Copula-based spatio-temporal modeling of air pollutant data incorporating covariate dependencies

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Spatio-temporal PM10 concentrations may exhibit both spatial and temporal dependencies. Additionally, interactions between PM10 and environmental factors can further influence the variability in PM10. Therefore, this study proposes a method that incorporates the spatio-temporal neighbors of covariates along side those of PM10 by adopting an approach that explains spatio-temporal interactions through spatio-temporal neighbors. Vine copulas are used to integrate the pairwise dependence structures between a given location and its surrounding spatio-temporal neighbors. We applied the model to weekly average PM10 data from South Korea in 2019, using PM2.5 and CO as covariates. The proposed model outperformed a Bayesian spatio-temporal model, a kriging method, and an alternative copula-based approach, particularly in predicting the top 5% of extreme values, by effectively capturing tail dependencies crucial for extreme value analysis. This study highlights the importance ofutilizing vine copulas to effectively model diverse dependency structures in spatio-temporal data while simultaneously accommodating spatial and temporal dimensions, including spatio-temporal dependencies among covariates. The results underscore the broader applicability of the proposed approach to other fields where complex dependency structures are present.