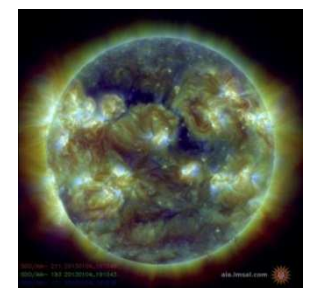


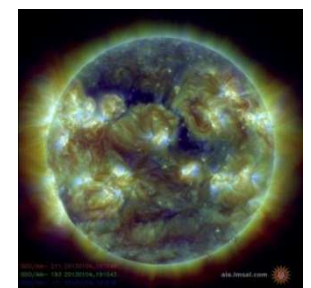


The Worldwide Interplanetary Scintillation (IPS) Stations (WIPSS) Network as a Potential Future ISWI Instrument

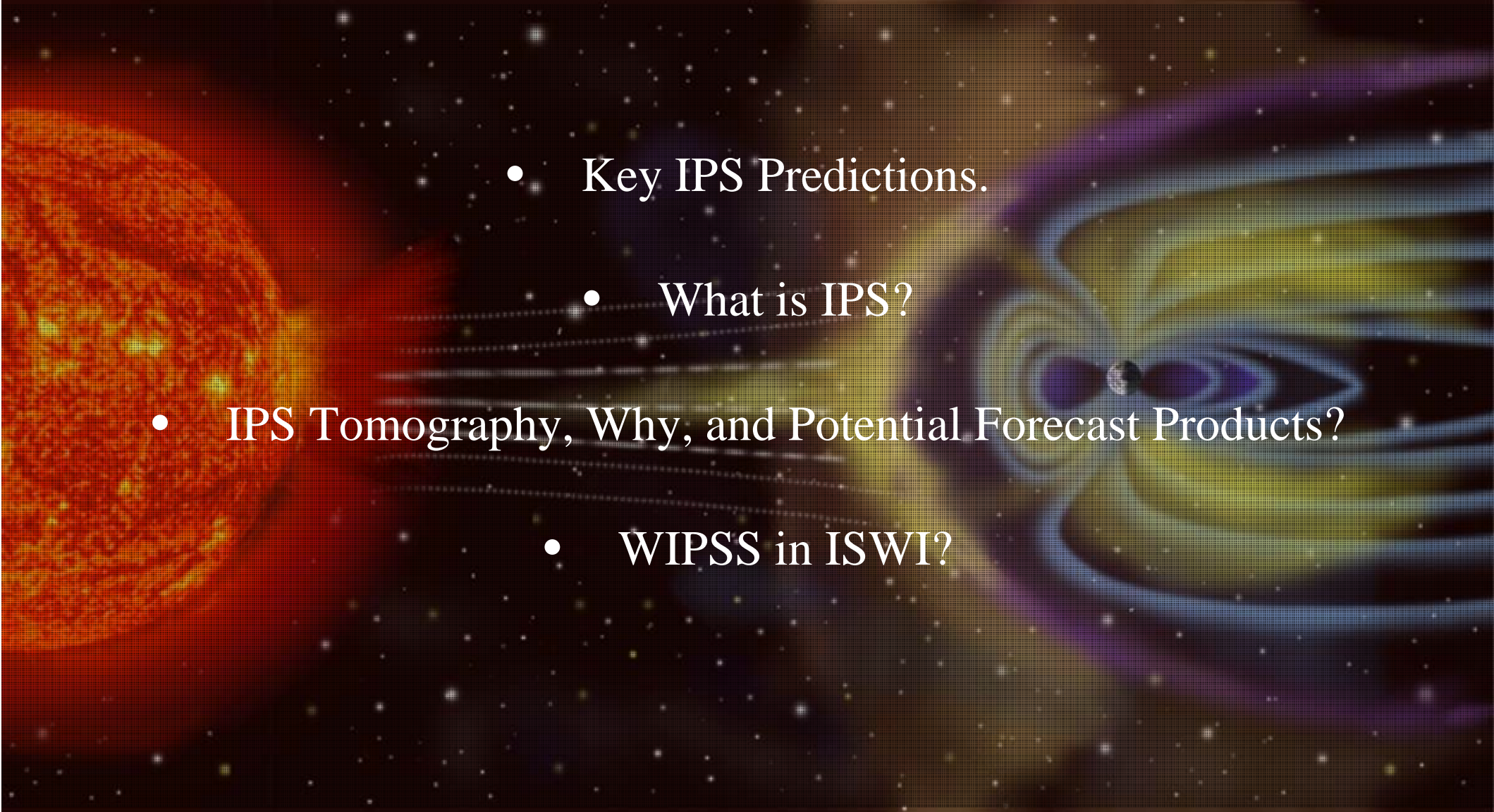




Mario M. Bisi (STFC RAL Space, UK – Mario.Bisi@stfc.ac.uk),
 David F. Webb (Boston College, USA), J. Americo Gonzalez-Esparza (UNAM,
 Mexico), Bernard V. Jackson (UCSD, USA), Igor Chashei (LPI, Russia), Munetoshi
 Tokumaru (Nagoya University, Japan), Periasamy K. Manoharan (Ooty, India),
 Richard A. Fallows (ASTRON, The Netherlands), Hsiu-Shan Yu (UCSD, USA),
 Ernesto Aguilar-Rodriguez (UNAM, Mexico), Sergei A. Tyul'bashev (LPI,
 Russia), Oyuki Chang (UNAM, Mexico), John Morgan (Curtin University, Australia),
 Julio C. Mejia-Ambriz (UNAM, Mexico), Ken'ichi Fujiki (Nagoya University,
 Japan), Vladimir Shishov (LPI, Russia), and David Barnes (STFC RAL Space, UK).



Outline

- 
- Key IPS Predictions.
 - What is IPS?
 - IPS Tomography, Why, and Potential Forecast Products?
 - WIPSS in ISWI?

Key IPS Space Weather Predictions

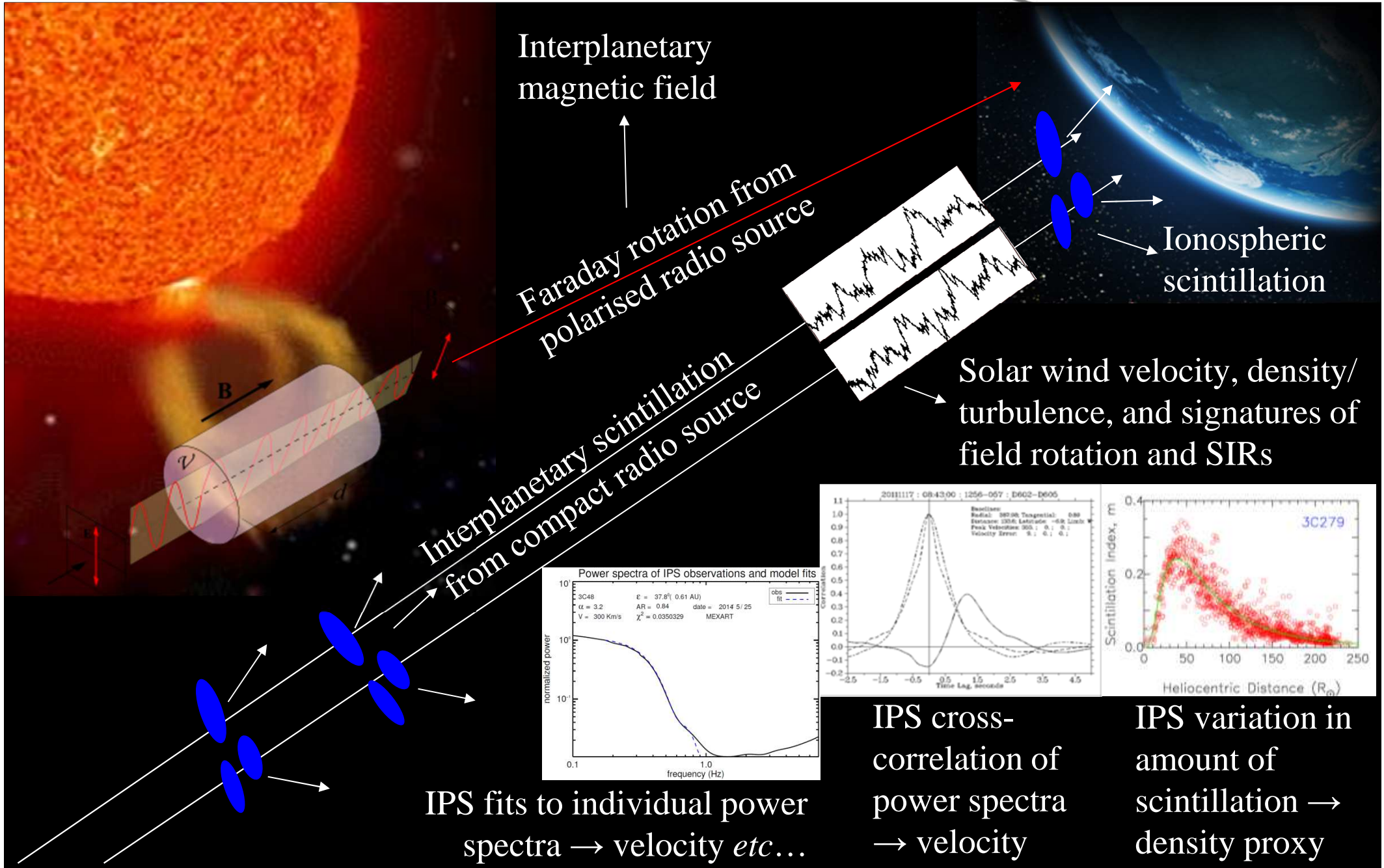
- IPS Tomographic Analyses:
 - ISEE, Japan; The UCSD iterative kinematic prediction technique; used primarily with ISEE observations, ready for WIPSS.
- IPS tomographic analysis, displays:
 - Combined analysis from multiple IPS data sets (WIPSS), driving MHD models, and 3D-MHD forward modelling.
- Magnetic-field component forward-modelling – in three components:
 - Part of the modelling effort developed at UCSD.
- **Key** new development:
 - B_z predicted in GSM coordinates at low resolution at Earth (forecast, nowcast, and aftcast – verifications are underway).

Interplanetary Scintillation (IPS)



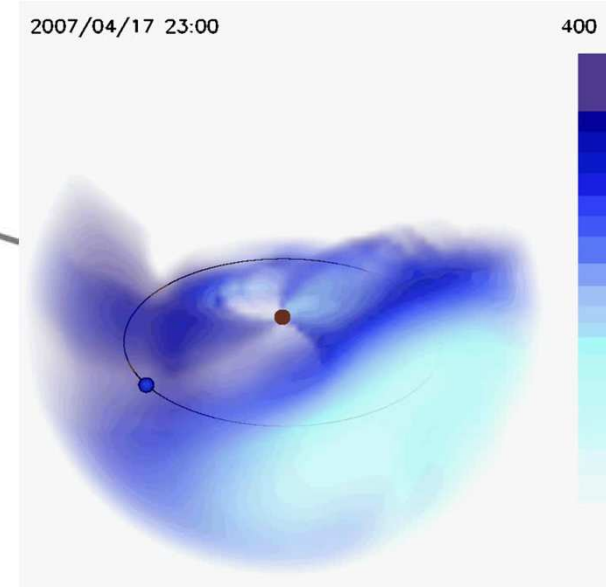
- *e.g.* see M.M. Bisi, “Planetary, heliospheric, and solar science with radio scintillation”, Chapter 13 of Heliophysics Volume IV “Active stars, their astrospheres, and impacts on planetary Environments”, Editors C.J. Schrijver, F. Bagenal, and J.J. Sojka, Cambridge University Press, 16 March 2016, and references therein.

What is IPS?



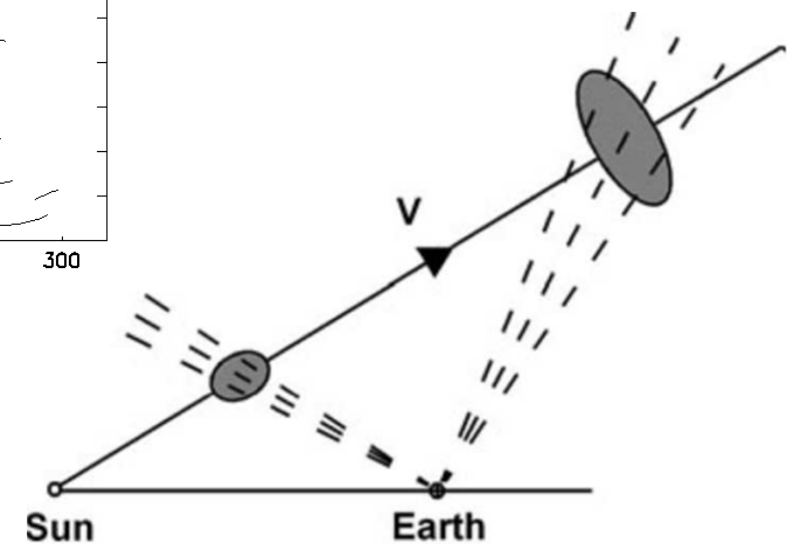
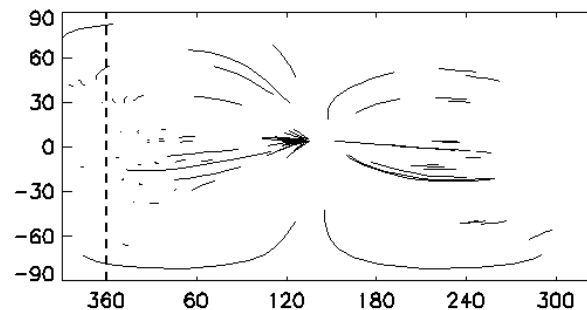
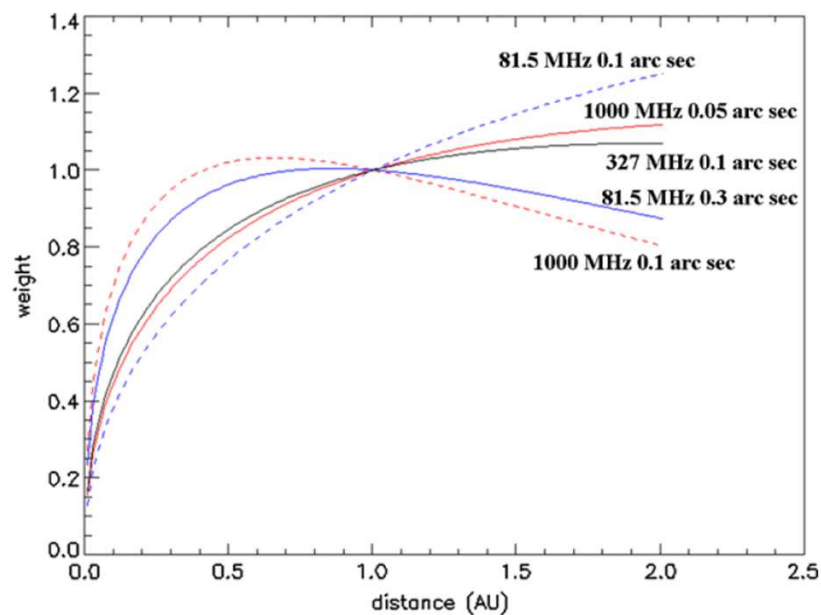
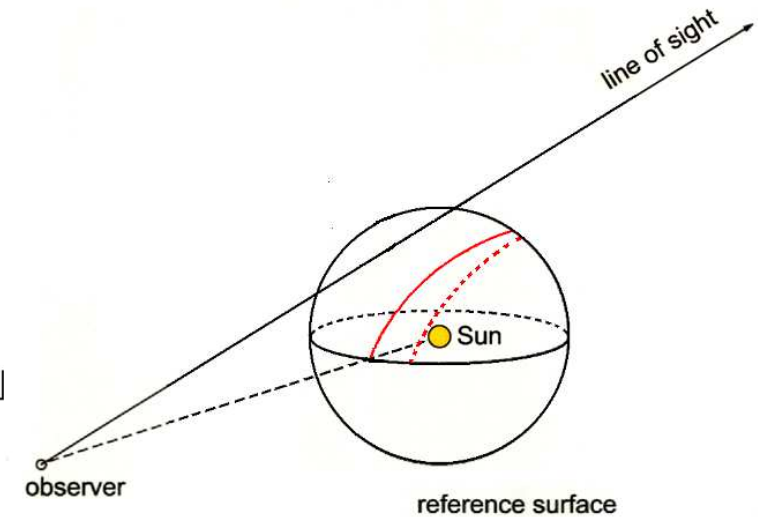
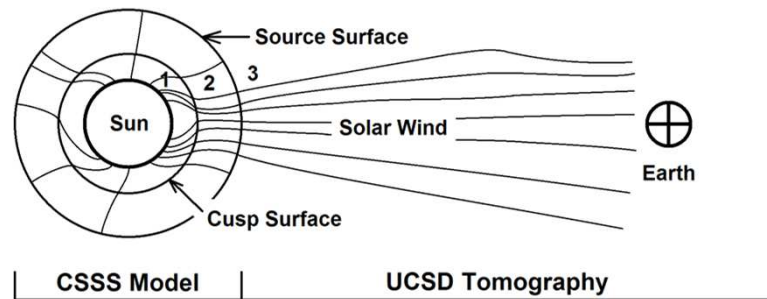
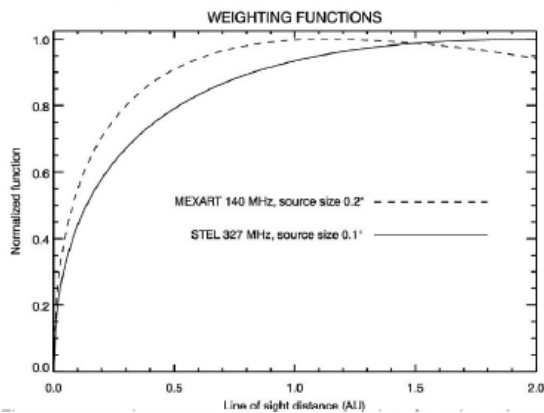
Heliospheric Imaging with IPS

- The disentangling of heliospheric structures between the Sun and Earth is no simple task.
- There are many different features: different solar-wind streams, stream interaction regions (SIRs), CMEs, *etc...*
- Remote-sensing heliospheric imaging via visible-light (Thomson scattered sunlight off of heliospheric structures) or radio (indirect via changes in signals from background sources) frequencies enables us to get a good handle on the large space between Sun and Earth (and beyond the Earth).
- Observations can be input into the University of California, San Diego (UCSD) 3-D tomography for reconstruction (top image) of the whole inner-heliospheric structure in several parameters...



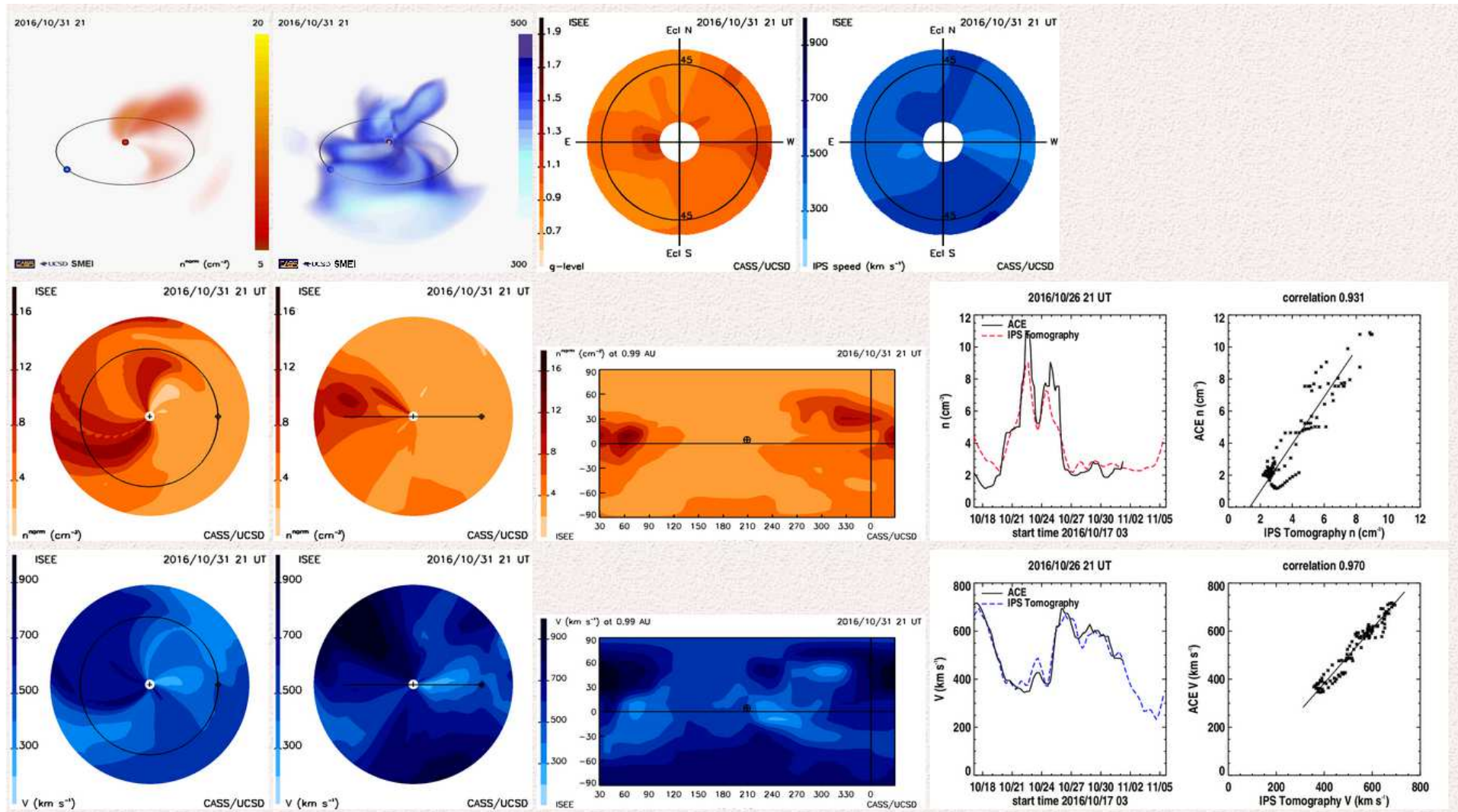
CASE ← UCSD EISCAT V (km s⁻¹) 200

University of California, San Diego (UCSD) IPS Tomography



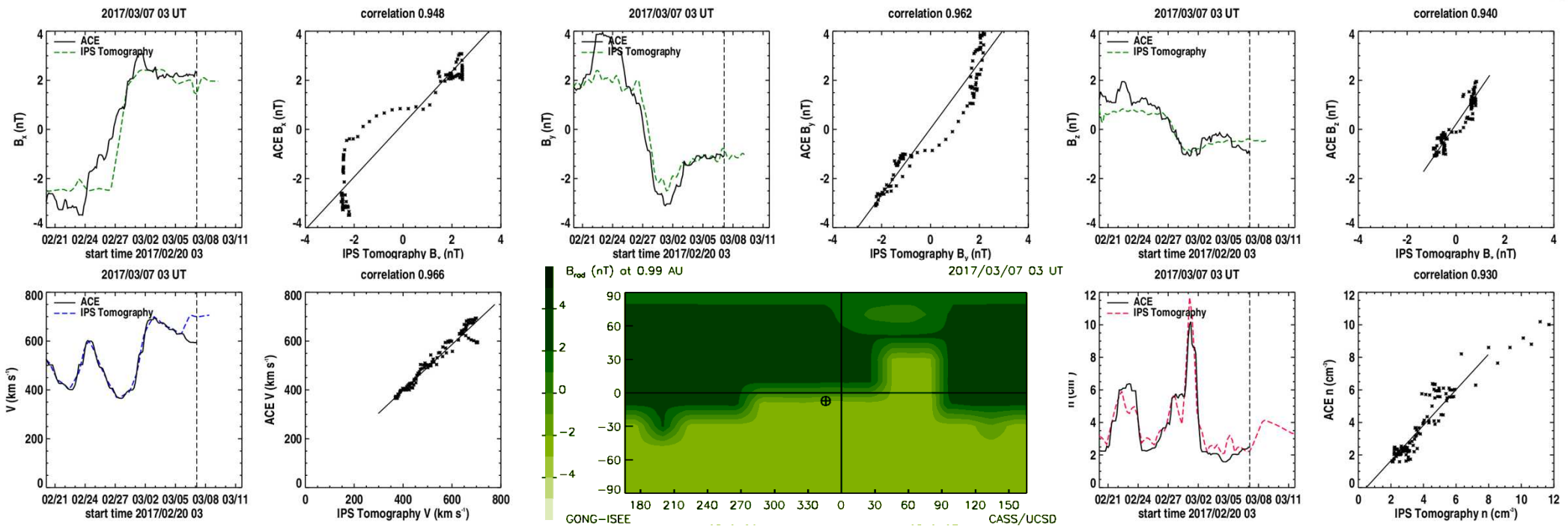
UCSD Predictions: Example Analyses using ISEE IPS and ACE data

(http://ips.ucsd.edu/ips_workshop_2016)



Web analysis currently runs automatically using Linux on a P.C. – not overly computer intensive.

Reconstructions Using ACE, ISEE IPS, and GONG Data...



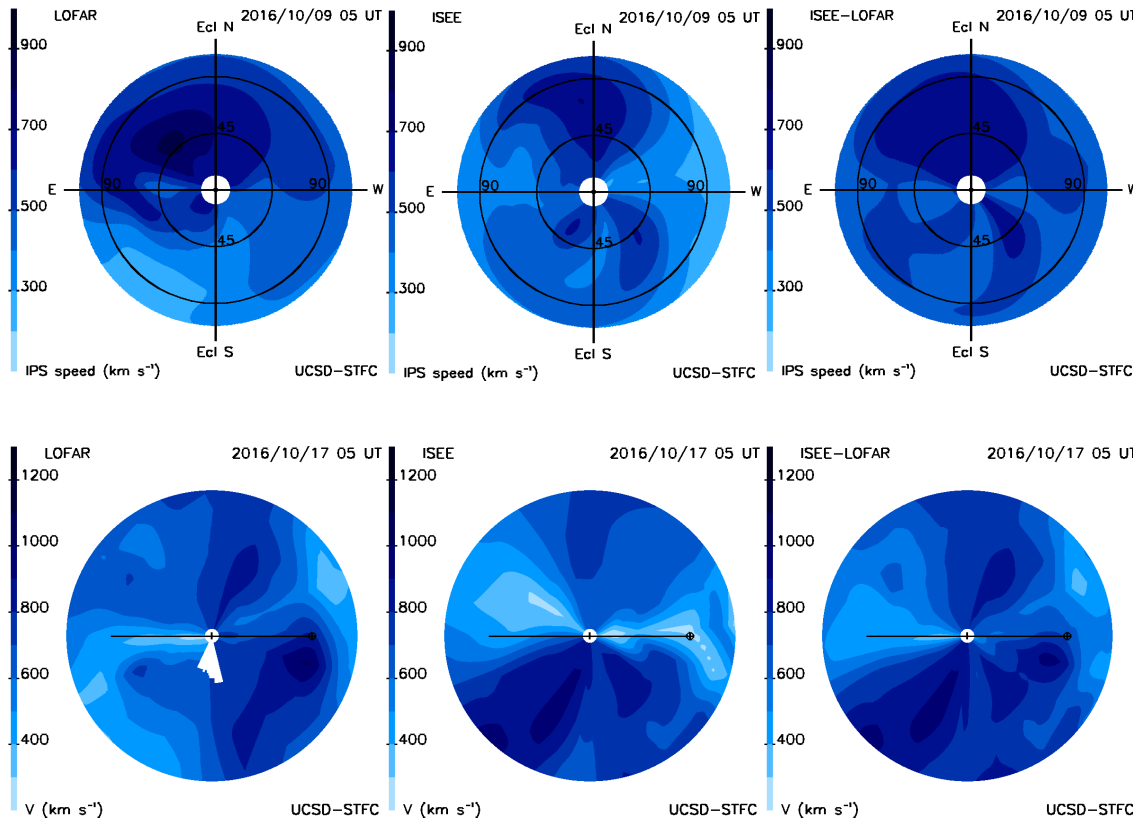
- B_x , B_y , B_z , v , B_r , and n values/forecast...
- Only velocity and density *in-situ* data incorporated (not \mathbf{B}).
- Taken from the 2016 UCSD IPS Workshop Pages (http://ips.ucsd.edu/ips_workshop_2016).

The locations of many of the current and future potential WIPSS Network Stations are in DAC Countries making this network an ideal candidate for a future ISWI Instrument...

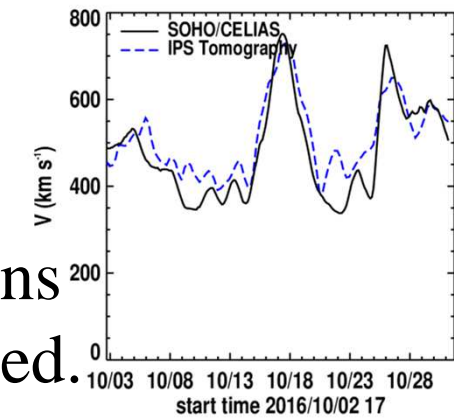
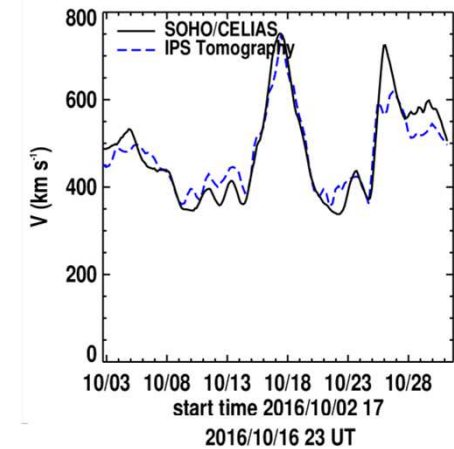
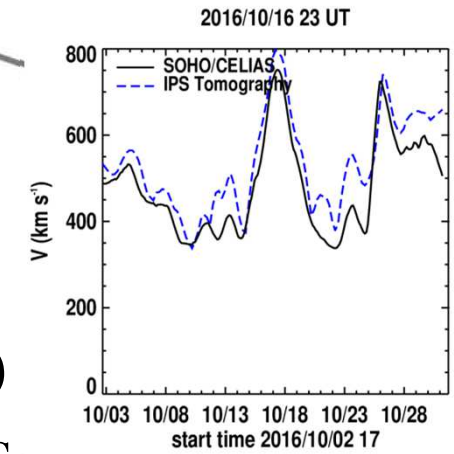
WIPSS Core Members

- **M.M. Bisi** – STFC RAL Space, UK.
- **J.A. Gonzalez-Esparza, E. Aguilar-Rodriguez, O. Chang, J.C. Mejia-Ambriz, V.H. De la Luz, P. Corona-Romero, and E. Romero-Hernandez** – SCIESMEX/MEXART/UNAM, Mexico.
- **B.V. Jackson**, and Hsiu-Shan Yu – CASS-UCSD, USA.
- M. Tokumaru, and K. Fujiki – ISEE, Nagoya University, Japan
- I.V. Chashei, S.A. Tyul'Bashev, V. Shishov – Pushchino Radio Astronomy Observatory, Russia.
- R.A. Fallows – ASTRON, The Netherlands.
- **P.K. Manoharan** – Ooty Radio Telescope, India.
- Future expected additions (some are much more science focused) from the Republic of Korea (South Korea) (2017), Ukraine (2017), China (2017), Australia (2017), and perhaps South Africa (TBC).

A WIPSS Example (1): Combining LOFAR and ISEE Data



- Combined IPS and CELIAS velocity (right) reconstructions – *in-situ* extractions (top-bottom) LOFAR ↓ ISEE ↓ ISEE-LOFAR combined.

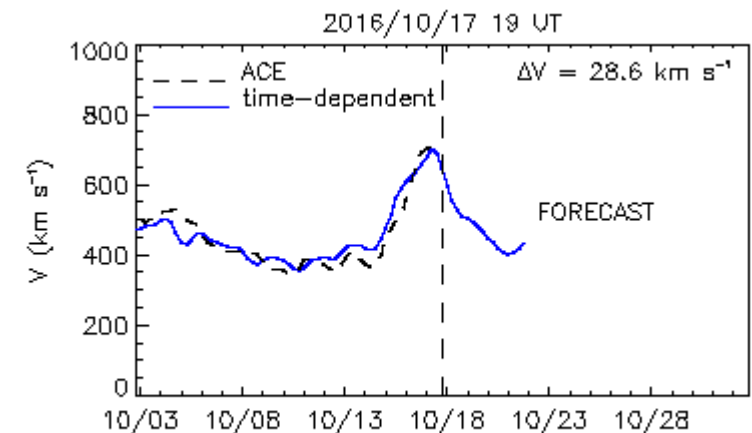
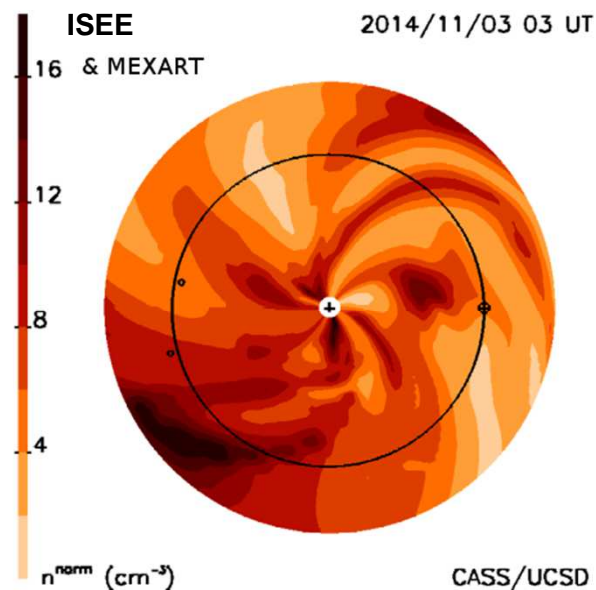
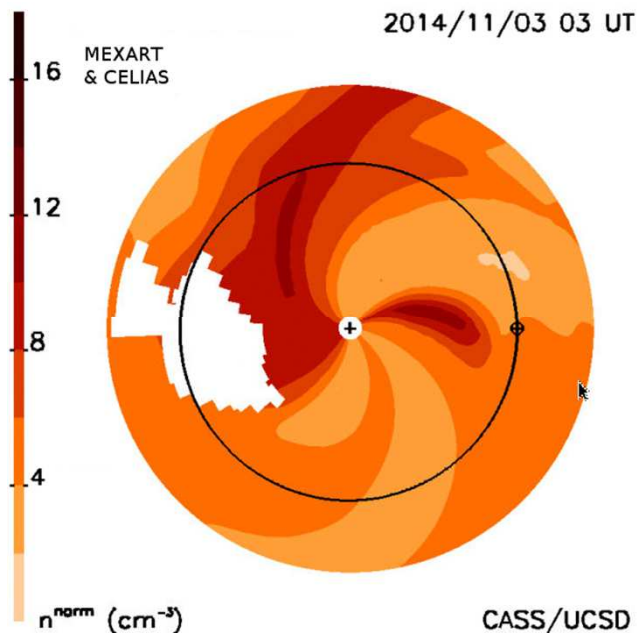
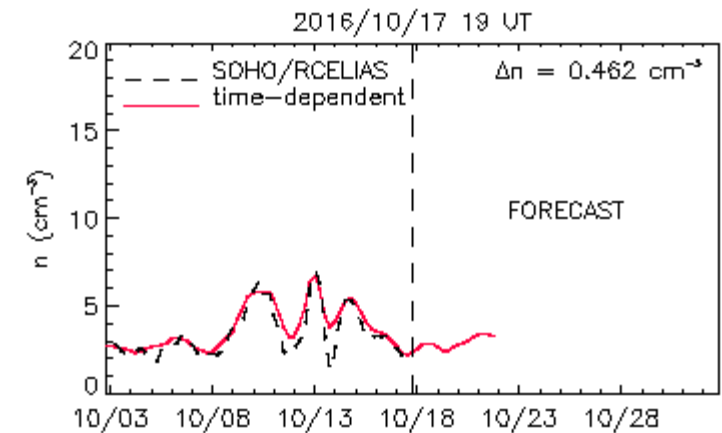


- Fisheye (above top) sky-plane and meridional (above bottom) cuts from three labelled velocity reconstructions (left-right) LOFAR → ISEE → ISEE-LOFAR combined.

A WIPSS Example (2): Combining MEXART, ISEE, and *in-situ* Data

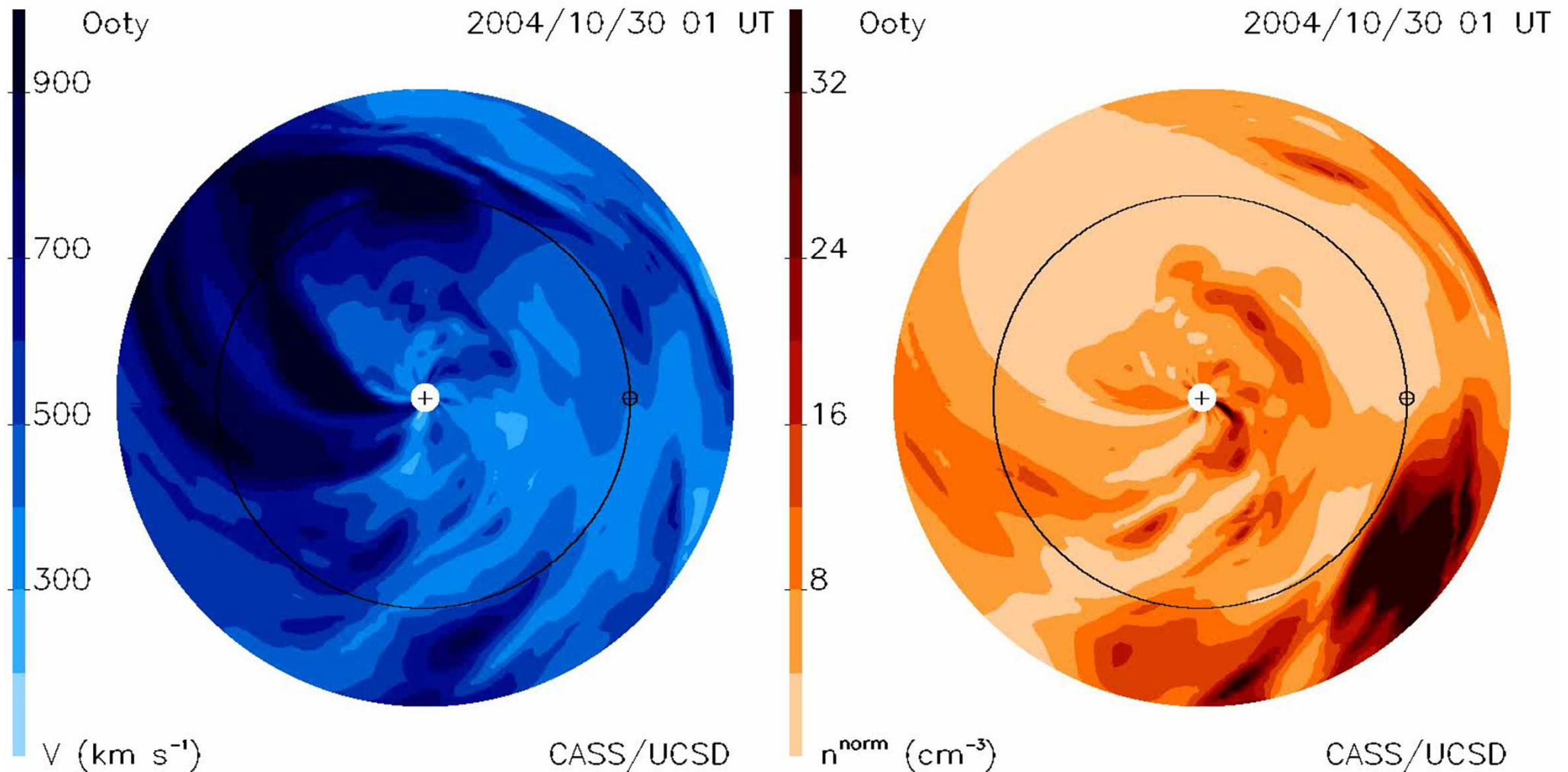


Data



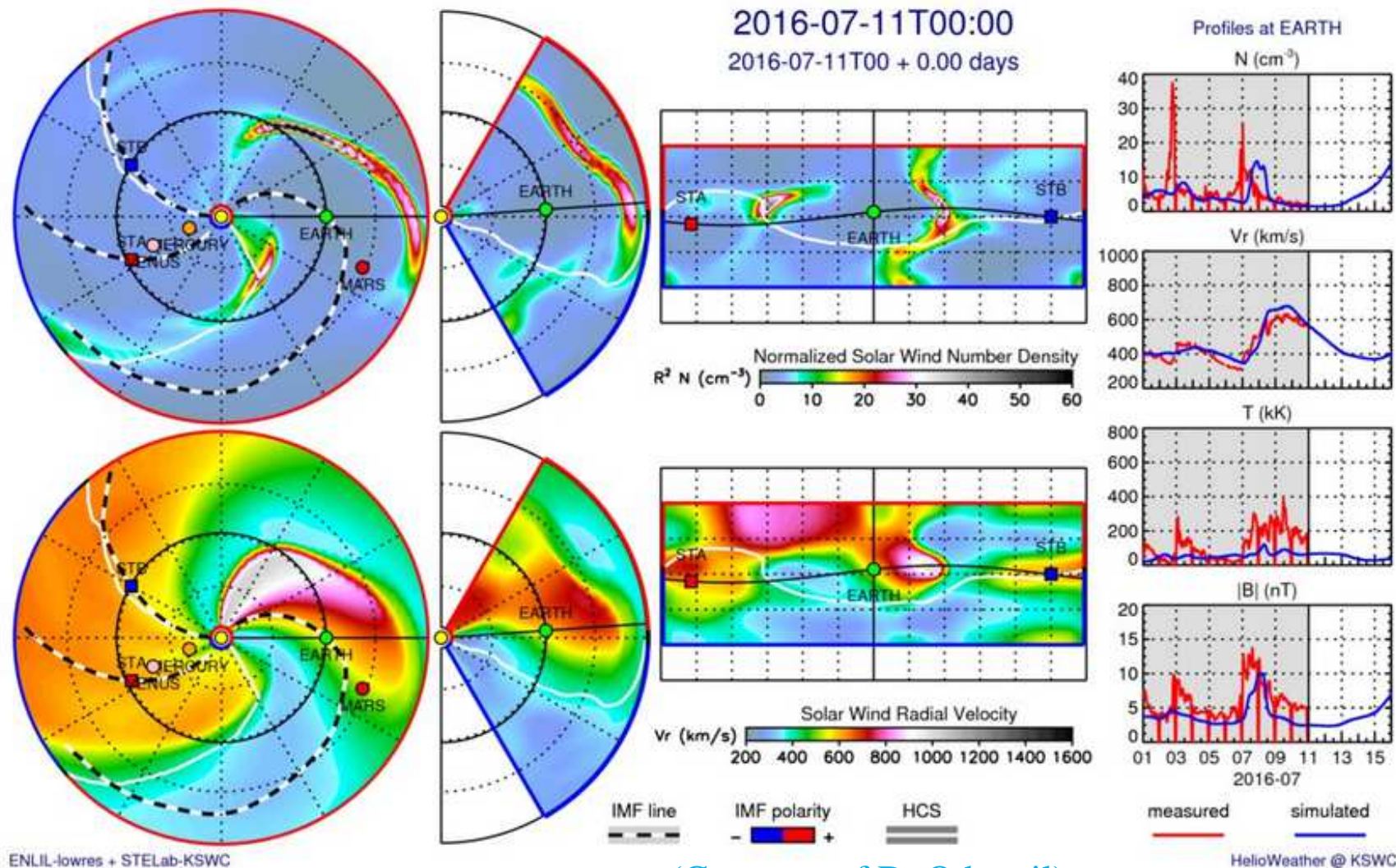
What we want from WIPSS (1)

- Using the UCSD 3-D Tomography for real-time heliospheric reconstruction and space-weather forecasting in this detail...



What we want from WIPSS (2)

- And to drive or use MHD using WIPSS IPS data as input...

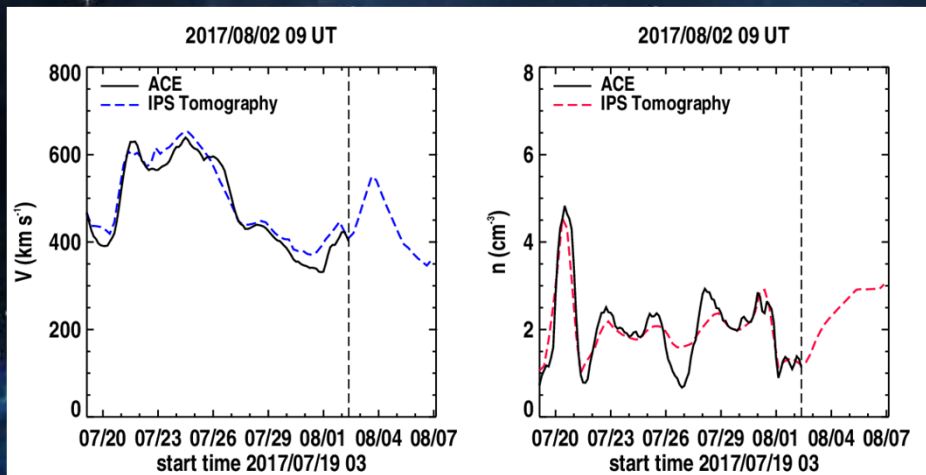
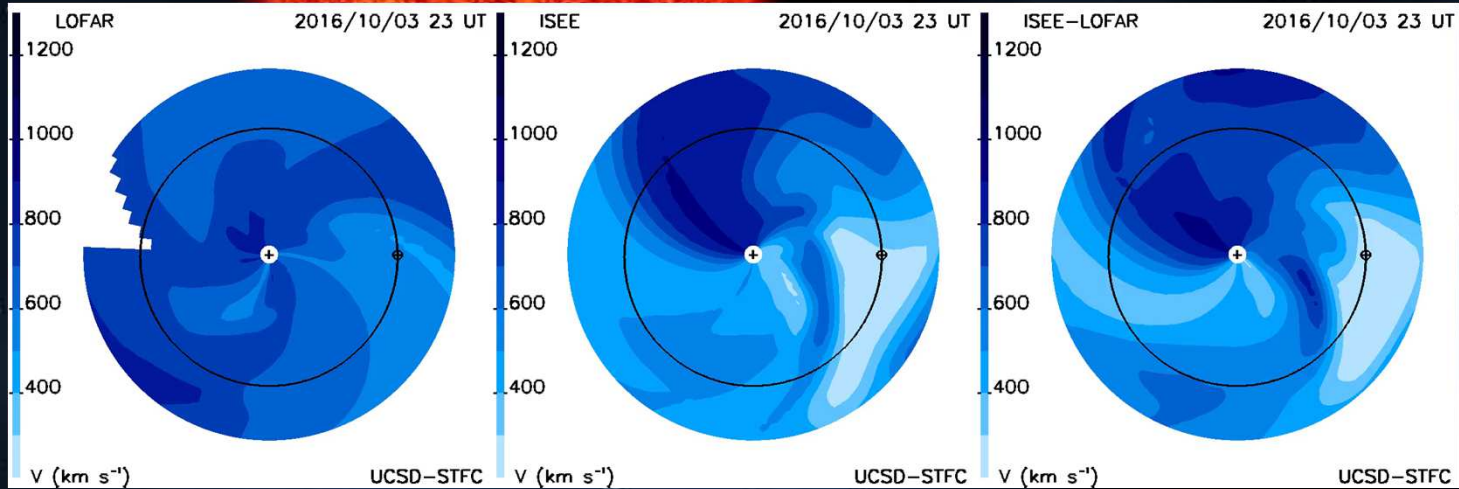


(Courtesy of D. Odstrcil)

SUSTAINABLE DEVELOPMENT GOALS



Next workshop – “Into the Red Dragon’s Lair: Four-in-One Workshop Tackling Outstanding Problems in Heliophysics and Space Weather”: <https://goo.gl/p1G3jZ> or <https://www.ukssdc.ac.uk/meetings/IntoTheRedDragonsLair/> – Clayton Hotel, Cardiff, Wales, UK (03-08 December 2017).



More current ISEE Forecasts can be seen at: <http://ips.ucsd.edu/>.

