

Random fields on spheres across time: modeling data evolving temporally over planet Earth

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Abstract: In recent decades, geostatistical approaches have become popular in many fields, such as climatology, ecology, environmental sciences and hydrology. For data observed over large portions of planet Earth it is necessary to take into account the curvature of the globe. Hence the need for random field models defined over spheres across time. In particular, the covariance function should depend on the geodesic distance, which is the most natural metric over the spherical surface. A suitable specification of the covariance structure allows to capture both the space-time dependencies between the observations and the development of accurate predictions.

In this work, several topics are explored. First, we develop transport effect models on spheres across time. We assess the dimple problem for covariances generated under this framework. Our findings are related to phenomena with the presence of prevailing winds or ocean currents. Secondly, we propose a simulation method based on the spectral representation of the field and study its level of accuracy in the L^2 sense. The method turns to be both fast and efficient. On the other hand, we consider models with multiple correlated variables instead of individual ones. We provide a complete characterization for the bounded and continuous matrix-valued covariances, being geodesically isotropic in the spatial component and stationary in the temporal one. We additionally propose flexible parametric families of covariance functions, with both marginal and cross structures of Gneiting type. Finally, we establish a strategy to add asymmetry in a given symmetric matrix-valued covariance. We assess the performance of our models through simulated and real data sets.

Keywords: Asymmetry; Covariance functions; Geodesic; Gneiting classes; Latent dimensions; Multivariate fields; Space-time; Spherical harmonics; Transport effects.