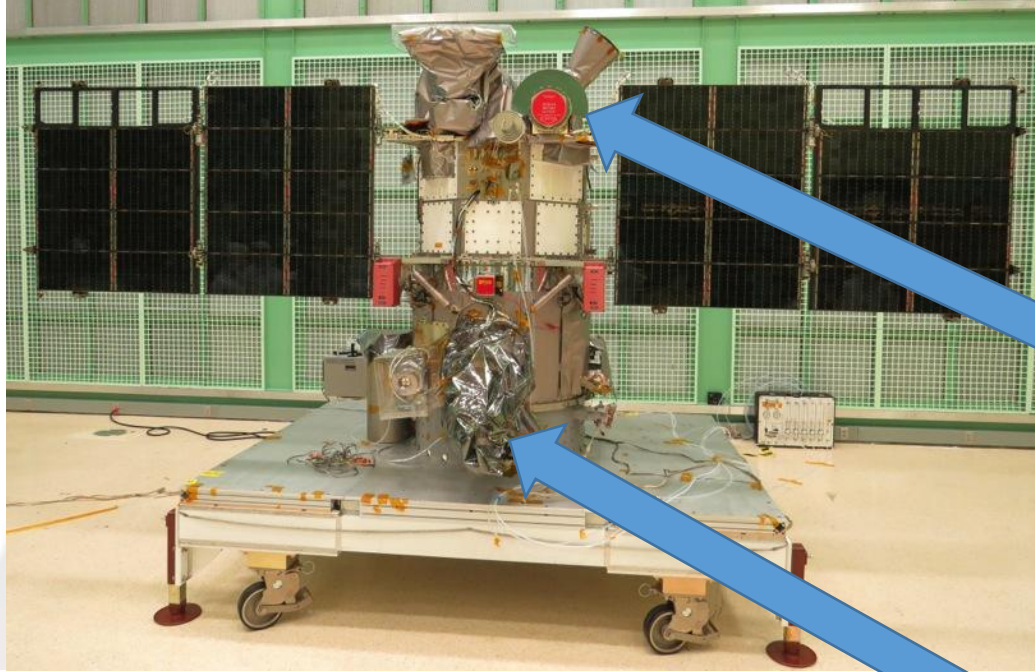




DSCOVR Halfway to L1

Doug Biesecker and the entire DSCOVR team
SWPC, NGDC, NESDIS, GSFC, USAF, CfA, UMich, SpaceX
NICT, KSWC, DLR



The instruments

Alan Lazarus Faraday Cup

CfA/UofMich & MIT

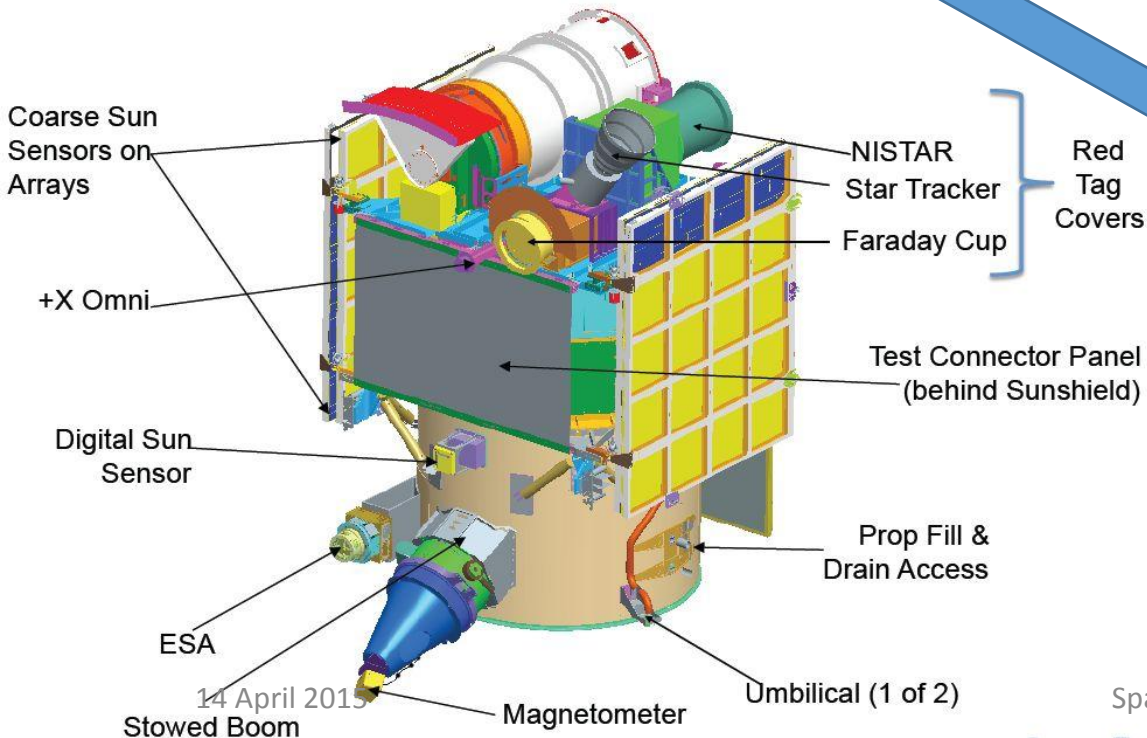
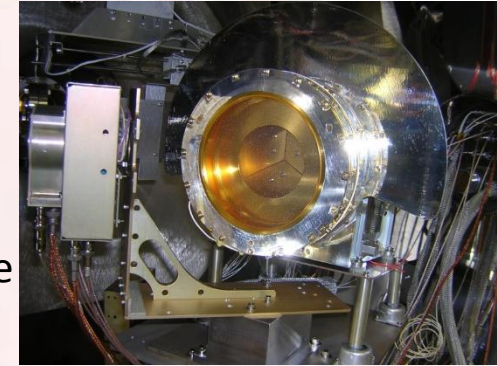
Solar wind protons and alphas

speed, density & temperature

high time resolution

~0.5 sec in peak tracking mode

~2.5 sec in full sweep mode

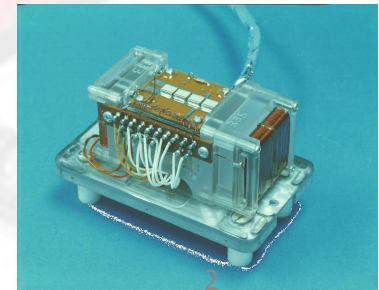


Tri-axial fluxgate Magnetometer

NASA/GSFC

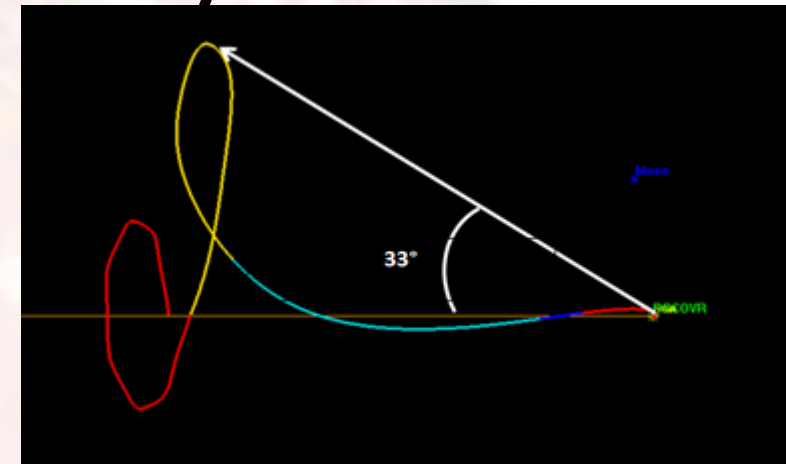
Interplanetary 3-d magnetic field

high time resolution (50 Hz)



The journey to L1 – 53% of the way there

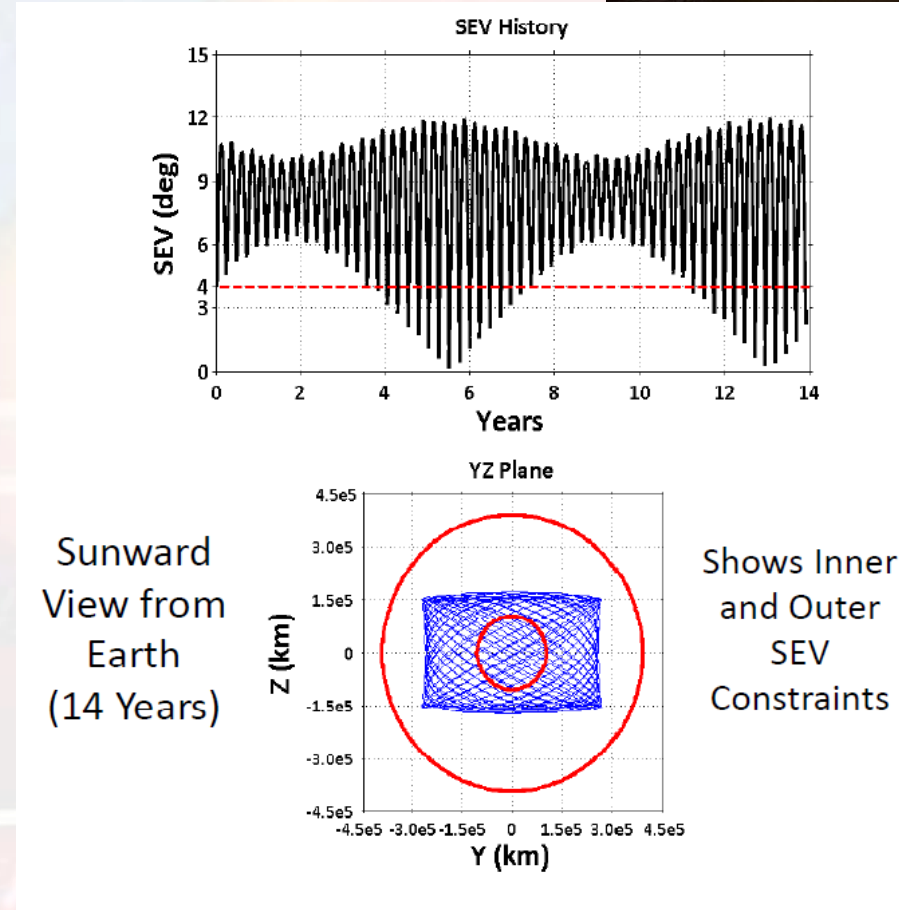
- Feb 11 – Launch
- Feb 15 – Magnetometer turned on and boom deployed
- Feb 17 – Faraday Cup HV turned on
- Apr 14 – Today: Mission Elapsed Time (MET 62 days)
- Apr 27 - Mid Course Correction 2 (burn of ~2 seconds)
- Jun 7-8 - Lissajous Orbit Insertion
 - MET: 116 days
 - 5 hour burn
- Preliminary estimate is ~10 years of fuel
- Transition from NASA to NOAA expected in July



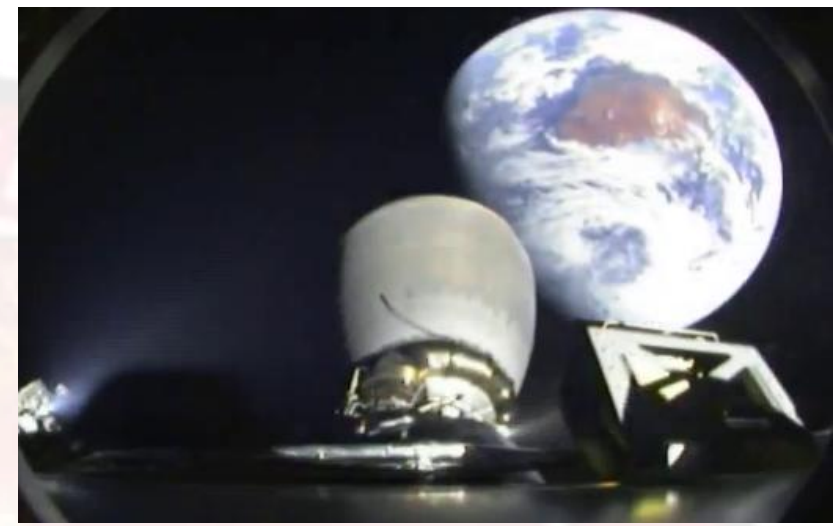
DSCOVOR – A Lissajous Orbit



- DSCOVOR's orbit very much like ACE, much smaller than Wind.
 - 6-month orbit period
 - Max Sun-Earth-Vehicle Angle of 12°
 - Unlike ACE, we plan to enforce Sun-Exclusion Zone of 4°
 - First encountered @L+3.4 years
 - Avoids solar RFI
 - Fuel Penalty



Instrument Data



Magnetometer

Parameter	Expected Performance
Bx, By, Bz Range	8 ranges: ± 4 - ± 65536 nT
Bx, By, Bz Accuracy	$< \pm 1$ nT

SWPC provided cadence: 1 second & 1 minute

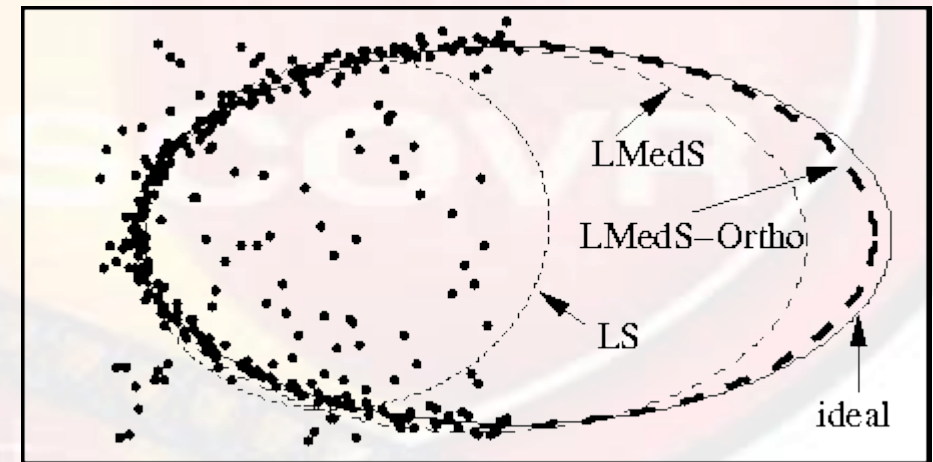
Alan Lazarus Faraday Cup

Parameter	Expected Performance
Velocity Range	168-1340 km/s
Velocity Accuracy	2%
Density Range	0.22 - 219 cm ⁻³
Density Accuracy	tbd
Temperature Range	3.9×10^4 - 7.3×10^7 K
Temperature Accuracy	$< 8.9\%$

SWPC provided cadence: 3 seconds & 1 minute

Robust Averaging of Data

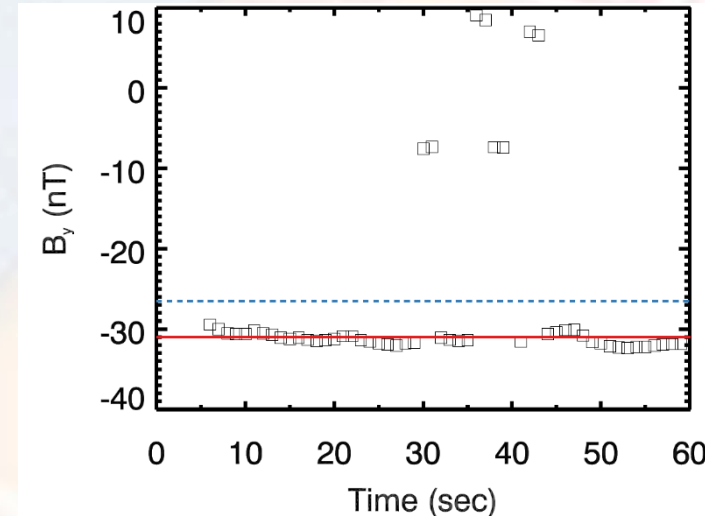
- Data are noisy and outliers will occur
 - Real-time operations -> manual screening not possible
- Use modern, robust statistics, designed to ignore small departures from model assumptions
 - e.g. normally distributed data
- Breakdown point
 - Proportion of incorrect observations an estimator can handle before giving an incorrect result
 - Theoretical limit is 50%
 - Mean has limit of 0 (zero).



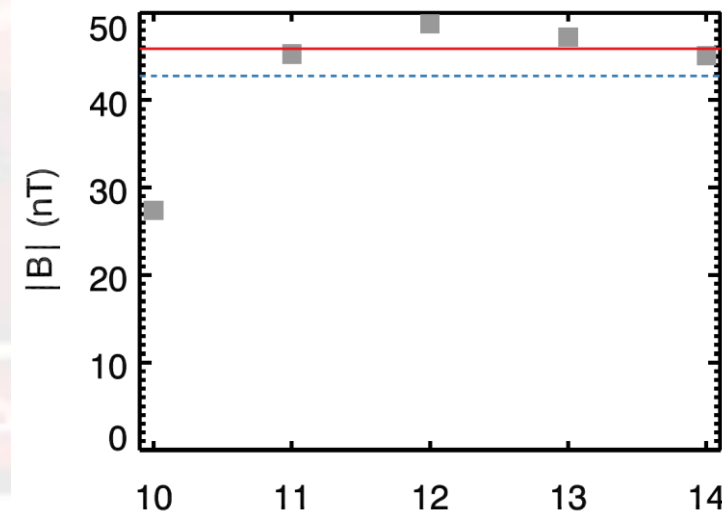
Data averaging– no more boxcars



- Magnetometer (50 Hz data)
 - Hodges-Lehmann Estimator (1963)
 - Breakdown point 29%
 - Form independent pairs, including the pair of each item taken twice
 - $n(n+1)/2$ pairs
 - Find the median of each pair
 - Find median of the medians
- Faraday Cup (between 0.3-25 Hz)
 - Huber M-Estimator (Huber 1963)
 - Breakdown point of 50%
 - Iterative scheme
 - Preferred for averages with fewer data points
 - Maximum likelihood type of estimator
 - Huber influence function

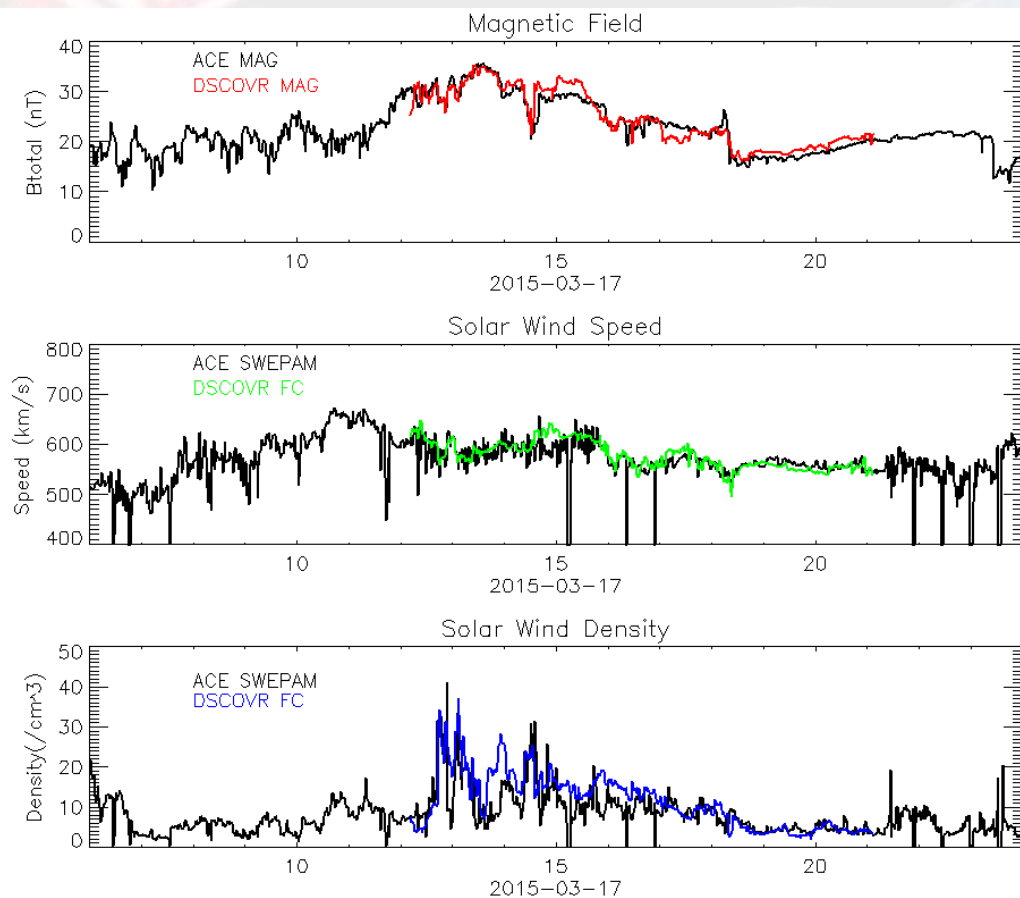


Boxcar
H-L

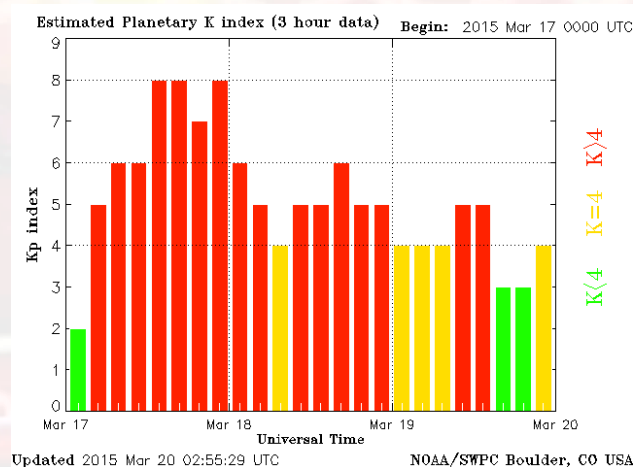


Huber
Boxcar

St. Patrick's Day Storm (17 March 2015)



- DSCOVR and ACE overlay looks great!
- Separated by $\sim 338,000$ km in Y-Z plane
 - X-axis (radial) $\sim 46,000$ km
- Data only during US daytime hours
 - Data flow from Wallops
- Processed in real-time
 - Pre-flight calibrations only



New DSCOVR Space Weather Products

Algorithms Currently in Development at NOAA/SWPC

- Solar Wind Transit Time (Estimated Time of Arrival)
 - To improve prediction of solar wind structure transit time from L1 to Earth
 - onset time of geomagnetic storm warnings
 - input to models (e.g. geospace, ionosphere, magnetopause crossing)
- Automatic Solar Wind Regime Identification
 - To increase situational awareness for forecasters and others

Algorithm Currently in Development at NOAA/NGDC

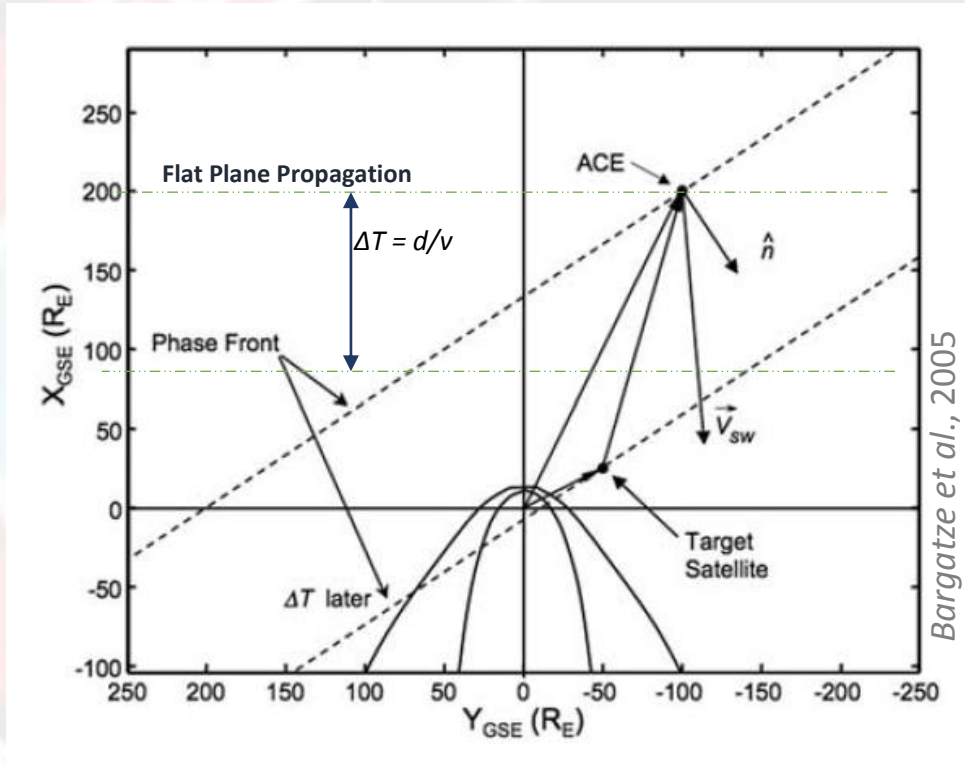
- Magnetopause Location and Geosynchronous Orbit Crossings
 - To increase situational awareness for satellite operators

New SWPC Webpage for Solar Wind Data

- Doing away with static images



Computing L1 to Earth Transit Time (see *Cash et al.* poster)



- Solar wind phase planes can be tilted from Sun-Earth line
- Assuming flat plane propagation results in errors in calculated arrival time of +/-15 min to over 30 min
- Errors depend on spacecraft distance from Sun-Earth line

- Use *Weimer and King* [2008] method to define the phase plane tilts:

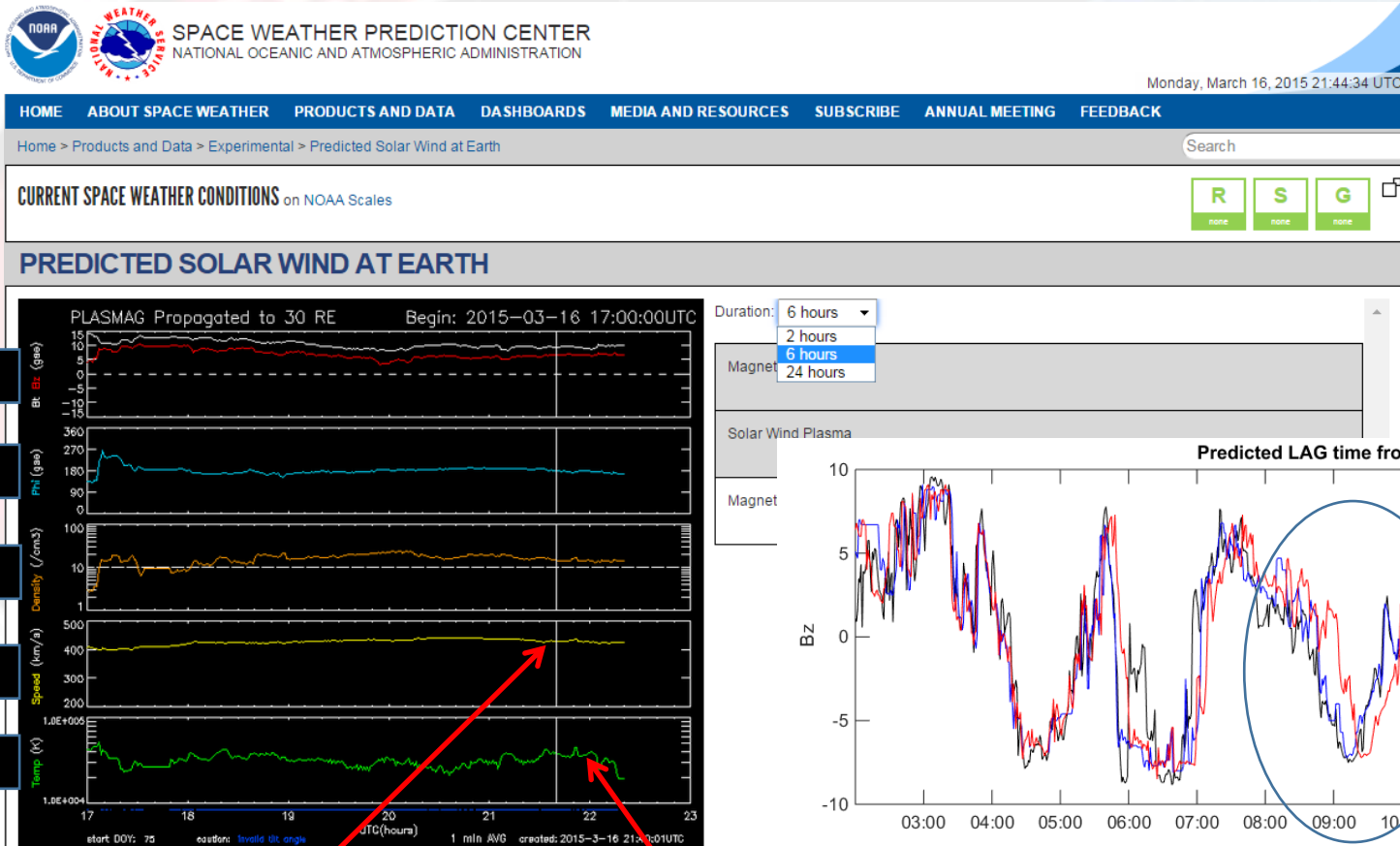
(1) Minimum Variance Analysis with $B=0$

(2) Cross Product Technique

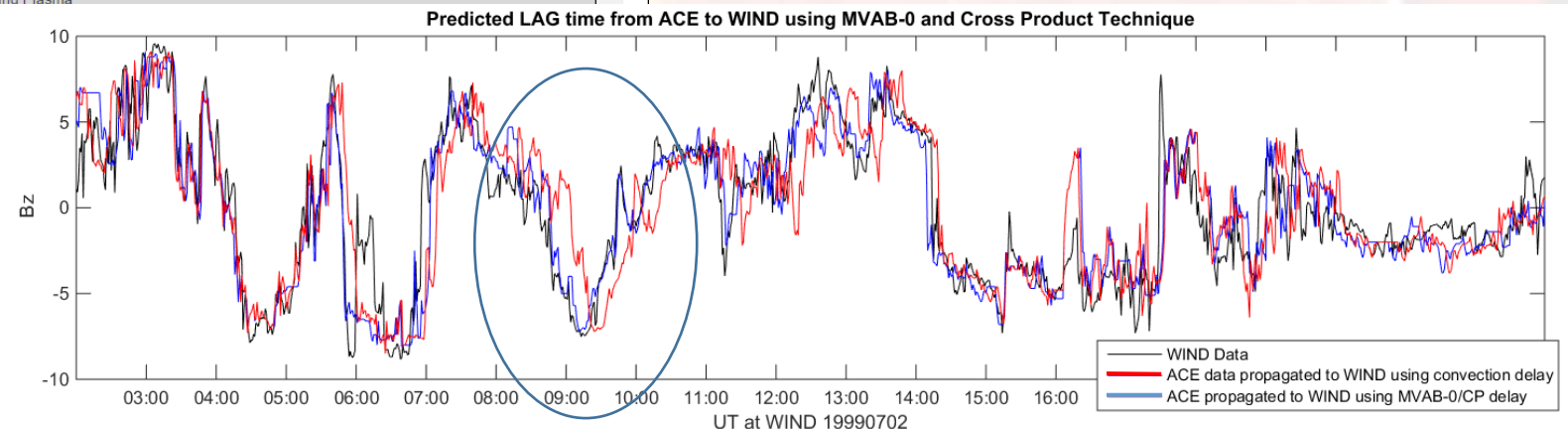
Tilt angle
must agree

Predicted Solar Wind At Earth

<http://www.swpc.noaa.gov/products/predicted-solar-wind-earth>



Validation example



Tilted phase plane method showed statistically significant improvement

Current Time

Solar wind expected to arrive in the near future

14 April 2015

Space Weather Workshop

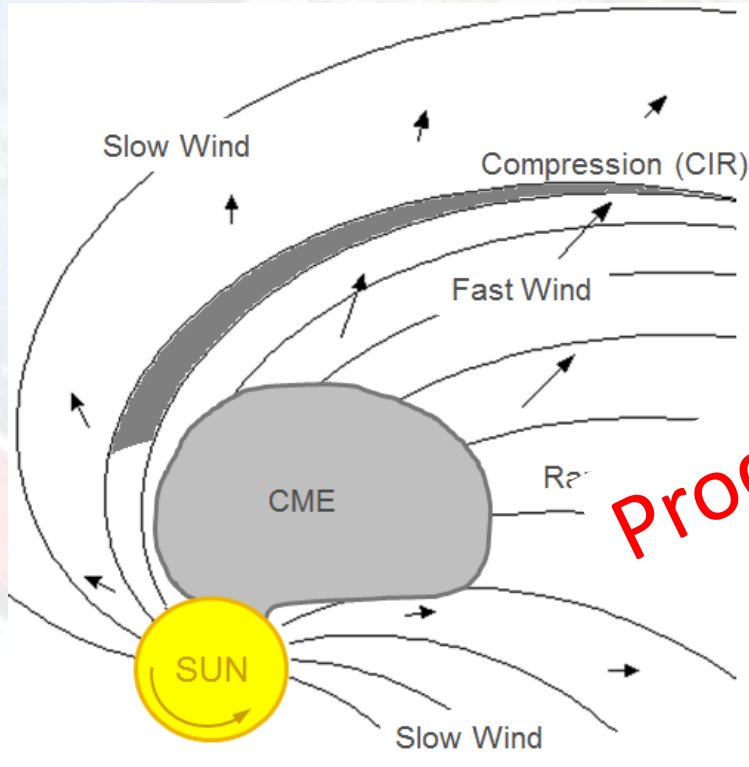
11

Solar Wind Regime Identification Product

Autonomously determine the current solar wind flow regime in order to increase forecasters' situational awareness

Solar wind flow regimes vary according to:

- Density
- Temperature
- Velocity



Product still in development

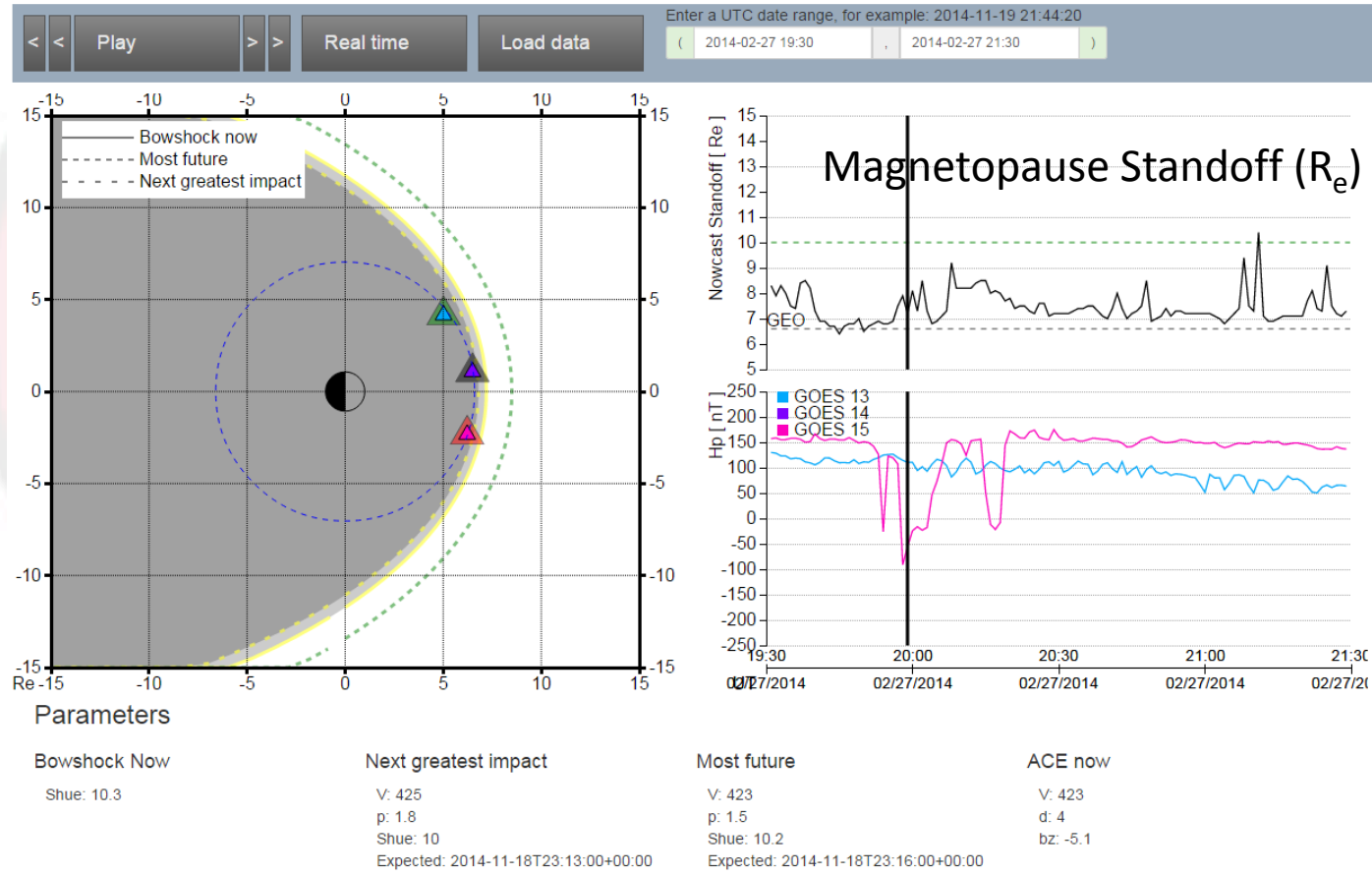
• Rule-based decision tree used to identify solar wind regime in real-time
Based on algorithm used by **Genesis** solar wind mission [Neugebauer et al., 2003]

- Changes are needed
 - won't have bi-directional e^- info
 - will use alpha particle info

Magnetopause Crossing Product

http://www.ngdc.noaa.gov/stp/mag_pause/

Real Time Magnetopause Location and Geosynchronous Crossings [beta]

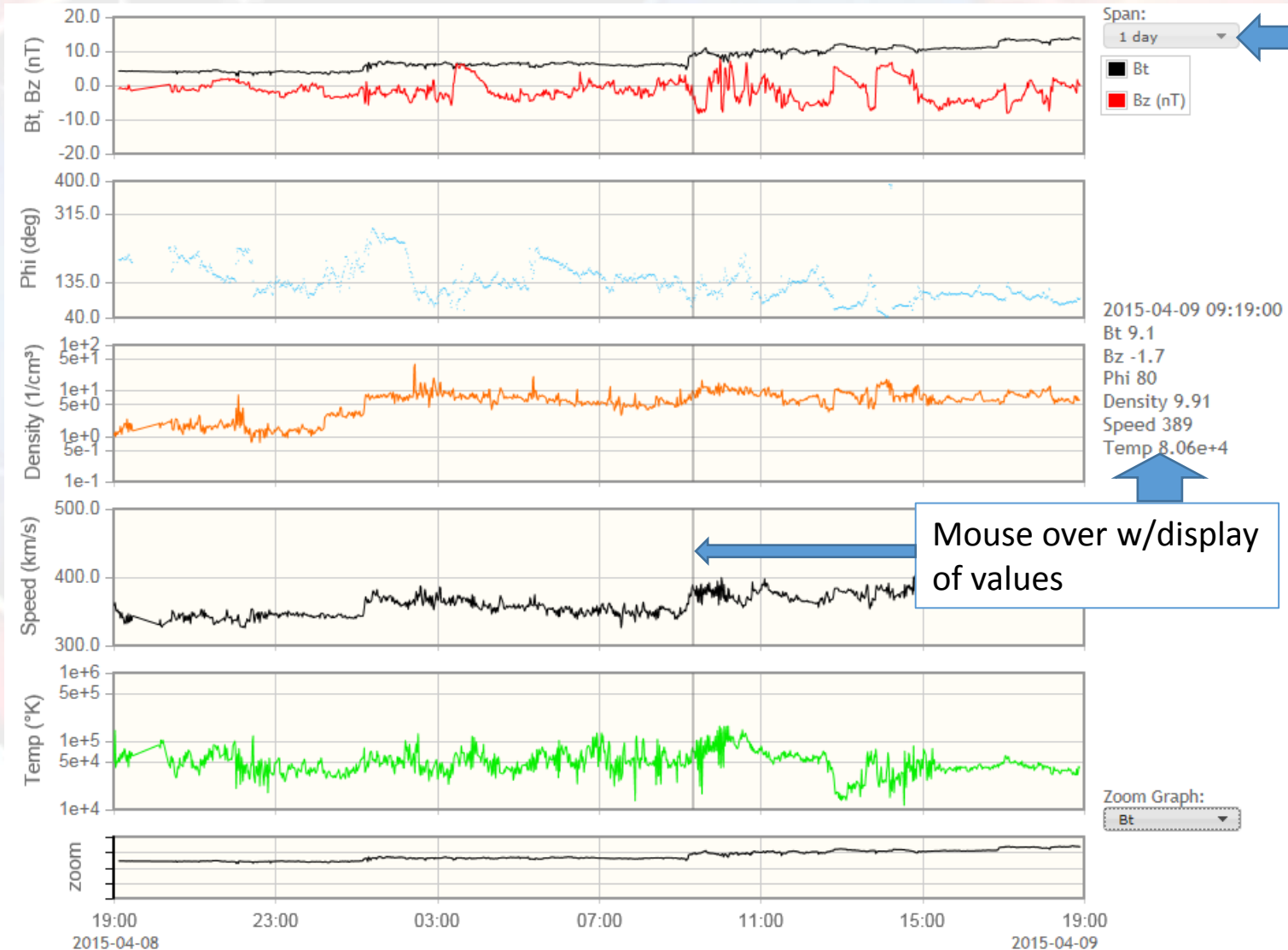


- Real-time forecast and nowcast product (beta)
 - Implementation of Shue *et al.* 1998
 - Displays GOES-13, 14, & 15
 - Driven by predicted solar wind @Earth
 - e.g. New SWPC product
 - Single click gives conditions at time selected

Prototype SWPC web page

jQuery/jqPlot

Interactive display



Choose default time span
2 or 6 hours
1, 3, or 7 days

Mouse over w/display
of values

Zoom to any time range

Possibly with high
time resolution?
1s, 3s data TBD

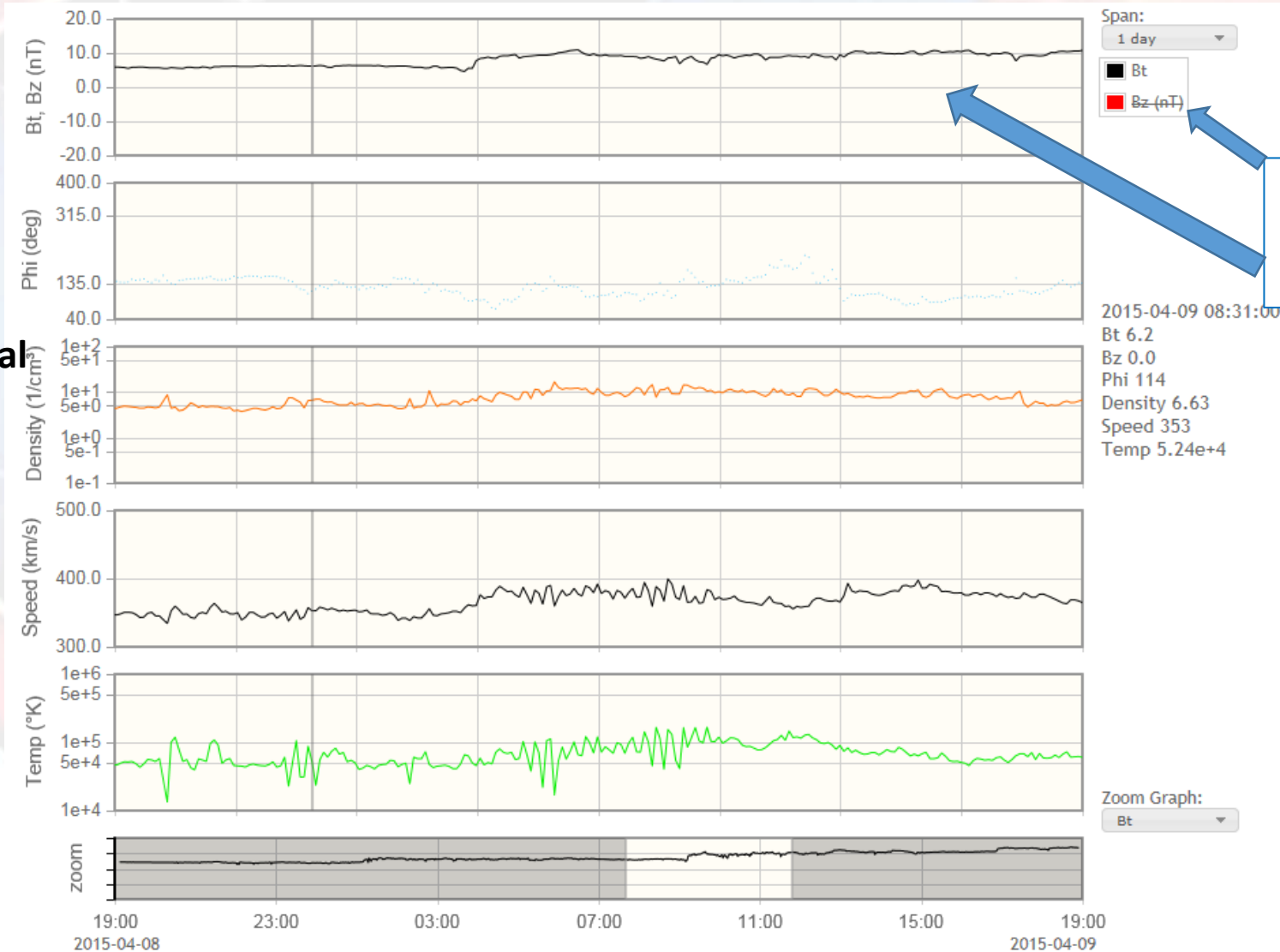


Zoom in for more detail with
just a click and drag
anywhere on the display

Display only the data you want?

Prototype w/ACE
available in May?

Expect several
iterations before
DSCOV^R operational
date



Add/Remove Variables with
single click
e.g. Bz

Archive at NOAA/NGDC (see poster by Rowland *et al.*)

- Reliable and maintainable archive process
 - DSCOVR dataset is one of the first to use NGDC's enterprise Common Ingest
- Generated high quality collection-level metadata
 - ISO compliant at [NGDC](#)
 - SPASE compliant entries for [VIRBO](#)
- Worked with SWPC to ensure useful documentation within granules
 - “Great! This is some of the best NetCDF I've ever seen” – Anna Milan

NGDC Asynchronous Access

- Data are accessible via the NGDC EXTRACT (NEXT)
- User friendly UI
 - Likely basis for other Time-series data sets.
- Further work is planned to expand search capabilities

NOAA NATIONAL GEOPHYSICAL DATA CENTER

DEEP SPACE CLIMATE OBSERVATORY (DSCOVR)

Show / Hide Search Form

Data Types

- ☒ Real-Time Observatory Telemetry
- ☐ Stored Observatory Telemetry
- ☐ Magnetometer L0 data
- ☐ Faraday Cup L0 data
- ☐ Magnetometer L1 data
- ☐ Faraday Cup L1 data

Dates: to

The Deep Space Climate Observatory (DSCOVR) satellite is a NOAA operated asset to be located at the L1 point. The primary space weather instrument is the PlasMag sensor complement consisting of a magnetometer (MAG), which will measure the local vector magnetic field, and a Faraday Cup (FC)...

Total: 19 file(s) / 10.80 MB Max Size: 200.00 MB

Enter your email

10 records per page Show / hide columns

<input checked="" type="checkbox"/>	Start Date	End Date	Data Type	Processing Environment	Processing Date	Filesize
<input checked="" type="checkbox"/>	2014-04-02T00:00:00Z	2014-04-02T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-04-03T00:00:10Z	2.55 MB
<input checked="" type="checkbox"/>	2014-04-01T00:00:00Z	2014-04-01T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-04-02T00:00:10Z	2.67 MB
<input checked="" type="checkbox"/>	2014-03-31T00:00:00Z	2014-03-31T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-04-01T00:00:23Z	0.10 MB
<input checked="" type="checkbox"/>	2014-03-30T00:00:00Z	2014-03-30T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-03-31T00:00:10Z	0.00 MB
<input checked="" type="checkbox"/>	2014-03-29T00:00:00Z	2014-03-29T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-03-30T00:00:10Z	0.00 MB
<input checked="" type="checkbox"/>	2014-03-28T00:00:00Z	2014-03-28T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-03-29T00:00:11Z	1.03 MB
<input checked="" type="checkbox"/>	2014-03-26T00:00:00Z	2014-03-26T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-03-27T00:00:00Z	0.44 MB
<input checked="" type="checkbox"/>	2014-03-19T00:00:00Z	2014-03-19T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-03-19T23:59:59Z	0.16 MB
<input checked="" type="checkbox"/>	2014-03-18T00:00:00Z	2014-03-18T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-03-18T23:59:59Z	0.17 MB
<input checked="" type="checkbox"/>	2014-03-17T00:00:00Z	2014-03-17T23:59:59Z	Real-Time Observatory Telemetry	IT	2014-03-17T23:59:59Z	0.13 MB

Showing 1 to 10 of 19 entries

First Previous 1 2 Next Last

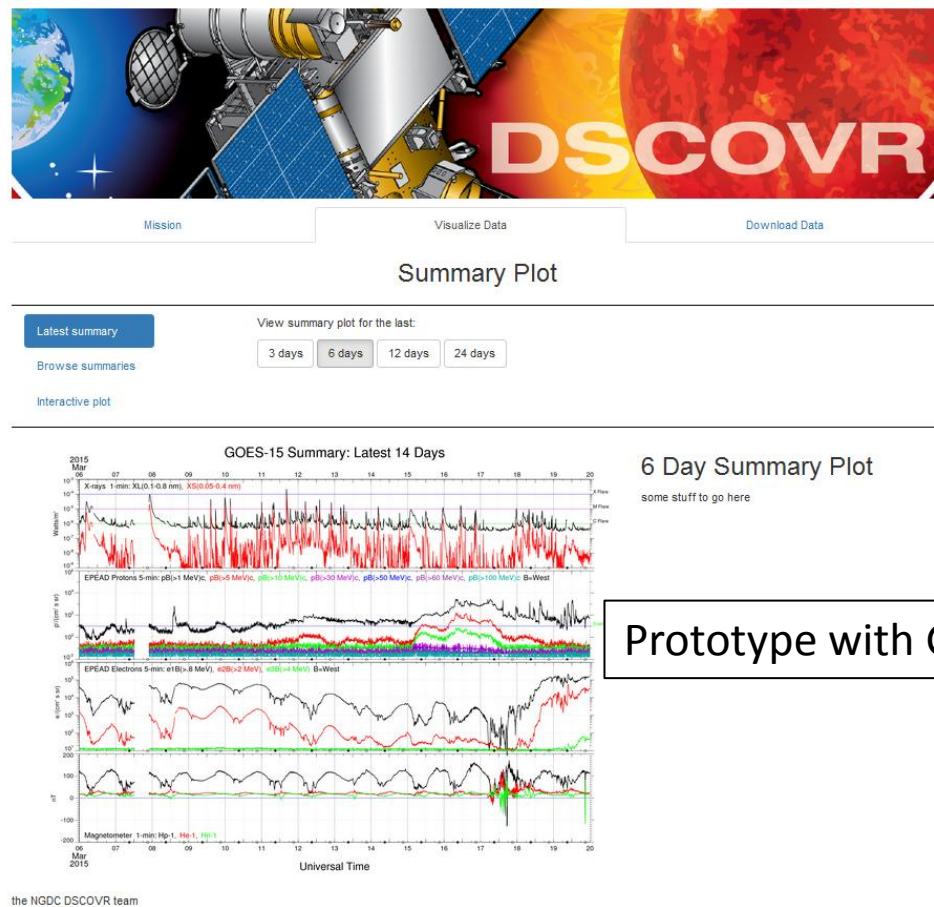
NOAA > NESDIS > NGDC > DSCOVR Satellite Data

Questions: William.Rowland@noaa.gov

NGDC Home | Contacts | Data | Disclaimers | Education | News | Privacy Policy | Site Map

NGDC Synchronous Access

Data Visualization



Prototype with GOES data

Data Download

The screenshot shows the NGDC DSCOVR Data Download interface. At the top is a banner with the DSCOVR logo and a satellite illustration. Below the banner are three tabs: "Mission", "Visualize Data", and "Download Data". The "Download Data" tab is active, displaying a "Download Data" section. This section includes a "Day files" button, a "Tape archive" link, and a "start date" and "end date" dropdown menu. The "start date" is set to "2015-03-15" and the "end date" is set to "2015-03-18". Below this is a "Files available:" section listing files for the dates 2015-03-15, 2015-03-16, 2015-03-17, and 2015-03-18. The files are listed as NetCDF files. The NGDC DSCOVR team logo is at the bottom left.

NetCDF files

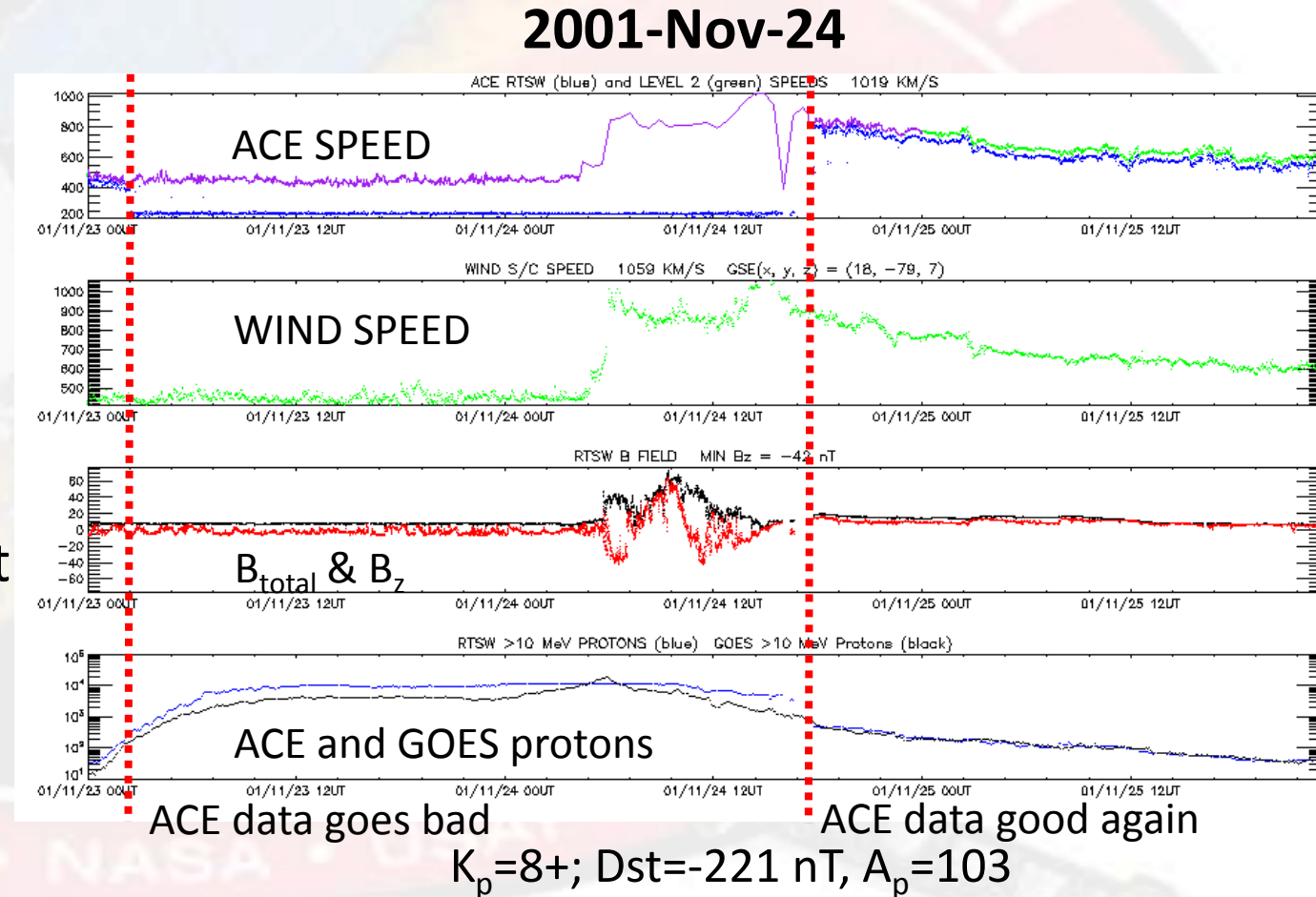
ACE in Real-Time vs DSCOVR

(see Biesecker *et al.* poster)

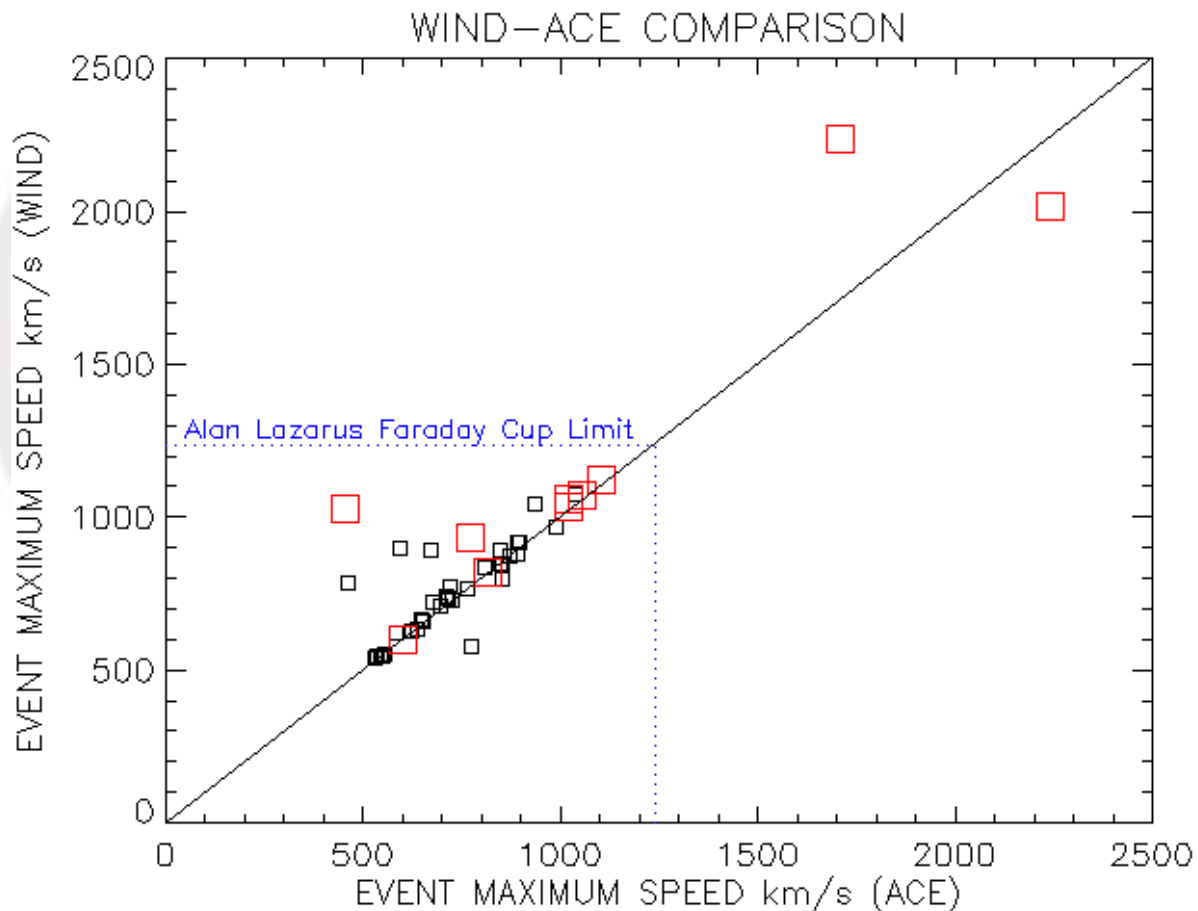
- Selected all geomagnetic storm events from 1998-2012 meeting ‘any’ definition of severe or extreme.
 - NOAA Scales: $K_p \geq 8$ - (Severe); $K_p = 9$ (Extreme)
 - Other indices: $Dst \leq -150$ nT; Running $A_p \geq 100$
- 44 events meet 1 or more of the above criteria
 - 21 meet K_p , Dst , and A_p criteria
 - 3 events meet $K_p = 9$ (extreme)
- Two main concerns
 - DSCOVR doesn’t fully meet SWPC velocity requirement
 - ACE V, n, T real-time processing fails during proton events

ACE SWEFAM Contamination Issues

- Large proton events confuse the ACE SWEFAM on-board algorithm
 - Skoug *et al.* 2004, Machol *et al.* 2013
- Results in loss of solar wind velocity, density and temperature data
- Blue – Real-time ACE
- Purple – Reprocessed ACE
- Wind worked throughout the event
 - Wind SWE and DSCOVR FC are equivalent instruments
- Identified 23 instances of significant contamination issues impacting ACE SWEFAM



DSCOVr Velocity Limit



- DSCOVr limit of 1238 km/s
 - Violated only twice from 1998-2012
 - Halloween storms (10/28 & 10/30)
 - ACE failed on these events as well
 - ACE returned bad data for 10 of 44 severe or extreme events
 - Large red squares
 - In real-time ACE only observed speeds in excess of 1238 km/s once
 - Max of 1280 km/s on 31 Oct 2003

Summary

- DSCOVR is on its way and looking good
- DSCOVR will provide more reliable real-time data
- Access to data in real-time will be up to modern standards
- The new products mentioned here are available now or will be soon
- More products will be available in the years to come thanks to generous funding from NOAA
- Real-Time Solar Wind data brought to you, as always, by
 - (NICT) National Institute of Information and Communications Technology
 - (KSWC) Korean Space Weather Center
 - (DLR) German Aerospace Center
 - (USAF) Air Force Satellite Control Network
 - (NOAA)



Backup slide (30-Oct-2003)

