Forecasting Transient Heliospheric Solar Wind Parameters at the Locations of the Inner Planets

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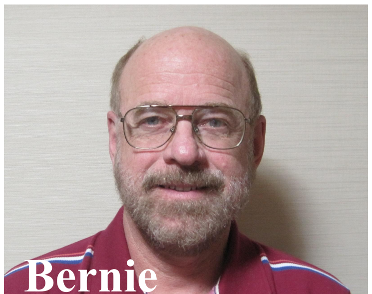
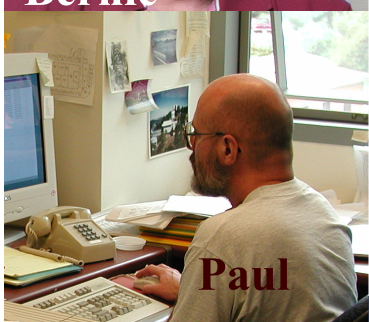
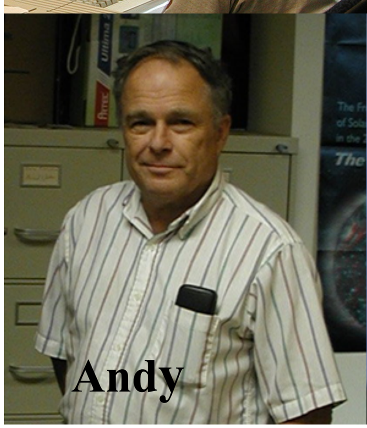
http://smei.ucsd.edu/ http://ips.ucsd.edu/ http://stesun5.stelab.nagoya-u.ac.jp/index-e.html/







Forecasting Heliospheric Solar Wind Parameters

Introduction:

The data: Interplanetary Scintillation (IPS)

3D density reconstructions from interplanetary scintillation (IPS)

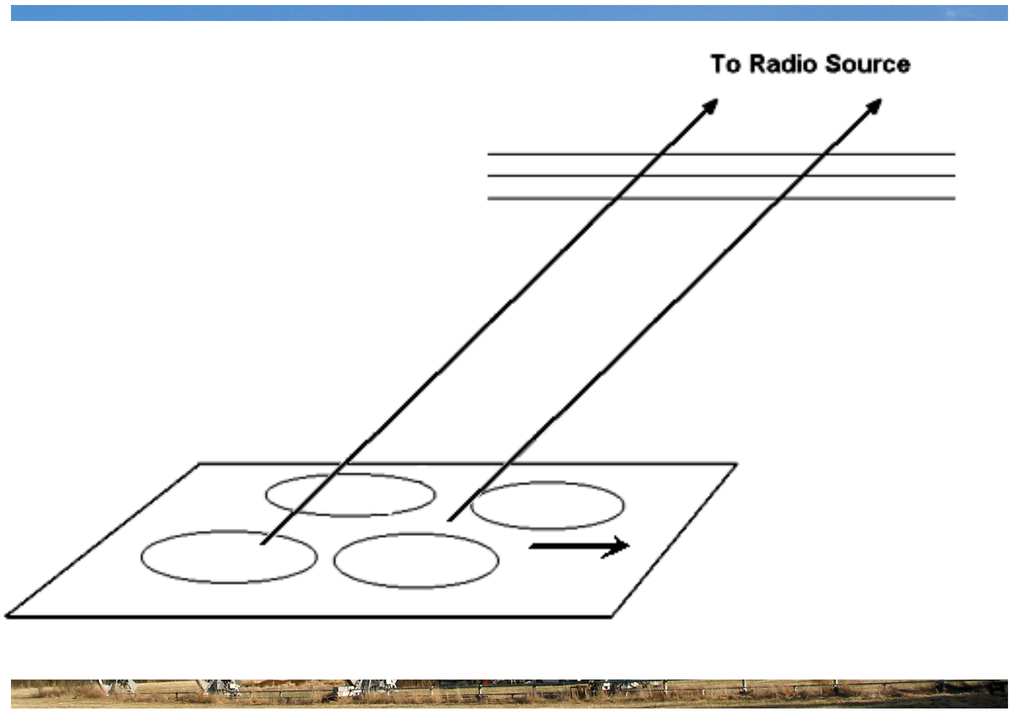
Recent programming enhancements and their use in forecasting

The future – near and distant

Forecasting Heliospheric Solar Wind Parameters

DATA

STELab IPS Heliospheric Analyses



STELab IPS array near Mt Fuji

IPS line-of-sight response

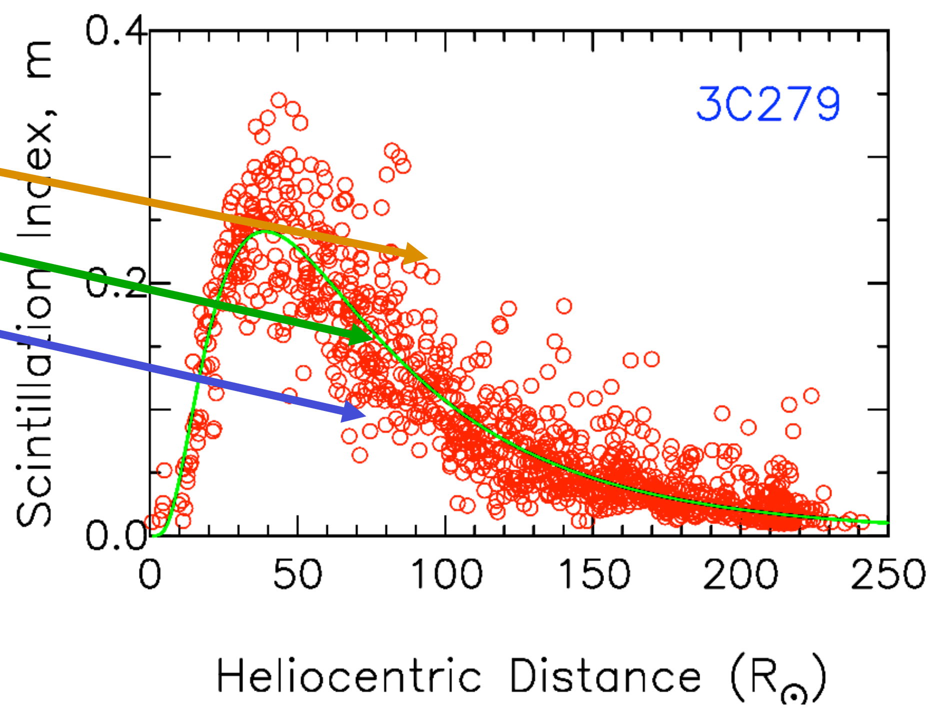
STELab IPS array systems

Forecasting Heliospheric Solar Wind Parameters

Density Turbulence

- Scintillation index, m, is a measure of level of turbulence
- Normalized Scintillation index, $g = m(R) / \langle m(R) \rangle$

- $g > 1 \rightarrow$ enhancement in δNe
- $g \approx 1 \rightarrow$ ambient level of δNe
- $g < 1 \rightarrow$ rarefaction in δNe



(Courtesy of P.K. Manoharan)

A scintillation enhancement with respect to the ambient wind identifies the presence of a region of increased turbulence/density and a possible CME along the line-of-sight to the radio source.

Forecasting Heliospheric Solar Wind Parameters

Other Current IPS Radio Systems

The Pushchino Radio Observatory 70,000 m^2 110 MHz array, Russia (summer 2006)
Now named the "Big Scanning Array of the Lebedev Physical Institute" (BSA LPI).

The Ootacamund (Ooty) off-axis parabolic cylinder 530 m long and 30 m wide (15,900 m^2) operating at a nominal frequency of 326.5 MHz

Forecasting Heliospheric Solar Wind Parameters

IHY - Other Current IPS Radio Systems

MEXART IPS 9,600 m^2 140 MHz IPS radio array near Michoacan, Mexico

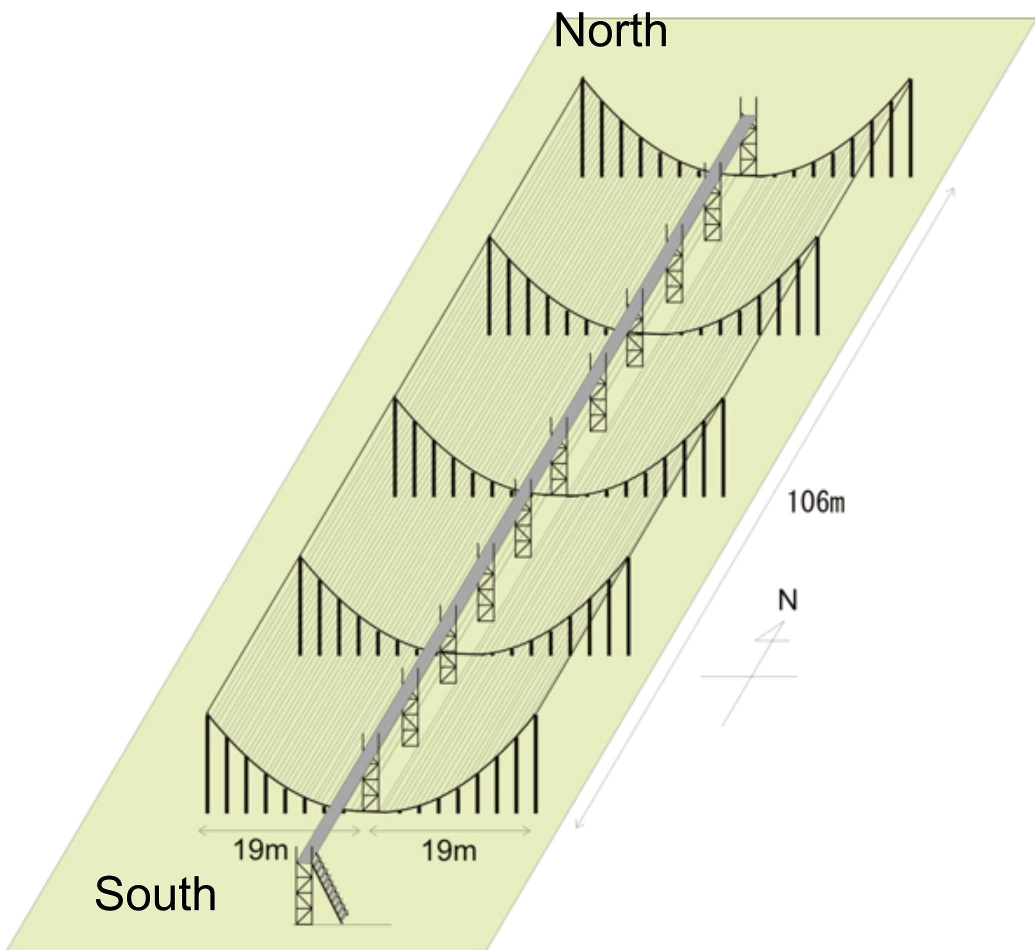
Forecasting Heliospheric Solar Wind Parameters

Current STELab IPS Heliospheric Analyses

New STELab IPS array at Toyokawa - photo February 17, 2007
(array now operates well – year-round operation)

Forecasting Heliospheric Solar Wind Parameters

Solar Wind Imaging Facility (SWIFT)



- Large-Aperture Parabolic Reflector
  - ➢**88m×39m×η=3432×η㎡**
  - ➢**Efficiency η_{obs}~0.65**
- 192-Elements Phased Array in N-S Direction
  - ➢**Single Beam with a Steerable Range of 60 deg S-30 deg N**
  - ➢1 Element = Combination of East and West λ/2-dipoles
  - ➢Delay Correction
- Low-Noise Receiver
  - ➢**327MHz ±5MHz max**
  - ➢Front-end: NF <1dB、VSWR <1.5
  - ➢Loop-Method Calibration System
- RFI Reduction
  - ➢Small Height of Focal Points
  - ➢Shielding Fence at North and South Ends

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., et al., 2012, *Adv. in Geosciences (under review)*

Potential future IPS systems

MWA (Western Australia)

(32 tiles are now operating. The full array 128 tiles can obtain IPS.)

LOFAR (Western Europe)

(Some parts of the system are now operating - Richard Fallows, Mario Bisi, are involved. IPS/FR tests are ongoing)

KASI (Korea)

(Tiles like those of MWA are being used. So far a small system is deployed)

AOGS Special Session
ST25 – Singapore 13-17 August

"Forecasting Solar Wind Parameters at the Earth and Planets"

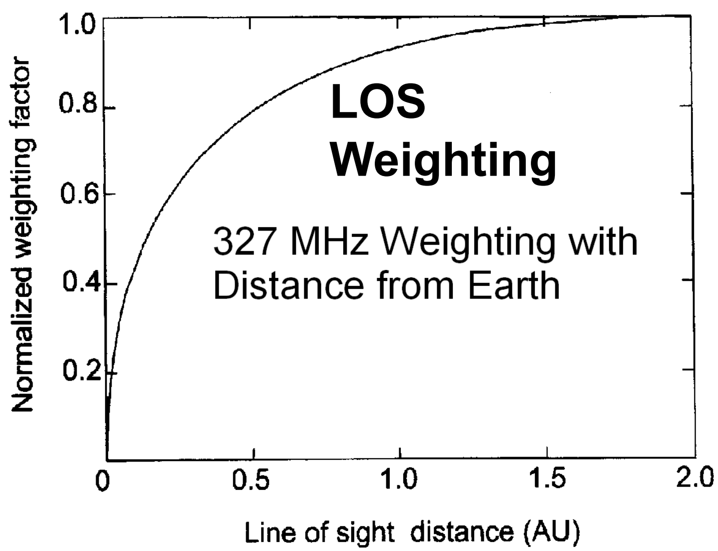
(B. Jackson, T. Nagatsuma, M. Tokumaru, P.K. Manoharan, M. Bisi, conveners)

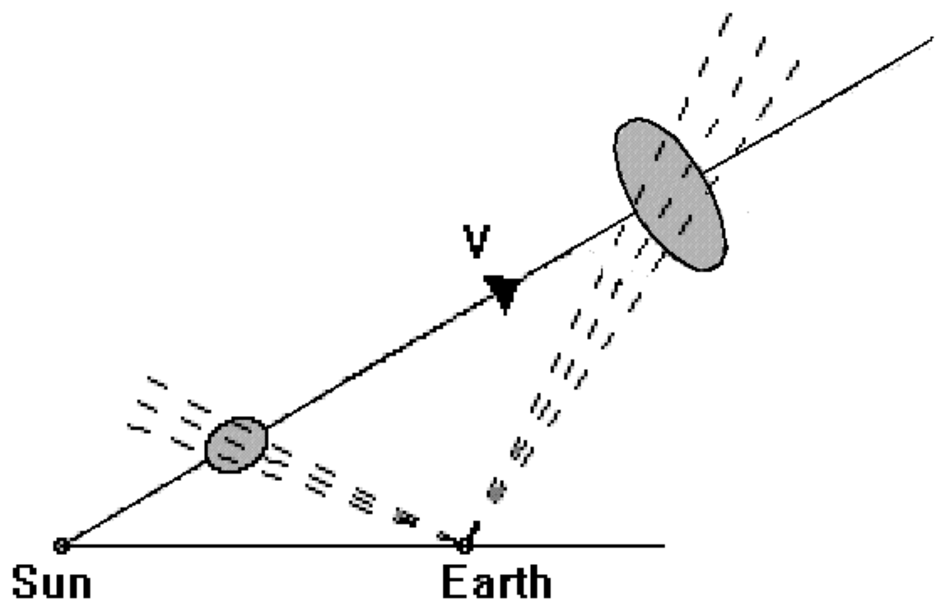
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., et al., 2008, *Adv. in Geosciences,* 21, 339

The outward-flowing solar wind structure follows very specific physics as it moves outward from the Sun

Heliospheric 3-D Reconstruction



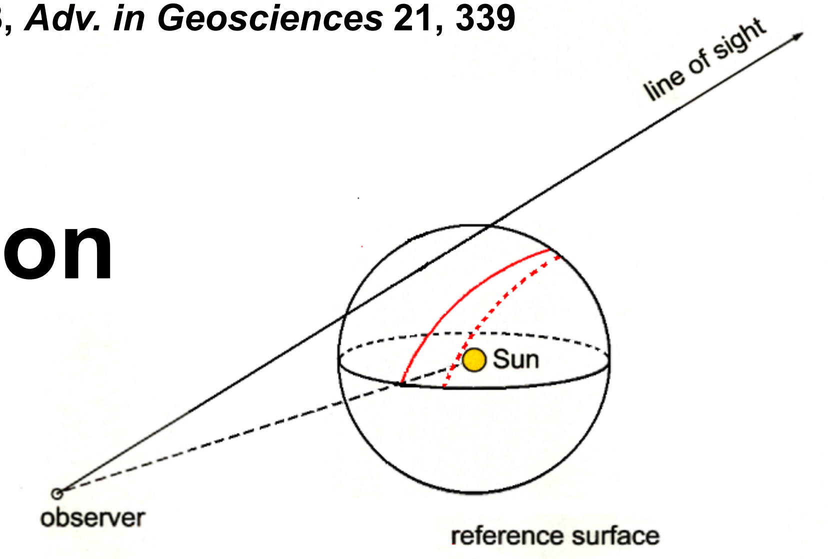


Forecasting Heliospheric Solar Wind Parameters

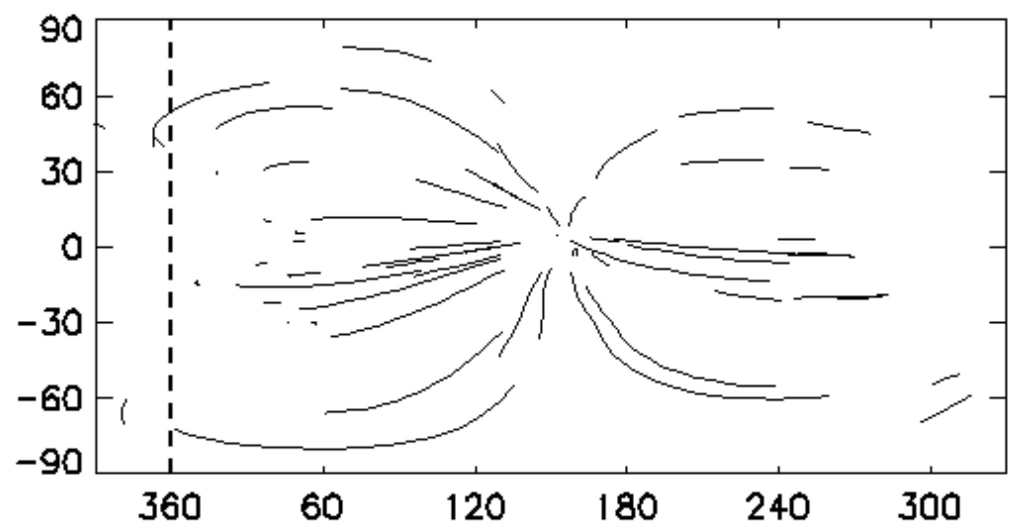
Jackson, B.V., et al., 2008, *Adv. in Geosciences* 21, 339

Heliospheric

3-D Reconstruction



Line of sight "crossed" components on a reference surface. Projections on the reference surface are shown. These weighted components are inverted to provide the time-dependent tomographic reconstruction.



14 July 2000

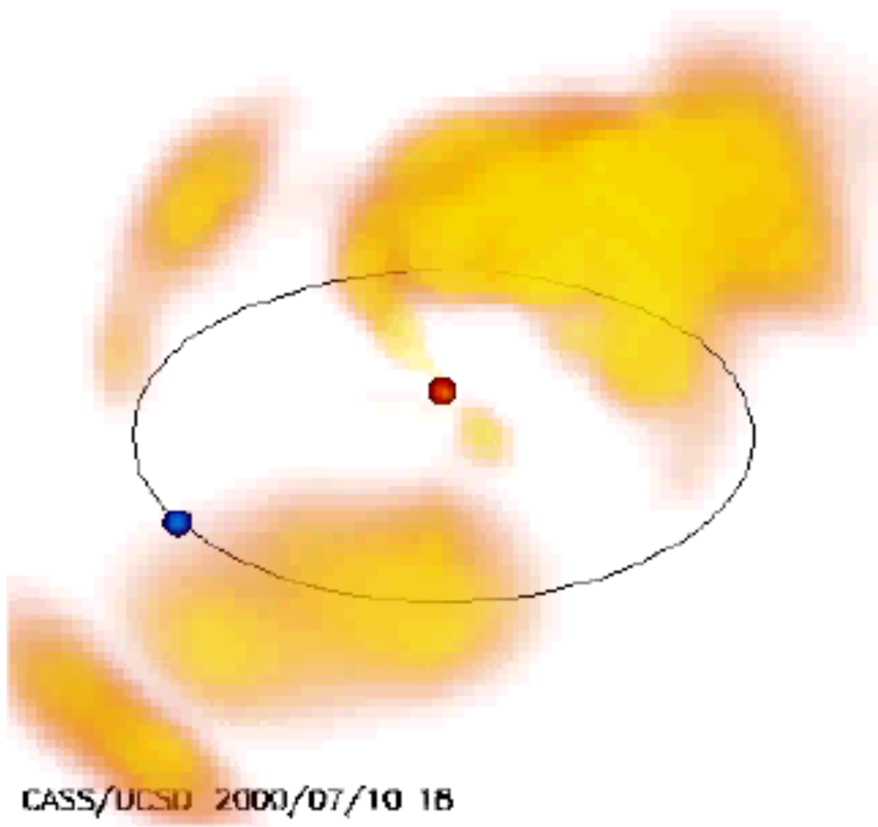
Forecasting Heliospheric Solar Wind Parameters

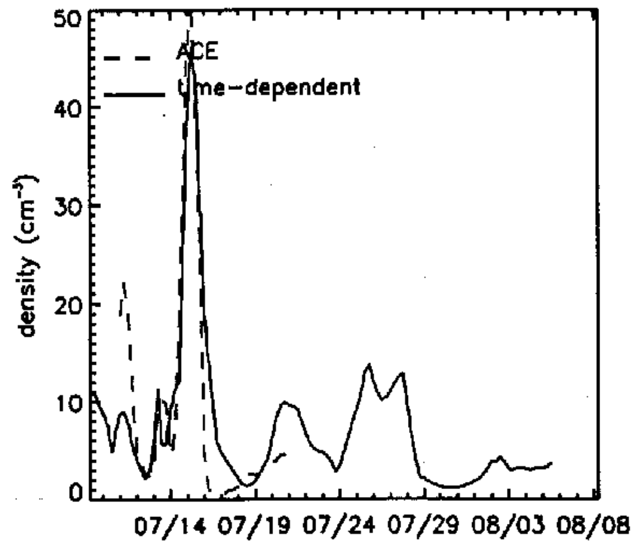
Jackson, B.V., et al., 2002, *Solar Wind 10*, 31

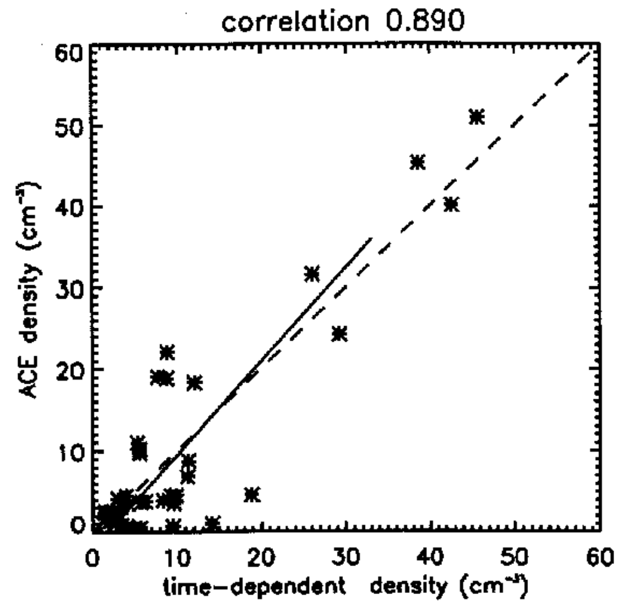
IPS C.A.T. Analysis

Bastille Day Event

14 July 2000







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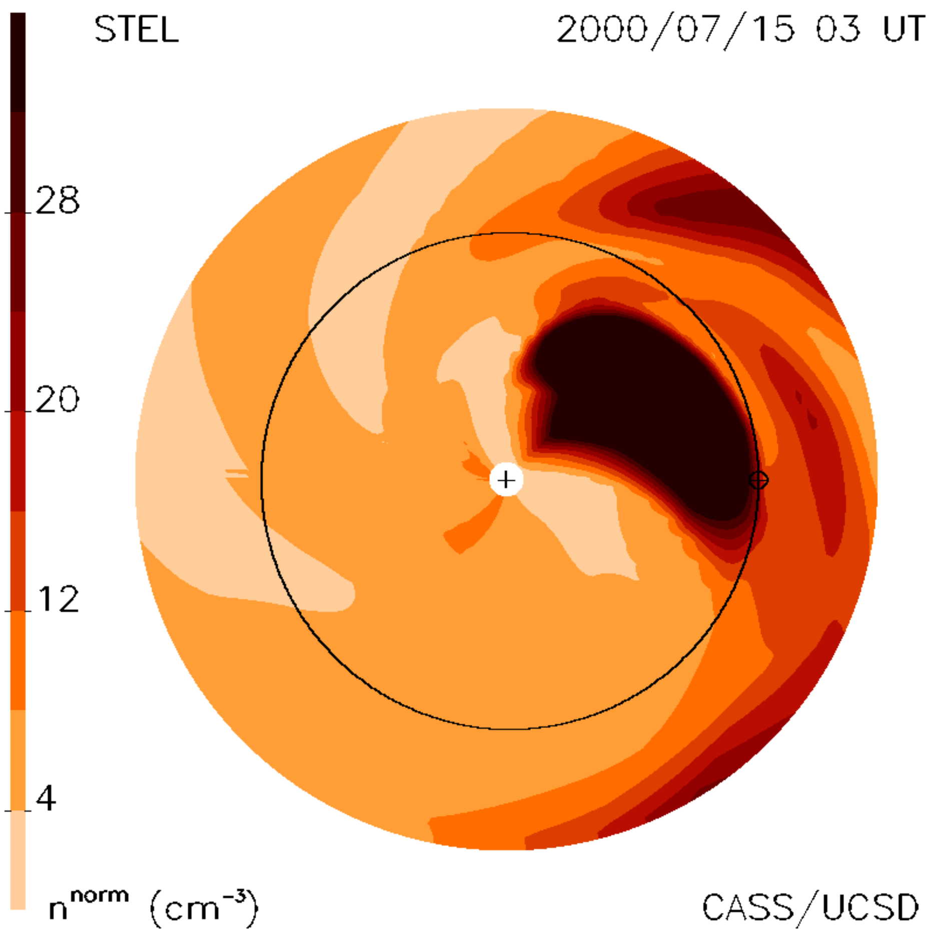

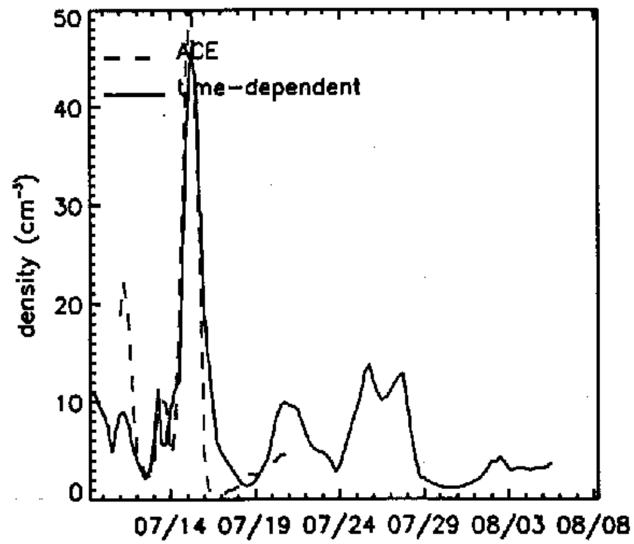

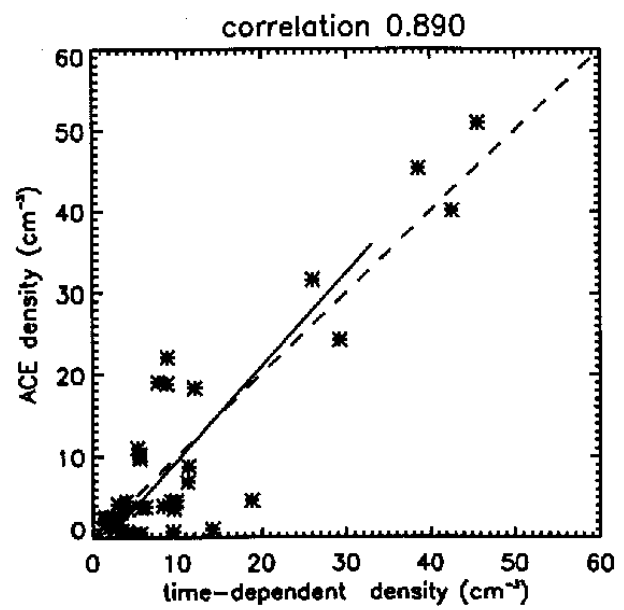

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., et al., 2002, *Solar Wind 10,* 31

IPS C.A.T. Analysis

Bastille Day Event

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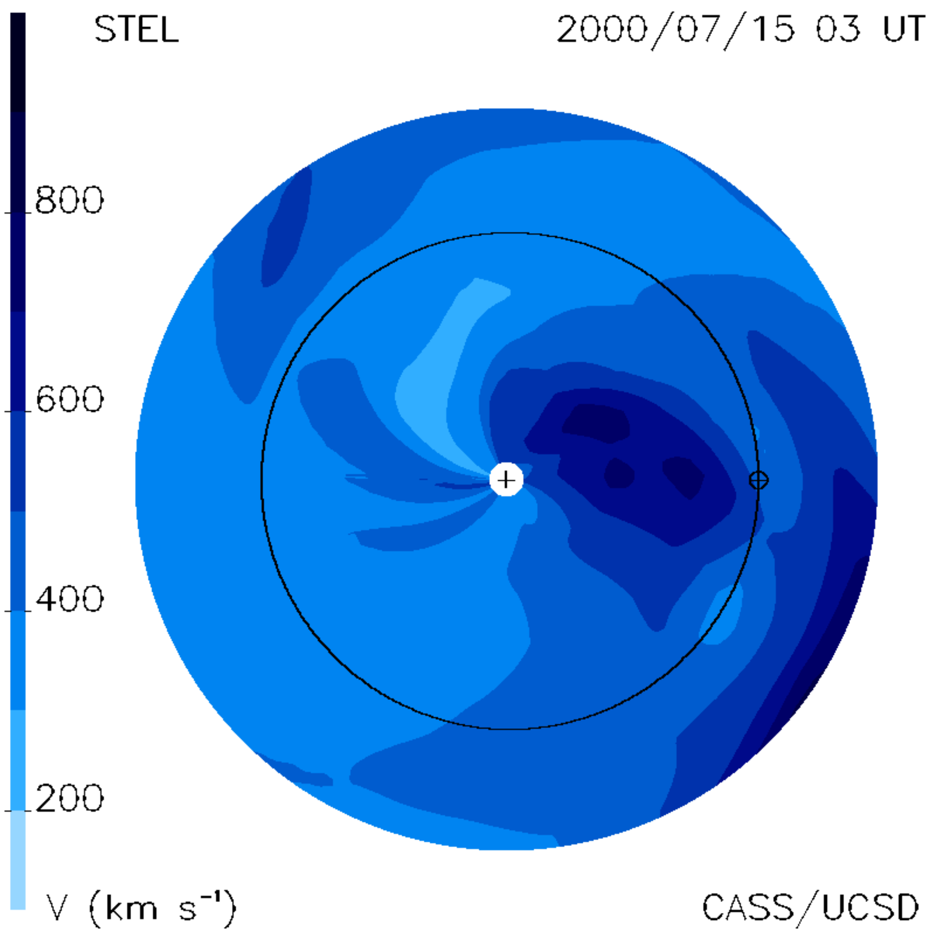
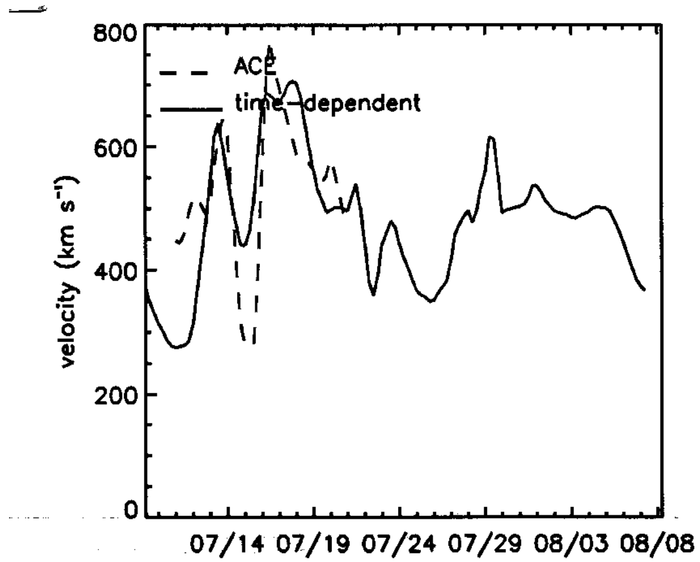
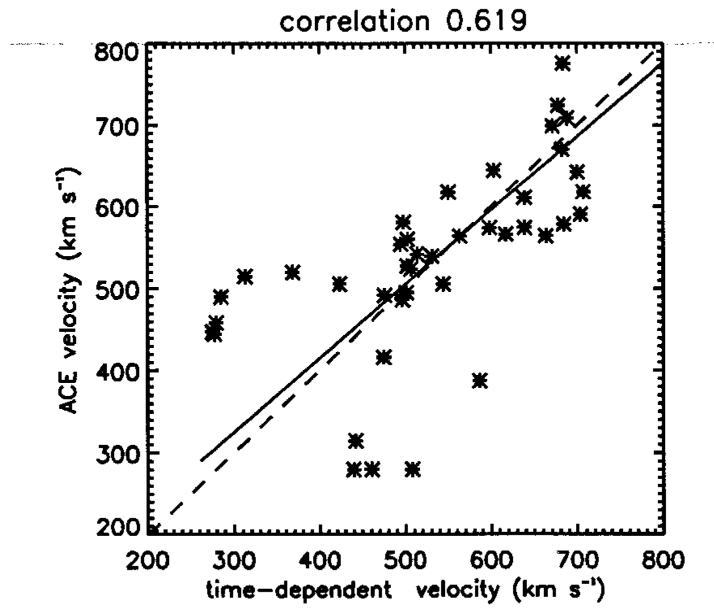






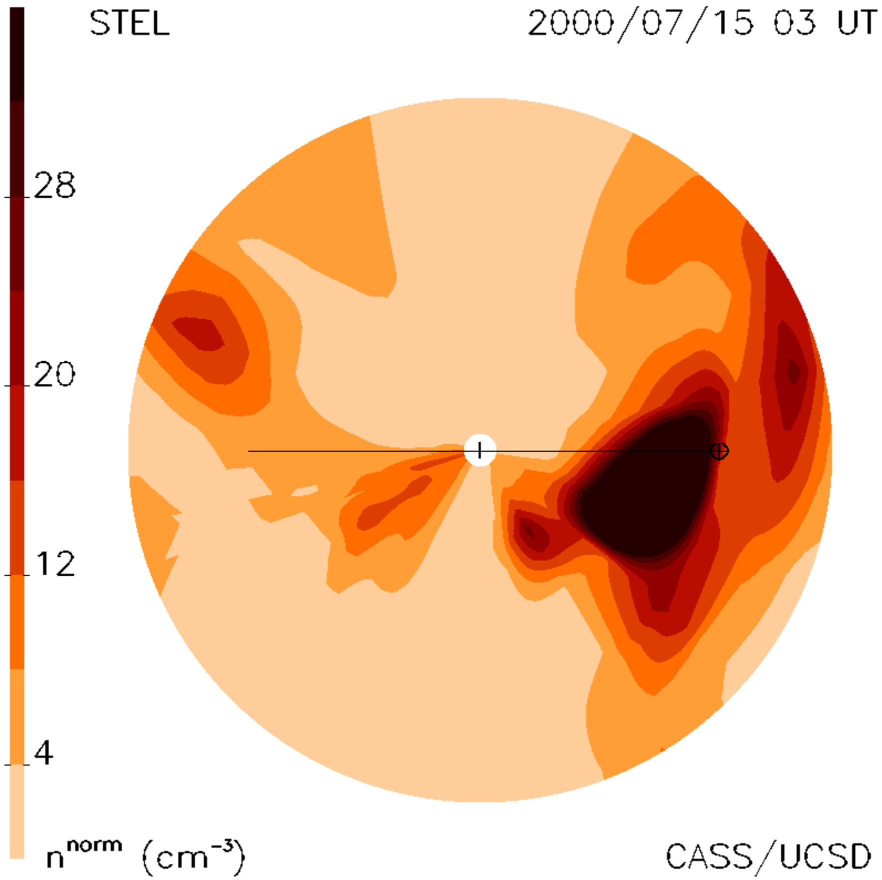
CASS/UCSD-STELab CCMC_2012

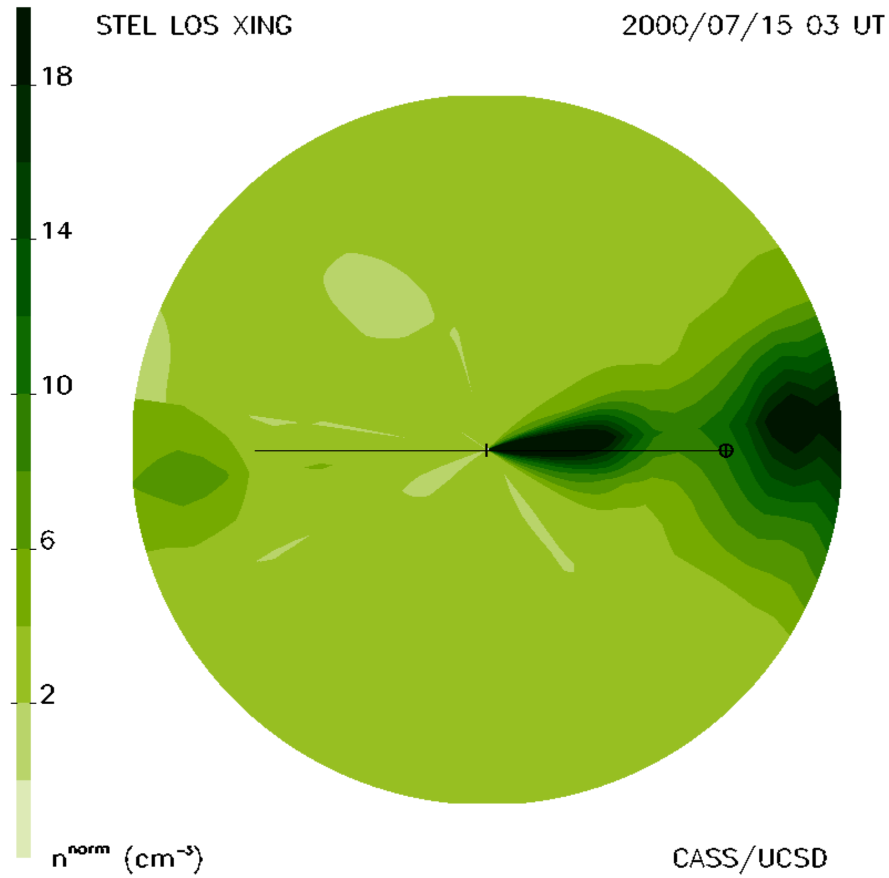
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., et al., 2002, *Solar Wind 10,* 31

IPS C.A.T. Analysis

Bastille Day Event 14 July 2000





CASS/UCSD-STELab CCMC_2012

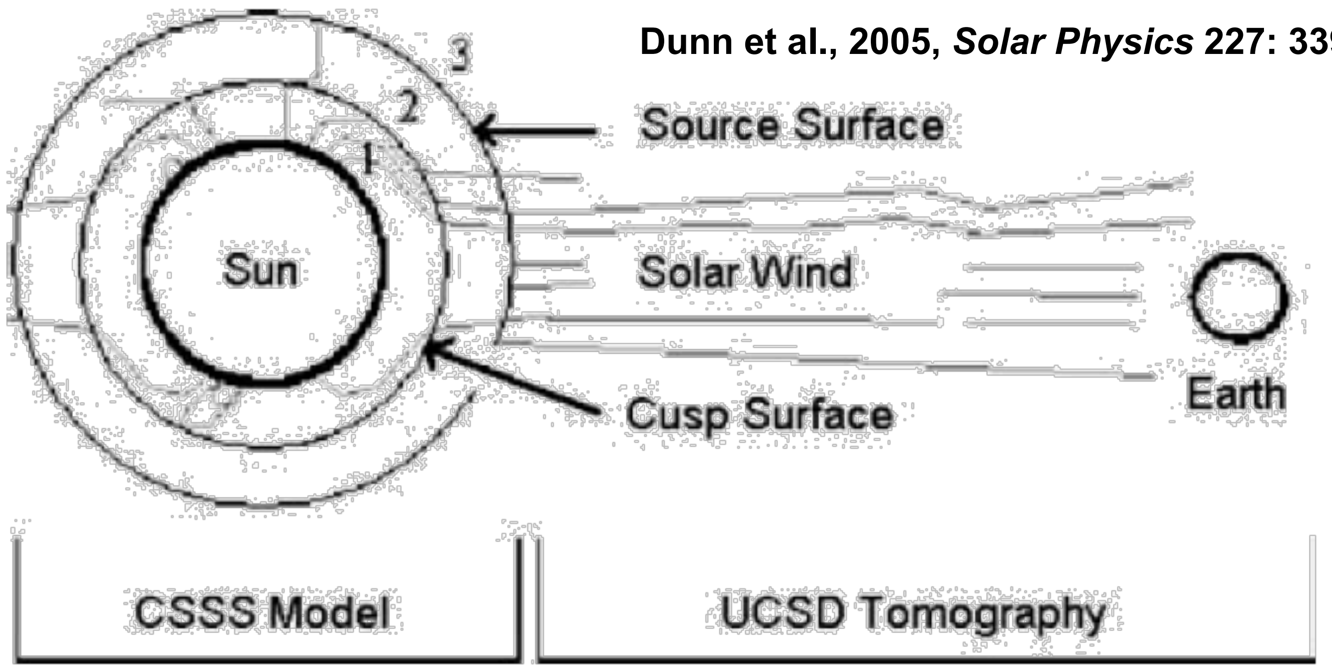
Forecasting Heliospheric Solar Wind Parameters

Zhao, X. P. and Hoeksema, J. T., 1995, *J. Geophys. Res.,* 100 (A1), 19.

http://ips.ucsd.edu/

Magnetic Field Extrapolation

Dunn et al., 2005, *Solar Physics* 227: 339–353.



1. **Inner region: the CSSS model calculates the magnetic field using photospheric measurements and a horizontal current model.**

2. **Middle region: the CSSS model opens the field lines. In the outer region.**

3. **Outer region: the UCSD tomography convects the magnetic field along velocity flow lines.**

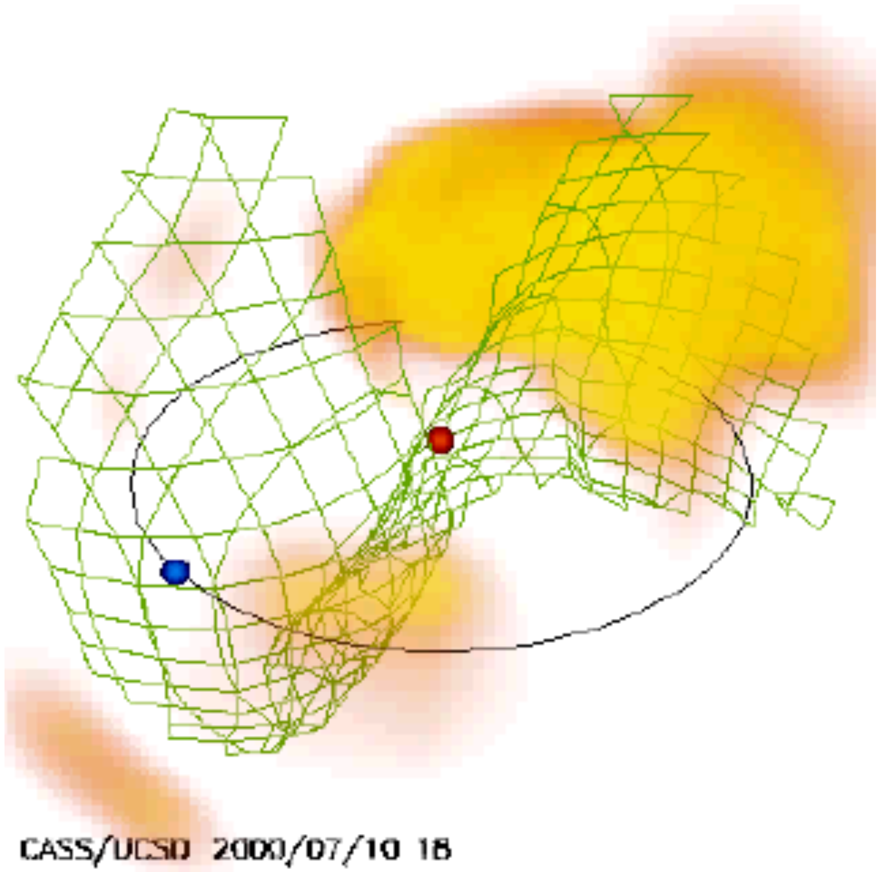
Jackson, B.V., et al., 2012, *Adv. in Geosciences (under review)*

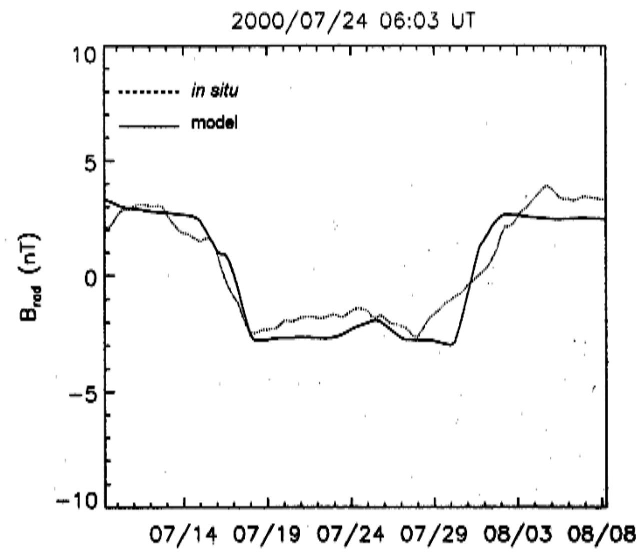
Forecasting Heliospheric Solar Wind Parameters

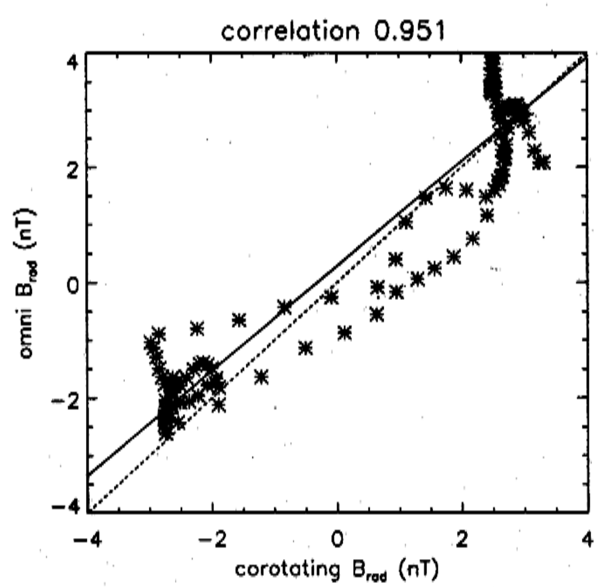
Dunn, T.J., *et al.*, 2005, *Solar Phys.*, 227, 339

IPS C.A.T. Analysis

Potential field modeling added







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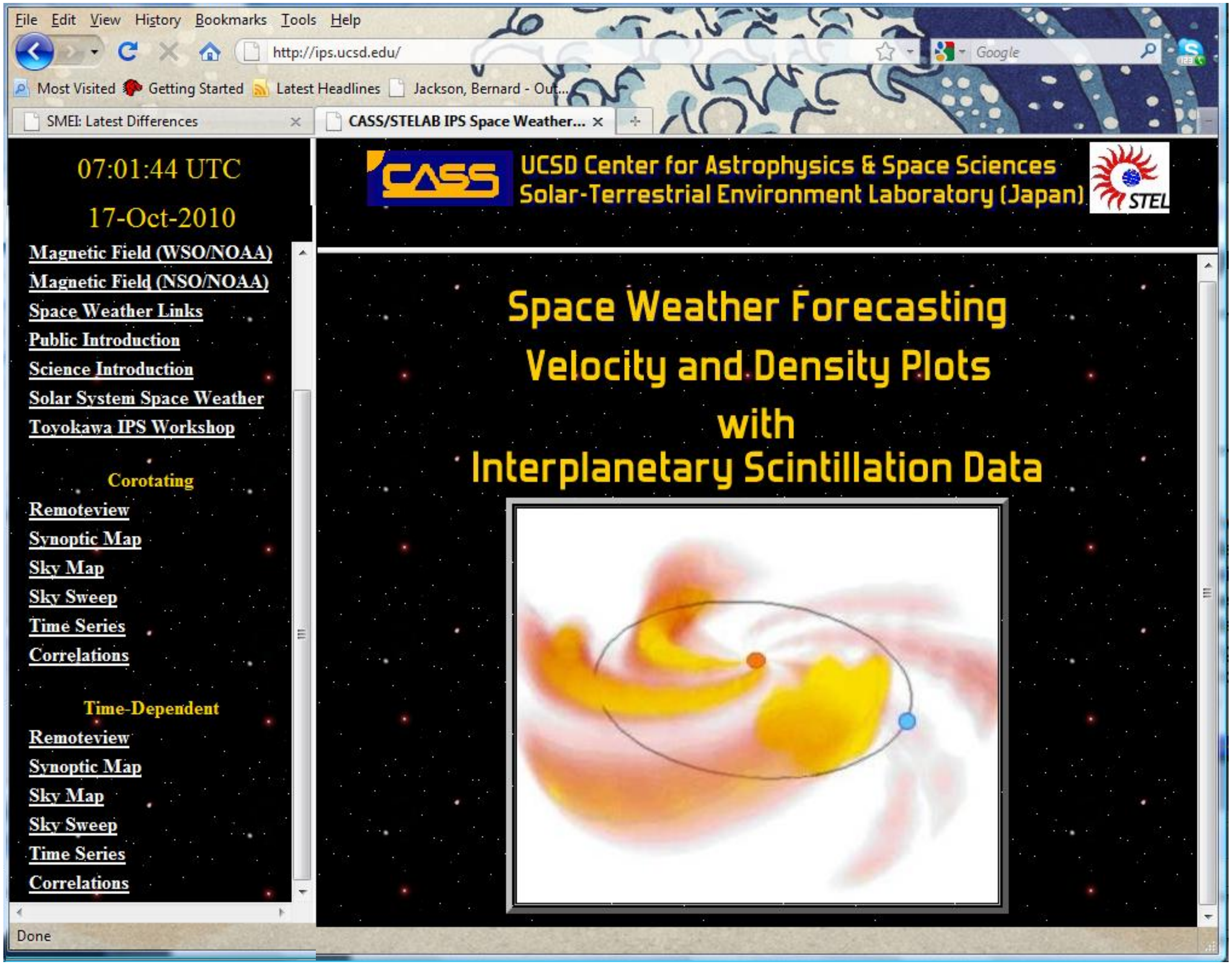
UCSD IPS analysis



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Forecasting Heliospheric Solar Wind Parameters

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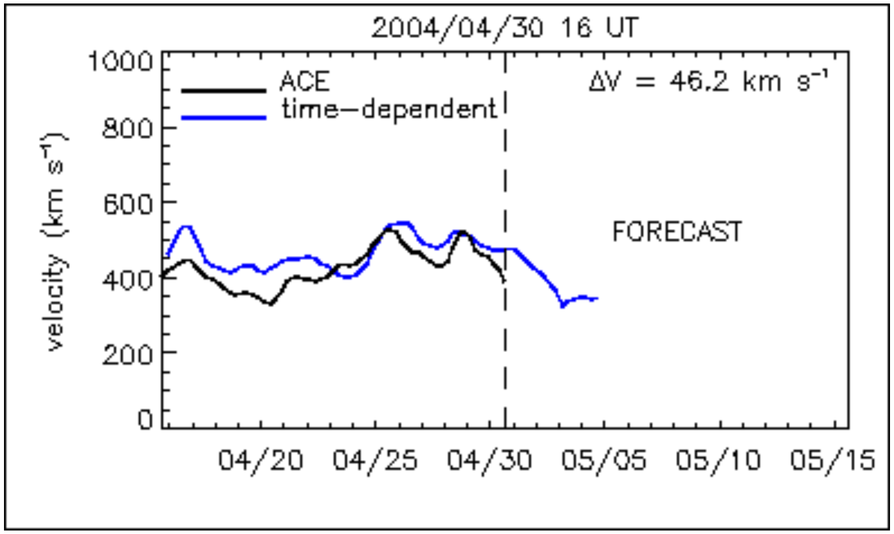
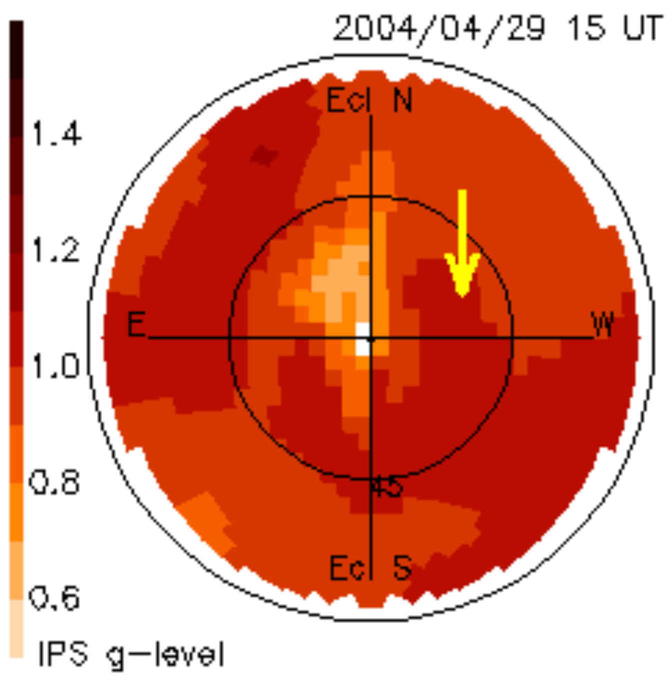
UCSD time-dependent IPS Web forecast

Velocity model time-series



G-level sky map



Real-time tomographic analysis of the solar wind on April 29-30, 2004 showing a halo CME response in the interplanetary medium.

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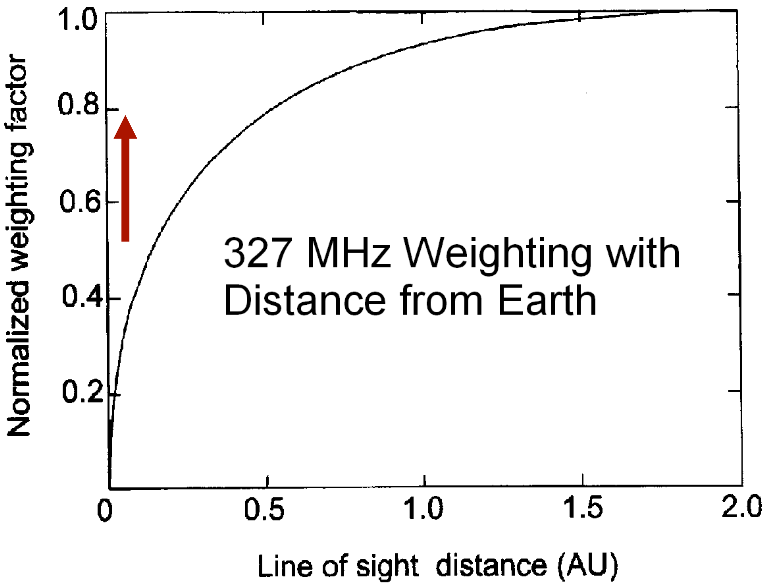
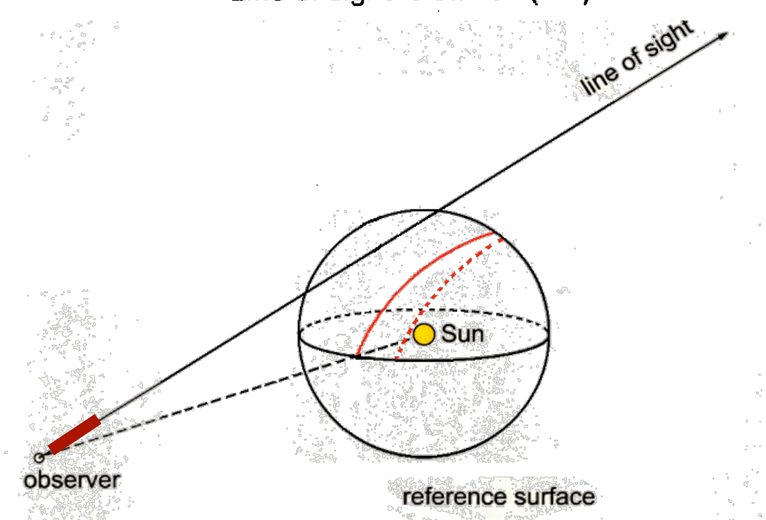
Forecasting Heliospheric Solar Wind Parameters

IPS line-of-sight response

Jackson, B.V., *et al*., 2010, *Solar Phys*., 265, 245-256.
Jackson, B.V., *et al*., 2008, *Adv. in Geosciences,* (under review).

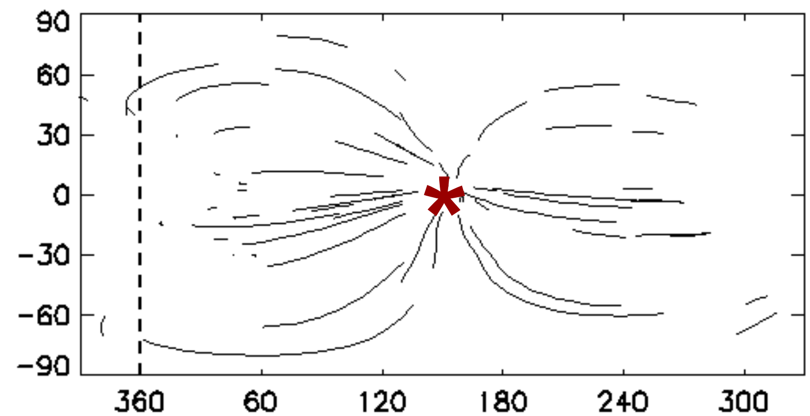




Heliospheric C.A.T. Analyses: example line-of-sight distribution for each sky location to form the source surface of the 3D reconstruction.

Innovation

STELab IPS



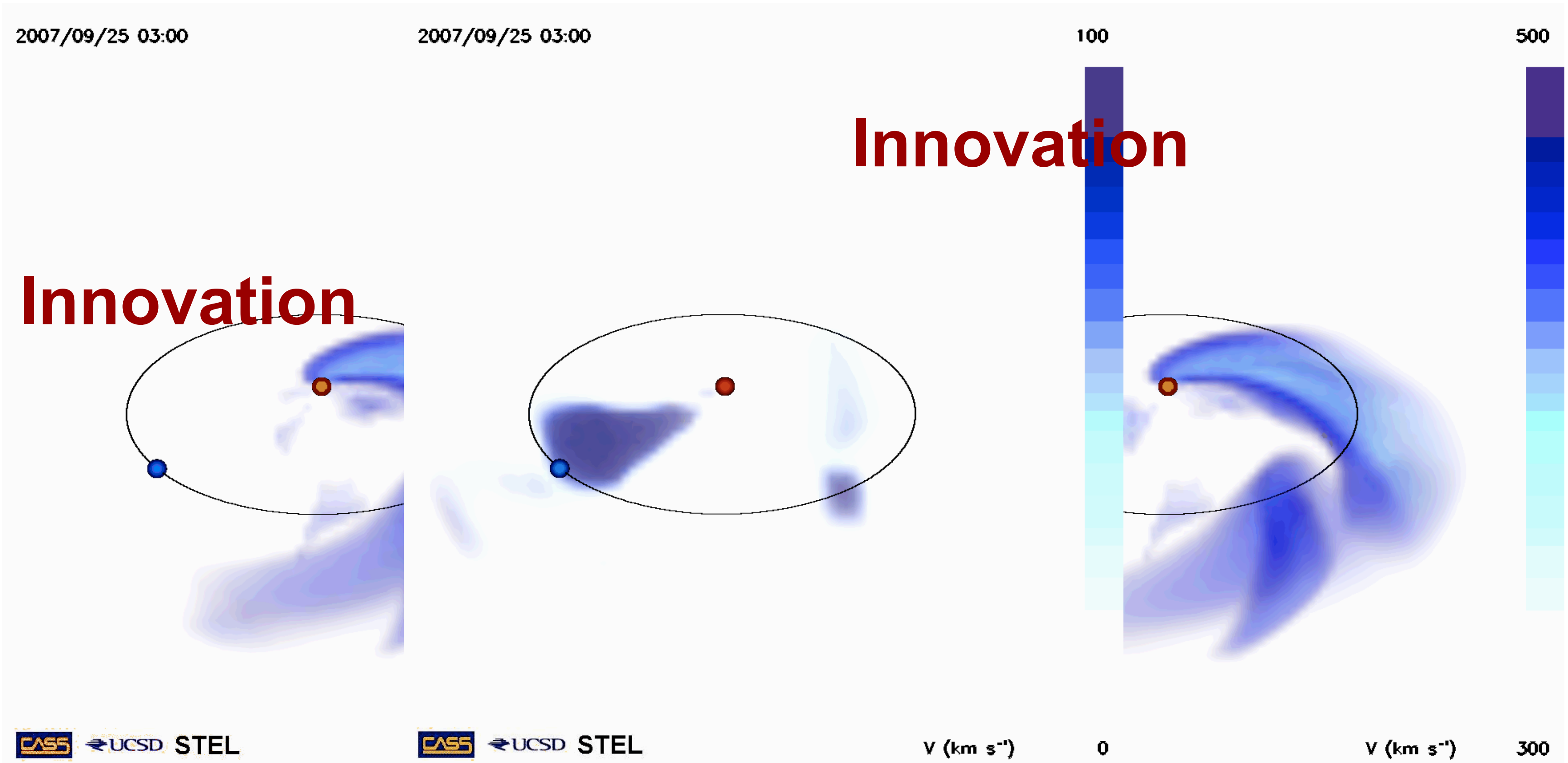
13 July 2000

Inclusion of in-situ measurements into the 3D-reconstructions

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al*., 2010, *Solar Phys*., 265, 245-256.

Heliospheric 3D-reconstructions



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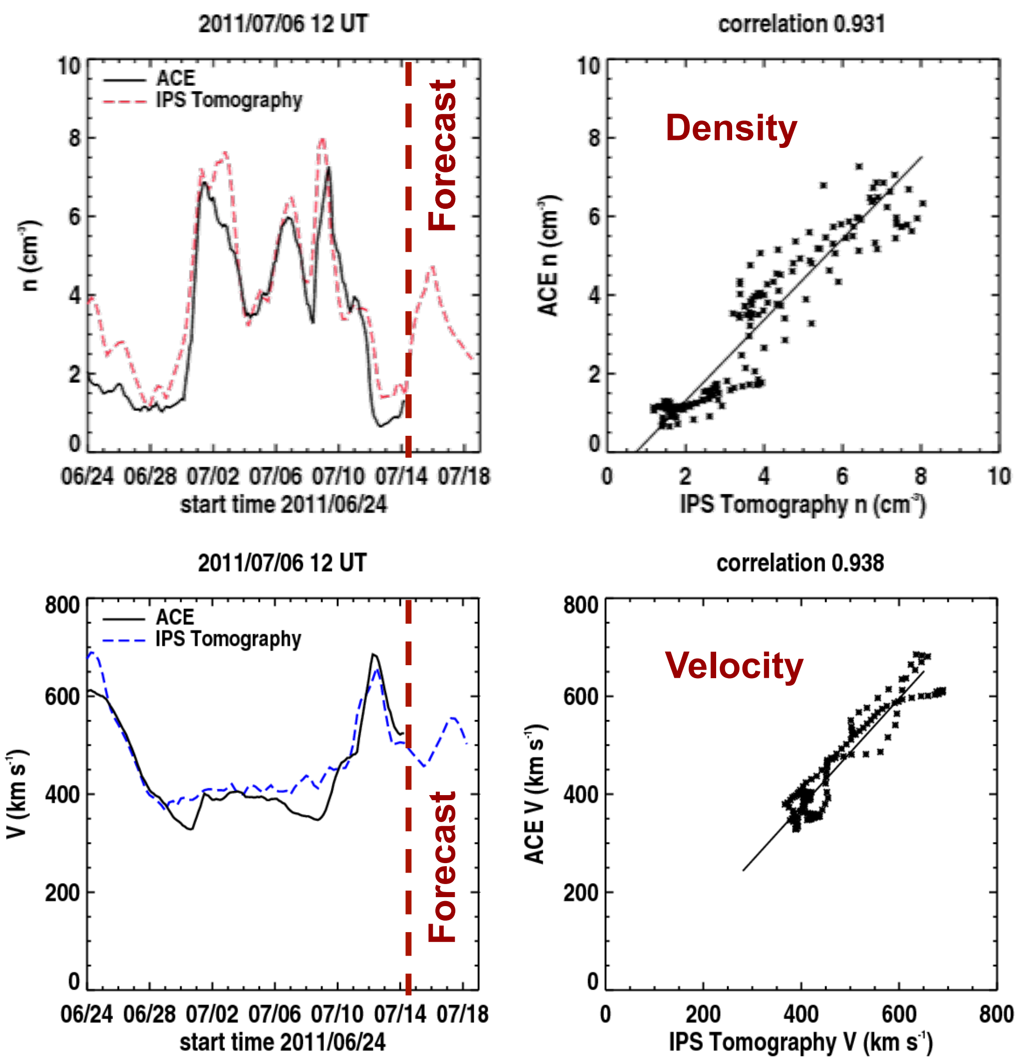
Being evaluated at the CCMC

Innovation



Heliospheric 3D-reconstructions

Inclusion of in-situ measurements into the 3D-reconstructions

Forecasts work better if the values match up to the present.

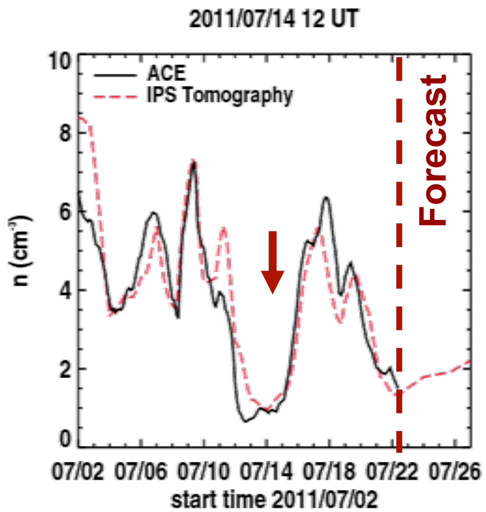
Forecasting Heliospheric Solar Wind Parameters

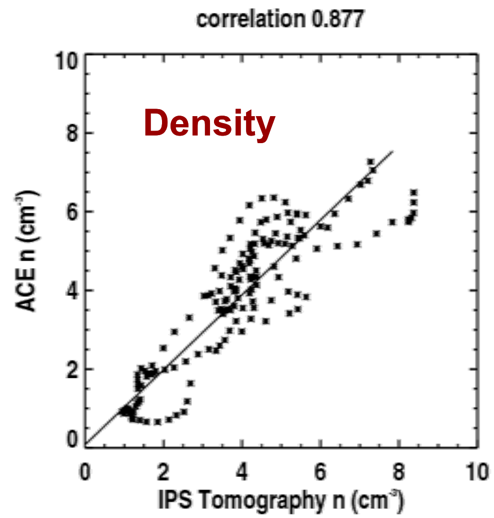
Jackson, B.V., et al., 2010, *Solar Phys.*, 265, 245-256.
Jackson, B.V., *et al.*, 2012, *Adv. in Geosciences,* (under review).

Being evaluated at the CCMC

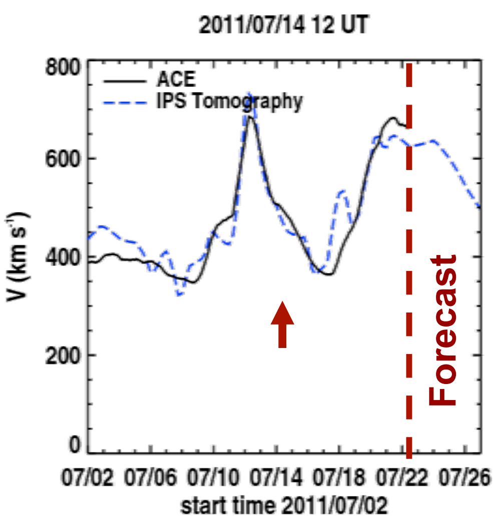
Innovation

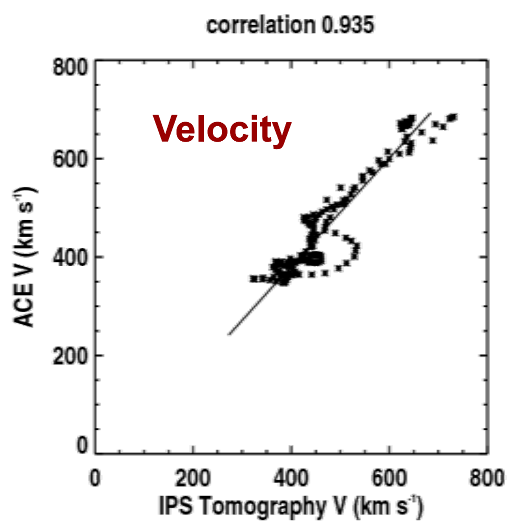
Heliospheric 3D-reconstructions





Inclusion of in-situ measurements into the 3D-reconstructions





Forecasts work better if the values match up to the present.

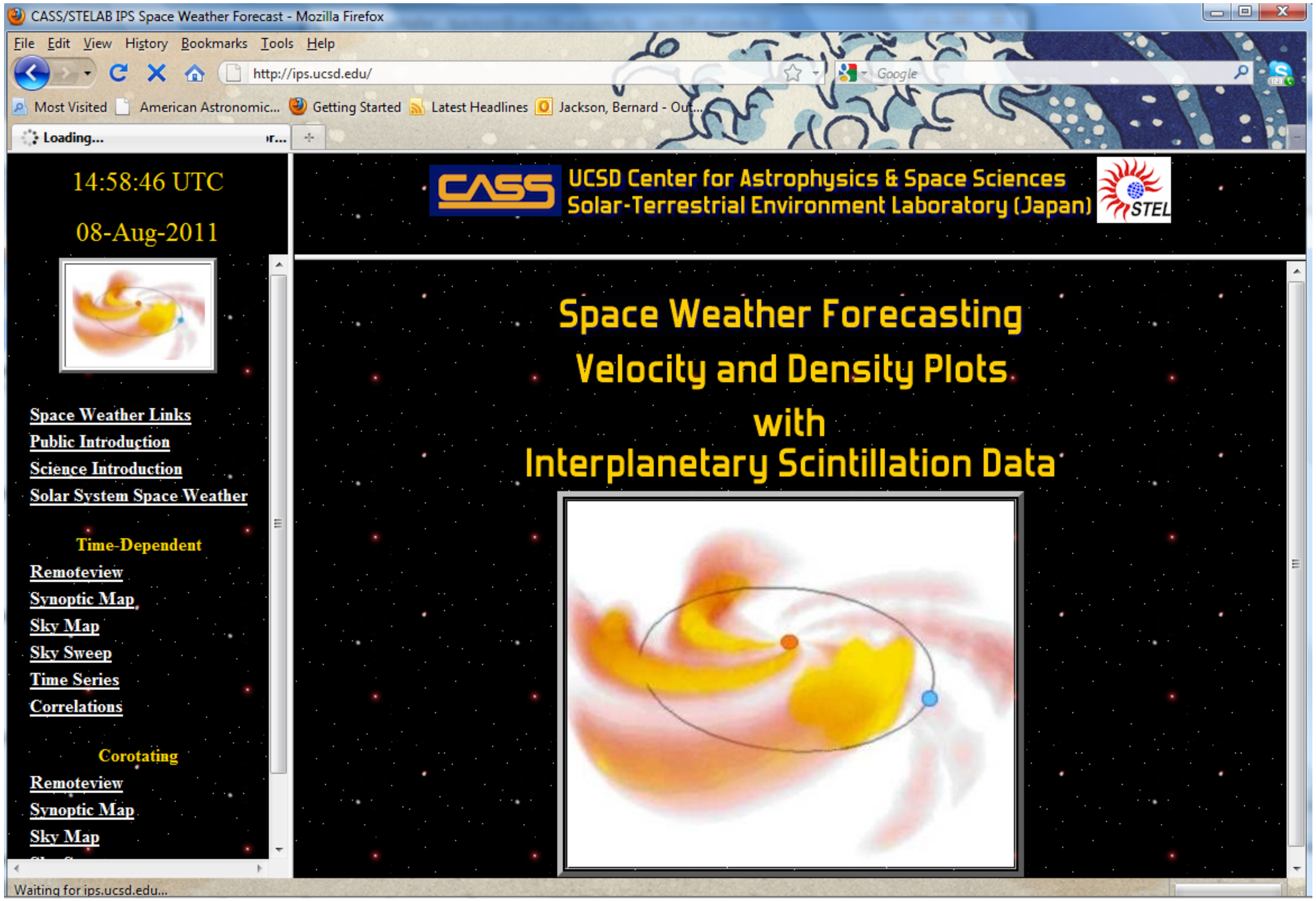
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2012, *Adv. in Geosciences,* (under review).

http://ips.ucsd.edu/

UCSD Web pages

UCSD IPS analysis



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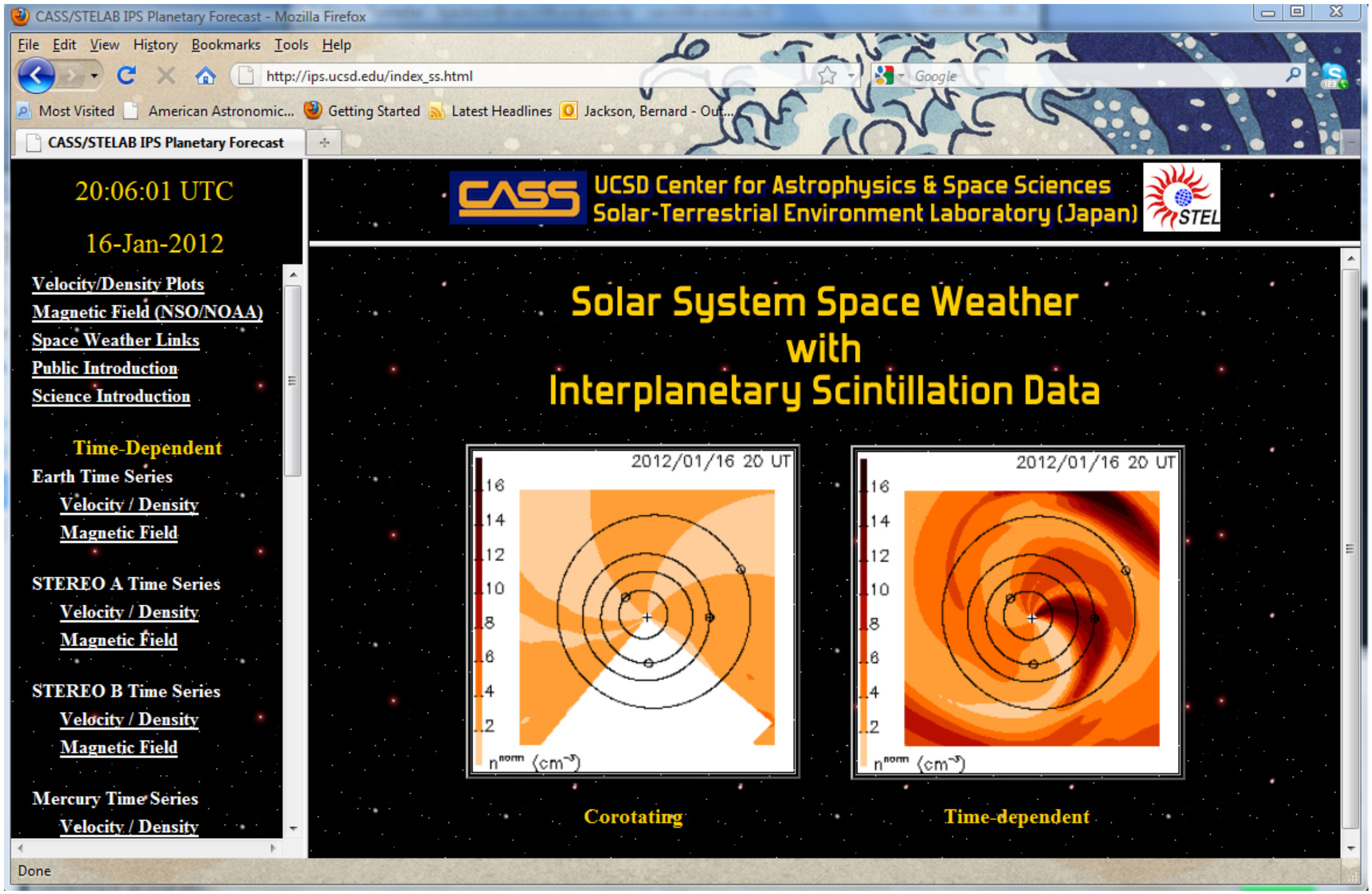
Density overview

UCSD IPS analysis



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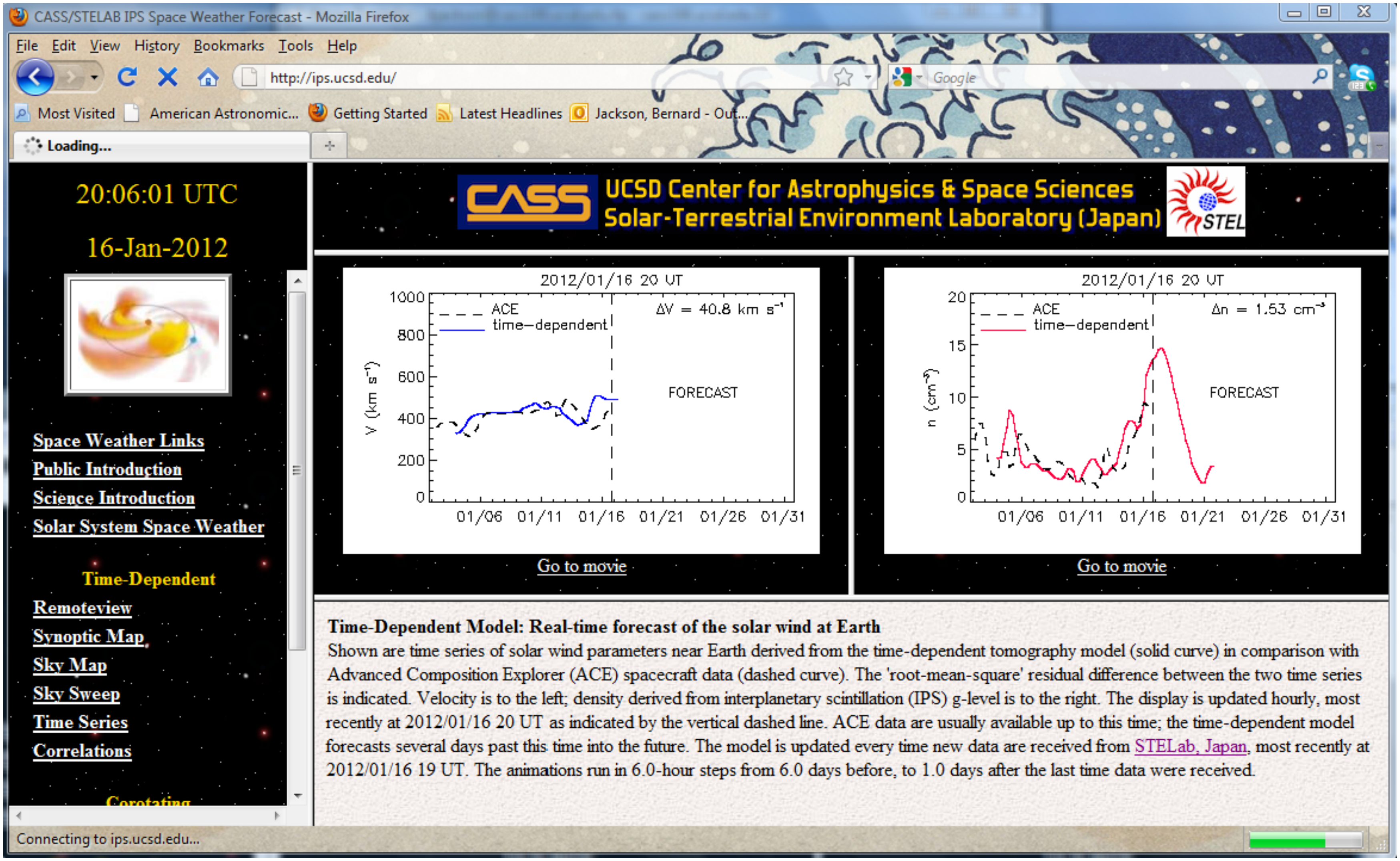
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2012, *Adv. in Geosciences,* (under review).

http://ips.ucsd.edu/ Earth Velocity and Density



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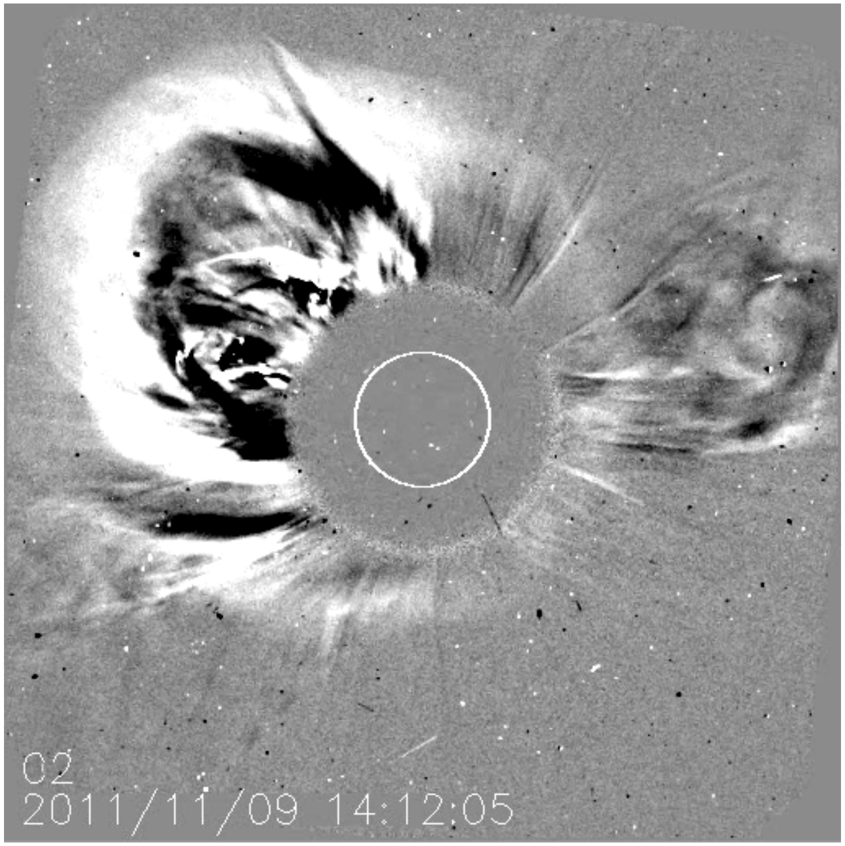
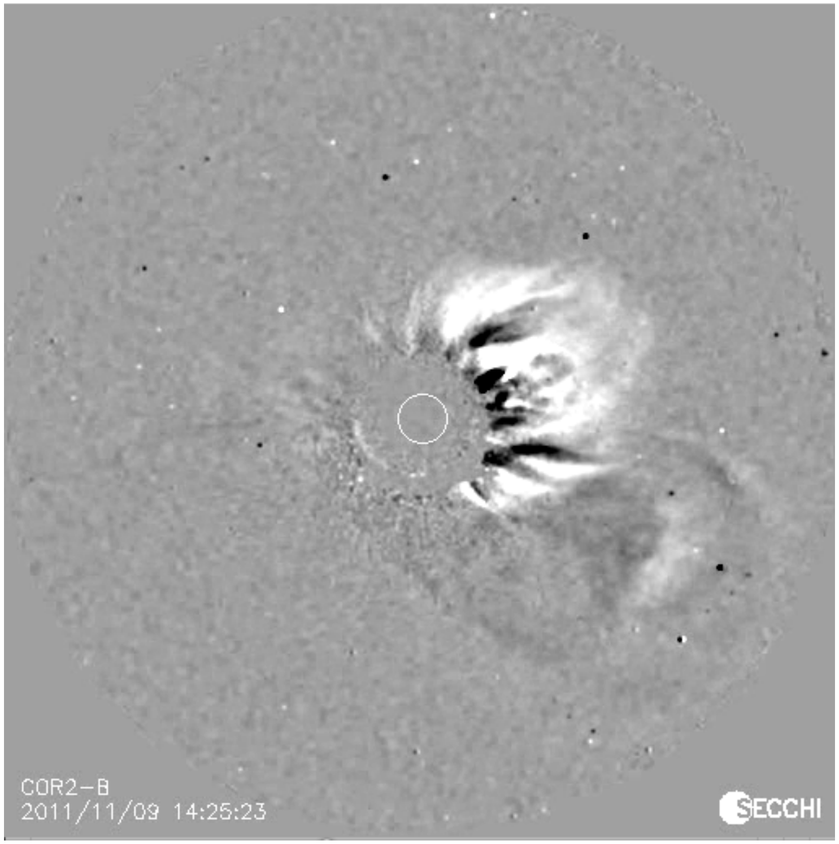
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al*., 2012, *Solar Phys.,* (in preparation).

9 November 2011 CME



LASCO

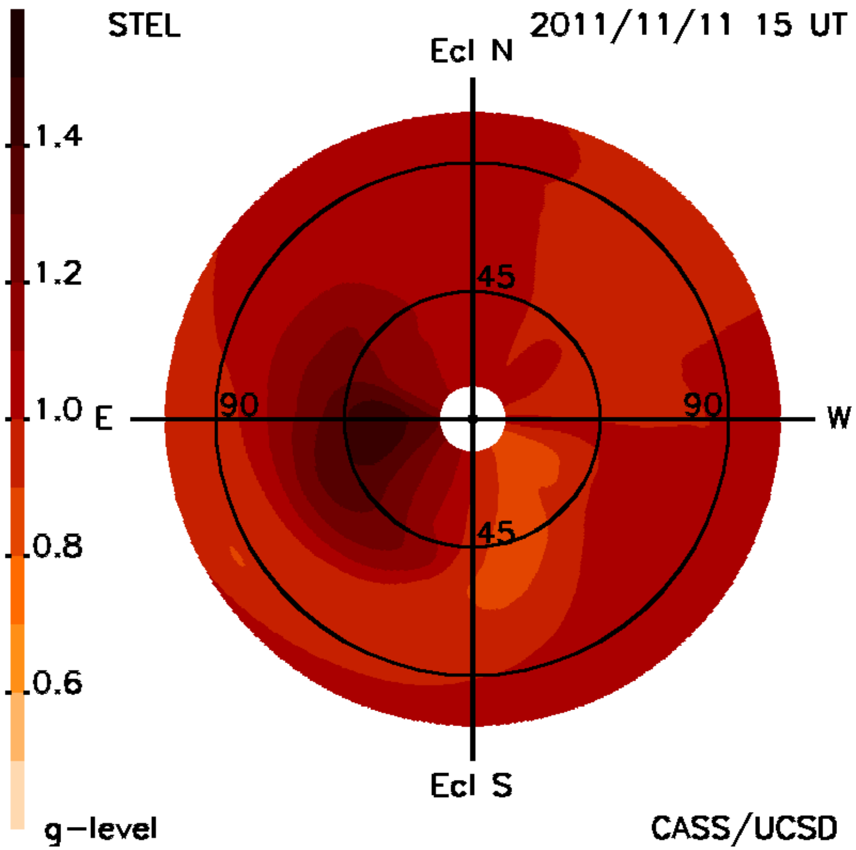


STEREO-B COR-2

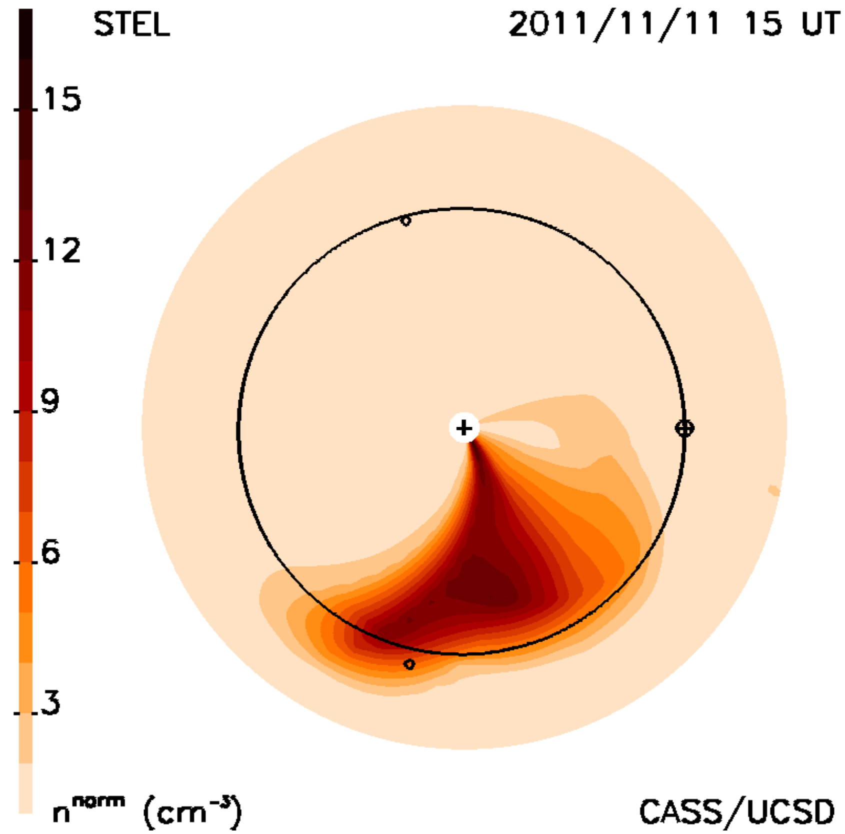
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al*., 2012, *Solar Phys.,* (in preparation).

9 November 2011 CME



IPS *g*-level fisheye skymap



Density ecliptic cut

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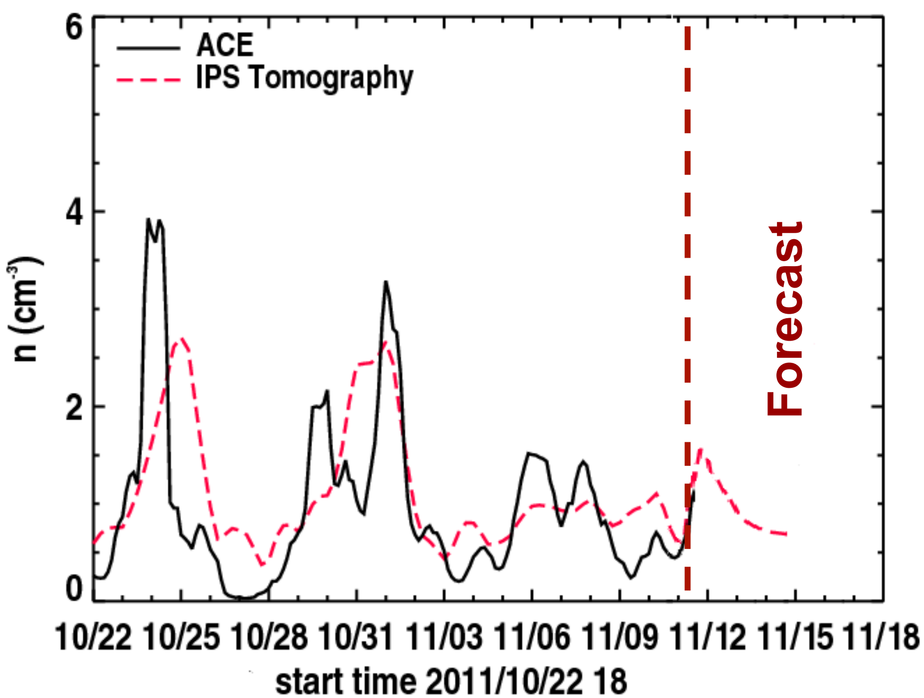
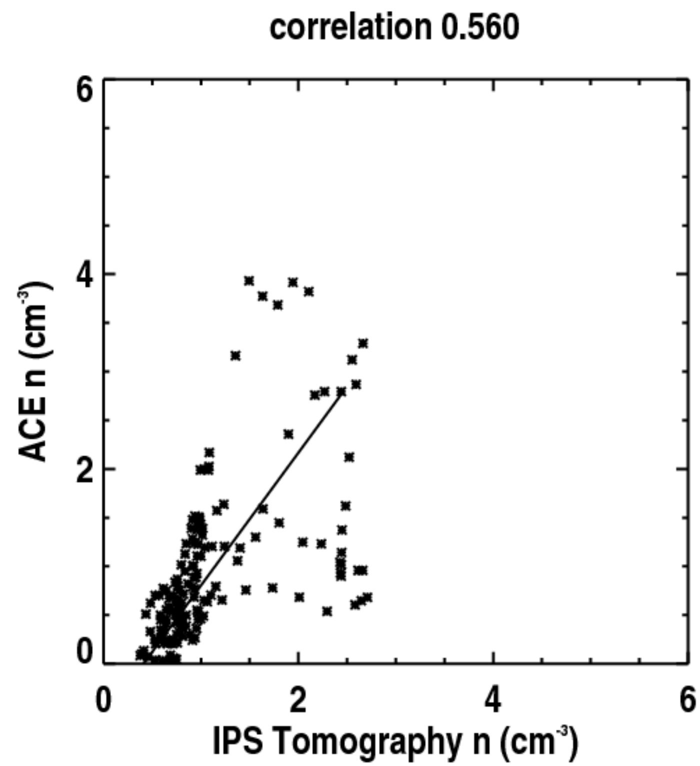
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2012, *Solar Phys.,* (in preparation).

9 November 2011 CME density





IPS time series compared to ACE

Correlation (to date)

Web Analysis Runs Automatically Using Linux on a P.C.

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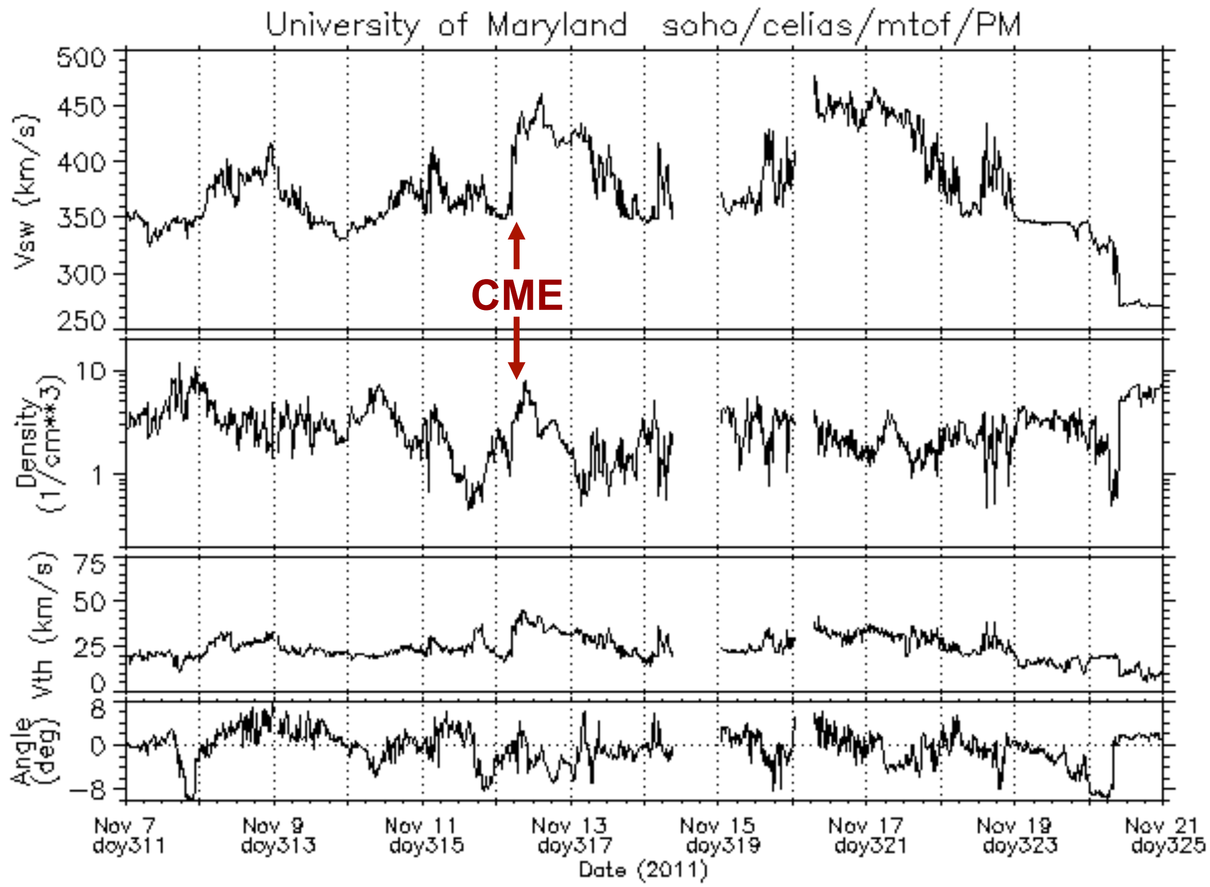
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al*., 2012, *Solar Phys.,* (in preparation).

9 November 2011 CME



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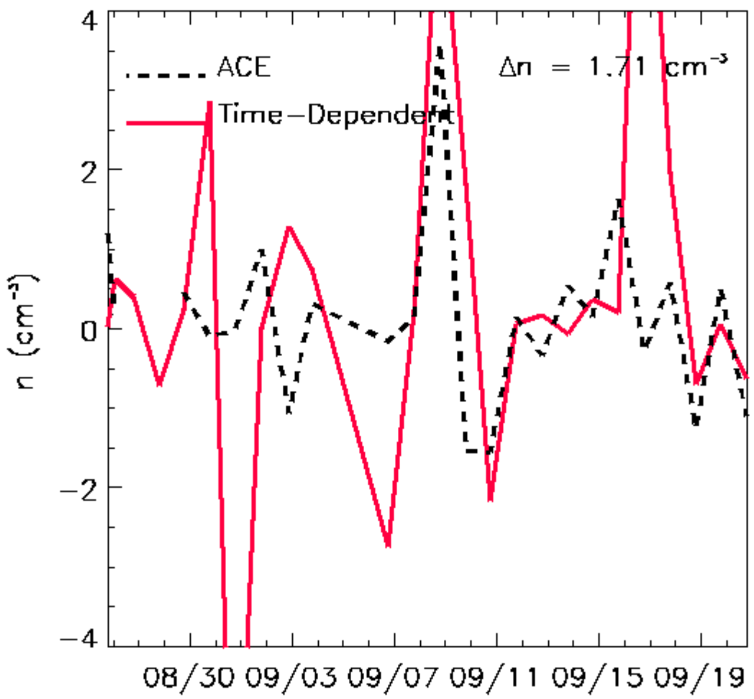
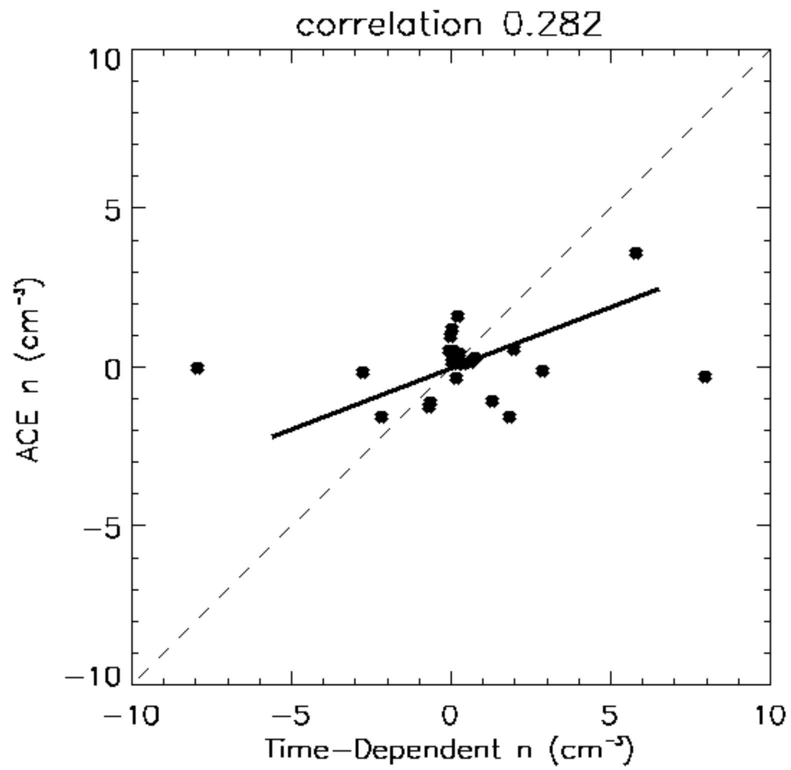
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al*., 2008, *Solar Phys.,* (in preparation).

Density analysis for all of CR 2114





IPS time series – time of tomographic run compared to ACE one day in advance

Correlation

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2008, *Solar Phys.,* (in preparation).

Analysis CR 2110 – CR 2116 (spring – winter 2011)

Table 1. Correlation of IPS Change from the Change Observed by ACE

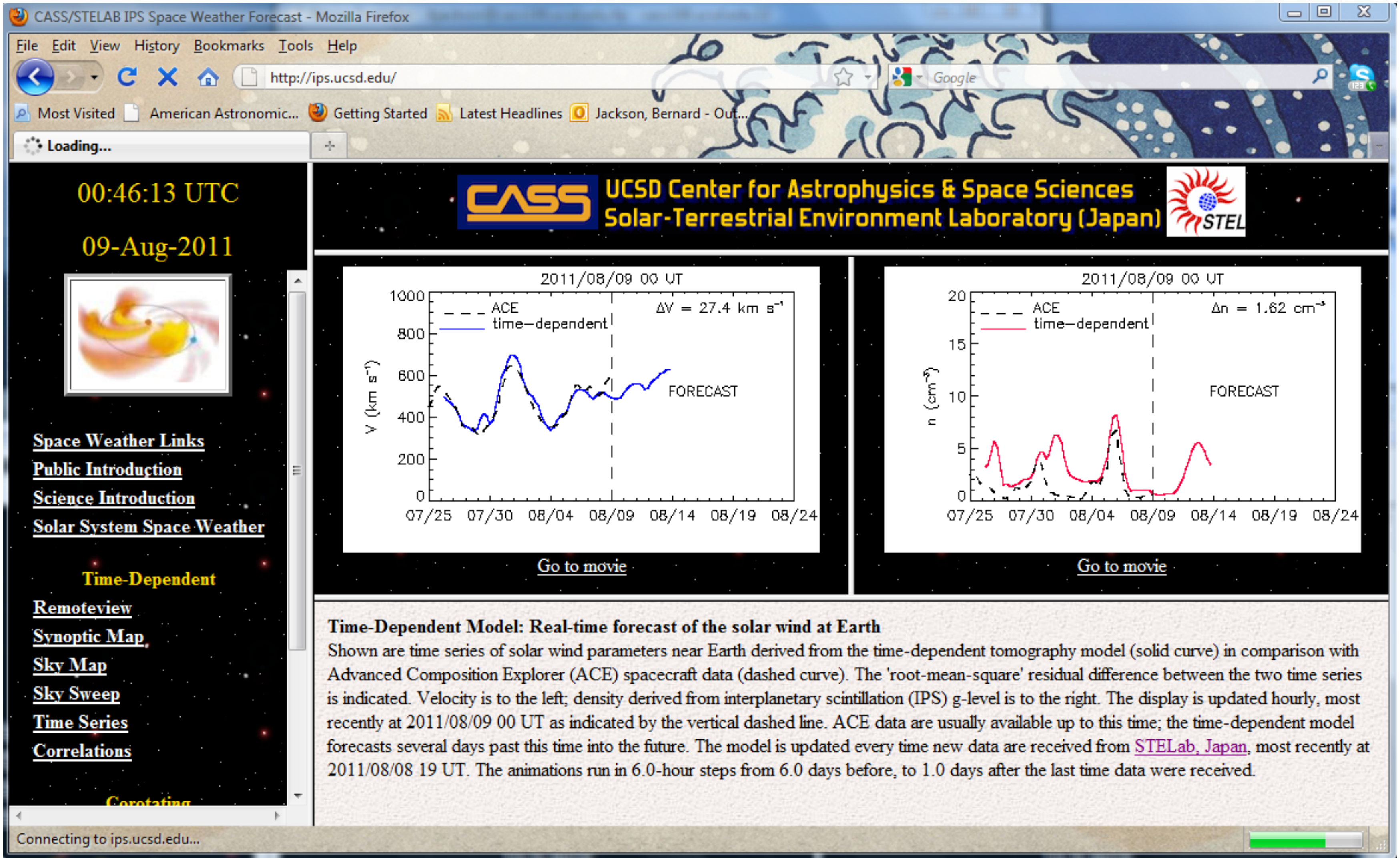
Carrington Rotation	24-hour Forecast Velocity	24-hour Forecast **Density**	48-hour Forecast Velocity	48-hour Forecast Density	72-hour Forecast Velocity	72-hour Forecast Density
2110	0.216	**-0.018**	-0.200	**0.263**	0.100	**0.050**
2111	-0.004	**0.364**	-0.010	**-0.049**	-0.374	**0.300**
2112	0.265	**0.059**	0.209	**-0.095**	-0.280	**0.089**
2113	0.102	**0.013**	0.324	**-0.124**	0.212	**0.013**
2114	0.356	**0.282**	0.268	**0.284**	-0.126	**-0.347**
2115*	0.290	**0.320**	0.150	**0.280**	-0.082	**0.145**
2116	0.027	**0.118**	-0.228	**0.076**	0.366	**-0.297**

* *Complete Carrington rotation analysis unavailable.*

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2012, *Adv. in Geosciences,* (under review).

http://ips.ucsd.edu/ **Earth** **Velocity and Density**

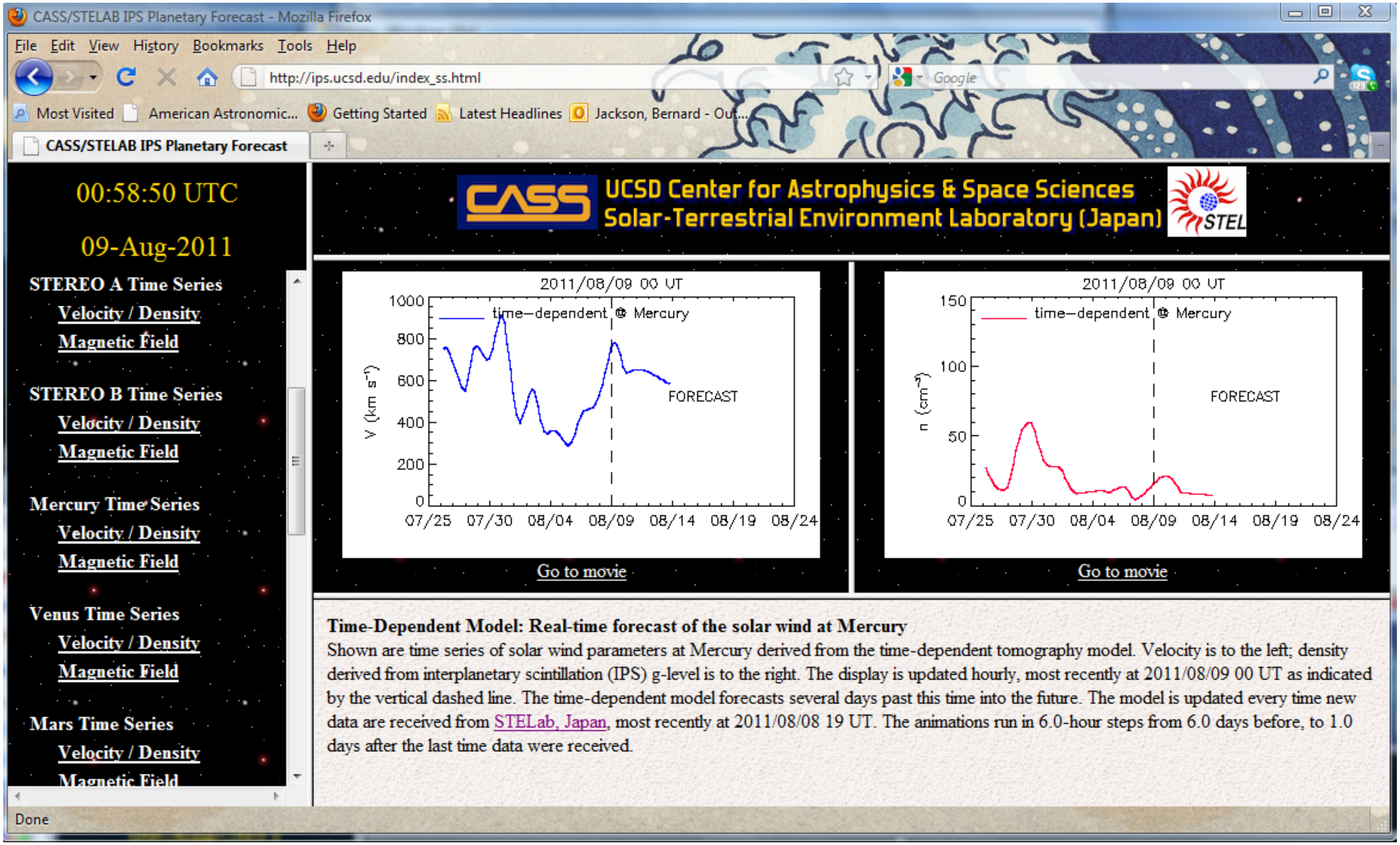


Web Analysis Runs Automatically Using Linux on a P.C.

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2012, *Adv. in Geosciences,* (under review).

http://ips.ucsd.edu/ **Mercury** **Velocity and Density**

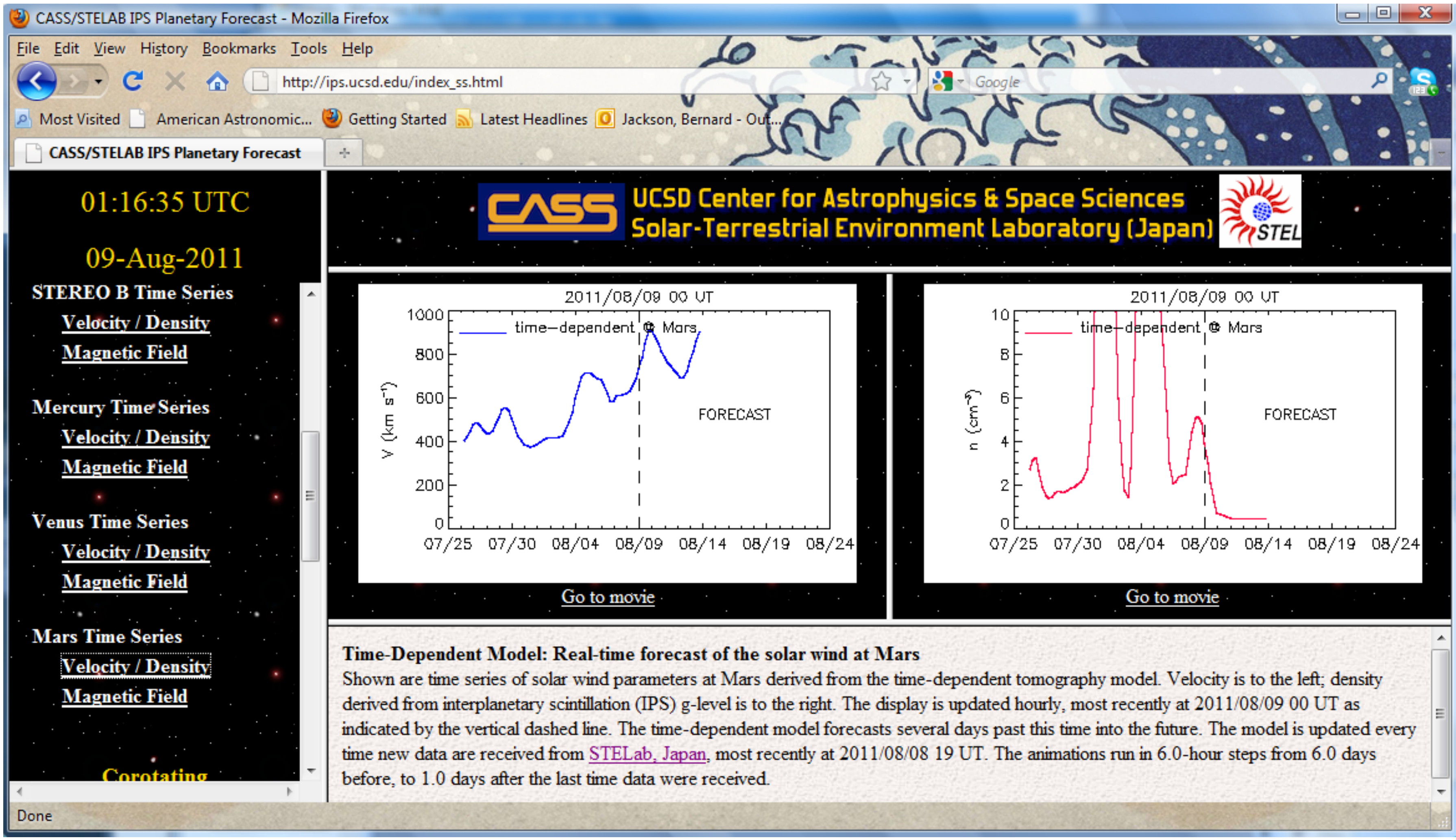


Web Analysis Runs Automatically Using Linux on a P.C.

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al*., 2012, *Adv. in Geosciences,* (under review).

http://ips.ucsd.edu/ **Mars** **Velocity and Density**

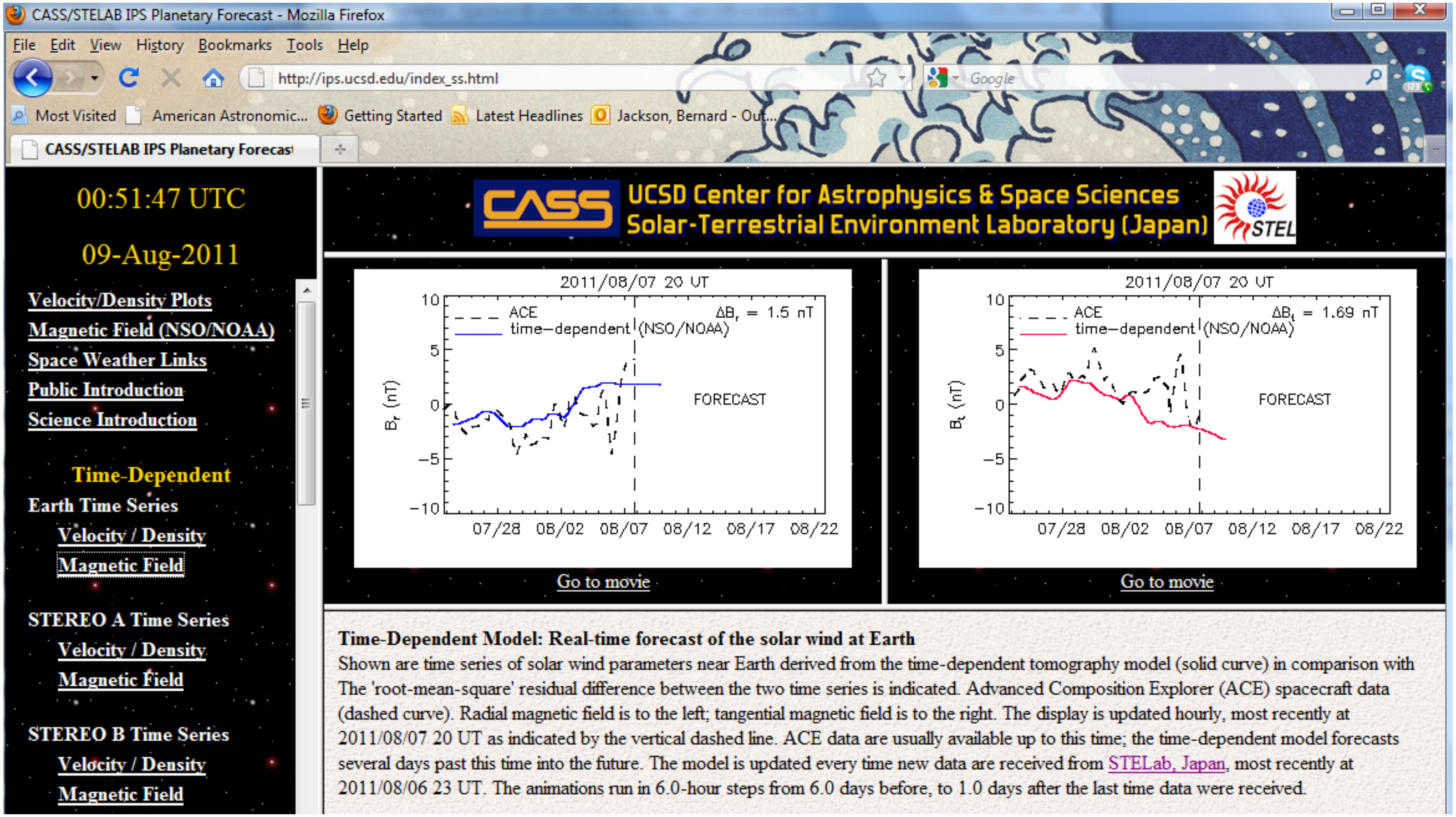


Web Analysis Runs Automatically Using Linux on a P.C.

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2012, *Adv. in Geosciences,* (under review).

http://ips.ucsd.edu/ Earth Radial and Tangential Magnetic Field

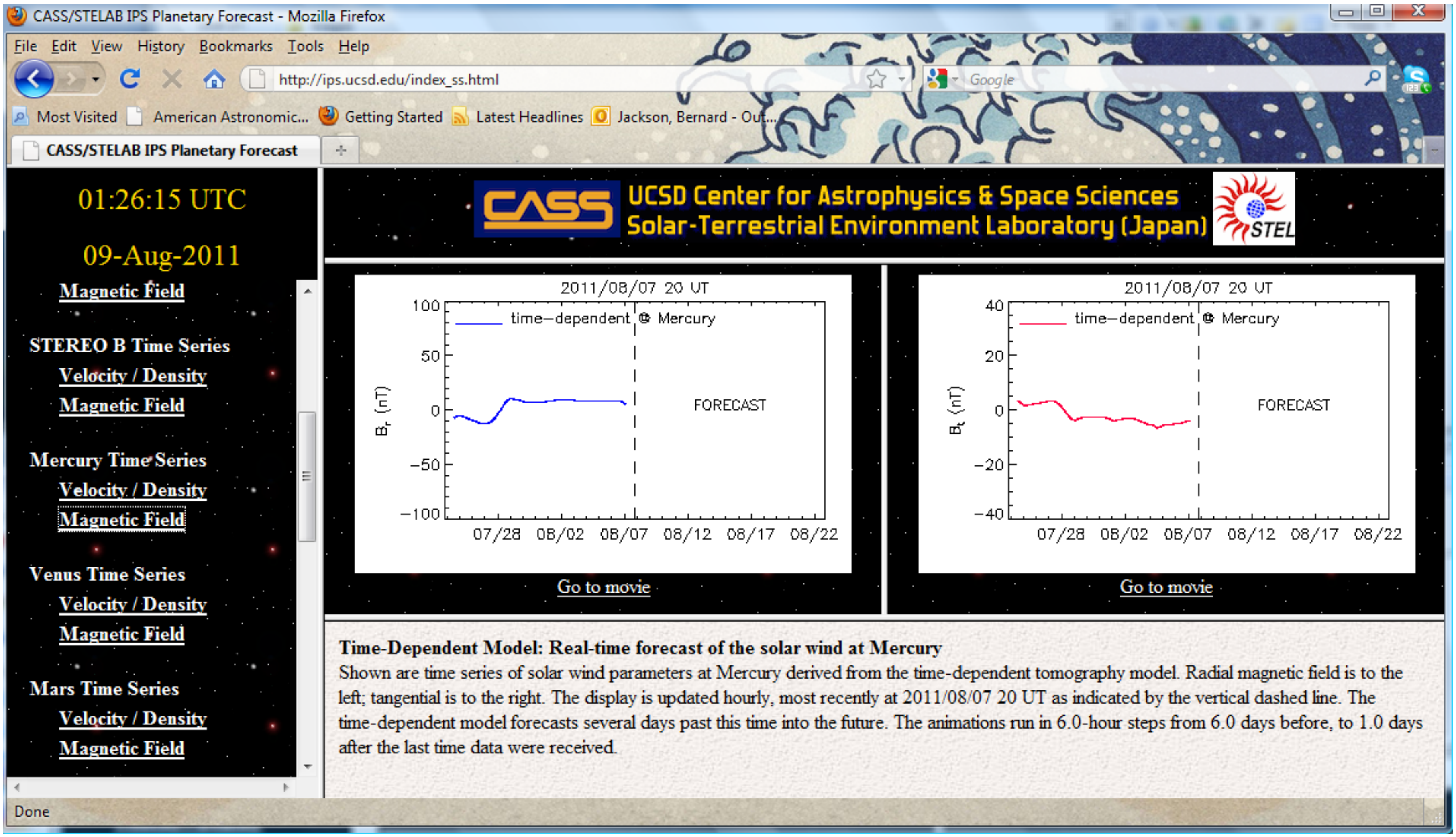


Web Analysis Runs Automatically Using Linux on a P.C.

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2012, *Adv. in Geosciences,* (under review).

http://ips.ucsd.edu/ Mercury Radial and Tangential Magnetic Field

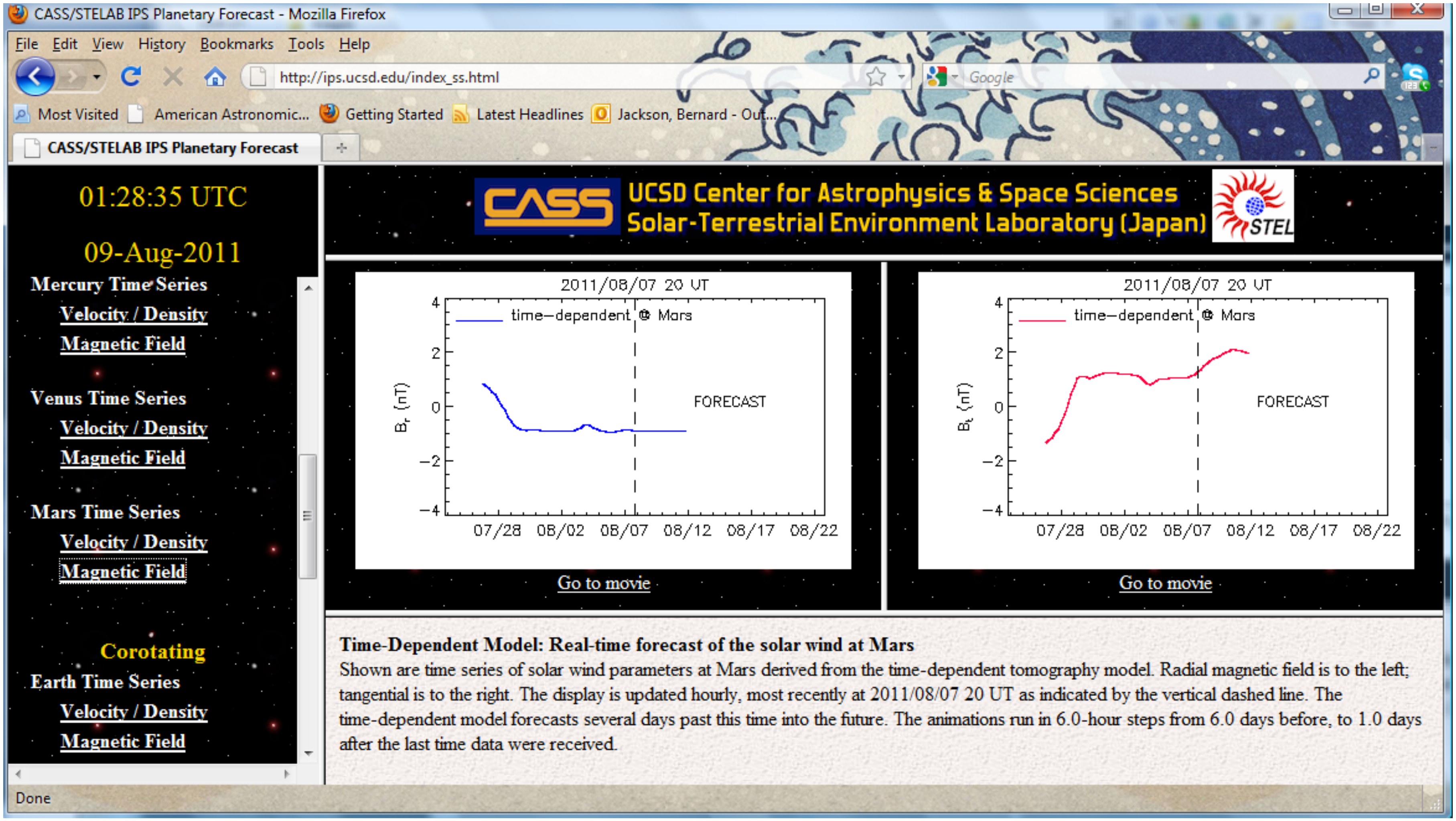


Web Analysis Runs Automatically Using Linux on a P.C.

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2012, *Adv. in Geosciences,* (under review).

http://ips.ucsd.edu/ **Mars** Radial and Tangential Magnetic Field



Web Analysis Runs Automatically Using Linux on a P.C.

Forecasting Heliospheric Solar Wind Parameters

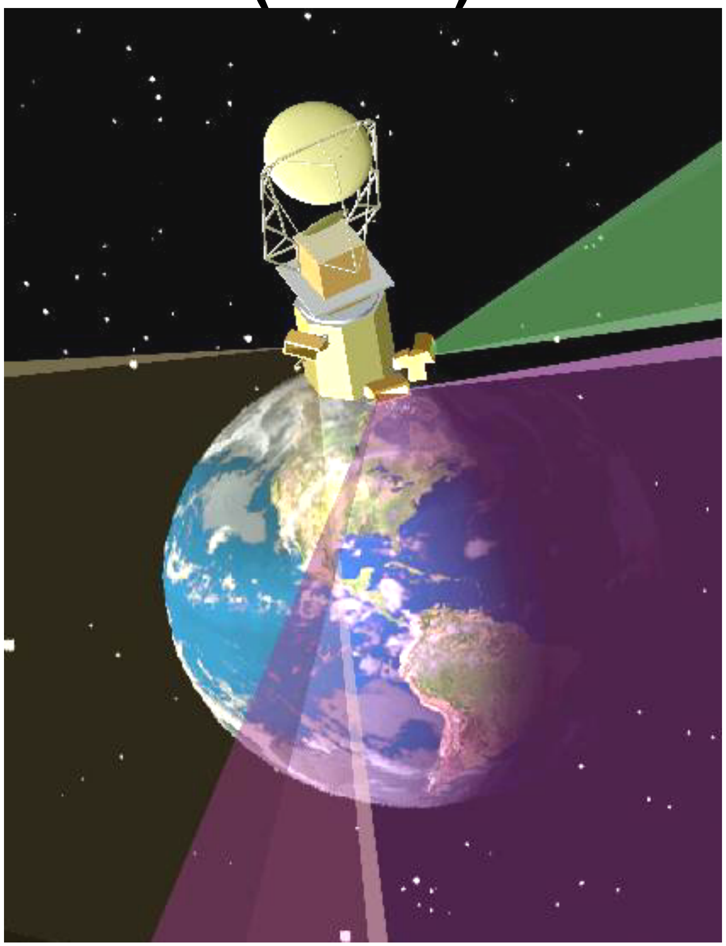
Summary:

The Future is here:

- IPS allows derivation of global velocity, and through conversion of g-level to density – global densities, at low resolution from STELab data, including CMEs.
- Forecasts with the IPS data (this has worked with STELab data for about 12 years)
- Forecasts in real-time with the inclusion of *in-situ data* (this works and has been available since spring 2011).
- Space borne instrumentation forecasting (needs better instrumentation with a dedicated group to calibrate the instrument).
- FR inversion to obtain vector fields (may work, but needs to be incorporated with a robust method of determining density to to back out 3-component magnetic fields)

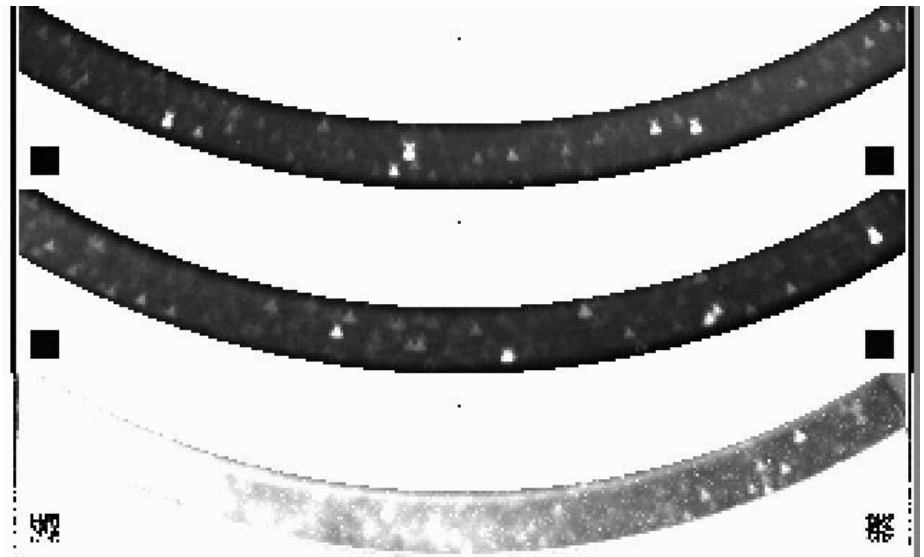
Forecasting Heliospheric Solar Wind Parameters

The Solar Mass Ejection Imager (SMEI)



Jackson, B.V., et al., 2004, *Solar Phys.*, 225, 177

“Stowed” 28 September 2002011



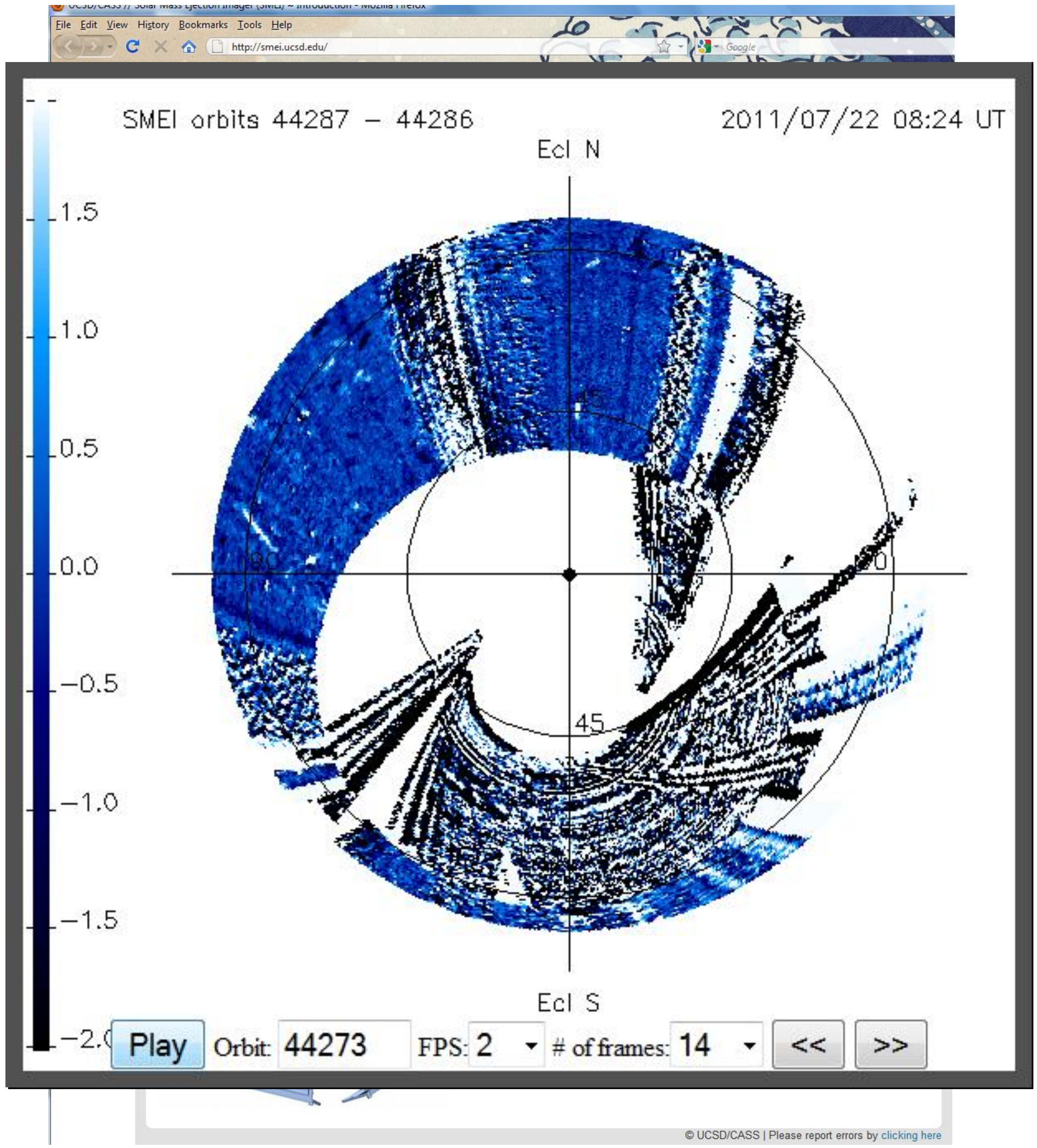
1 gigabyte/day; now ~4 terabytes

Simultaneous images from the three SMEI cameras.

Forecasting Heliospheric Solar Wind Parameters

http://ips.ucsd.edu/

UCSD SMEI analysis



Web Analysis Runs Automatically Using Linux on a P.C.

Forecasting Heliospheric Solar Wind Parameters

2011 February 15

SCIENCE QUEST
BY GARY ROBBINS

UCSD tracking huge solar flare that might cause aurora

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Written by Gary Robbins

6:58 p.m., Feb. 16, 2011

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Also of interest

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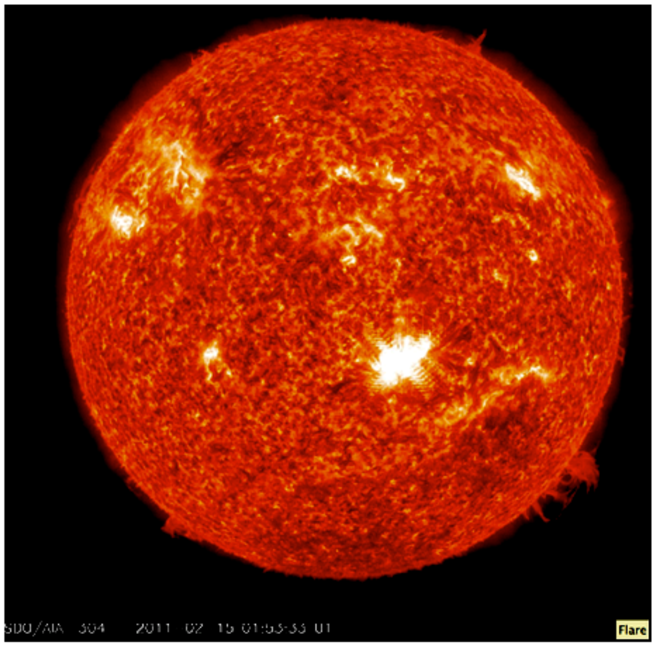
Solar flare erupts, creating spectacular images

Will Californians see the aurora borealis tonight?



NASA's Solar Dynamics Observatory took this image of a solar flare erupting 21 degrees south of the sun's equator on February 15th. — NASA

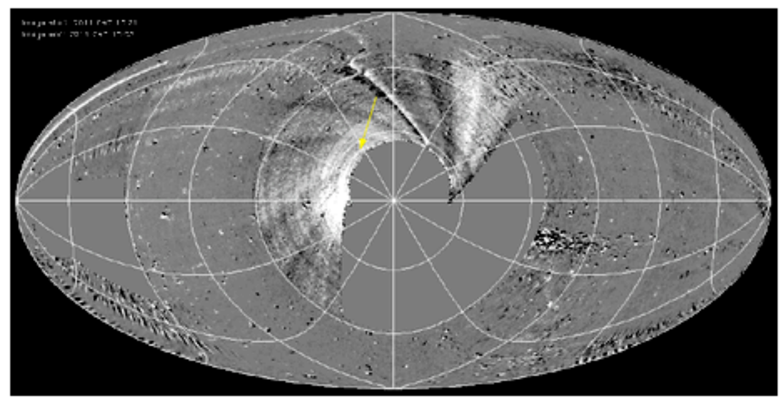
The largest solar flare to erupt on the sun since December 2006 has sent plasma streaming toward Earth, a usually benign but sometimes troublesome phenomenon that's being monitored by a sophisticated satellite instrument developed by UC San Diego.

Such flares can disrupt telecommunications on Earth, in addition to setting off the wondrous aurora borealis.

"The plasma from the flare contains ionized particles that could cause an aurora borealis in the northern latitudes," said Bernard Jackson, a research scientist at UCSD's Center for Astrophysics and Space Science. "The plasma should hit Earth's magnetosphere on Thursday."

The flare erupted on Feb. 15th, producing plasma that was imaged today (Wednesday) by the Solar Mass Ejection Imager (SMEI), an instrument that Jackson designed at UCSD. SMEI is traveling aboard Coriolis, a satellite that's in polar orbit around Earth. The Sun is centered in this image of the whole sky made from a composite of 1500 smaller portions over one 102-minute orbit. The yellow arrow points to an area of brightness that is the plasma ejecta on its way toward Earth.

"This is one of the largest flares of the current solar cycle," Jackson said on Wednesday night. "It is exciting because the sun is really waking up and coming to life. We're now able to forecast the arrival of the ejecta in a pretty robust way."



This image of the sky was taken on Wednesday. The yellow arrow points to the plasma flowing toward Earth. The image was taken by the Solar Mass Ejection Imager, an instrument designed by UCSD's Bernard Jackson. — UCSD Center for Astrophysics and Space Science

UCSD/SMEI journal articles in the last two years!!

Bisi, M.M., B.V. Jackson, A. Buffington, J.M. Clover, P.P. Hick, and M. Tokumaru, 2009, 'Low-Resolution STELab IPS 3D Reconstructions of the Whole Heliosphere Interval and Comparison with in-Ecliptic Solar Wind Measurements from STEREO and Wind Instrumentation', *Solar Phys.* - STEREO Science Results at Solar Minimum Topical Issue, 256, 201-217, doi:10.1007/s11207-009-9350-9.

Bisi, M.M., Jackson, B.V., Clover, J.M., Manoharan, P.K., Tokumaru, M., Hick, P.P., and. Buffington, A., 2009, '3D reconstructions of the early-November 2004 CDAW geomagnetic storms: analysis of Ooty IPS speed and density data', *Annales Geophysicae,* 27, 4479.

Bisi, M.M., Jackson, B.V., Clover, J.M., Tokumaru, M., and Fujiki, K., 2009, 'Large-Scale Heliospheric Structure during Solar-Minimum Conditions using a 3D Time-Dependent Reconstruction Solar-Wind Model and STELab IPS Observations', *AIP* (Solar Wind 12 Proceedings) 1216, 355.

Bisi, M.M., Jackson, B.V., Clover, J.M., Hick, P.P., and Buffington, A., 2009, '3D Reconstructions of the Whole Heliosphere Interval and Comparison with in-Ecliptic Solar Wind Measurements from STEREO, ACE, and Wind Instrumentation: a Brief Summary', XXVIIth IAU General Assembly, August 2009, *Highlights of Astronomy*, 15, 119.

Bisi, M.M., Jackson, B.V., Breen, A.R., Dorrian, G.D., Fallows, R.A., Clover, J.M., and Hick, P.P., 2009, 'Three-Dimensional (3-D) Reconstructions of EISCAT IPS Velocity Data in the Declining Phase of Solar Cycle 23', *Solar Phys.*, 265, 233-244.

Bisi, M.M., Breen, A.R., Jackson, B.V., Fallows, R.A., Walsh, A.P., Mikic, Z., Riley, P., Owen, C.J., Gonzalez-Esparza, A., Aguilar-Rodriguez, E., Morgan, H., Jensen, E.A., Wood, A.G., Tokumaru, M., Manoharan, P.K., Chashei, I.V., Giunta, A.S., Linker, J.A., Shishov, V.I., Tyul'bashev, S.A., Agalya, , G., Glubokova, S.K., Hamilton, M.S., Fujiki, K., Hick, P.P., Clover, J.M., Pinter, B., 2009, 'From the Sun to the Earth: the 13 May 2005 Coronal Mass Ejection', *Solar Phys.*, 265, 49-127.

Buffington, A., Bisi, M.M., Clover, J.M., Hick, P.P., Jackson, B.V., Kuchar, T.A., and Price, S.D., 2009, 'Measurements of the Gegenschein brightness from the Solar Mass Ejection Imager (SMEI)', *Icarus*, 203, 124, doi:10.1016/j.icarus.2009.04.007.

Jackson, B.V., Hick, P.P., Buffington, A., Bisi, M.M., and Clover, J.M., 2009, 'SMEI direct, 3D-reconstruction sky maps and volumetric analyses, and their comparison with SOHO and STEREO observations', *Annales Geophysicae*, 27, 4097.

Jackson, B.V., Hick, P.P., Buffington, A., Bisi, M.M., Clover, J.M., Tokumaru, M., and Fujiki, K., 2009, '3D Reconstruction of Density Enhancements Behind Interplanetary Shocks from Solar Mass Ejection Imager White-Light Observations', *AIP* (Solar Wind 12 Proceedings) 1216, 659.

Jackson, B.V., Hick, P.P., Buffington, A., Bisi, M.M., Clover, J.M., and Tokumaru, M., 2008, 'Solar Mass Ejection Imager (SMEI) and Interplanetary Scintillation (IPS) 3D-Reconstructions of the Inner Heliosphere', *Adv. in Geosciences* 21, 339.

Jackson, B.V., Hick, P.P., Bisi, M.M., Clover, J.M., and Buffington, A., 2009, 'Inclusion of in-situ Velocity Measurements in the UCSD Time-Dependent Tomography to Constrain and Better- Forecast Remote-Sensing Observations', *Solar Phys.*, 265, 245-256, doi: 10.1007/s11207-010-9529-0.

Jackson, B.V., Buffington, A., Hick, P.P., Bisi, M.M., and Clover, J.M., 2009, A Heliospheric Imager for Deep Space: Lessons Learned from Helios, SMEI, and STEREO', *Solar Phys.*, 265, 257-275, doi: 10.1007/s11207-010-9579-3.

Jackson, B.V., Buffington, A., Hick, P.P., Clover, J.M., Bisi, M.M., and Webb, D.F., 2010, 'SMEI 3-D reconstruction of a CME interacting with a co-rotating solar wind density enhancement: The 26 April 2008 CME', *Astrophys J.* (in press).

Jackson, B.V., Hick, P.P., Buffington, A., Bisi, M.M., Clover, J.M., Tokumaru, M., Kojima, M., and Fujiki, K., 2010, 'Three-dimensional reconstruction of heliospheric structure using iterative tomography: a review', *J. Atmospheric and Solar-Terrestrial Phys.* (in press)

Jackson, B.V., Hamilton, M.S., Hick, P.P., Buffington, A., Bisi, M.M., and Clover, J.M., Tokumaru, M., and Fujiki, K., 2010, 'Solar Mass Ejection Imager (SMEI) 3-D reconstruction of density enhancements behind interplanetary shocks: in-situ comparison near Earth and at STEREO', *J. Atmospheric and Solar-Terrestrial Phys.* (submitted).

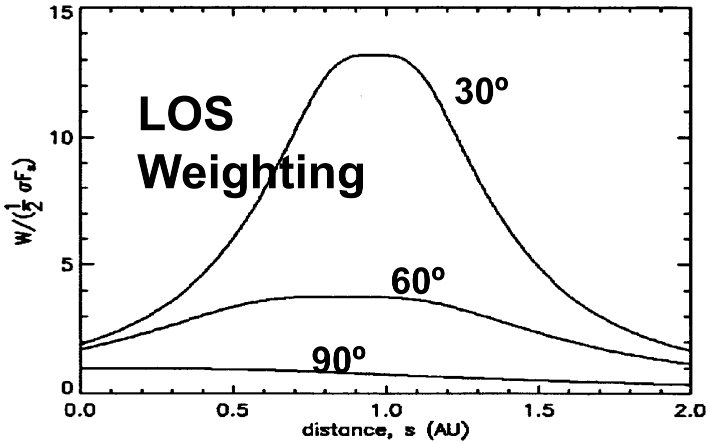
Jensen, E.A., Hick, P.P., Bisi, M.M., Jackson, B.V., Clover, J., and Mulligan, T.L., 2010, 'Faraday Rotation Response to Coronal Mass Ejection Structure', *Solar Phys.*, 265, 31-48 doi: 10.1007/s11207-010-9543-2.

Webb, D.F., Howard, T.A., Fry, C.D., Kuchar, T.A., Odstrcil, D., Jackson, B.V., Bisi, M.M., Harrison, R.A., Morrill, J.S., Howard, R.A., and Johnston, J.C., 2009, 'Study of CME Propagation in the Inner Heliosphere: SMEI and STEREO HI Observations of the January 2007 Events', *Solar Phys.*- STEREO Special Issue, 256, 239, doi: 10.1007/s11207-009-9351-8.

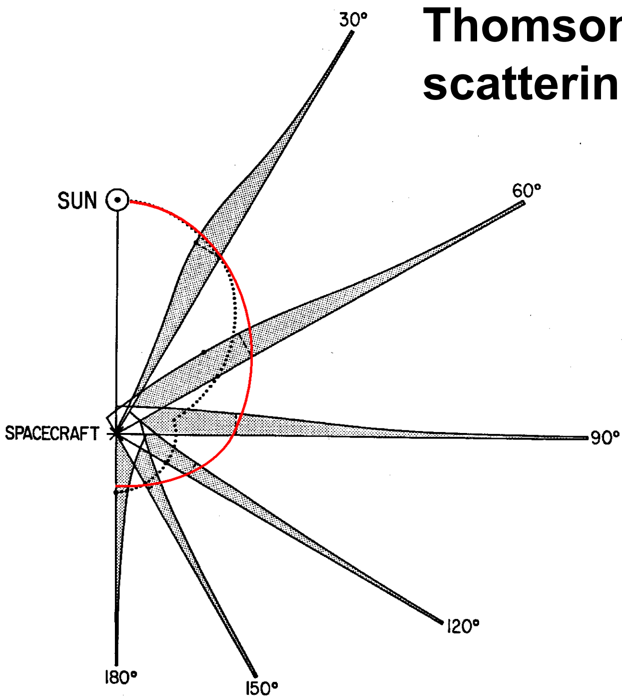
Webb, D. F., Howard, T. A., Fry, C. D., Kuchar, T. A., Mizuno, D. R., Johnston, J. C., and Jackson, B. V., 2009, 'Studying Geoeffective ICMEs between the Sun and Earth: Space Weather Implications of SMEI Observations', *Space Weather*, 7, S05002, doi:10.1029/2008SW000409.

Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., et al., 2008, *Adv. in Geosciences*, 21, 339-366

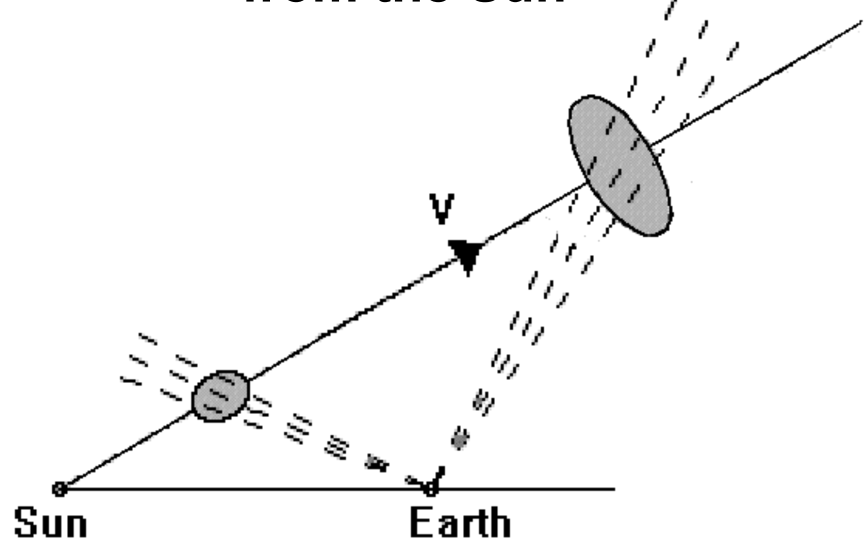


Thomson scattering



Heliospheric 3D-reconstructions

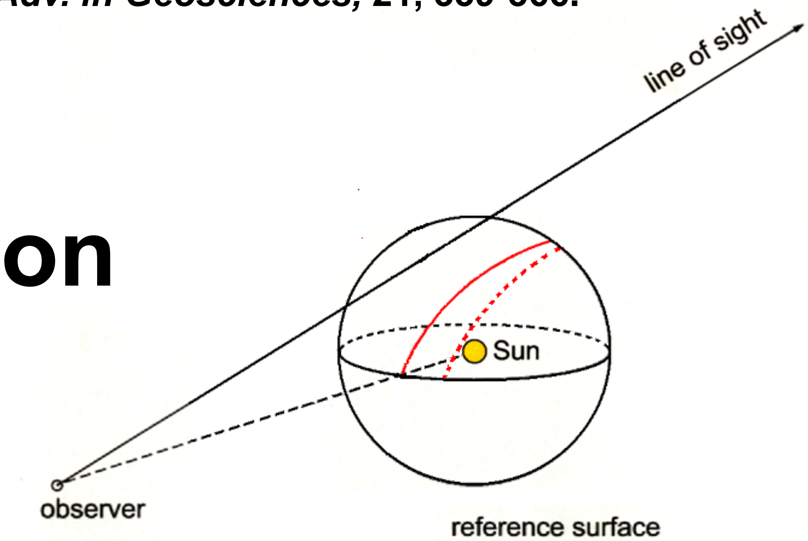
The outward-flowing solar wind structure follows very specific physics as it moves outward from the Sun



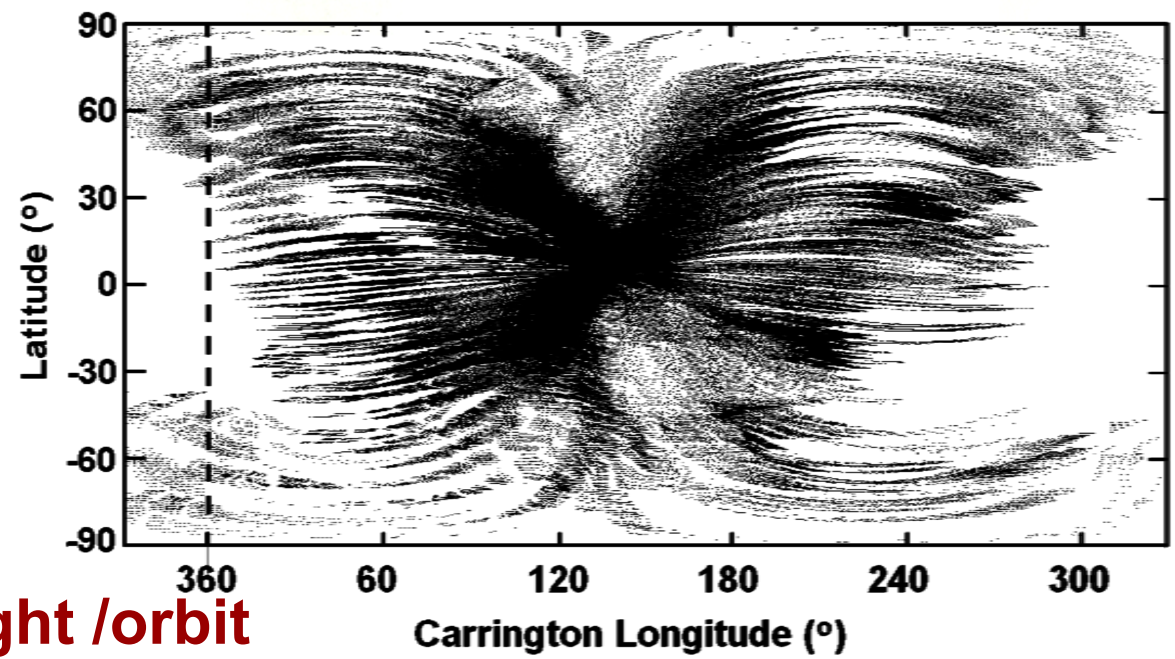
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., et al., 2009, *Adv. in Geosciences*, 21, 339-366.

Heliospheric 3-D Reconstruction



Line of sight "crossed" components on a reference surface. Projections on the reference surface are shown. These weighted components are inverted to provide the time-dependent tomographic reconstruction.

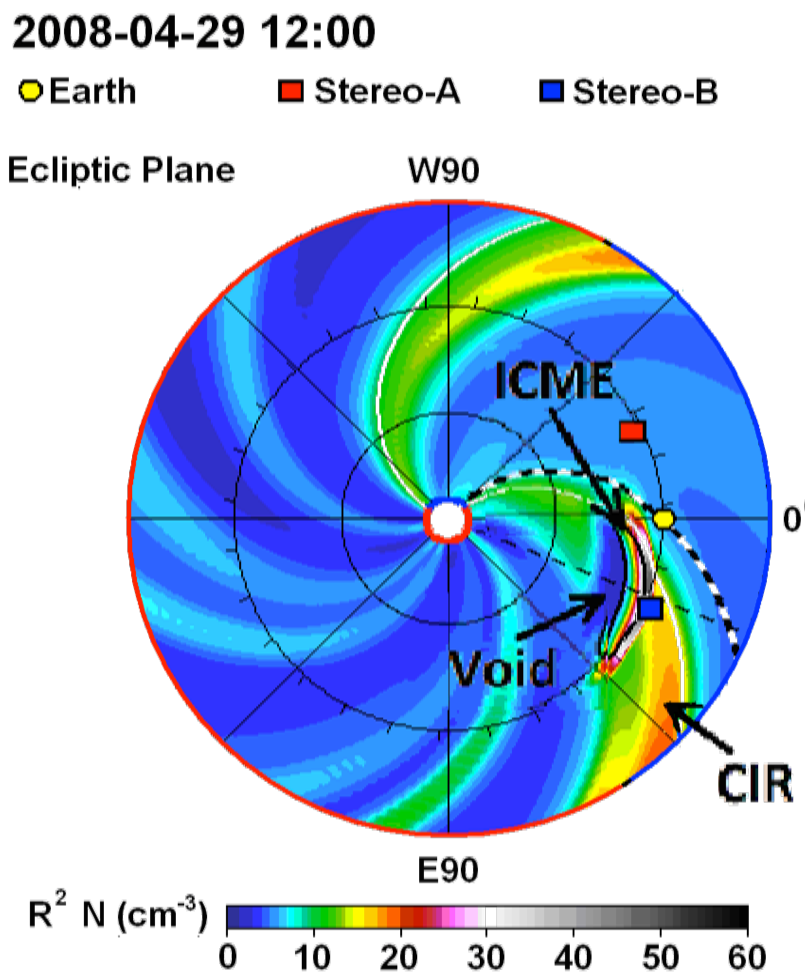


>10,000 lines of sight /orbit
>5,000,000 /month!

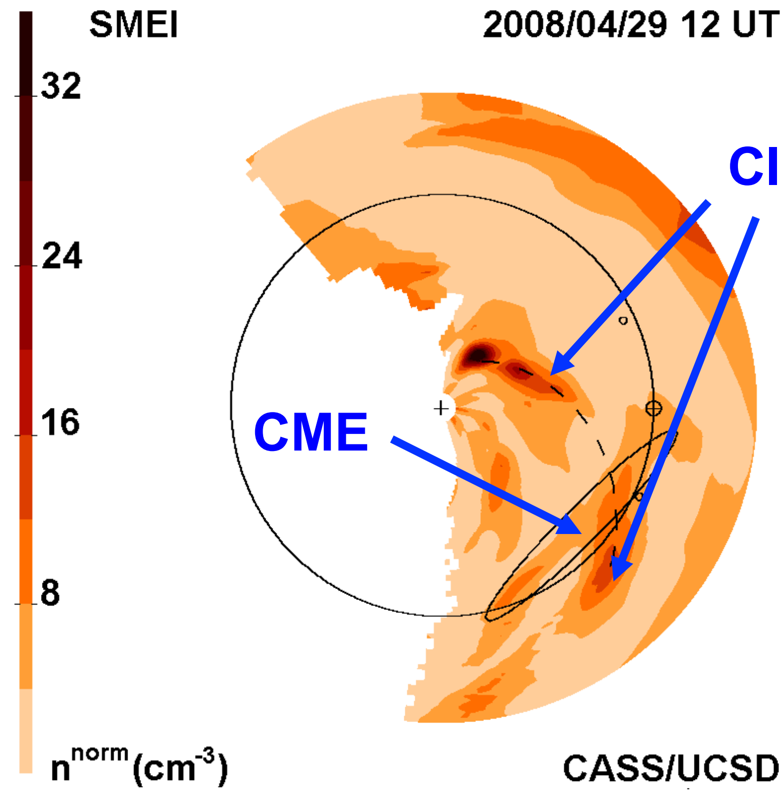
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2010, *Astrophys. J.*, 724, 829-834

Post-WHI April 2008 analysis (26 April CME)

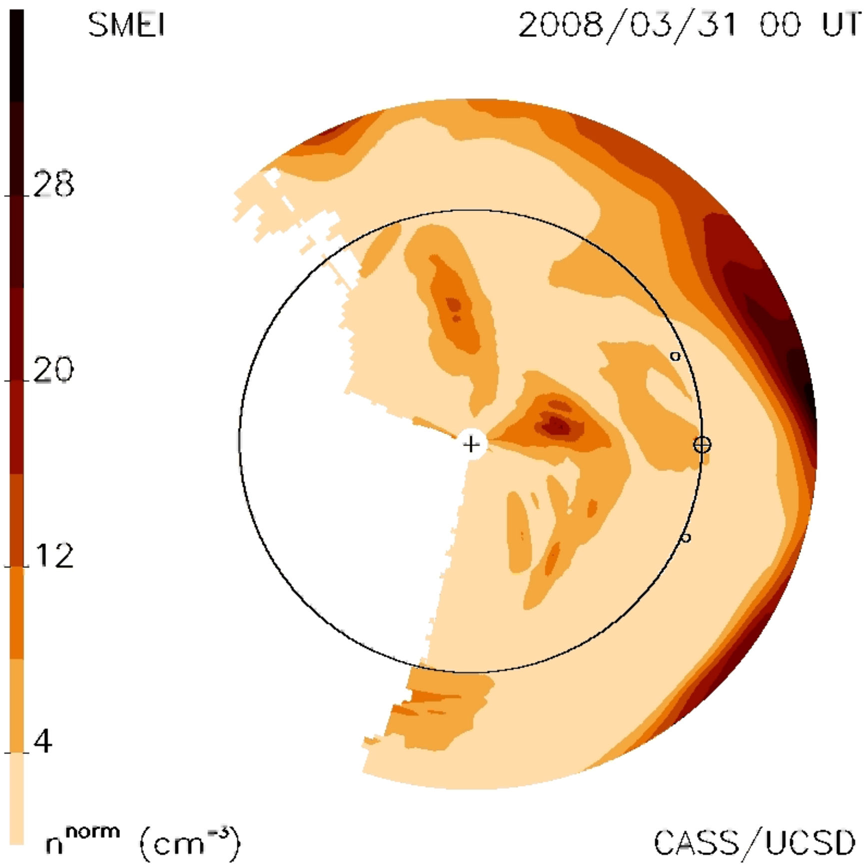


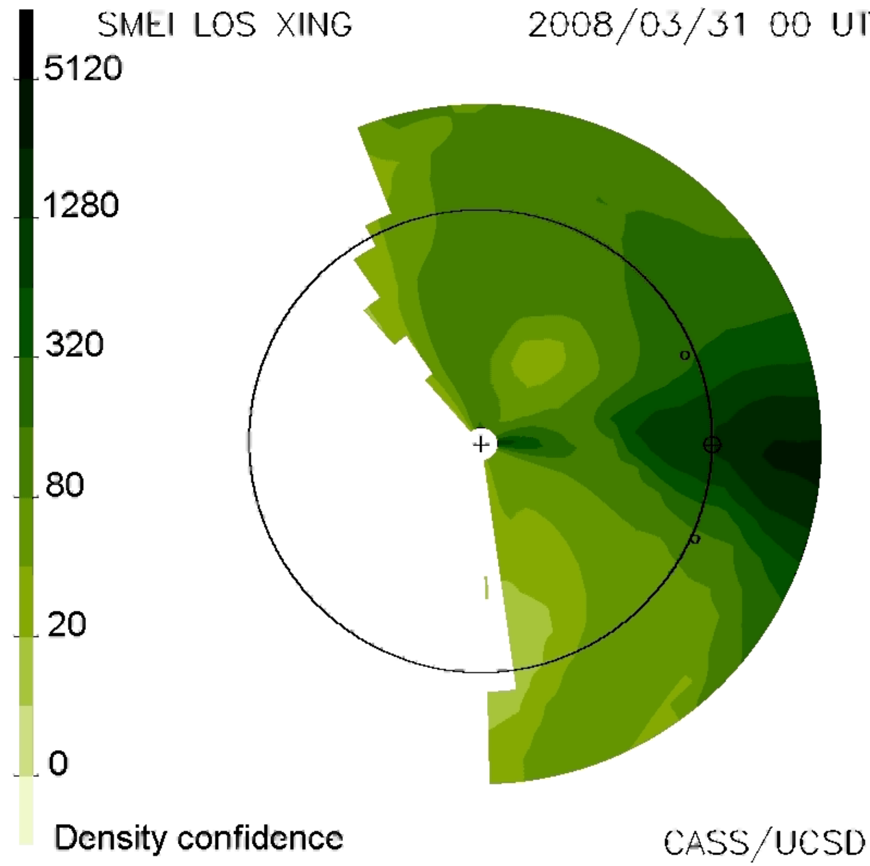
ENLIL 3-D MHD model with a cone-model addition and comparison with a SMEI ecliptic cut comparison



Forecasting Heliospheric Solar Wind Parameters

Line of sight crossing error example- the WHI period



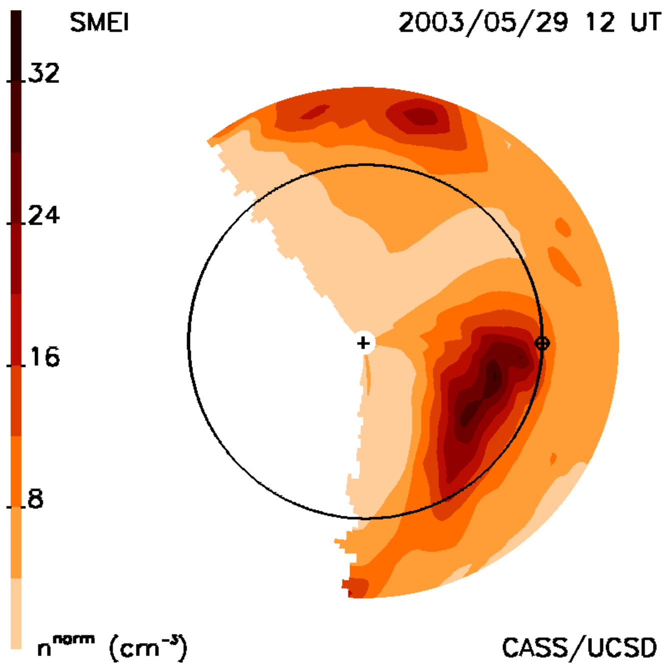


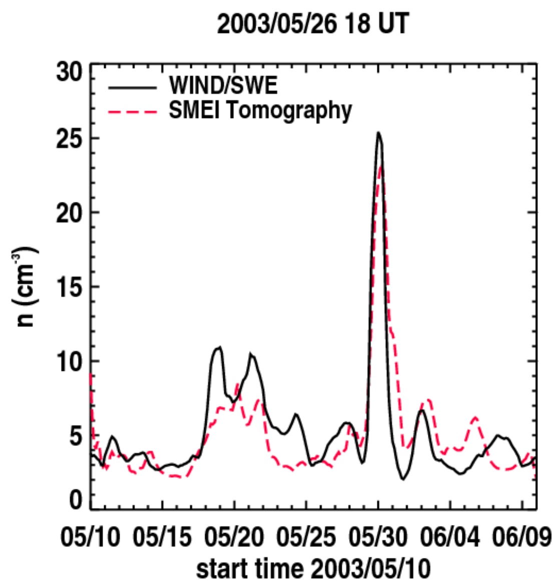
SMEI data analysis

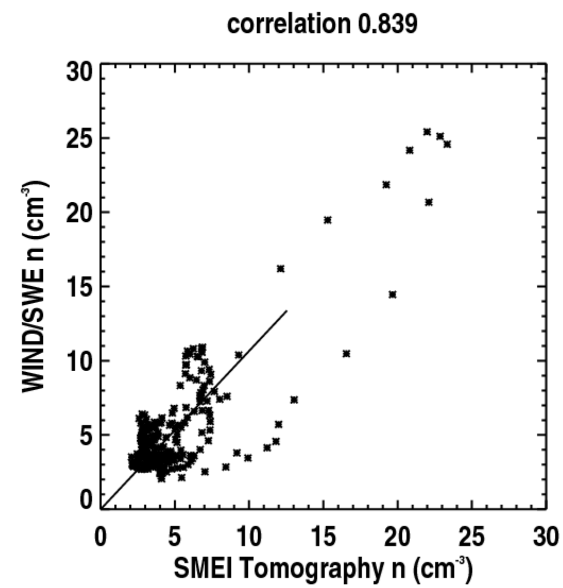
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., et al., 2008, *J. Geophys Res.*, 113, A00A15, doi:10.1029/2008JA013224

27-28 May 2003 CME event period







12-hour cadence, 7° x 7° lat, long

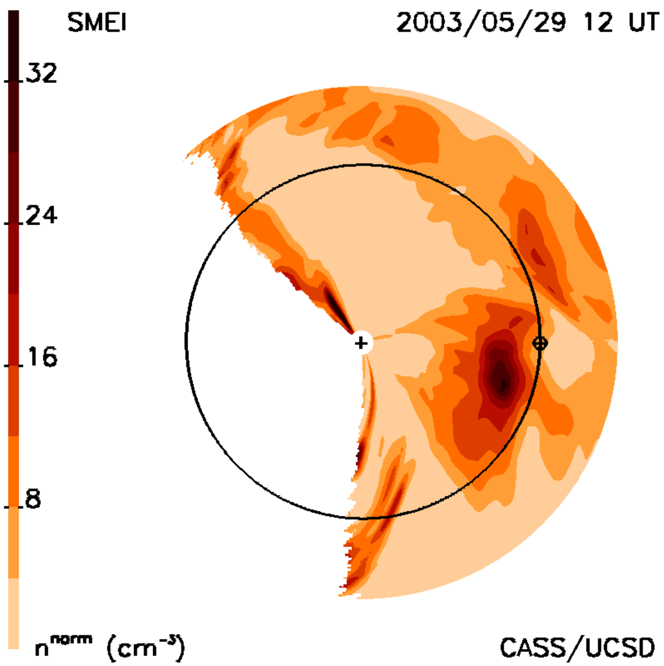
SMEI proton density reconstruction for the 27-28 May 2003 halo CME sequence. Reconstructed and Wind *in-situ* densities are compared over one Carrington rotation.

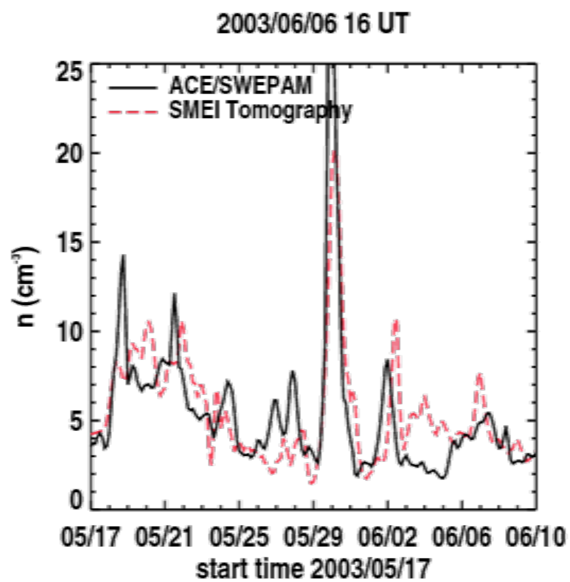
Forecasting Heliospheric Solar Wind Parameters

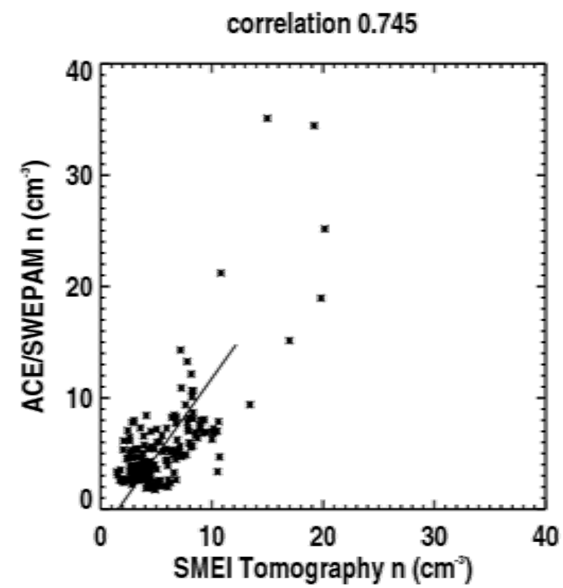
Jackson, B.V., et al., 2008, *J. Geophys Res.*, 113, A00A15, doi:10.1029/2008JA013224

27-28 May 2003 CME event period

~10,000 lines of sight /orbit







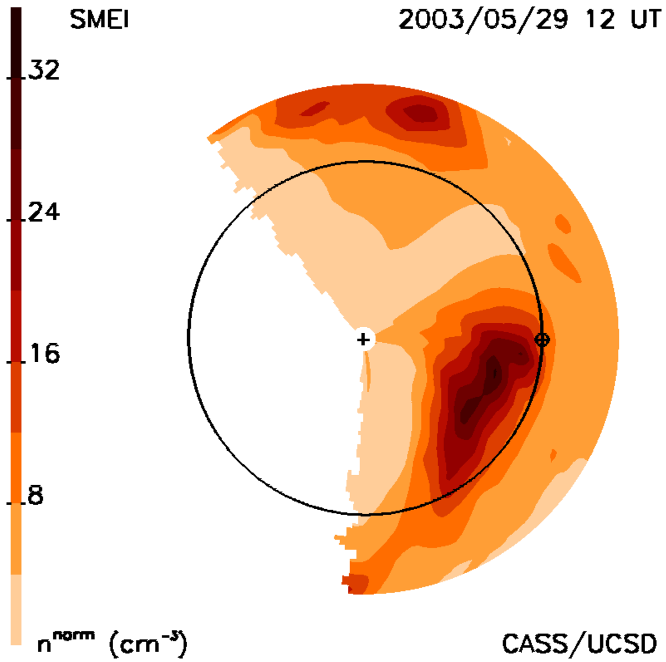
Full SMEI data set, 6-hour cadence, 3º x 3º lat, long

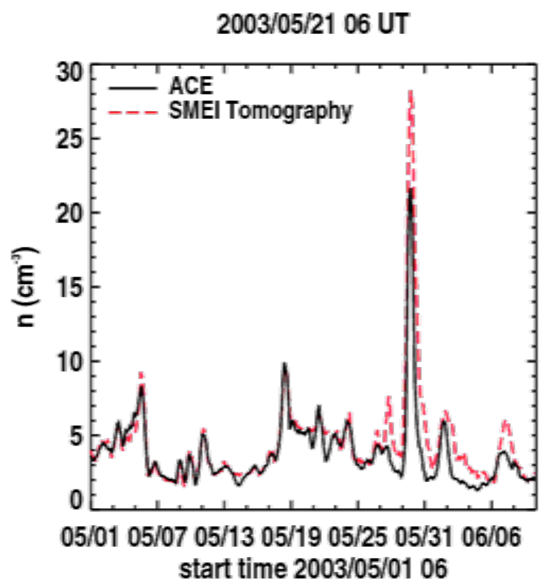
SMEI proton density reconstruction for the 27-28 May 2003 halo CME sequence. Reconstructed and ACE L2 *in-situ* densities are compared over one Carrington rotation.

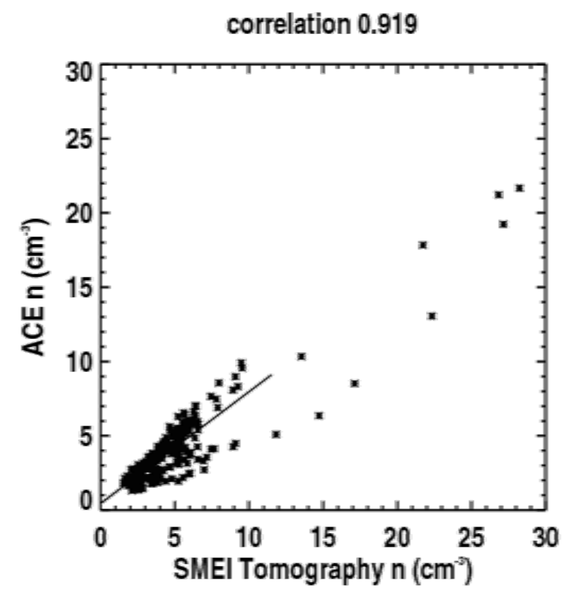
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., et al., 2008, *J. Geophys Res.*, 113, A00A15, doi:10.1029/2008JA013224

27-28 May 2003 CME event period







12-hour cadence, 7º x 7º lat, long

Inclusion of the in-situ as in the forecast analysis allows a far more precise measurement and somewhat finer 3D resolution at Earth.

Forecasting Heliospheric Solar Wind Parameters

Summary:

a) IPS allows derivation of global velocity, and through conversion of g-level to density – global densities, at low resolution from STELab data, including for CMEs.

b) SMEI allows derivation of global densities including that from CMEs at high spatial and temporal resolution using Thomson-scattering brightness.

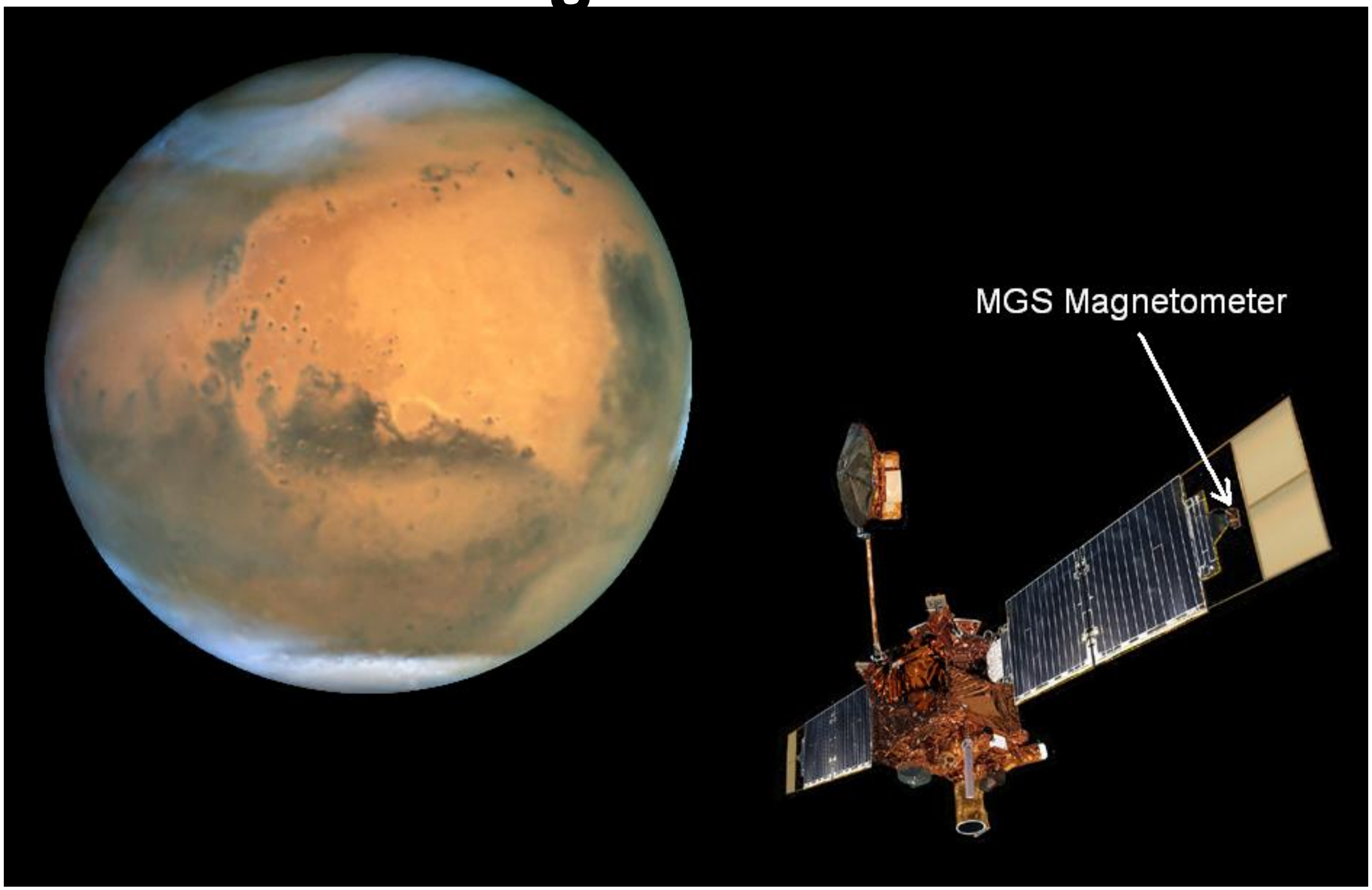
c) The IPS analysis run in near real-time allows a low-resolution forecast of velocity and density all the time at the inner planets – right now!

Wish List – higher resolution, dedicated calibrated systems, greater Earth longitude coverage or a space-based system. A breakthrough to determine magnetic field remotely. More resources! $$$, ¥¥¥, NT$

Forecasting Heliospheric Solar Wind Parameters

Crider, D.H., *et al.*, 2003, *J. Geophys. Res.*, 108(A12), 1461

Solar Wind Pressure derived from the MGS Magnetometer at Mars

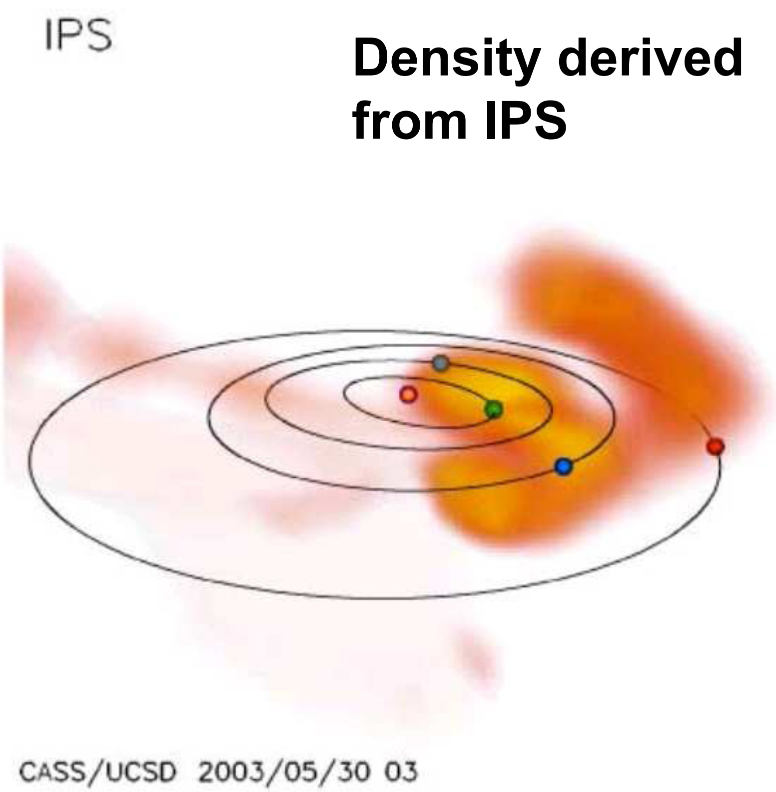


Forecasting Heliospheric Solar Wind Parameters

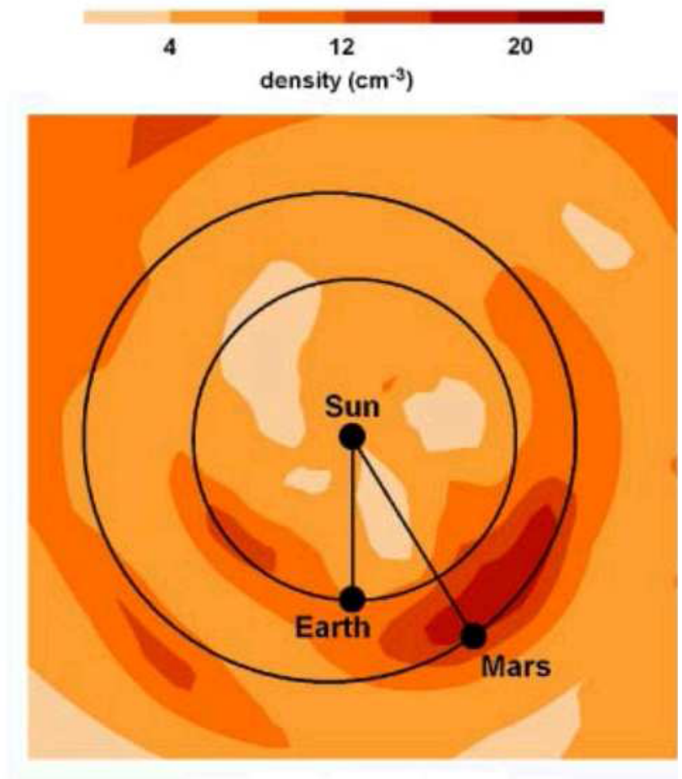
Jackson, B.V., *et al.*, 2007, *Solar Phys.*, 2007, 241: 385–396

IPS 3D Reconstruction

28 May 2003 'Halo' CME event sequence



Density derived from IPS



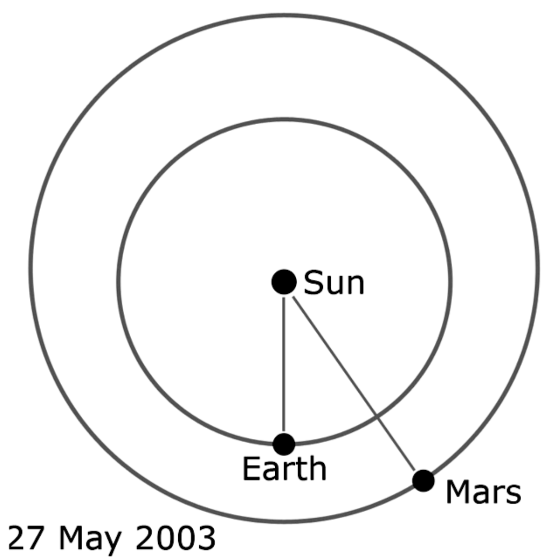
Forecasting Heliospheric Solar Wind Parameters

Jackson, B.V., *et al.*, 2007, *Solar Phys.*, 241: 385–396

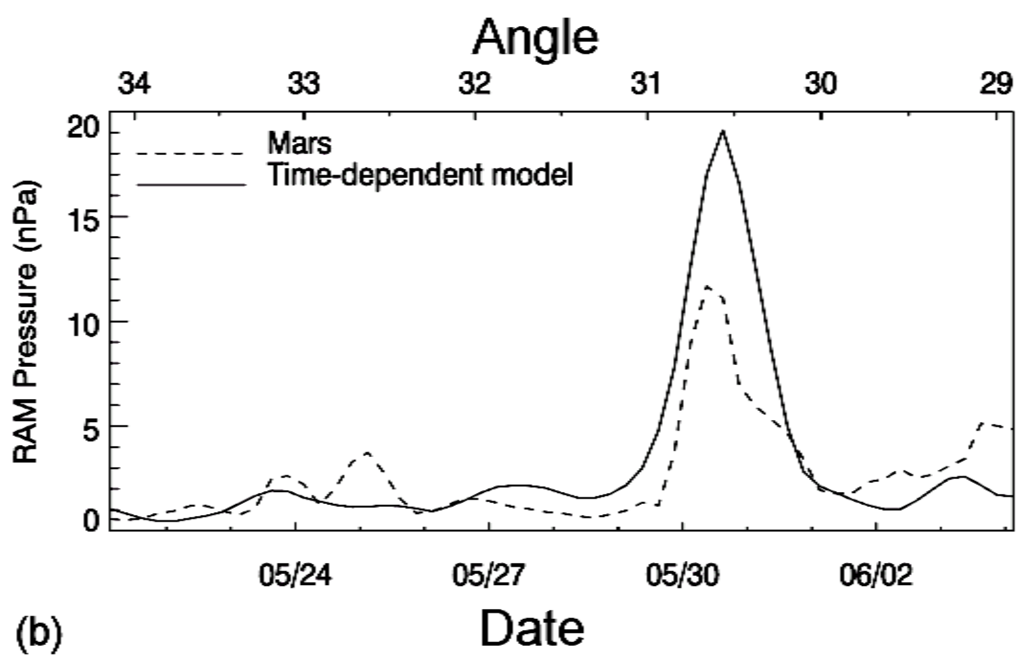
IPS 3D-Reconstruction

20 May – 05 June 2003, (28 May 'Halo' CME)

Pressure derived from IPS at Mars



Solar Wind Pressure ($\rho = 2 \times 10^6\ nV^2$)



Forecasting Heliospheric Solar Wind Parameters

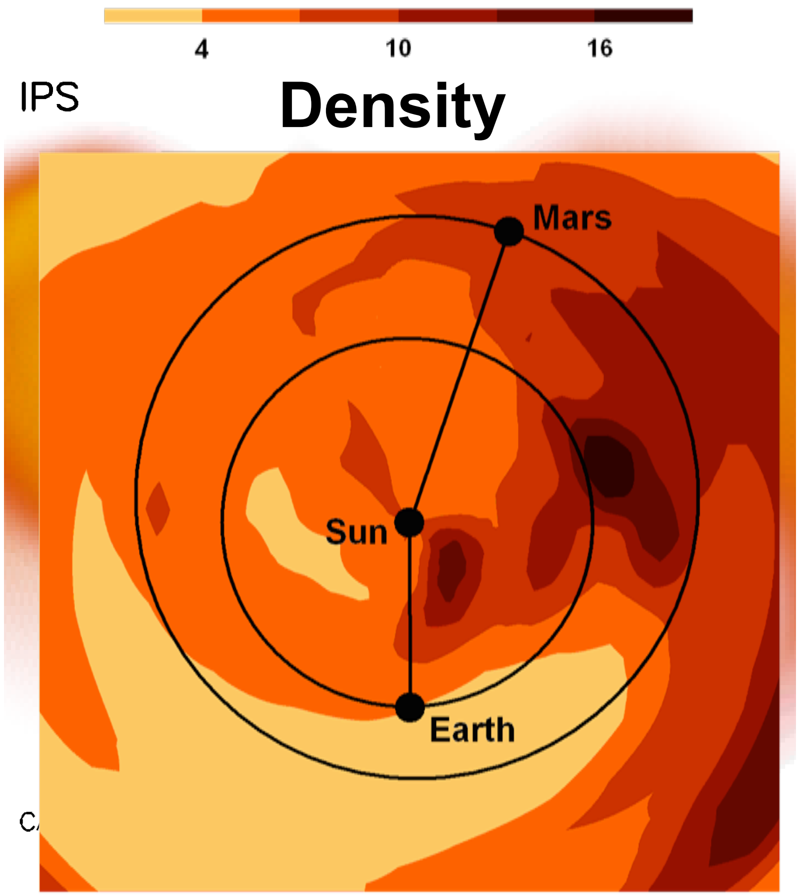
Jackson, B.V., *et al.*, 2007, *Solar Phys.*, 2007, 241: 385–396

IPS 3D-Reconstruction

12 September – 26 September 2002 period

IPS

Density



Pressure ($\rho = 2 \times 10^6 \; nV^2$)