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A Spatial Bayesian Hierarchical Postprocessing of Wind Gusts

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We present a spatial Bayesian hierarchical model for postprocessing surface maximum wind gusts in COSMO-REA6. Our approach uses a non-stationary extreme value distribution (GEV) at the top level, with parameters that vary based on linear regressions of predictor variables from the COSMO-REA6 reanalysis. To capture spatial patterns in surface extreme wind gust behavior, the regression coefficients are modeled as 2D Gaussian random fields with a constant mean and an isotropic covariance function that depends only on the distance between locations. Additionally, we incorporate an altitude factor into the distance calculation, allowing us to include data from mountain top stations in the training process and utilize all available information. We evaluate the predictive performance using Brier Score and Quantile Score, comparing our model against climatological forecasts and a non-hierarchical, spatially constant baseline model. Our spatial model demonstrates up to 5% more skill in predicting quantile levels and shows high skill for more extreme wind gusts compared to the baseline model. Furthermore, the model improves the prediction of threshold levels at about 60-80% of the 109 locations investigated, depending on the threshold level. While a spatially constant approach already provides high skill, our model further enhances forecasts and improves spatial consistency. Additionally, by using Gaussian random fields, our model can be easily interpolated to unobserved locations, accounting for local characteristics.

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