Explaining the Different Manifestations of Active and Break Spells in Flood and Drought Years

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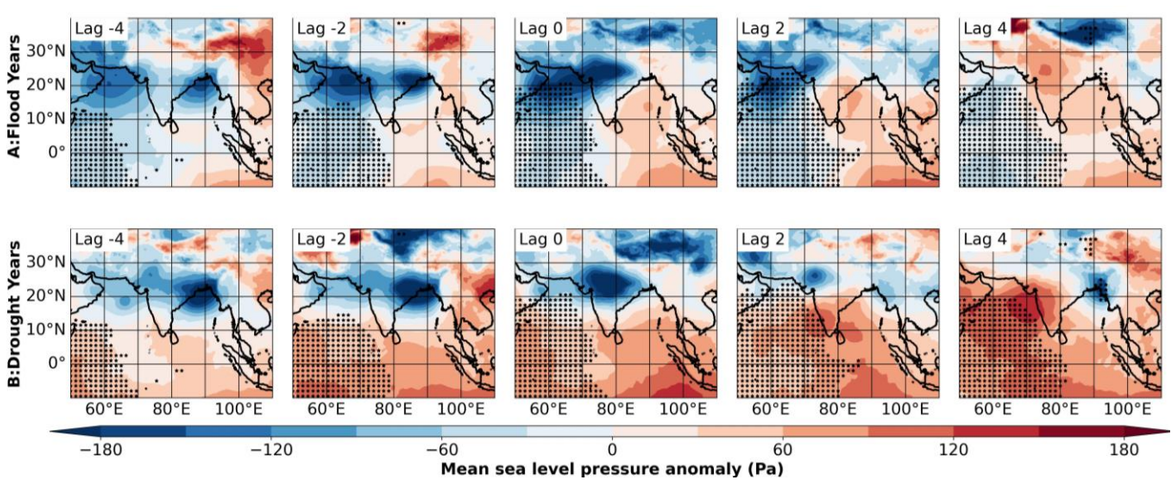
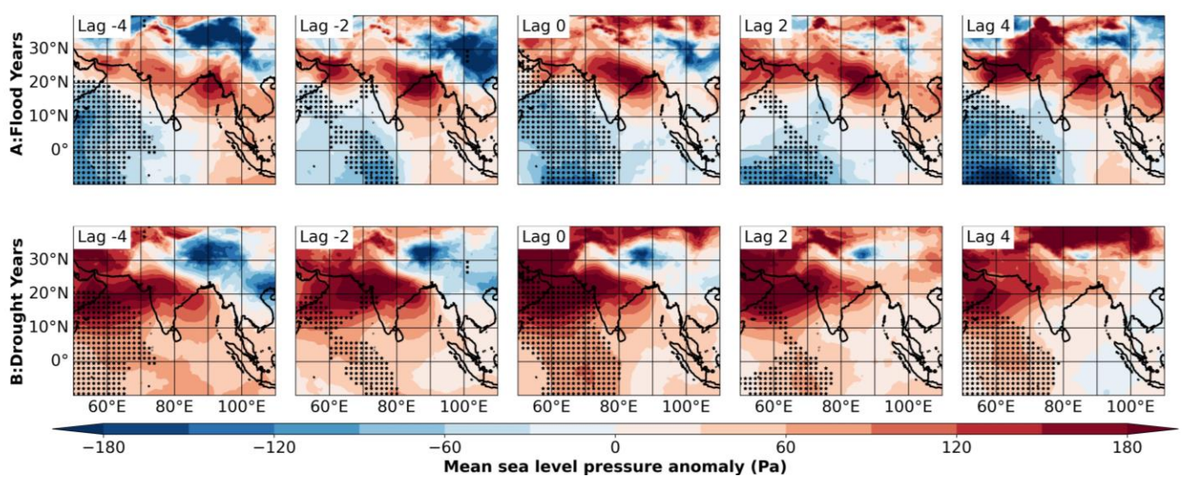
Background and Objective

1. The intra-seasonal variation of the Indian summer monsoon is marked by alternating "active" periods of high rainfall and "break" periods of deficient or no rainfall.
2. While previous studies have extensively documented the characteristics of active and break spells, there is limited understanding of how these spells manifest differently across flood and drought years.
3. We show that active spells on average occur more frequently in flood years (4.6 per year) than in drought years (2.3 per year), although their typical durations remain similar. Break spells are more frequent (3.9 per year) and longer during drought years compared to flood years (1.2 per year).
4. This study examines the significant differences in the frequency and duration as well as propagation associated with active and break monsoon spells between flood and drought years.

Mean sea level pressure (MSLP)



Active Spell: The significant difference is that flood years have negative MSLP anomaly over the Western Indian Ocean and Arabian Sea, compared to positive anomaly for drought years.

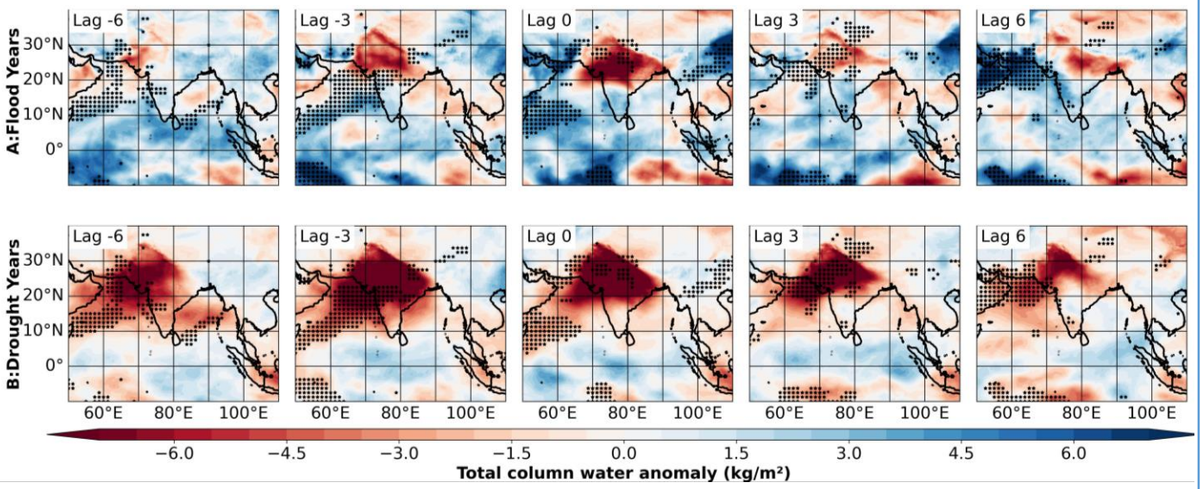


Break Spell: The westward movement of positive MSLP anomalies during flood years shortens break spells, while their slower northward propagation in drought years prolongs them.

Intraseasonal oscillation modes (ISO)

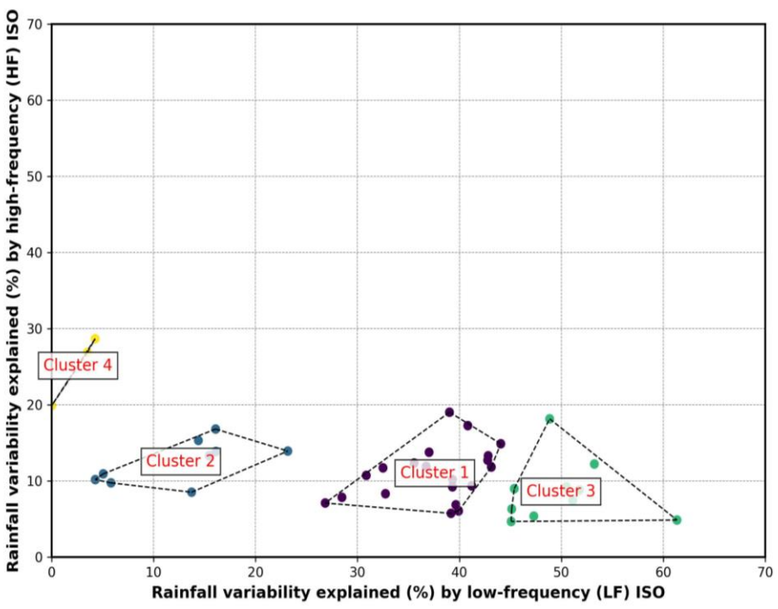
- **Low Frequency (LF) ISO Dominance in Drought Years**: LF-ISO (20–60 days) explains **36.1% of rainfall variance** in drought years, compared to **16.7% in flood years**, indicating stronger poleward propagation in drought years.
- **High Frequency (HF) ISO Dominance in Flood Years**: HF-ISO (10–20 days) contributes **16.7% of rainfall variance** in flood years, compared to **8.3% in drought years**, highlighting stronger westward propagation from the Bay of Bengal in flood years.
- **Over 90% of active days** align with the positive phase of HF-ISO, while **85–90% of break days** coincide with its negative phase in flood years.
- In drought years, **active days** align with the positive phase of LF-ISO, while **break days** occur during its negative phase.

Total column water (TCW)



Break Spell: The negative anomaly is more intense and extensive during drought years, pointing to potential midlatitude dry air intrusions during drought.

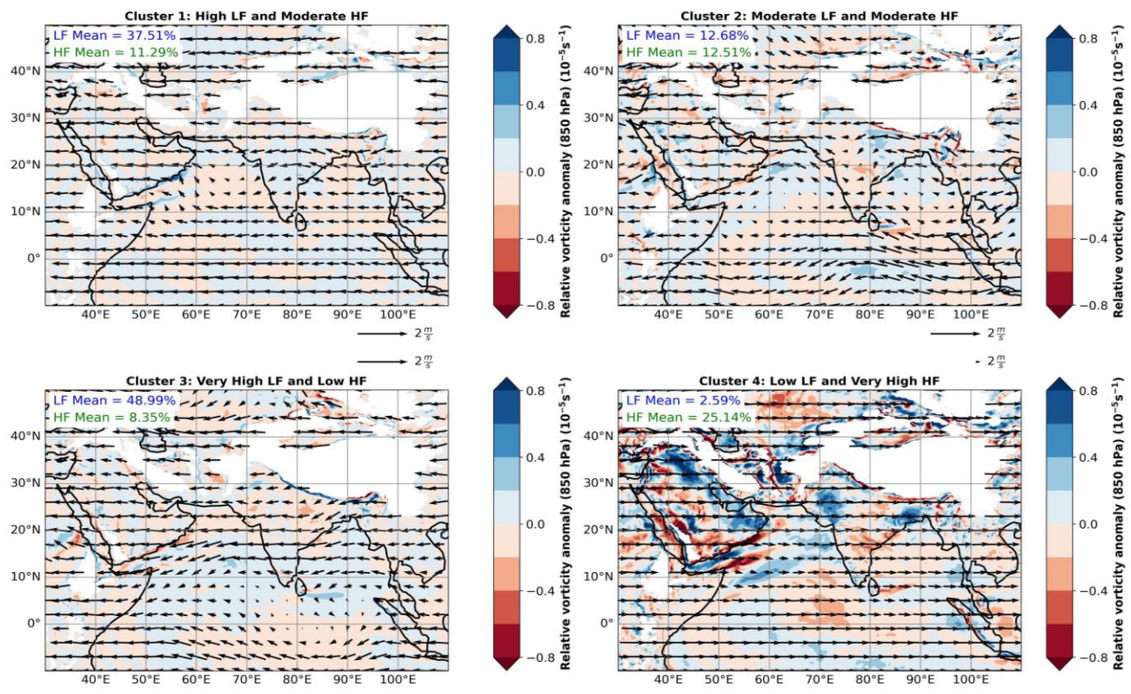
Cluster based on LF and HF ISO intensity



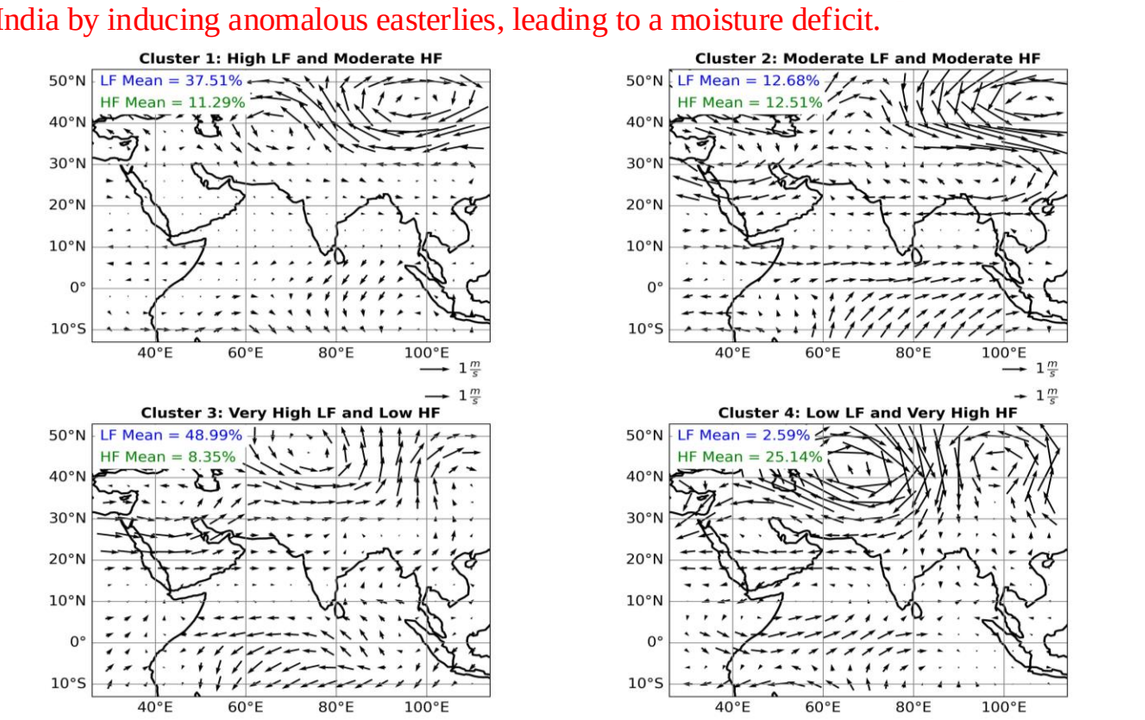
Cluster	Description	LF Variability (%)	HF Variability (%)	Rainfall over CI (% of Mean)
1	High LF and Moderate HF	37.51	11.29	100.1
2	Moderate LF and Moderate HF	12.68	12.51	104.2
3	Very High LF and Low HF	48.99	8.35	92.0
4	Low LF and Very High HF	2.59	25.14	112.1

- The cluster with the strongest LF-ISO and weakest HF-ISO records the lowest rainfall (92% of the long-term mean), while the opposite cluster experiences the highest rainfall (112% of the long-term mean).
- These findings align with observed HF and LF ISO intensities during flood and drought years.
- Strong HF-ISO activity is associated with enhanced formation and north-westward propagation of low-pressure systems from the Bay of Bengal to Central India, contributing to above-normal rainfall.

Seasonally averaged composites of Wind at 850 hPa and 200 hPa



Wind at 850 hPa : Stronger LF-ISO intensity weakens moisture transport to Central India by inducing anomalous easterlies, leading to a moisture deficit.



Wind at 200 hPa : A robust Tibetan High north of CI for Cluster 4 and a strong upper-tropospheric low for Cluster 3.

Conclusion

- We found a notable difference in the frequency and duration of active and break spells between flood and drought years.
- MSLP composites show a transitional difference from negative to positive anomalies between flood and drought years.
- A decreasing relationship exists between seasonal rainfall and LF-ISO strength, while an increasing relationship is observed with HF-ISO strength.
- Seasonally averaged wind shows strong vertical shear during strong HF-ISO years, whereas in strong LF-ISO years, weaker shear leads to dry air intrusion from the mid-latitudes.

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