Coronal and Heliospheric Modeling at Predictive Science Inc.

Data Products, Tools, and Capabilities

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Link to Poster PDF

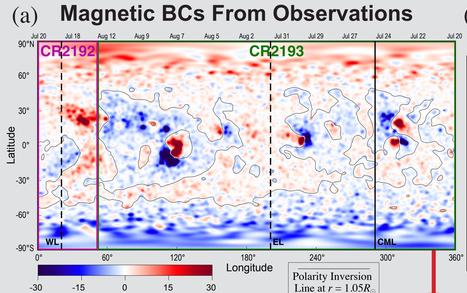
MAS: A 3D Global Thermodynamic MHD model for the CORona and inner HELiosphere.

- With over 30 years of development, the Magnetohydrodynamic Algorithm outside a Sphere (MAS) code is a flexible mode for global coronal and heliospheric modeling.
- By leveraging magnetic field observations and low-coronal energy transport terms, MAS can be used to study the corona and inner heliosphere at a given time of interest.

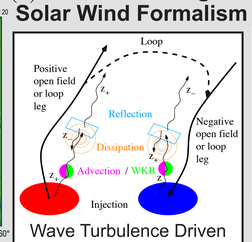
KEY INPUTS a-b

EXAMPLE OUTPUTS c-g

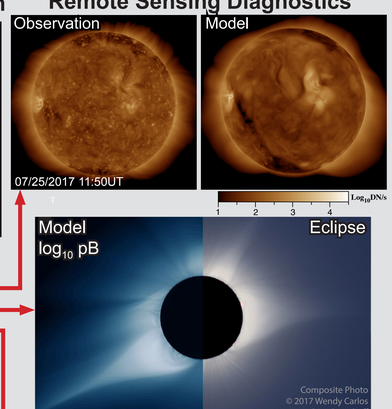
(a) Magnetic BCs From Observations



(b) Coronal Heating / Solar Wind Formalism

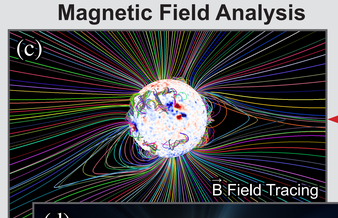


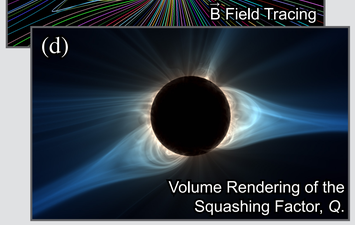
(e) Forward Modeling / Remote Sensing Diagnostics



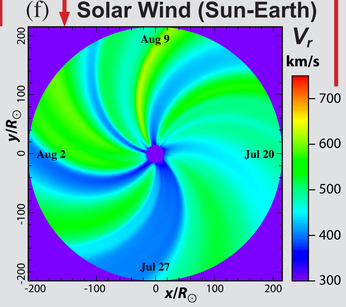
MAS

(c) Magnetic Field Analysis

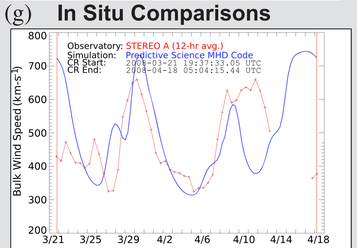




(f) Solar Wind (Sun-Earth)



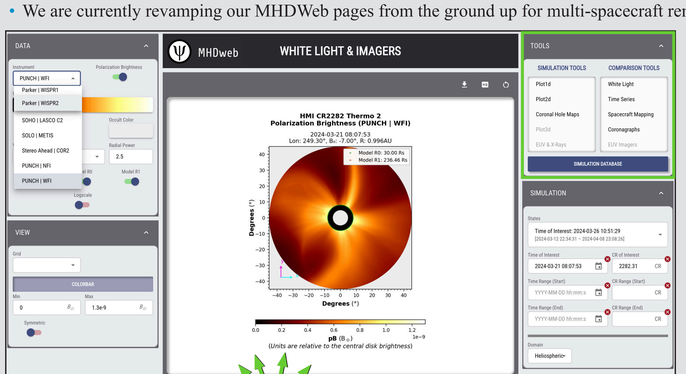
(g) In Situ Comparisons



Details, equations and references at predsci.com/mas

MHDWeb: A Database of Coronal and Heliospheric Models Spanning Multiple Solar Cycles

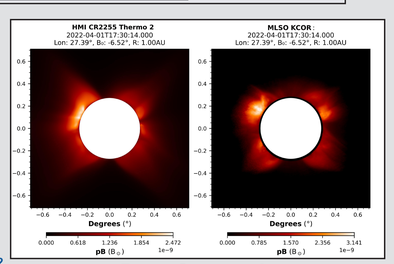
- In an effort to make our models more broadly useful to the community, we routinely run MAS/CORHEL MHD models for every Carrington rotation.
- Our current database spans the SOHO and SDO eras (1996-Present) and includes over a thousand distinct coronal and heliospheric calculations.
- For every permutation of model type (coronal, helio, polytropic, thermodynamic) we have built web interfaces for browsing and interacting with model results.
- These models can provide useful context for observational data analysis as well as for forward modeling synthetic observations.
- We are currently revamping our MHDWeb pages from the ground up for multi-spacecraft remote sensing and in situ data analysis, including PUNCH!



Interactive Tool Pages for Multi Spacecraft Analysis

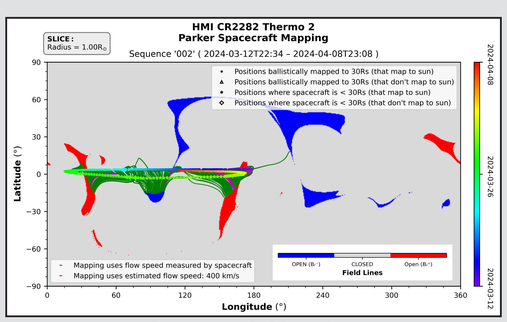
Original MHDWeb (Classic Interface) www.predsci.com/mhdweb

NEW MHDWeb (beta) (Modern Interactivity) www.predsci.com/mhdweb2



Data Comparisons

Flexible Filters for Model Database



Spacecraft Mapping

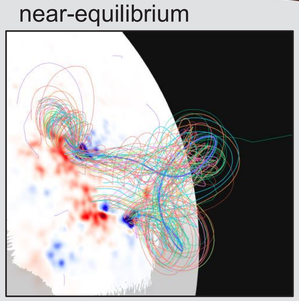
CORHEL-CME: An interface for modeling solar eruptions from 1Rs to 1AU.

- Bulding MHD models of observed CMEs is traditionally a very involved task, requiring one to model the energized pre-eruptive state, onset, and ensuing evolution.
- Over the years we have developed a host of flux-rope models and gained experience with insertion and eruption techinques to facilitate this process in MAS.
- We have distilled these ideas into a high-level interface for the community, CORHEL-CME, which allows one to easily buld eruptive configurations for any case.
- The interface is **LIVE** at the NASA Community Coordinated Modeling Center (CCMC), with Runs on Request launched on NASA AWS GPU Cloud Infrastructure.

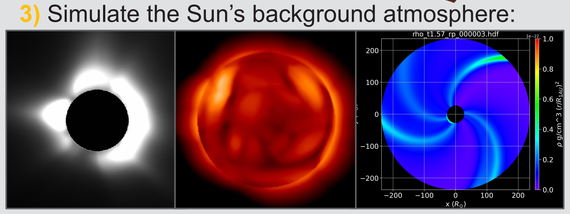
A Recipe for CMEs

1) Get the Sun's surface magnetic field from satellite observations:

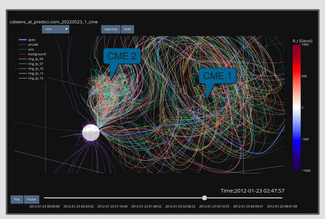
2) Design twisted magnetic rope(s) near-equilibrium



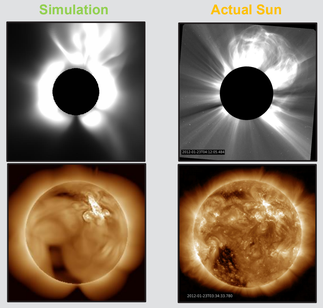
3) Simulate the Sun's background atmosphere:



4) Insert the rope(s) and run a simulation to make them erupt and travel to Earth!

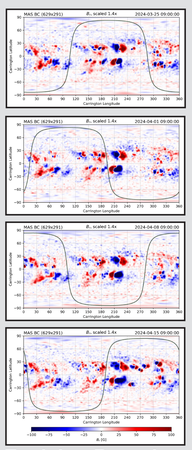


Simulation | Actual Sun



New Frontier: A Data Driven Time-Evolving Global Corona and Heliosphere

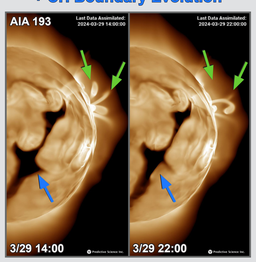
- We recently developed the capability to drive MAS with maps from data-assimilative surface flux-transport models (e.g. HipFT).
- This allows one to capture the dynamic response of the corona and heliosphere to surface evolution and helicity injection.
- As a demonstration, we ran a continuous "Live Prediction" model for the April 8th 2024 eclipse, spanning 32.7 days of evolution.
- A variety of time-dependent dynamics are captured in the driven model that are not present in steady state calculations.
- Many of these processes (connectivity changes, streamer blobs, CMEs etc.) are relevant to white-light tructures seen by PUNCH.



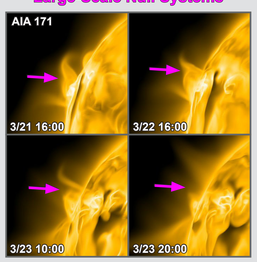
Evolving Boundary

For details see predsci.com/eclipse2024

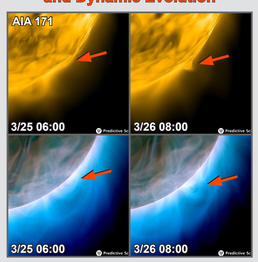
a) Thermal Non-Equilibrium + CH Boundary Evolution



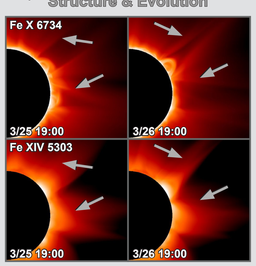
b) Cool Plasma Dynamics at Large-Scale Null Systems



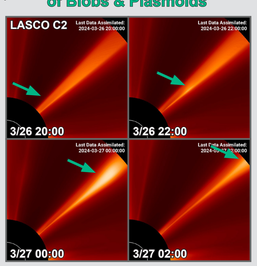
c) Filament Channel Activation and Dynamic Evolution



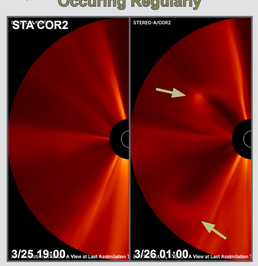
d) Multi-Thermal Streamer Structure & Evolution



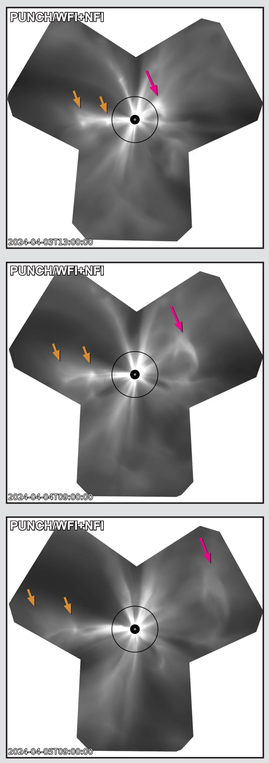
e) Streamer Collapse, Formation of Blobs & Plasmoids



f) Coronal Mass Ejections Occuring Regularly



Coronal Dynamics



Heliospheric Dynamics