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Spatial predictive distribution for precipitation based on numerical weather predictions (NWP) and quantile regression

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This work is motivated by a need from hydro power producers in Norway.Their short-term run-off predictions depend on precipitation and temperature forecasts. To quantify the uncertainty in run-off forecast, the uncertainty in the precipitation forecast is needed. A dataset for four and a half years of daily NWP from the European Center for Medium-Range Weather Forecasts (ECMWF) and precipitation observations for 436 locations in Southern Norway is used in this study.

The aim is to find a spatial predictive distribution for precipitation that is calibrated and sharp, as discussed in Gneiting et al [J. Roy. Statist. Soc. Ser. B (2007): 243-268].

From exploratory analysis we find that the NWP precipitation forecasts are biased, and that this bias has a spatial structure. Further it varies with season
and weather system. We construct a model by combining and extending the single site model of Bremnes [Mon. Weather Rev. (2004):132: 338-347], the spatial model of Berrocal et al [The An. of Appl. Stat. (2008):2, 1170-1193] and the Bayesian spatial quantile regression method of Reich et al [Jour of Amer.Stat.Asoc, 2011 (online early)]. Our model is a two stages model with one model for precipitation occurrence and an independent model for amount of precipitation given occurrence.
In addition to the precipitation forecast we also allow weather system proxies as explanatory variable, and we have found the NWP wind forecast to be valuable.

In the first stage of the model we use a spatial probit model with the NWP for precipitation and wind as an explanatory variable. This implies that the probability for no occurrence of precipitation given that the NWP is 5mm may differ at different locations, and with different wind forecasts.

For the second stage of the model, amount of precipitation given occurrence, we use spatial quantile regression. I.e. each quantile of the predictive distribution has its own dependency to the NWP and to other explanatory variables, i.e. wind. This gives the appealing flexibility that the median (50% quantile) might be only dependent of the NWP, while the wind forecast can be very important for the 95% quantile. Also the precipitation amount model is spatial.

The results are evaluated with Brier score and the continuous rank probability score both for a test period at locations
where the model is trained, and at locations where the model is not trained. For most location our model preforms considerable better then the raw
forecast.