Modelling spatio-temporal variation in rainfall using a hierarchical Bayesian regression model

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Abstract

Rainfall is a critical component of climate but is not always measured, necessitating prediction of its values in space and time. This can be complex and challenging, especially where the rain gauge network is sparse and measurements are recorded inconsistently, leading to many missing values. Here, we develop a hierarchical Bayesian model for predicting rainfall in space and time and apply it to data collected at 23 rain gauges in Narok County, Kenya, from 1965 to 2015. The model incorporates geographical, meteorological and other covariates and performs better than the Gaussian process, Kriging, simple linear and Bayesian linear models on the Narok dataset. We use the model to predict total monthly rainfall on a 5 $\times$ 5km grid and Monte Carlo integration to estimate seasonal and annual rainfall and their standard errors for 29 sub-regions of Maasai Mara ecosystem of Narok. The predictions are sufficiently precise for most practical purposes and have a correlation of 0.80 with blended station and satellite rainfall. We show that wild herbivore biomass increases with the wet and dry season rainfall in the Maasai Mara ecosystem in Narok County. The model is applicable to other variables recorded on sparse networks with missing values.

Keywords: Maasai Mara ecosystem, Non-stationary covariance function, Gaussian Process, Ungulate Biomass, MCMC.

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