

Extending Terrestrial Weather R2O/O2R to Space Weather at NASA's SPoRT Center

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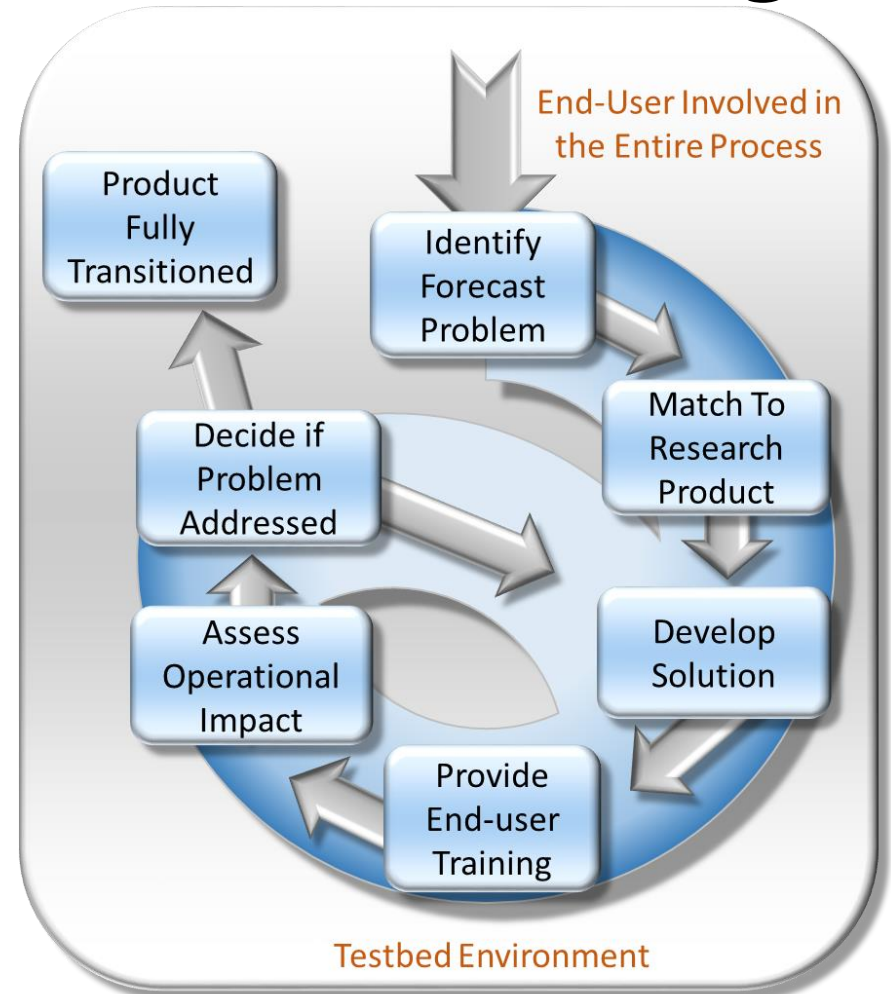
2018 American Geophysical Union Fall Meeting

December 11, 2018



SPoRT & Established R2O/O2R Paradigm

- SPoRT has transitioned terrestrial satellite observations or satellite-enhanced models to operational decision makers since 2002
- Partnerships with more than 60 operational decision making groups
- Proven paradigm for transitioning NASA research data across the “Valley of Death” (right) through collaborative interaction with decision makers to develop value-added solutions to operational forecasting challenges



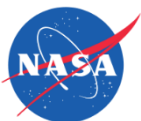
Short-term Prediction Research and Transition (SPoRT) staff works collaboratively with decision makers to tailor experimental product solutions to meet their needs



Paradigm Demonstration at SWPC

- **NOAA/NCEP and SWPC management encouraged establishing low-level of effort collaborations to test drive the SPoRT paradigm as a potential approach for Space Weather R2O/O2R**
- **Site visit to SWPC in August 2017 to learn forecast process and challenges**

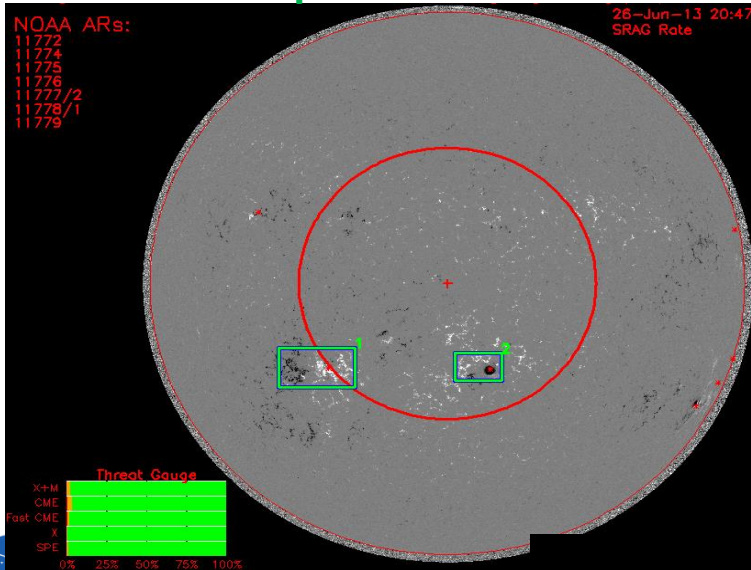
R2O Challenge	R2O Solution
1. Subjective McIntosh approach is time-consuming and can be cumbersome, especially if there are multiple active regions at one time.	1. Forecaster <i><u>pull</u></i> for MSFC-developed, experimental MAG4 product as one solution to enable more objective forecasting approach.
2. MAG4 not available consistently enough for forecaster needs—cadence too low; university-run website down too frequently.	2. Integrated model into operational SPoRT product data stream and created dynamic website to display output.
3. More details about the model outputs needed beyond graphic available from current website or other online portals.	3. Created graphical interface that links magnetogram image to tabular display of model output.
4. Questions about how to interpret the product.	4. Developed user-focused training.



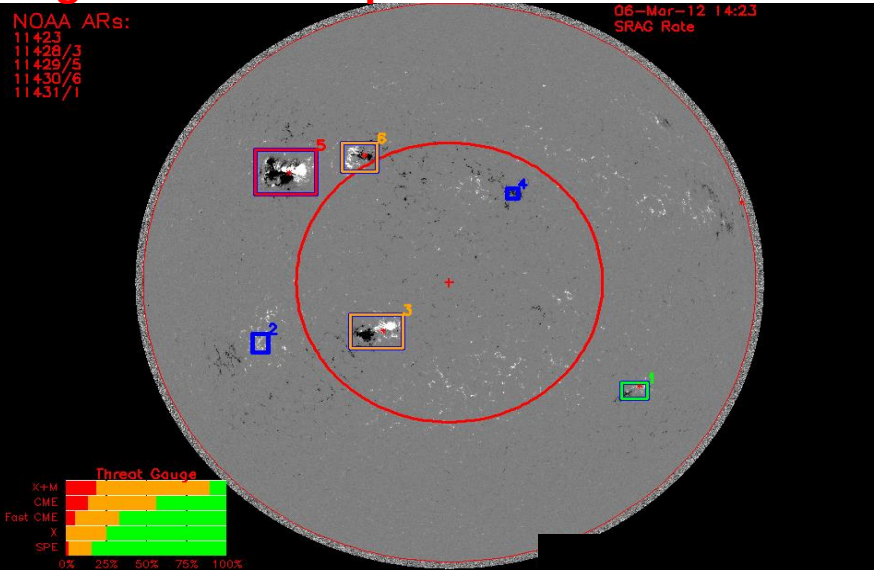
R2O Solution #1: MAG4

- Uses empirical relationships between magnetic free energy and event rates to objectively categorize the current state of flare/CME risk on the Sun
- Probabilistic information on threat with quicker/easier analysis than current McIntosh approach for categorizing flare
- Provides guidance on preflare/CME probabilities within 30 degrees (and some reduced reliability within 30-60 degrees) of solar center—foreshortening limitation suffered by any observational source

All Clear Example: 26 June 2013

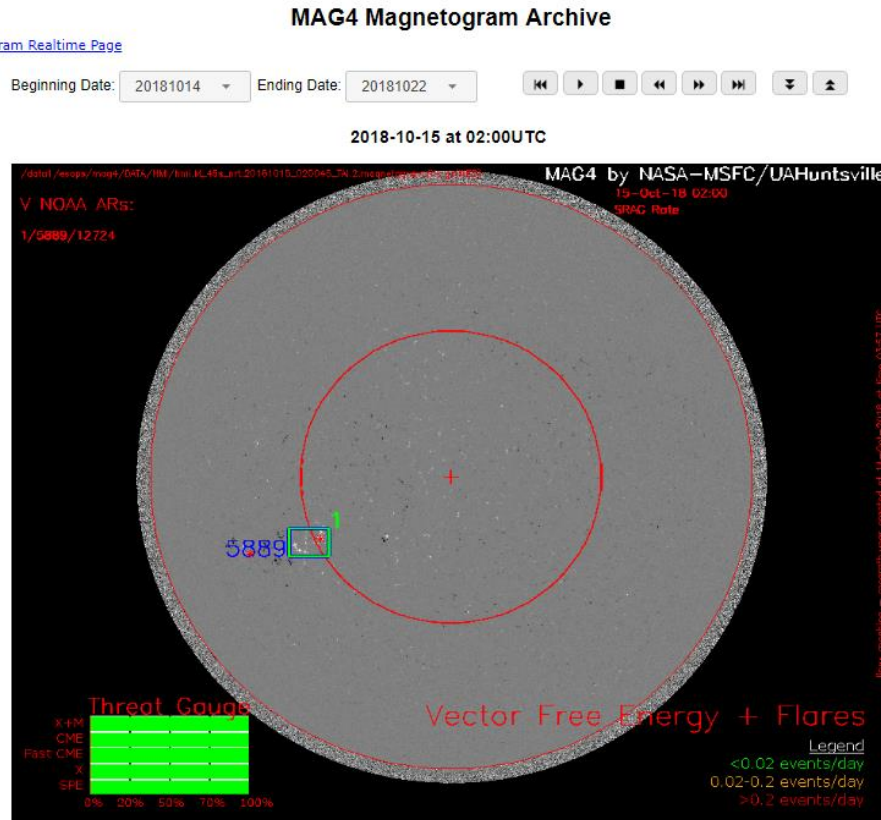


High Threat Example: 7 March 2012



R2O Solution #2 and #3: Dynamic MAG4 Website

- Link to: [MAG4 Magnetogram Realtime Page](#)



Active Regions - Rates **Active Regions - Probabilities** Full Disk - Rates Full Disk - Probabilities

AR#	#	Location	M&X	CME	FCME	X	SPE	Distance	WL _{SG}
Units								Degrees	kG
12724	1	S7E25	1%	1%	1%	1%	1%	25	0

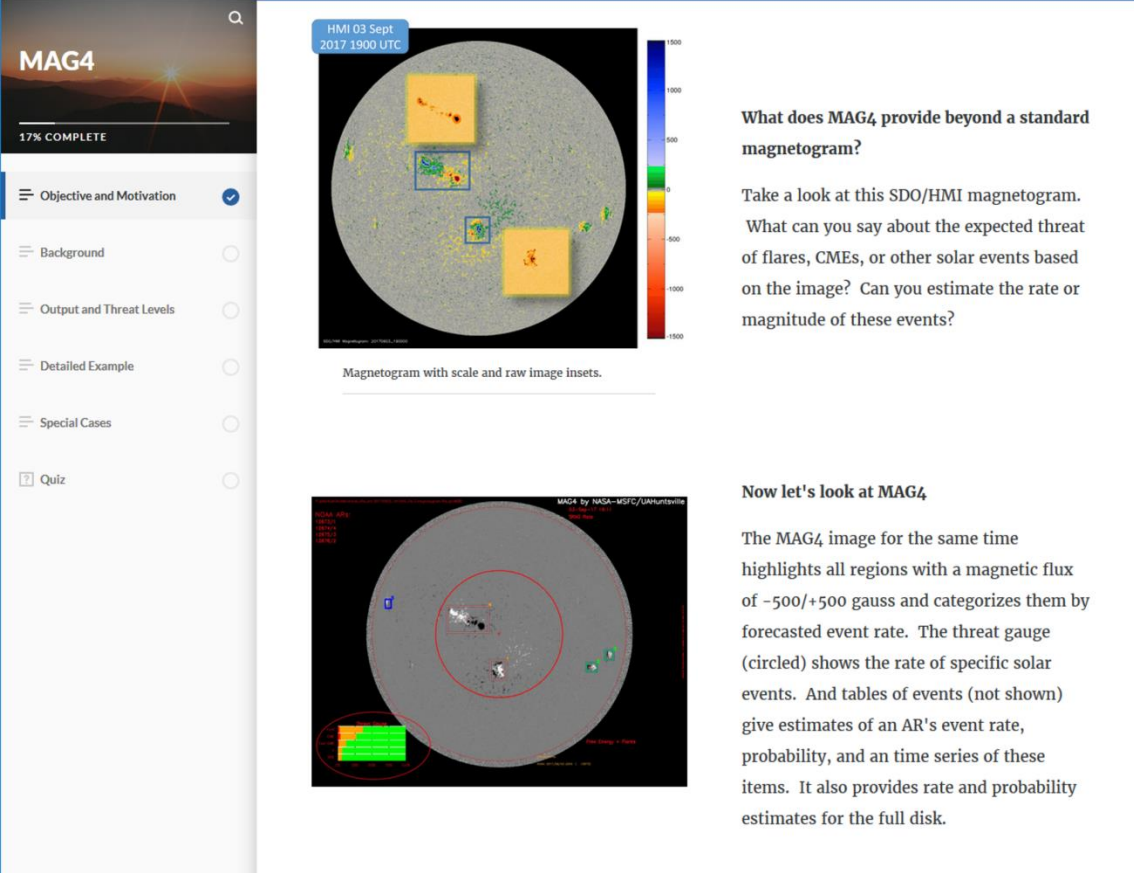
- MAG4 code successfully integrated onto SPoRT processing machines to produce real-time output; running stably
- Real-time (previous 48 hours) and archive (previous 28 days) websites created
 - Automatically links hourly (cadence requested by SWPC forecasters) MAG4 output to graphical site
 - Tabular output with event rates and probabilities
- Iterated with SWPC forecasters on website functionality and look via multiple telecons

Real-time link: <https://weather.msfc.nasa.gov/cgi-bin/sportPublishMAG4.pl?dataset=mag4realtime>

Archive link: <https://weather.msfc.nasa.gov/cgi-bin/sportPublishMAG4.pl?dataset=mag4archive>

R2O Solution #4: User-Focused Training

- Short, online training module produced using Articulate Rise
 - Relevant background for the space weather forecasting
 - Brief overview of MAG4 product
 - Example of how MAG4 can be used to supplement other operational products
 - Tutorial on how to interpret the imagery and use the new website
 - Follows instructional design guidelines for creating
- Follows instructional design guidelines for creating online learning items
- Hands-on training was delivered during a multi-day Science Sharing Session site visit at SWPC



MAG4
17% COMPLETE

- Objective and Motivation
- Background
- Output and Threat Levels
- Detailed Example
- Special Cases
- Quiz

HMI 03 Sept 2017 1900 UTC

Magnetogram with scale and raw image insets.

MAG4 by NASA-MSFC/UMaryville

What does MAG4 provide beyond a standard magnetogram?

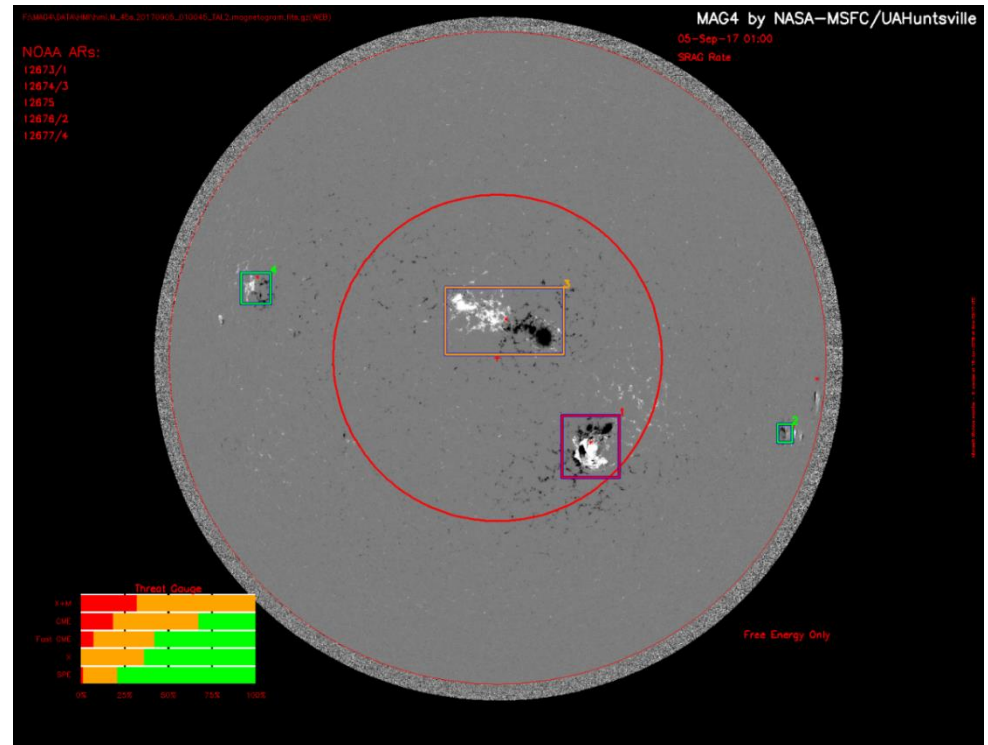
Take a look at this SDO/HMI magnetogram. What can you say about the expected threat of flares, CMEs, or other solar events based on the image? Can you estimate the rate or magnitude of these events?

Now let's look at MAG4

The MAG4 image for the same time highlights all regions with a magnetic flux of $-500/+500$ gauss and categorizes them by forecasted event rate. The threat gauge (circled) shows the rate of specific solar events. And tables of events (not shown) give estimates of an AR's event rate, probability, and a time series of these items. It also provides rate and probability estimates for the full disk.

Summer 2018 Testbed Activity

- September 2017 CME event processed and reproduced on archive website for demonstration due to low level of solar activity in summer 2018
- Testbed activity walked forecasters through their forecast process leveraging training to show ways products like MAG4 would add value to forecast process
- Quantitative probabilities defined objectively by MAG4 closely matched the more time-consuming subjective analysis performed by forecasters
- Forecasters foresee MAG4 as both a first-look, objective flare threat indicator and a source to enable higher confidence flare forecasts



	M&X	CME	FCME	X	SPE
Disk All-Clear Forecast Probabilities	20%	40%	70%	70%	90%
Disk Probability of Event	80%	60%	30%	30%	10%
Uncertainties	30%	30%	30%	50%	20%
Risk Category	Expected	Likely	Chance	Chance	Slight Chance

AR#	#	Location	M&X	CME	FCME	X	SPE	Distance Degrees	WL _{SG} kG
12673	1	S8W16	87%	55%	26%	26%	10%	17	109



NASA's SnAP Activity

- **Representatives from NASA Centers with relevant space weather expertise and missions (GSFC, MSFC, JPL, JSC, LaRC) and operational decision making organizations (NOAA, Air Force) have had multiple meetings to develop a Space Weather Science Applications Project (SnAP) to enable more effective translation of NASA-funded space weather research into operations.**
- **See Terry Onsager's invited presentation (IN42B-06) on Thursday morning at 11:35 A.M. for more details.**



Summary

- **SPoRT's R2O/O2R paradigm that has resulted in 15+ years of success for terrestrial weather can be applied to space weather challenges**
- **Forecaster pull for MAG4 enabled opportunity to demonstrate proof of concept; transition focused on four specific forecast challenges collaboratively identified with SWPC**
- **Feedback from SWPC forecasters and management has been positive regarding the approach of forecaster engagement and implementation of R2O solutions**
- **Further expansion of work will be enabled through NASA's SnAP activities, which aims to connect NASA with NOAA, DoD, NSF, universities, and the private sector community**



Questions / Comments / Discussion

Website: <http://weather.msfc.nasa.gov/sport/>

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discussions/collaborative opportunities

