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Predicting the Probability of Lightning Occurrence with Generalized Additive Models

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This study investigates the predictability of lightning in complex terrain. The main objective is to estimate the probability of lightning occurrence in the Alpine region during summertime afternoons (12–18 UTC) at a spatial resolution of 64×64 km^2.

Lightning observations are obtained from the ALDIS lightning detection network. The probability of lightning occurrence is estimated using generalized additive models (GAM). GAMs provide a flexible modelling framework to estimate the relationship between covariates and the observations. The covariates, besides spatial and temporal effects, include numerous meteorological fields from the ECMWF ensemble system. The optimal model is chosen based on a forward selection procedure with out-of-sample mean squared error as a performance criterion.

Our investigation shows that convective precipitation and mid-layer stability are the most influential meteorological predictors. Both exhibit intuitive, non-linear trends: higher values of convective precipitation indicate higher probability of lightning, and large values of the mid-layer stability measure imply low lightning potential. The performance of the model was evaluated against a climatology model containing both spatial and temporal effects. Taking the climatology model as a reference forecast, our model attains a Brier Skill Score of approximately 46%. The model's performance can be further enhanced by incorporating the information about lightning activity from the previous time step, which yields a Brier Skill Score of 48%.

These scores show that the method is able to extract valuable information from the ensemble to produce reliable spatial forecasts of the lightning potential in the Alps.