Dynamic Features of 2023 Himachal Pradesh Floods: Multiscale Insights

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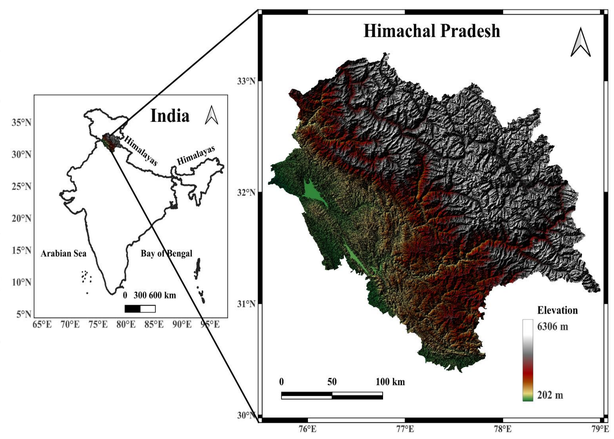
Background

- Himachal Pradesh saw 436% excess rains (734.4 mm) from 7-11 July 2023.
- Unprecedented rainfall resulted in flash floods and landslides that eventually led to widespread destruction.
- The estimated cost of the damage is reportedly over $1.27 million USD.
- Understanding atmospheric dynamics that contribute to such catastrophic events necessitates an examination of both local and large-scale meterological features.
- Such integrated approach, improves our ability to understand and forecast extreme events in changing climate.

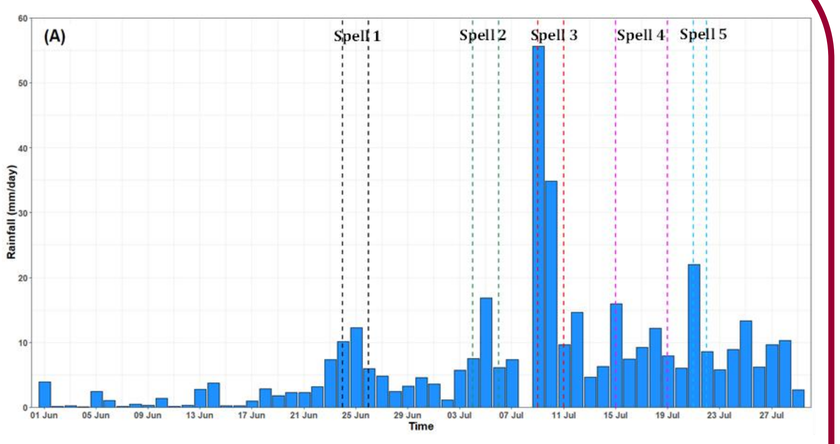
Methodology

- Analyzed Local scale meteorological features in the HP region (30^{0}N - 33.5^{0}N and 75.5^{0}E - 79^{0}E)
- Analyzed Large scale meteorological features over the extensive geographic region (0.0°N - 8.0°N and 100.0°E - 150.0°E)



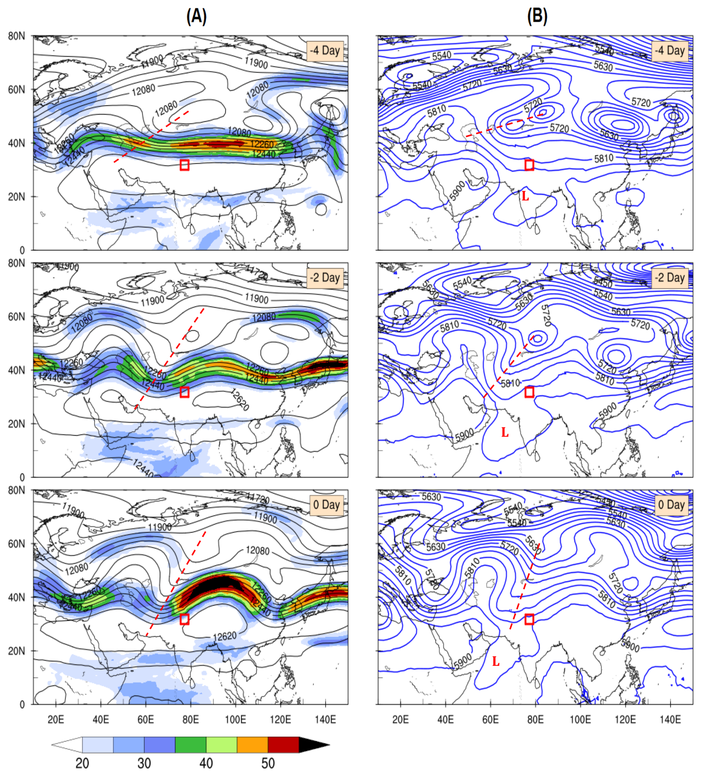
Results

Climatology of Precipitation

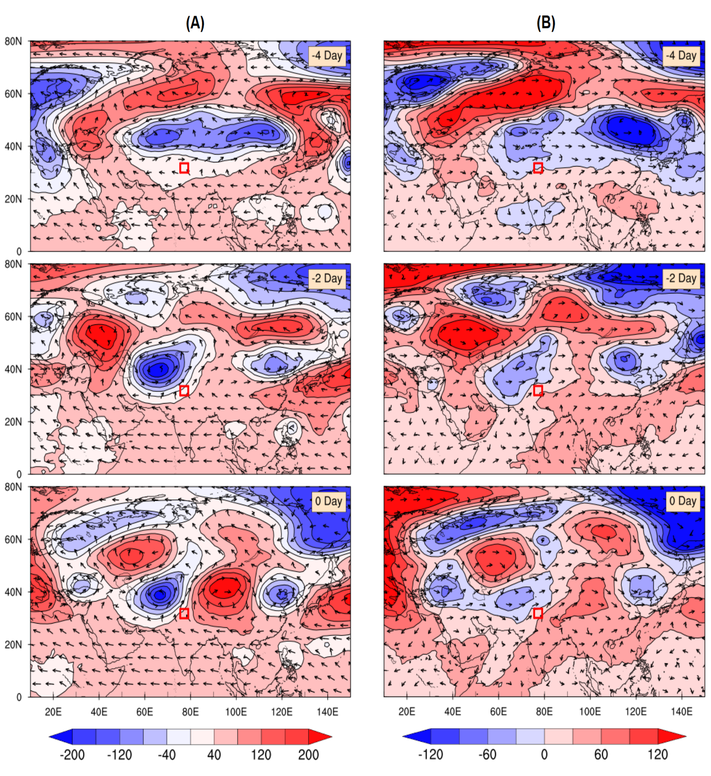


Dynamic features at large scale

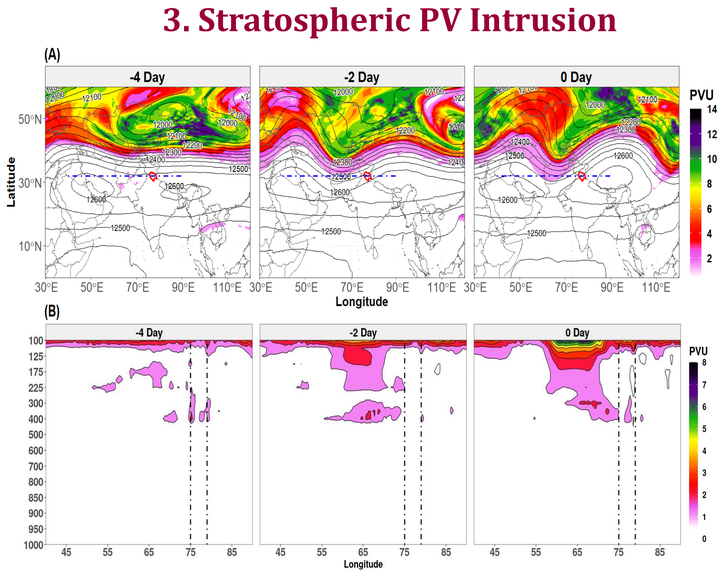
1. Monsoon-Extratropical Interaction



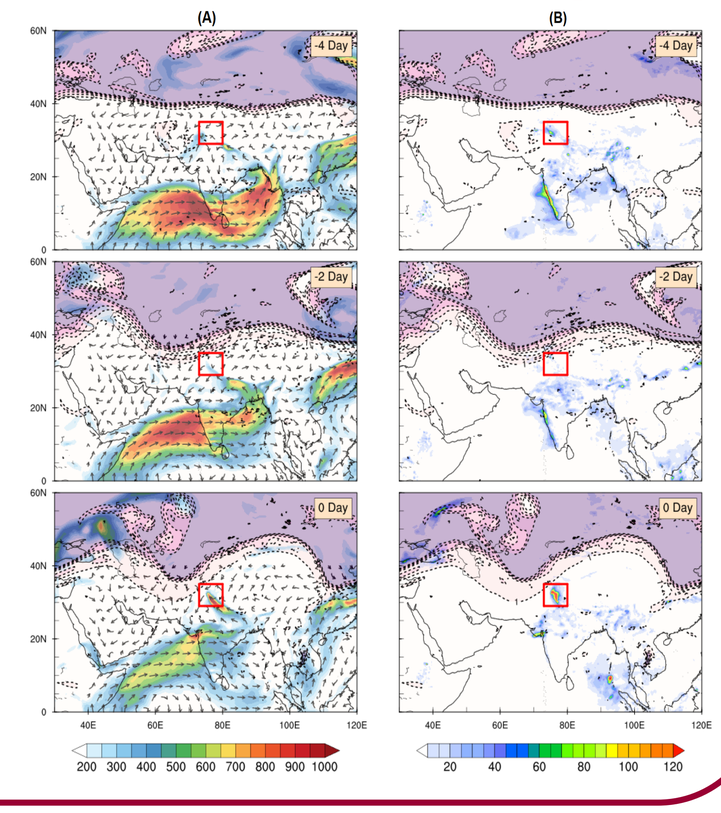
2. Rossby Wave Train & Blocking High



3. Stratospheric PV Intrusion

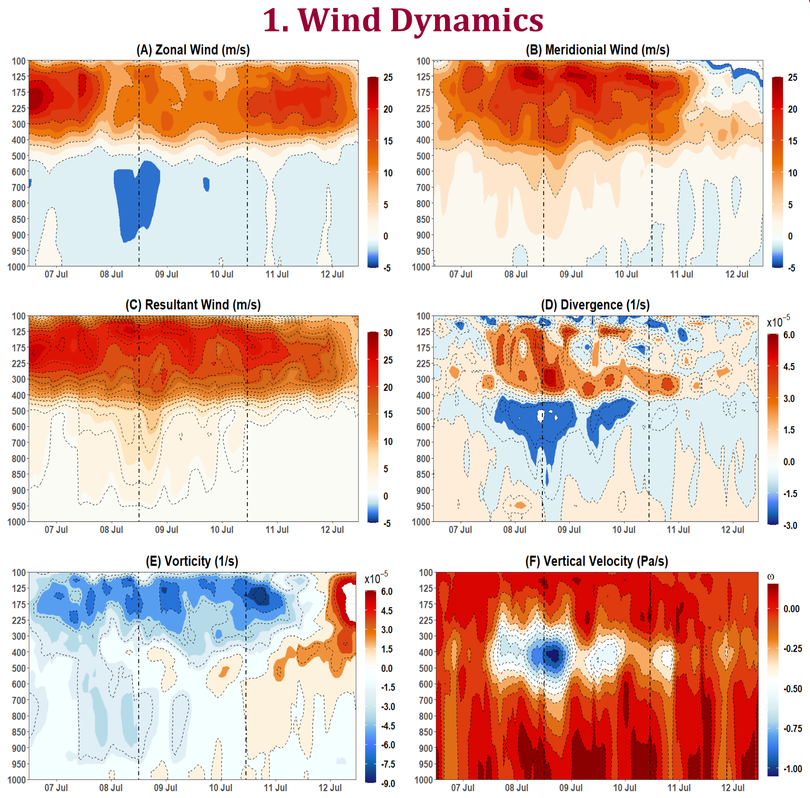


4. Enhanced Moisture Transport

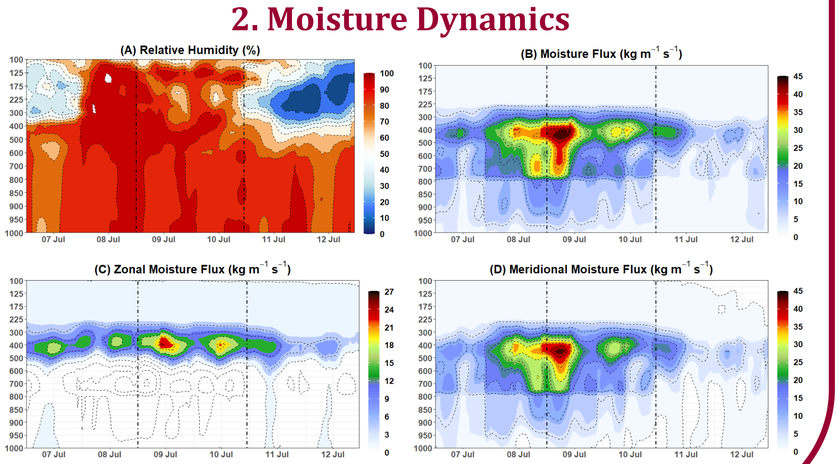


Dynamic features at local scale

1. Wind Dynamics



2. Moisture Dynamics



Conclusions

- Prior to flood, moderate rain spells saturated mountainsides, increasing landslide and flash flood risks.
- Local wind dynamics suggest strong low-level convergence and upper-level divergence, signaling a rapid and intense spell.
- Anomalous moisture transport is a key feature in the occurrence of extreme precipitation over the region.
- Large-scale circulation patterns revealed transient merging of monsoon lows and midlatitude westerly troughs prior to extreme precipitation producing floods.
- The merging is driven by a combination of Rossby wave train patterns and blocking highs in the mid to upper troposphere, observed two days before the flood event.
- Rossby wave breaking downstream of the blocking high enabled the movement of high PV stratospheric air toward the equatorial region, penetrating the troposphere northwest of the study area.
- Intense moisture transport and extreme precipitation occurred due to intense vertical motion and low-pressure area formation ahead of the PV trough.

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