SPACE ENVIRONMENT TECHNOLOGIES
*Space Weather Division*

**CME Scorecard**

# Operational specification and forecasting advances for Dst

## CCMC Workshop 2014
## April 3, 2014

**W. Kent Tobiska**, Ramkumar Bala, Bruce Bowman, D. Bouwer, J. Bailey, Delores Knipp, W.J. Burke, M.P. Hagan, J. Gannon

# Areas of ongoing improvements for operational Dst

## Dst forecasting issues

- Customer-driven forecasts
- Operational systems
  - ✓ "Stream A" primary forecasts (ENLIL/Rice)
  - ✓ "Stream B" backup forecasts (Anemomilos)
- Metrics & CCMC CME Scorecard

# 1. Customer-driven forecasting

- USAF Space Command requires operational Dst to drive JB2008 thermospheric density model
- Fully redundant systems is a customer requirement:
  - ✓ Facilities
  - ✓ Servers
  - ✓ Algorithms
  - ✓ Input data stream sources
  - ✓ Output data stream indices

# SET Facilities and Servers

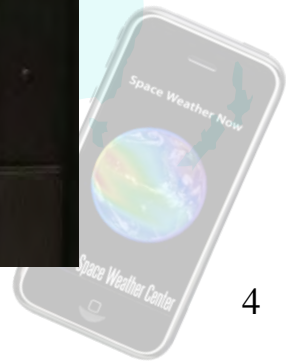
Denver USAF support servers

Logan USAF support servers

Tobiska *et al.*

http://spacewx.com

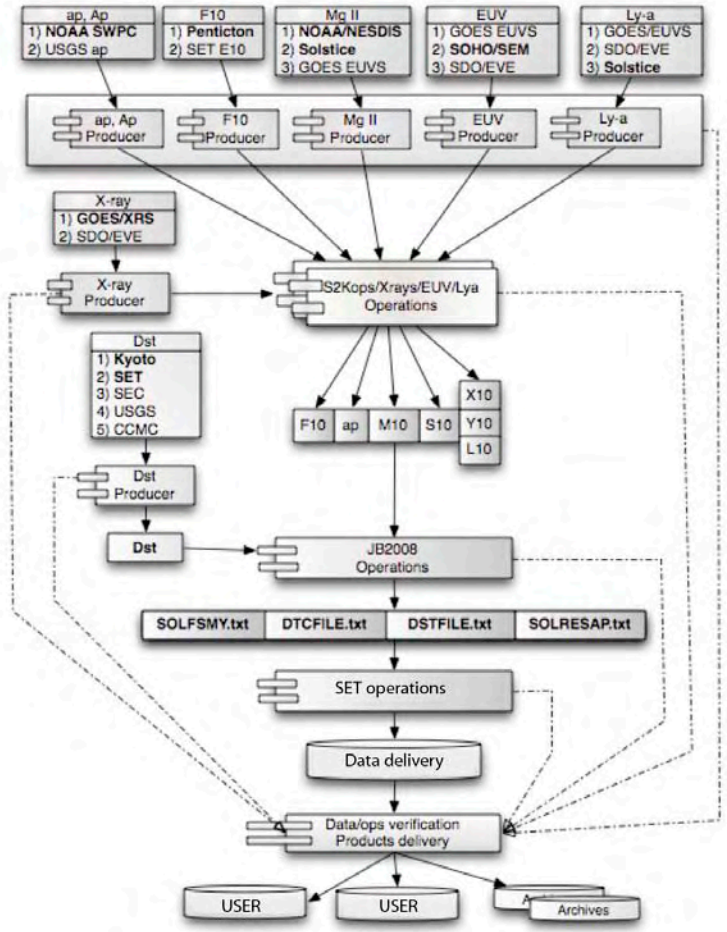
*SpaceWeather* app



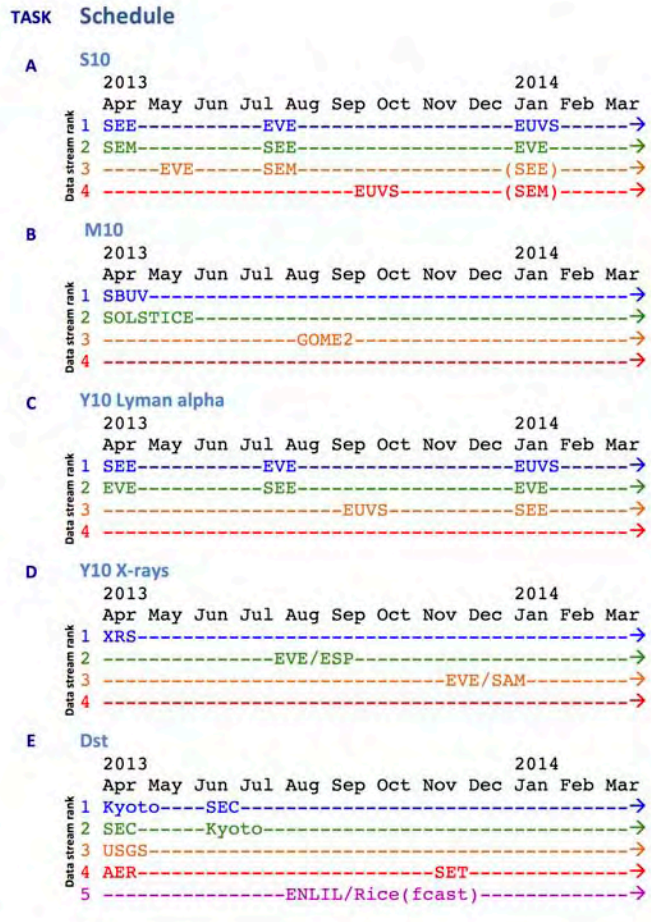
CME Scorecard

# Algorithms & Data streams

## Algorithm and data stream architecture




## Data streams upgrades



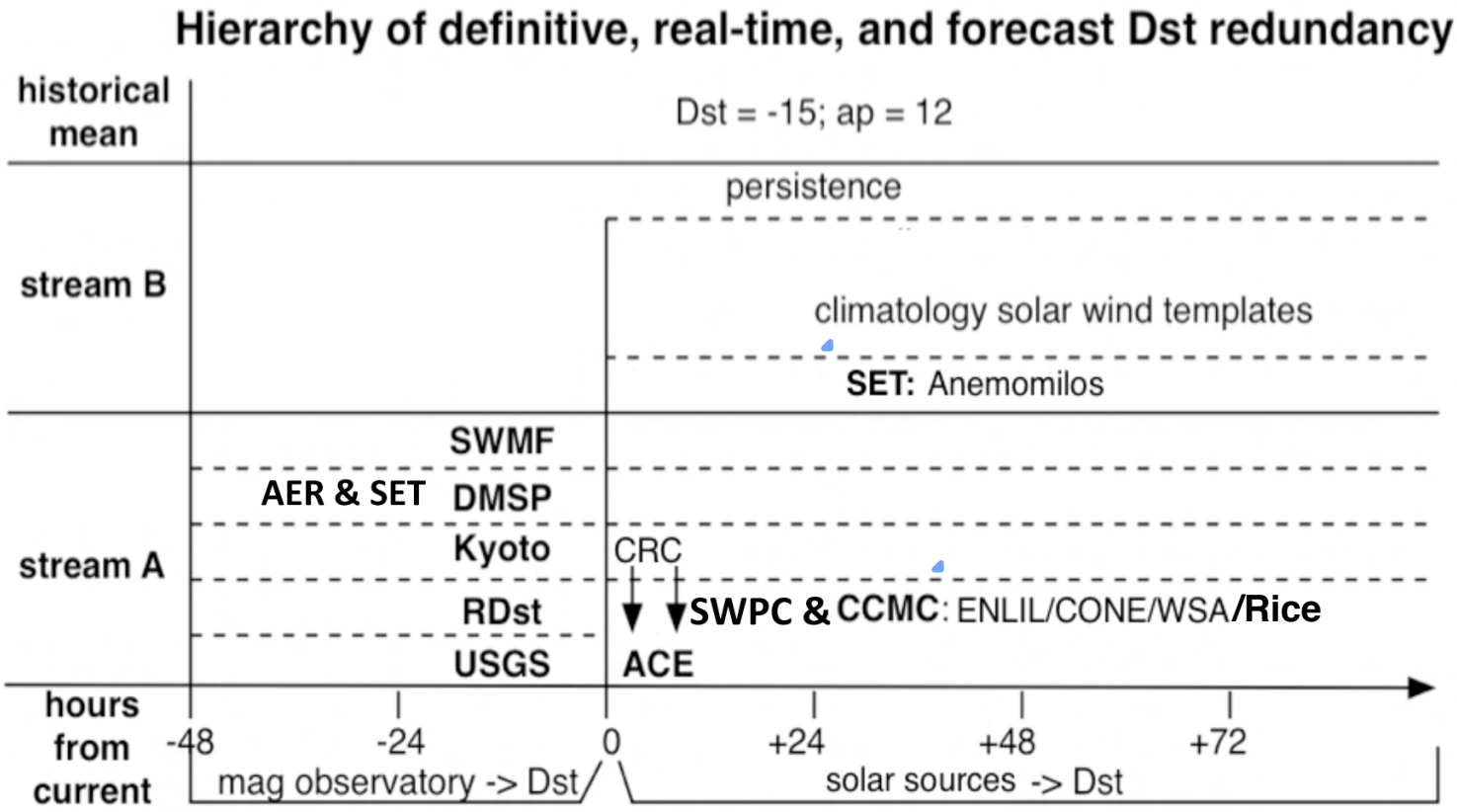

Tobiska *et al.* http://spacewx.com *SpaceWeather* app

# 2. Operational Dst status

- ✓ Primary (stream "A"): ENLIL/Rice Dst forecasts
- ✓ Backup (stream "B"): Anemomilos Dst forecasts
- ✓ http://sol.spacenvironment.net/~sam_ops/index.html?
- ✓ Citation: Tobiska, W. K., D. Knipp, W. J. Burke, D. Bouwer, J. Bailey, D. Odstrcil, M. P. Hagan, J. Gannon, and B. R. Bowman (2013), The Anemomilos prediction methodology forDst, SpaceWeather, 11, 490–508, doi:10.1002/swe.20094.

CME Scorecard

# Operational Dst requirement: -48 to +72 hours with 3-hour granularity, 3-hour latency

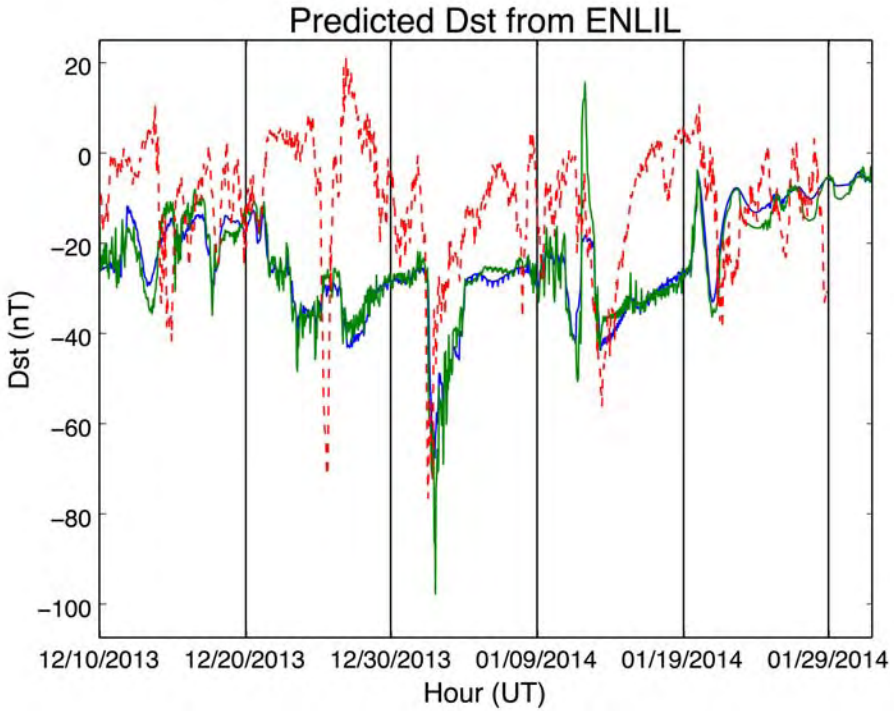


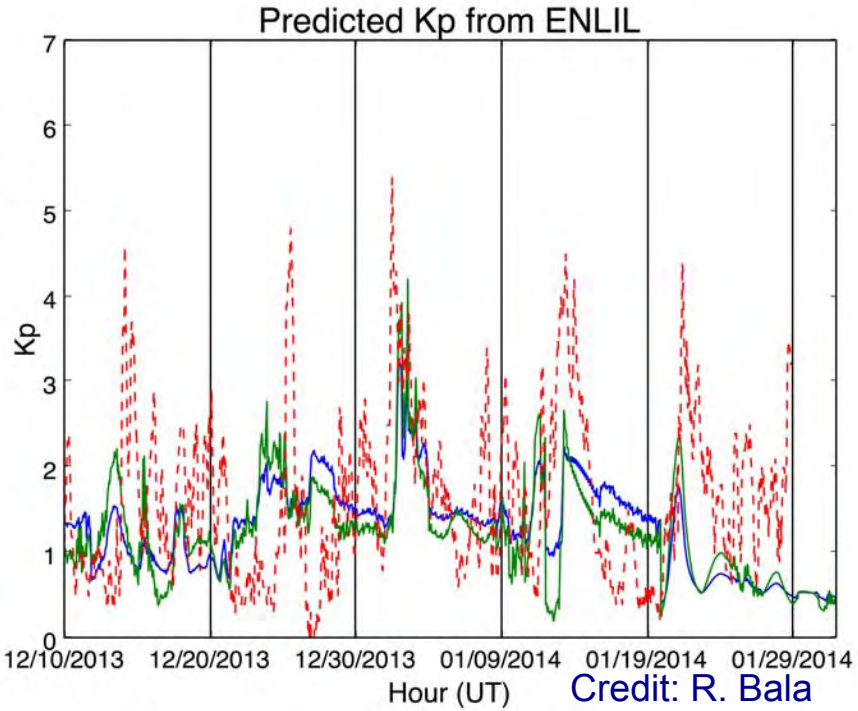

**Operational goal achieved: redundant Dst, ±6-days with 1-hour granularity and 1-hour latency**

# CME Scorecard

## ENLIL/Rice Prime Dst Forecast and ACE Comparison

- ACE near-realtime predictions are plotted here in red
- http://mms.rice.edu/realtime/forecast.html
- ENLIL/Rice models under predict but largely in line with the trend and are within acceptable range
- Magnetospheric activity on the New Year's day is well captured



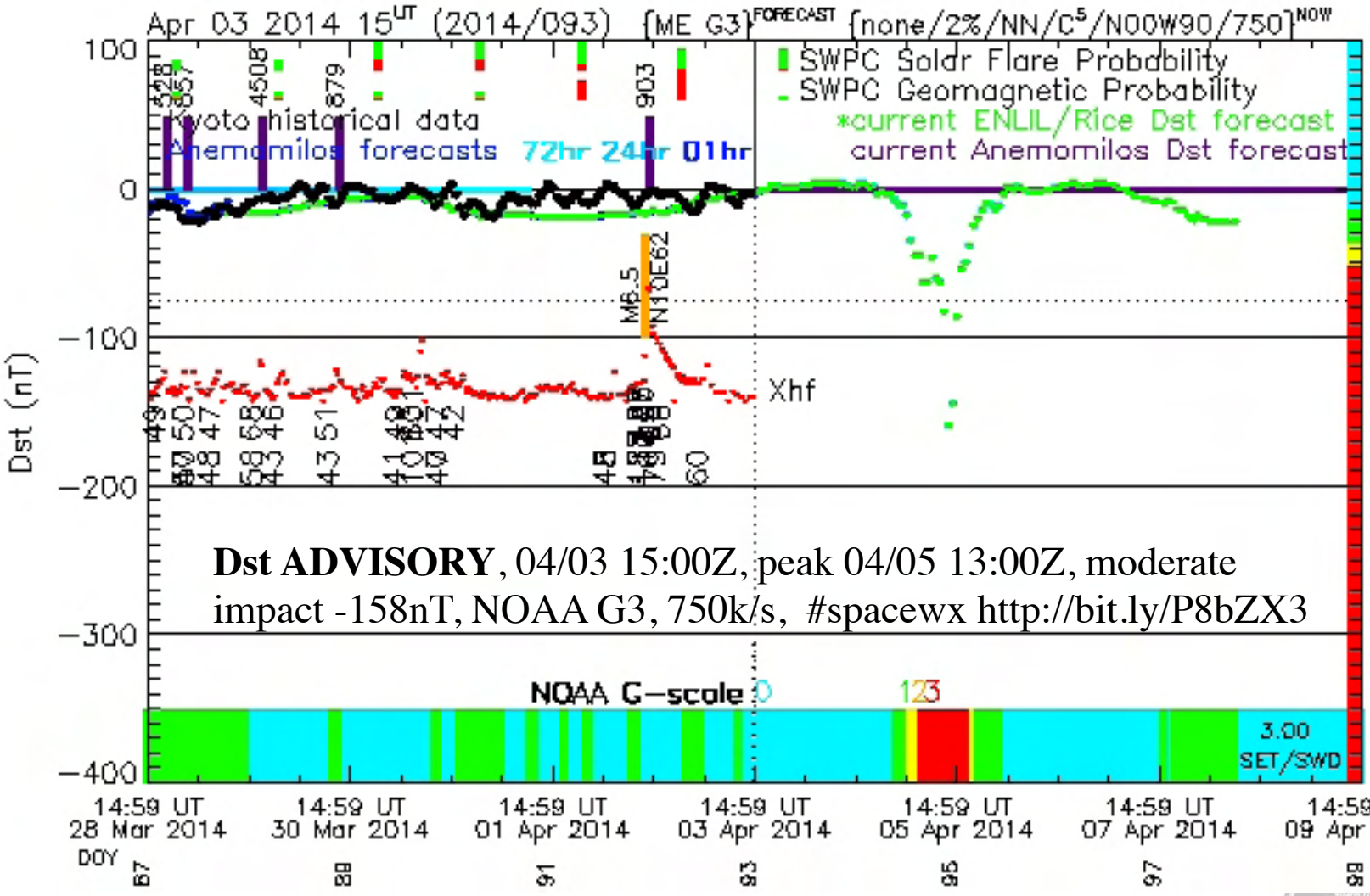

Credit: R. Bala

Tobiska *et al.* http://spacewx.com *SpaceWeather* app

SPACE ENVIRONMENT TECHNOLOGIES
*Space Weather Division*

# CME Scorecard

## ENLIL/Rice Prime and Anemomilos Secondary



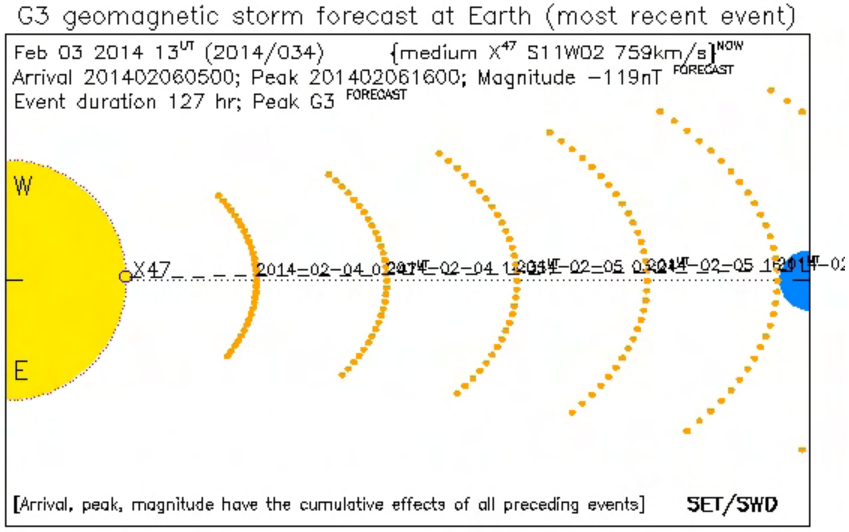

**Dst ADVISORY**, 04/03 15:00Z, peak 04/05 13:00Z, moderate impact -158nT, NOAA G3, 750k/s, #spacewx http://bit.ly/P8bZX3

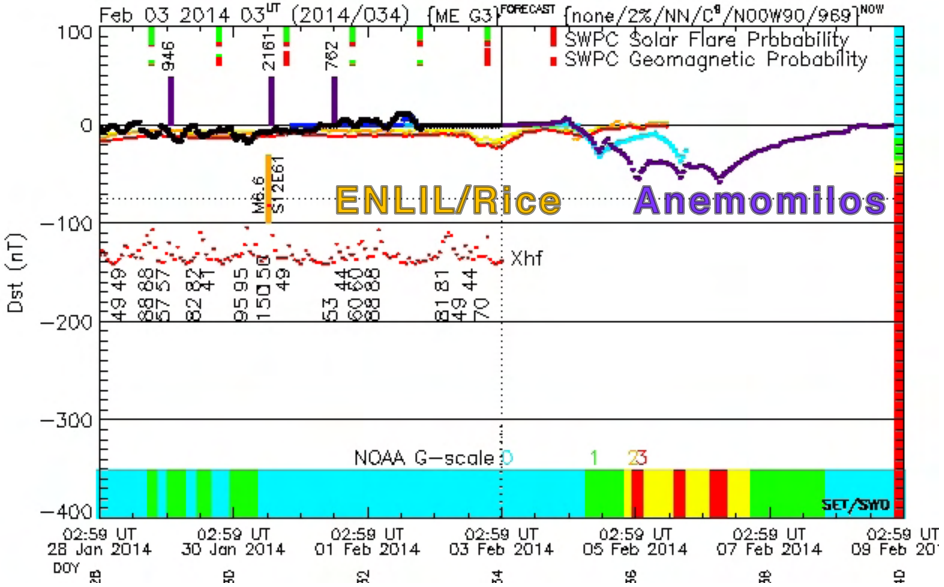
Tobiska *et al.* http://spacewx.com *SpaceWeather* app


9

# CME Scorecard

## SET's operational Dst forecasting



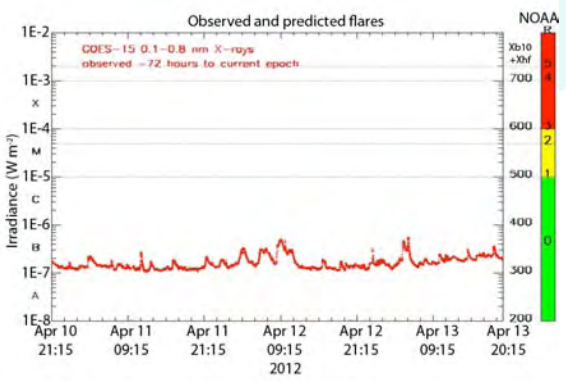

- *Anemomilos* is the Greek word for "windmill"
- The data-driven deterministic algorithm uses **3 solar observables** to identify geoeffective events: **http://sol.spacenvironment.net/~sam_ops/index.html?**
- It has a **15-minute cadence**, **1-hour time granularity**, **144-hour prediction** window (+6 days), and 1-hour latency
- Most flare events above a certain irradiance threshold, occurring within defined solar longitude/latitude regions and having sufficient liftoff velocity of ejected material, will produce a geoeffective Dst perturbation

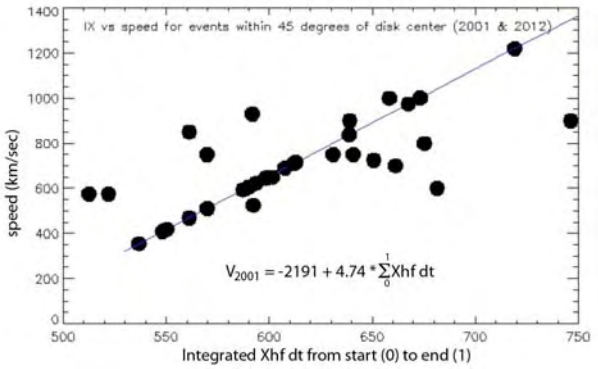
# CME Scorecard

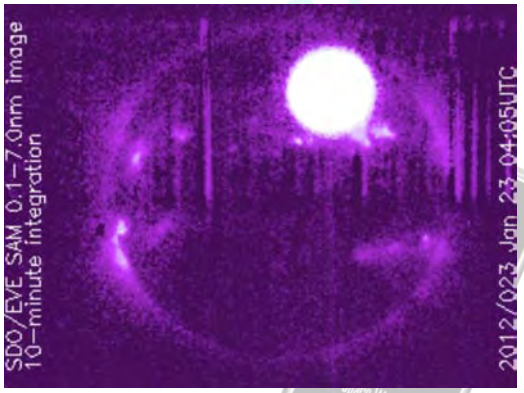
## Anemomilos Basis

**Three solar observables are used for operational Dst forecasting: flare magnitude, integrated flare irradiance, and event location**

- Magnitude is a proxy for ejecta quantity (mass) and, combined with speed derived from the integrated flare irradiance, represents the kinetic energy
- Speed is estimated as line-of-sight velocity for events within 45° radial of solar disk center
- Solar disk, not limb, observable features are used for predictive techniques based on SDO/EVE/SAM centroid of flare event



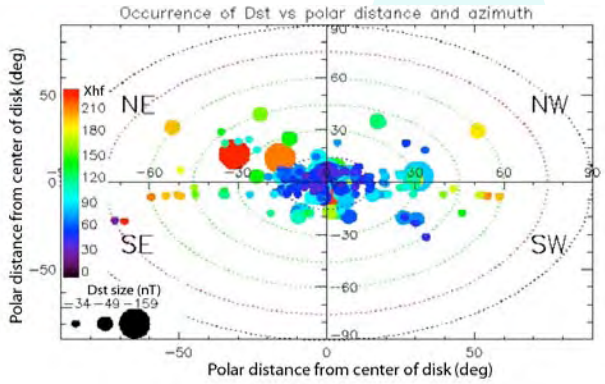



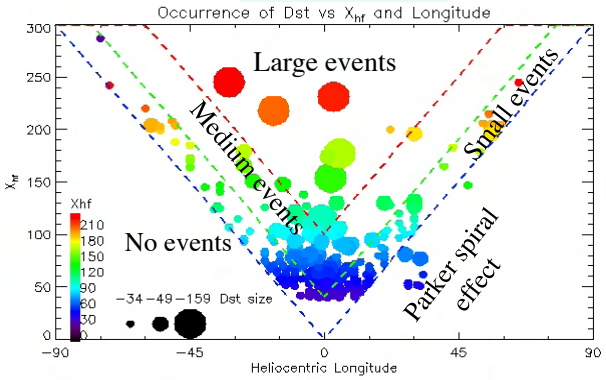
# Anemomilos geoeffectiveness of location

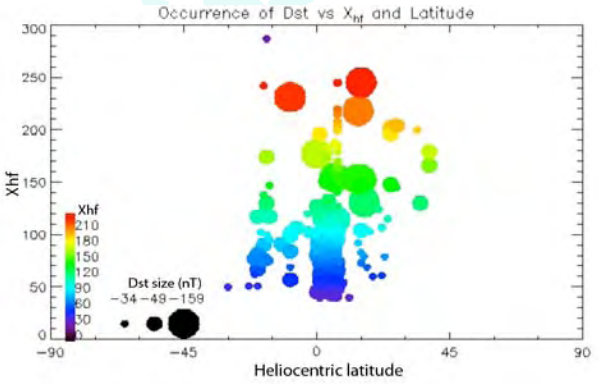
Occurrence of Dst vs Xhf in solar latitude & longitude (25 months)

- 2001 (Jan-Jul), 2005 (Mar-Sep), 2011-2012 (Dec-Nov)

Resulting Dst event size can be sorted by Xhf size and flare longitude/latitude



# 3. Metrics & CME Scorecard

- Metrics – in progress (skill score)
- CME Scorecard value to developer
  - Enables comparison with other forecast methods for identifying strengths and weaknesses
  - Allows a consistent cross-comparison for many methods
  - Enables potential users to identify capabilities of methods
- CME Scorecard suggestions for upgrades
  - Automated download of events from developer sites
  - Skill score table