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Introduction

Understanding the Indian Summer Monsoon (ISM) rainfall variability is a scientific challenge. El Niño Southern Oscillation (ENSO) has been known to exert the most dominant forcing on ISMR (eg. Webster & Yang 1992). Tropical Indian ocean (TIO) warming and equatorial central eastern Pacific cooling sustain an anomalous Western North Pacific anticyclone (WNP AC) during rapid El Niño decaying/La Niña developing summer (eg. Chen et al 2016). 2019 was a weak El Niño year that vanishes quickly in spring and transmits to La Niña in 2020. All-ISM rainfall during 2020 is above normal with 109% of its long-period average (LPA). The rainfall over country was 118%, 90%, 127% and 104% of LPA during June, July, August and September respectively and exhibited a prominent month-to-month variability with unexpected low precipitation in July over Indian subcontinent.

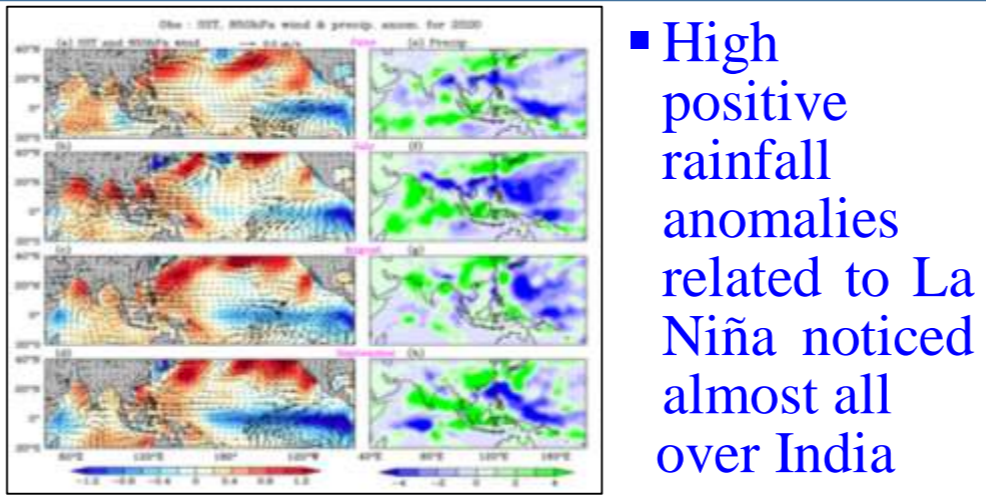
Objectives

To investigate possible factors determining the unusually reduced rainfall in July 2020 in observation and coupled model

Data & Methodology

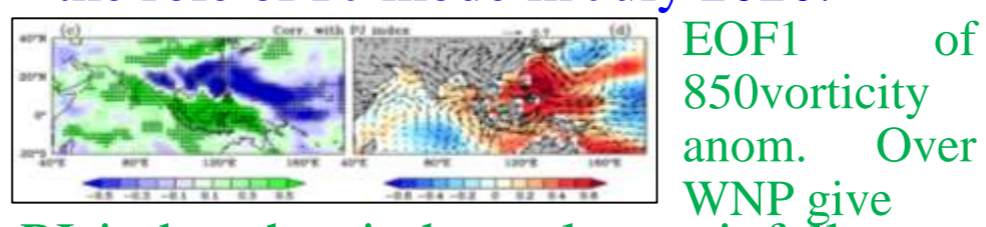
Study Period: 1979-2020
SST from Extended Reconstructed Sea Surface Temperature version 5 (ERSST v5), All level winds, specific humidity, sea level pressure (SLP), air temperature data from The National Centers for Atmospheric Prediction (NCEP) and the National Center for Atmospheric Research (NCAR), Rainfall from Global Precipitation Climatology Project (GPCP v2.3)
Statistical Methods performed - Empirical Orthogonal functions (EOF), Correlation analysis
NCEP Climate Forecast System version -2 (CFSv2) is coupled ocean-atmosphere model, 9-months hindcast prepared from 1985 to 2020 initialized in May and February.

Results & Discussion

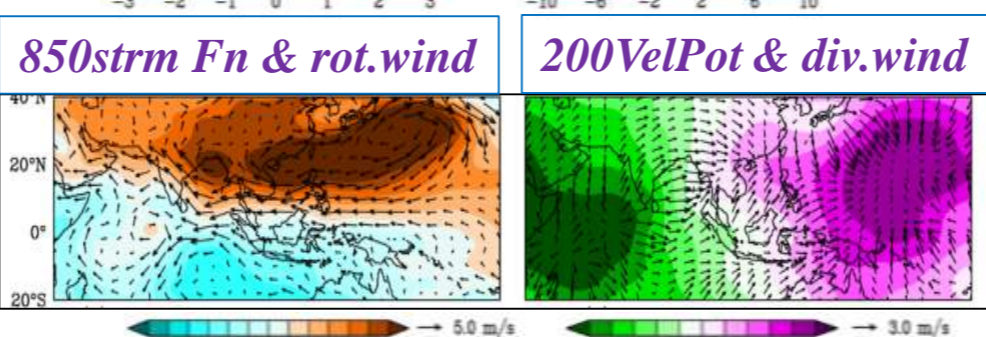
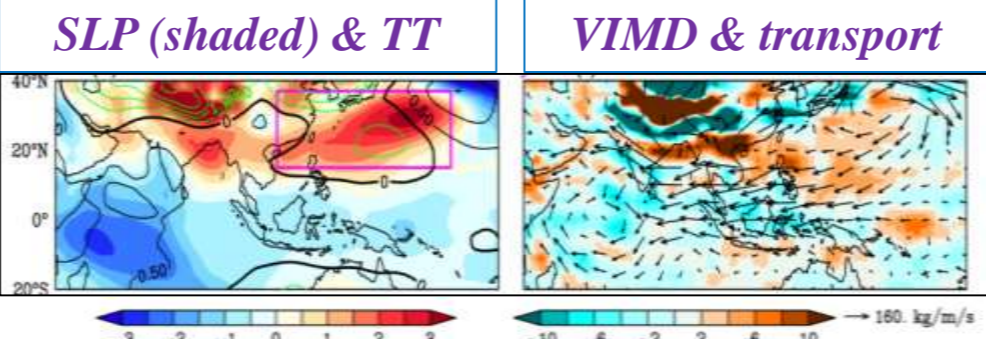


High positive rainfall anomalies related to La Niña noticed almost all over India

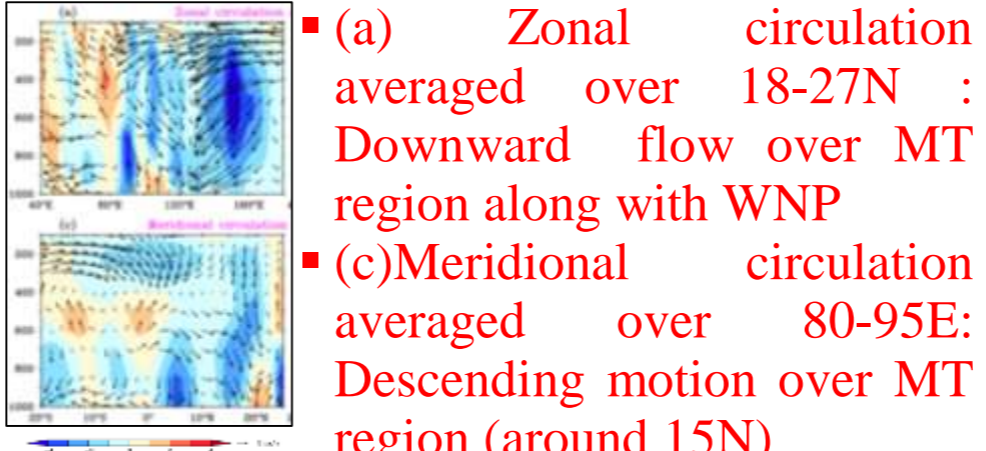
- from Jun to Sept 2020 except in July
- July :strong negative rainfall anom. over monsoon trough (MT) region from Bay of Bengal to northwest of India; mainly because of westward extended anomalous WNP AC/Pacific-Japan (PJ) pattern seen in low level anomalous wind in July
- Inter-basin interaction between PJ and TIO anomalous SST warming called as the Indo-western Pacific ocean capacitor (IPOC) mode (eg. Xie et al 2016, Chowdary et al 2019)
- So, here it is important to investigate the role of PJ mode in July 2020.



PJ index that induces less rainfall over MT region like July 2020



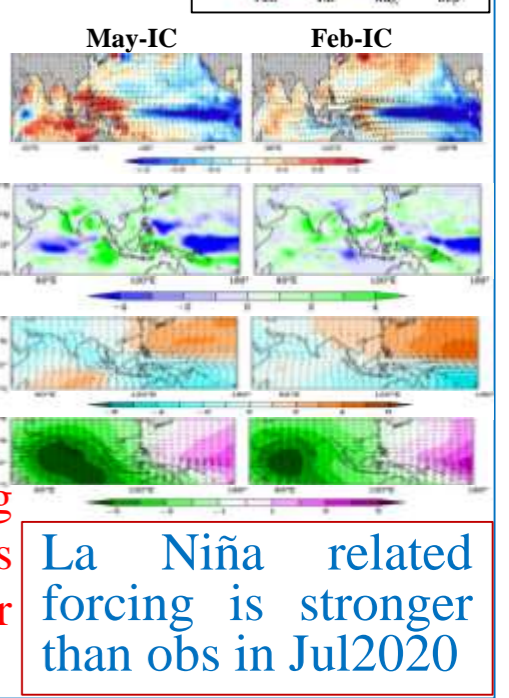
Strong PJ with westward stretch with positive SLP/850 SF over MT area



- (a) Zonal circulation averaged over 18-27N : Downward flow over MT region along with WNP
- (c) Meridional circulation averaged over 80-95E: Descending motion over MT region (around 15N)
- Usually subtropical jet stream (STJ) gradually shifts northward, cross 40N by mid-July & locks the Meiyu-Baiu Rain front in a narrow meridional band.
- July: Jet position more southward that weakens the Tibetan high. This may have impact on tropical easterly jet and further influence monsoon

CFSv2 model Prediction: Jul 2020

- Unlike obs, ISMR index in models show high (low) rainfall in July (Jun) 2020
- Overestimated positive (negative) precip. anom. over India in July (June)
- Anomalous low-level WNP AC missing in both hindcasts in July 2020
- 200hPa div strong over India unlike obs in May-IC and over Arabian sea in Feb-IC



Summary/Conclusion

- Unusual rainfall anom. seen in obs in July 2020 with southwest-northeast dipole pattern showing positive anom. over southern and southwestern India and negative anom. Over MT region
- Less than normal rainfall over MT in obs in July 2020 mainly due to:
 - 1) Anomalous westward extension of WNP AC associated to strong PJ mode
 - 2) Southward displacement of STJ
 - 3) Less number of low pressure systems developed in July in Indian ocean
- CFSv2 model show low skill in reproducing month-to-month rainfall variation in summer
- July precip. pattern over India is not well simulated by CFSv2 model hindcast products in May-IC as well as Feb-IC. Instead they produced high rainfall in July in contrast the obs.
- Key reasons for anomalously high July rainfall in model:
 - 1) Highly overestimated La Niña in models throughout the summer monsoon season
 - 2) Overestimated La Niña controls the upper-level/low-level divergence/convergence anomaly
 - 3) Absence of anomalous low-level circulation over WNP in July 2020

Acknowledgements & References

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