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Modeling Temporally Evolving and Spatially Globally Dependent Data

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The last decades have seen an unprecedented increase in the availability of data sets that are inherently global and temporally evolving, from remotely sensed networks to climate model ensembles. This paper provides an overview of statistical modeling techniques for space–time processes, where space is the sphere representing our planet. In particular, we make a distintion between (a) second order-based approaches and (b) practical approaches to modeling temporally evolving global processes. The former approaches are based on the specification of a class of space–time covariance functions, with space being the two-dimensional sphere. The latter are based on explicit description of the dynamics of the space–time process, that is, by specifying its evolution as a function of its past history with added spatially dependent noise.

We focus primarily on approach (a), for which the literature has been sparse. We provide new models of space–time covariance functions for random fields defined on spheres cross time. Practical approaches (b) are also discussed, with special emphasis on models built directly on the sphere, without projecting spherical coordinates onto the plane.

We present a case study focused on the analysis of air pollution from the 2015 wildfires in Equatorial Asia, an event that was classified as the year's worst environmental disaster. The paper finishes with a list of the main theoretical and applied research problems in the area, where we expect the statistical community to engage over the next decade.