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# Analyzing energy–water exchange dynamics in the Thar desert

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**Abstract** Regions of strong land–atmosphere coupling will be more susceptible to the hydrological impacts in the intensifying hydrological cycle. In this study, micrometeorological experiments were performed to examine the land–atmosphere coupling strength over a heat low region (Thar desert, NW India), known to influence the Indian summer monsoon (ISM). Within the vortex of Thar desert heat low, energy–water exchange and coupling behavior were studied for 4 consecutive years (2011–2014) based on sub-hourly measurements of radiative–convective flux, state parameters and sub-surface thermal profiles using lead-lag analysis between various E–W balance components. Results indicated a strong (0.11–0.35) but variable monsoon season (July–September) land–atmosphere coupling events. Coupling strength declined with time, becomes negative beyond 10-day lag. Evapotranspiration (LE) influences rainfall at the monthly time-scale (20–40 days). Highly correlated monthly rainfall and LE anomalies ($r = 0.55$, $P$ 0.001) suggested a large precipitation memory linked to the local land surface state. Sensible heating (SH) during March and April are more strongly ($r = 0.6$–$0.7$) correlated to ISM rainfall than heating during May or June ($r = 0.16$–$0.36$). Analyses show strong and weak couplings among net radiation (Rn)–vapour pressure deficit (VPD), LE–VPD and Rn–LE switching between energy-limited to water-limited conditions. Consistently, +ve and −ve residual energy $[(dE) = (Rn - G) - (SH + LE)]$ were associated with regional wet and dry spells respectively with a lead of 10–40 days. Dew deposition (18.8–37.9 mm) was found an important component in the annual surface water balance. Strong association of variation of LE and rainfall was found during monsoon at local-scale and with regional-scale LE (MERRA 2D) but with a lag which was more prominent at local-scale than at regional-scale. Higher pre-monsoon LE at local-scale as compared to low and monotonous variation in regional-scale LE led to hypothesize that excess energy and water vapour brought through advection caused by pre-monsoon rainfall might have been recycled through rainfall to compensate for early part of monsoon rainfall at local-scale. However, long-term measurements and isotope analysis would be able to strengthen this hypothesis. This study would fill the key gaps in the global flux studies and improve understanding on local E–W exchange pathways, responses and feedbacks.

**Keywords** Energy–mass exchange · Surface fluxes · Sensible heating · Land–atmosphere coupling · Thar desert heat low · Indian summer monsoon

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