Integrating SolO/PHI magnetograms into global solar magnetic maps

Sam Schonfeld[1], Carl Henney[2], Shaela Jones[3], Nick Arge[3]

[1]Institute for Scientific Research, Boston College | [2]Air Force Research Laboratory | [3]NASA Goddard Space Flight Center

Introduction

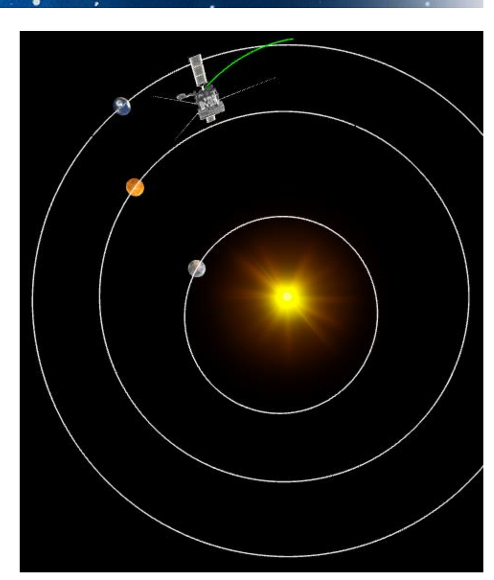
- The full-Sun photospheric magnetic field is used to drive models of the solar corona, the solar wind, and the heliosphere
  - Until recently, these fields were only measured from one perspective, along the Sun-Earth line
    - This provides reliable measurements of only about ¼th of the solar disk at any one time
- Photospheric flux transport models advect magnetic fields subject to known plasma flows to represent the unobserved solar surface
  - We use ADAPT, the **A**ir Force **D**ata **A**ssimilative **P**hotospheric flux **T**ransport model (Arge et al. 2010, 2011)
- The Solar Orbiter (SolO, Müller et al. 2020) mission is the first to carry a magnetograph off of the Sun-Earth line
  - Incorporating these observations will improve full-Sun photospheric magnetic maps and the models they drive
- We present initial results from the incorporation of Polarimetric and Helioseismic Imager (PHI, Solanki et al. 2020) Full Disk Telescope (FDT) images into ADAPT full-Sun magnetic field maps
  - These are used to drive Wang-Sheeley-Arge (WSA, Arge and Pizzio 2000, Arge et al. 2003, 2004) coronal and solar wind models that demonstrate the importance of incorporating non-Earth viewpoints of the solar photosphere

ADAPT

- Assimilates observations into existing full-Sun maps
- Transports flux via differential rotation, meridional circulation, and supergranular diffusion
  - Also randomly emerges weak bipolar flux
- Models 12 realizations of the magnetic field to account for uncertainty in the unobserved polar and far-side evolution
  - Largest uncertainties near the East limb, just before the photosphere rotates back into view from the Earth

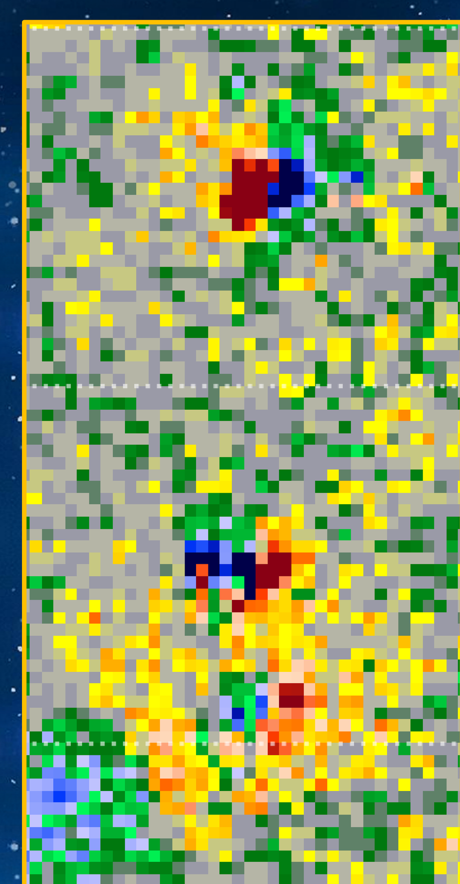
SolO / PHI / FDT

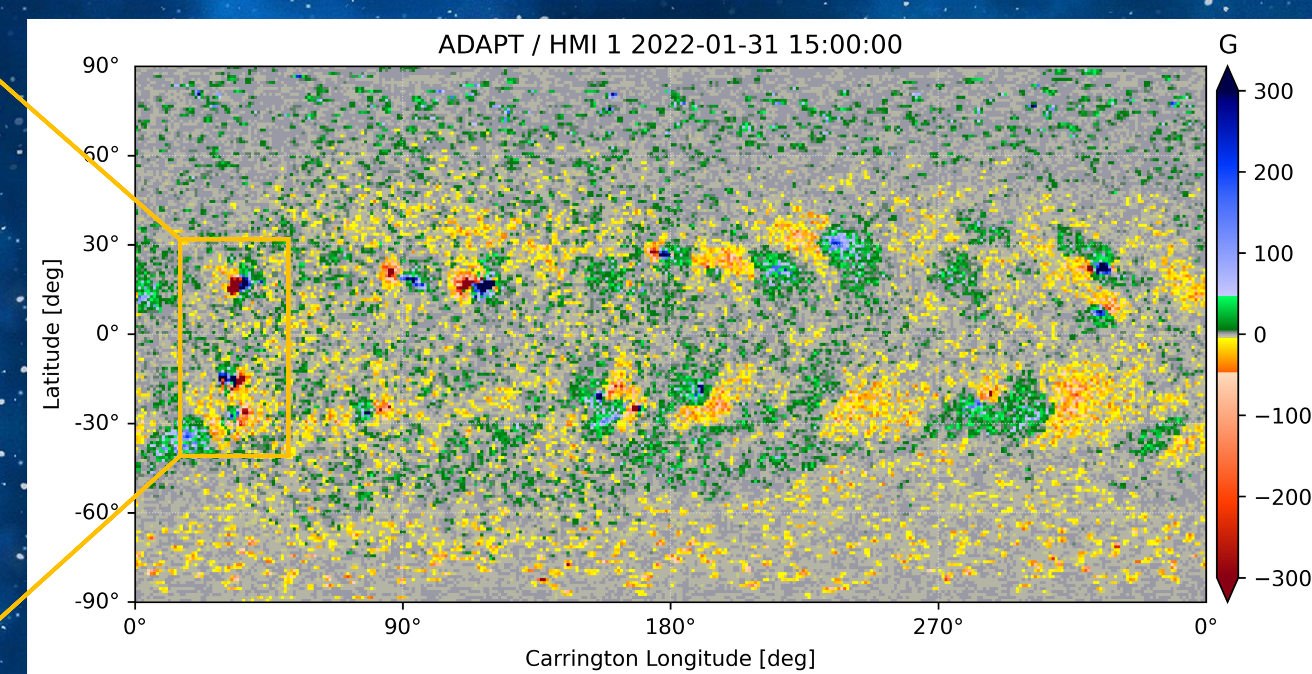
- Full-disk magnetograms during all phases of the SolO mission
  - Resolution depends on $d_{\odot}$
- During this observation, SolO trailed Earth by ~18°
  - Observed features rotating onto the East limb one day earlier
- Assimilated FDT data into an ADAPT ensemble generated with SDO / HMI data (Scherrer et al. 2011)



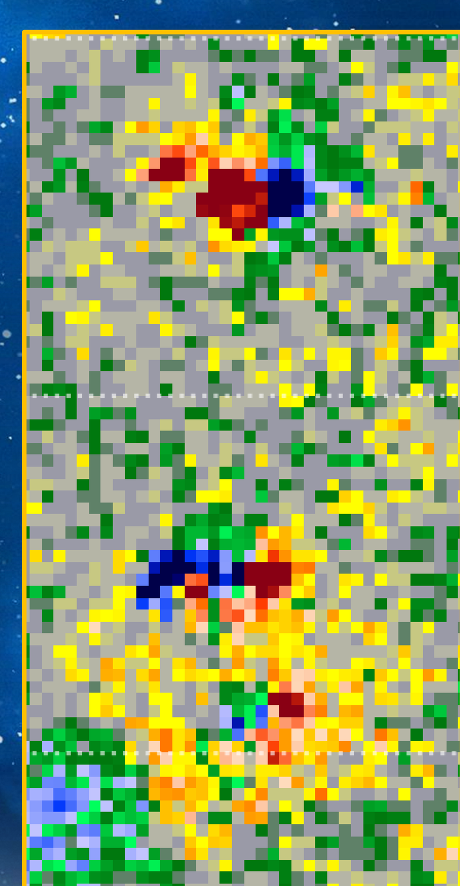
solarorbiter.esac.esa.int/where

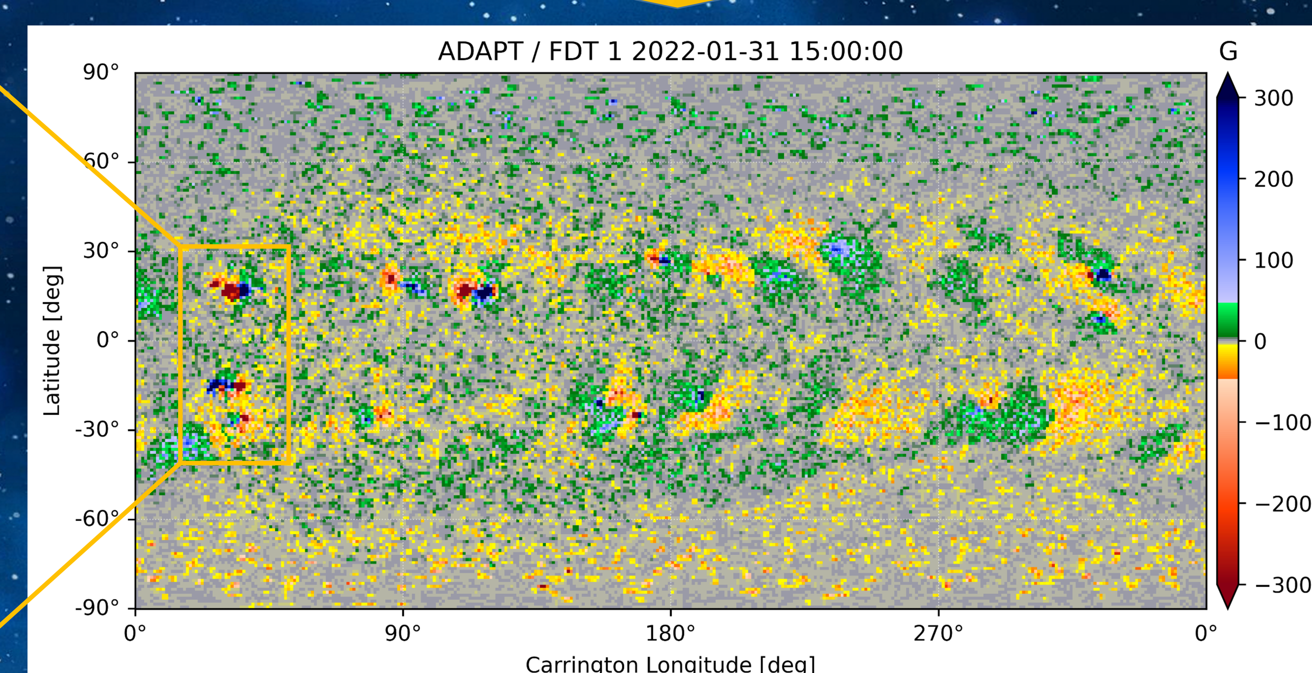
Assimilating **farside FDT magnetogram** data into ADAPT-HMI maps **reduces** the ensemble **uncertainty**.





Assimilating FDT Data



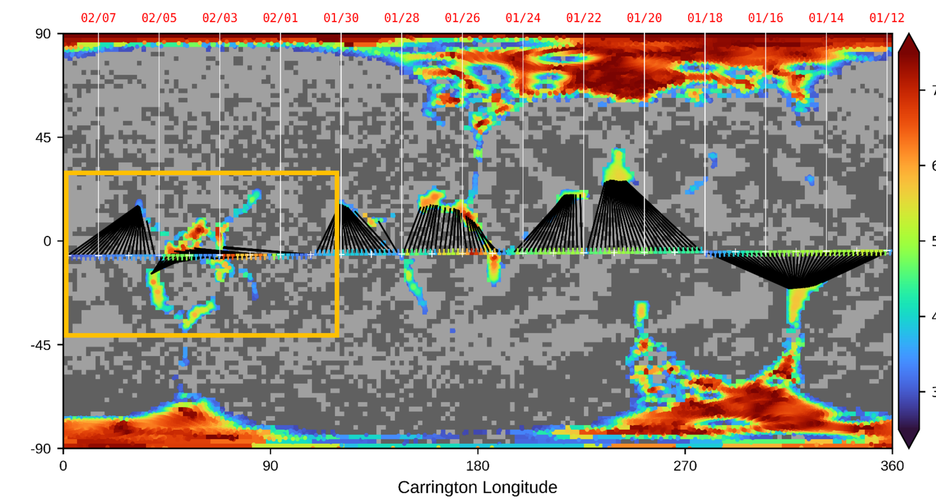


We thank the PHI Team for making these preliminary data available through the Solar Orbiter 8 workshop tutorials: github.com/SolarOrbiterWorkshop/solo8_totorials

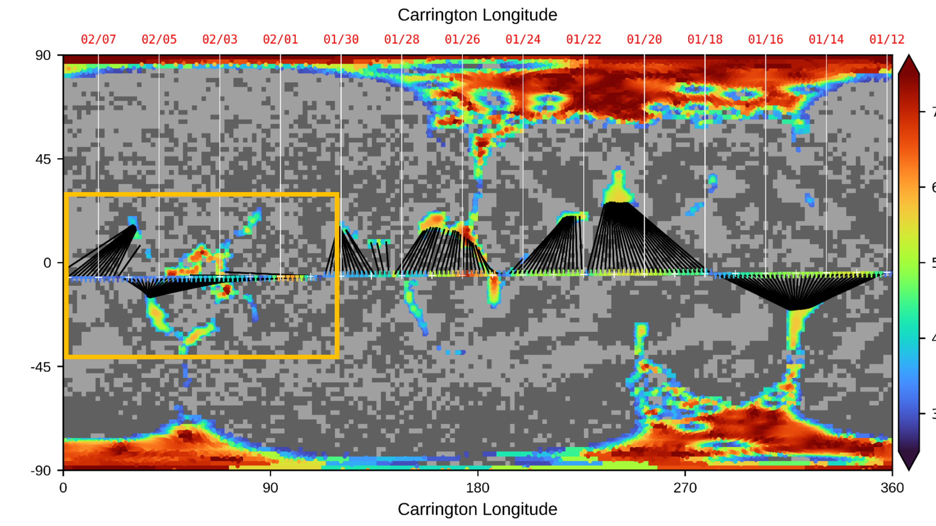
FDT impact on WSA models

- WSA models the coronal magnetic field and predicts in situ solar wind from full-Sun photospheric magnetic field maps
- For this example, adding FDT data changes the spacecraft connectivity with little impact on the modeled coronal holes

HMI Only

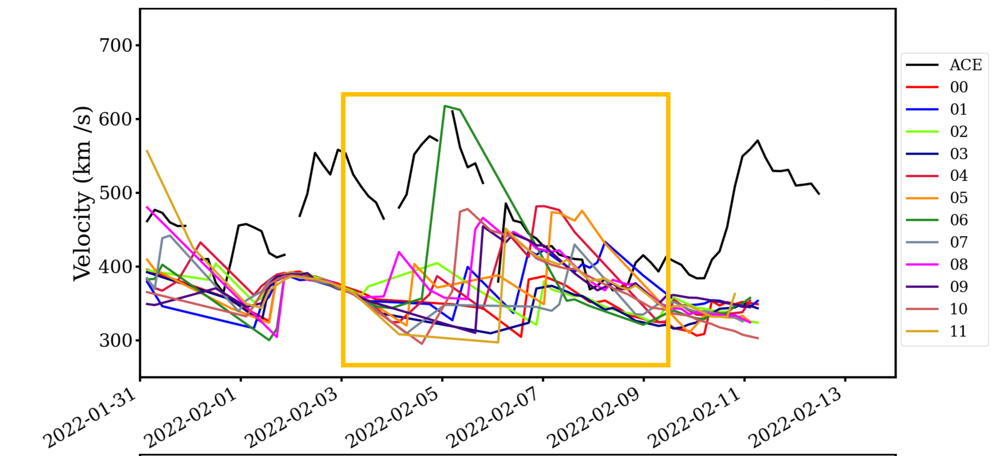


+FDT

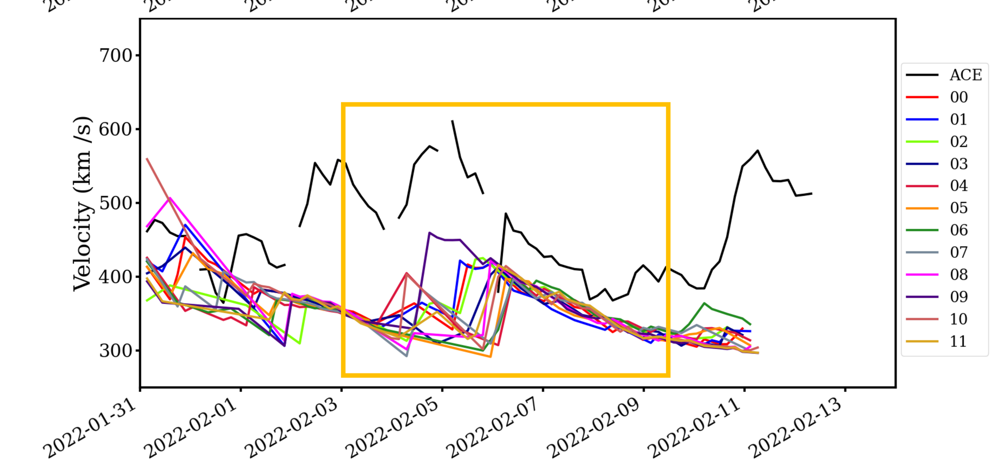


- Adding this preliminary FDT data collapses the ensemble of solar wind predictions but does not improve the average

HMI Only



+FDT



References

- Arge, C. N., Henney, C. J., Koller, J., et al. 2010, in AIP Conf. Proc. 1216, Twelfth Int. Solar Wind Conf., 1216, ed. M. Maksimovic, K. Issautier, & N. Meyer-Vernet (Melville, NY: AIP), 343
- Arge, C. N., Henney, C. J., Koller, J., et al. 2011, in ASP Conf. Ser. 444, 5th Int. Conf. of Numerical Modeling of Space Plasma Flows (ASTRONUM 2010), ed. N. V. Pogorelov, E. Audit, & G. P. Zank (San Francisco, CA: ASP), 99
- Arge, C. N., Luhmann, J. G., Odstrcil, D., Schrijver, C. J., & Li, Y. 2004, JASTP, 66, 1295
- Arge, C. N., Odstrcil, D., Pizzo, V. J., & Mayer, L. R. 2003, in AIP Conf. Ser. 679, The Tenth Int. Solar Wind Conf., ed. M. Velli et al. (Melville, NY: AIP), 190
- Arge, C. N., & Pizzo, V. J. 2000, JGR, 105, 10465
- Müller, D., Cyr, O. C., St, Zouganelis, I., et al. 2020, A&A, 642, A1
- Scherrer, P. H., Schou, J., Bush, R. I., et al. 2011, SoPh, 275, 207
- Solanki, S. K., Del Toro Iniesta, J. C., Woch, J., et al. 2020, A&A, 642, A11

This work utilizes data produced collaboratively between the Air Force Research Laboratory (AFRL) and the National Solar Observatory. The ADAPT model development is supported by AFRL.