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Remote effects spatial process models for modeling teleconnections

Joshua Hewitt[1], Jennifer A. Hoeting[1], James M. Done[2] and Erin Towler[2]

[1]Colorado State University
[2]National Center for Atmospheric Research

Abstract: While most spatial data can be modeled with the assumption that distant points are uncorrelated, some problems require dependence at both far and short distances. We introduce a model to directly incorporate dependence in phenomena that influence a distant response. Spatial climate problems often have such modeling needs as data are influenced by local factors in addition to remote phenomena, known as teleconnections. Teleconnections arise from complex interactions between the atmosphere and ocean, of which the El Niño–Southern Oscillation teleconnection is a well-known example. Our model extends the standard geostatistical modeling framework to account for effects of covariates observed on a spatially remote domain. We frame our model as an extension of spatially varying coefficient models. Connections to existing methods are highlighted and further modeling needs are addressed by additionally drawing on spatial basis functions and predictive processes. Notably, our approach allows users to model teleconnected data without pre-specifying teleconnection indices, which other methods often require. We adopt a hierarchical Bayesian framework to conduct inference and make predictions. The method is demonstrated by predicting precipitation in Colorado while accounting for local factors and teleconnection effects with Pacific Ocean sea surface temperatures. We show how the proposed model improves upon standard methods for estimating teleconnection effects and discuss its utility for climate applications.