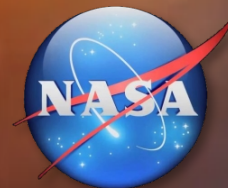


Coronal Prediction for the 2026 Total Solar Eclipse

Ronald M. Caplan, **Cooper Downs**,
Jon A. Linker, James Turtle, Ryder Davidson, Andres Reyes,
Roberto Lionello, Emily Mason, Erika Palmerio, Michal Ben-Nun, Pete
Riley, Viacheslav Titov, Tibor Torok, and the Solar Orbiter PHI Team





PSI and Eclipse Predictions

- The team at PSI has posted eclipse predictions for decades
- Comparing predictions to observations helps refine our models, and can provide context for observational planning
- Originally, predictions used quasi-relaxed MHD simulations of the solar corona, posted ~2 weeks before the event
- Starting in 2024, we now use a continually running, data assimilative MHD simulation in near real-time

 April 8, 2024 ↗ Near solar maximum of cycle 25	 December 4, 2021 ↗ Rising phase of solar cycle 25	 December 14, 2020 ↗ Early rising phase of solar cycle 25	 July 2, 2019 ↗ Solar minimum between cycles 24 and 25
 August 21, 2017 ↗ Declining phase of solar cycle 24	 November 13, 2012 Approaching solar maximum of cycle 24	 July 11, 2010 Rising phase of solar cycle 24	 July 22, 2009 Solar minimum between cycles 23 and 24
 August 1, 2008 Solar minimum between cycles 23 and 24	 March 29, 2006 Declining phase of solar cycle 23	 December 4, 2002 Near solar maximum of cycle 23	 June 21, 2001 Near solar maximum of cycle 23
 August 11, 1999 Approaching solar maximum of cycle 23	 February 26, 1998 Rising phase of solar cycle 23	 March 9, 1997 Solar minimum between cycles 22 and 23	 October 24, 1995 Solar minimum between cycles 22 and 23

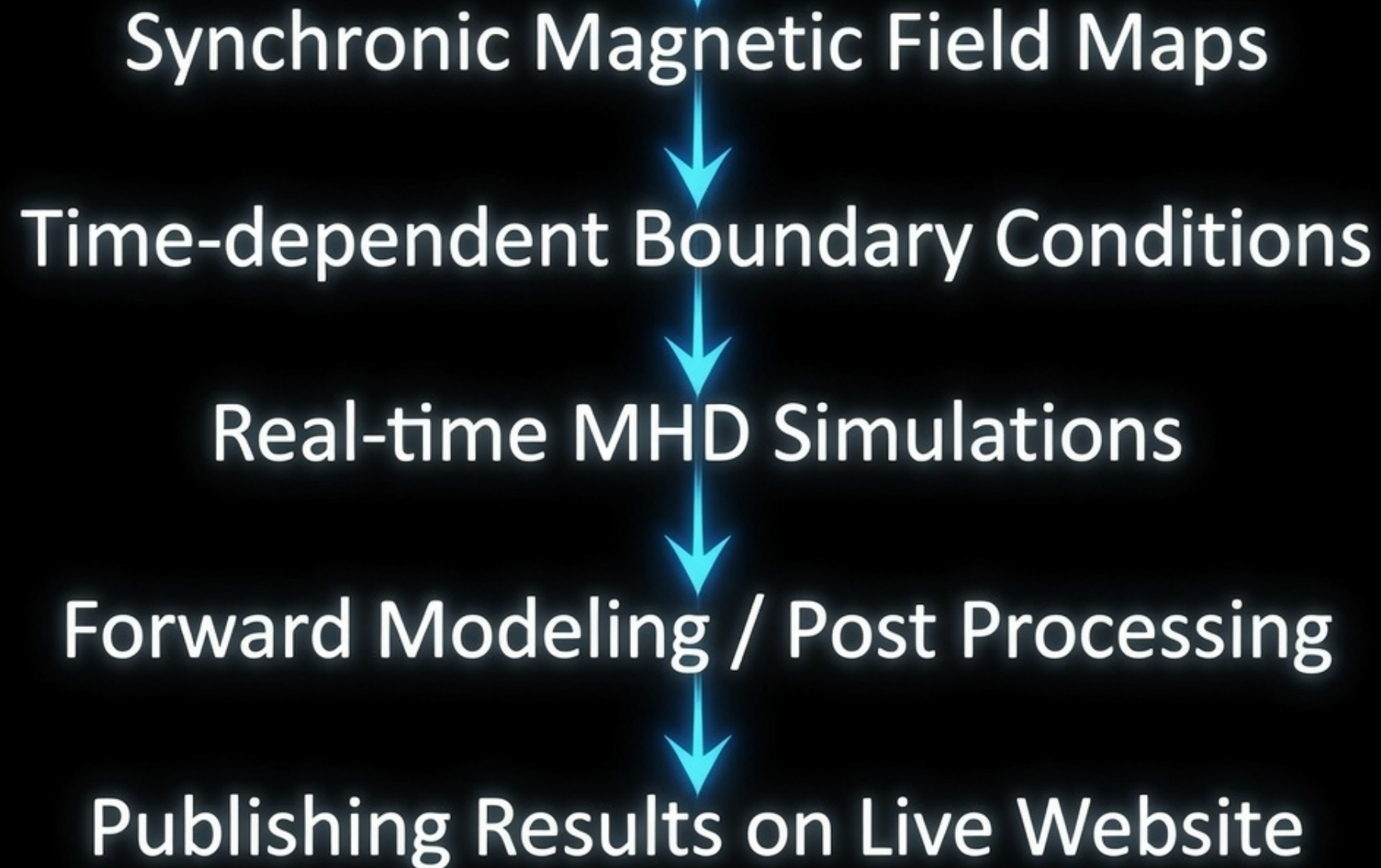
2024

Prediction	Observation
 2017	 Composite Photo © 2017 Wendy Carlos and Jay Pasachoff. All rights reserved.
 2019	 © 2019 Williams College Eclipse Expedition (Jay Pasachoff, David Sliski, Alan Sliski, Christian Lockwood, Jon Inoue, Erin Meadows)/Solar Terrestrial Program, NSF Atmospheric and Geospace Sciences Division. Digital assembly and composite by Wendy Carlos. All rights reserved.
 2020	 Jay Pasachoff, Patricio Rojo, Vero Espinosa, et al./Williams College Expedition/NSF AGS computer composition by Wendy Carlos. © 2020. All rights reserved.
 2021	 © 2021 Williams College Expedition; airborne Jay Pasachoff, Peter Knowlton, David Sliski, Nicole Massetti; Union Glacier: Theo Boris, Christian Lockwood, Janet Boris, Zev Hoover. Digital image assembly Wendy Carlos — All Right Reserved

predsci.com/eclipses



PSI 2026 Eclipse Prediction Real-Time Pipeline



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Synchronic Magnetic Maps: Surface Flux Transport Model



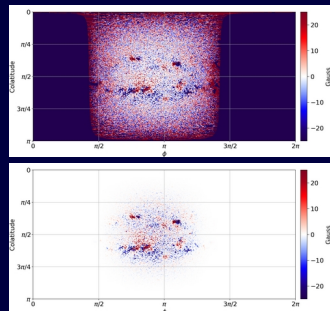
[github.com/
predsci/oft](https://github.com/predsci/oft)

Open Source Flux Transport
A Tool for Generating Full-Sun Synchronic Magnetic Field Maps

MagMAP

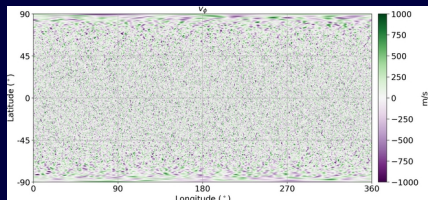
Magnetic Mapping And Processing

Acquire, process, map, and bin observational magnetic field data into data-assimilation database



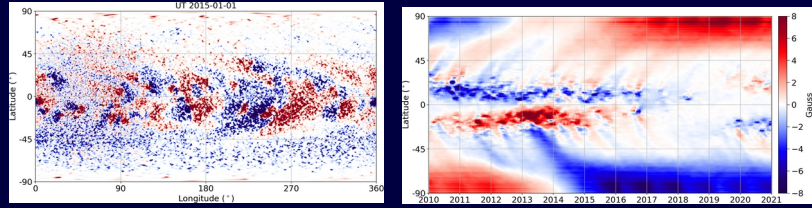
Convective Flow generator

Generate sequence of supergranular flow fields



High-performance Flux Transport

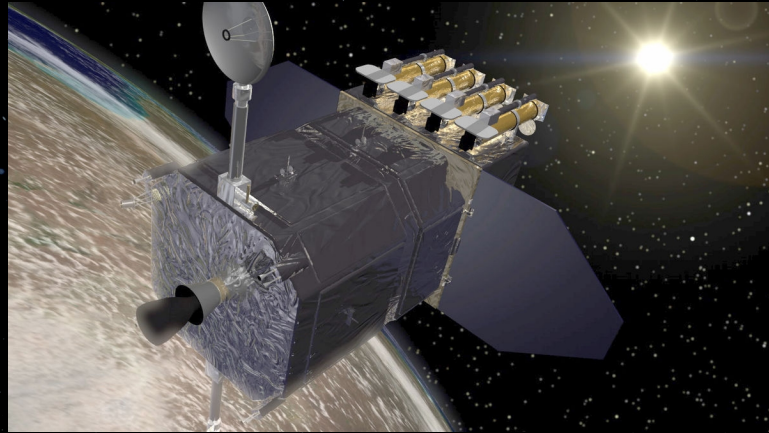
Integrate surface flux transport model with differential rotation, meridional flows, diffusion, and flux sources using high-order numerical schemes and CPU/GPU parallelism over multiple realizations





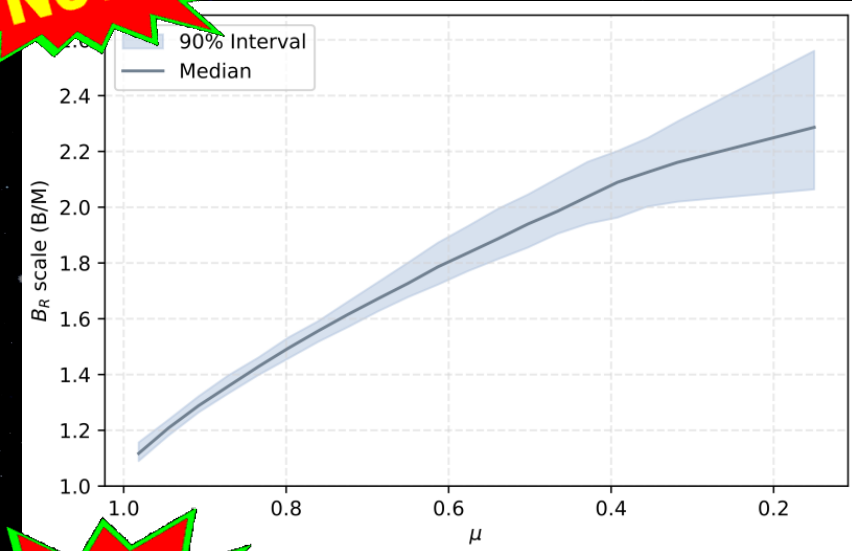
Synchronic Magnetic Maps: Data Acquisition and Mapping

SDO HMI LOS+Vector Magnetograms



- HMI vector data better captures strong field characteristics but has low signal-to-noise in weak fields (quiet Sun)
- We combine LOS data with vector data using quality mask
- Differences in magnitudes require scaling LOS data – done by analyzing data from center to limb

New!



Solo PHI Magnetograms

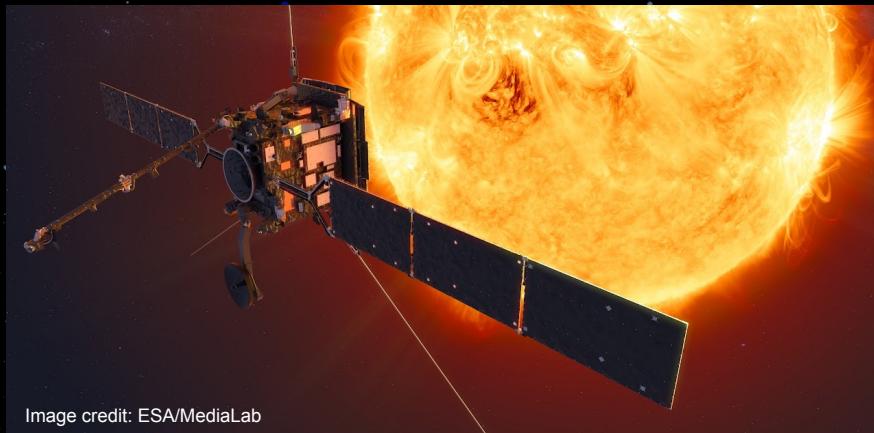
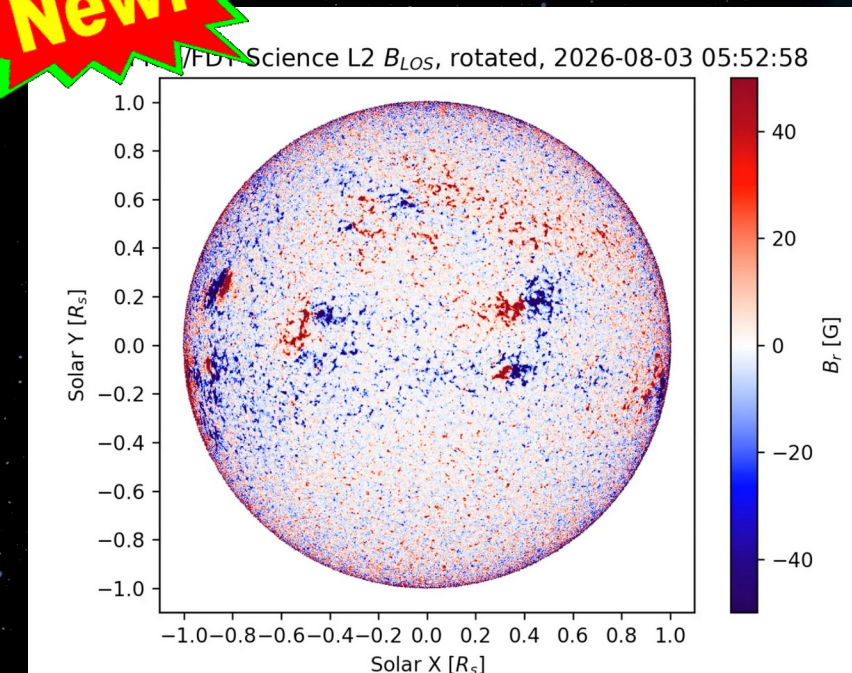


Image credit: ESA/MediaLab

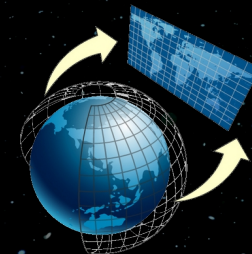
- Solar Orbiter allows us to use far-side magnetic field data
- Low-latency PHI data is available, but we require science quality data – was rushed to us by the PHI team at a 2-day cadence
- Since data is a single snapshot and would be assimilated non-smoothly, it is spread over 10 hours through running HipFT on the snapshot

New!



MagMAP

[github.com/
predsci/magmap](https://github.com/predsci/magmap)

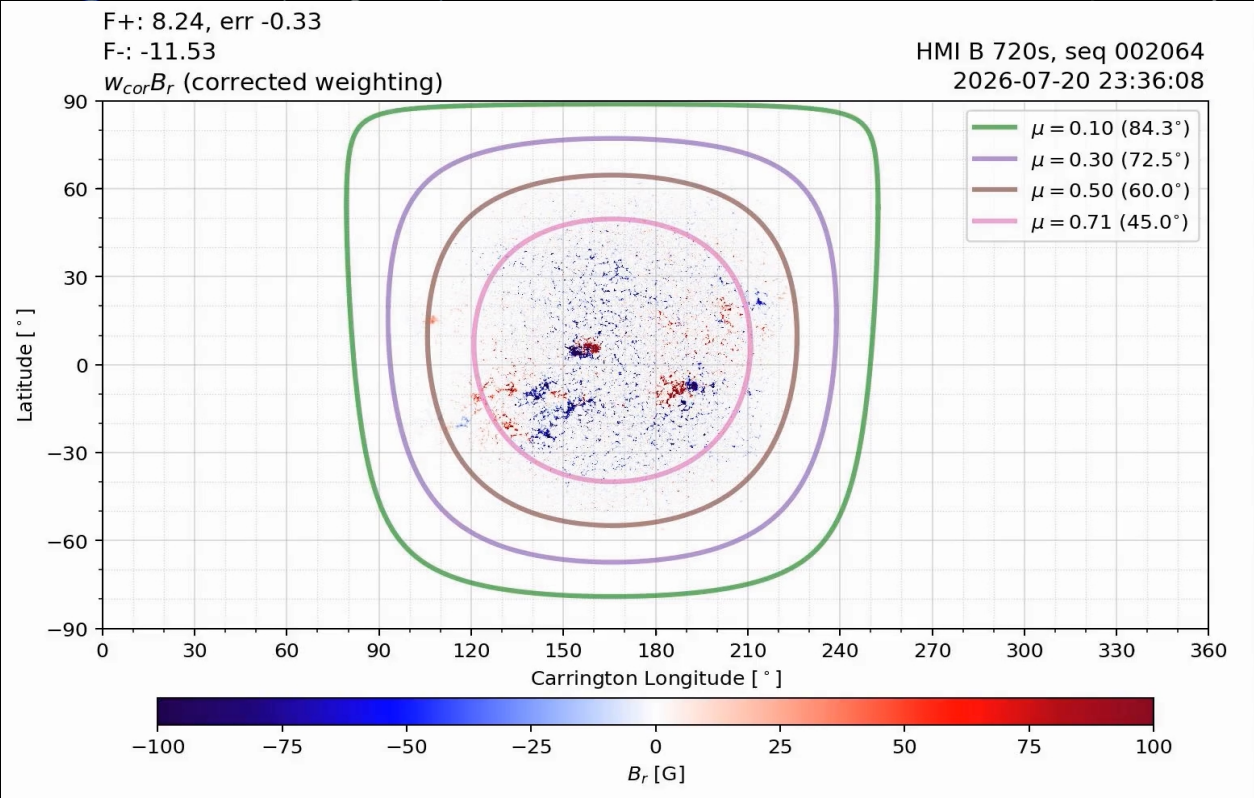


eclipse.predsci.com



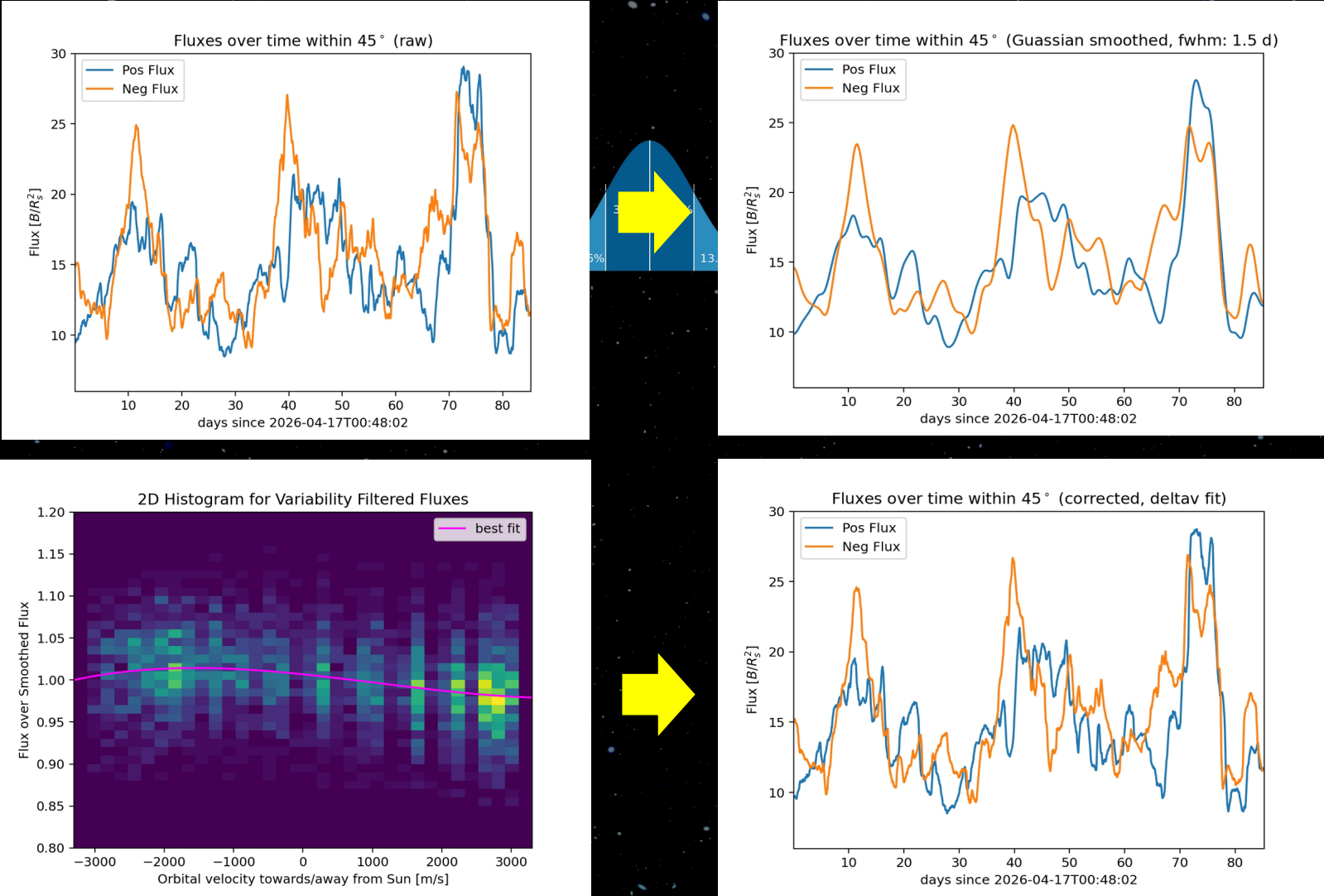
Synchronic Magnetic Maps: Data Assimilation

- Data and weights stored in a sequence of indexed files ready for use in the SFT model
- Left-right ramping of weights to smoothly ingest active regions



$$\mu = \cos \theta_d \in [0, 1]$$

- HMI data had orbital variations that can cause “fake” dynamics in the MHD run
- We reduce it using an empirical, data-driven approach based on the last 3 months of data





Synchronic Magnetic Maps: SFT Model cont.



[github.com/
predsci/hipft](https://github.com/predsci/hipft)

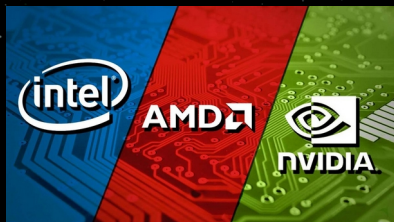
$$\frac{\partial B_r}{\partial t} = -\nabla_s \cdot (B_r \mathbf{v}) + \nabla_s \cdot (\nu \nabla_s B_r) + S,$$

- Surface Flows
 - Differential rotation and meridional flows
 - Flow attenuation
 - Super-granular convective flows (ConFlow)



[github.com/
predsci/conflow](https://github.com/predsci/conflow)

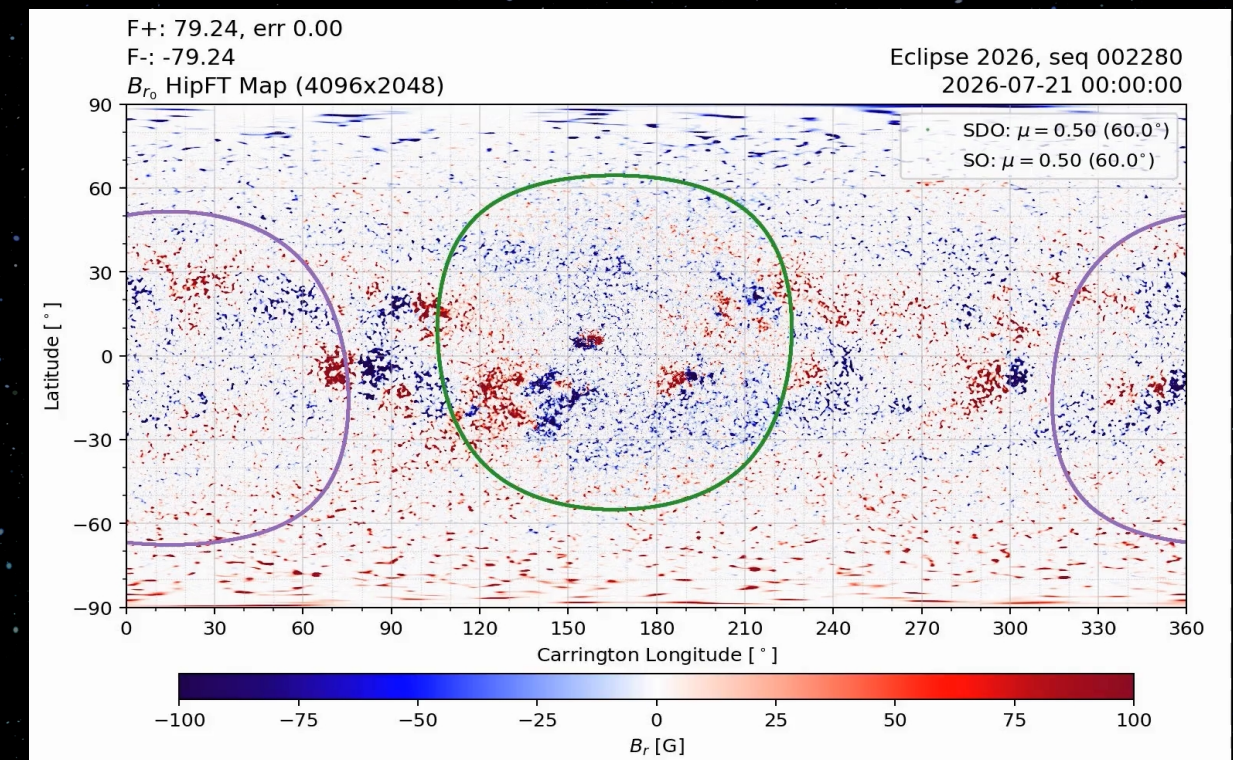
- Diffusion
- Random Flux Emergence (tuned for current time period and model resolution)
- Data Assimilation
- Flux Balancing (multiplicative)
- **Fortran 2023**, parallelized for **CPUs** and **GPUs**



- In-house desktop with **Intel ARC B580 GPU** able to run ~10x faster than real-time



- Highest resolution OFT run yet (4096x2048)





Time-Dependent Boundary Conditions: Map Processing

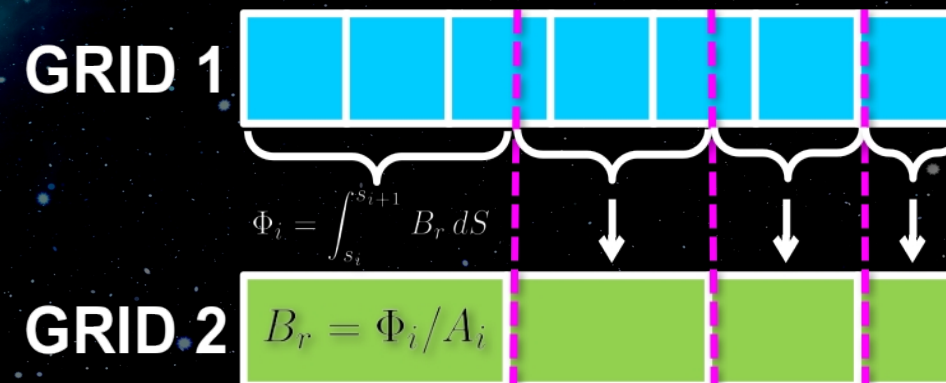
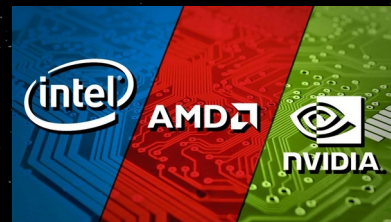
- Flux-preserving integral re-mesh from OFT resolution (4096 x 2048) to MHD resolution (629 x 291)
- Smoothing with surface heat equation:
 - Grid-based diffusivity (resolvability)
 - Very strong fields can strain model, so we smooth such regions locally
 - Generate 3D potential field with POT3D, take radial slice of $|B|$ at 1.05 R_s
 - Diffusivity modified proportional to $|B|$

$$\nu = f_b \nu_{\text{grid}} \quad f_b = 0.5 + 7.5 \frac{|\vec{B}|}{200 \text{ Gauss}}$$

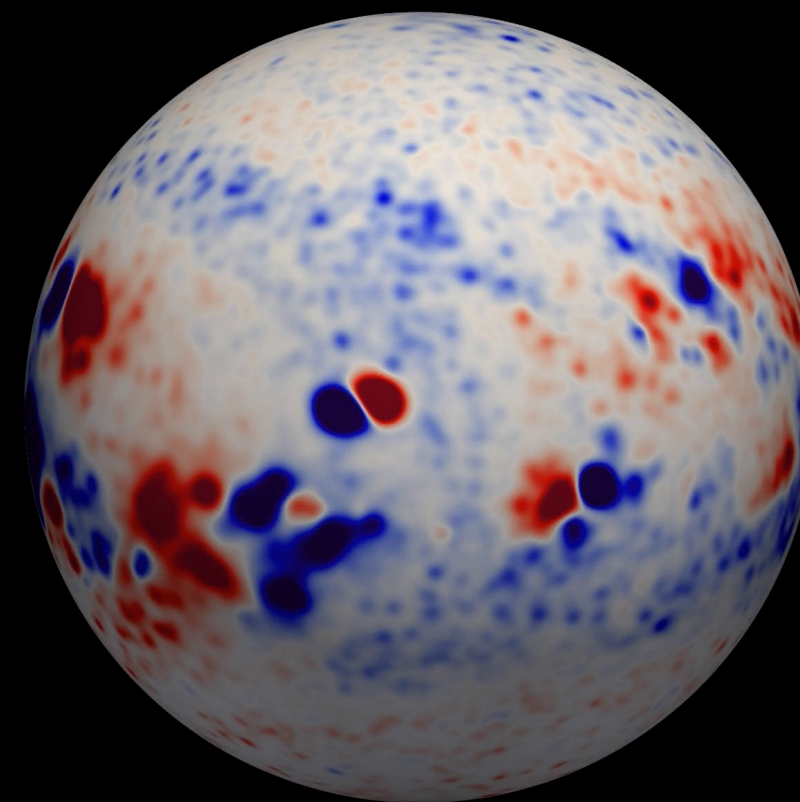
DIFFUSE

POT3D

[github.com/
predsci/pot3d](https://github.com/predsci/pot3d)



Last Data Assimilated:
2026-07-21 00:00:00



Live Prediction, Earth View at Last Assimilation Time

Predictive Science Inc.

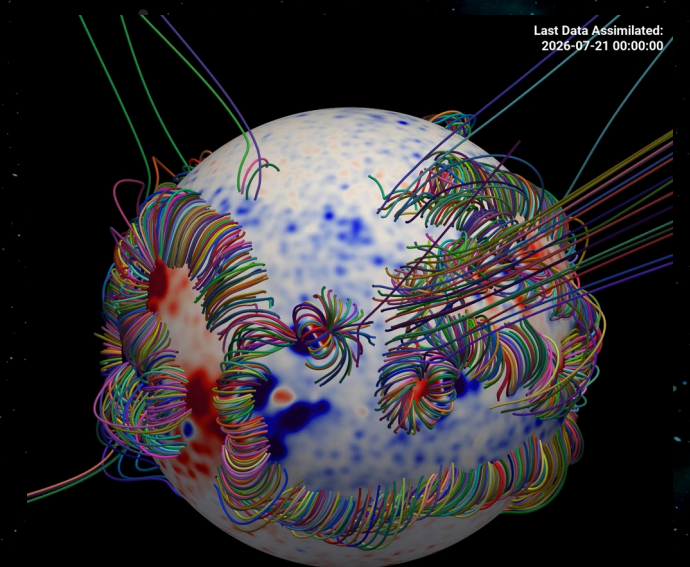
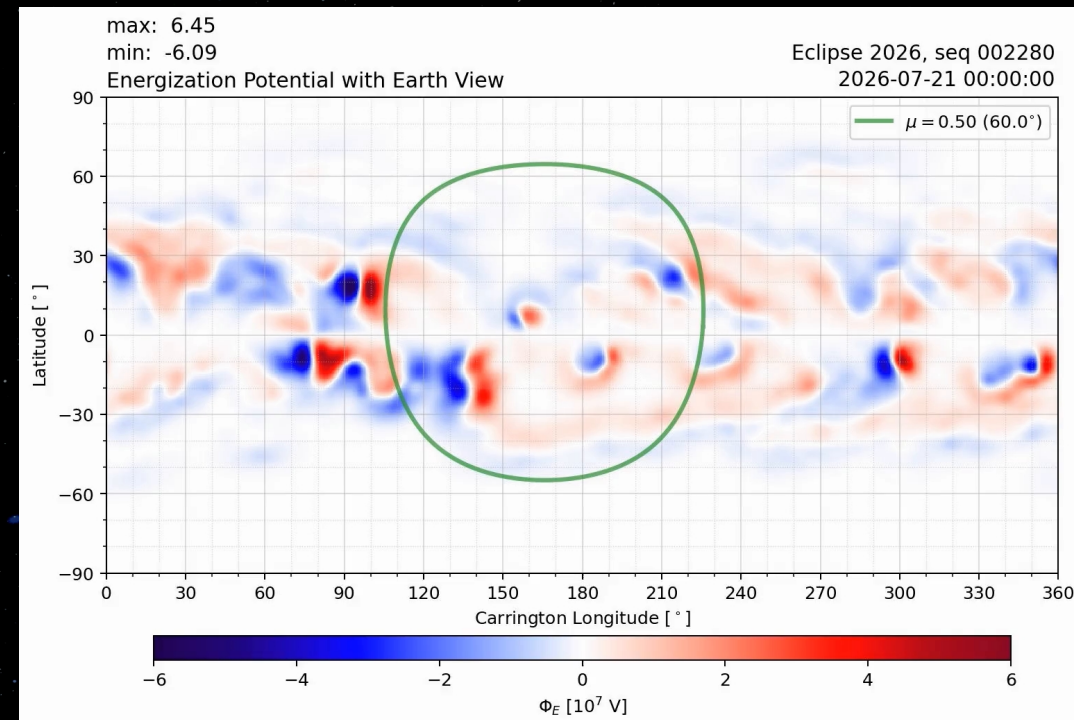
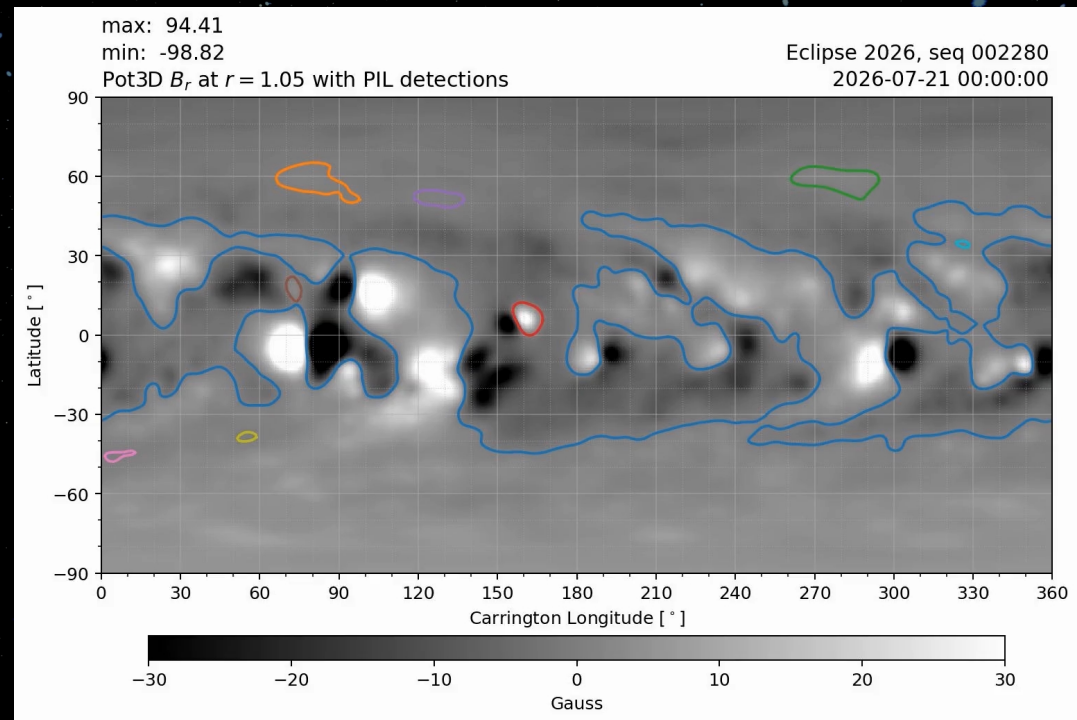
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Time-Dependent Boundary Conditions: Energization

- On the real Sun, not only Br evolves!
- Shear and helicity emerge and energizes the large-scale corona
- Very difficult to match the full vector field and velocities from observations, so instead we statistically emerge shear and helicity
- We use a PFSS solution to detect polarity inversion lines (PiLs) at 1.05 Rs and use them to build an empirical electric potential that emerges shear proportional to the overlying field
- This is combined with the large-scale differential rotation and meridional flows used in OFT to determine the free component of the transverse electric field, energizing the corona
- Details can be found in [Downs et. al. 2025], [Lionello, et. al. 2023], and [Mason, et. al. 2023]

$$c \nabla_t^2 \Phi = -\nabla_t \cdot (\mathbf{v} \times \mathbf{B})_t$$



Live Prediction, Earth View at Last Assimilation Time

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Real-time MHD Simulations: Corona

MAS

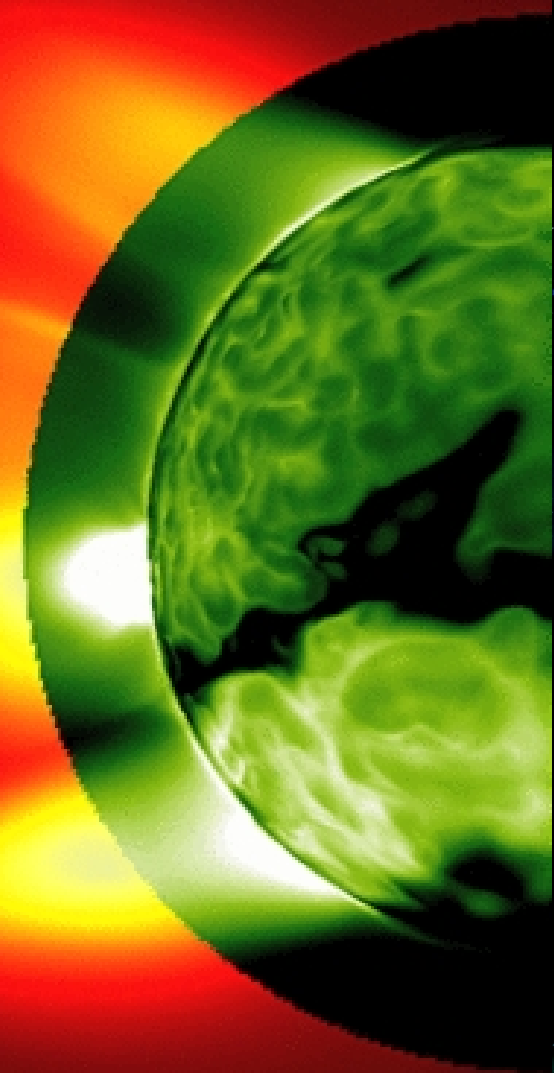
MAGNETOHYDRODYNAMIC
ALGORITHM
OUTSIDE A SPHERE

github.com/predsci/mas

- The MAS model has a long history of use and been developed/improved over 30 years
- Public runs-on-demand provided by NASA's CCMC through CORHEL/CORHEL-CME; open-source on GitHub
- Coronal simulation has resolution of ~60 million cells
- Running faster than real-time on La Palma supercomputer using 120 CPU nodes (5760 cores)



eclipse.predsci.com





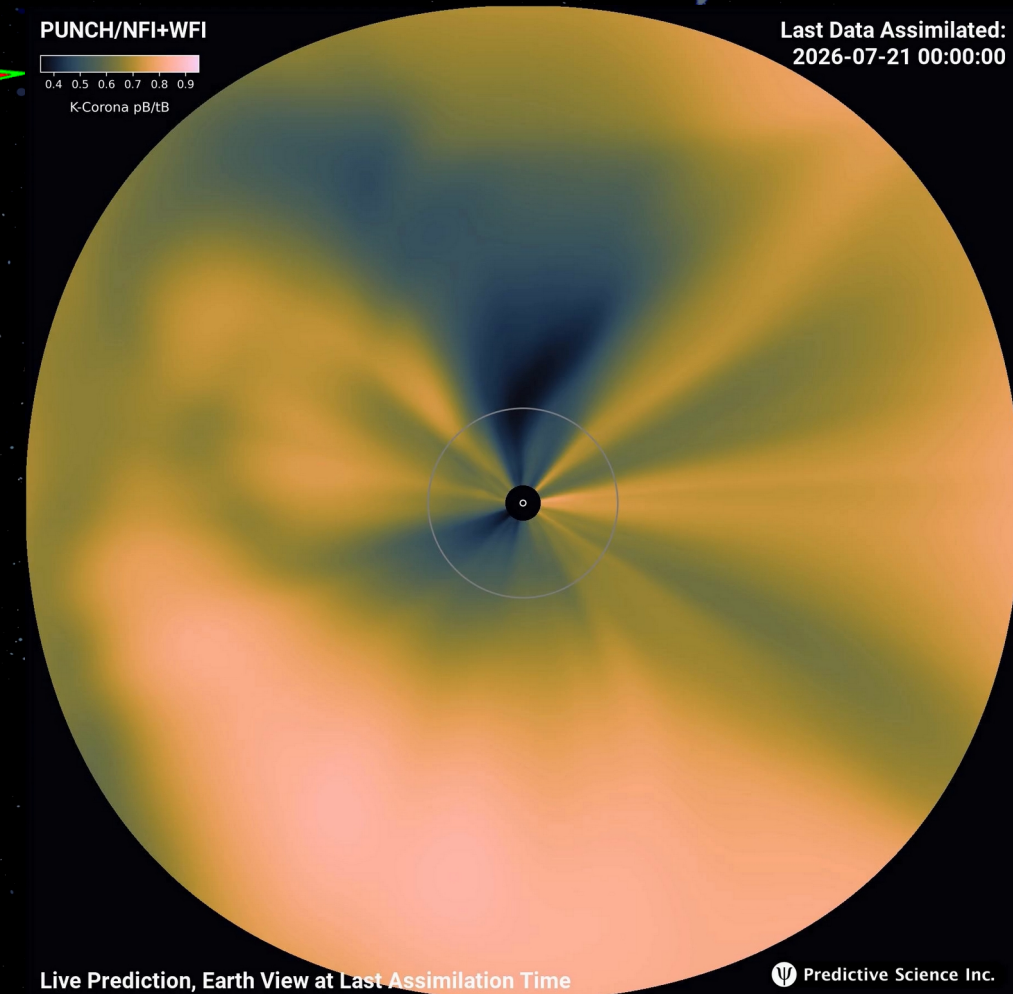
Real-time MHD Simulations: Heliosphere

- MAS can also model the time-dependent heliosphere driven by the outer boundary slices of the coronal simulation
- Much faster than coronal model, allowing higher resolution with less computational resources
- Resolution: ~80 million cells
- Runs ~12x faster than real-time with in-house desktop on a single **NVIDIA A100-80GB GPU**



PUNCH/NFI+WFI
0.4 0.5 0.6 0.7 0.8 0.9
K-Corona pB/tB

Last Data Assimilated:
2026-07-21 00:00:00



Live Prediction, Earth View at Last Assimilation Time

Predictive Science Inc.

MAS MAGNETOHYDRODYNAMIC
ALGORITHM
OUTSIDE A SPHERE

github.com/predsci/mas

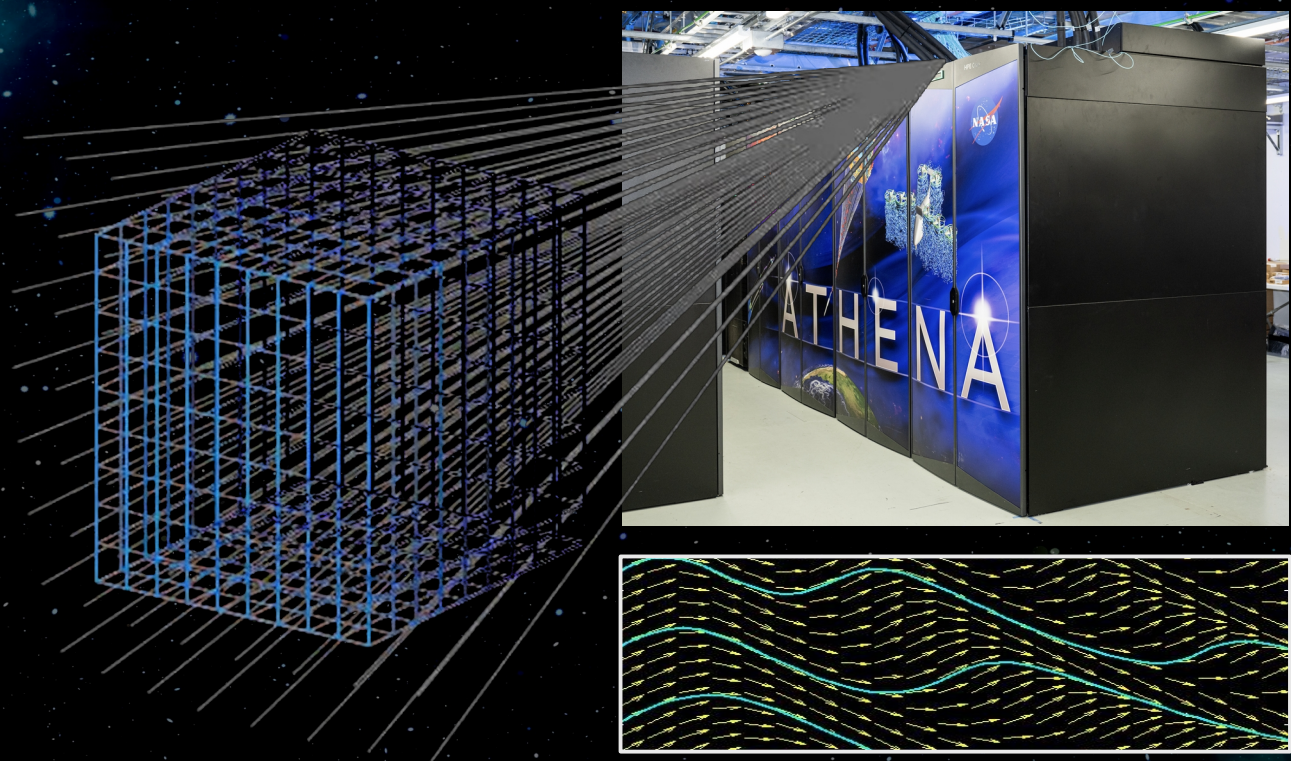


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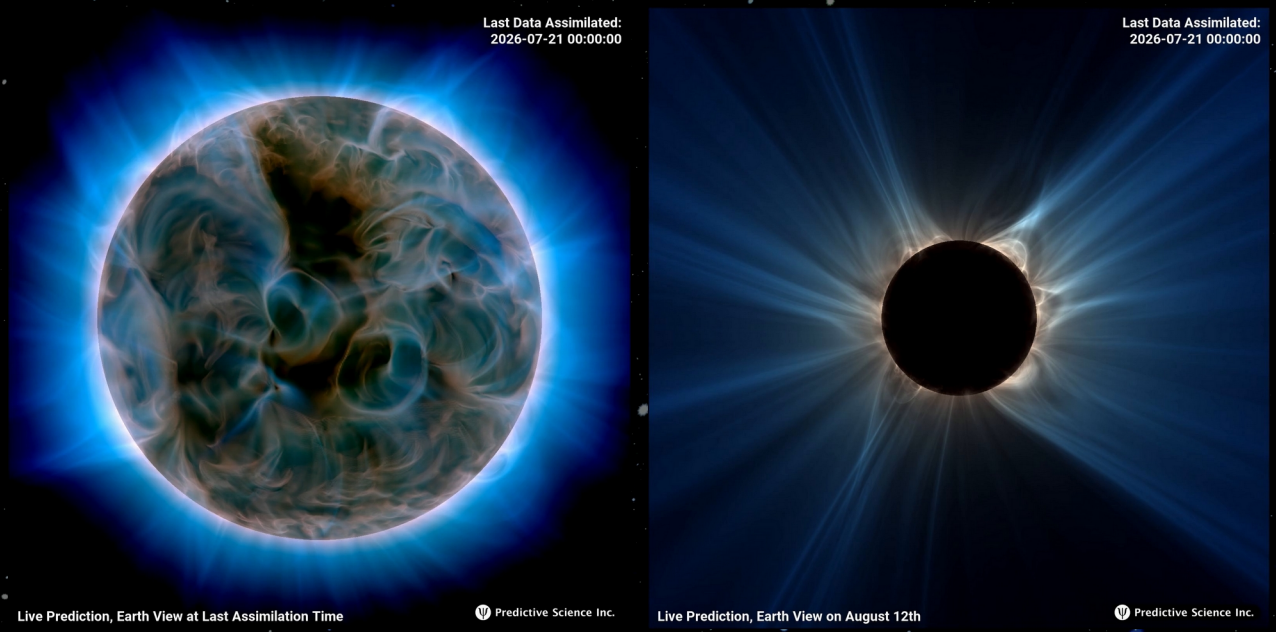


Forward Modeling and Post Processing

- We integrate through simulation 3D output to create synthetic observations comparable to instruments
- Tracing magnetic field lines is used to show spacecraft connectivity and compute structural analysis quantities like volumetric 'squashing factor' (Q)
- Processing performed multi-threaded on a high-end CPU node of the Athena supercomputer at NASA HECC NAS much faster than real-time

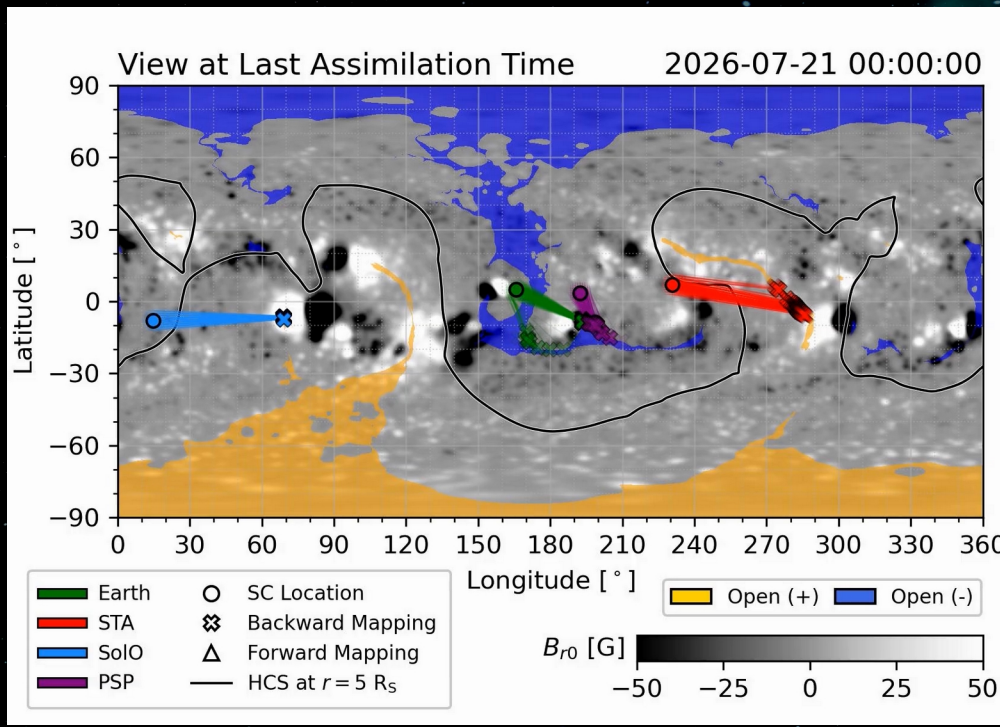
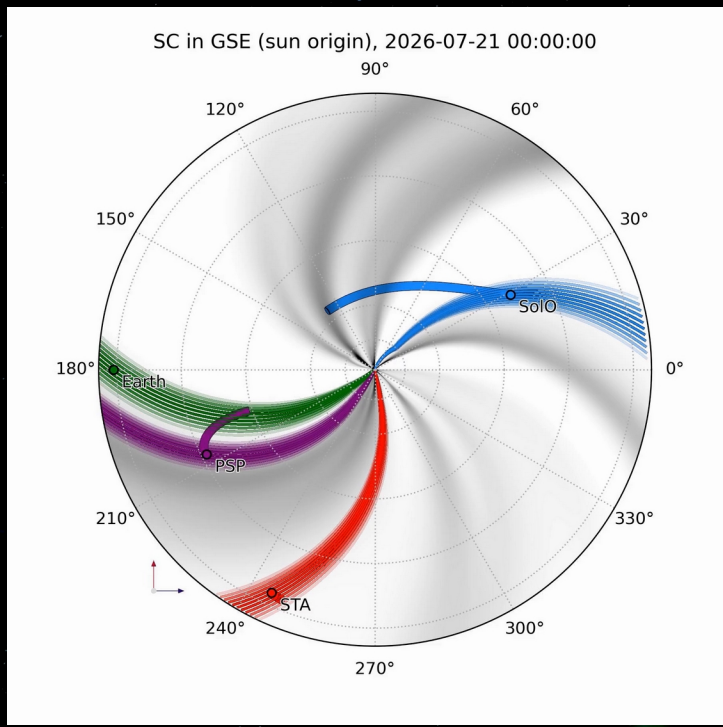


New!



MAFFL

[github.com/
predsci/mapfl](https://github.com/predsci/mapfl)



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New Magnetic Field Visualizations



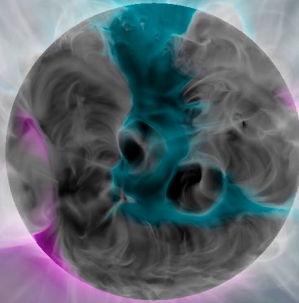
Last Data Assimilated:
2026-07-21 00:00:00



Live Prediction, Earth View at Last Assimilation Time

Predictive Science Inc.

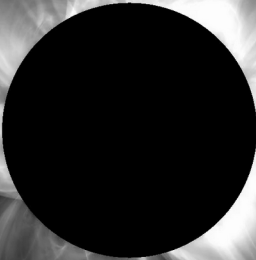
Last Data Assimilated:
2026-07-21 00:00:00



Live Prediction, Earth View at Last Assimilation Time

Predictive Science Inc.

Last Data Assimilated:
2026-07-21 00:00:00



Live Prediction, Earth View on August 12th

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Forward Modeling and Post Processing: Synthetic Observables



SUVI

Last Data Assimilated:
2026-07-21 00:00:00



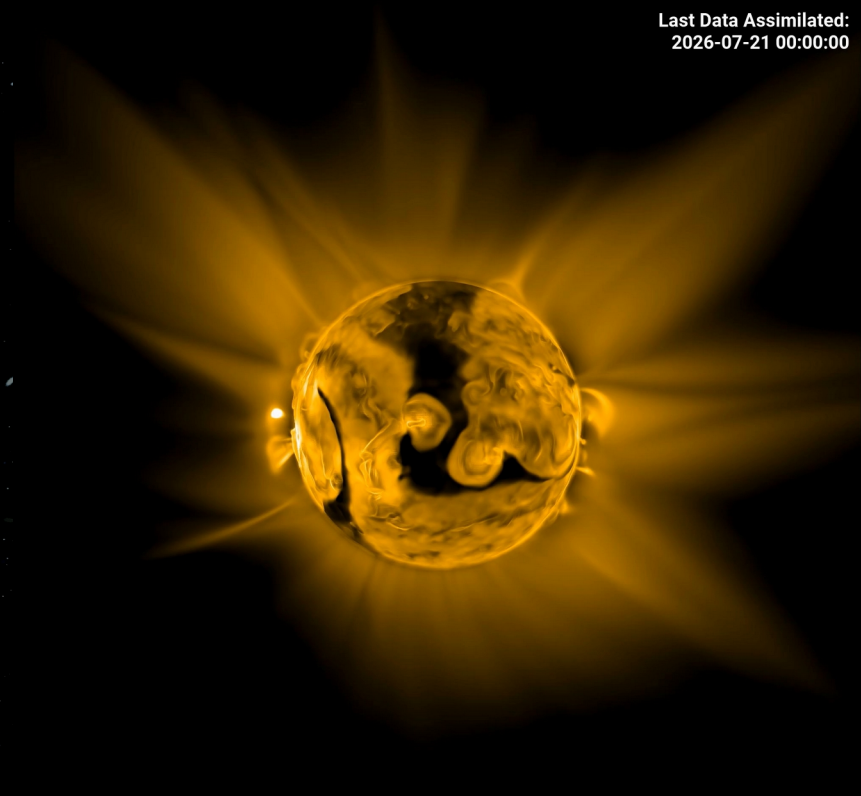
XRT

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2026-07-21 00:00:00



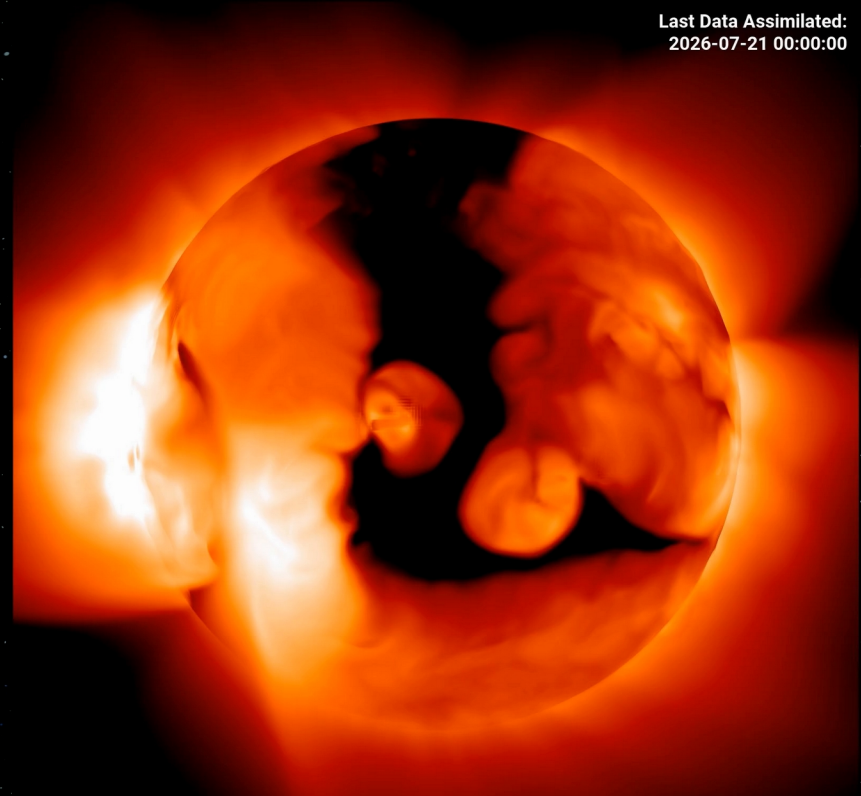
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2026-07-21 00:00:00

Last Data Assimilated:
2026-07-21 00:00:00



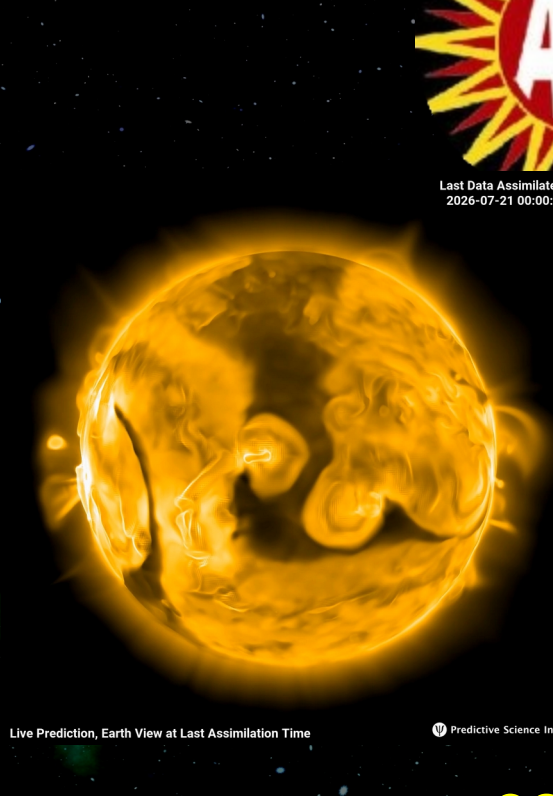
Live Prediction, Earth View at Last Assimilation Time

Predictive Science Inc.



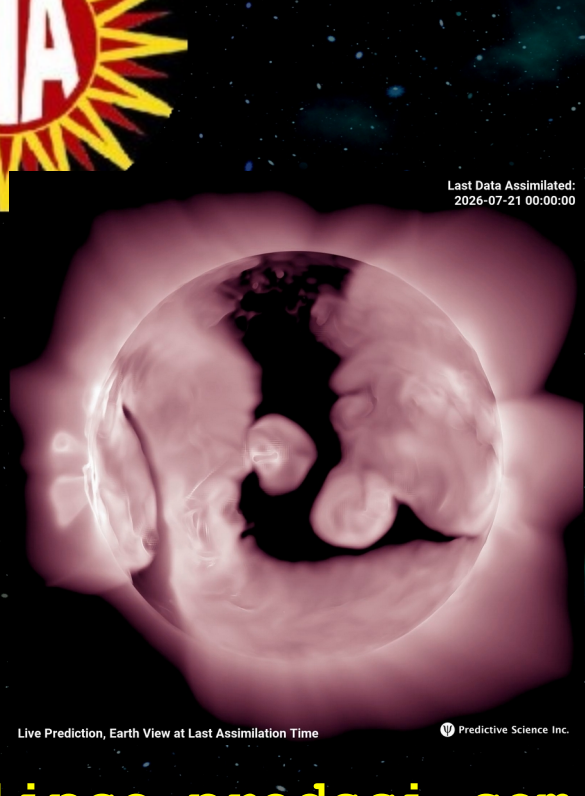
Live Prediction, Earth View at Last Assimilation Time

Predictive Science Inc.



Live Prediction, Earth View at Last Assimilation Time

Predictive Science Inc.



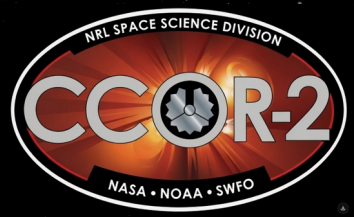
Live Prediction, Earth View at Last Assimilation Time

Predictive Science Inc.

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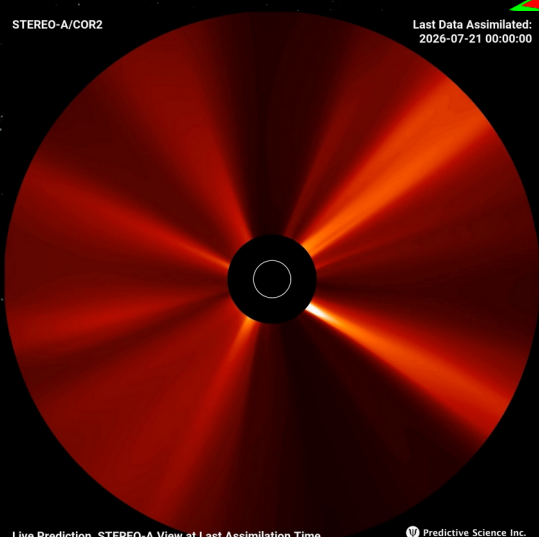
Forward Modeling and Post Processing: Synthetic Observables



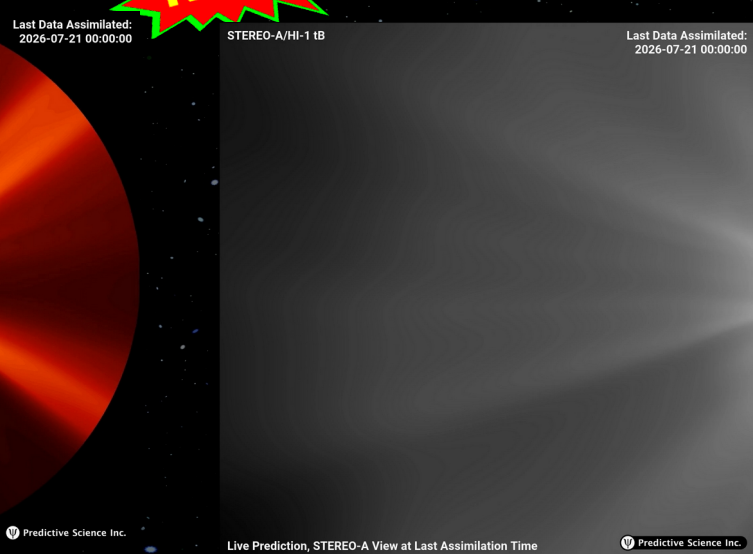
HI-1



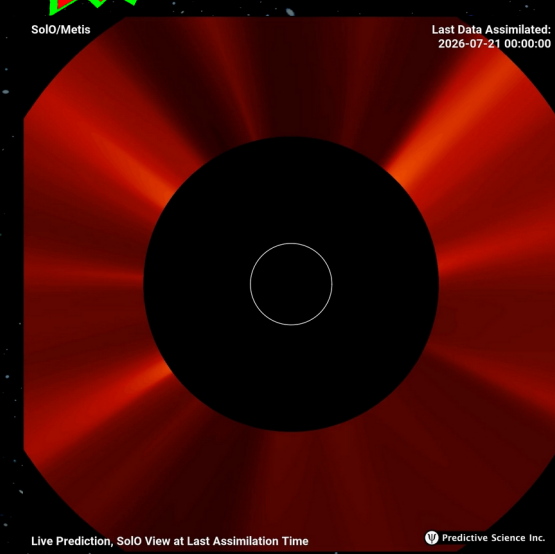
SoloHI



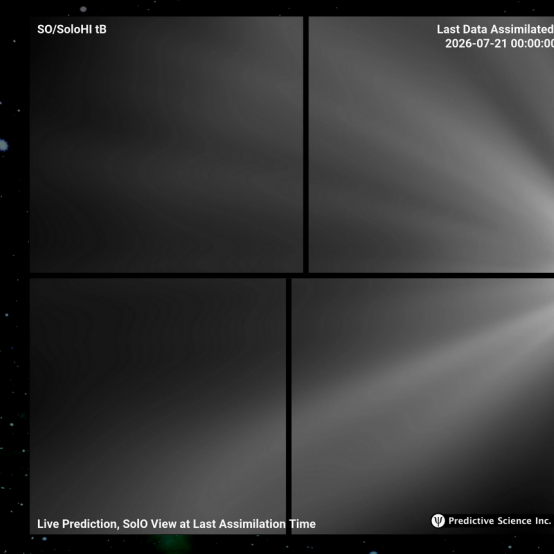
Live Prediction, STEREO-A View at Last Assimilation Time Predictive Science Inc.



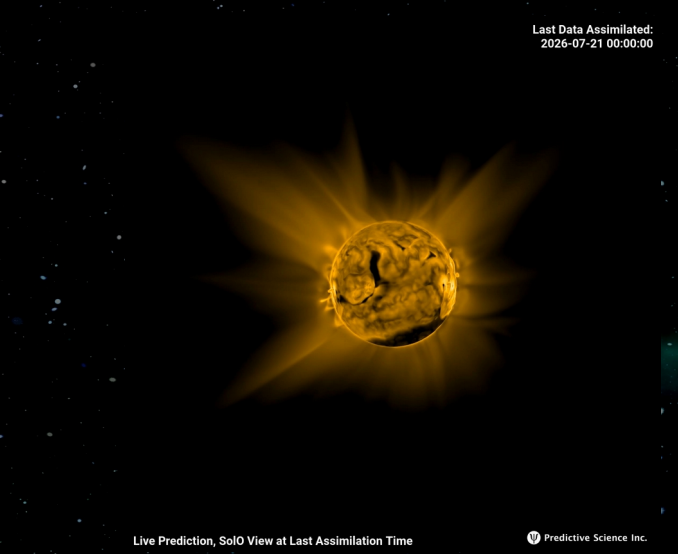
Live Prediction, STEREO-A View at Last Assimilation Time Predictive Science Inc.



Live Prediction, Solo View at Last Assimilation Time Predictive Science Inc.



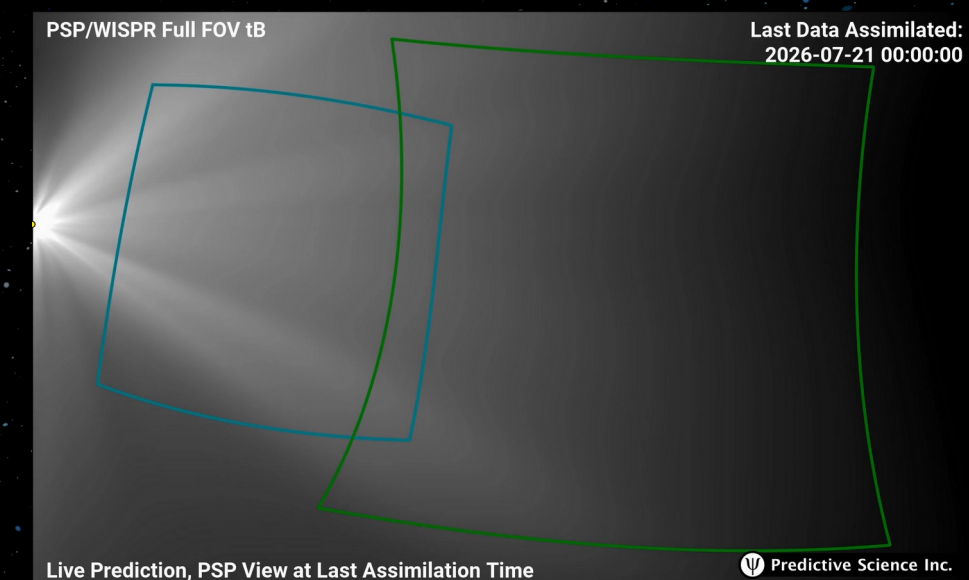
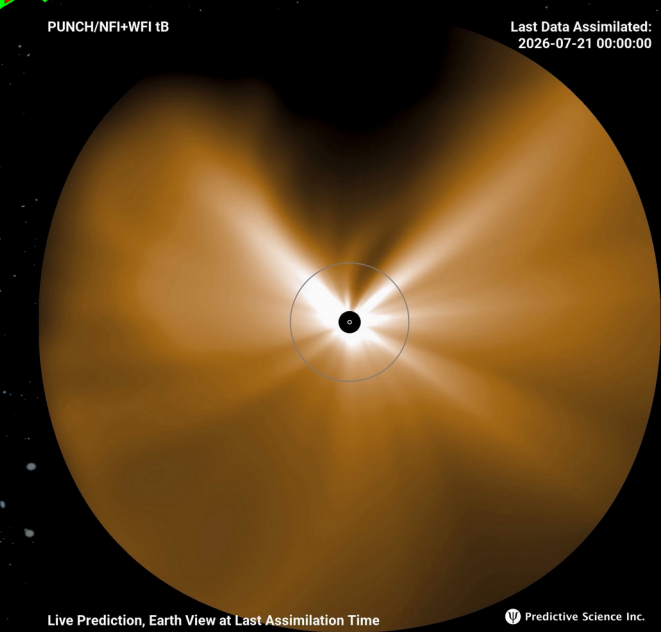
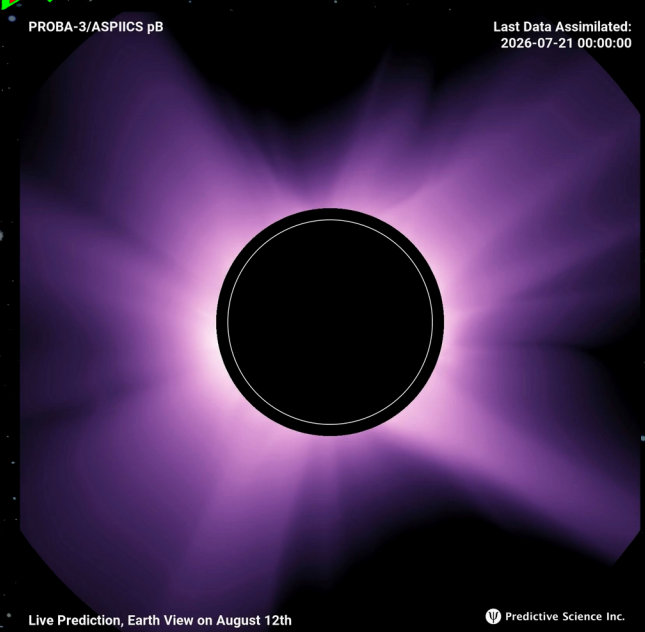
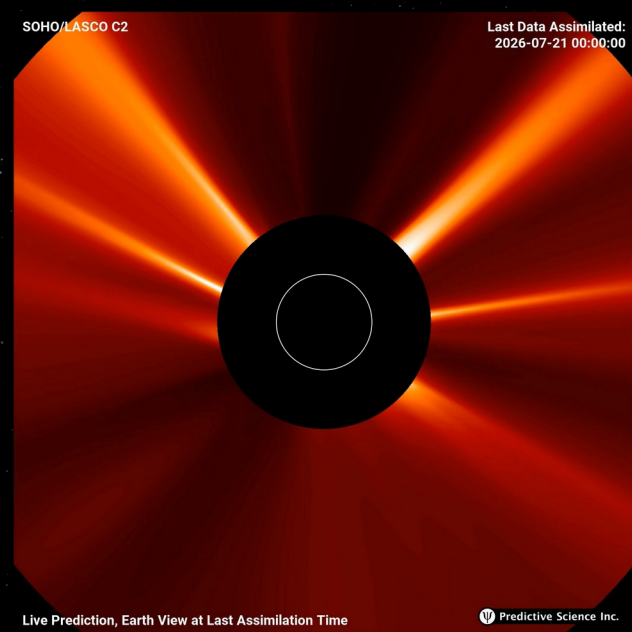
Live Prediction, Solo View at Last Assimilation Time Predictive Science Inc.



Live Prediction, Solo View at Last Assimilation Time Predictive Science Inc.

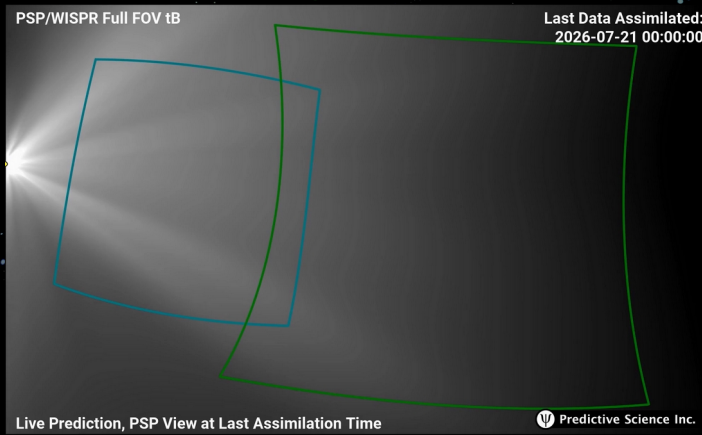
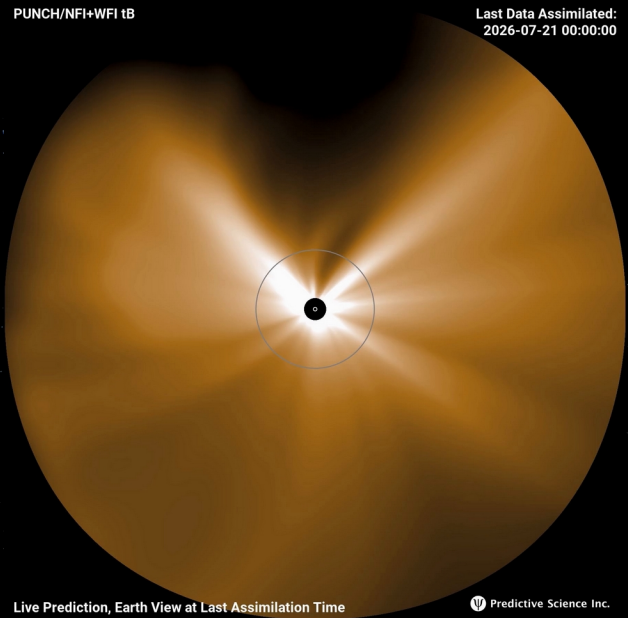


Forward Modeling and Post Processing: Synthetic Observables cont.

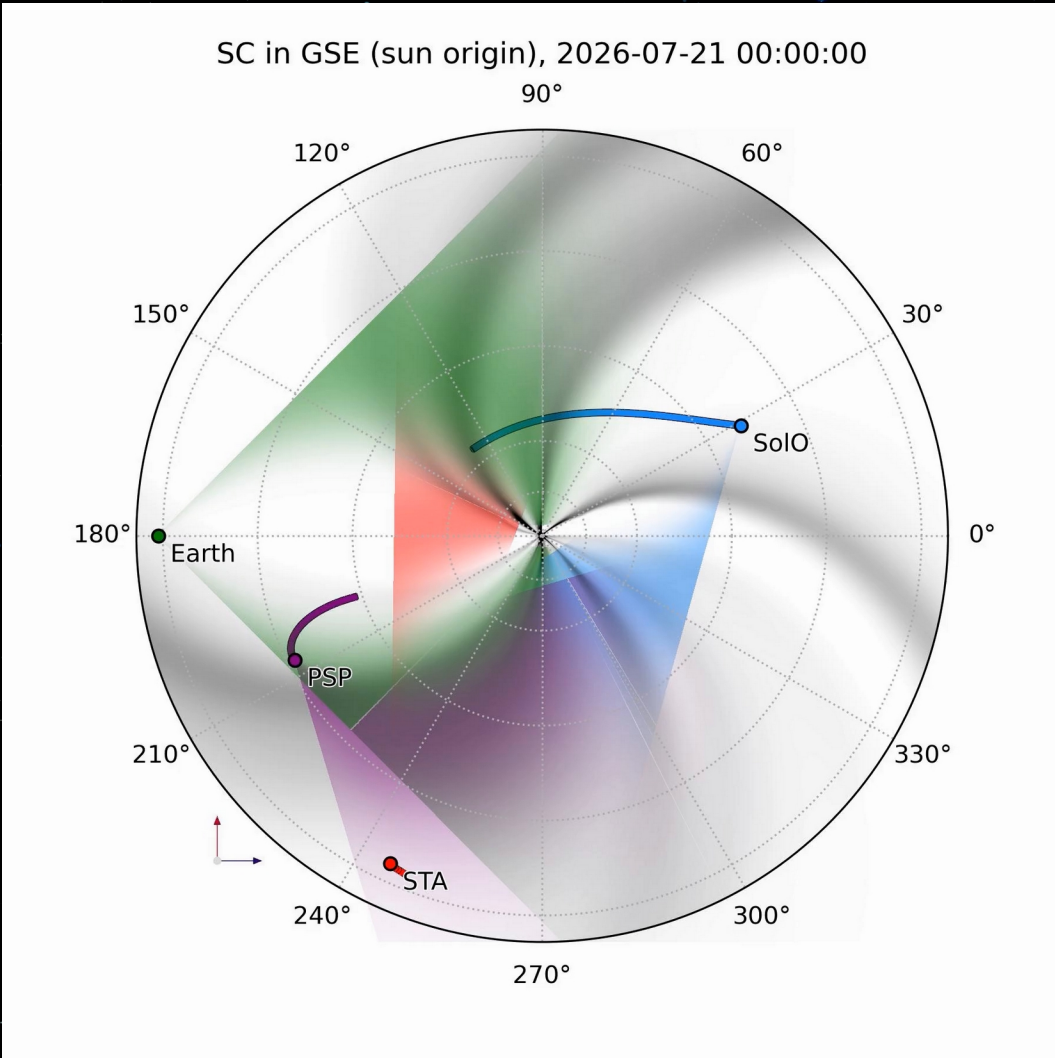




Forward Modeling and Post Processing: Heliospheric Imagers

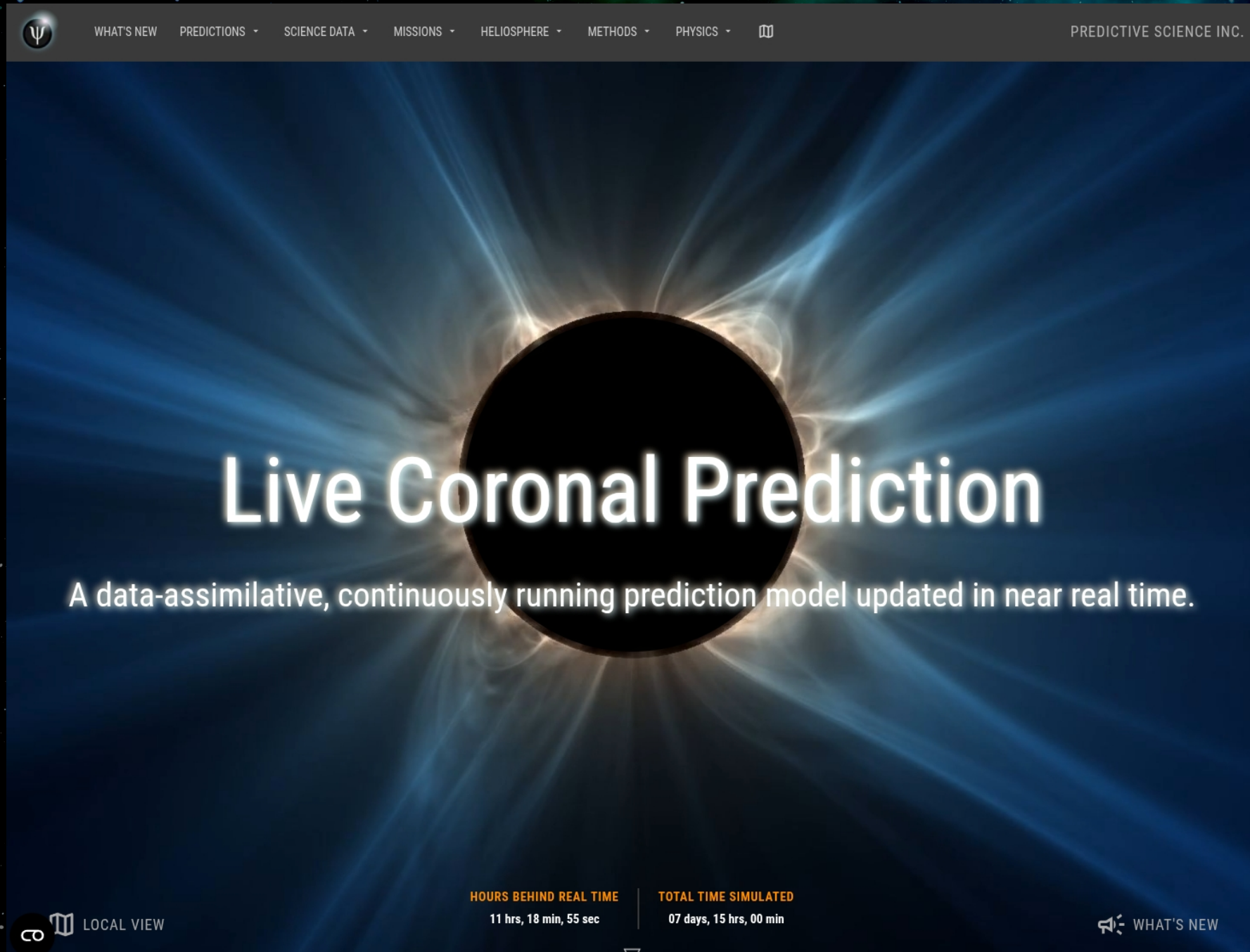


New!





Publishing Results on Live Website



- Results auto-uploaded to server for web site
- Live automatic updates
- AWS redundant mirrors for fast access
- Science data available in fits format



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The PSI 2026 Eclipse Prediction (as of 2026-08-09 10:00:00)

Last Data Assimilated:
2026-08-09 10:00:00

Last Data Assimilated:
2026-08-09 10:00:00



eclipse.preds-ci.com