Dynamic Multiscale Spatiotemporal Models for Poisson Data: Spatiotemporal dependence structure

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We propose a new class of dynamic multiscale models for Poisson spatiotemporal processes. Specifically, we use a multiscale spatial Poisson factorization to decompose the Poisson process at each time point into spatiotemporal multiscale coefficients. We then connect these spatiotemporal multiscale coefficients through time with a novel Dirichlet evolution. Further, we propose a simulation-based full Bayesian posterior analysis. In particular, we develop filtering equations for updating of information forward in time and smoothing equations for integration of information backward in time, and use these equations to develop a forward filter backward sampler for the spatiotemporal multiscale coefficients. Because the multiscale coefficients are conditionally independent a posteriori, our full Bayesian posterior analysis is scalable, computationally efficient, and highly parallelizable. Moreover, the Dirichlet evolution of each spatiotemporal multiscale coefficient is parametrized by a discount factor that encodes the relevance of the temporal evolution of the spatiotemporal multiscale coefficient. Therefore, the analysis of discount factors provides a powerful way to identify regions with distinctive spatiotemporal dynamics. We present results on the spatial and spatiotemporal dependence structure. Two applications to real datasets illustrate the usefulness of our multiscale spatiotemporal Poisson methodology: mortality ratios in the state of Missouri, and tornado reports in the American Midwest.

Keywords: Bayesian dynamic models; Dependence structure; Massive datasets; Time series models for counts.