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Bayesian hierarchical modeling of extreme sub-daily precipitation in Norway

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Spatial maps of extreme precipitation are a critical component of flood estimation in hydrological modeling, as well as in the planning and design of important infrastructure.
This is particularly relevant in countries with large spatial precipitation gradients, such as Norway; where hydropower facilities imply significant risk of infrastructure damage due to flooding.

We present a method for estimating spatially coherent maps of the distribution of extreme sub-daily precipitation in Norway, in terms of return levels, by linking Generalized Extreme Value (GEV) distributions with latent Gaussian fields in a Bayesian hierarchical model. Generalized linear models on the GEV parameters, estimated from station measurements, are able to incorporate location-specific geographic and meteorological information and thereby accommodate these effects on extreme precipitation. Our model incorporates a Bayesian model averaging component that directly assesses model uncertainty in the effect of the proposed covariates. Gaussian fields on the GEV parameters capture additional unexplained spatial heterogeneity and overcome the sparse grid on which observations are collected.

Our study, presented in Dyrrdal et al. (2015), showed that mean summer precipitation, mean summer temperature, latitude, longitude, mean annual precipitation and elevation are good covariate candidates for hourly precipitation extremes. We were able to appropriately characterize both the spatial variability of the distribution of extreme hourly precipitation in Norway and the associated uncertainty in these estimates, and a cross-validation study concludes that the spatial model estimates are broadly consistent with return levels that would be estimated via maximum likelihood on station series.

The spatial maps, along with station design values, will play a key role in a new web-based tool for IDF (Intensity-Duration-Frequency) values to be launched by the end of 2017, enabling the user to obtain precipitation design values at any point in Norway. With time, the quality of estimated design values will improve due to additional observational sites, longer time series and possibly more appropriate covariates.

References

Dyrrdal, A.V., Lenkoski, A.,Thorarinsdottir, T.L., and Stordal, F., 2015: Bayesian hierarchical modeling of extreme hourly precipitation in Norway. Environmetrics, 26(2), p.89-106.