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Surface atmosphere exchange in dry and a wet regime over the Ganges valley: a comprehensive investigation with direct observations and numerical simulations

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Land atmosphere interactions in the Ganges Valley basin is a topic of significant importance as it is most vulnerable region due to extreme weather, air pollution, etc. The complete energy balance observations over this region was conducted as part of the CAIPEEX-IGOC (Cloud Aerosol Interaction and Precipitation Enhancement Experiment - Integrated Ground based Observational Campaign) experiment for an entire year. These observations give first insight into the partitioning of energy in this vulnerable environment during the dry and wet regimes, which are typically part of the intraseasonal oscillations during the Indian monsoon season. These transitions wet-dry and dry-wet are poorly represented in GCMs and is the motivation for the detailed investigation here. Observations conducted with micrometeorological tower instrumented with eddy covariance sensors, radiation balance, soil heat flux measurements, microwave radiometer, sodar, radiosonde data are used in the present study. A set of numerical investigations of different Planetary Boundary Layer (PBL) schemes is also carried out to investigate features of the diurnal cycle during the wet and dry regimes.
General behaviour of both local and nonlocal PBL schemes found from the investigation is to accomplish enhanced mixing, leading to a deeper PBL in the valley. However, observations give clear evidence of residual boundary layer characterised by a weak stratification, playing a key role in the exchange of PBL air mass with that of free atmosphere. Impact of changes in parameterization and controlling factors on the PBL height are investigated. Case studies for a dry phase during the incidence of a heat wave and a wet phase during a land depression are presented. Observed diurnal features of the surface meteorological parameters including the surface energy budget components were well captured by local and nonlocal PBL schemes during both the cases. Vertical profiles of temperature, mixing ratio and winds from microwave radiometer, radiosonde sounding and SODAR measurements compared well with the model vertical profiles. All the schemes are able to capture the development of a drying phase, its persistence and revival after the drying, similar to observation.
The characteristic features of the drying such as decrease in mixing ratio, PBL warming, enhanced PBL growth, variations in wind speed, etc were reproduced by the model simulations. Results indicate that model is simulating a drier and deeper surface and mixed layer, compared to the observations, which is assisted by enhanced mixing through deep updrafts rooted from the surface layer and downdrafts associated with the subsiding air reaching down to the surface. Two issues are identified with model as a) relating to enhanced mixing also assisted by the subsiding air at top of the boundary layer and b) the energy partitioning at the surface with significantly excess energy partitioned in to sensible heat flux, thus warming the model surface layer. A few aircraft observations are used to investigate entrainment issue and results from these analysis and inferences will be presented. The surface layer eddy covariance measurements of sensible and latent heat fluxes and surface layer relationships are used to tune the surface layer exchanges.