Changes in Asian Jet meridional displacement and its influence on Indian summer monsoon rainfall in observations and CFSv2 hindcast

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Introduction

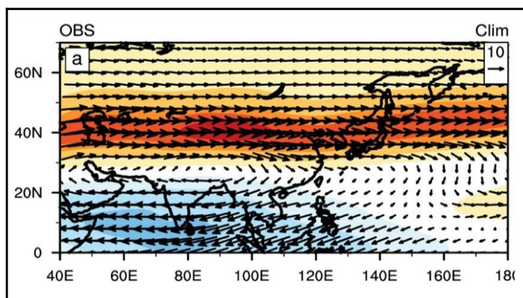


Figure shows the JJAS Climatology of zonal wind at 200hpa from period 1985:2019 using ERA5 data.

The upper-level Subtropical westerly Jet also known as Asian Jet is a planetary-scale atmospheric circulation system in the upper troposphere over Eurasian continent throughout the year at around climatological axis of 40N (as shown in fig). Studies have analyzed the meridional displacement of Asian jet (MDAJ) and its influence on East Asian rainfall (e.g., Yan et al. 2019; Wang et al. 2018); however, the relation with Indian summer monsoon rainfall (ISMR) is not fully explored, limiting the prediction skill of ISMR. The southward intrusion of midlatitude westerly trough to Indian Summer Monsoon (ISM) region triggers monsoon breaks by weakening the Tibetan High (e.g., Ramaswamy, 1962). In this study the impact of MDAJ on the ISMR in observations and Climate Forecast System version 2 hindcast is examined, for the period of 1985 to 2019 boreal summer (JJAS).

Objective

To study the impact of meridional displacement of the Asian jet on the Indian summer monsoon (ISM) rainfall in observations and Climate Forecast System version 2 (CFSv2) hindcast.

Datasets used & Methodology

- Monthly mean sea level pressure (SLP), winds at different levels, temperature, humidity, data are obtained from the ECMWF, ERA5 and ERSSTv5 SST data, GPCPv2.3 rainfall data is used for analysis.
- The CFSv2 retrospective forecast (hindcast) is prepared for 9-months and covers a period of 35 years from 1985 to 2019 at Indian Institute of Tropical Meteorology (IITM).
- Retrospective forecasts start from a specific month May, with 10 atmospheric initial conditions to generate 10 ensemble members.
- Utilized the ensemble mean forecasts obtained by averaging the 10 ensemble members
- The Empirical orthogonal function (EOF) analysis is performed on the JJAS 200 hPa zonal wind over the region 20°–60° N, 40°–160° for the period 1985 to 2019 as the meridional displacement is the leading mode of variability of the Asian jet.
- Correlation and regression analyses are also used. The Student's t test is applied to test for statistical significance in the analysed results.

Results

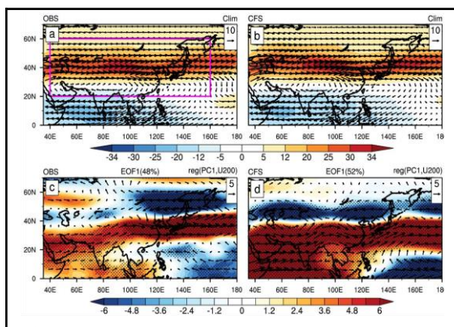
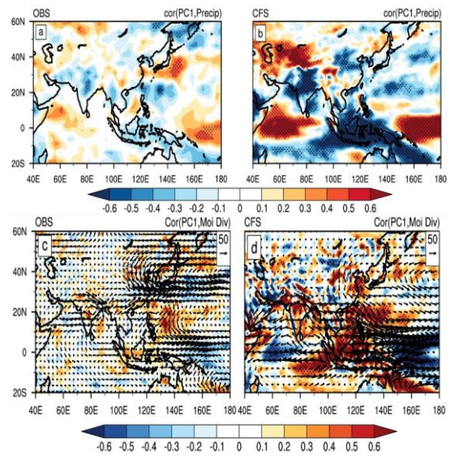


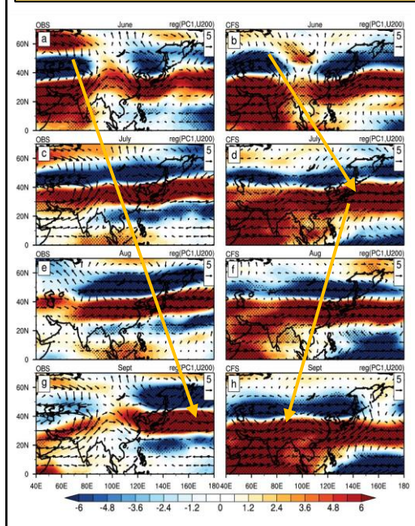
Fig shows a) climatology of JJAS 200 hPa zonal wind (shaded; m/s) and winds (vectors; m/s) from the observations, and b) same as a but for CFSv2 model. C) Regression of JJAS 200 hPa zonal wind anomaly (shaded: m/s) and total winds (vectors: m/s) onto the PC1 in observations, and d same as in c but for the CFSv2 model.

- Strong Asian Jet centered on 40°N is apparent in both the observations and model.
- The southward displacement of the Asian jet (SWDAJ) is strong over the east Asian region compared to west Asian region in the observation but the southward migration of jet is strong from west Asian to east Asian region in the model.
- Anomalous cyclonic circulation at 200 hPa over the East Asian jet region is stronger than in the west Asia region in observations.
- In case of the model, the upper level cyclonic circulation is evident both in central/west Asian and east Asian regions owing to SWDAJ.

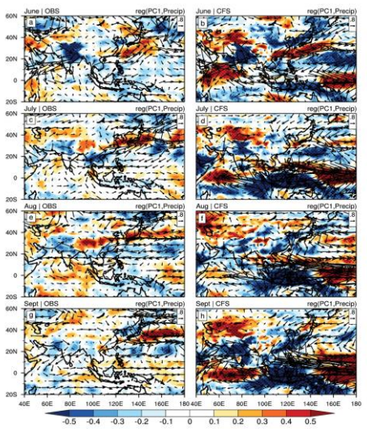


- An equatorward displacement in the Asian jet causes rainfall to decrease over the Indian subcontinent, in particular over the north central India, which is also apparent in model but with overestimation in strength.
- Associated with SWDAJ, weakening of TEJ over the ISM region is evident reducing the divergence centre at 200 hPa level and alters low-level circulation, moisture convergence decreasing the ISMR as seen in the observations and model.

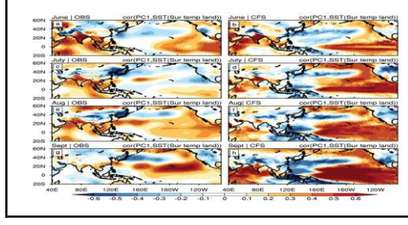
Month to month Asian jet variability



- Maximum strength of meridional displacement of jet is shifted from West Asian region to East Asian region from June to September in the observations but such variability is missed in the model especially in the second half of the season.
- Thus, in the model, misrepresentation of meridional displacement of jet strength and location on the seasonal mean is mainly contributed by jet variability in August and September.



- Observations show that the influence of SWDAJ on ISM rainfall is stronger in June compared to other months which is similar in model.
- In July and August, anomalous northwesterlies over north India are associated with negative rainfall in the model.
- Misrepresentation of rainfall pattern associated with SWDAJ on seasonal time scale is contributed by variations in September rainfall pattern.



- equatorial Pacific SST warming in the model would influence the SWDAJ interaction with monsoon rainfall unlike in the observations as in seasonal mean

Conclusions

- The meridional displacement of jet on the seasonal mean is stronger over the East Asian region in observations, which is not well represented in the model.
- In response to SWDAJ, weak TEJ alters the low level ISM circulation and causes reduced rainfall over Indian subcontinent.
- Anomalous low-level anticyclone corroborated by moisture divergence highly provokes negative rainfall in most of north India.
- High tropospheric temperature over the Indian Ocean region as compared to South Asian region favors reduction in rainfall over India in both the observations and model.
- An anomalous upper level cyclonic circulation over the central/western Asia in the model has vigorous influence on the ISM rainfall unlike in the observations.
- Over the East Asian region, strong westerlies, moisture convergence, and positive rainfall in the Meiyu-Baiu rain band are completely missed in the model.
- Month to month variations of SWDAJ are well captured by the model in June and July, but failed to capture in other months.
- It is noted that the seasonal mean changes in the Asian jet position can be modulated by monthly variations in observations but these month to month changes SWDAJ position is not well represented in model.
- Most importantly, the meridional displacement of Asian jet is strongly influenced by ENSO in the model particularly in the late monsoon months.
- This limits the skill of the model in simulating/predicting the correct link between the Asian jet variability and ISM rainfall variations.

Acknowledgement & and references

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