The MAG4 Flare Forecast Tool and Iterative O2R2O

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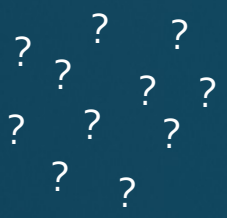
Anticipating solar flares and subsequent particle events and their intensity is a forecast challenge to operational space weather groups like NOAA's Space Weather Prediction Center and NASA Space Radiation Analysis Group. To address this need, a probabilistic forecast model called MAG4 was developed by Dr. David Falconer at the University of Alabama in Huntsville, in collaboration with NASA Marshall Space Flight Center. MAG4 predicts the likelihood of X and M class flares, SPEs, CMEs, and fast CMEs by Active Region and full disk for the upcoming 24 hour time period using a database of magnetograms and the prior activity from them.

In 2018, the NASA Earth Science SPoRT project (Short-term Prediction Research to Transition Center) partnered with SWPC and SRAG to investigate the possibility of using SPoRT's terrestrial weather research to operations paradigm as a framework for R2O in space weather. Those activities were summarized in two assessment reports for SPoRT. A main takeaway from those reports is the iterative nature of O2R2O activities, in which end users provide feedback regarding a product's latency, display, and capabilities, and the research and development team attempts to address those suggestions to help the product provide greater value in the operational environment. Herein, we will describe the SPoRT methodology of O2R2O, using the MAG4 product's evolution at SWPC and SRAG as our example.

Motivation

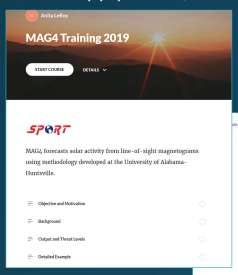
Research to Operations Chasm

- How do you get promising, cutting edge research to decision makers?
- How do you know what's promising?
- How can researchers learn what is needed in ops?
- What products, in what formats, at what latency, etc.?
- Who transitions and maintains the product?
- Who provides resources for all this?

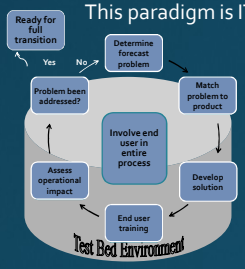


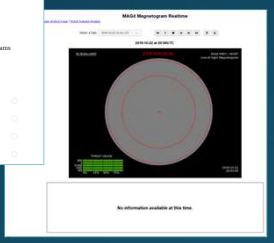
SPoRT Paradigm R2O2R

Short, applications-based training to help analysts use and apply MAG4



This paradigm is ITERATIVE!

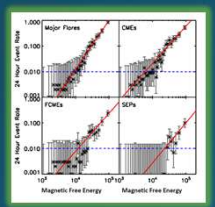


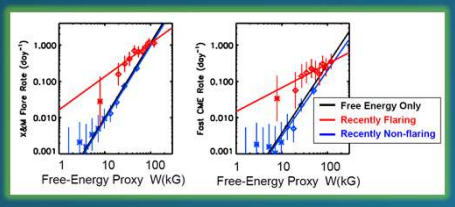


- Web-based product by SWPC's request
- Made available in Real-time and Archive modes, due to lack of solar activity

What is MAG4?

- MAG4 uses a magnetic free energy proxy within ARs, as well as prior flare activity in an AR, predict future flares .
- Forecast curves are from MDI magnetograms, with new HMI forecast curves in development.
- Uses deprojected vector magnetograms with LoS mode available for back-up.





SWPC and SRAG

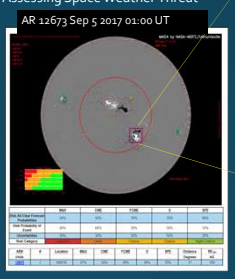
SWPC Mission: Space Weather Prediction Center provides space weather analiysis and forecasts for a variety of stakeholders. Solar flares impact HF comms, CMEs can harm power grids, etc.

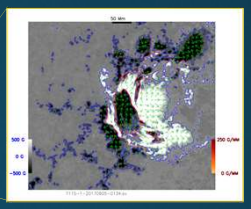
SRAG Mission: Space Radiation Analysis Group ensures astronauts are exposed to as little radiation as possible
Needs: Detection and prediction (i.e., forecasting) of solar particle events, magnitude, and duration

Assessments and Iterative Improvements

SWPC:
- In person demo and job shadowing
- Comparison of MAG4 output for archived event with actual forecast and results
- Soliciting additional recommendations, such as a way to zoom into ARs and see field lines

Assessing Space Weather Threat





Active Region Zoom (with overlays) Improves MAG4 Decision Support Tool Value

SRAG:
- Collaborative team to help provide improvements
  - E.g., moving code from IDL to Python
- Weekly tag-ups with Dr. Falconer and SRAG development team and others.
- Expanding database and forecast curves into HMI era and evaluating results.

Outcomes

Fully engaging in R2O2R requires a **relationship** with end users and the capacity to iteratively improve a product to meet their needs.
- Understanding what the end user HAS and NEEDS
- An ability to provide the new product in a way that the end user needs
- Brief, to-the-point training on the product's use/interpretation
- Assessing the impact of a potential new product
- Making changes to the product to address recommendations
- Wash, rinse, repeat!

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