Environmental risk assessment via multivariate penalized hidden semi-Markov models

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Abstract

Environmental risk assessment is inherently a multivariate problem, as pollutants are often emitted simultaneously and interact within complex atmospheric and chemical processes. In addition, exposures and their effects exhibit strong autoregressive structures, which means that past environmental conditions influence current and future risks. Standard models struggle to capture these interdependencies, often treating environmental variables as independent risk factors rather than interconnected components of a broader system.

To address these challenges, we propose a novel concomitant-variable multivariate penalized hidden semi-Markov model with autoregression for environmental risk assessment. This framework integrates multiple environmental risk factors, accounts for their temporal dependencies, and incorporates penalization techniques to improve the model's interpretability.

The model proposal is tested on simulated data and then applied to an original daily time-series of five pollutants that has been recorded in Bergen from 2020 to 2022. Our objective is to characterize the complex dynamics of environmental risk to provide actionable insights for policymakers and public health official.