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Modeling Ensemble Forecasts of Solar Flares

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In the past decade several new methods for forecasting solar flares have been developed. Different methods often produce different forecasts for the same event because they are based on different empirical relations or models, use different input data, and/or they are trained with different datasets. In addition, some of these methods might depend partially or entirely on human decisions and expertise. Therefore, direct comparison between the performances of different methods has proven to be a difficult task thus far.

In this work we investigate the use of numerical weather prediction methods as an alternative to historical flare forecasting techniques. Ensemble forecasting has been used in terrestrial weather forecasting for many years as a way to combine different predictions in order to obtain a more accurate result. Here we construct ensemble forecasts for major solar flares (M and X classes) by linearly combining the full-disk probabilistic forecasts from a group of operational forecasting methods (ASSA, ASAP, NOAA, MAG4, MOSWOC, and SolarMonitor). Forecasts from each method are weighted by a factor that accounts for the method's ability to predict previous events. These combination weights are then calculated in several ways: 1) by metric optimization using probabilistic forecasts, 2) by metric optimization using categorical forecasts, and 3) by estimation of the cumulative partial quadratic errors. Several performance metrics (probabilistic and categorical) were considered in this analysis.

The results provide space weather forecasters with a set of parameters (combination weights and thresholds) that allow them to select the most appropriate values for constructing the ensemble value, according to the performance metric of their choice. In this way different forecasts can be made to fit different end-users needs.