

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

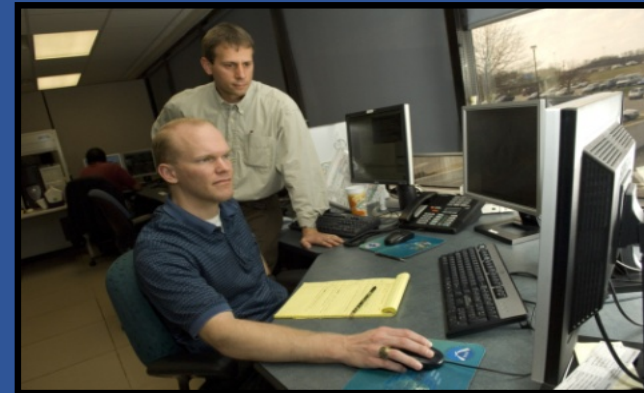
Planetary Science

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

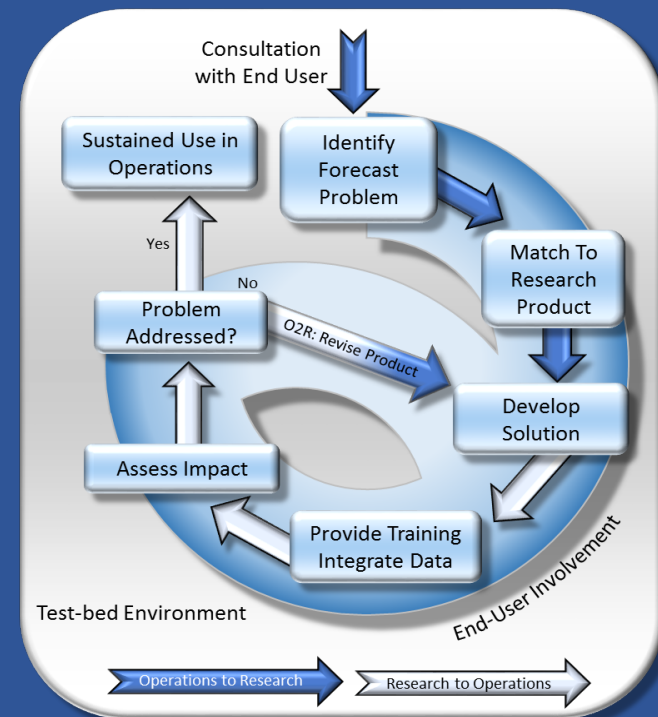
Marshall science research spans SMD divisions

SPoRT R2O/O2R Paradigm

Short Term Prediction and Research Center
MSFC Earth Science



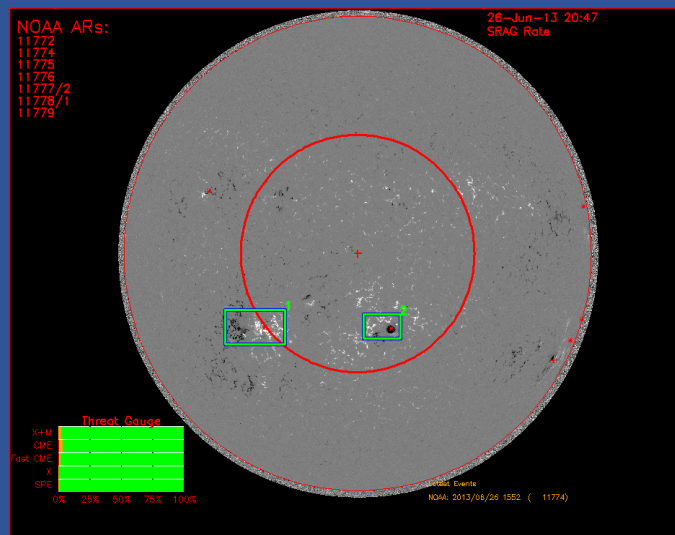
- Bridge the “Valley of Death” through interactive partnership with end users
 - Maintain interactive partnerships with help of specific advocates
 - Integrate into user decision support tools
 - Create product training
 - Perform targeted product assessments
- Concept has been used to successfully transition 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”**



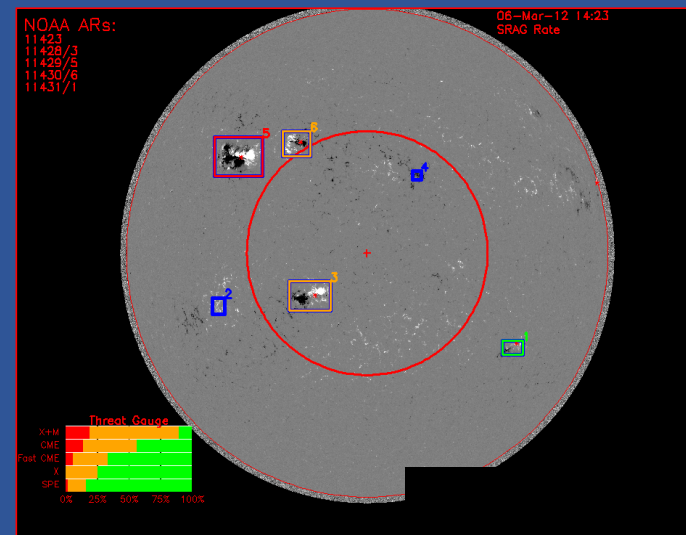
Overview of MAG4

- 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



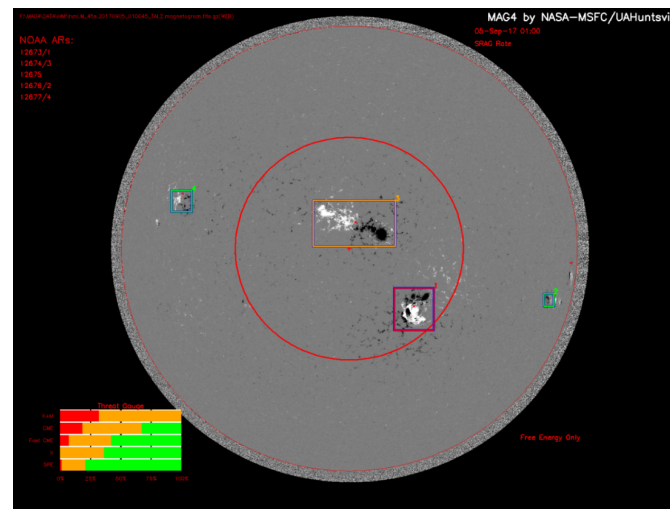
High Threat Example: 7 March 2012



MAG4 Product Improvements

Results – Assessment and Forecaster Feedback

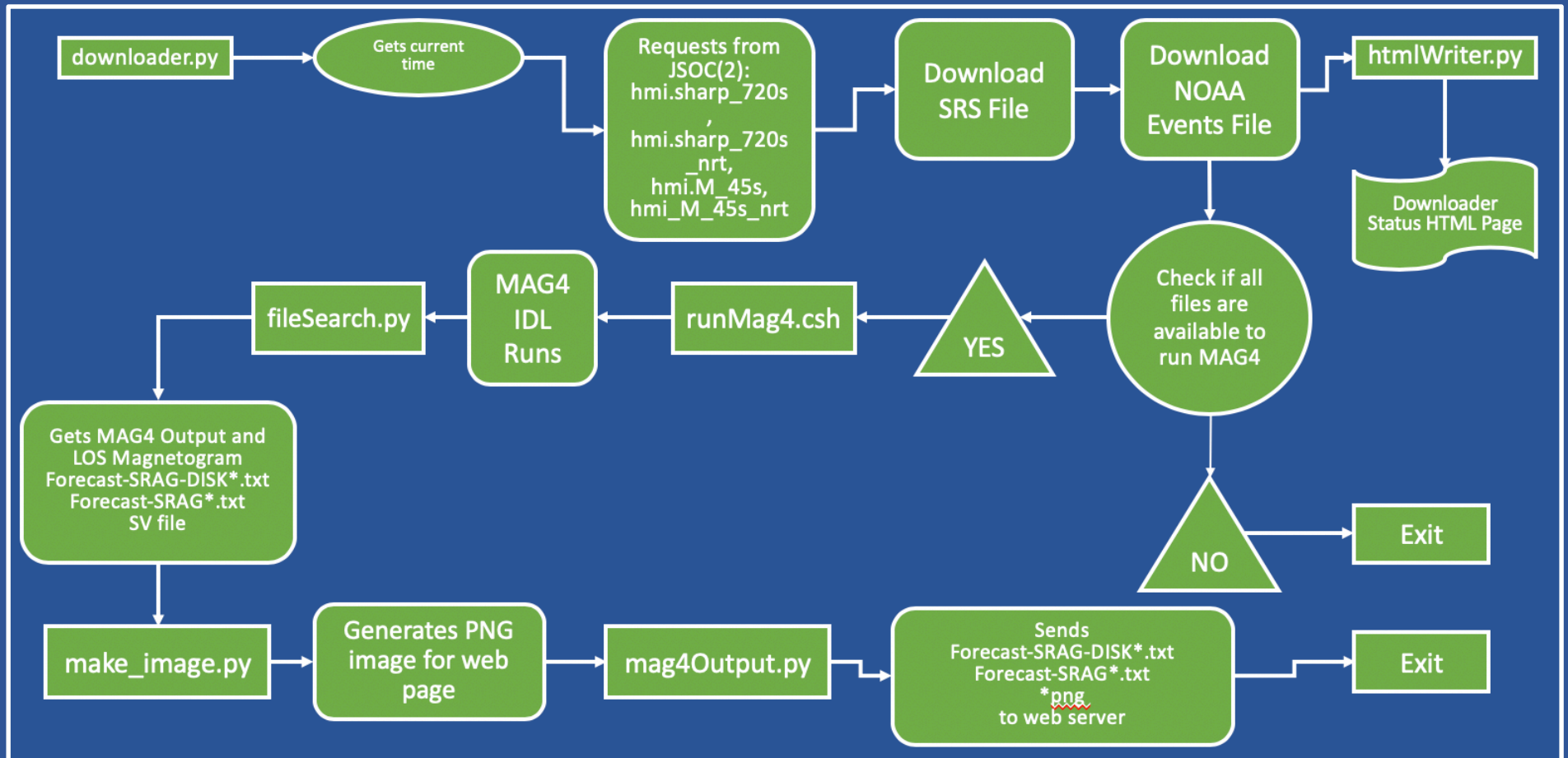
- September 2017 CME event processed and reproduced on archive website for demonstration due to low level of solar activity in summer 2018
- Testbed activity walked forecasters through their forecast process leveraging training to show ways products like MAG4 would add value to forecast process
- Quantitative 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 ₅₀ kG
12673	1	SBW16	87%	55%	26%	26%	10%	17	109

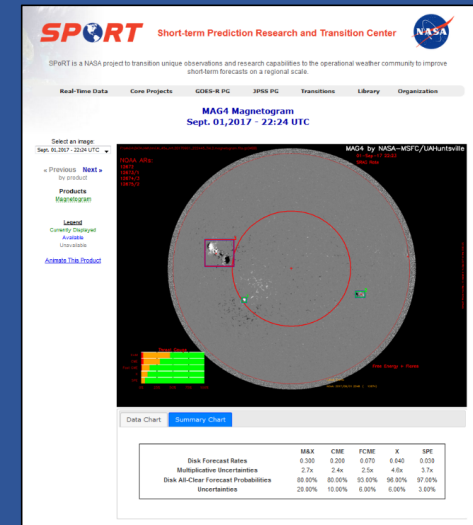
Workflow of MAG4 Downloader and Display



Transition Activities with NOAA/SWPC

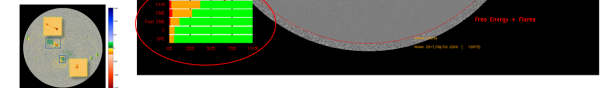
- Website (top right) where real-time MAG4 output flows into SPoRT processing; allows animation and previous history
- Training slides (bottom right) on the use and interpretation of the product using instructional design techniques to reinforce learning concepts
- Testbed assessment for forecasters 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.

**MAG4
Example
on SPoRT
website**



Application Example

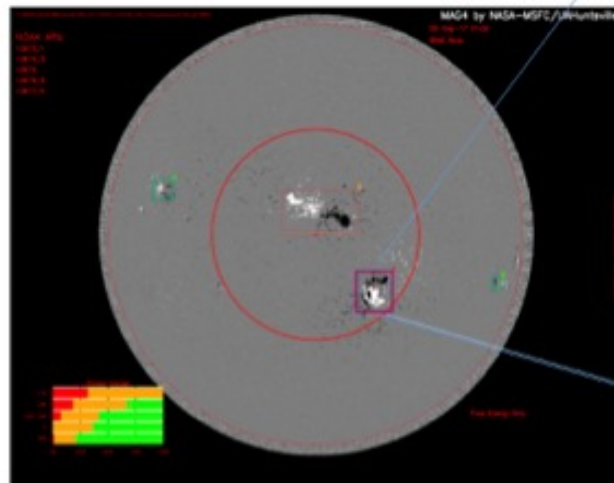
- Based on the observational data from the highlighted ARs, what can you say about the future threat of flares? CMEs? Other events? Rate and magnitude of these events?
- What is your prediction based on?
- With MAG4, threat predictions are calculated based on empirical relationships between magnetic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



Slide from short training module for MAG4 developed at SPoRT

Additional MAG4 Product Improvements

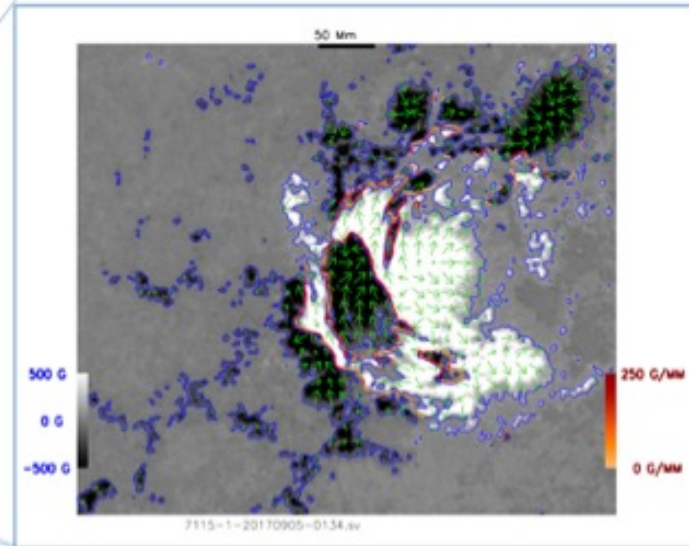
Assessing the Space Weather Threat
AR 12673 Sep 5 2017 01:00 UT



	MFL	CME	FCME	X	SPE
Event Ad-Clear Forecast Probabilities	20%	40%	70%	20%	90%
Event Probability of Event	80%	60%	30%	30%	10%
Uncertainties	20%	20%	50%	50%	20%
Risk Category	Low	Low	Chance	Chance	Slight Chance

AR	#	Location	MFL	CME	FCME	X	SPE	Distance Degrees	BL ₁₀ kG
AR12673	1	S09W	17%	33%	20%	20%	10%	11	130

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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