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Improved spatial prediction: A combinatorial approach

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Linear combinations of model forecasts have been extensively used to combine forecasts in a temporal setting. Using two or more models, the prediction error of past forecasts is used to find the error variance for each model and the correlation between the model errors. This knowledge can be used to calculate a combination weight for future forecasts which minimizes the mean square error. This presentation outlines the basis for such a combination approach, using spatial interpolation of a hydrological field as an example for illustrating the logic.

In the temporal setting a suitable window of previous prediction errors is used to calculate the combination weights. In the spatial analogue, instead of using a temporal window a suitable number of nearest neighbors is used. Errors at the nearest neighbor locations are calculated using interpolation with the location removed and then subtracting the known value from the predicted value. Using these leave-one-out errors from a suitable number of nearest neighbors allows the error variance for each interpolation method and the correlation of the errors for the interpolation methods to be calculated. A combination weight at the unknown location can then be calculated and used for combining the different interpolation methods and improving the spatial forecast.

In order to test the proposed method, the method of spatial forecasts was applied to different sized daily precipitation data sets covering differing extents of Sydney, Australia. In this particular example we chose to use two different types of copula interpolation for prediction: 'global' copula interpolation and 'local' copula interpolation. The global copula interpolation was based on using a copula where the copula parameters were estimated using the entire data set, whereas the local copula interpolation used a copula where the copulas parameters were estimated using a local neighborhood. This gave two competing interpolation predictions, both which interpolated the data well however resulted in different error variances. Although both methods performed equally well the use of the spatial combinations resulted in a consistent reduction in the prediction error. Using the two different data sets showed that the results are sensitive to the merit of the two competing interpolation methods, and best performance of combination of forecasts is likely to be obtained when both interpolation methods have similar merit. However, even when one model is consistently poorer, combining forecasts still resulted in an improvement above that of each individual method. Further sensitivity testing was performed on the choice of neighborhood for the calculation of the combination weights. Using both a local and global neighborhood for the estimation of the combination weights showed that using a local neighborhood gave better results suggesting that the most critical factor in improving interpolation forecasts is correctly estimating the error variance and correlation at the unknown location and future research will focus on improving the estimate or the error variance and correlation at unknown locations.

Although the method of combining spatial predictions is presented in the context of copula interpolation, it can be applied to any data set and interpolation problem where there are two or more spatial predictions being performed. Additional details regarding the combination approach are available from Wasko et al. (2013).

References

Wasko, C., A. Sharma, and P. Rasmussen (2013), Improved spatial prediction: A combinatorial approach, Water Resources Research, doi:10.1002/wrcr.20290.