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Land-Atmosphere Interactions over North West Himalaya

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Precipitation can originate from evaporated water over oceans and land in remote locations or from local terrestrial sources. The precipitation due to these local sources is called recycled precipitation. Recycled precipitation has been used extensively to study land-atmosphere interaction and has shown to be helpful when studying the relationship between atmospheric or terrestrial variables and precipitation. Mountainous areas such as the Himalaya, Tibetan Plateau, Alps, Andes, and the Rocky Mountains are a hotspot for high local recycling and land-atmosphere interaction. The North West Himalaya (NWH) has drawn attention recently to the issue of climate change due to the region's drastically reduced rainfall and rapidly rising temperature over the past century. Climate change also affects the large number of processes involved in land-atmosphere interaction. The complex topography and heterogeneous climate of NWH makes it challenging to understand the land-atmosphere interaction in this region. In this study, we use an Eulerian water tagging method implemented into the Weather Research and Forecasting (WRF) model to study land-atmosphere interaction in NWH. This method is considered one of the most accurate techniques to quantify recycled precipitation. We simulated summer (June, July, August, and September) and winter (December, January, February, and March) precipitation in the NWH for twenty years from 2001 to 2020.

Results show that, due to availability of more thermal energy the summer experienced more recycling than winter. The western disturbances in winter and southwest monsoon during summer contributes to the locally evapotranspirated moisture and affects the recycling ratio of NWH. However, the irregular western disturbances lead to high variability in the winter recycling ratio. Our analysis shows a strong diurnal cycle of recycling ratio in NWH which peaks in the afternoon. The trend analysis from twenty years although did not show any significant trend in recycled precipitation, other variables affecting land-atmosphere interaction such as soil moisture, latent heat and 2-meter air temperature showed significant trends in NWH. We also studied land-atmosphere interaction over two contrasting regions: the foothills of Himalaya and the high-elevation region. The recycled precipitation was high in the lower elevations during summer and at higher elevations during winter. We also found higher land-atmosphere interaction during summer at higher elevations and during both summer and winter at foothills. However, due to continuous precipitation along the foothills of NWH, a brief shift in soil moisture to a wet regime is expected during monsoon which reduces the influence of soil moisture on the atmosphere leading to low land-atmosphere interaction. However, good land-atmosphere interaction exists throughout the summer in the higher Himalaya, where this change in regime is not apparent.