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The interaction of moist convection and mid-level dry air in the advance of the onset of the Indian monsoon

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A new interpretation of the Indian monsoon onset is presented, to explain the progression of the onset isochrone from the south of India, around 1 June, to the extreme northwest some 6 weeks later. In contrast to other monsoon regions, this progression does not directly follow the moisture flux vectors, and is normal to, or against the direction of the wind, which is generally westerly and northwesterly in the lower troposphere.

Observations show that the northern limit of the monsoon corresponds to a mid-tropospheric transition, from northwesterly dry advection in the pre-onset zone in the north, to deeper moist westerlies in the monsoon zone to the south. In the north, deep convection is suppressed by very dry mid-level air from the desert regions of the north-west; as this air is advected towards the southeast, it is progressively moistened and eroded by shallow convection, so that the inhibition of convection diminishes downwind. The most favourable location for deep convection is at the extreme downwind limit of the dry intrusion in the south and east, and for this reason onset first occurs in the extreme south of India.

Lagrangian timescales for advection of air through the monsoon system are a few days; fast relative to the timescale of overall monsoon onset. Therefore the monsoon exists in a dynamic and thermodynamic balance between low level monsoon fluxes from the west, the dry intrusion from the north-west which suppresses convection, and land-surface feedbacks. The onset corresponds to a shift in this balance. As the monsoon fluxes increase in the pre-onset period, moist convection more effectively humidifies the northwesterly dry intrusion so that deep convection can first emerge in the extreme south. Intensifying monsoon flow and weakening mid-level dry advection shift the convective regime so that the northern limit of the monsoon progresses to the northwest. An increasingly wet land surface, and advanced vegetation, support the maintenance of the monsoon regime, by sustaining the moist convective fluxes. These results demonstrate the importance of shallow and deep convective processes to the continental monsoon onset.