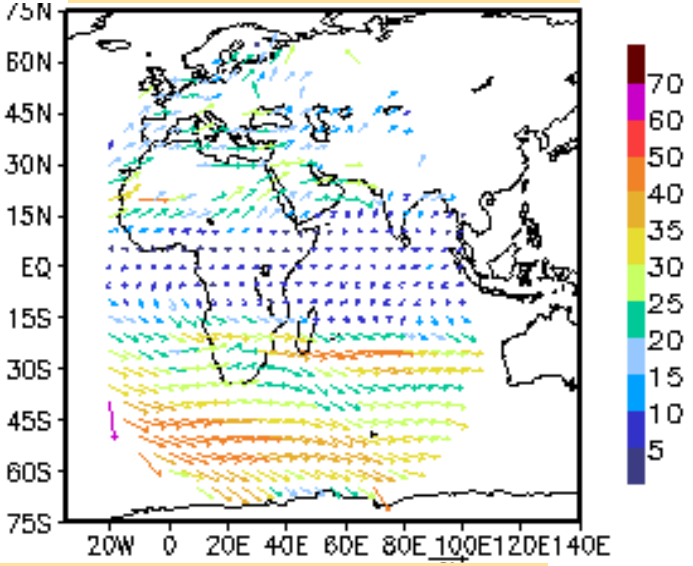


Mean wind flow of INSAT and Meteosat-8 IR Winds

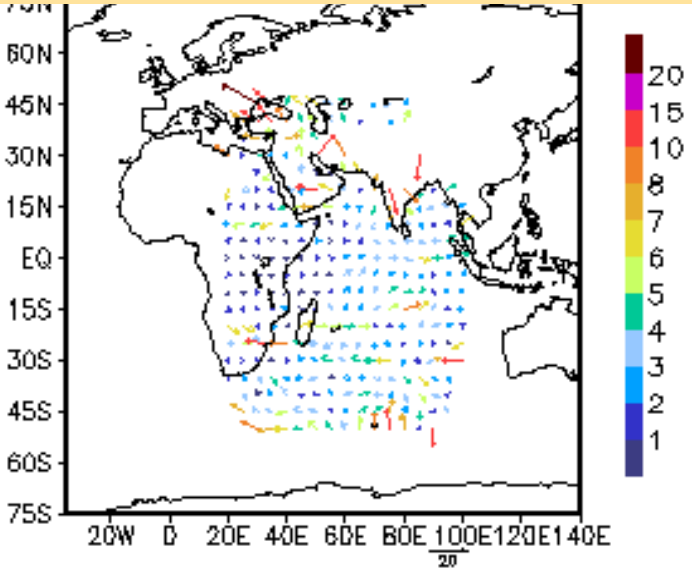
Mean INSAT AMVs



Mean Meteosat-8 AMVs



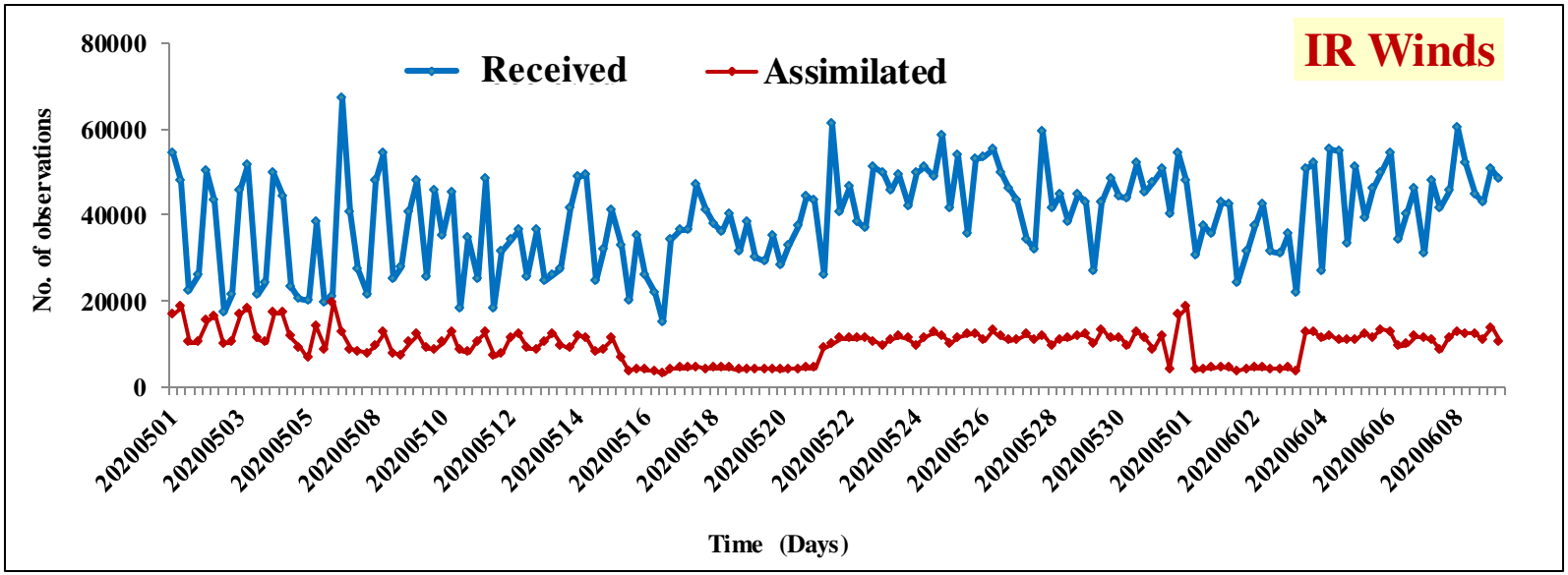
Mean Vector Difference (INSAT-Meteosat-8)

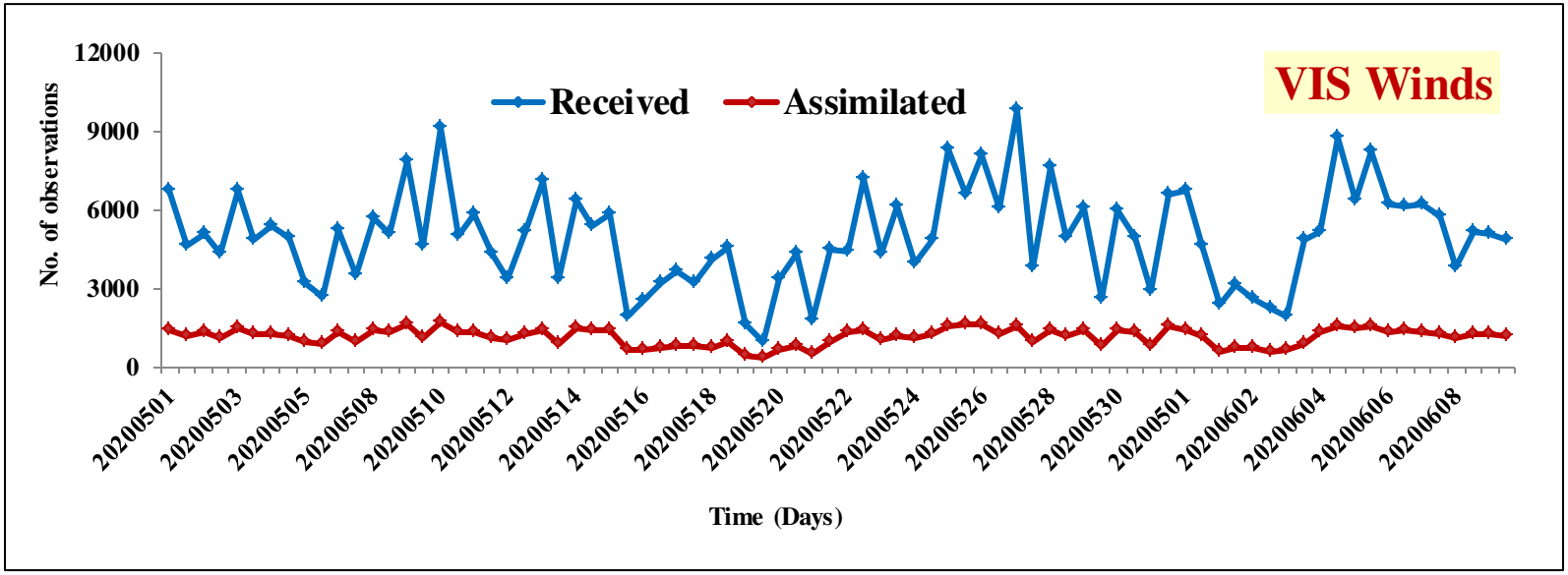


Assimilation of INSAT (3D & 3DR) AMVs

- OSE with INSAT (3D & 3DR) AMVs
- Thinning criteria:
  horizontal - 200 km, vertical -100 hPa and temporal - 2 hrs
- Study period : 1 May to 10 June 2020
- NGFS 4D-VAR data assimilation system
- Control Run : Data from operational NCMRWF daily archive
- Experiment : Control data + INSAT (3D & 3DR) AMVs
- Simulation of Indian Sumer Monsoon onset features

INSAT(3D & 3DR) Winds received at NCMRWF and assimilated during the study period





Significant features during the study period

Onset over Bay of Bengal

- 1 – 25 May 2020
- "Amphan" cyclone formed over Bay of Bengal during 16 - 21 May 2020

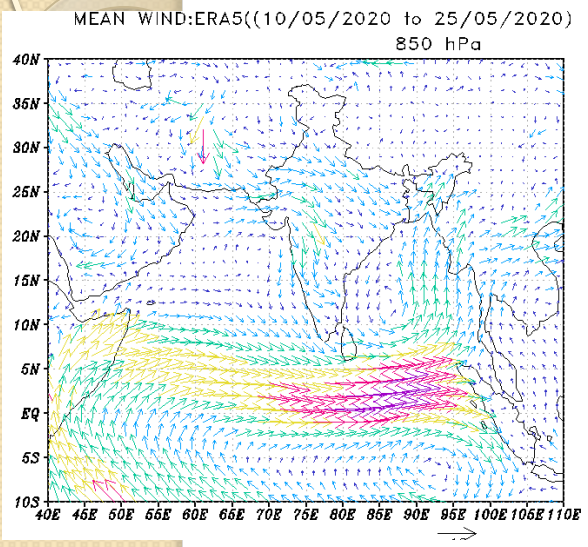
Onset over Arabian Sea

- 25 May to 10 June 2020
- "Nisarga" cyclone formed over Arabian Sea from 1 - 4 June 2020
- Onset of Indian Sumer Monsoon

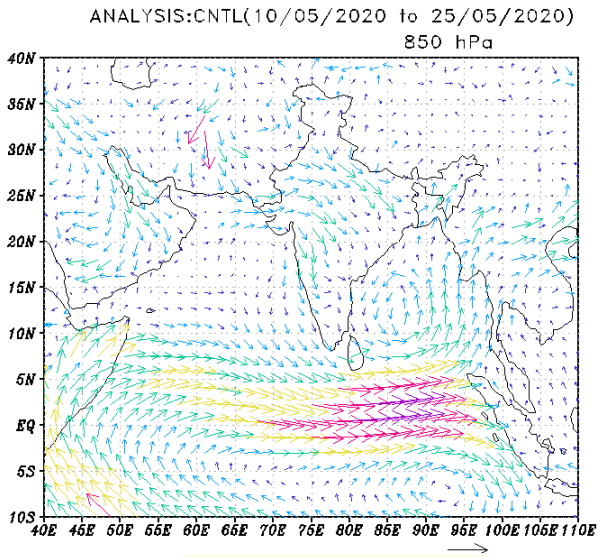
Onset over Bay of Bengal

850 hPa Mean Wind Analysis

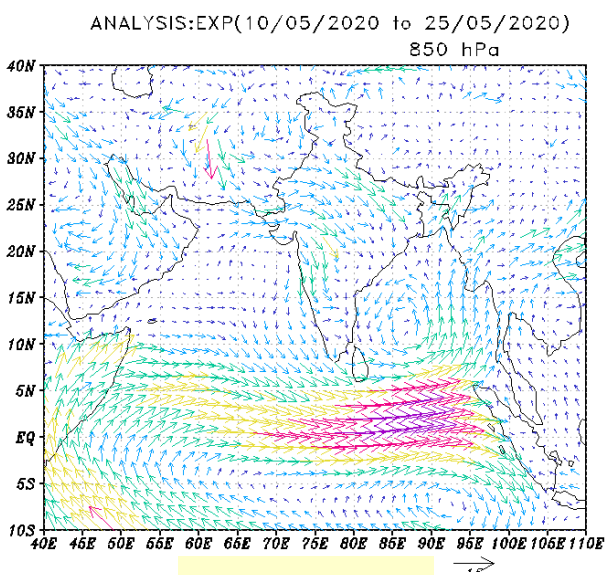
ERA5



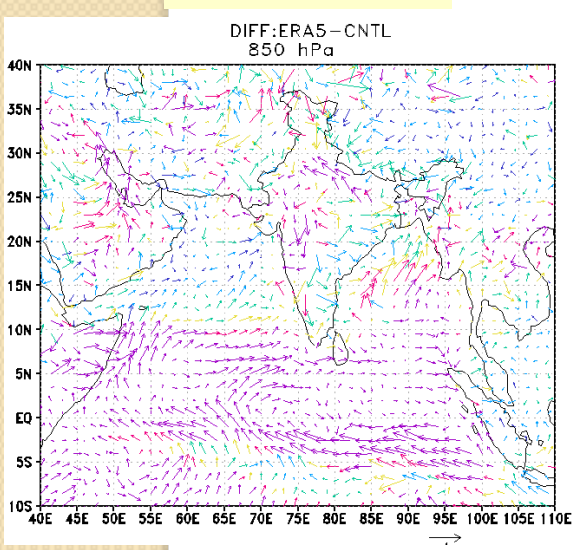
CNTL



EXP



ERA5-CNTL



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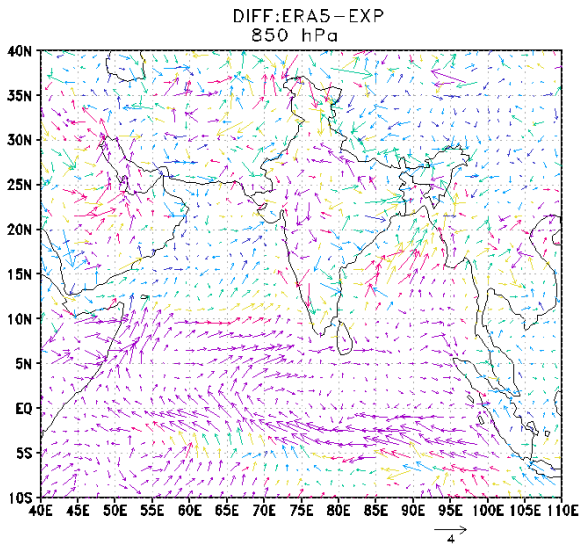
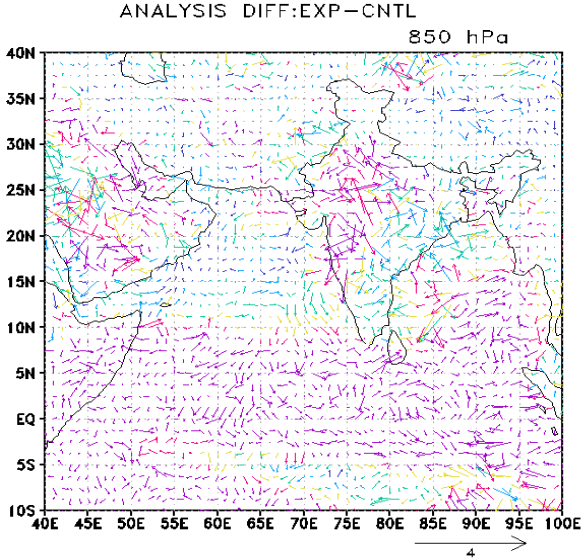


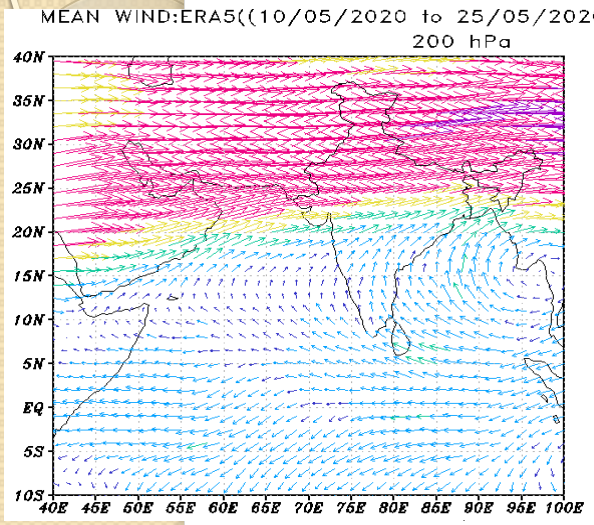
EXP-CNTL



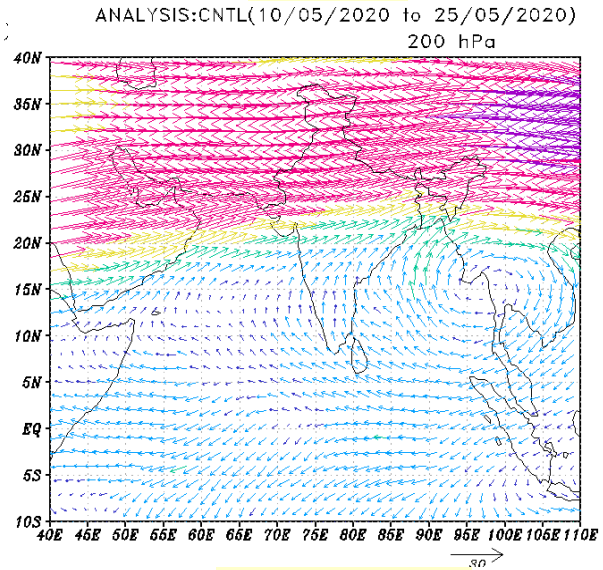
Onset over Bay of Bengal

200 hPa Mean Wind Analysis

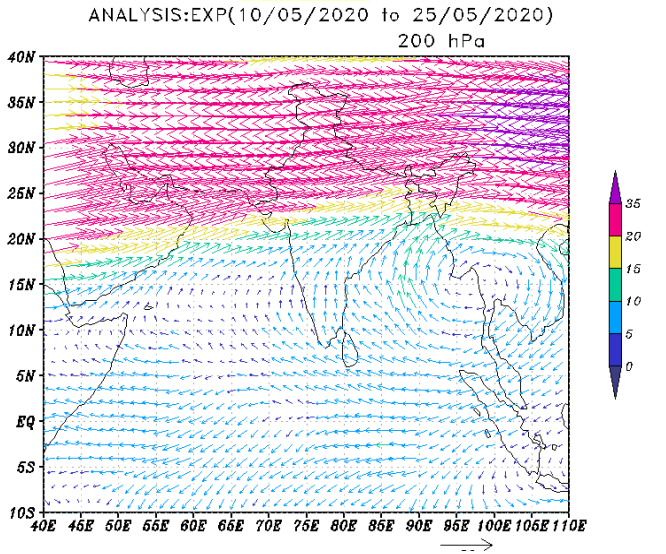
ERA5



CNTL



EXP



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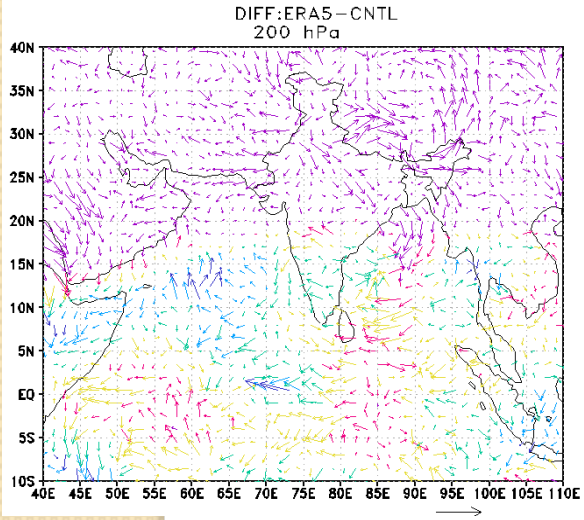

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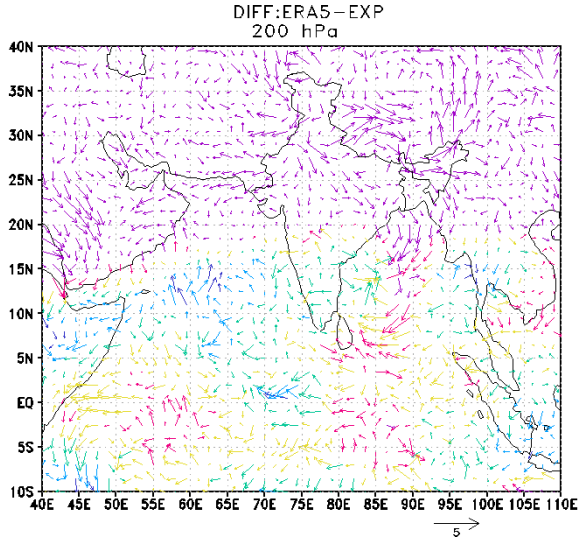
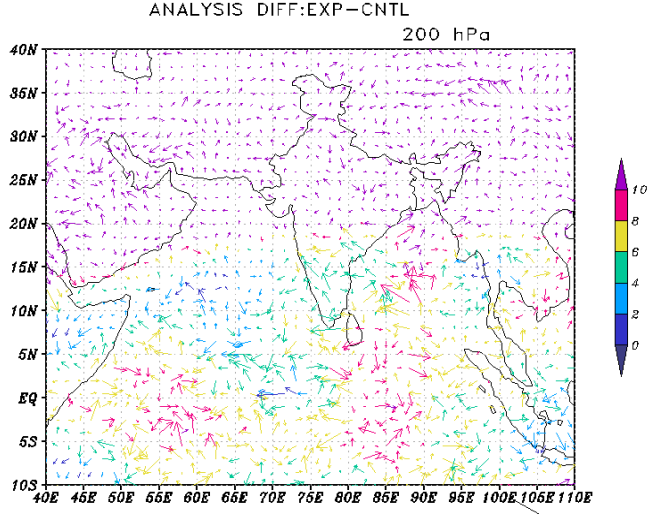


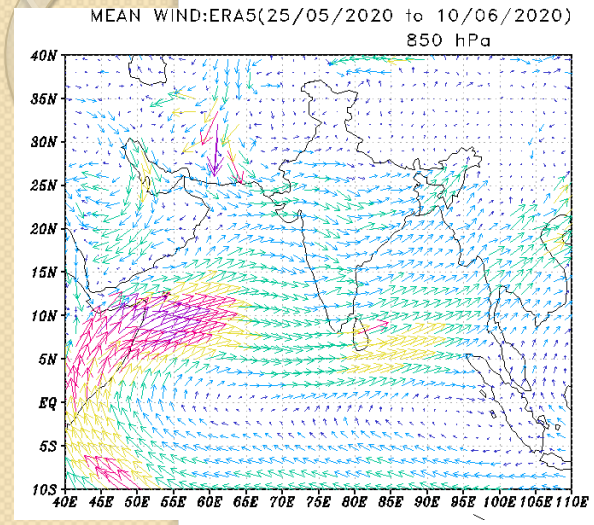
EXP-CNTL



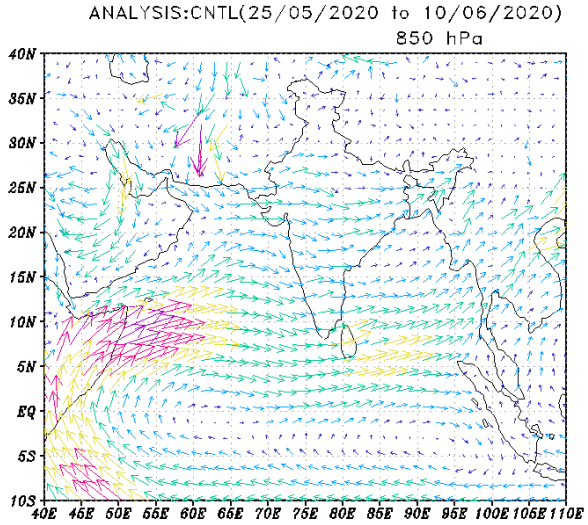
Onset over Arabian sea

850 hPa Mean Wind Analysis

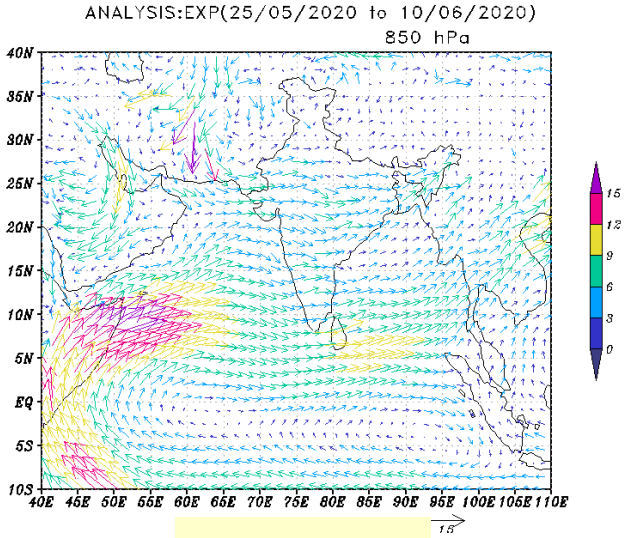
ERA5



CNTL



EXP



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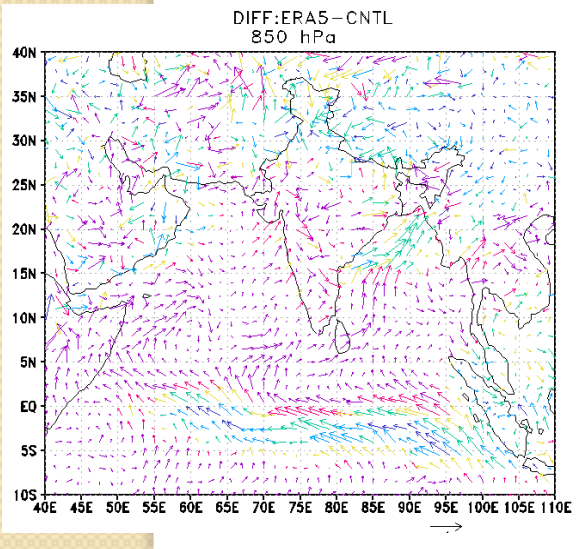

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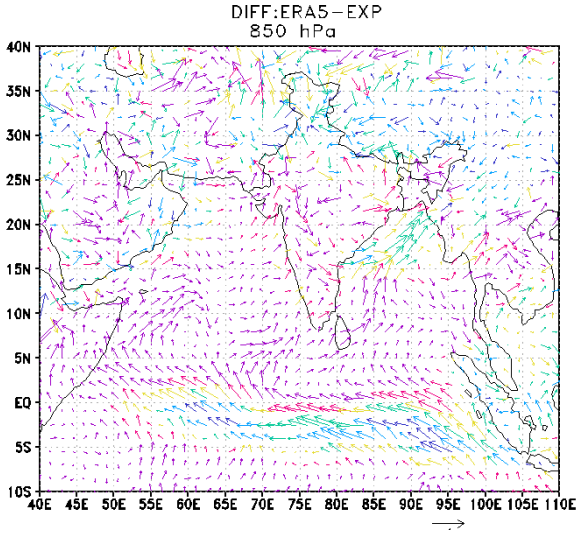
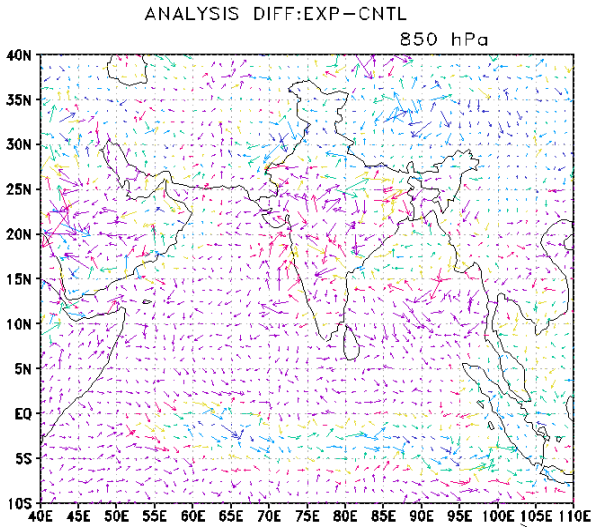


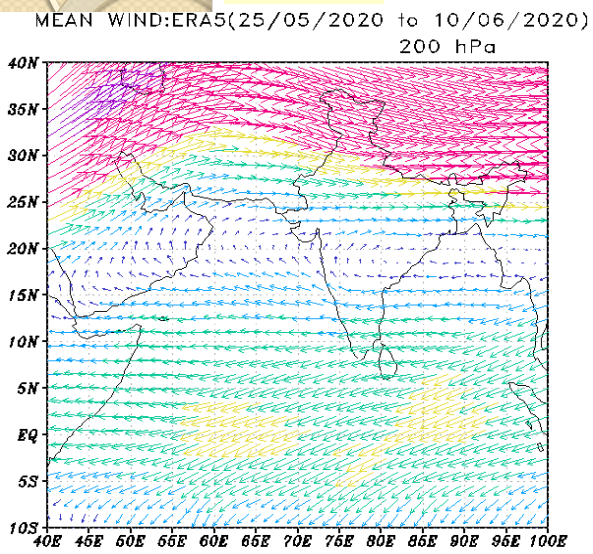
EXP-CNTL



Onset over Arabian sea

200 hPa Mean Wind Analysis

ERA5



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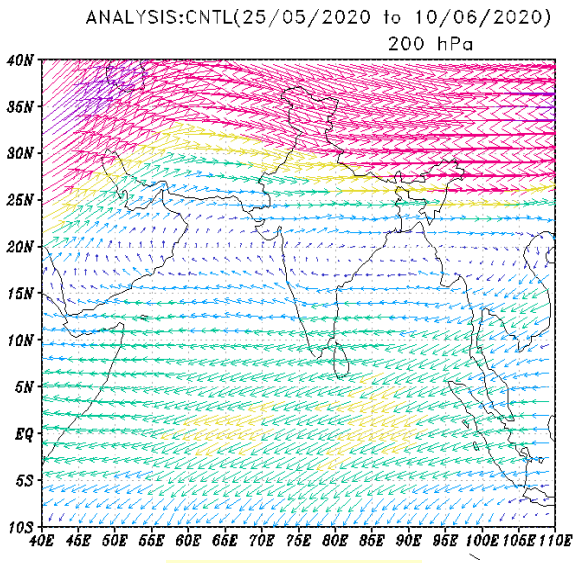

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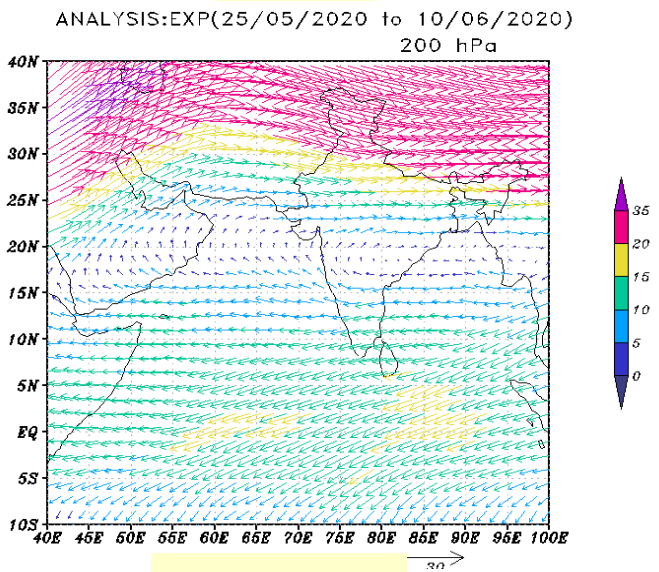
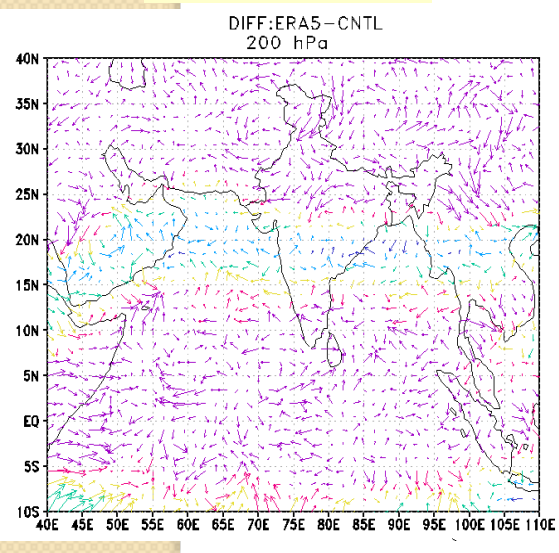


ERA5-CNTL



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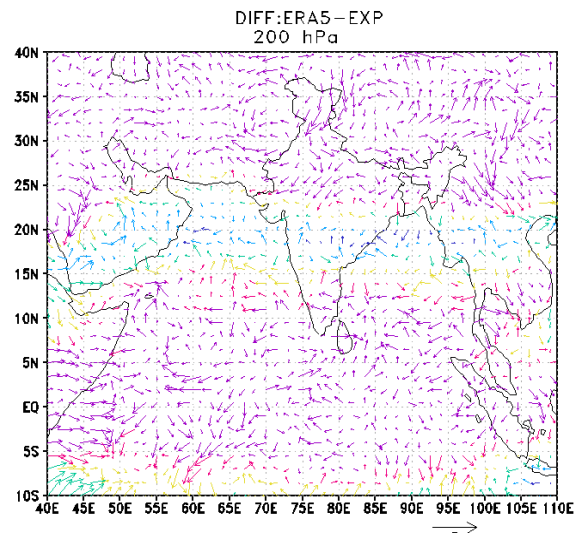
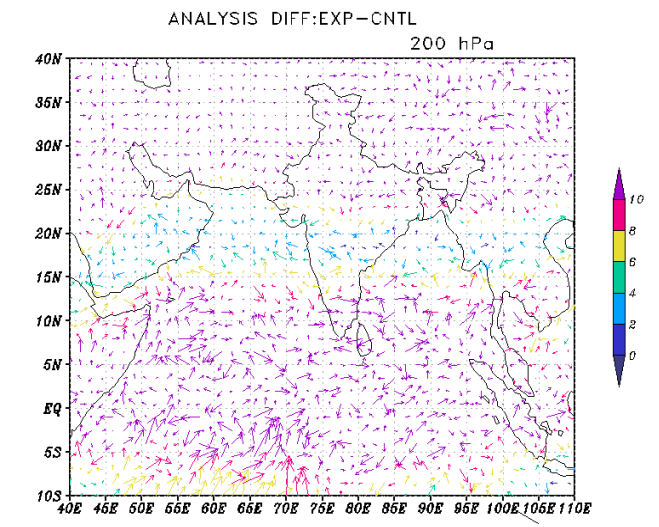
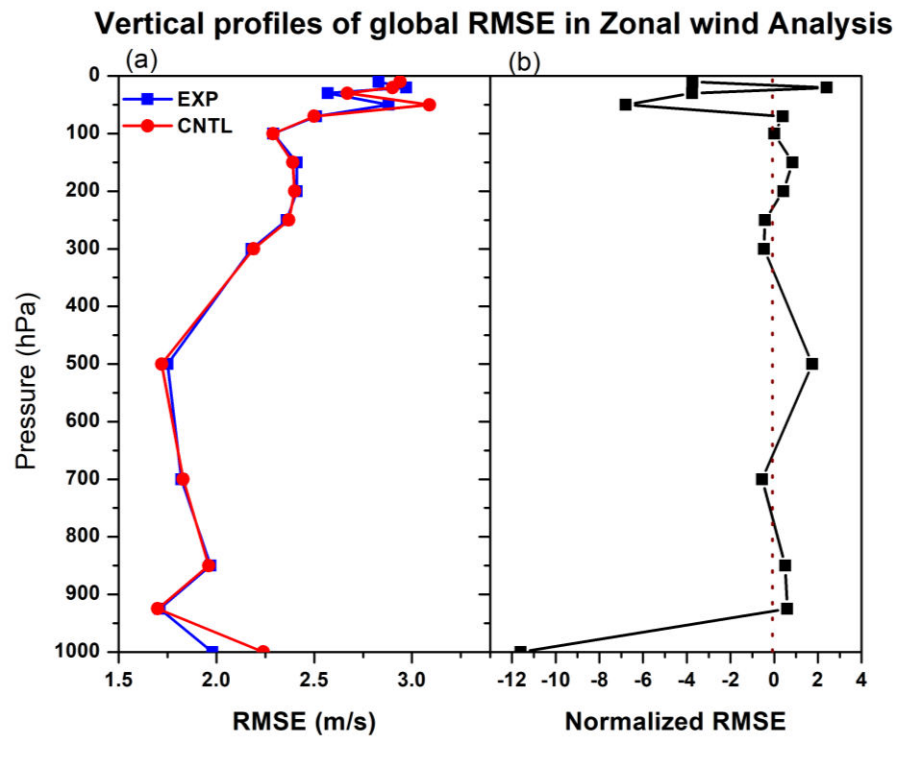


EXP-CNTL

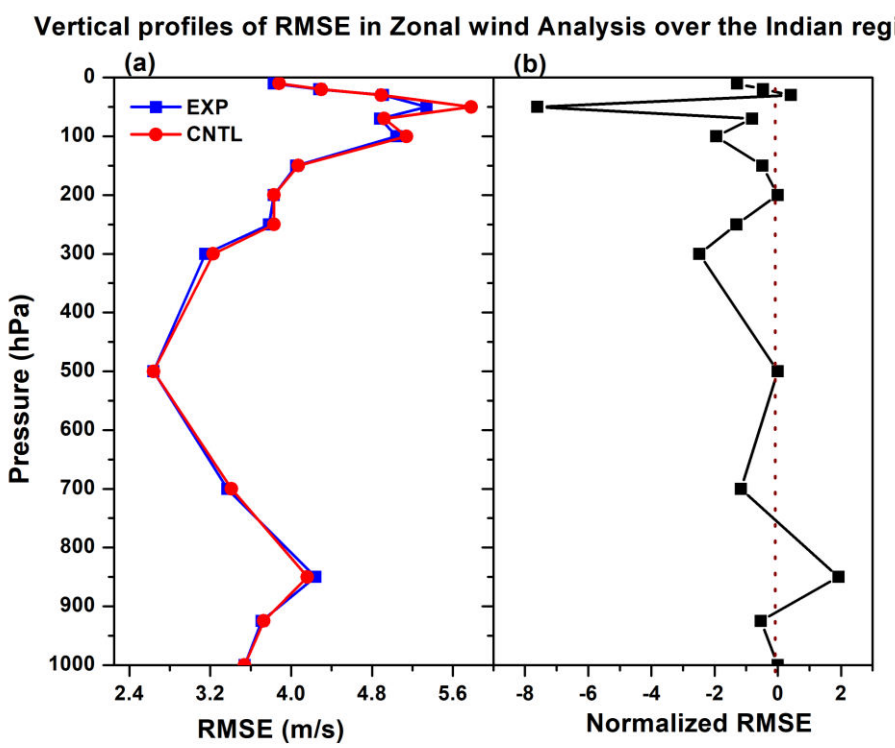


RMSE of analysed Zonal winds at various pressure level for EXP and CNTL

Global



Indian Region

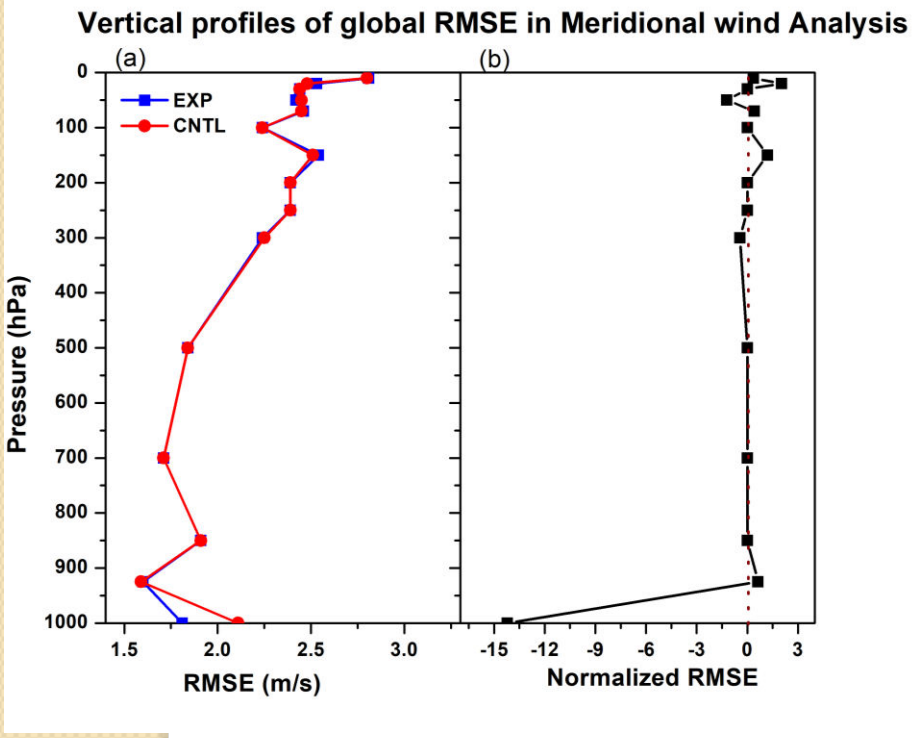


Averaged for 1 May 2020 to 10 June 2020

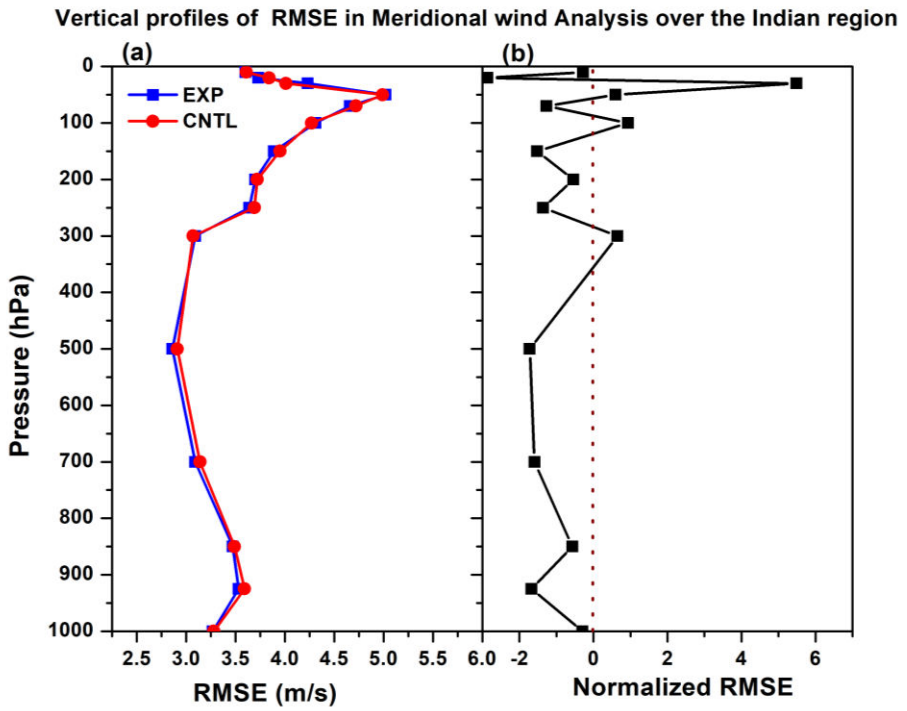
$$Normalized RMSE = \frac{RMSE(EXP) - RMSE(CNTL)}{RMSE(CNTL)} \times 100$$

RMSE of analysed Meridional winds at various pressure level for EXP and CNTL

Global



Indian Region



Averaged for 1 May 2020 to 10 June 2020

$$Normalized RMSE = \frac{RMSE(EXP) - RMSE(CNTL)}{RMSE(CNTL)} \times 100$$

Meridional Component of Wind at Equator

CNTL

EXP

CNTL: Analysis

D3 FCST-ANAL

D5 FCST-ANAL

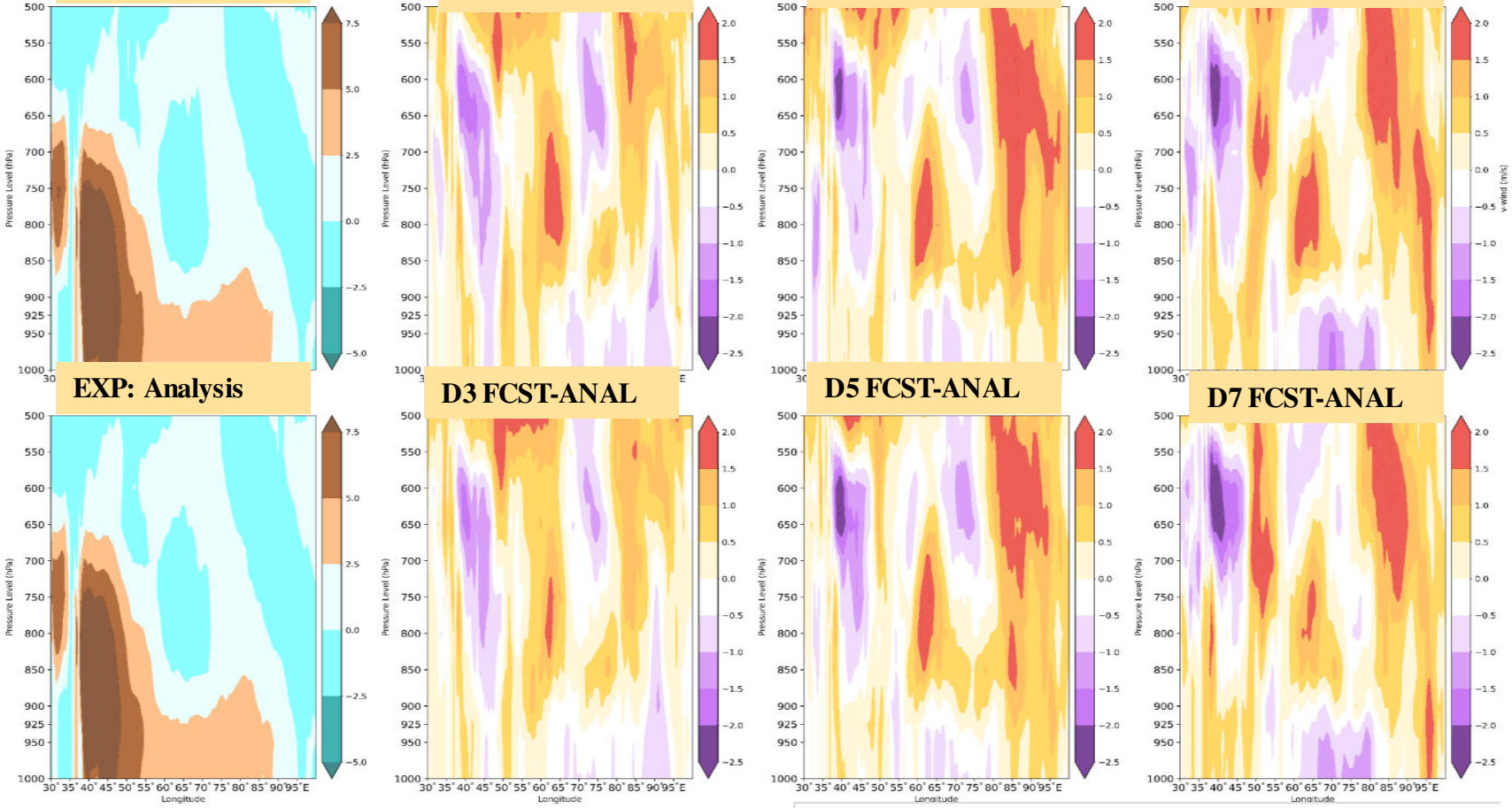
D7 FCST-ANAL

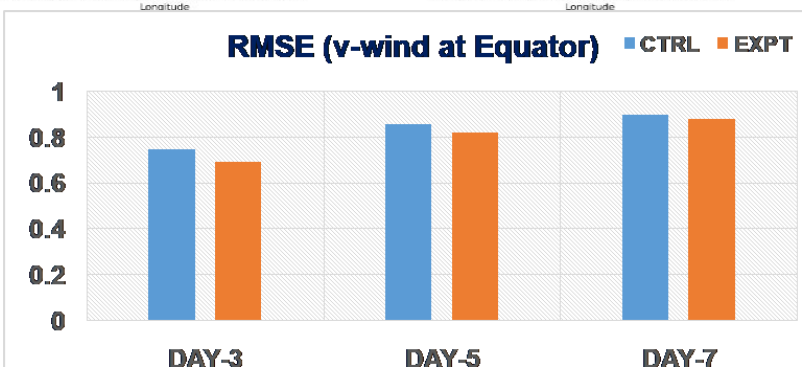
EXP: Analysis

D3 FCST-ANAL

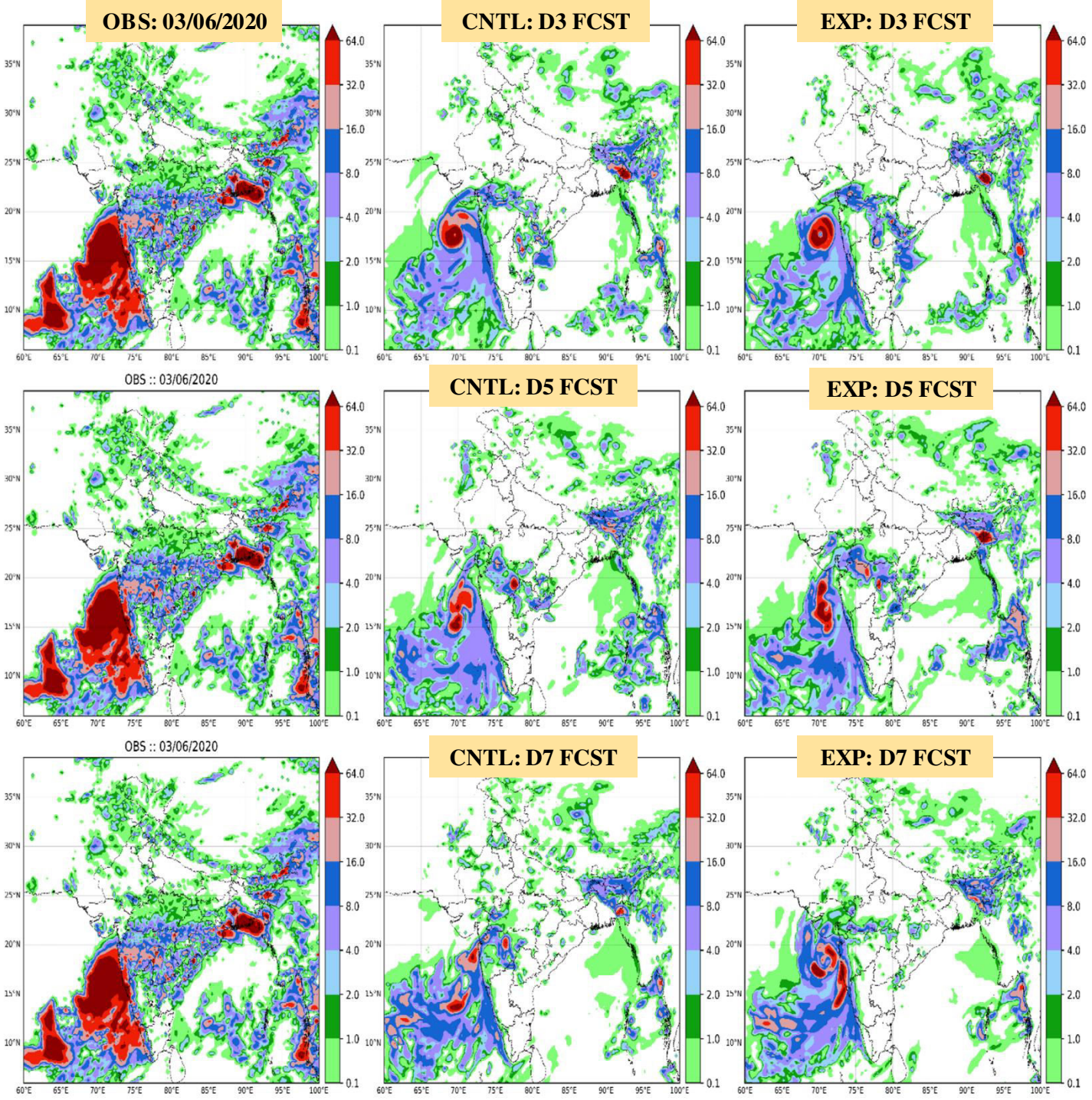
D5 FCST-ANAL

D7 FCST-ANAL

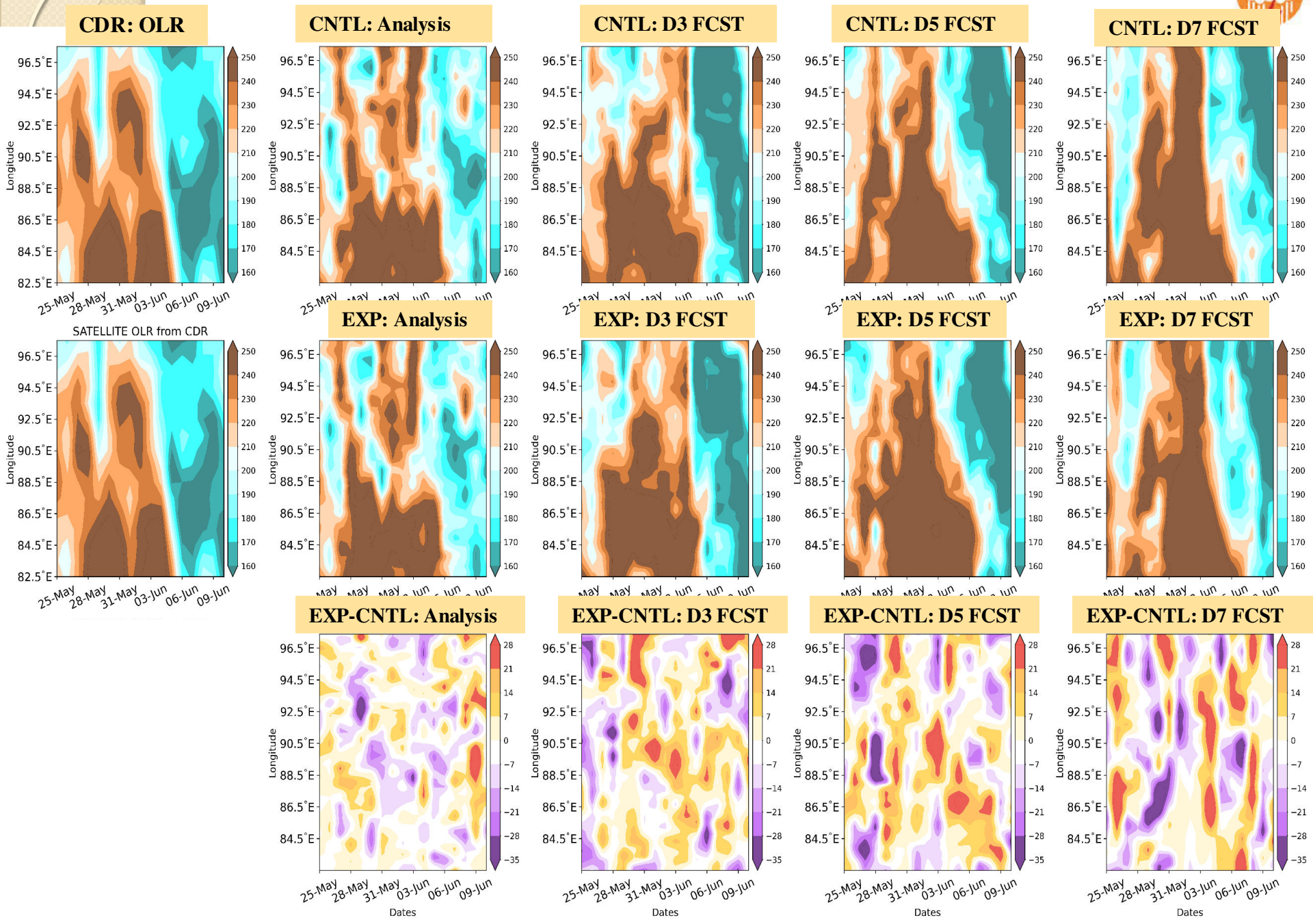


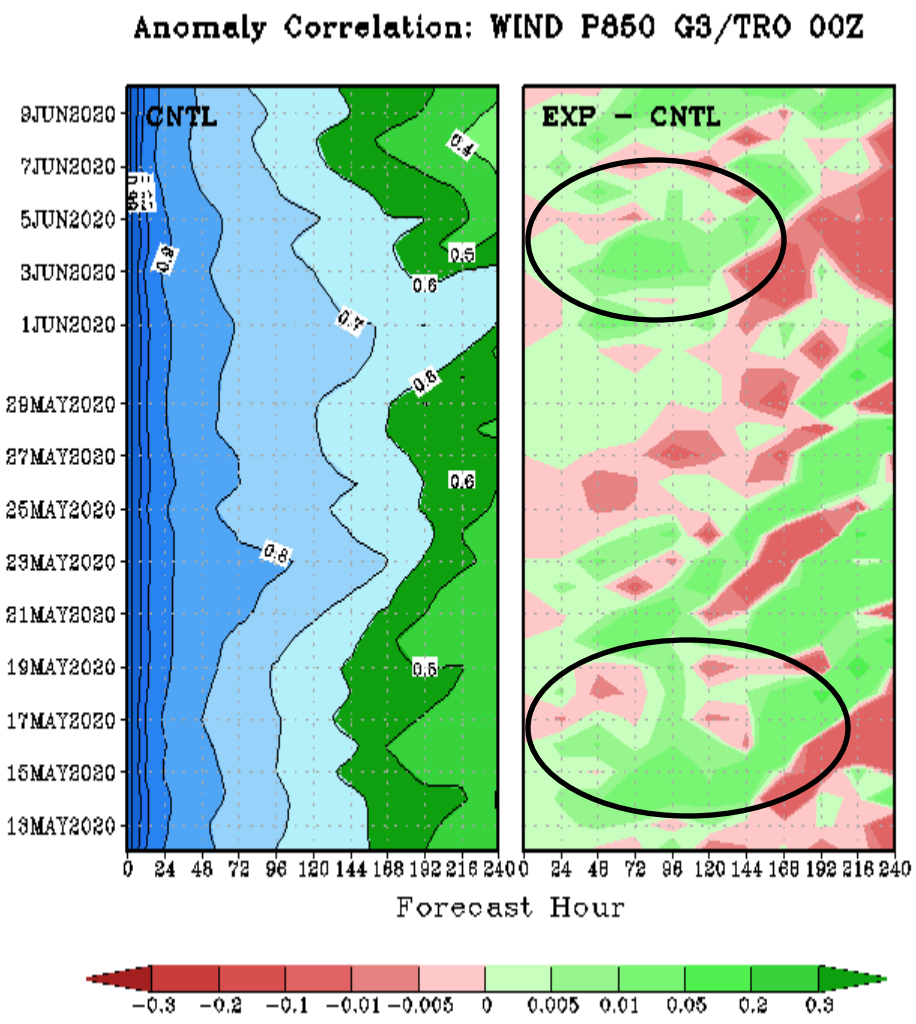


Verification of Rainfall on 03 Jun 2020 (Day-3, Day-5, Day-7) with Merged Satellite Rainfall Observation



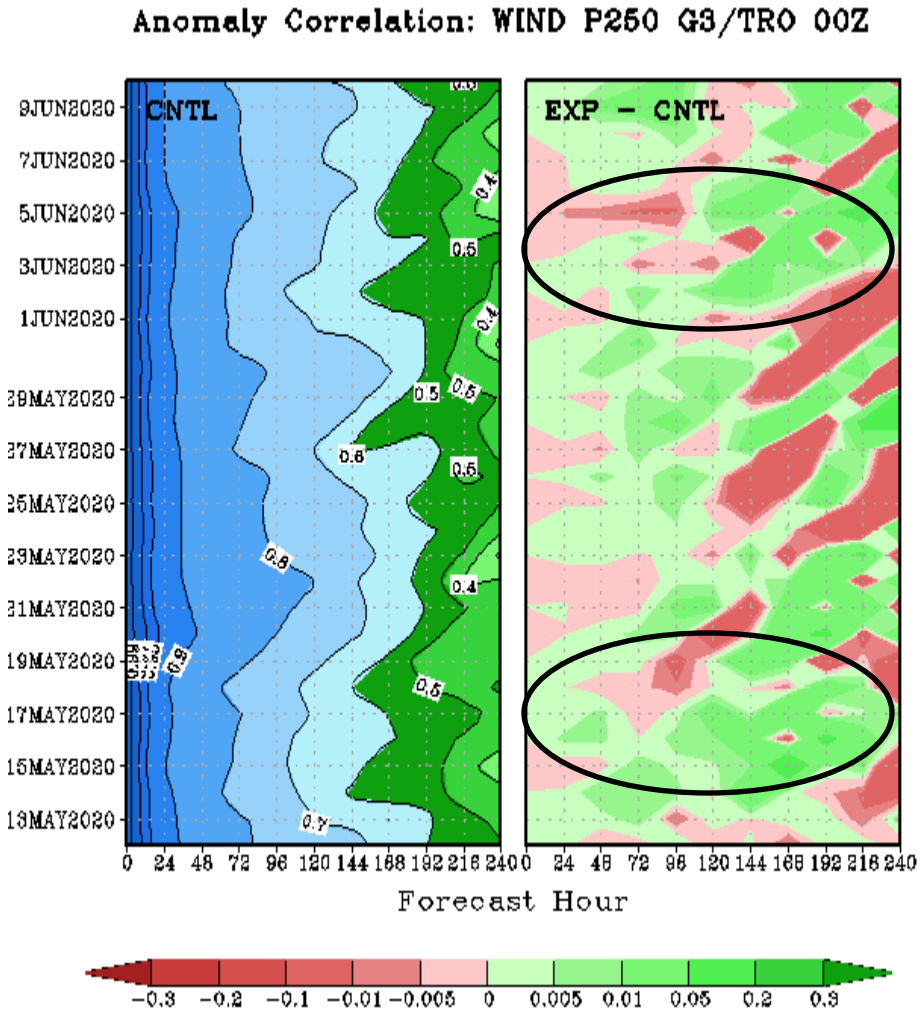
OLR over Bay of Bengal during Onset of ISM





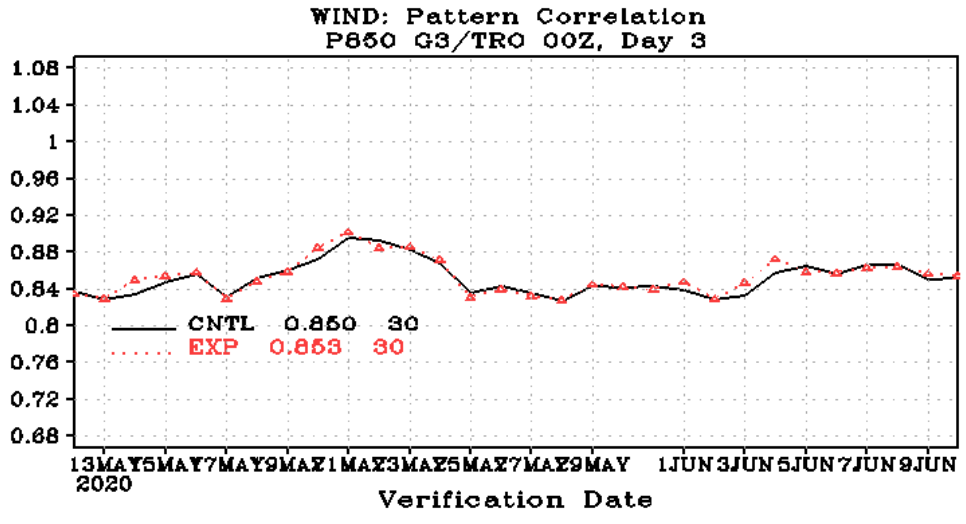
Anomaly Correlation in Wind at 850 hPa over Tropics

Anomaly Correlation in Wind at 250 hPa over Tropics

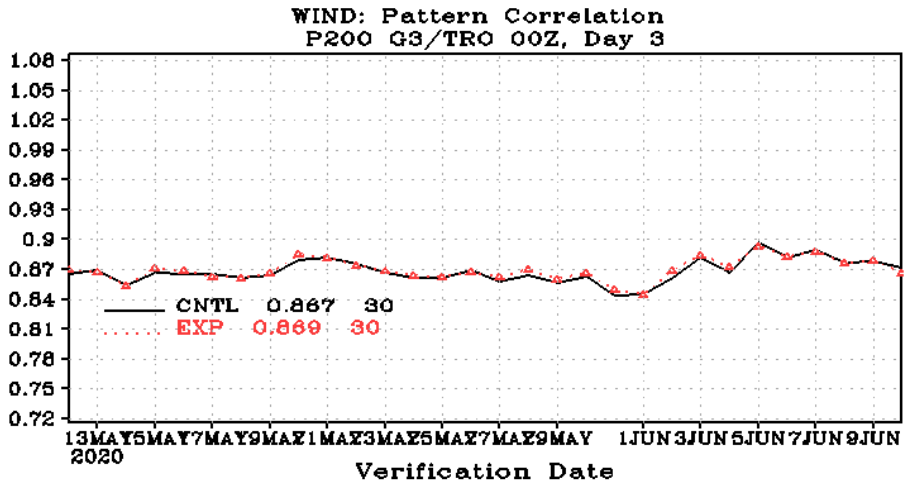


Forecast Verification: Correlation in Wind Pattern

850 hPa



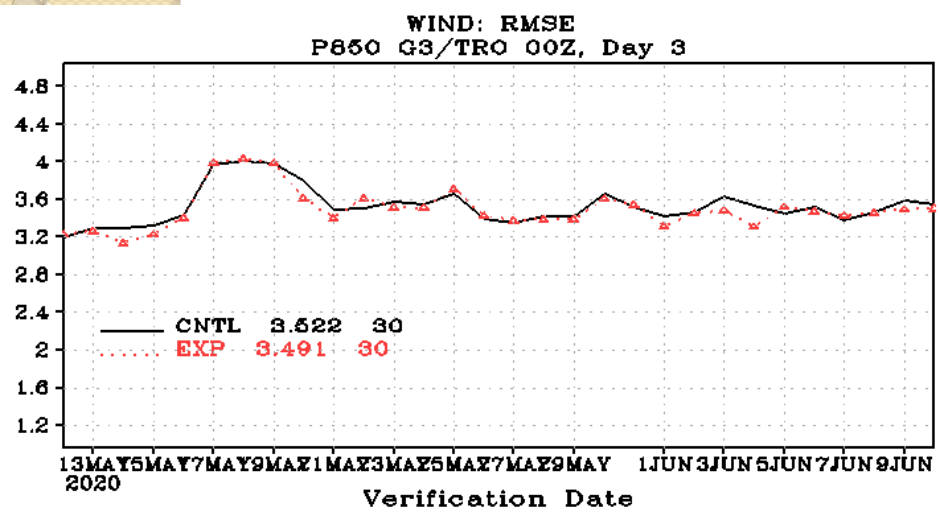
200 hPa



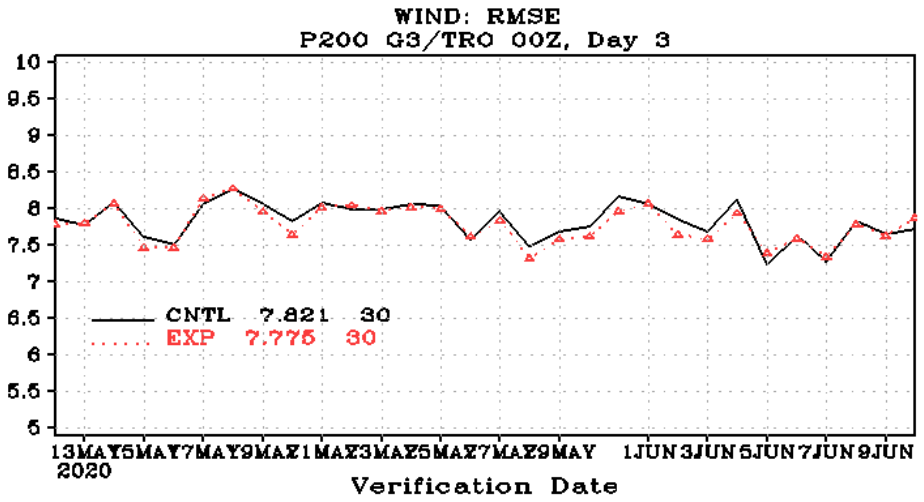
Forecast Lead Time	CNTL-850hPa	EXP-850hPa	CNTL-200hPa	EXP-200hPa
DAY 3	0.850	0.853	0.867	0.869
DAY 5	0.800	0.800	0.810	0.812
DAY 8	0.710	0.711	0.724	0.727

Forecast Verification : RMSE in Wind

850 hPa

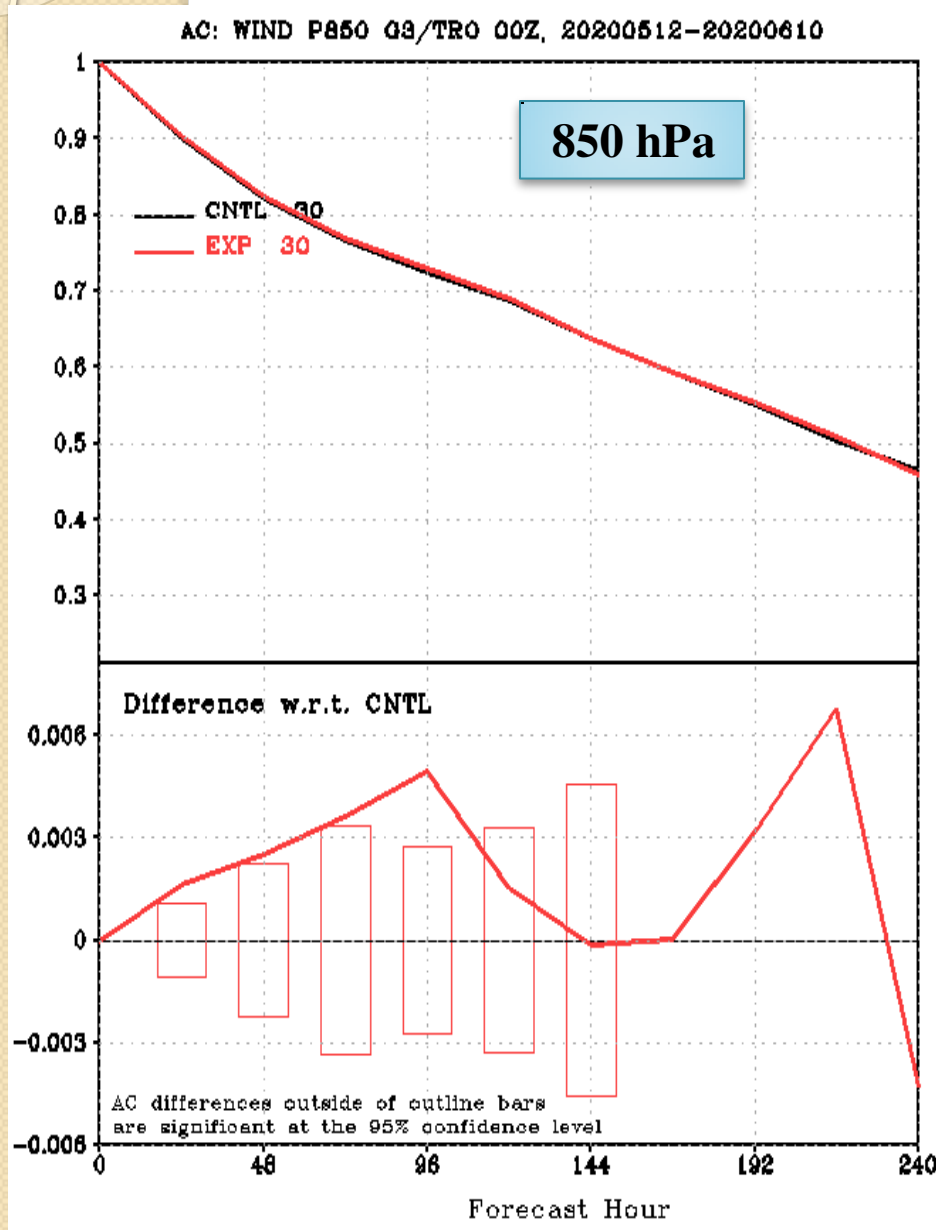


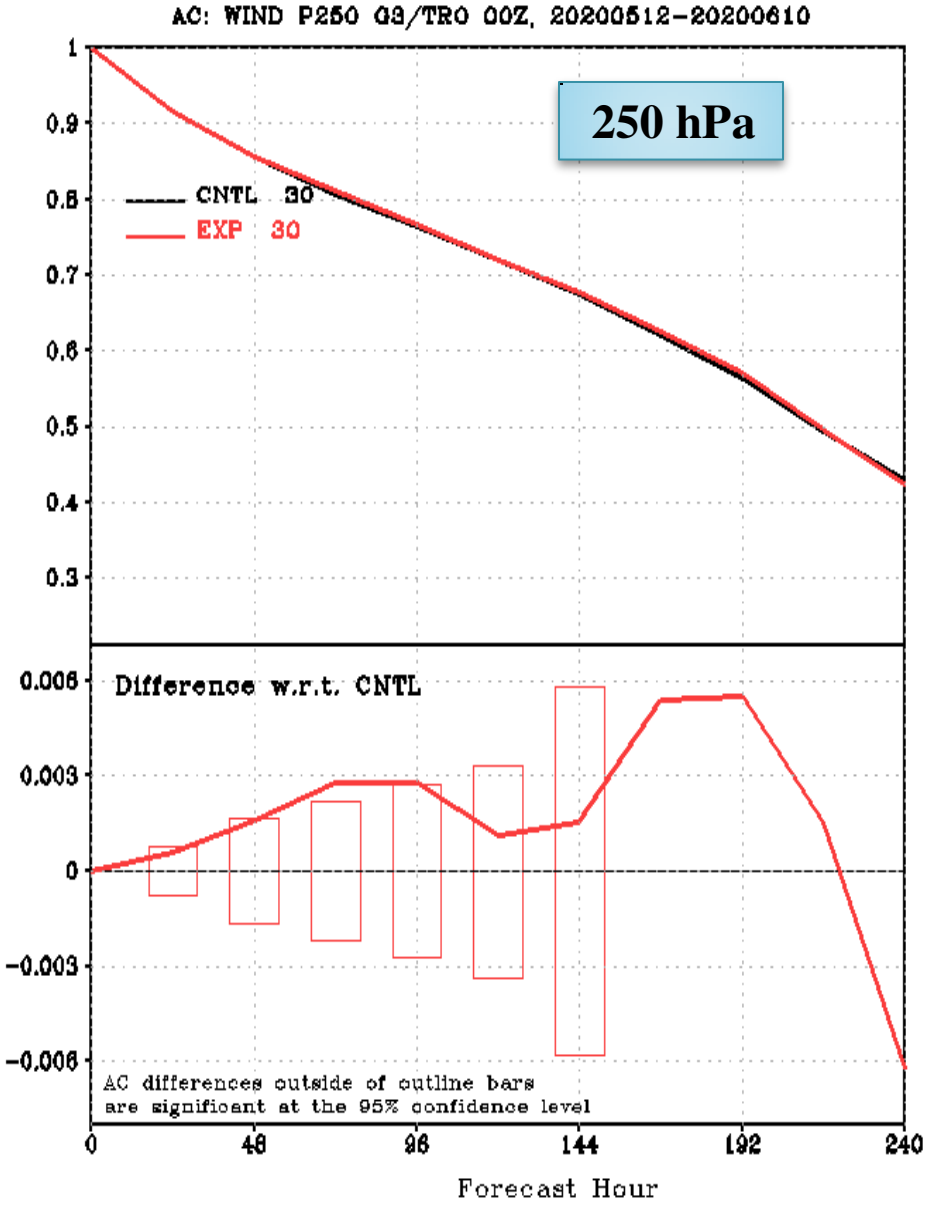
200 hPa



Forecast Lead Time	CNTL-850hPa	EXP-850hPa	CNTL-200hPa	EXP-200hPa
DAY 3	3.522	3.491	7.821	7.775
DAY 5	4.069	4.064	9.366	9.337
DAY 8	4.852	4.824	11.31	11.22

Anomaly Correlation in Winds with forecast lead time





Conclusions

- INSAT(3D &3DR) AMVs are validated against NCMRWF NWP short forecast and in-situ observations.
- The quality of INSAT(3D & 3DR) AMVs is found to be comparable with AMVs from other satellites.
- Assimilation of INSAT(3D & 3DR) AMVs shows improvement in forecasting the Indian Summer Monsoon onset features compared to the baseline experiment.

Thanks