There have been many developments over the past decade in strategies for modeling spatio-temporal environmental data, including work published in at least three major texts on the subject. Some consider spatiotemporal data from the perspective of a temporal sequence of spatial processes, sometimes with dynamic temporal modeling. Others consider modeling from the perspective of parallel, correlated time series of observations at spatial locations, perhaps arbitrarily many. Again, temporal structure may be represented through dynamic models. Most modeling strategies provide a decomposition of a spatio-temporal process in terms of a spatio-temporal mean or trend and stochastic deviations about that trend. And many, if not all, models can be specified in a hierarchical manner.

Properties of environmental monitoring data that must be addressed in modeling and analysis include the fact that data may come from various monitoring networks and are often irregular in space and time. Furthermore, most spatiotemporal environmental processes have clearly nonstationary structure in both the mean fields and the spatial covariance structure of the deviations from the mean, depending on the spatial scale of the application. We will present our flexible spatio-temporal modeling strategy, developed for air quality monitoring data from multiple monitoring networks with highly irregular or unbalanced sampling in space and time. It uses an empirical, nonparametric characterization of spatially varying temporal structure with a large database of spatial (GIS-based) covariates and also spatio-temporal covariates that may be derived from remote sensing or deterministic air quality models. We will demonstrate this modeling for purposes of exposure estimation in environmental epidemiology using the SpatioTemporal package in the R system. We will also present recent work characterizing nontstationary spatial covariance structure using the Sampson-Guttorp spatial deformation model.