

Applying the NASA SPoRT R2O/O2R Paradigm to Space Weather: MAG4 Applications and Assessment at SWPC

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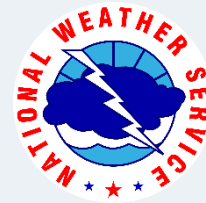
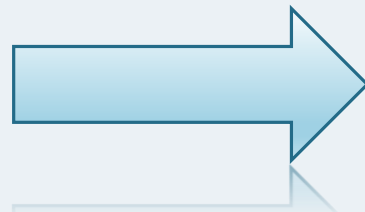
⁴NASA MARSHALL SPACE FLIGHT CENTER

Short-term Prediction Research and Transition (SPoRT) Center

SPoRT is focused on transitioning **unique** NASA and NOAA observations and research capabilities to the operational weather community to improve short-term weather forecasts on a regional and local scale.

- close collaboration with numerous WFOs and National Centers across the country
- SPoRT activities began in 2002, first products to AWIPS in 2003
- co-funded by NOAA since 2009 through satellite “proving ground” activities

Proven paradigm for transition of research and experimental data to “operations”



Benefit

- demonstrate capability of NASA and NOAA experimental products to weather applications and societal benefit
- prepares forecasters for use of data from next generation of operational satellites (JPSS, GOES-R)

NASA Missions and SPoRT Capabilities



Sentinel-6A/B ■

Earth Science Instruments on ISS:

RapidScat
 CATS
 LIS ■
 SAGE III (on ISS)
 TSIS-1
 OCO-3
 ECOSTRESS ■
 GEDI
 CLARREO-PF
 TSIS-2



Remote Sensing

Lightning

Modeling and Data
Assimilation

Develop and transition/assimilate value-added products

- Terra, Aqua, S-NPP imager and sounder data prepared forecasters for GOES-R and JPSS
- GPM and SMAP fill critical atmospheric and land surface observation gaps

Engage with upcoming missions to leverage R2O/O2R expertise

- Early Adopters for ICESat-2, SWOT, and NISAR
- Science Team participation with ECOSTRESS, TEMPO, and TROPICS

SPoRT O2R/R2O

Match forecast problem with experimental products

Provide multiple avenues of training

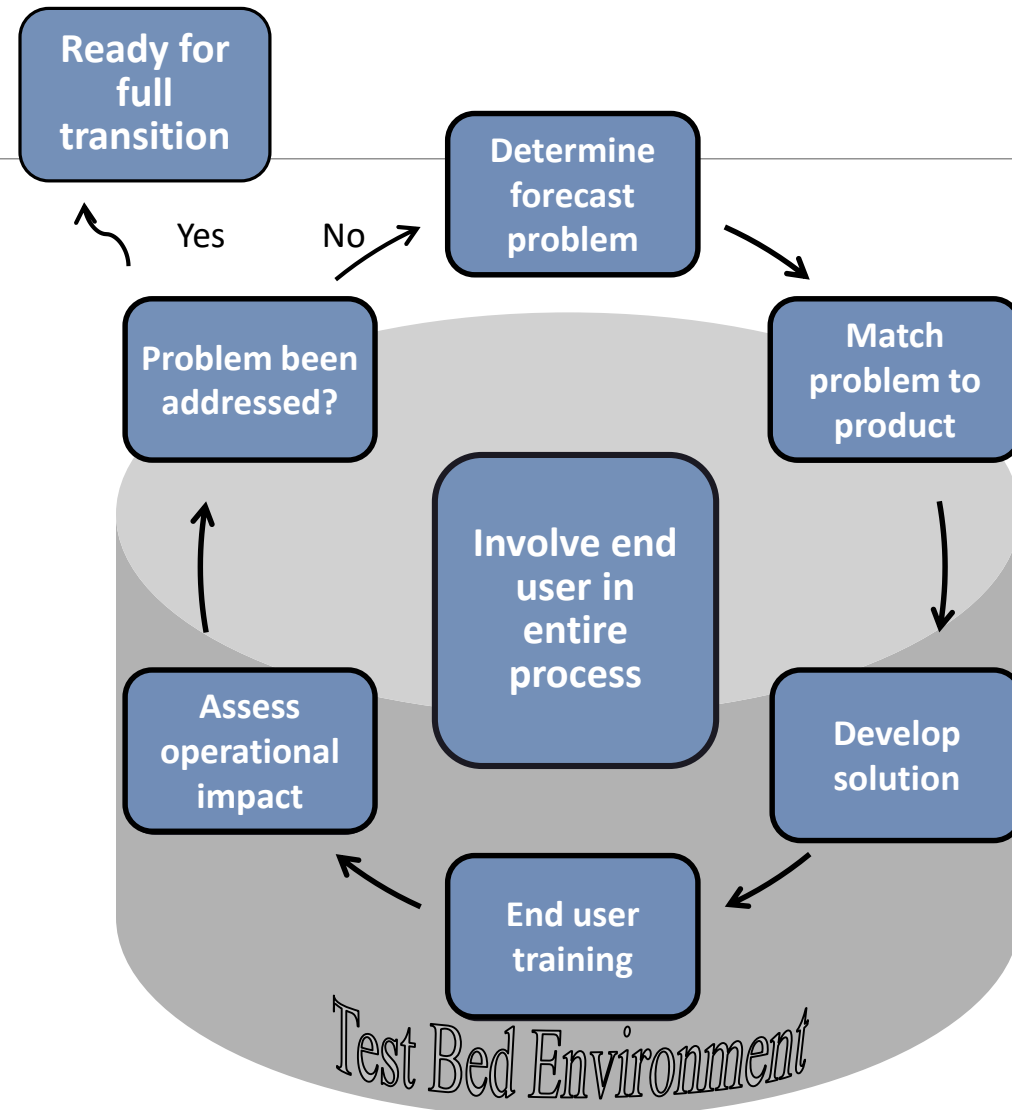
- Tele-training
- Online video and self-guided modules
- Quick Guides
- On-site training (when feasible)
- Wide World of SPoRT blog (peer-to-peer training)

Feedback given in online form, emails, calls, etc.

Trial (testbed)

- For experimental products
- Less intensive assessment

Reports and recommendations published at SPoRT website



Training

Goal: to provide applications-based training that is relatively quick to complete

~Self-paced training modules, Quick guide reference sheets, applications library items, in-person training, blog posts

Forecasters provide helpful feedback to improve training

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

The image displays a composite of three screenshots related to the NASA SPoRT training platform. The top screenshot shows the main website navigation with a header menu (HOME, RECENT TRAINING / ASSESSMENTS, TRAINING PROGRAM OVERVIEW, CONTACT, APPLICATIONS LIBRARY, ASSESSMENTS, QUICK GUIDES) and a large banner for "NASA SPoRT Training" over a satellite map. Below the banner is a section for the "GPM SWATH RAIN RATES TRAINING MODULE" with a post date of August 19, 2016, by Jennifer Redstreak Geary. The middle screenshot shows a blog post titled "THE WIDE WORLD OF SPoRT" with the tagline "Fostering interaction between product developers and end users" and a search bar. The bottom screenshot is a video player for the "GPM Swath Rain Rates Training Module_2016" (00:22 / 16:53). The video content includes an "Introduction" section with "Objectives of module" listed as: -Describe benefits of GPM swath rain rates and how it derives rain rates; -Identify where you should have high/low confidence in the GPM swath rain rates; -Use GPM rain rates in operations with complementary products. The video player also features a sidebar menu with 15 items, a user profile for Anita LeRoy, and a NASA logo at the bottom.

Assessment Process

SPoRT Assessments

- Short (4-8 weeks) and intensive (aim for 1 survey per day)
- One or several products that meet similar needs
- Formal assessments preceded by formal teletraining, with product developers whenever possible, and access to training Quick Guides
- Forecasters often share insight during SPoRT partner calls
- Use of online form and email follow-ups to acquire actionable feedback for product developers

NASA GPM Swath Rain Rates and IMERG Assessment 2016

Question Page

NWS Office ID
Choose ▾

Name (optional):
Your answer

Email (optional):
Your answer

Feature Date :
Choose the date of the event, not the date of the survey
MM DD YYYY
_ / _ / 2016

Time of Shift:
 Day
 Evening
 Night

Training
Please check all that apply:

The screenshot shows the SPoRT Assessments website. At the top, there is a navigation bar with links for HOME, RECENT TRAINING / ASSESSMENTS, TRAINING PROGRAM OVERVIEW, CONTACT, APPLICATIONS LIBRARY, ASSESSMENTS, and QUICK GUIDES. Below the navigation bar is a header with the word "Assessments" and the SPoRT logo. The main content area is titled "ASSESSMENTS" and contains a paragraph of text explaining the purpose of the surveys. Below this text is a section titled "Current Assessments – '2 Minute' Feedback Forms" which features a small image of a satellite map and a link to "GPM Swath Rain Rates and IMERG Rain Rates". To the right of the main content area, there are two sidebars. The first sidebar is titled "GO TO TRAINING" and has a "Select Category" dropdown menu. The second sidebar is titled "TRAINING MATERIALS:" and lists several training materials, including "Application Assessments", "aviation Multispectral (RGB) Imagery", "QPE/QPF Quick Guide", "satellite Meteorology", and "Total Lightning". At the bottom of the page, there is a "Provide Feedback" button with a pencil icon.

MAG4 Background

Near-realtime forecast tool to predict the 24 hour event rate of flares, CMEs, fast CMEs, and SPEs for active regions.

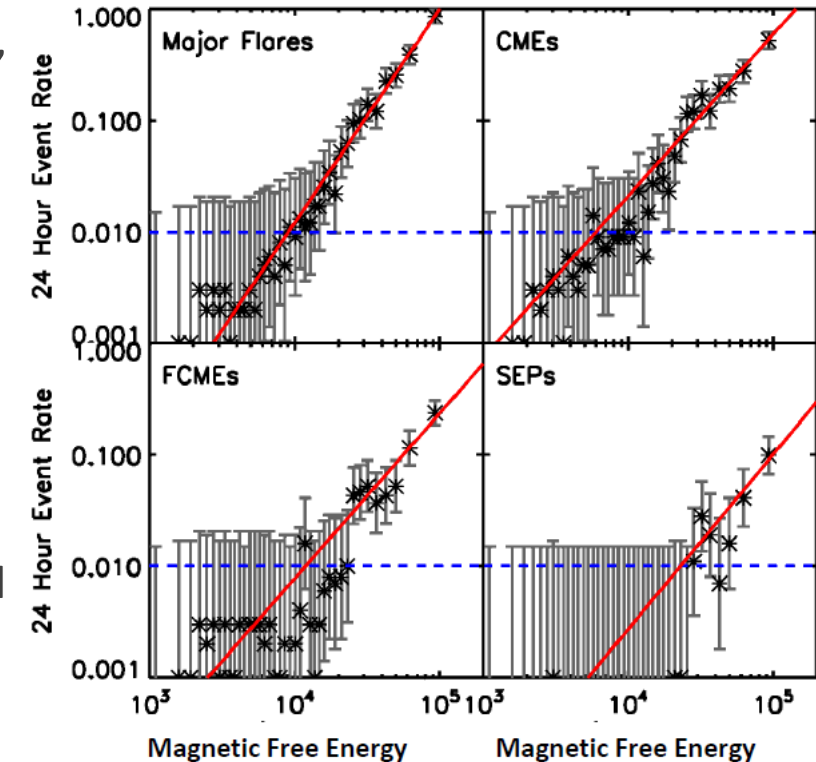
Output is probabilities (not necessarily timing/impact/magnitude)

Comprises a database of MDI/HMI magnetograms

- Approx. 40,000 active region magnetograms
- Approx. 1300 active regions

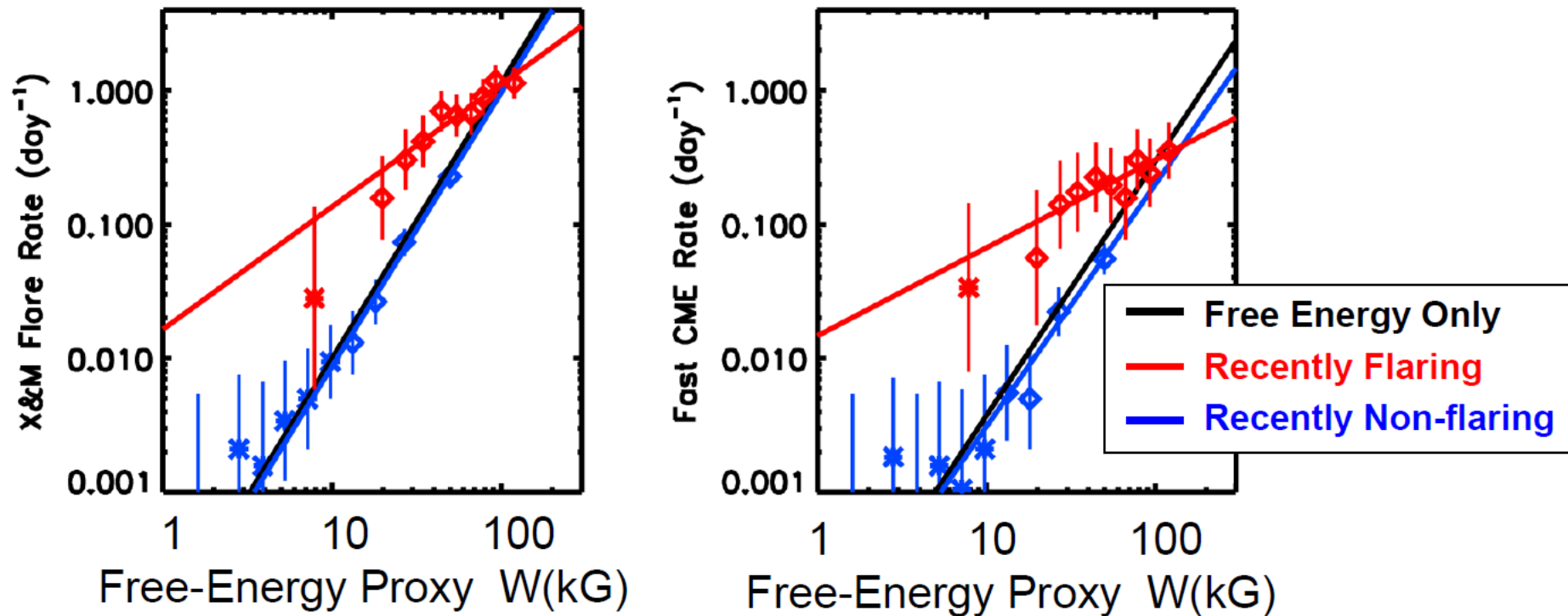
Forecasting curves (currently using MDI curves)

- Utilizes a power-law relationship between free magnetic energy proxy and event rate
 - Free energy proxy: integral of the gradient along the neutral line in an AR



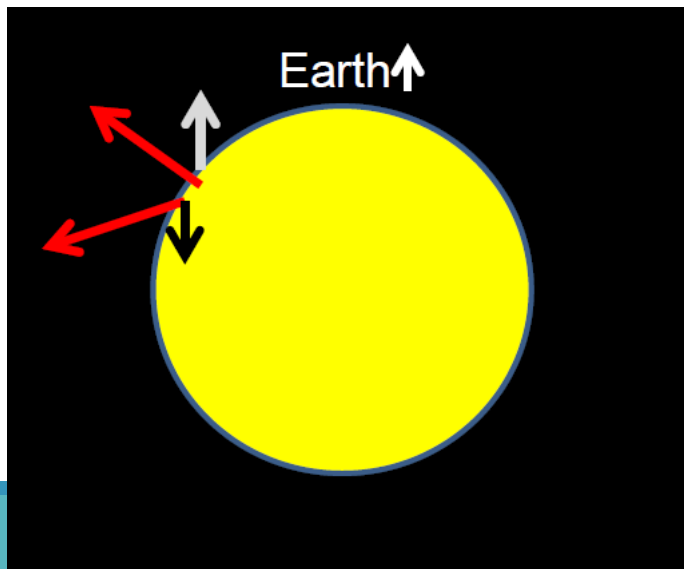
Using Prior Flare Activity

- Active regions that have recently produced an X- or M-class flare are more likely to produce flares in the near future



Using Vector Magnetograms

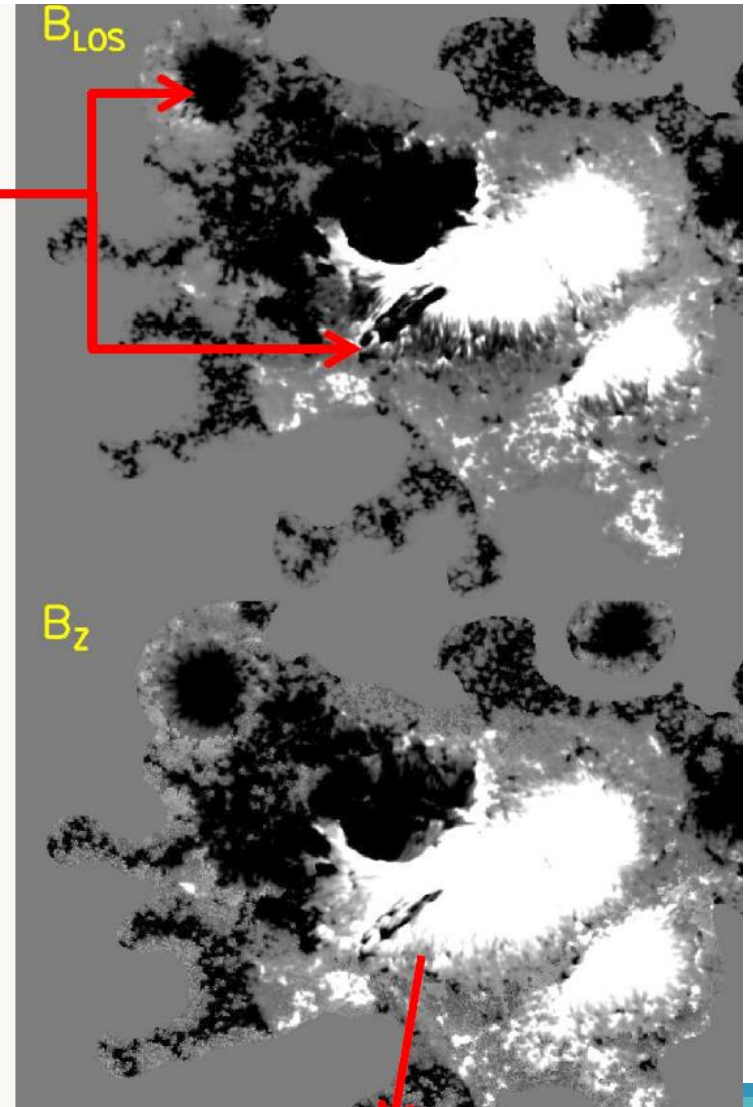
- Vectors out of the sun have positive B_z but opposite sign B_{LOS}
- Leads to an unphysical neutral line in the line-of-sight field
- Vector magnetograms mitigate this effect and improve the event probabilities limbward



Actual Examples

False Neutral Lines occur on limbward sides of sunspots.

Problem fixed by converting from B_{LOS} and $B_{Transverse}$ to B_z and $B_{Horizontal}$



Limbward

MAG4 Modes

Using free energy proxy and line-of-sight magnetograms

Using free energy proxy and previous flare history of active region using line-of-sight magnetograms

Using free energy proxy and deprojected HMI vector magnetograms

Using free energy proxy and previous flare history of active regions using deprojected HMI vector Magnetograms

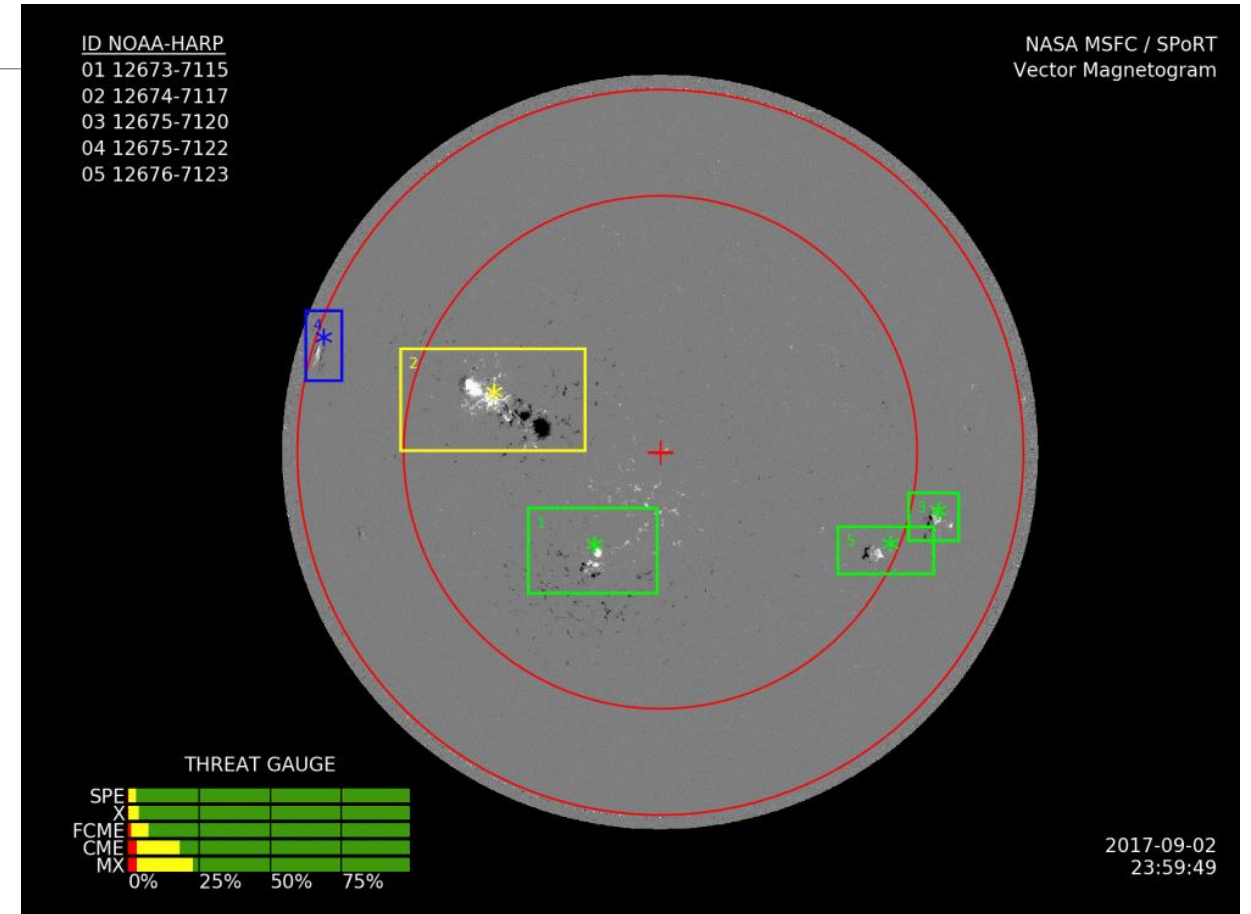
SPoRT version of MAG4 incorporates flare history and can be run in vector or LOS mode

Under development: using HMI forecasting curve (which will likely have smaller error bars than the MDI forecast curve)

MDI forecast
curve

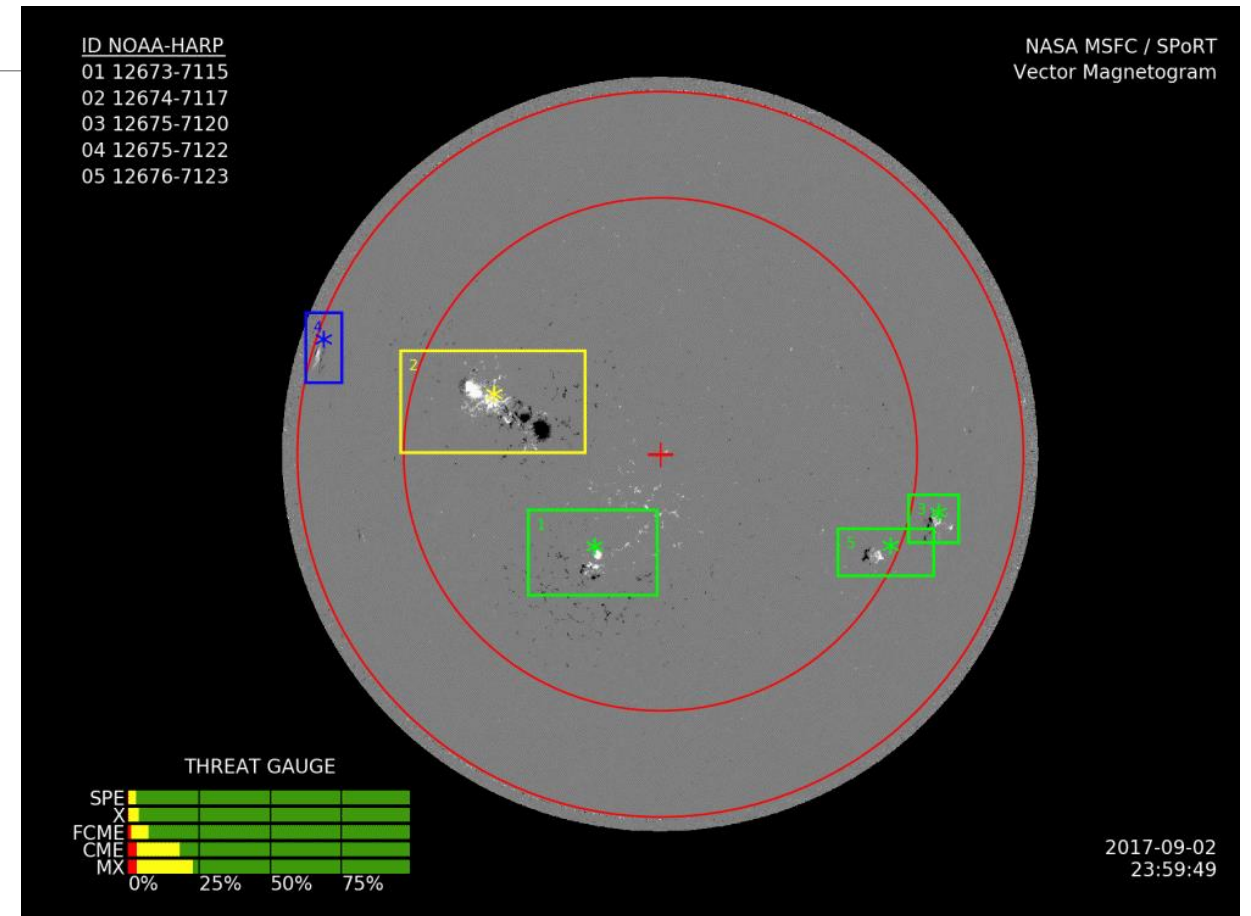
MAG4 Display and Threat Gauge

- Numbering shows each AR's MAG4 ID, its NOAA AR number, and its HARP tile number
- Outer circle is the edge of the solar disk
- Inner circle is 45 degree ring, where we expect forecasts to be most accurate
- Boxes are places around ARs
 - Scaled with +/-500 G magnetic flux
 - Green box: < 0.02 events/day
 - Yellow box: 0.02-0.2 events/day
 - Red box: > 0.2 events/day
 - Blue box: no NOAA active region assigned
 - Curved box: When a part of an AR appears in another box (i.e., highly overlapped), HMI active region masks are used instead.
- The Threat Gauge shows the probability of each type of event. Yellow bar is the 1-sigma error for that threat probability



MAG4 Display and Threat Gauge

- Users at SWPC requested some changes to a previous version:
 - Preferred a website
 - Clearer fonts and colors for text
 - Half-hourly cadence of data
 - “Fail gracefully”, i.e., messages that indicate whether product is down or product is not producing data due to lack of solar activity

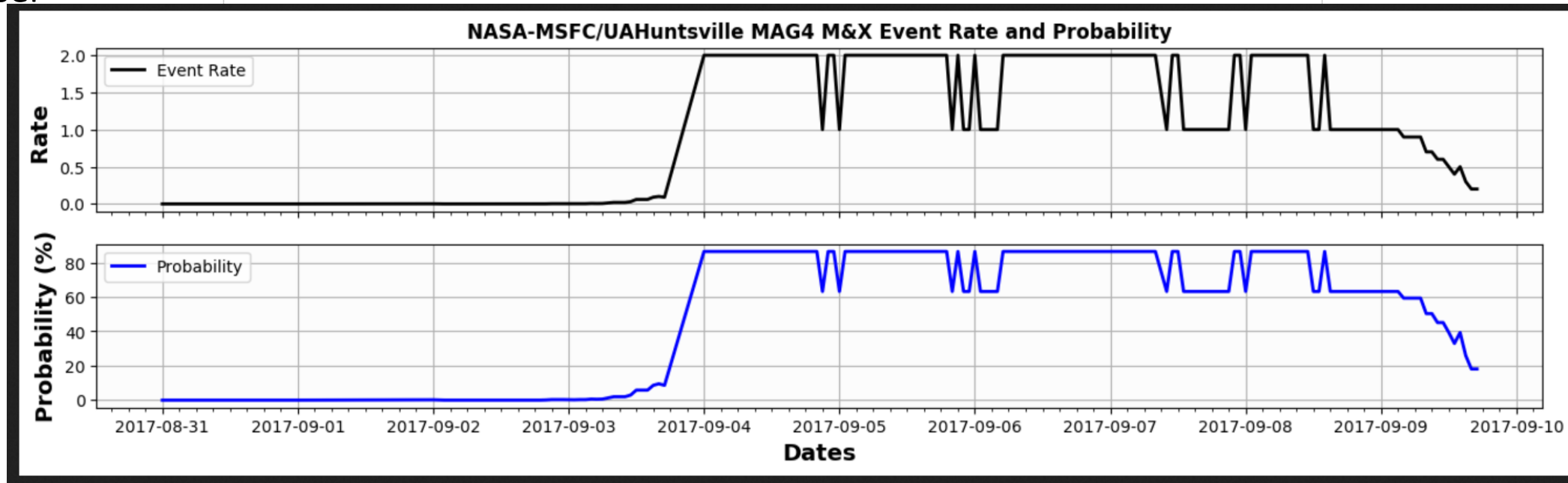


MAG4 Output and Tables

- By request:
 - Trends in ARs
 - Full disk vs AR tables
 - Risk Categories that match end user categories

Active Regions - Rates
Active Regions - Probabilites
Full Disk - Rates
Full Disk - Probabilities

	M&X	CME	FCME	X	SPE
Disk All-Clear Forecast Probabilities	97%	98%	99%	99%	99%
Disk Probability of Event	3%	2%	1%	1%	1%
Uncertainties	3%	2%	1%	1%	1%
Risk Category	Null				



MAG4 Webpage

Can be found here:

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

Available in Realtime and Archived modes

Training Link available on the page

Training is “applications-based” and self-paced

AL Anita LeRoy

MAG4 Training 2019

START COURSE DETAILS

SPORT

MAG4 forecasts solar activity from line-of-sight magnetograms using methodology developed at the University of Alabama-Huntsville.

- Objective and Motivation
- Background
- Output and Threat Levels
- Detailed Example

MAG4 Magnetogram Realtime

Links to: [MAG4 Magnetogram Archive Page](#) | [MAG4 Training Module](#)

Select a Date: 2019-10-22 20:00 UTC

2019-10-22 at 20:00UTC

ID NOAA-HARP EXPERIMENTAL NASA MSFC / SPoRT Line-of-Sight Magnetogram

THREAT GAUGE

SPE X FCME CMX

0% 25% 50% 75%

2019-10-22 20:00:00

No information available at this time.

Conclusions

- SPoRT transition center is working to evaluate the MAG4 product in operations
- MAG4 forecasts X and M flares, CMEs, Fast CMEs, and SPEs
- Forecasts are probabilistic
- Operational product produces an output display, a threat gauge, quantitative tables, and a timeline of AR activity