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Bayesian spatiotemporal interpolation of rainfall in the Central Chilean Andes

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Water availability in the populous and economically significant Central Chilean region is governed by complex interactions between precipitation, temperature, snow and glacier melt, and streamflow. Streamflow prediction at daily time scales depends strongly on accurate estimations of precipitation in this predominantly dry region, particularly during the winter period. This can be difficult as gauged rainfall records are scarce, especially in the higher elevation regions of the Chilean Andes, and topographic influences on rainfall are not well understood. Remotely sensed precipitation and topographic products can be used to construct spatiotemporal multivariate regression models to estimate rainfall at ungauged locations. However, classical estimation methods such as kriging cannot easily accommodate the complicated statistical features of the data, including many 'no rainfall' observations, as well as non-normality, non-stationarity, and temporal autocorrelation. We use a separable space-time model to predict rainfall using the R-INLA package for computationally efficient Bayesian inference, using the gridded CHIRPS satellite-based rainfall dataset and digital elevation models as covariates. We jointly model both the probability of rainfall occurrence on a given day (using a binomial likelihood) as well as amount (using a gamma likelihood or similar). Correlation in space and time is modelled using a Gaussian Markov Random Field (GMRF) with a Matérn spatial covariance function which can evolve over time according to an autoregressive model if desired. It is possible to evaluate the GMRF at relatively coarse temporal resolution to speed up computations, but still produce daily rainfall predictions. We describe the process of model selection and inference using an information criterion approach, which we use to objectively select from competing models with various combinations of temporal smoothing, likelihoods, and autoregressive model orders.