

ENLIL Modeling Support to the HELCATS Project

Dusan Odstrcil

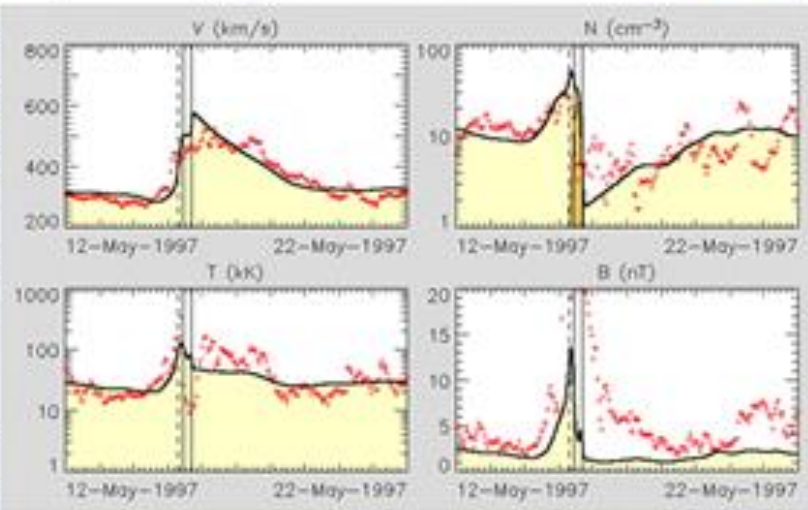
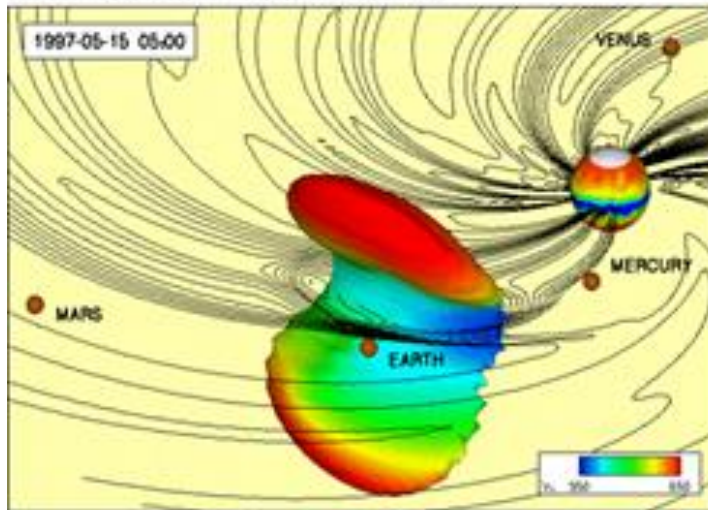
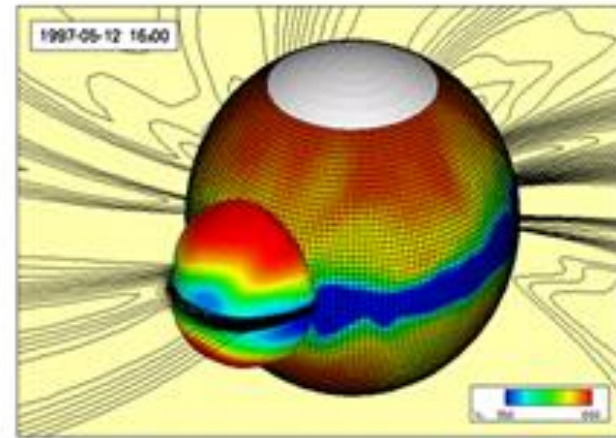
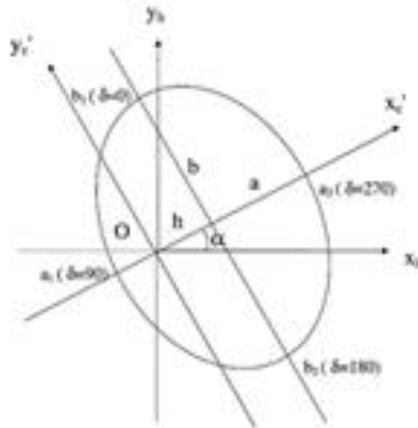
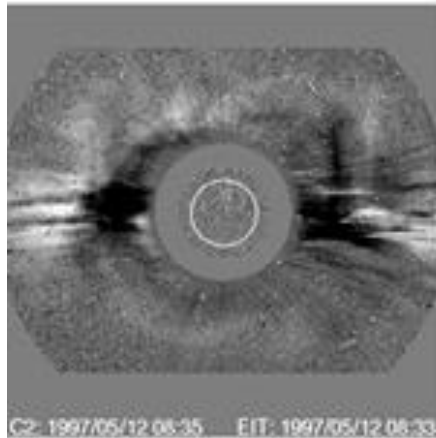
George Mason University & NASA/GSFC Space Weather Lab (Code 674)



Outline

- WSA-ENLIL-Cone modeling system
- Evolving background solar wind
- Using heliospheric imaging – IPS
- Using heliospheric imaging – white-light
- SEP events – Shock detection
- Heliospheric missions support

WSA-ENLIL-Cone Modeling System



- Observationally driven, near-real time modeling system
- Routine simulation of corotating streams and CMEs, event-by event
- Much faster than real-time

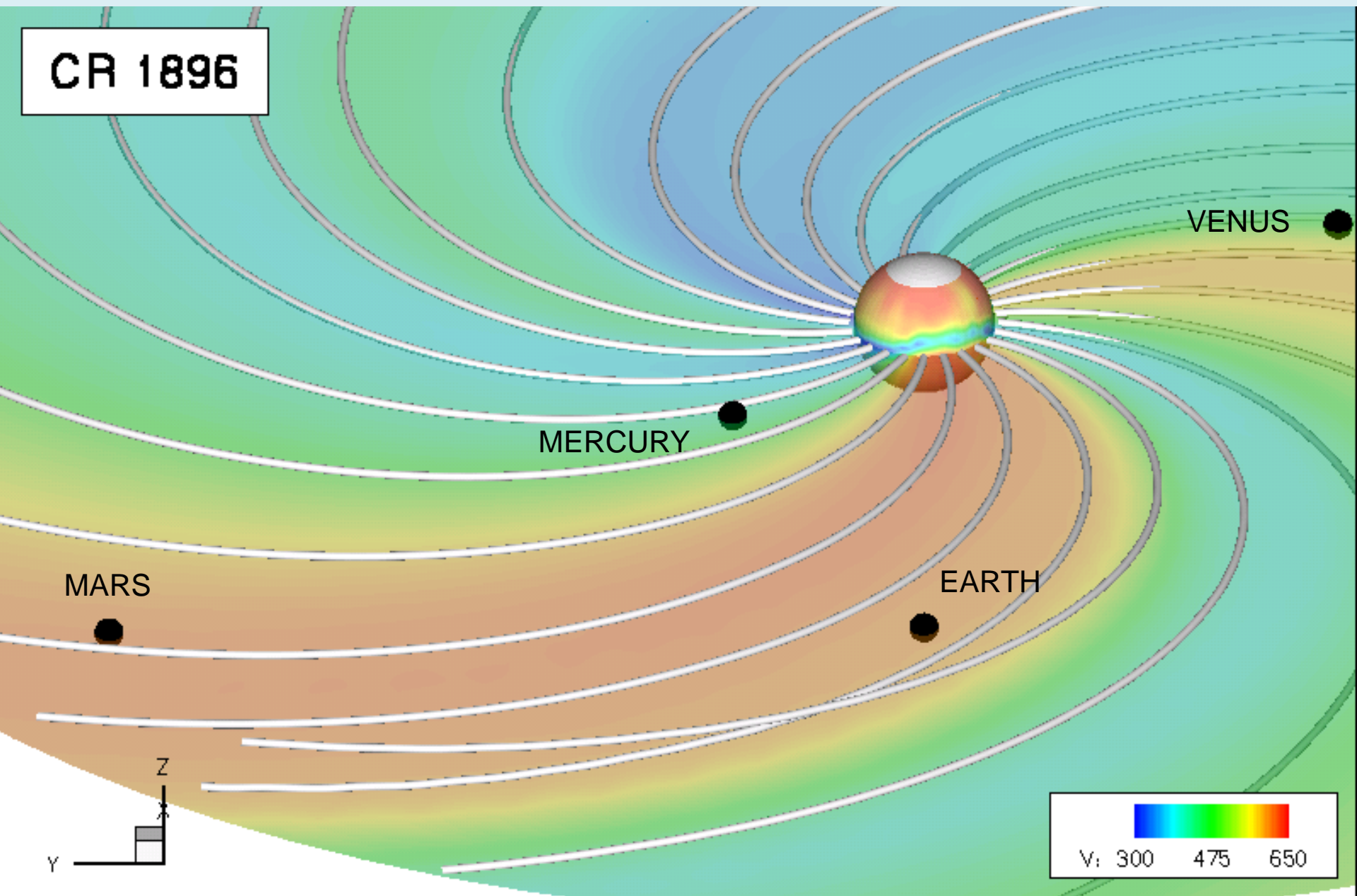
NASA+NSF Partnership for Collaborative Space Weather Modeling (PCSWM)

(*NASA Living With a Star (LWS) Strategic Capability Program*)

- Medium Range Thermosphere-Ionosphere Forecasts
- A First-Principle-Based Data Assimilation System for Global Ionosphere
- MHD and Kinetic Effects into Global Magnetosphere Models
- Magnetic Flux Emergence and Transport
- Coronal Global Evolutionary Models
- A Modular Community Modeling of Flares, CMEs, and Interplanetary Impacts
- Corona-Solar Wind Energetic Particle Acceleration
- **Integrated Real-Time Modeling System for Heliospheric Space Weather Forecasting**

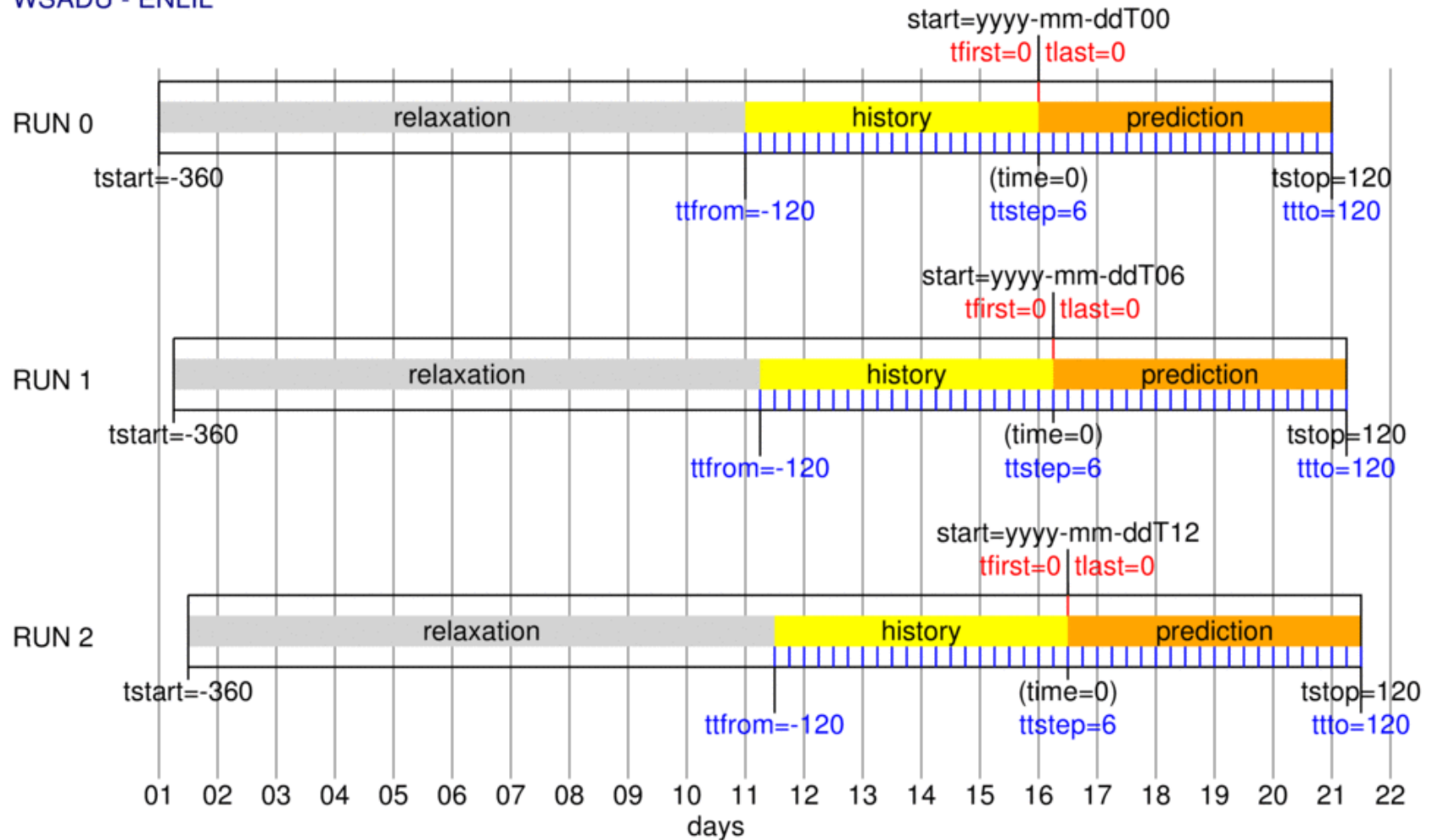
Evolving Background Solar Wind

Near Solar Minimum



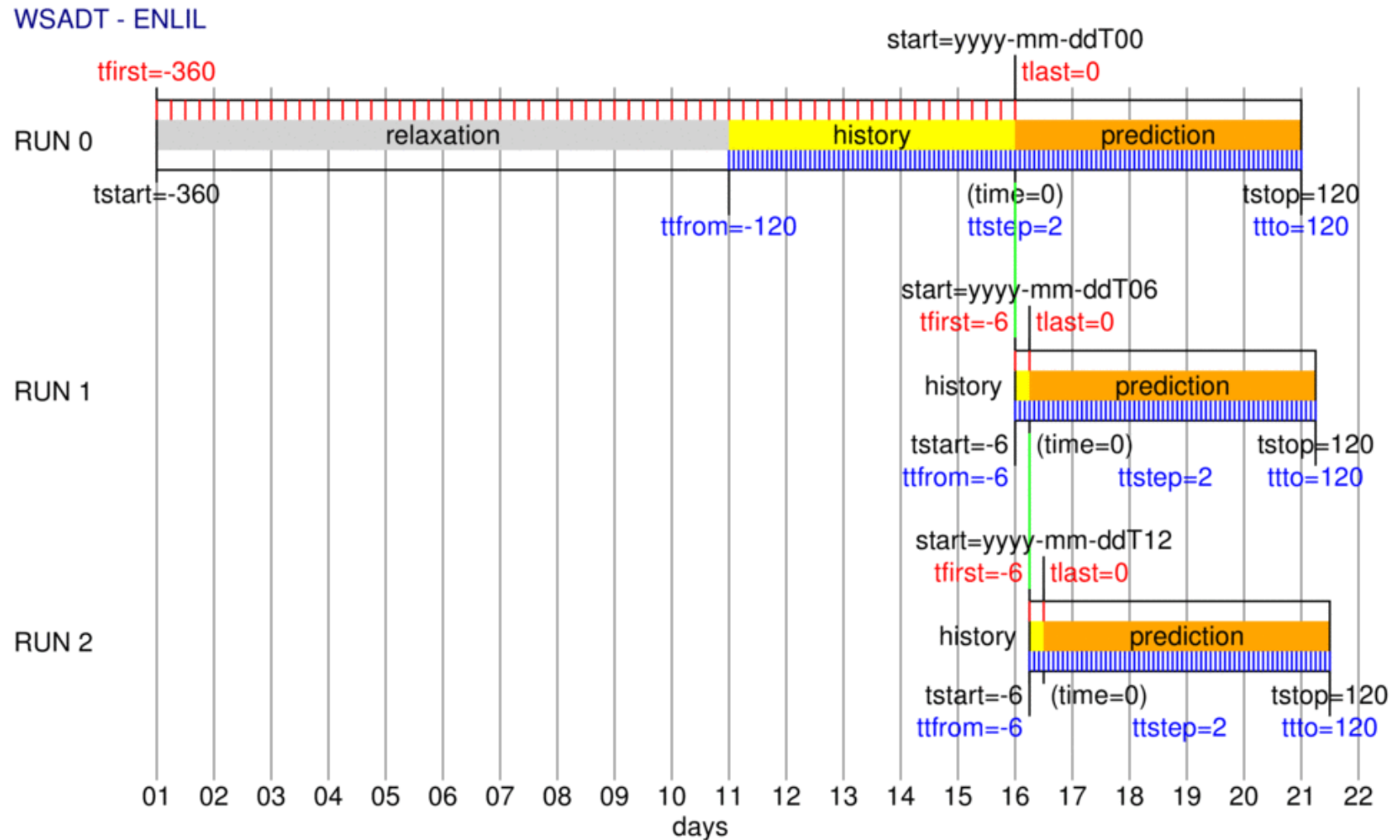
Run Schematic (Old) – “Single-map”, Corotating Background

WSADU - ENLIL



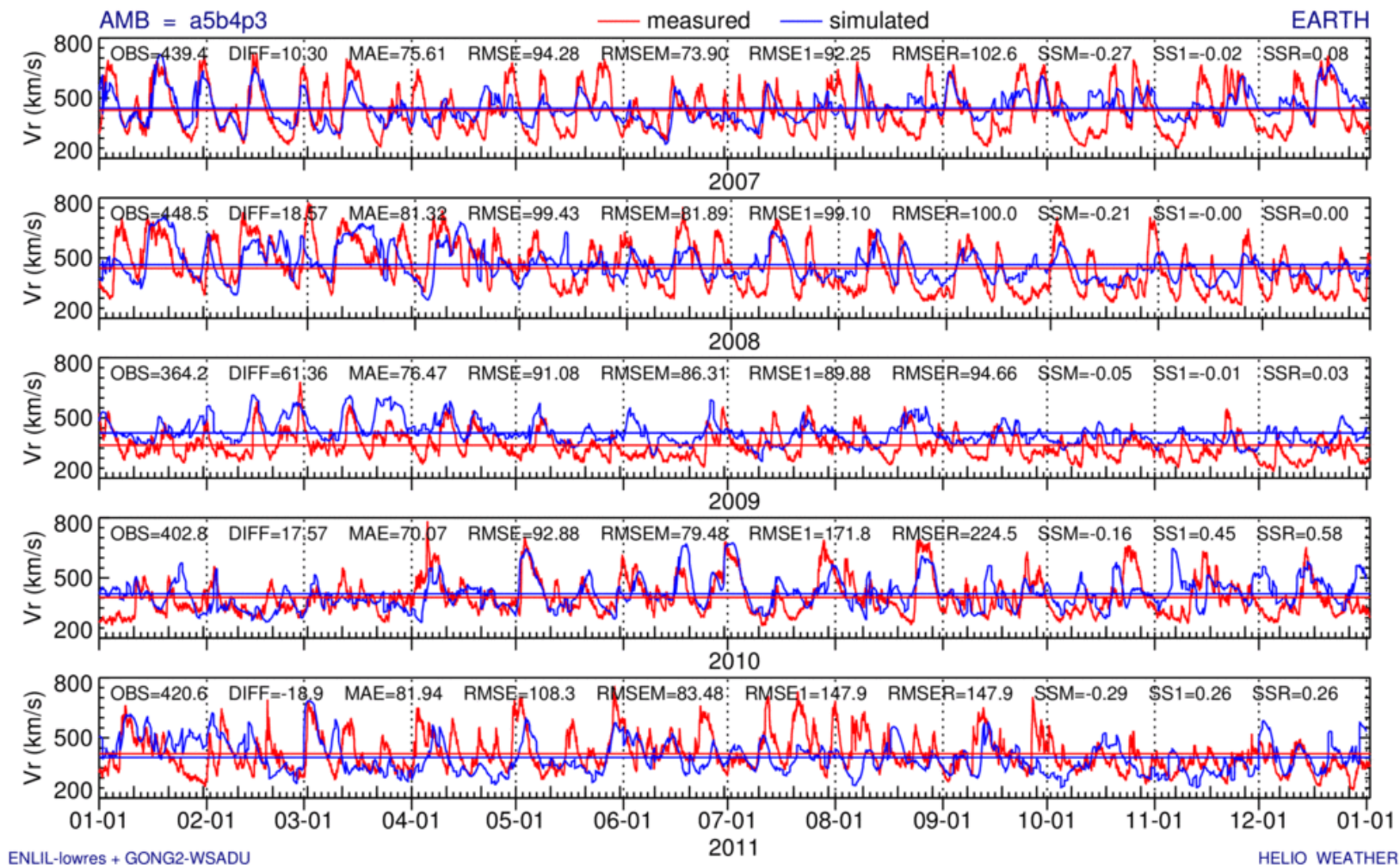
- Numerical relaxation is needed to establish self-consistent background in the computational domain – about 10 days up to Mars
- Numerical relaxation is needed for each prediction

Run Schematic (New) – “Multiple-Maps”, Evolving Background



- Continuously evolving background is achieved by resuming from previous runs
- Significant savings in computational time

Solar Wind Velocity: GONGz-WSADU: 2007-2011



- Prediction of global solar wind parameters at Earth (blue) depends on the coronal model input and also on the heliospheric model free parameters
- WSA maps based on the NSO/GONG daily-updated magnetograms provide positive skill scores for 1-day persistency (SS1) and 27-day recurrence (SSR)

Using Heliospheric Imaging – IPS

Development/Monitoring of IPSBD-ENLIL

IPSbd-ENLIL – Solar Wind Prediction – Density-2

Model Input:

[IPSbd](#)

[IPSbd-SWRC](#)

[WSAdub-SWRC](#)

[WSAduz-SWRC](#)

[WSAdtb-SWRC](#)

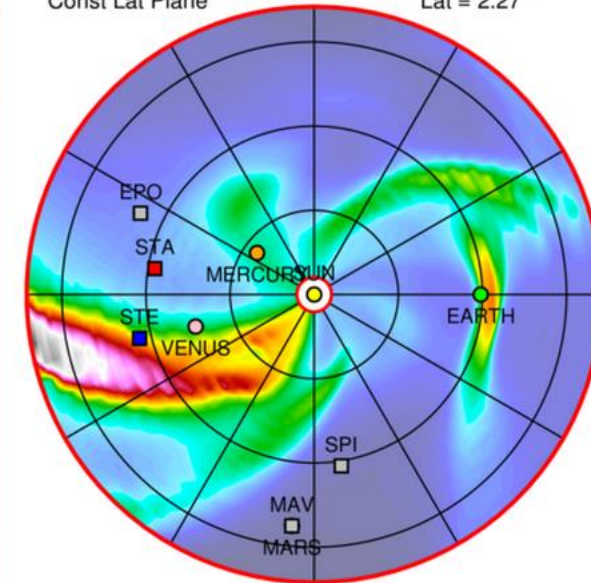
[Main Page](#)

2014-11-20T00:00

Const Lat Plane

W90

Lat = 2.27°



$R^2 N$ (cm^{-3})

ENLIL-lowres + STELab-UCSD

IMF polarity
- +

HCS

[INFO](#)

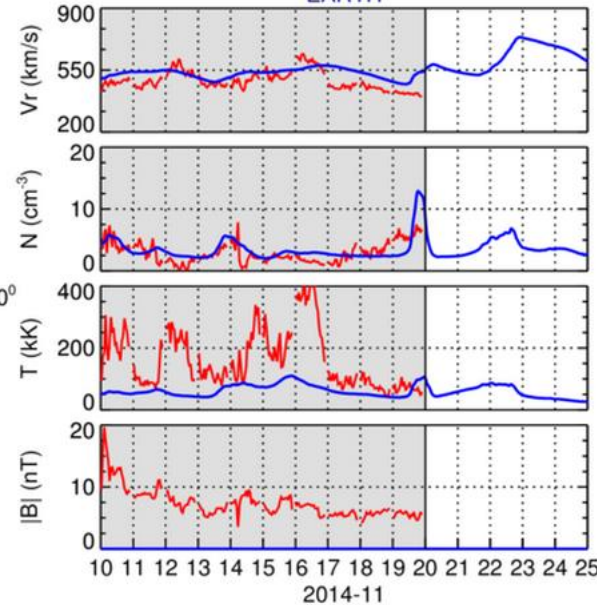


+00T00 ▾

[Download](#)

2014-11-20T00 + 0.00 days

EARTH



measured simulated

HELIO WEATHER

Model Output:

[Velocity-1](#)

[Velocity-2](#)

[Density-1](#)

[Density-2](#)

[STEREO-1](#)

[Evolution](#)

[J-Maps](#)

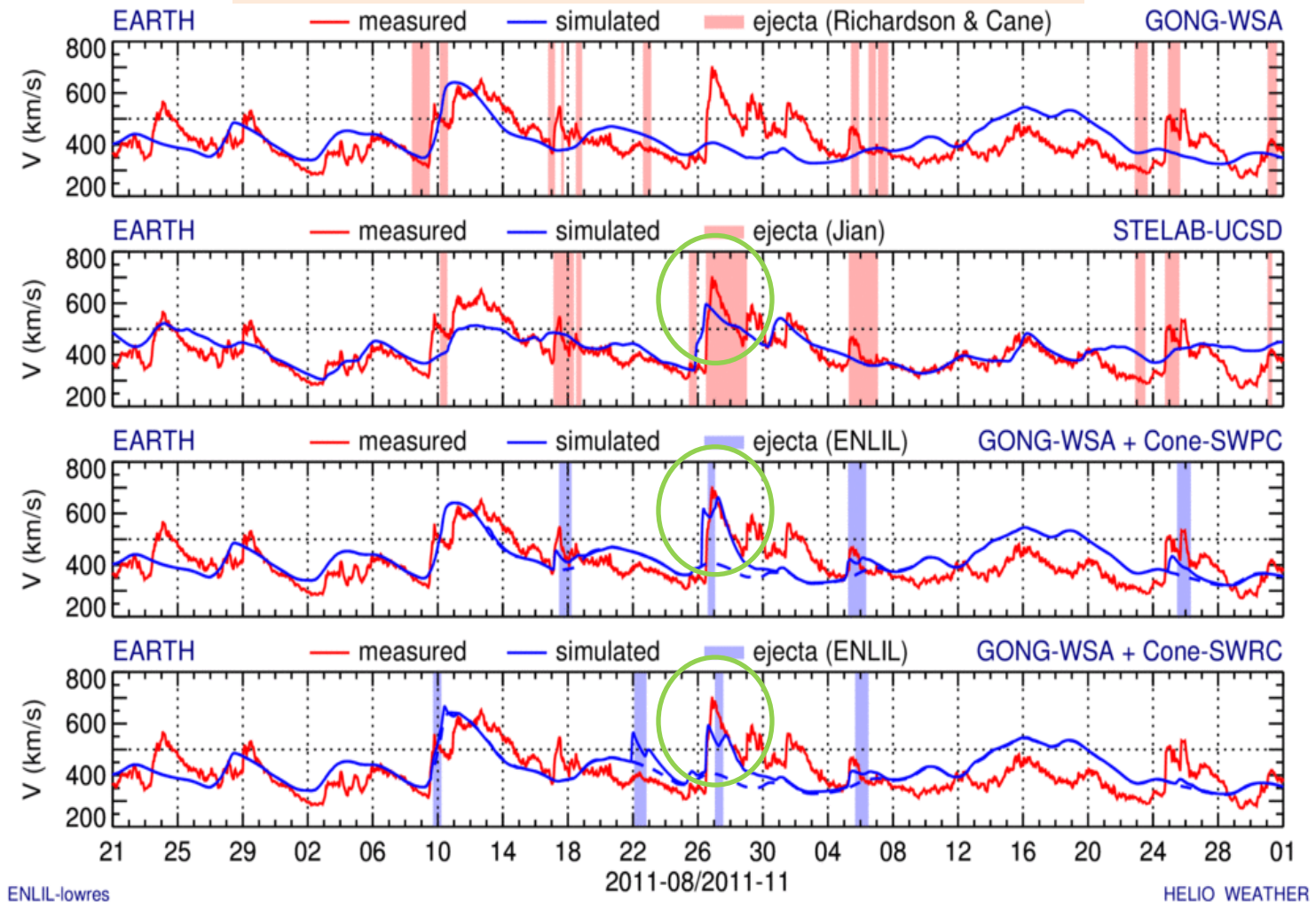
[R-Time](#)

[Main Page](#)

- Main page: <http://helioweather.net>
- Updated daily around 3 AM (7 AM) for WSA (IPS) based input

Using IPSBD – Near the Sun-Earth Line

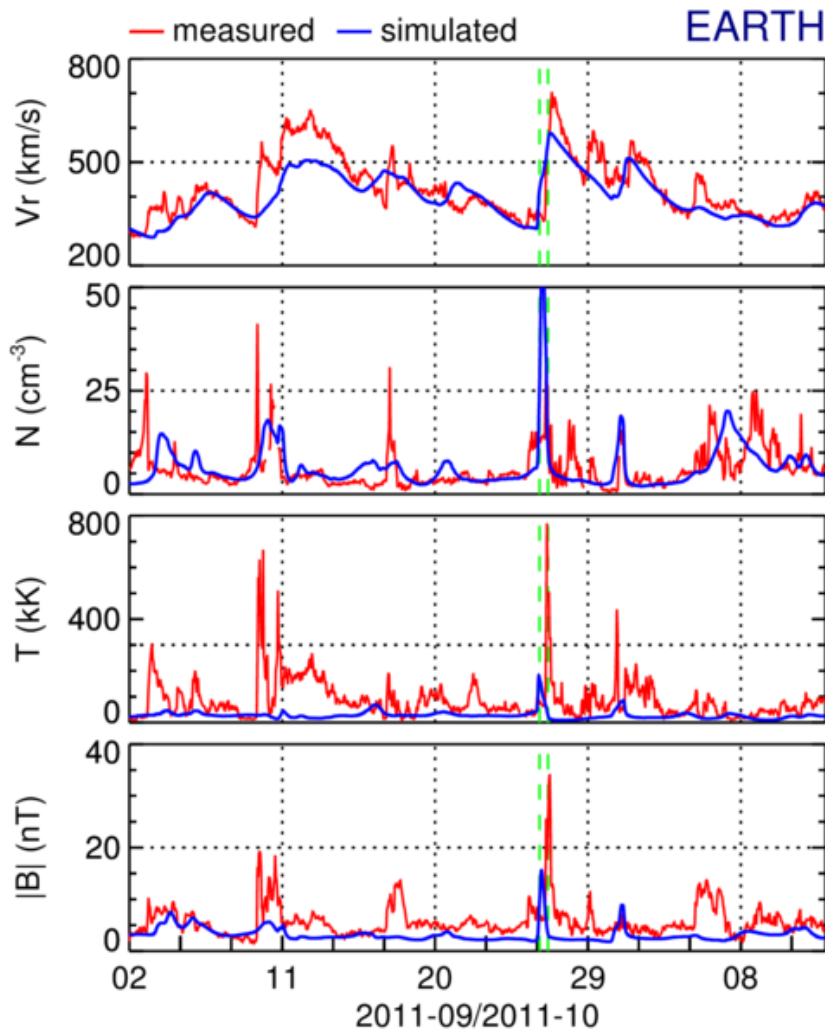
Solar Wind Velocity at Earth by 4 Models



- No ICME on 2011-09-27 in Richardson & Cane caused by poor ACE data
- The 2011-09-24 CME arrives at Earth similarly on 09-27 for all cases

Effect of Temperature

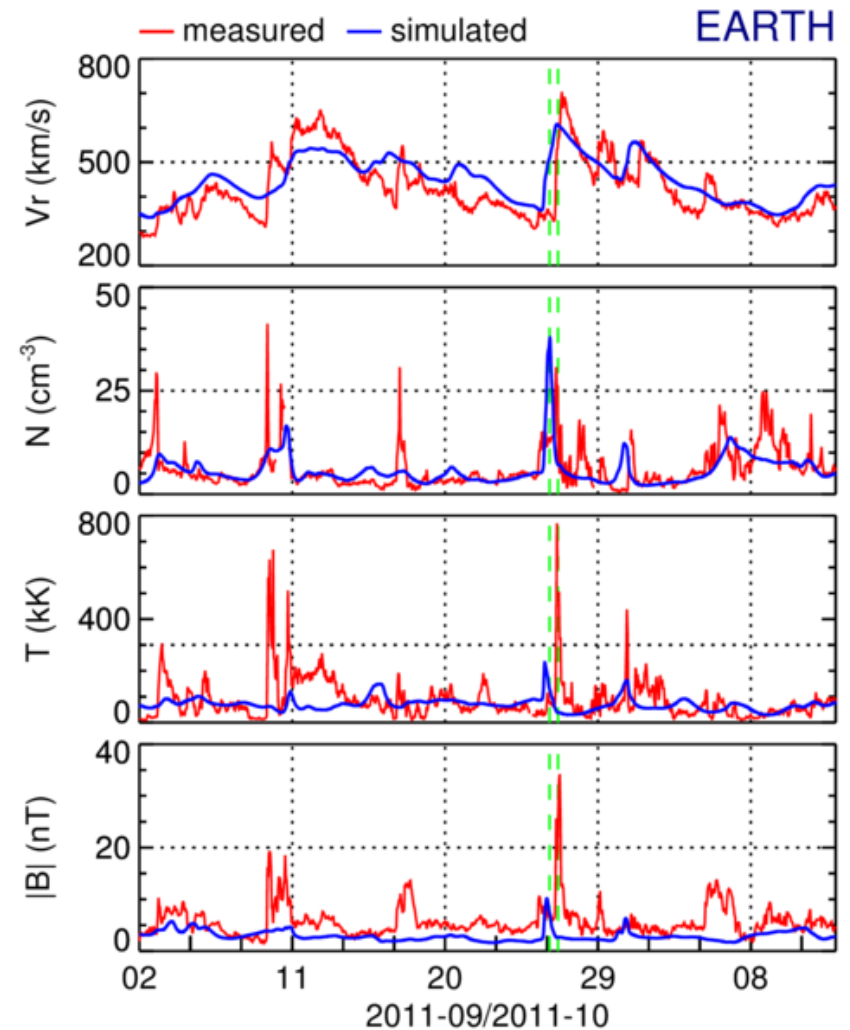
T = 1 MK



ENLIL-lowres + ethe-v50t1b1-g53q5

HELIO WEATHER

T = 3 MK



ENLIL-lowres + ethe-v50t3b1-g53q5

HELIO WEATHER

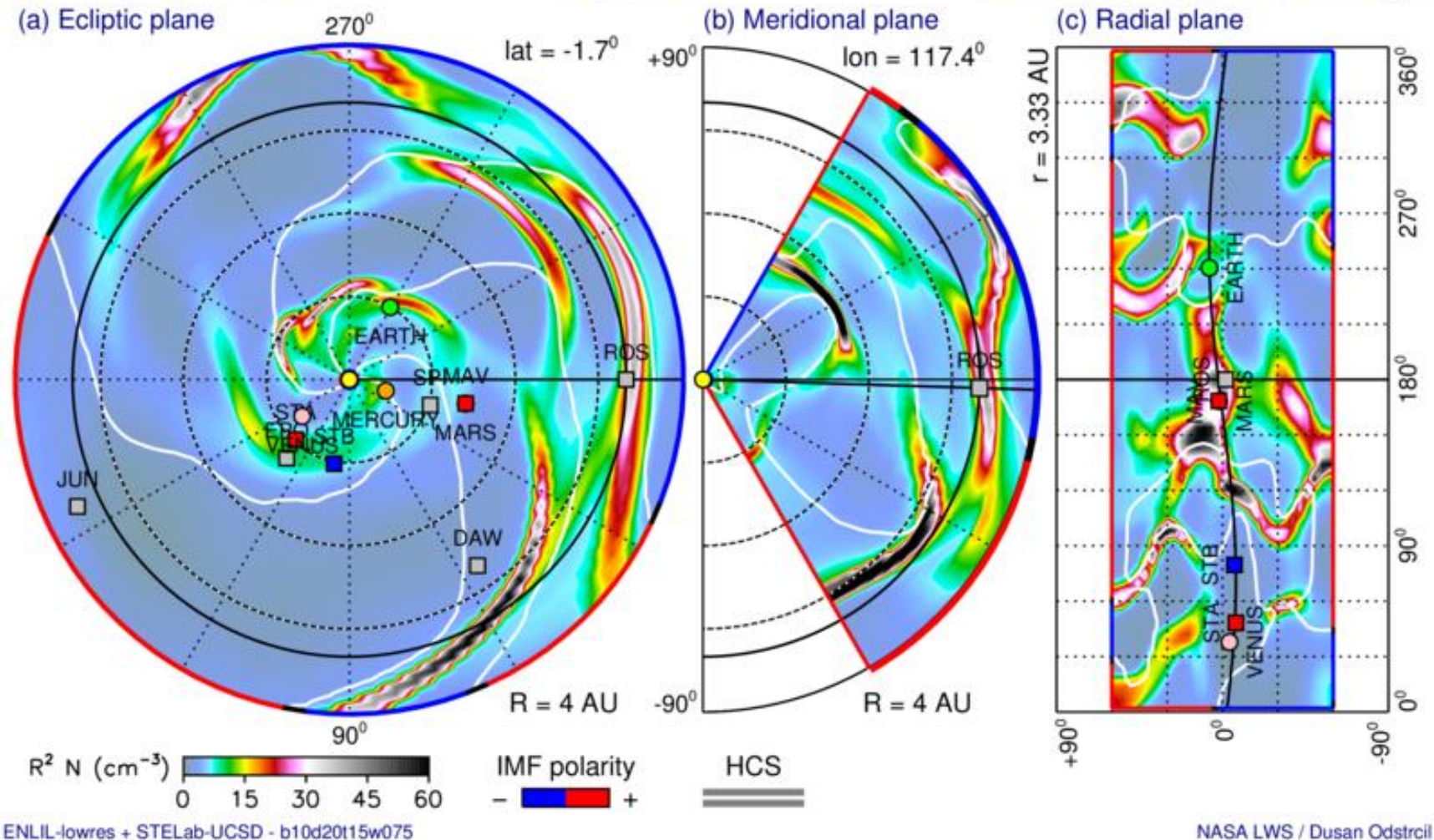
- A density structure on 9/26 is “sandwiched” between forward and reverse shocks
- Higher solar wind temperature cases broadening of the structure and smaller density peak

Using IPSBD – Away from the Sun-Earth Line

2014-09-19T12:00

ROSETTA

2014-09-01T00 +18.50 days



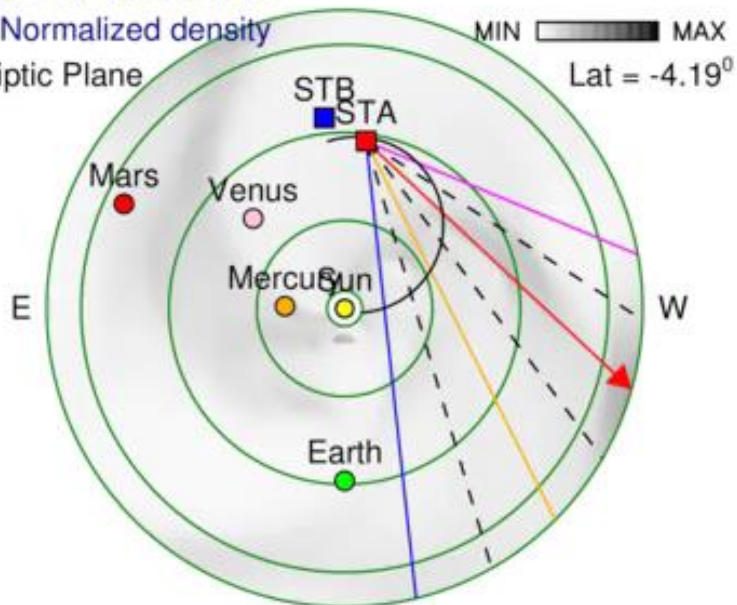
- ROSETTA 60° west from Sun-Earth line; IPS observed – predicts disturbance arrival
- Photospheric field not observed; 23.5-days old data used – WSA maps not accurate

Using Heliospheric Imaging – White-Light

Synthetic White-Light Imaging: 2015 Jan-Apr

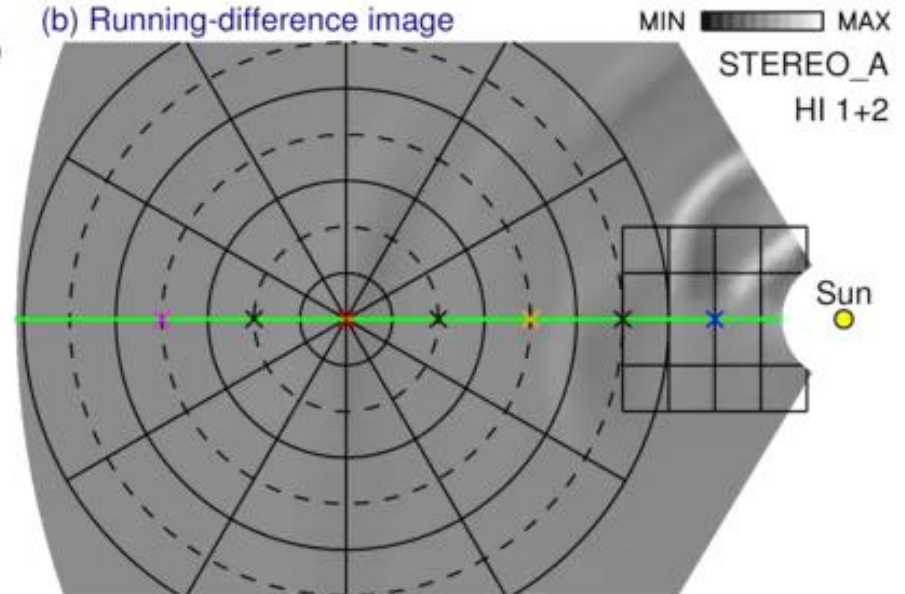
2015-01-01T00:00

(a) Normalized density
Ecliptic Plane

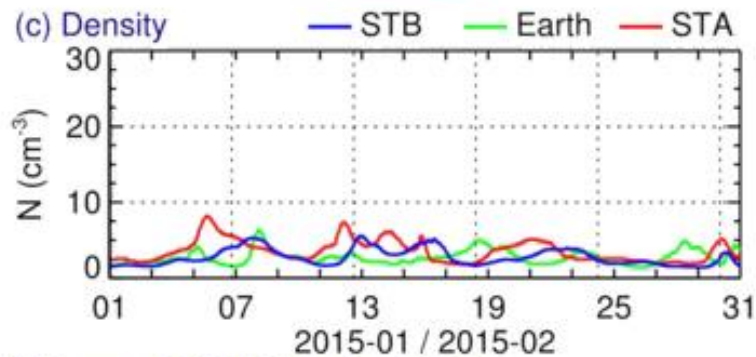


2015-01 + 0.00 days

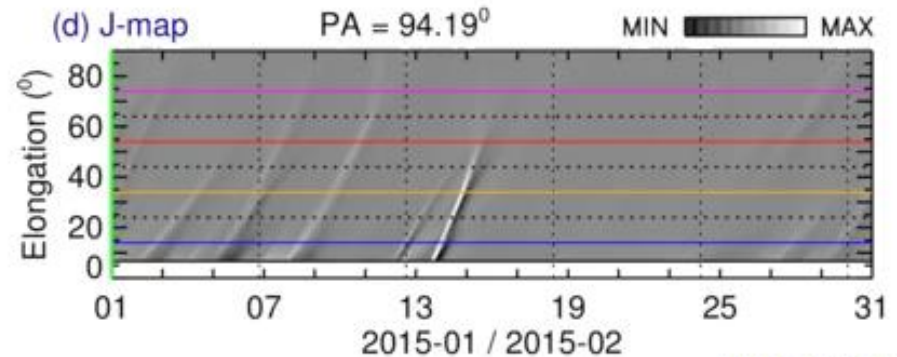
(b) Running-difference image



(c) Density



(d) J-map



ENLIL-lowres + GONGz-WSADT + Cone-SWRC

HELIO WEATHER

- Results for SIRs and CMEs in 2011-2015 are grouped by calendar months

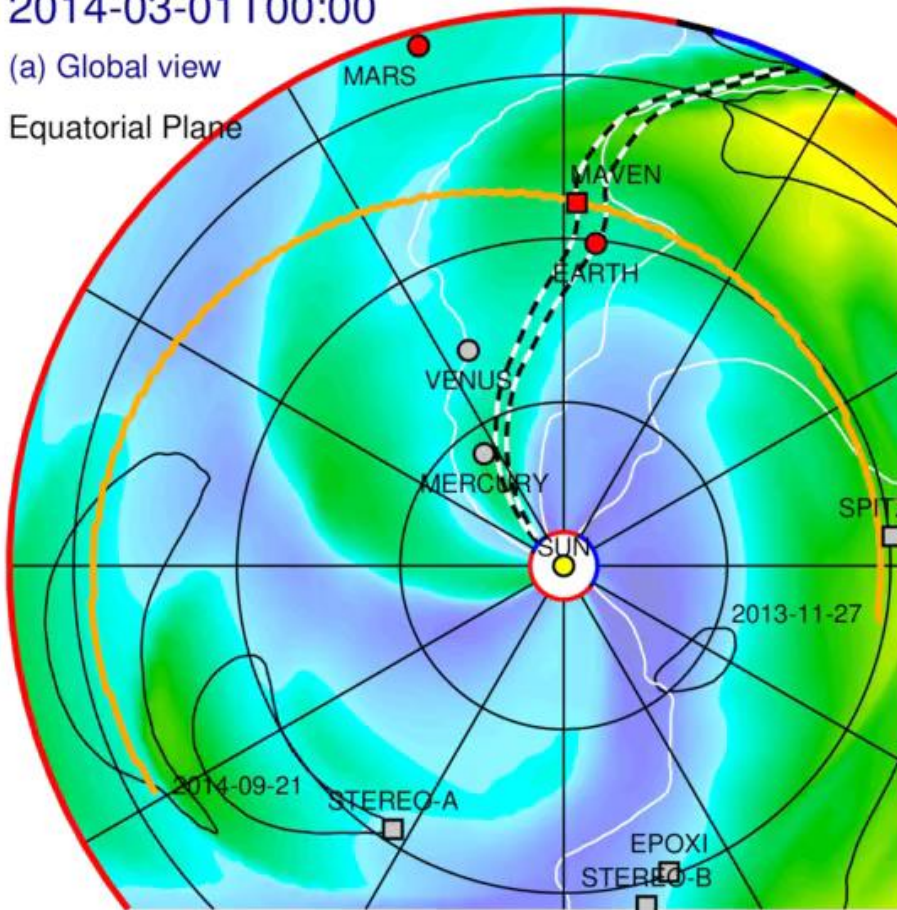
SEP Events – Shock Detection

MAVEN Cruise to Mars – Predicted CMEs

2014-03-01T00:00

(a) Global view

Equatorial Plane



V_r (km/s) 200 550 900 1250 1600

ENLIL-lowres + WSADT-GONGb + Cone-SWRC

IMF polarity - +

HCS

IMF line

CME

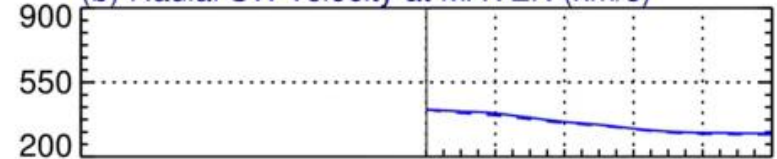
measured

simulated

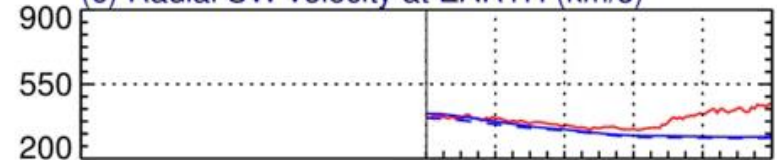
HELIO WEATHER

2014-03-01T00 + 0.00 days

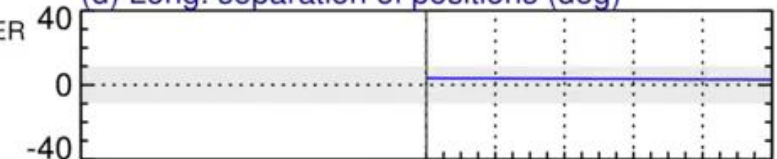
(b) Radial SW velocity at MAVEN (km/s)



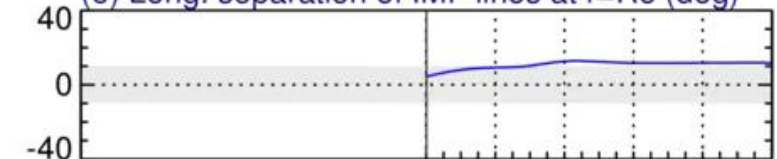
(c) Radial SW velocity at EARTH (km/s)



(d) Long. separation of positions (deg)



(e) Long. separation of IMF lines at $r=R_e$ (deg)



01 02 03 04 05 06
2014-03

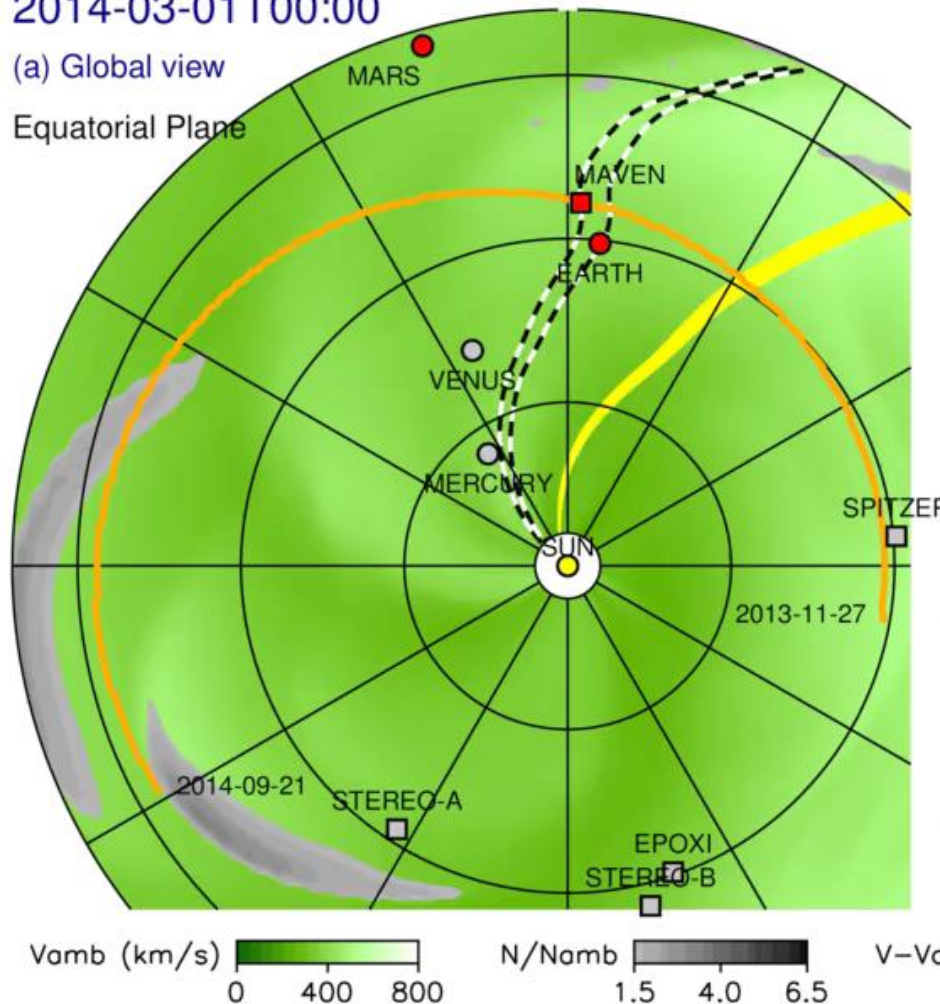
- Earth-MAVEN magnetic connectivity exists for months; but it can be broken by CMEs

MAVEN Cruise to Mars – Predicted SEPs Alerts

2014-03-01T00:00

(a) Global view

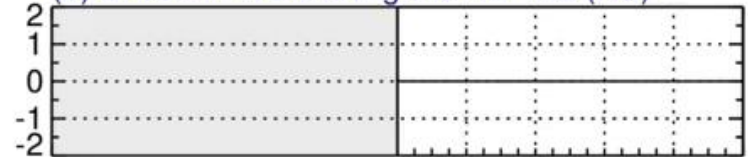
Equatorial Plane



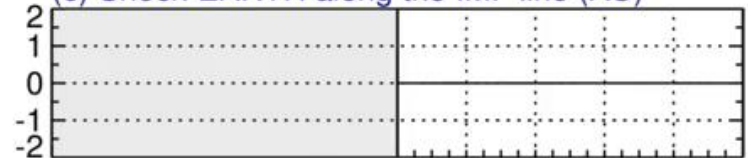
ENLIL-lowres + WSADT-GONGb + Cone-SWRC

2014-03-01T00 + 0.00 days

(b) Shock-MAVEN along the IMF line (AU)



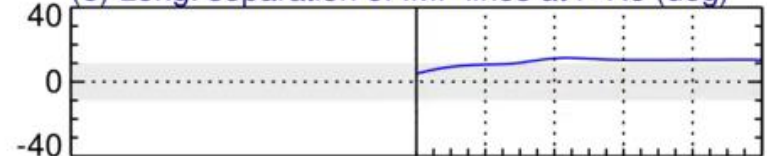
(c) Shock-EARTH along the IMF line (AU)



(d) Long. separation of positions (deg)



(e) Long. separation of IMF lines at $r=R_e$ (deg)



01 02 03 04 05 06

2014-03

IMF line

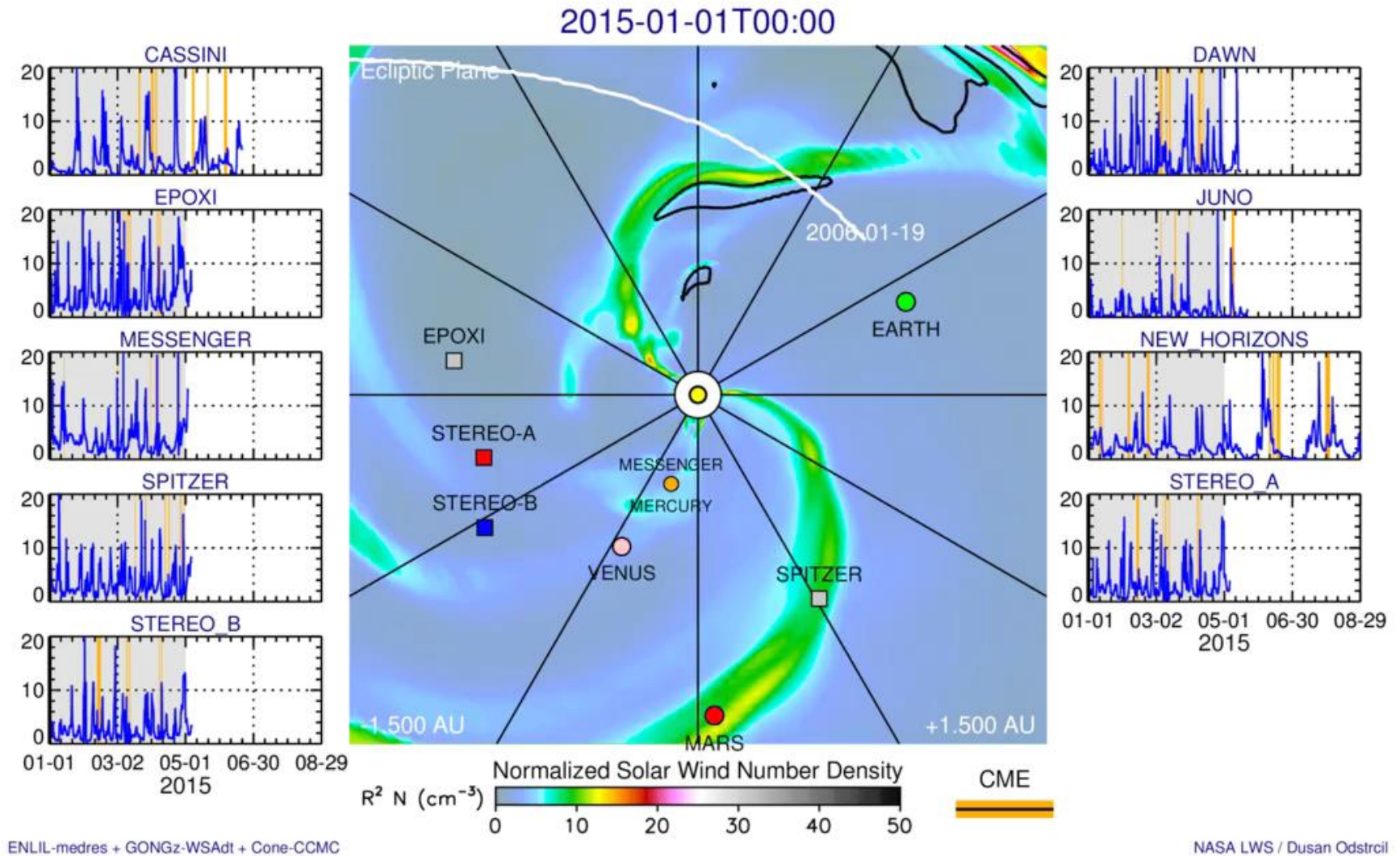
--- IMF line

HELIO WEATHER

- Visualization of “all-clear” and “alerts” for SEPs accelerated by heliospheric shocks

Heliospheric Missions Support

NEW HORIZONS – Concept for Space Weather Prediction

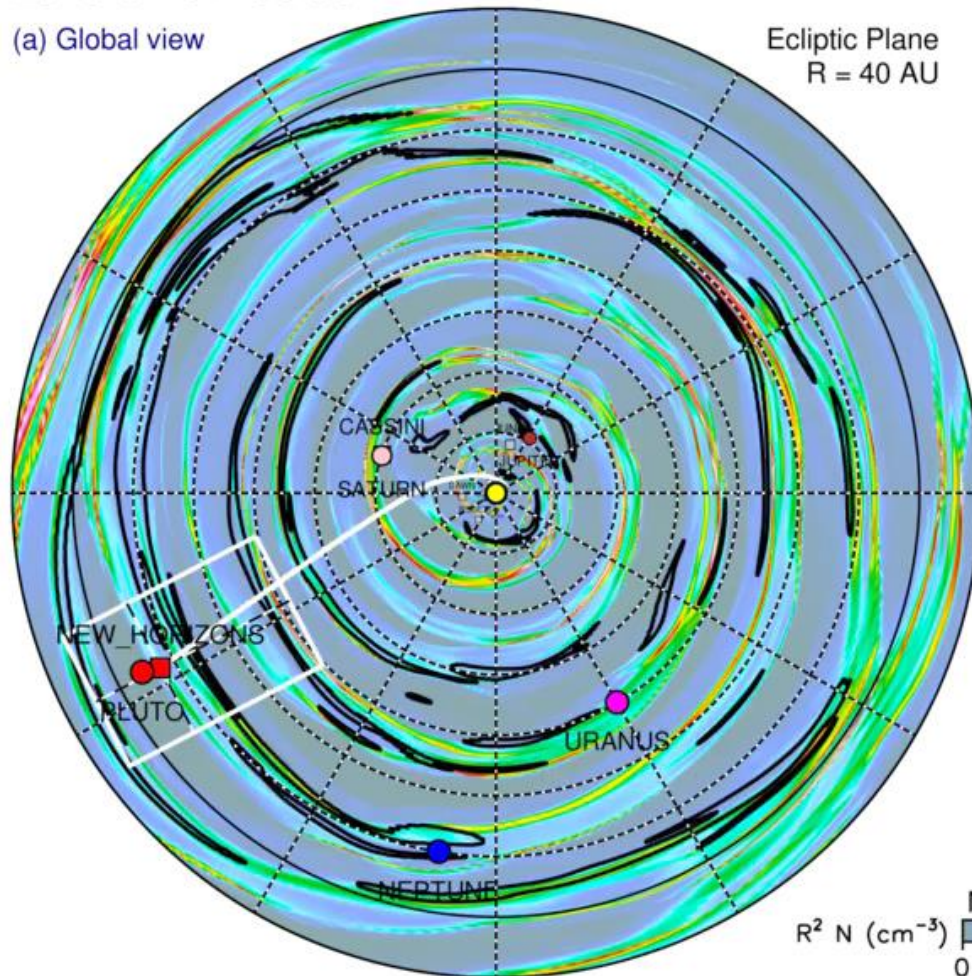


- All CMEs ($>500 \text{ km/s}$) fitted by CCMC in past 8 months are used for 4-months fcst

NEW HORIZONS – Concept for Space Weather Prediction

2015-01-01T00:00

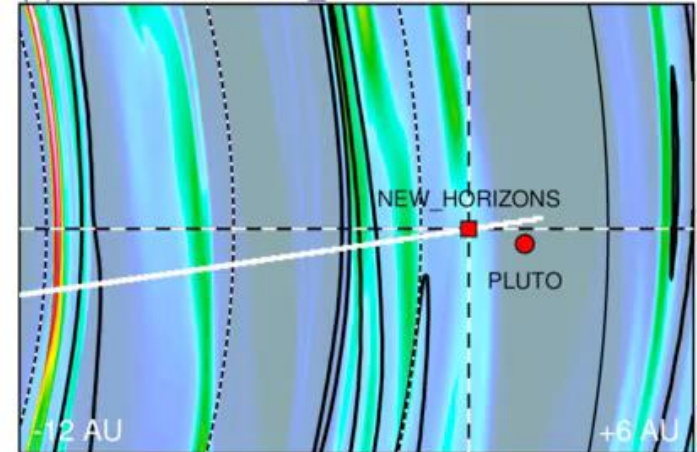
(a) Global view



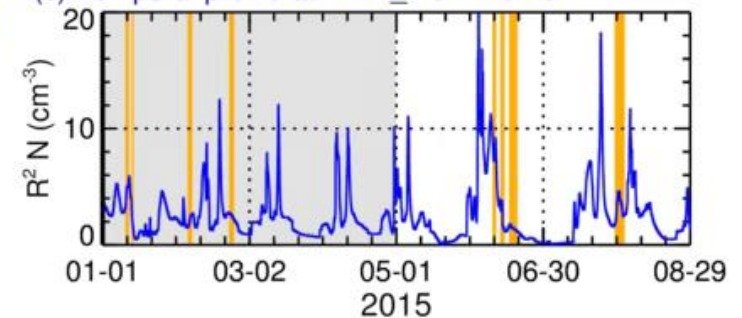
ENLIL-medres + GONGz-WSAdt + Cone-CCMC

2015-05-01 -120.000 days

(b) Detail view at NEW_HORIZONS



(c) Temporal profile at NEW_HORIZONS



Normalized Solar Wind Number Density
 $R^2 N$ (cm^{-3})

CME

NASA LWS / Dusan Odstrcil

- Pluto's atmosphere may be immersed in low-density rarefaction followed by GMIR

Conclusions

- Improvements of the heliospheric modeling system are under development
- Evolving solar wind:
 - more realistic background
 - extended runs
- Using IPSBD maps:
 - alternative to coronagraph observations
 - promising approach with upcoming more data
- Using heliospheric imaging – white-light
 - interpretation of 3D density structures
 - “mid-course” correction
- Predicting SEP events associated with IP shocks
 - IMF topology and shock parameters
 - “alert/all-clear” plots

THANK YOU

Questions, Comments, Suggestions