Department of Meteorology &
National Centre for Atmospheric Science

University of Reading

The role of midlatitude dry air during the withdrawal of the Indian summer monsoon

Madeleine Nicolas (distributed via imaggeo.egu.eu)

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IWM-8, 17th March 2025

@akshaydeoras

The onset progression and withdrawal of the monsoon

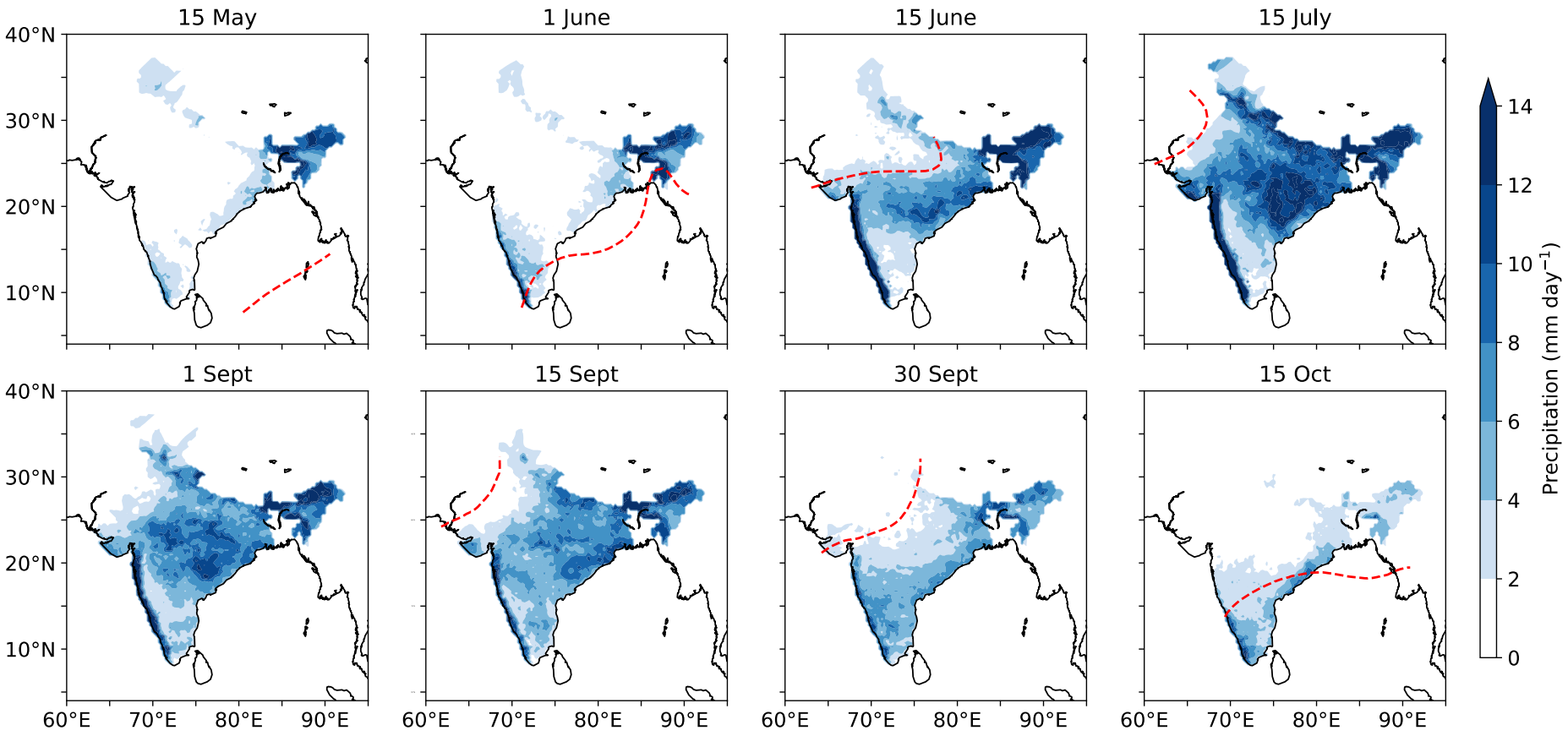
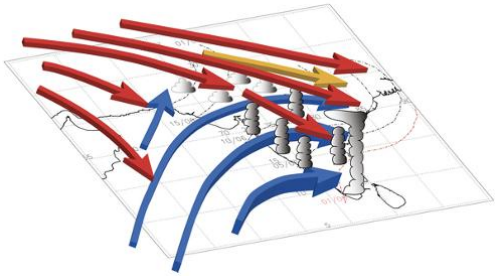


Figure: Pentad centred precipitation and climatological onset (top) and withdrawal (bottom) isochrones (dashed red) during 1979–2022.

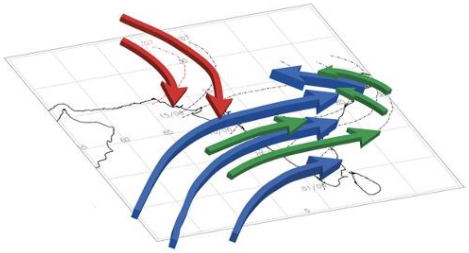
- The monsoon progresses toward the northwest in May–July and withdraws toward the southeast in September–October

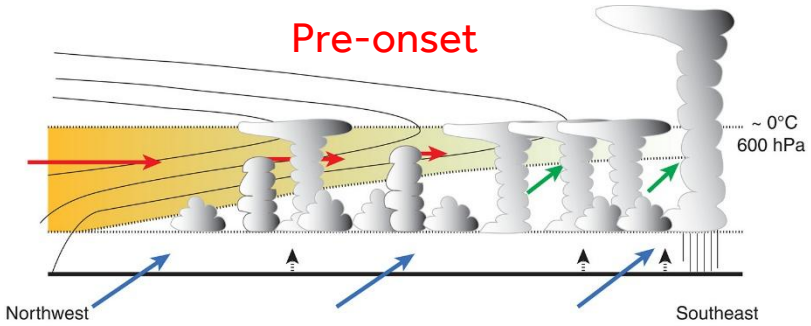
The retreat of mid-level dry air during the monsoon progression

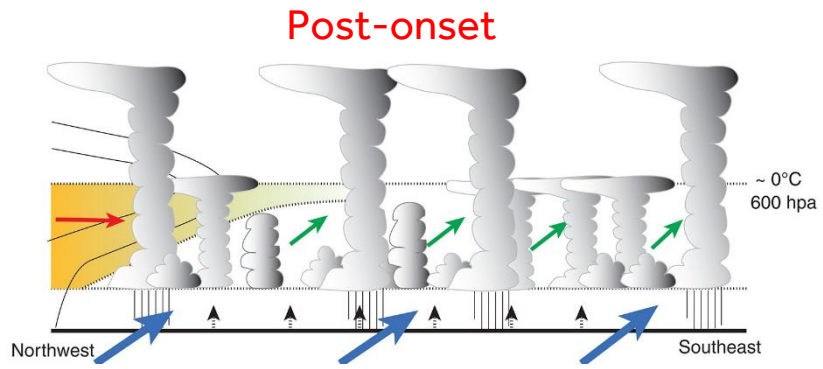
Pre-onset (~1 June)



Post-onset (~15 July)



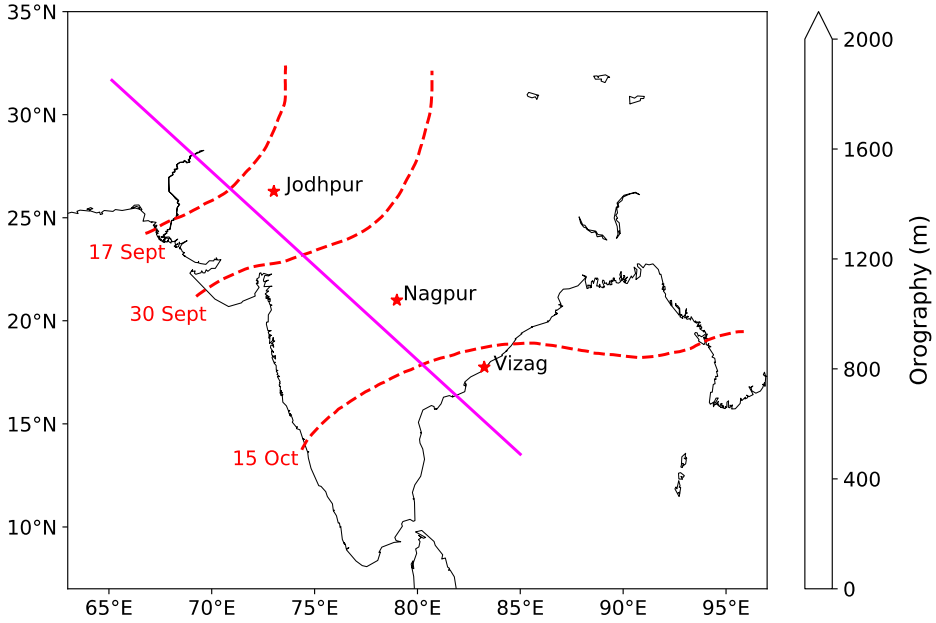




- A wedge of mid-level dry air emanating from the midlatitudes is present over India prior to the monsoon onset
- Parker et al. (2016) showed that most favourable environment for deep convection occurs in the southeast first, leading to the monsoon onset around 1 June
- The dry air retreats northwestward due to increased moistening from below (detrainment from shallow cumulus and congestus clouds) and advection of moisture from the Arabian Sea

Source: Parker *et al.* (2016). The interaction of moist convection and mid-level dry air in the advance of the onset of the Indian monsoon. *QJRMS*, doi:10.1002/qj.2815

Questions arising about the monsoon withdrawal



Source: Deoras et al. (2024). The role of midlatitude dry air during the withdrawal of the Indian summer monsoon. *QJRMS* (under review)

- When does the climatological mid-level dry air intrusion re-emerge from the northwest and does it play any role in the monsoon withdrawal?
- Do the tropical and midlatitude airmasses behave in a "reverse-Parker" manner during the monsoon withdrawal?
- We adapt the Parker research framework to uncover the dynamic and thermodynamic processes associated with the progression of the monsoon withdrawal during 1940–2022 (Deoras et al., 2024)

The re-emergence of the climatological mid-level dry air intrusion

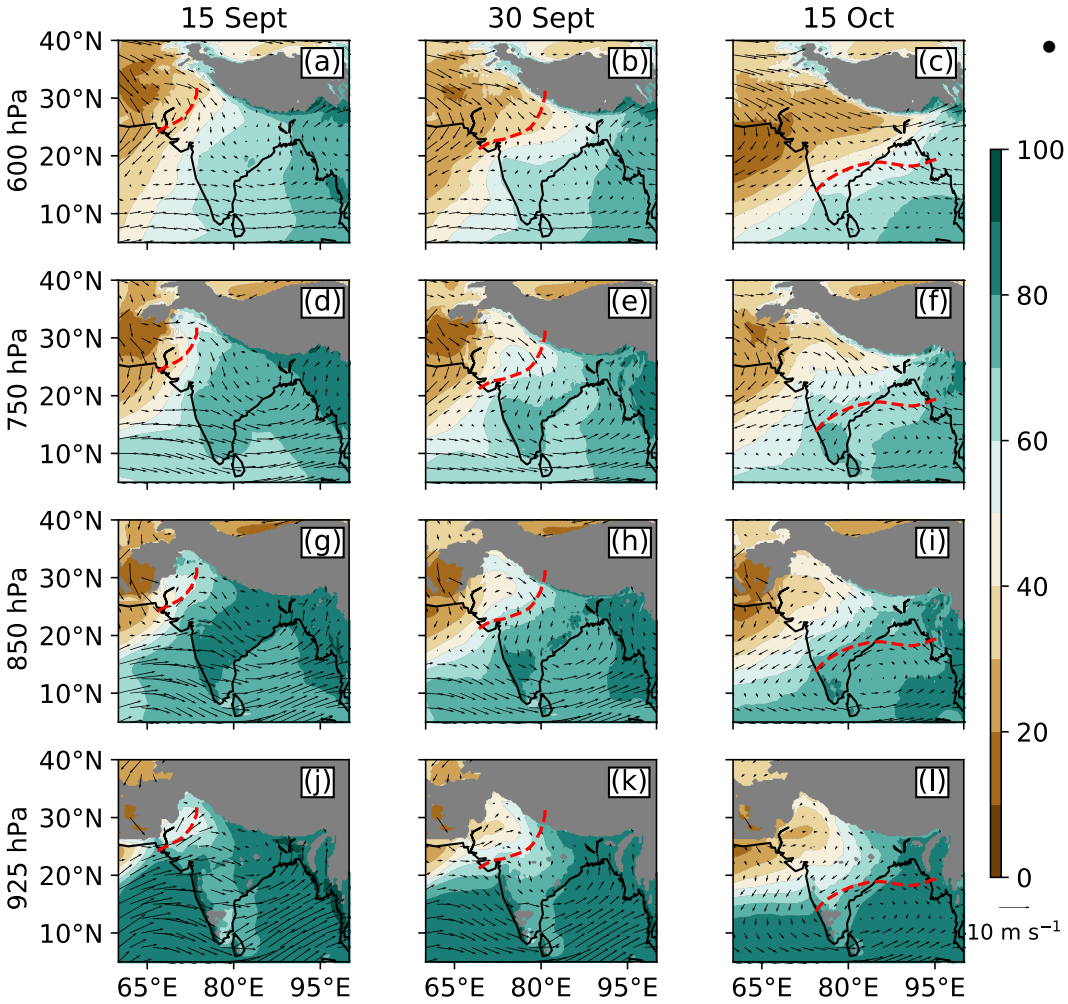


Figure: Pentad mean relative humidity (shading) and winds (vectors) during 1940–2022. Dashed red lines show the climatological withdrawal isochrones.

- The climatological mid-level dry air intrusion from the northwest re-emerges around mid-September, which strengthens and flows toward the southeast in subsequent days

Evolution of the mid and low-level flow during the withdrawal

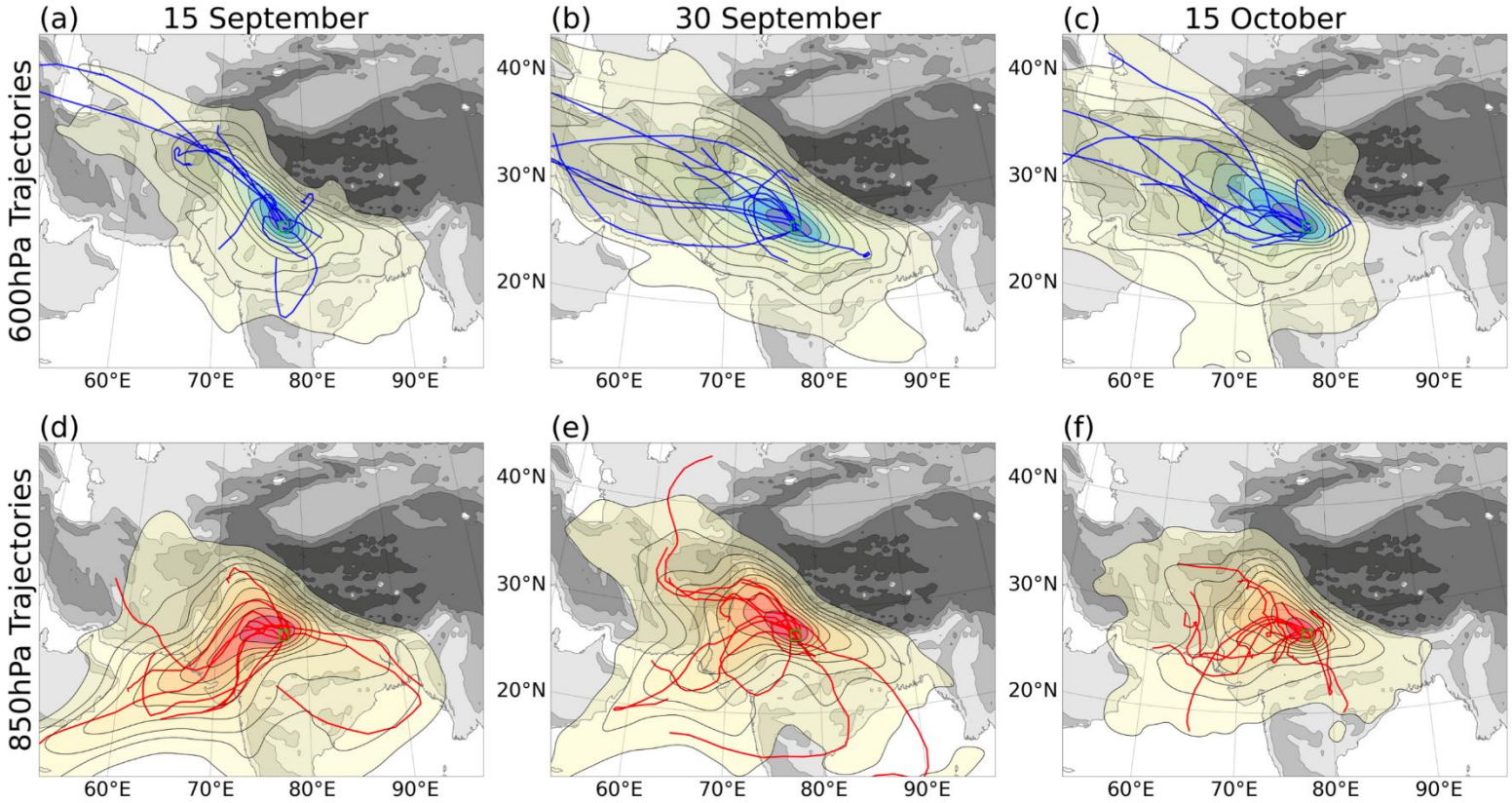


Figure: Six-day back trajectories released on dates shown in the title from the green box. Shading shows the Kernel density estimate of trajectory points (intervals at every 10% of the maximum density).10 individual trajectories are shown in each case.

- Mid and low-level flow becomes predominantly northwesterly by 15 October and is descending in nature

Increased tropospheric stability due to the mid-level dry intrusion

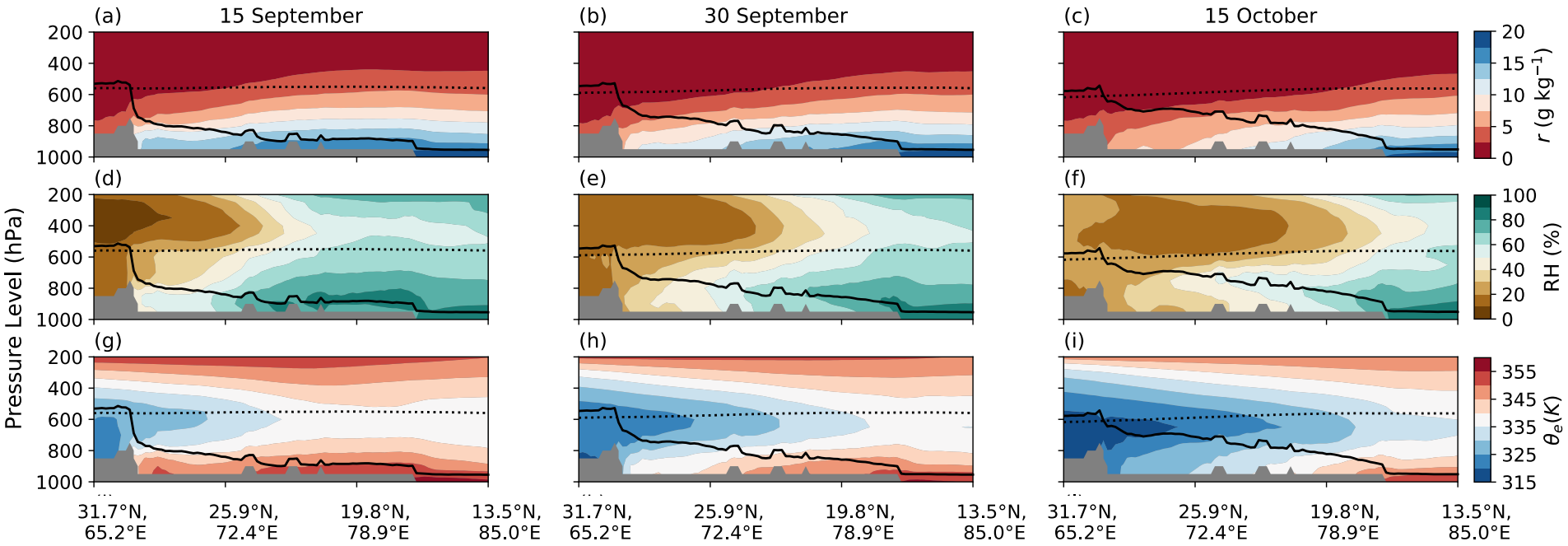
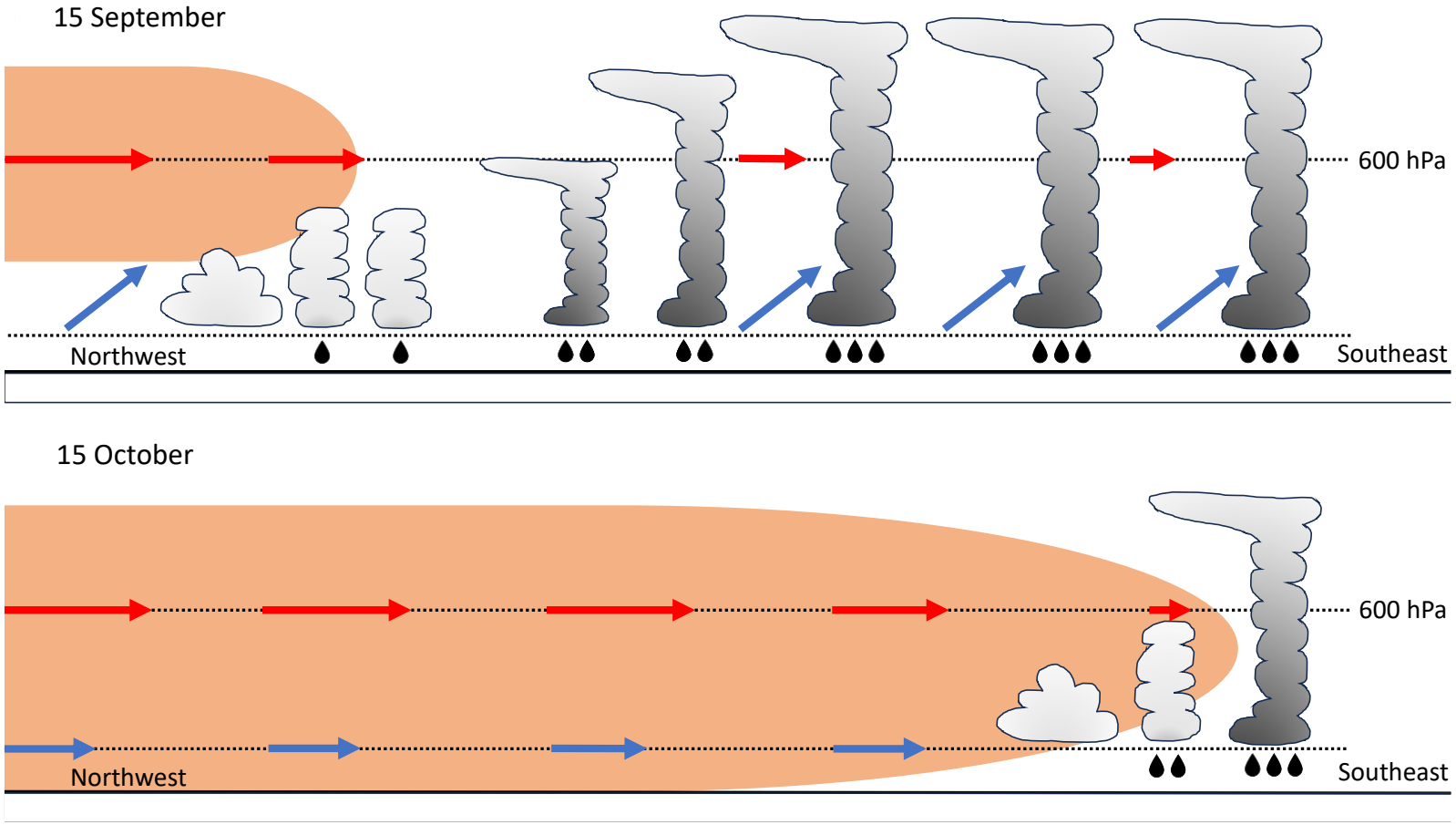


Figure: Vertical cross sections of thermodynamic fields along a northwest to southeast transect. Solid (dotted) black line shows the lifted condensation level (freezing level).

- The expanding and descending mid-level dry intrusion from the northwest increases the tropospheric stability, suppressing deep convection, and ultimately driving the monsoon withdrawal toward the southeast

Summary



- The strengthening of the mid-level dry intrusion from the midlatitudes can explain the withdrawal of the monsoon and its direction, in a reversal of the processes at work during progression of the onset

Quarterly Journal of the Royal Meteorological Society / Volume 150, Issue 765 / p. 5094-5112

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First published: 30 September 2024
https://doi.org/10.1002/qj.4859

Outstanding questions (suggested future work)

- How steady is the monsoon withdrawal process?
- What large-scale conditions control the interannual variability of the withdrawal?
- How well do numerical weather prediction models represent the interaction between the mid-level dry air and moist convection?

POSTER SHOWCASE at IWM-8

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- What's the role of dry intrusions in breaks of the Indian summer monsoon?

  - 4.30 pm, Monday, 17th March 2025

- How does soil moisture impact the inland penetration of Indian monsoon low-pressure systems?

  - 2.3p pm, Wednesday, 19th March 2025

The retreat of deep convection during the monsoon withdrawal

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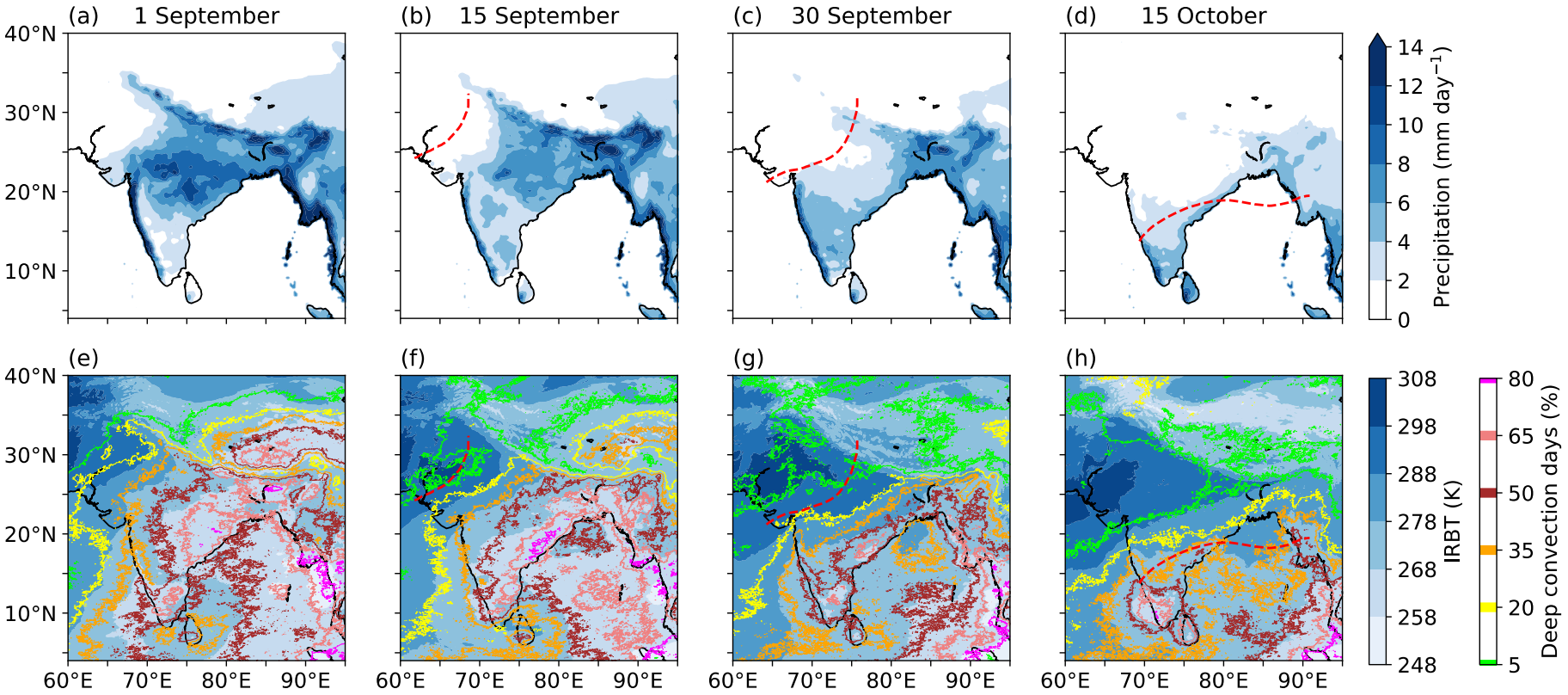
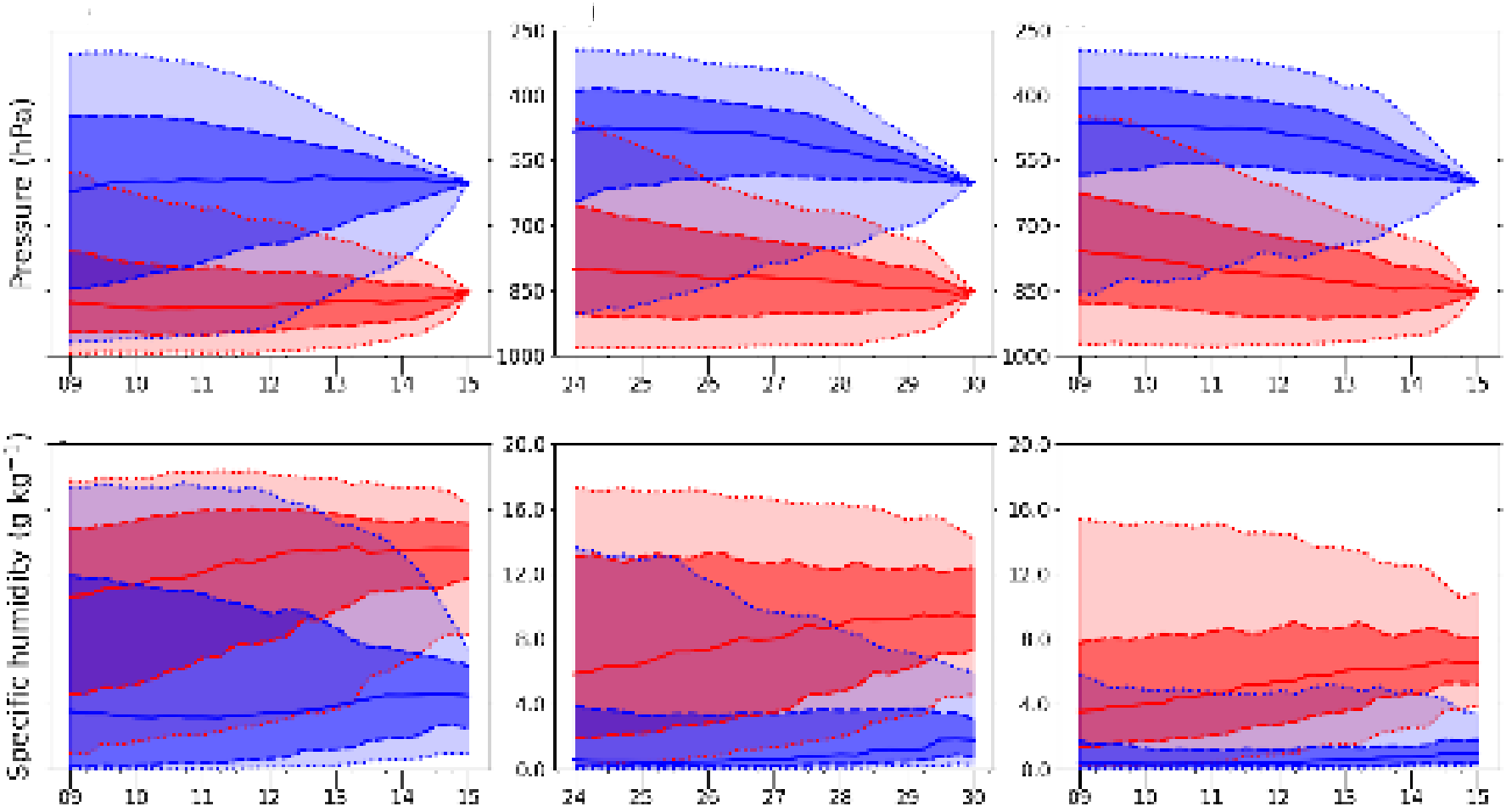


Figure: Pentad mean precipitation (mm day^{-1}) averaged over 1951–2007 (top panel; a–d), and pentad mean infrared brightness temperature (IRBT; K) averaged over 2000–2022 (bottom panel; e–h). Coloured line contours in (e)–(h) show the percentage of days with deep convection (IRBT≤233.15 K) at each grid point in respective pentads during 2000–2022.

Evolution of fields along back trajectories



Time evolution of pressure and specific humidity along trajectories shown in blue for trajectories starting at 600 hPa and in red for those starting at 850 hPa. Solid lines show the median of each field, dashed lines with dark shading between them show the 25th and 75th percentiles, and dotted lines show the 5th and 95th percentile.

Analysis of radiosonde data

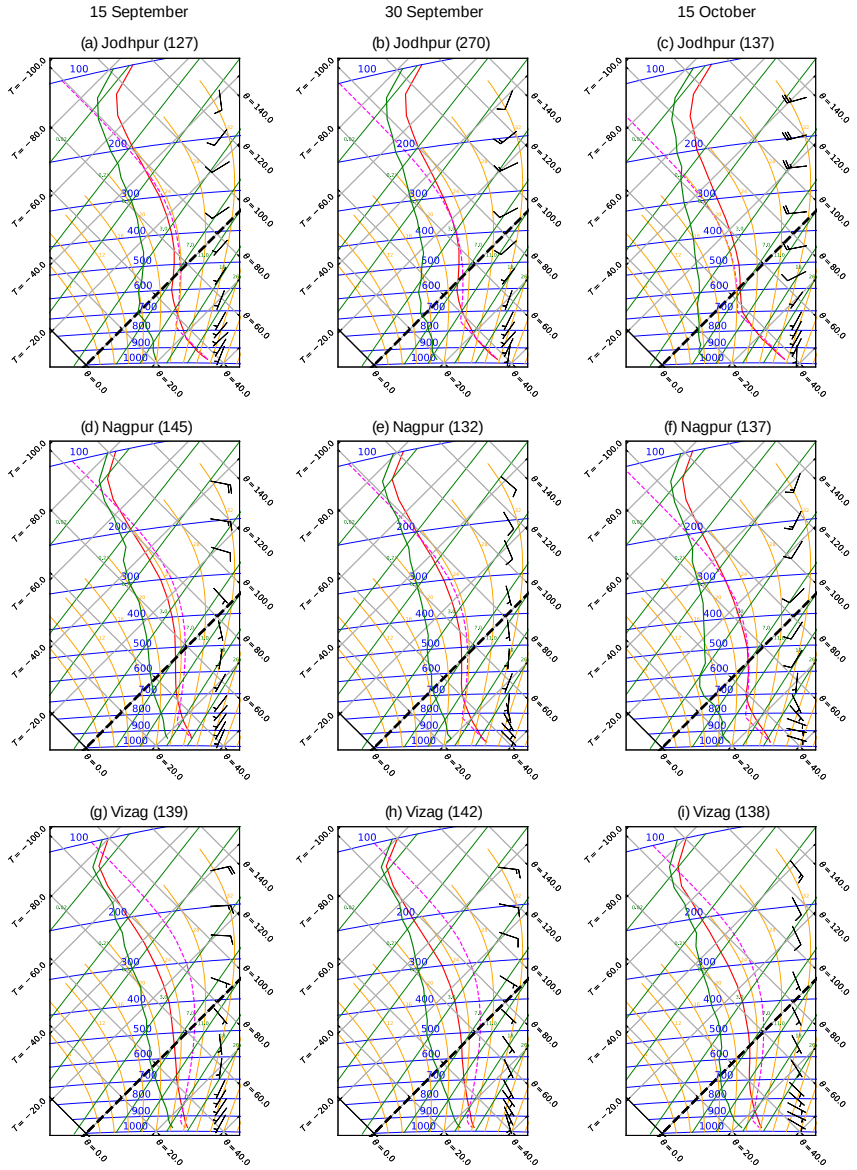


Figure: Tephigrams at Jodphpur, Nagpur and Vizag during 1971-2019.