

National Aeronautics and
Space Administration



Applying the SPoRT Paradigm to Transitioning the Near Real-Time MAG4 Solar Event Forecast Model into Space Weather Operations

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MARSHALL
SPACE FLIGHT CENTER



Marshall Science Across the Universe

Earth Science

- Weather, Energy and Water Cycle, Surface Processes, Atmospheric Modeling
- Lightning physics, processes, instrumentation
- Research to Applications (SPoRT, SERVIR, Disaster Detection and Monitoring)
- Data Science and Informatics (IMPACT)

Astrophysics

- Black Holes, Neutron Stars, Nebula, and Pulsars in the X-ray
- Gamma-ray Bursts
- Extreme-energy Particles and their Sources

Heliophysics

- Solar Transition Region and Magnetic Atmosphere
- Thermal Plasma/Plasmasphere Modeling, Analysis, and Instrument Development
- Ionospheric Disturbances
- Space Weather R2O/O2R

Planetary Science

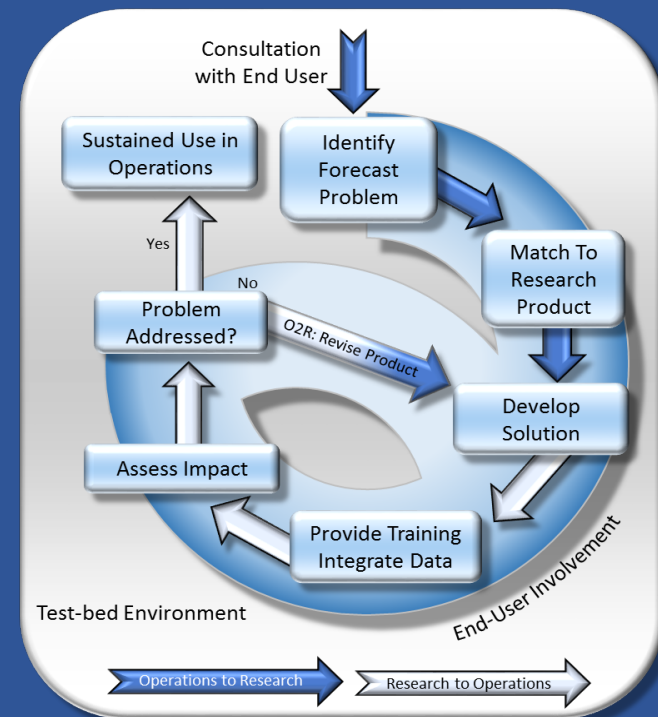
- Planetary Missions Program Office
- Planetary Surfaces and Interiors
- Science Integration with Exploration Capabilities

Marshall science research spans SMD divisions

SPoRT R2O/O2R Paradigm

Short Term Prediction and Research Center
MSFC Earth Science

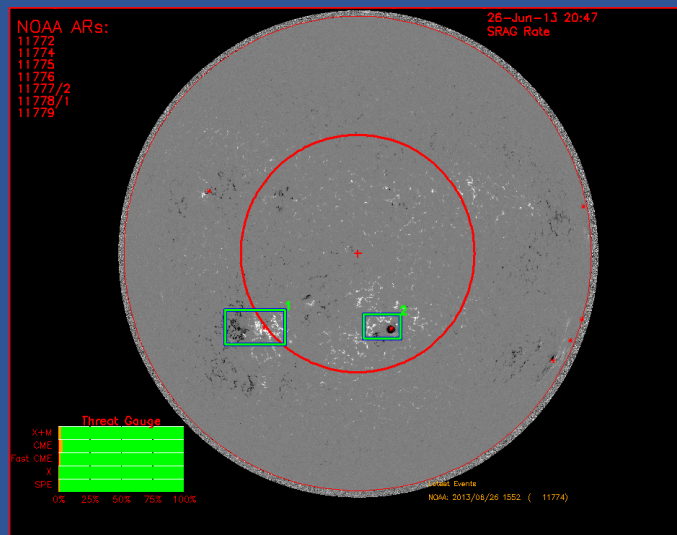
- Bridge the “Valley of Death” through interactive partnership with end users
 - Maintain interactive partnerships with help of specific advocates
 - Integrate into user decision support tools
 - Create product training
 - Perform targeted product assessments
- Concept has been used to successfully transition more than 40 satellite datasets to operational users for nearly 18 years
- **SPoRT-like approach is a candidate to take space weather transition “the last mile”**



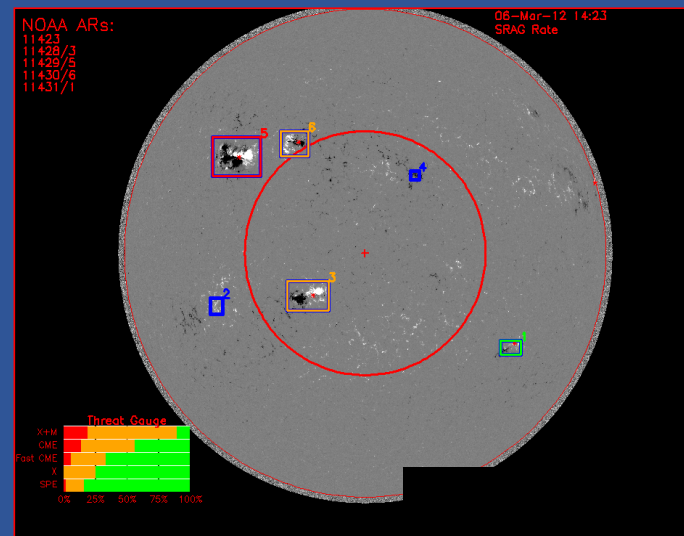
Overview of MAG4

- 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 active regions
- Provides guidance on pre-flare/CME probability

All Clear Example: 26 June 2013



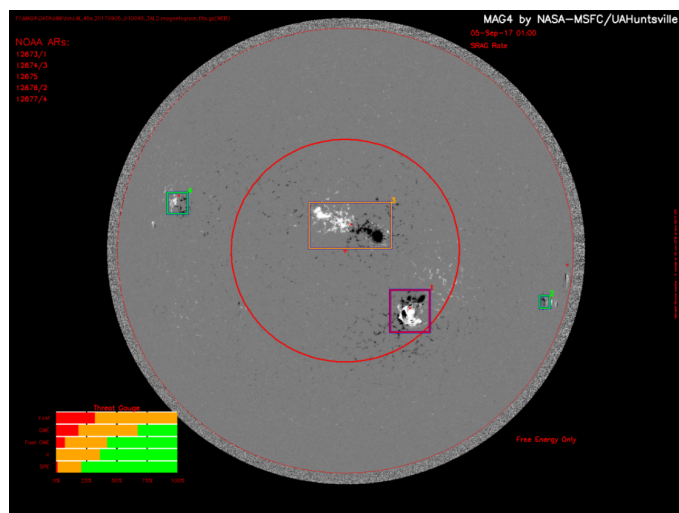
High Threat Example: 7 March 2012



MAG4 Product Improvements

Results – Assessment and Forecaster Feedback

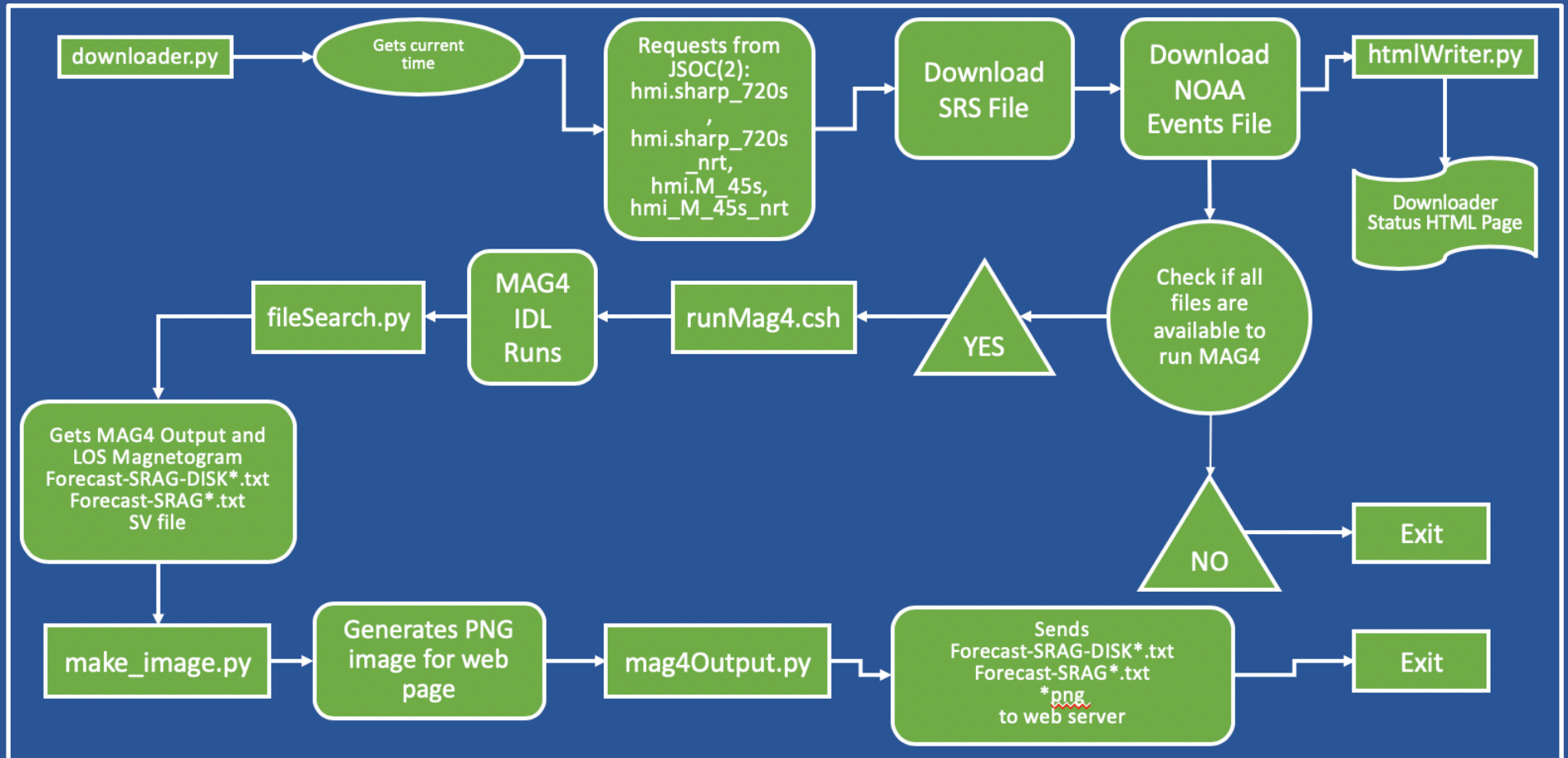
- September 2017 CME event processed and reproduced on archive website for demonstration due to low level of solar activity in summer 2018
- Testbed activity walked forecasters through their forecast process leveraging training to show ways products like MAG4 would add value to forecast process
- Quantitative 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	SBW16	87%	55%	26%	26%	10%	17	109

Workflow of MAG4 Downloader and Display



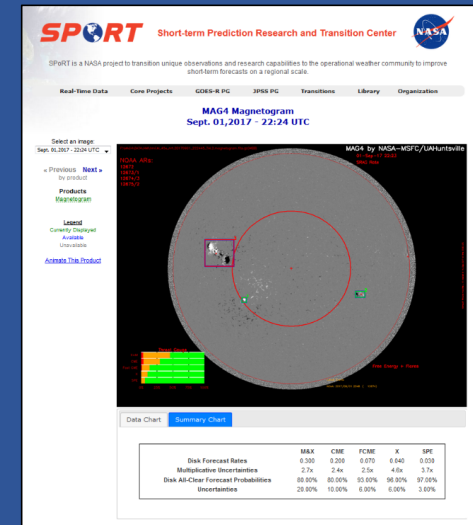
Transition Activities with NOAA/SWPC

- Website (top right) where real-time MAG4 output flows into SPoRT processing; allows animation and previous history
- Training slides (bottom right) on the use and interpretation of the product using instructional design techniques to reinforce learning concepts
- Testbed assessment for forecasters to evaluate product impacts alongside other operational forecasting tools; short 5-minute Likert scale survey to capture feedback and communicate success metrics
- Weekly telecons with SWPC lead forecaster throughout the development cycle.



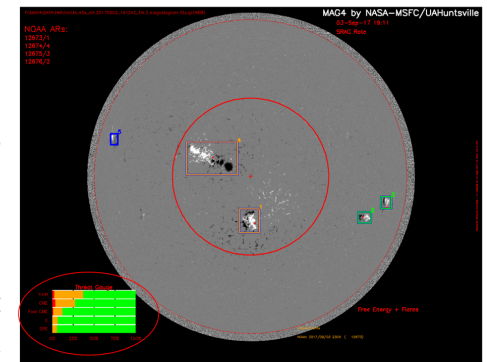
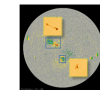
Slide from short training module for MAG4 developed at SPoRT

**MAG4
Example
on SPoRT
website**



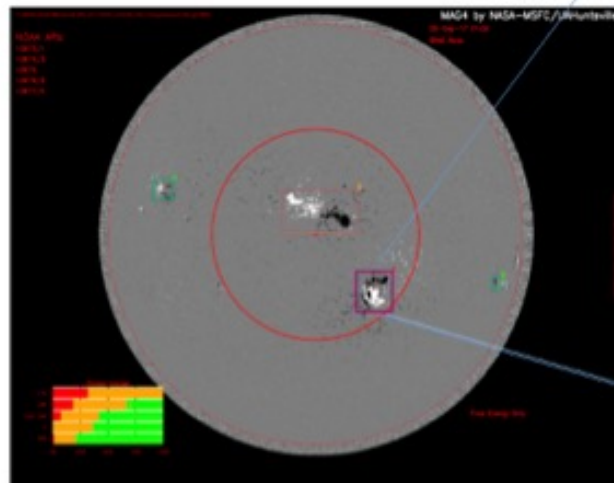
Application Example

- Based on the observational data from the highlighted ARs, what can you say about the future threat of flares? CMEs? Other events? Rate and magnitude of these events?
- What is your prediction based on?
- With MAG4, threat predictions are calculated based on empirical relationships between magnetic free energy and event rates



Additional MAG4 Product Improvements

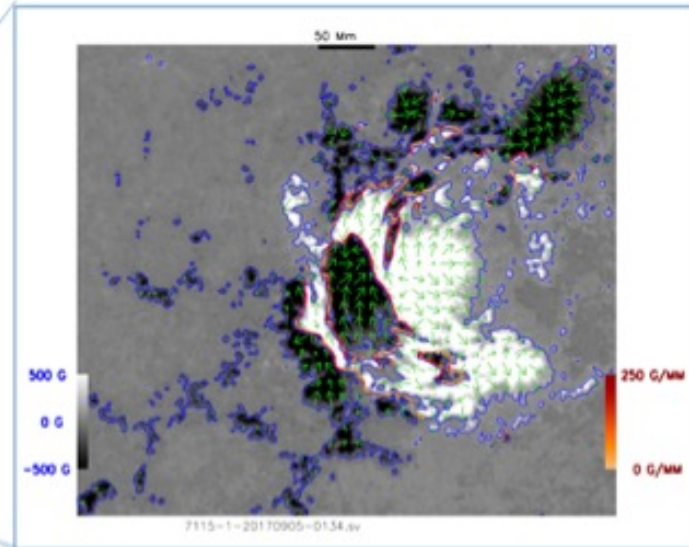
Assessing the Space Weather Threat
AR 12673 Sep 5 2017 01:00 UT



	MLI	CME	FCME	X	SPE
Next 24-Hour Forecast Probabilities	20%	40%	70%	20%	60%
Next Probability of Event	30%	60%	30%	30%	50%
Uncertainties	20%	30%	50%	50%	20%
Risk Category	Low	Low	Chance	Chance	Slight Chance

AR#	#	Location	MLI	CME	FCME	X	SPE	Distance	BL ₁₀
Units								Degrees	10
12673	1	S09W	17%	55%	20%	20%	10%	11	100

Full Disk Magnetogram with Threat Gauge and Solar Event Probabilities



Active region (AR) zoom (with overlays)
Improves MAG4 Decision Support Tool Value.

SPoRT/MAG4 Collaboration
FY18/FY19

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

MSFC Space Weather R2O/O2R

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- SPoRT's R2O/O2R paradigm has resulted in 17+ years of success for terrestrial weather
- SPoRT's seed-funded testbed activity demonstrates paradigm can be applied to space weather challenges
- SPoRT paradigm provides an opportunity to establish a bridge between research community and operational forecasters for terrestrial / space weather applications
- Requires access to Near Real Time satellite data and processing to enable advanced Space Weather forecast products

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