The Skill Of Subseasonal To Seasonal Forecast Models In Predicting The Eddy Forcing Associated With Extratropical-Tropical Interaction

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Introduction

Numerous studies have pointed out that the mean flow modulation due to eddy forcing is a significant part of the atmospheric general circulation over the extratropics and the tropics. The transient eddy heat and momentum flux transport from the extratropical to the tropical (E2T) region causes a significant variation of weather and climate in the tropical region. The local impacts of 3D transient eddy and its structure can be analyzed using E-vector diagnostic tool (James, 1994; Trenbirth, 1986; Lau Haolopainen, JAS, Hoskins et al. 1983). Furthermore, the direction of E-vector indicates eddy propagation, so the E-vector convergence and divergence region manifests the eddy forcing (Novak et al. 2014) .

$$\boldsymbol{E} = \left(\overline{v'^2 - u'^2},\ \overline{-u'v'},\ \frac{f}{\partial\theta/\partial p}\,\overline{v'\theta'}\ \sim\overline{v'T'}\right) \quad \text{.....1}$$

The diagnostics of the E2T interaction based on eddy transport indices described in Kalshetti et al. 2020 suggest that an E-vector-based approach is useful in diagnosing extratropical-tropical interactions. The present study tests the skill of sub-seasonal to seasonal (S2S) scale operational forecast by isolating days which are under the influence of transient eddies.

Objectives

- Eddy forcing are known to cause explosive development of extratropical extreme events.
- To identify and address the critical factors responsible for E2T interactions in the real-time rainfall forecast and various aspects of monsoon intraseasonal variabilities with the help of dynamical modeling.

Methodology & Study Area

Data and methodology: Wind, Temperature, Geopotential Height observation from ERA5 reanalysis, Rainfall observation from TRMM. Model- ERPAS IC20130610 (T382 & T126 L64, ensemble members -16), IITM, Pune.

Study Area: North India and Monsoon Core Zone (JJAS, 1989-2019).

Methodology: In this study, the indices for monitoring of the eddy momentum (heat) transport (EMF/EHF) and hence eddy forcing over the Indian region has been used (f_H=2-30days, f_L=30-60days, Kalshetti et al. 2020). Positive (negative) values of index suggest poleward (equatorward) transport of transient fluxes. The forecast skill tested for presence and absence of the extratropical transient influence on ISM. Next, we have used the local E-vector formalism (Hoskins et al. 1983) to study the three-dimensional structure of transient eddies. The E-vector indicates the direction of eddy propagation and thus can be used to compute the eddy forcing.

Result & Discussion

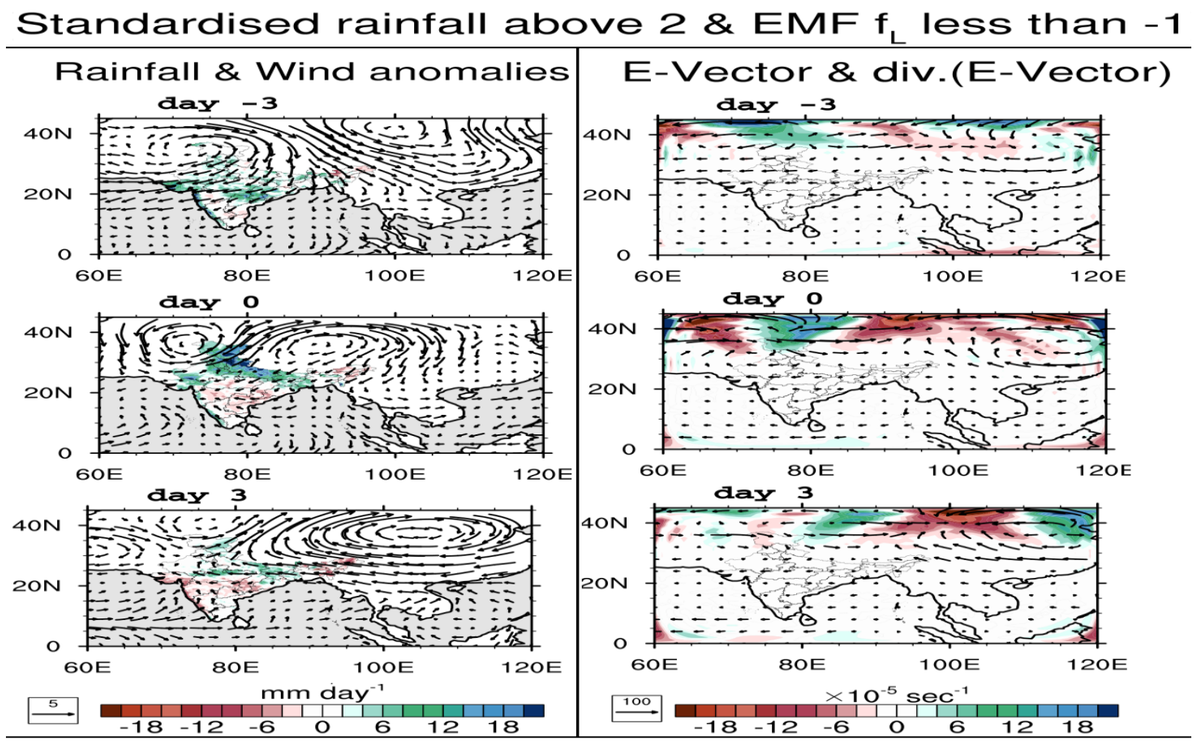
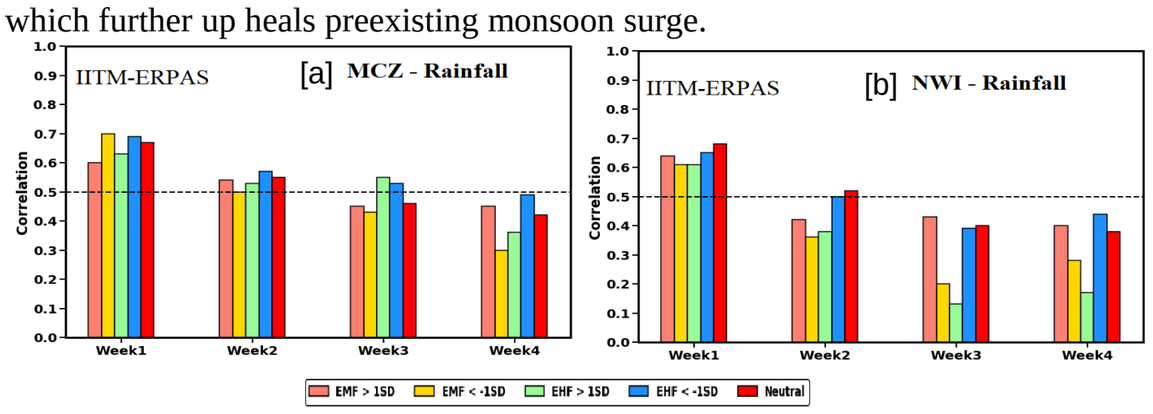


Fig3. Left panel shows lag rainfall-wind (200hPa) and right panel shows E-vector-Div.E-vector (200hPa) composites (24 cases) for the condition when North Indian standardized rainfall anomalies grater than +2σ and EMF F_L < -1σ during JJAS. Earlier we have seen E2T influence on ISM-ISO, in present; eastward migrating forcing pattern (right) induces southward strong upper level anticyclonic pattern which further up heals preexisting monsoon surge.



No. IC 233 225 171 176 1164 (Total cases 2074)

Fig4. In the E2T scenario, IITM-ERPAS forecast skill for rainfall tested under the 5 critical condition of transient eddies. Left panel shows skill over Monsoon Core Zone (MCZ) and right panel shows skill over North-west India (NWI, 25-38N/65-100E). The bottom numbers states the number of ICs are involved for skill testing. Over MCZ, rainfall skill is for all conditions are better predictable up to 3rd week and for EHF<-1σ (equatorward transport) predictable up to 4th week. The NWI is region often witness WD type influence through out the year. Only skill under the influence of EHF<-1σ and neutral condition has predictability limit up to 2nd week.

Result & Discussion

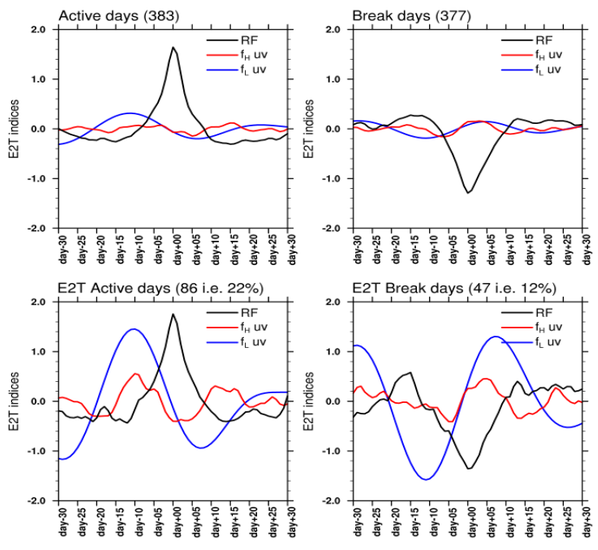


Fig.1 First row shows standardized rainfall anomalies over Monsoon Core Zone during JJAS, 1989-2019 for Active (left column) and Break spells (right column). Along with standardized rainfall indices; the EMF transport index time series on same events are shown (f_H=2-30days and f_L=30-60 days). In second panel; the all index cases for wherever EMF f_L indices >+1σ for active and <-1σ for break days leading by 13 days are shown.

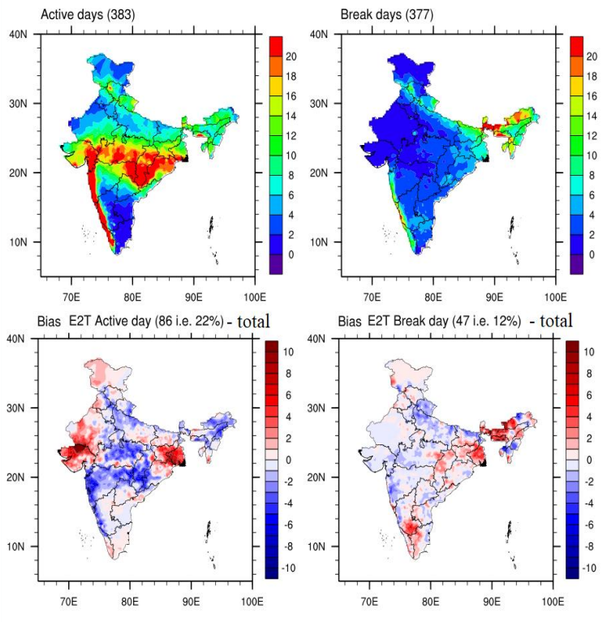


Fig.2 First row shows rainfall composites during Active & Break spells of ISM (1989-2019). Second panel for biases; total rainfall from Active and Break days are subtracted from all response of 13 day leading EMF f_L >+1σ and EMF f_L <-1σ days for Active and Break days respectively. EMF f_L >+1σ composites suggests intense Active spell spatial orientation over North-West Indian region (Gujarat, Rajasthan) and over West Bengal. Deficient over Western Ghats and Central India. Break spell shows positive anomalies over the NE India.

Conclusion

- An Eddy forcing based mechanism is proposed to quantify the forecast of extreme rainfall events associated with tropical-extratropical interaction.
- For the first time E-vector diagnostics is used for the purpose of defining the E2T monsoonal interaction. Also, active and break spell rainfall patterns associated with extratropical forcing are presented for the first time.
- Observation depicts EMF index could act as 13 days lead precursor for tropical phenomenon such as onset of Active/Break spells.
- Extratropical originated transient can influence anomalous extreme rainfall.
- A rare 2σ North Indian rainfall composite suggest upper tropospheric eastward migrating forcing pattern (right) induces southward strong upper level anticyclonic pattern which further up heals preexisting monsoon surge.
- The skill of subseasonal forecast over MCZ is not always robust when there are no extratropical transient eddies. The present analysis suggests that S2S skills would improve if extratropical transient eddies are better simulated.

Acknowledgements & References

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References Kalshetti, M., R. Chattopadhyay, R. Phani, S. Joseph, and A. K. Sahai, 2020: Climatological patterns of subseasonal eddy flux transfer based on the <scp>co-spectral</scp> analysis over the Indian region and the derivation of an index of eddy transfer for operational tracking. Int. J. Climatol., joc.6821, https://doi.org/10.1002/joc.6821.

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