The dynamic and thermodynamic structure of the monsoon over southern India: New observations from the INCOMPASS IOP

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Abstract: Some of the highest summer monsoon rainfall in South Asia falls on the windward slopes of the Western Ghats mountains on India's west coast and offshore over the eastern Arabian Sea. Understanding of the processes determining the spatial distribution and temporal variability of this region remains incomplete. In this paper, new Interaction of Convective Organization and Monsoon Precipitation, Atmosphere, Surface and Sea (INCOMPASS) aircraft and ground-based measurements of the summer monsoon over the Western Ghats and upstream of them are presented and placed within the context of remote sensing observations and reanalysis. The transition from widespread rainfall over the eastern Arabian Sea to rainfall over the Western Ghats is documented in high spatial and temporal resolution. Heavy rainfall offshore during the campaign was associated primarily with mid-tropospheric humidity, secondarily with sea surface temperature, and only weakly with orographic blocking. A mid-tropospheric dry intrusion suppressed deep convection offshore in the latter half of the campaign, allowing the build-up of low-level humidity in the onshore flow and enhancing rainfall over the mountains. Rainfall on the lee side of the Western Ghats occurred during the latter half of the campaign in association with enhanced mesoscale easterly upslope flow. Diurnal cycles in rainfall offshore (maximum in the morning) and on the mountains (maximum in the afternoon) were observed. Considerable zonal and temporal variability was seen in the offshore boundary layer, suggesting the presence of convective downdrafts and cold pools. Persistent drying of the subcloud mixed layer several hundred kilometres off the coast was observed, suggesting strong mixing between the boundary layer and the free troposphere. These observations provide quantitative targets to test models and suggest hypotheses on the physical mechanisms determining the distribution and variability in rainfall in the Western Ghats region.