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Using satellite products to evaluate statistical downscaling with generalised linear models

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Generalised linear models (GLMs) have been around for some time and are routinely used for statistical downscaling of rainfall data. However, in many regions it is difficult to evaluate them because of a lack of in situ data. Downscaling models are frequently fitted using data from rain gauges. Therefore the validation of models using the same data can result in over-confidence of the model. One such region is northern India owing to the complexity of the monsoon system and relative lack of availability of raw raingauge data. Here we present a method to evaluate GLM-based downscaling using satellite products. We fit a multi-site downscaling model using generalised linear models for a case study region in the Upper Ganges, using data from 32 daily rain gauges from the Indian Meteorological Department for our study. The Asian monsoon is one of the largest manifestations of the annual cycle in the Earth System And given its importance for water resources in northern India, the analysis and projection of rainfall series in the Upper Ganges basin is of great significance for the region.

We use correlations analyses to select physically meaningful predictors for the monsoon season for JJAS. Our GLM is fitted using rain gauge data for the period 1951-1999 using separate regressions for rainfall occurrence and amount. For the amounts model, we use sea surface temperature predictors from the Niño-3 region, moisture flux across the zonal plane at 850hPa over the Arabian Sea, specific humidity at 850hPa and air temperature at 2m over the Ganges basin. For the occurrence model we use air temperature at 2m over the Ganges basin. Additional predictors were trialled but were not significant. Our model is validated using a split-sample test for 1999-2005 using rain gauge data and independent satellite and reanalysis rainfall products. We use the TRMM 3B42 v7a and APHRODITE satellite rainfall products and the Princeton downscaled NCEP reanalysis rainfall to form an ensemble of rainfall observations. We compare the uncertainty of the observations with 100 realisations from GLM simulations. We find that our ensemble of observations falls within the envelope of uncertainty from the GLM simulations during the monsoon season. Downscaling models are frequently evaluated only for their performance using average statistics. More detailed analyses of daily rainfall plots therefore give increased confidence that downscaling models may also have potential for use over shorter time scales. Our findings suggest that in data-sparse and remote regions, satellite and reanalysis products can provide an important independent verification to downscaling models.