Verification of flare forecasts at the Met Office
Space Weather Operations Centre
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1. Abstract
One essential component of operational space weather forecasting is prediction of solar flares. The Met Office Space Weather Operations Centre (MOSWOC) produces a Sunspot Region Summary (SRS) every six hours, including flare predictions for numbered active regions, as well as a full disk four-day Flare Forecast twice daily. Verification of these predictions provides an understanding of the strengths and weaknesses of the flare forecasting process. Here we present verification of M-class flare forecasts since data archiving began in 2014, including reliability diagrams and relative operating characteristic (ROC) curve areas. The results highlight the value of forecaster experience and the difficulty forecasting beyond 24-hour periods [1].

2. Sunspot Region Summaries
- The SRS lists magnetic classification for each active region of interest on disk as well as M- and X-flare probabilities for the next 24 hours.
- Flare predictions for each active region are based on a Poisson statistics technique [2] using ~20 years of archived data.
- Total disk probabilities are also provided; in raw form from the Poisson output, as well as ‘forecaster-edited’ issued probabilities.

![Figure 1: Reliability diagrams for SRS raw (left) and issued (right) forecasts for a one year period beginning 2015 July 10.](image)

- Figure 1 shows that issued forecast is more reliable than raw model output (which tends to over-forecast). Forecasts issued with high probabilities (rarest in data set) seem to under-predict; however, this observation is rather tentative as sample size is extremely small.
- As reliability diagrams are conditioned on forecasts, we also produced ROC curves (conditioned on observations). These measure forecast discrimination; the area under the curve is a summary statistic of the discriminatory ability. Area under the raw curve was 0.83, and issued was 0.92, indicating that a human has more skill (than model) in distinguishing events from non-events.

3. Flare Forecasts
- Flare forecasts are issued for the next four days as part of the MOSWOC Space Weather Guidance Document.
- The Day 1 forecast is based on the total issued SRS forecast, manually updated by MOSWOC forecasters.
- The Day 2, 3, and 4 probabilities are edited as necessary from the Day 1 probability, depending on what active regions are expected to emerge or leave the solar disk.

![Figure 2: Reliability diagrams for total disk issued Day 1 (upper left), Day 2 (upper right), Day 3 (lower left), and Day 4 (lower right) forecasts between 2014 January 1 - 2016 July 10.](image)

- Figure 2 shows that the Day 1 forecast is most reliable; however, forecasts issued with probabilities >30% appear to over-predict flares – this tendency becomes more pronounced at longer forecast ranges.
- The ROC area for Days 1 to 4 are 0.82, 0.78, 0.73, and 0.71 respectively, again highlighting that the Day 1 forecasts are more skillful at correctly distinguishing flare events from non-events.

4. Real-time verification
- MOSWOC forecasters have internal access to webpages showing real-time verification of their flare forecast products (see Figure 3).
- These are produced by the Area Forecast Verification System [3] which was originally developed to verify numerical weather prediction products such as the shipping forecast.
- Ranked Probability Skill Scores are displayed together with 90% confidence intervals (bootstrapped with replacement), comparing the forecast on Days 1, 2, 3 and 4 against a rolling 2-year flare climatology.

![Figure 3: An internal Met Office webpage displaying the latest rolling 12 monthly performance of the flare forecasting service](image)

References

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