

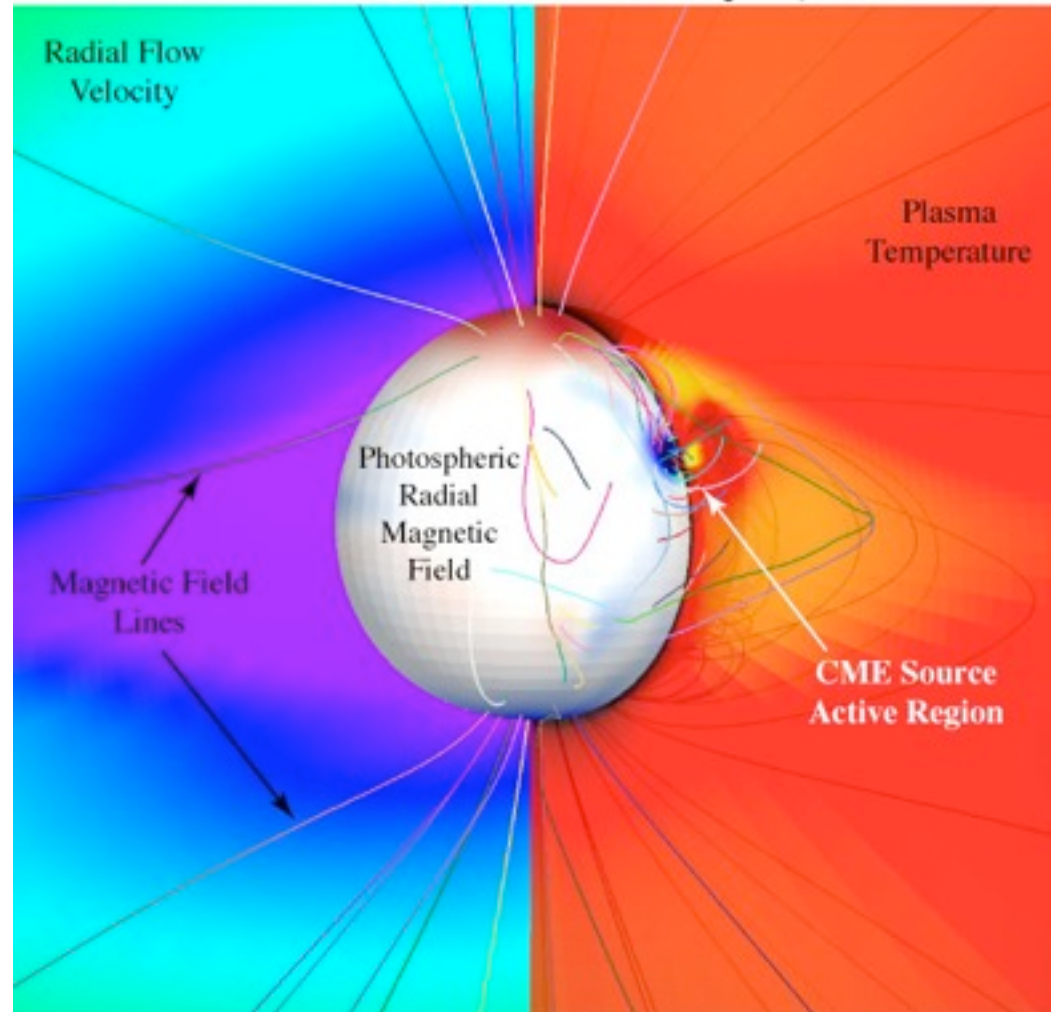
Using LOS Magnetograms in Global Heliospheric MHD Models

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Structure of the Corona on May 12, 1997



Some Acronyms:

- **MAS:** Magnetohydrodynamics Around a Sphere (The PSI coronal MHD code)
- **Enlil:** God of Wind (NOAA/SEC Heliospheric code)
- **CORHEL:** CORona and HELiosphere (Coupled MAS, WSA, PFSS, PFCS, Enlil, MASIP Package)
- **MASIP:** MAS in the InterPlanetary medium
- **WSA, PFSS, PFCS:** More acronyms. Will it ever end?

A better acronym of “ADAPT”

- ADAPT: Air Force data Assimilation for Photospheric Flux Transport
- AFART: Air Force Assimilation of Flux and Transport

The 'old' version of CORHEL (MAS really) relies on a polytropic relationship between pressure and density

$$\nabla \times \mathbf{A} = \mathbf{B},$$

$$\frac{\partial \mathbf{A}}{\partial t} = \mathbf{v} \times \mathbf{B} - \frac{c^2 \eta}{4\pi} \nabla \times \mathbf{B},$$

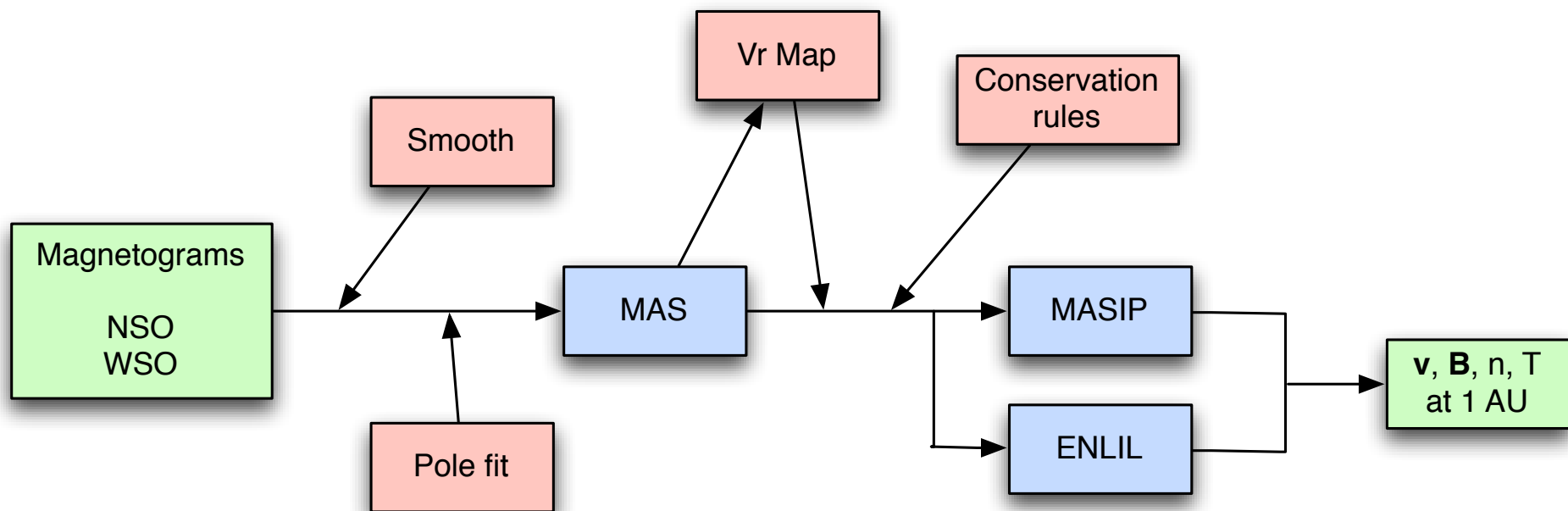
$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0,$$

$$\frac{1}{\gamma - 1} \left(\frac{\partial T}{\partial t} + \mathbf{v} \cdot \nabla T \right) = -T \nabla \cdot \mathbf{v},$$

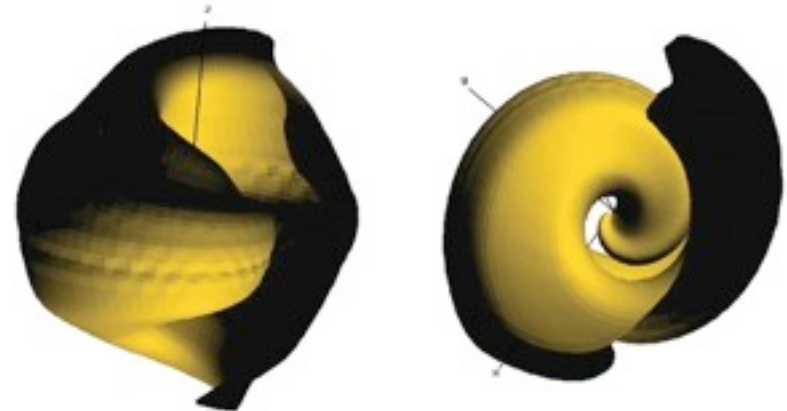
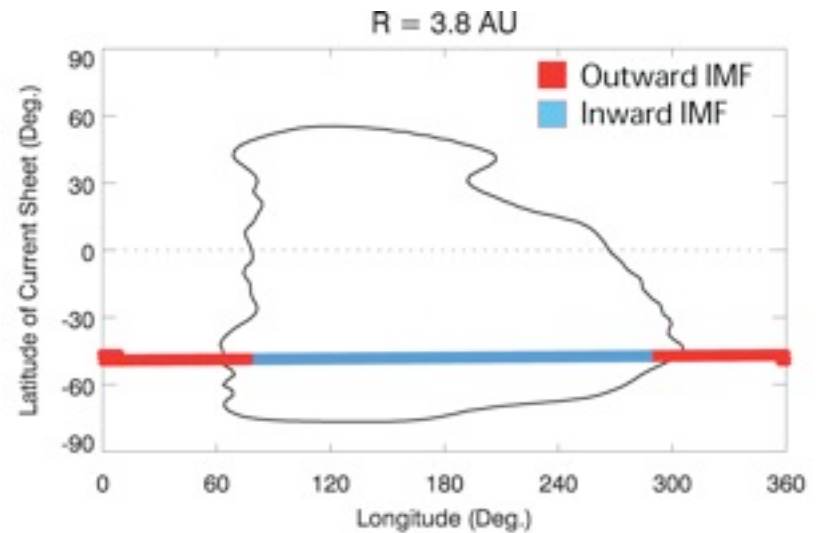
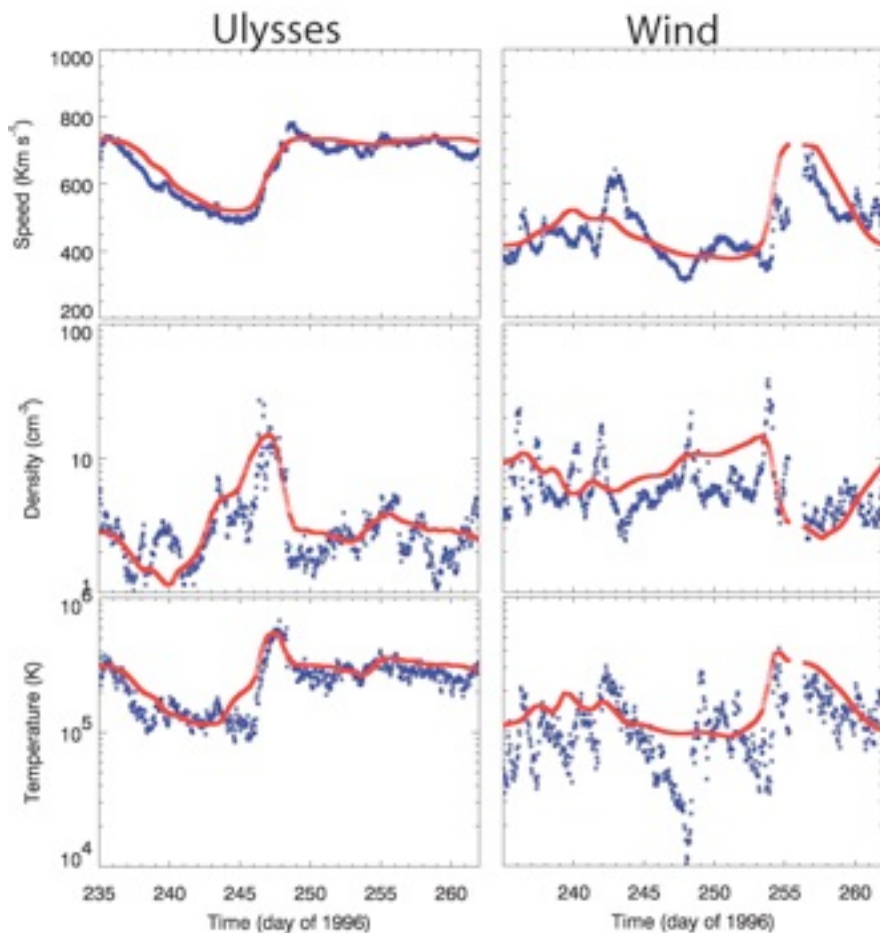
$$\rho \left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} \right) = \frac{\nabla \times \mathbf{B} \times \mathbf{B}}{4\pi} - \nabla p + \rho \mathbf{g} + \nabla \cdot (\nu \rho \nabla \mathbf{v}),$$

$$\gamma = 1.05.$$

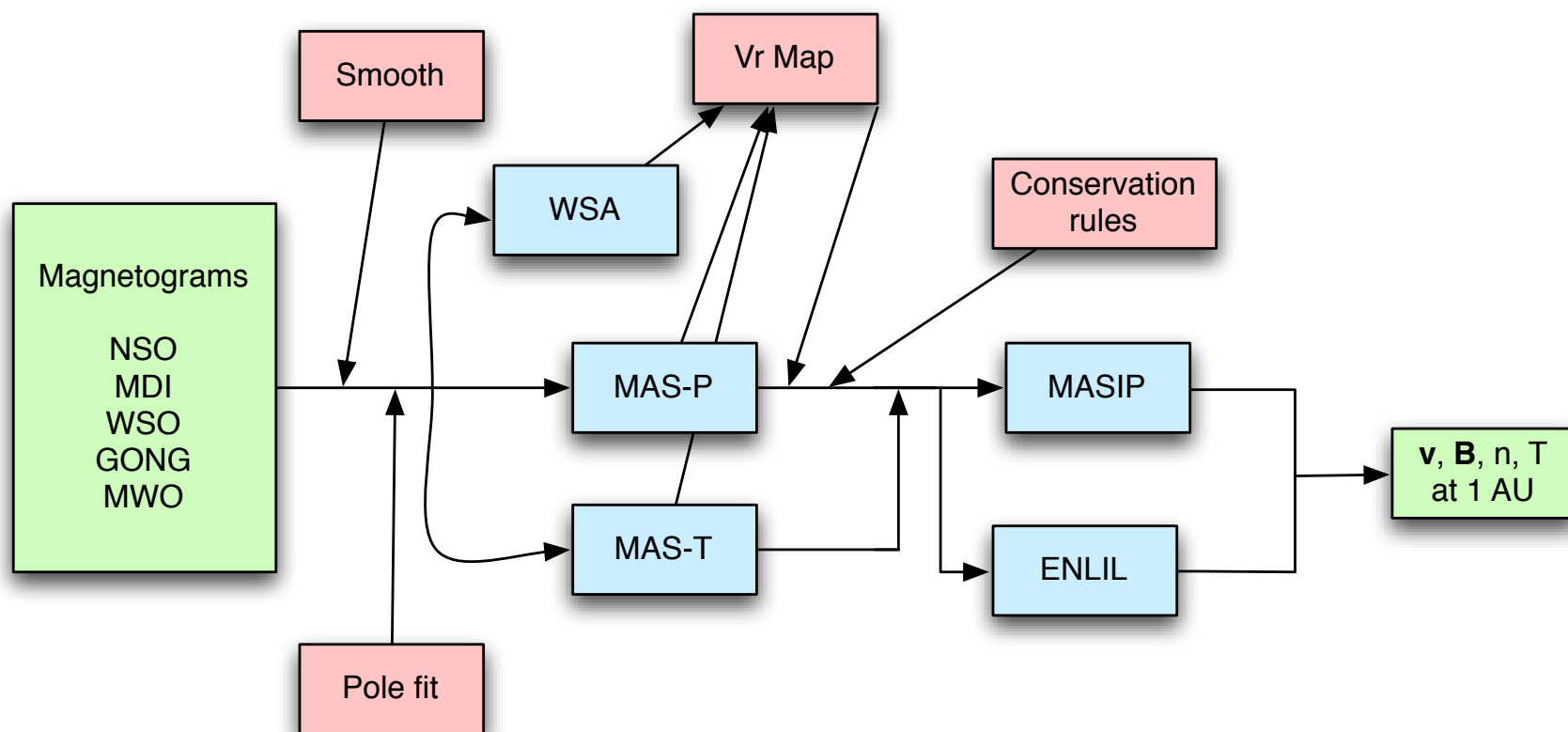
CORHEL 3.5/4.0



Comparisons with in situ data demonstrate that the model can reproduce essential observations



Improvements to CORHEL currently under Development



The latest version of MAS includes energy transport processes

$$\nabla \times \mathbf{B} = \frac{4\pi}{c} \mathbf{J}$$

$$\nabla \times \mathbf{E} = -\frac{1}{c} \frac{\partial \mathbf{B}}{\partial t}$$

$$\mathbf{E} + \frac{1}{c} \mathbf{v} \times \mathbf{B} = \eta \mathbf{J}$$

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0$$

$$\rho \left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} \right) = \frac{1}{c} \mathbf{J} \times \mathbf{B} - \nabla p - \nabla p_w + \rho \mathbf{g} + \nabla \cdot (\nu \rho \nabla \mathbf{v})$$

$$\frac{\partial p}{\partial t} + \nabla \cdot (p \mathbf{v}) = (\gamma - 1) (-p \nabla \cdot \mathbf{v} - \nabla \cdot \mathbf{q} - n_e n_p Q(T) + H)$$

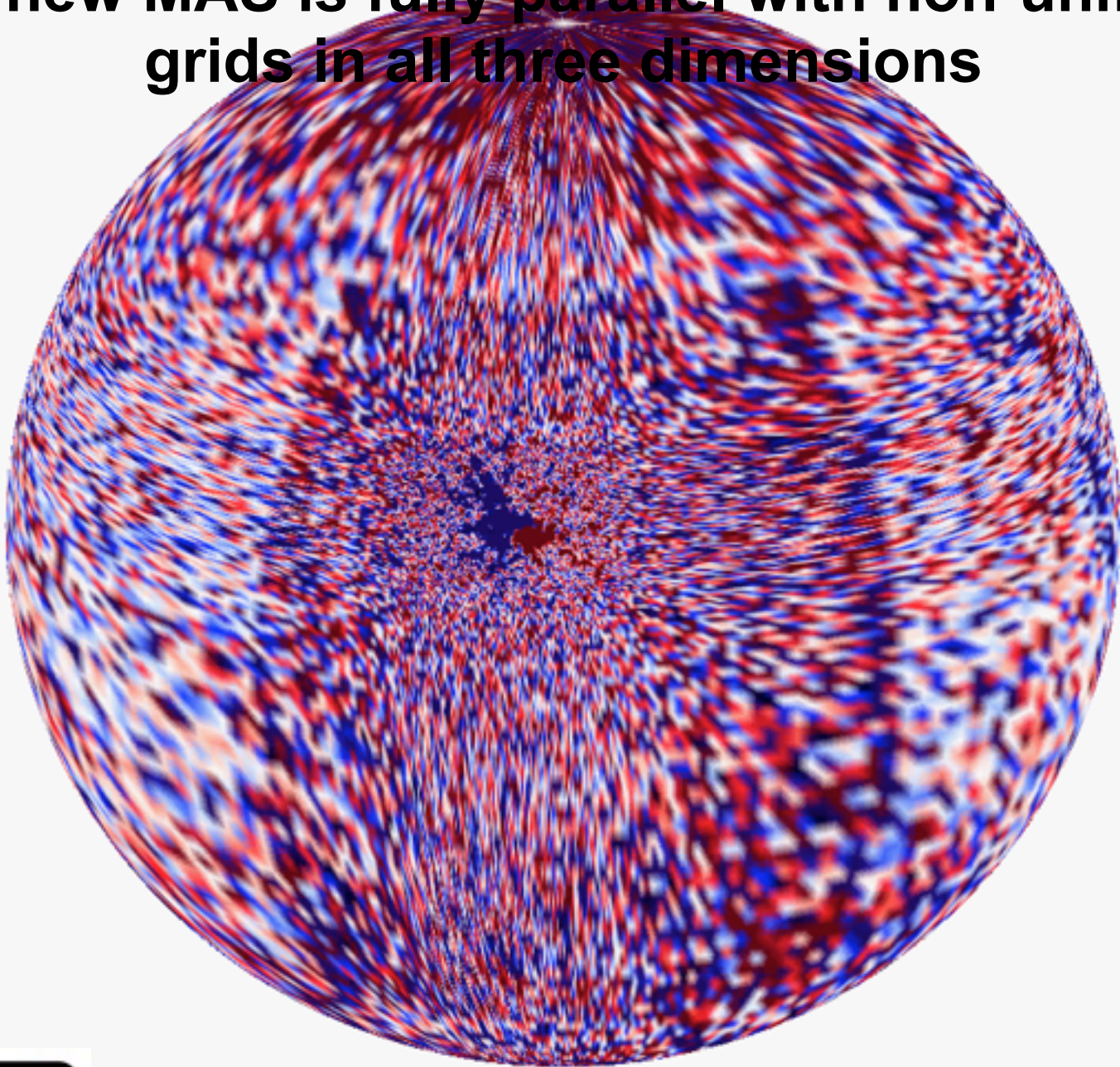
$$\gamma = 5/3$$

$$\mathbf{q} = -\kappa_i \hat{\mathbf{b}} \hat{\mathbf{b}} \cdot \nabla T \quad (\text{Close to the Sun, } r \lesssim 10R_s)$$

$$\mathbf{q} = 2\alpha n_e T \hat{\mathbf{b}} \hat{\mathbf{b}} \cdot \mathbf{v} / (\gamma - 1) \quad (\text{Far from the Sun, } r \gtrsim 10R_s)$$

+ WKB equations for Alfvén wave pressure p_w evolution

The new MAS is fully parallel with non-uniform grids in all three dimensions

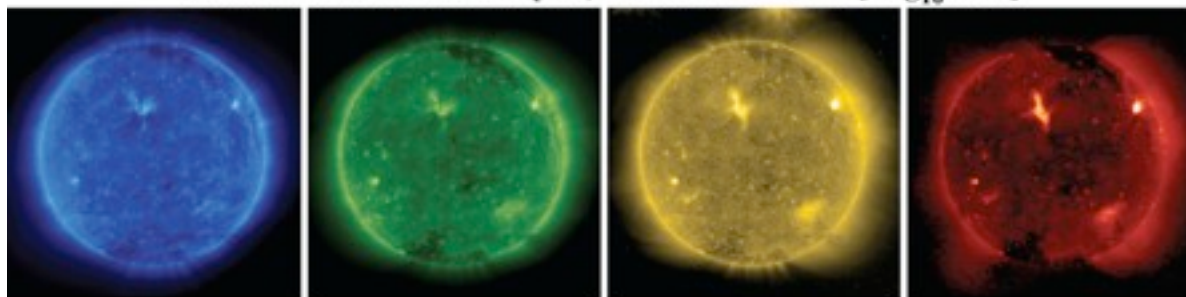


The new MAS can reproduce white-light and emission measurements

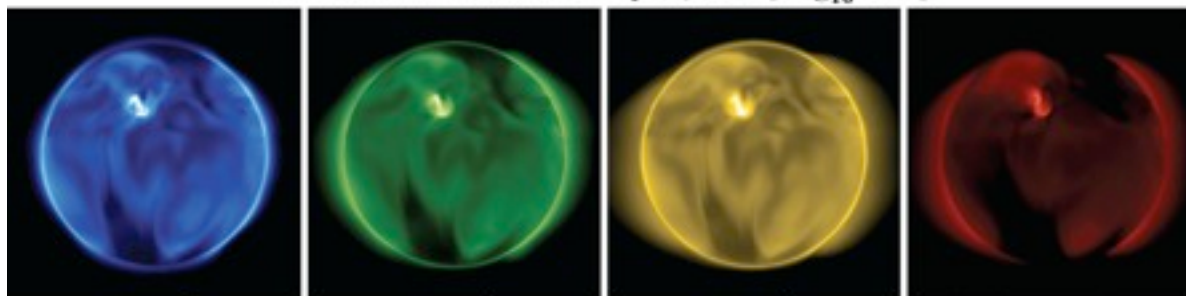
March 29, 2006 Total Solar Eclipse (Predicted vs. Actual)



Observed Emission on May 11, 1997 near 01:00UT [$\text{Log}_{10}\text{DN/s}$]



Simulated Emission on May 11, 1997 [$\text{Log}_{10}\text{DN/s}$]



EIT 171Å

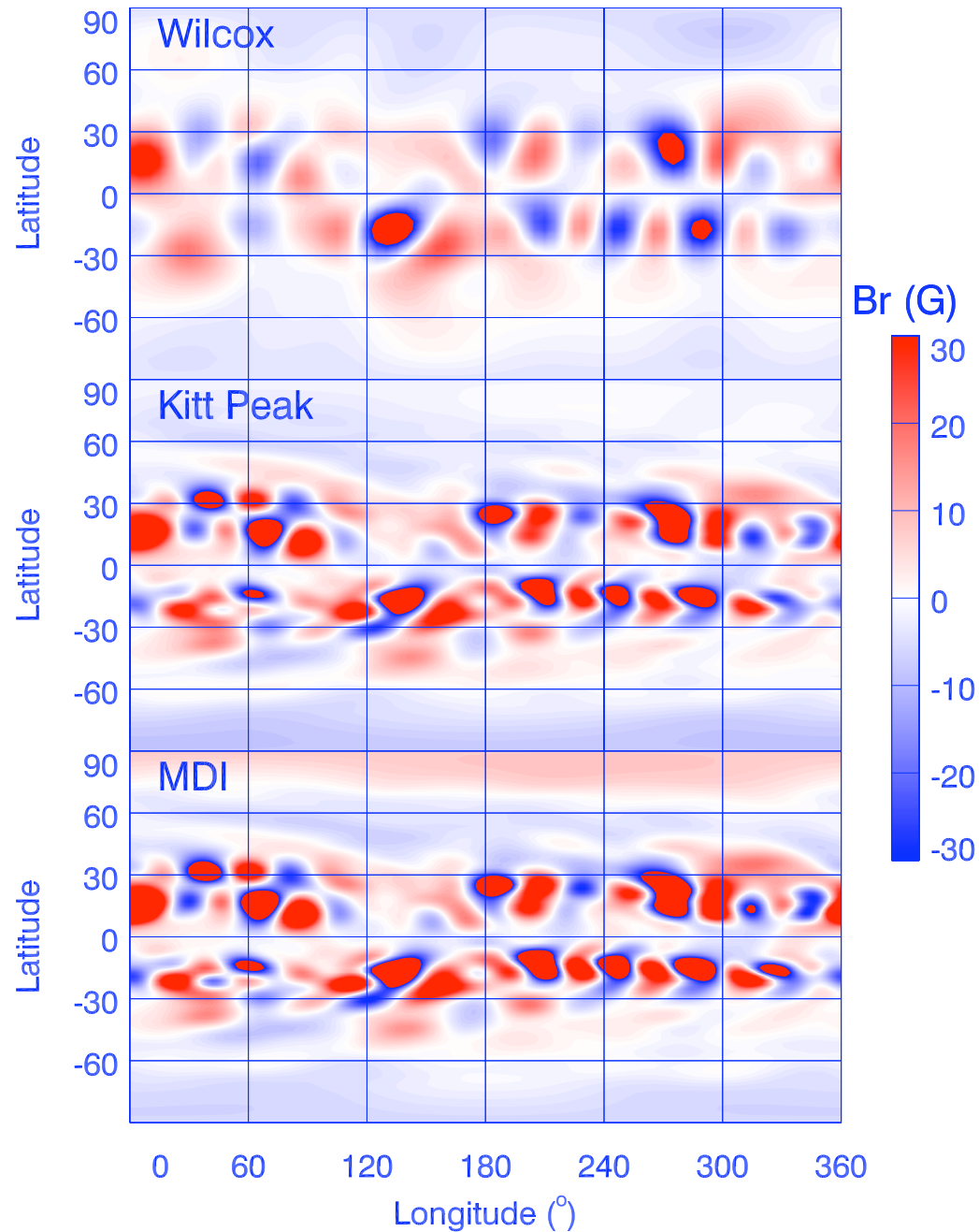
EIT 195Å

EIT 284Å

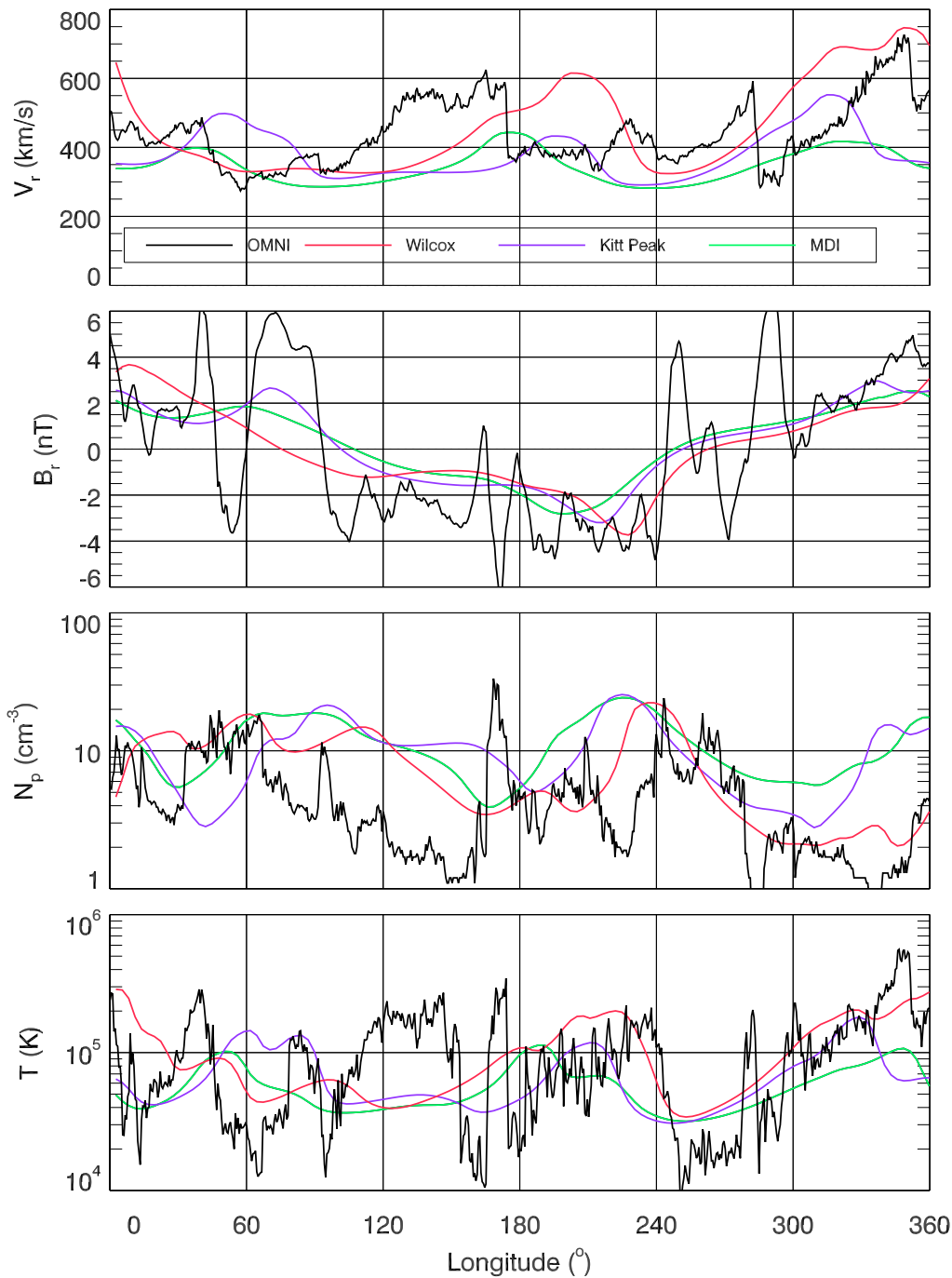
SXT Composite Filter



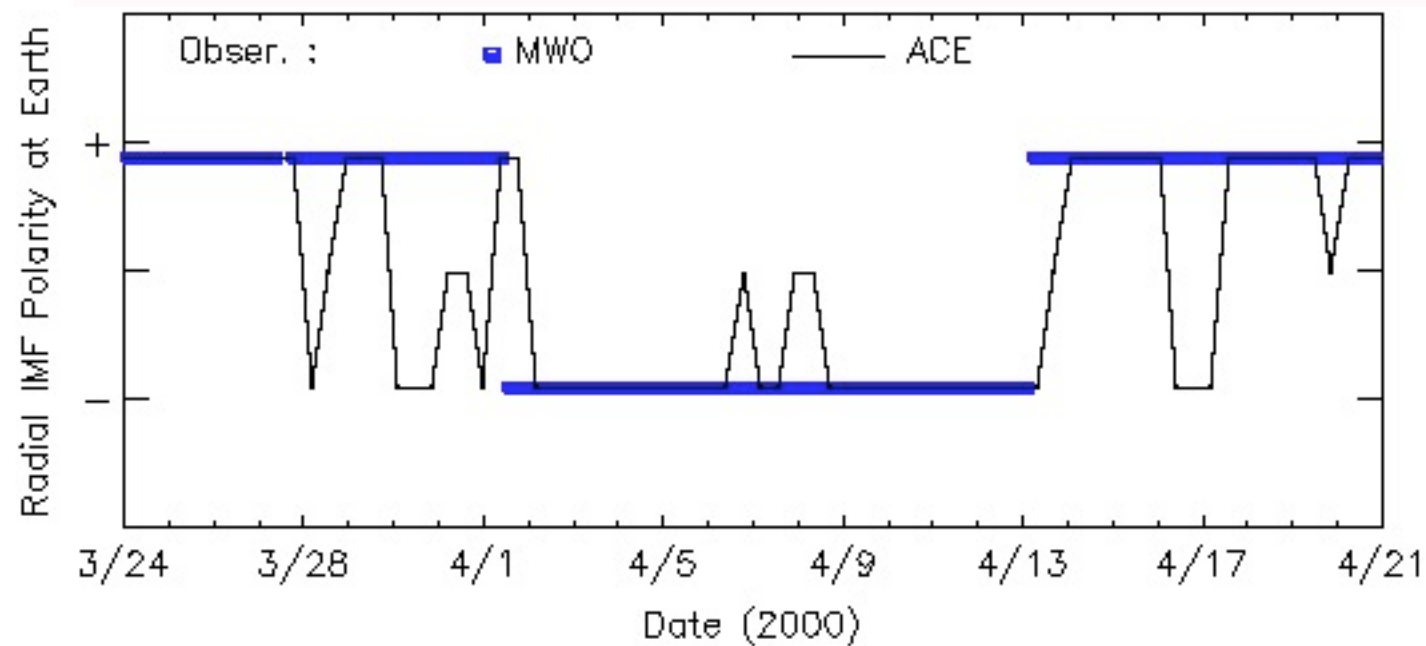
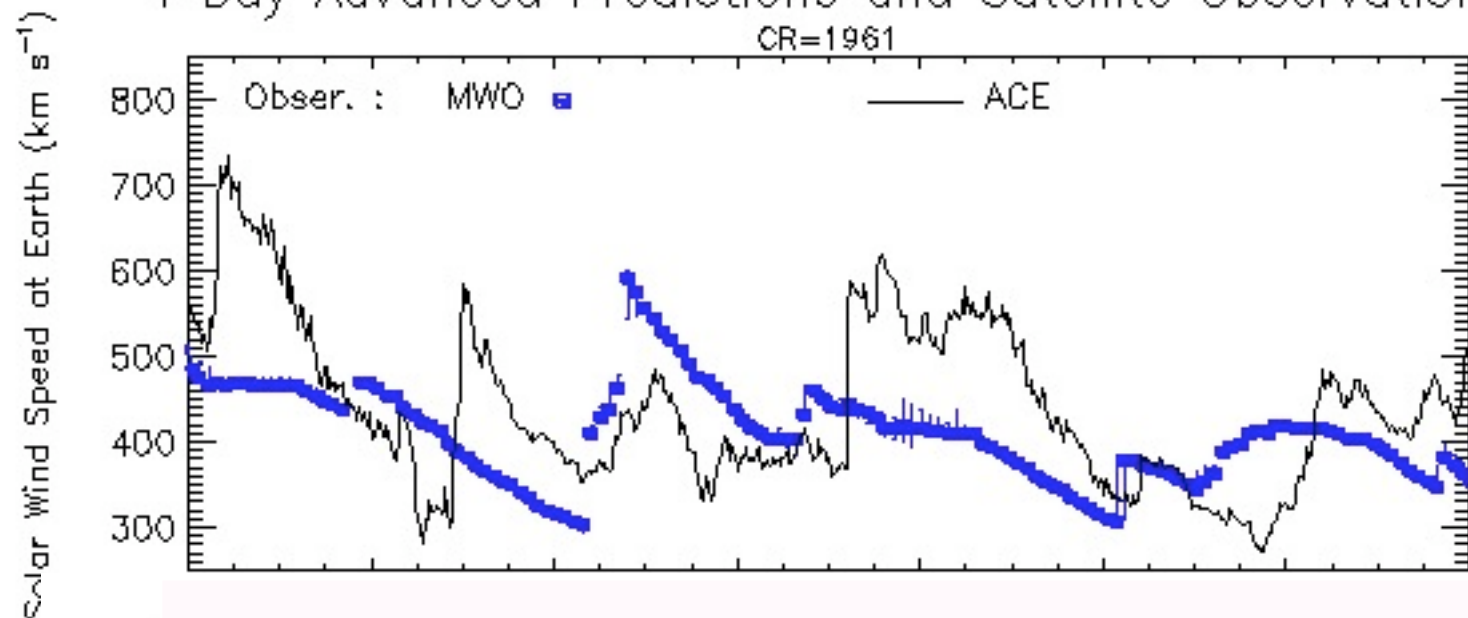
Processed Magnetograms for CR1961



Carrington Rotation 1961

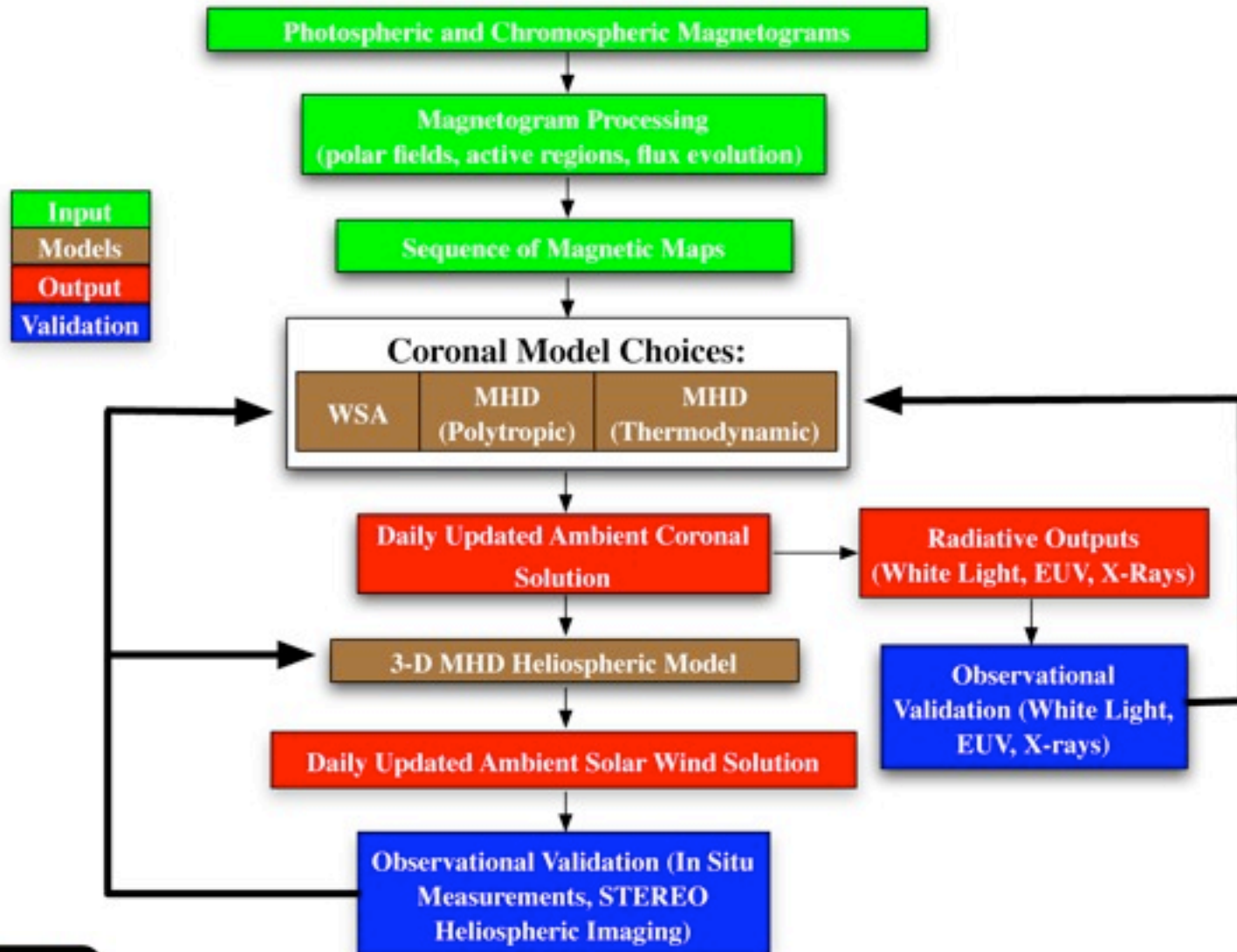


CR=1961



Our LWS Strategic Capability will eventually provide a near-real time SW model

A Next-Generation Model of the Corona and Solar Wind



In summary, MAS and CORHEL development is proceeding well. The quality, accuracy, and “ground truth” of the input magnetograms remains one of the most important unknowns.

- **Input magnetograms**

- “Ground truth” values
- Polar fitting
- Far-side data
- Synchronic maps

- **Improved physical processes**

- Thermal conduction
- Radiation
- Coronal heating
- Alfvén Waves

- **Fully parallel code**

- Runs on Columbia, Ranger, & smaller clusters (e.g., Mac Pros)
- Higher resolution
- Non-uniform meshes

