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Spatial forecast verification with wavelets

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The quality of spatial precipitation forecasts is difficult to evaluate objectively because images with disjoint features surrounded by zero intensities cannot easily be compared pixel by pixel: Any displacement between observed and predicted field is punished twice, generally leading to better marks for coarser models. To answer the question whether a highly resolved model truly delivers an improved representation of precipitation processes, alternative tools are thus needed. Wavelet transformations can be used to summarize high-dimensional data in a few numbers which characterize the field's texture. A comparison of the transformed fields judges models solely based on their ability to predict spatial correlations. The fidelity of the forecast's overall structure is thus investigated separately from potential errors in feature location.
This study introduces several new wavelet based structure-scores for the verification of deterministic as well as ensemble predictions. We furthermore demonstrate how to obtain a well defined sign for the error, answering the important question whether forecast fields are too small- or too large-scaled.
The properties of our novel scores are rigorously tested in an idealized setting: A recently developed stochastic model for precipitation extremes based on the moisture budget generates realistic pairs of synthetic observations and forecasts with prespecified spatial correlations.
The wavelet-scores are found to react sensitively to differences in structural properties, meaning that the objectively best forecast can be determined even in cases where this task is difficult to accomplish by naked eye. Random rain fields prove to be a useful test-bed for any verification tool that aims for an assessment of structure.