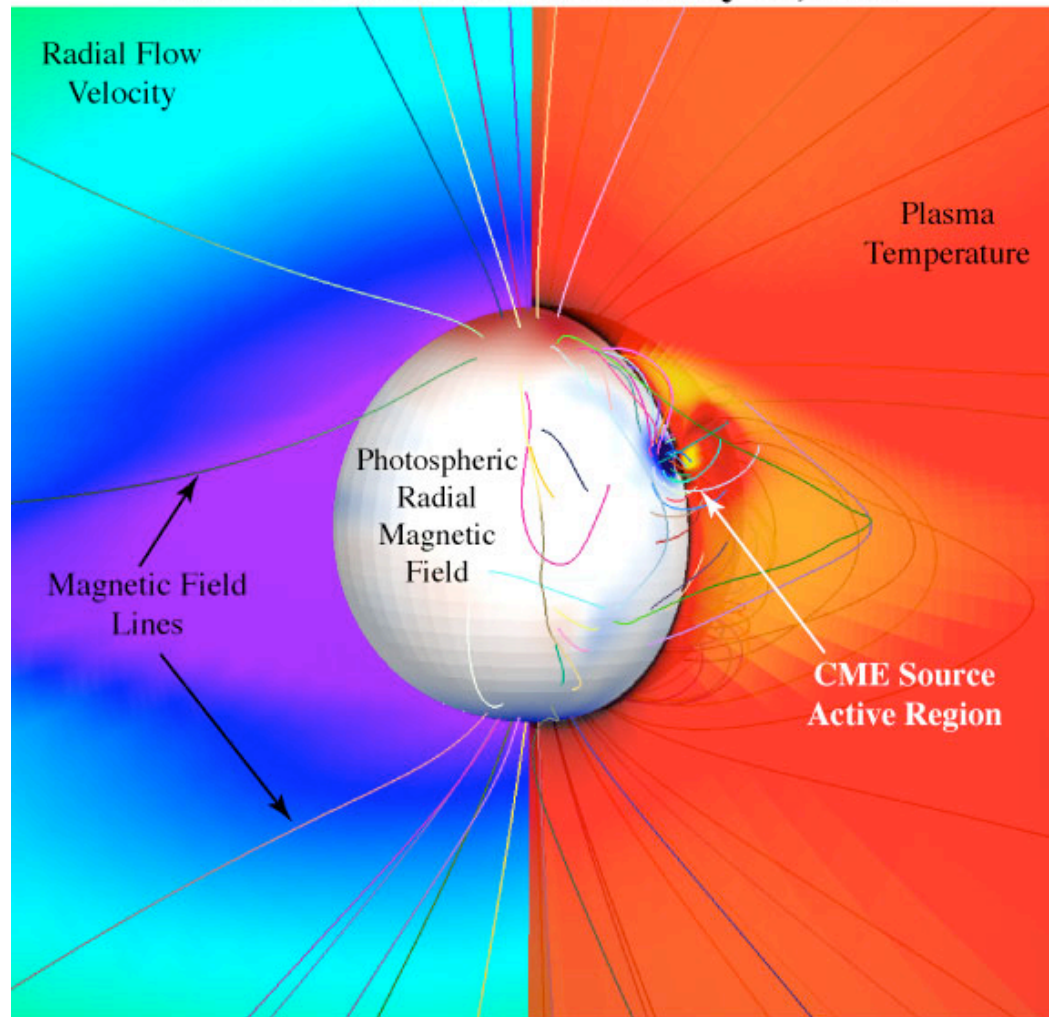# Current Status of and Future Plans for MAS at the CCMC

**Pete Riley,
Zoran Mikic,
Jon A. Linker,
Roberto Lionello**
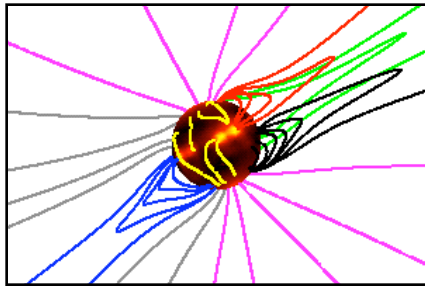
SAIC, San Diego, CA.

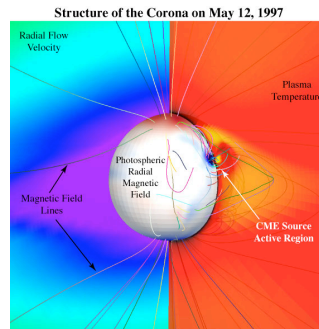**Arecibo Observatory,
November 6, 2007**
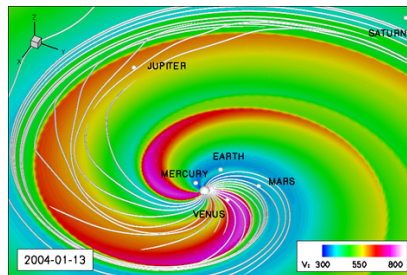
Structure of the Corona on May 12, 1997

This talk reviews the current implementation of MAS at the CCMC and our future plans

Current version of MAS at CCMC: Polytropic, serial, lower resolution, AND robust

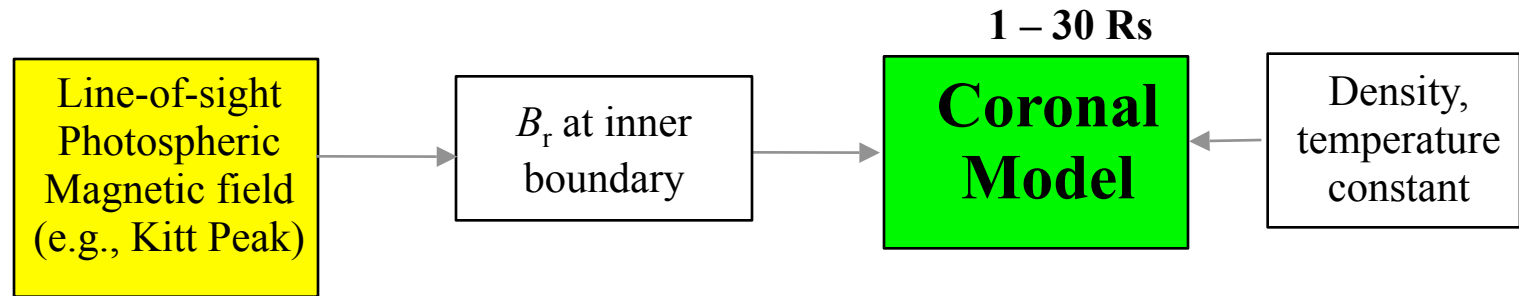**Our latest in-house version: Thermodynamic, parallel, higher resolution, BUT more temperamental**

Leveraging other programs: CISM and the LWS Strategic Capability "A Next Generation Model of the Corona and Solar Wind
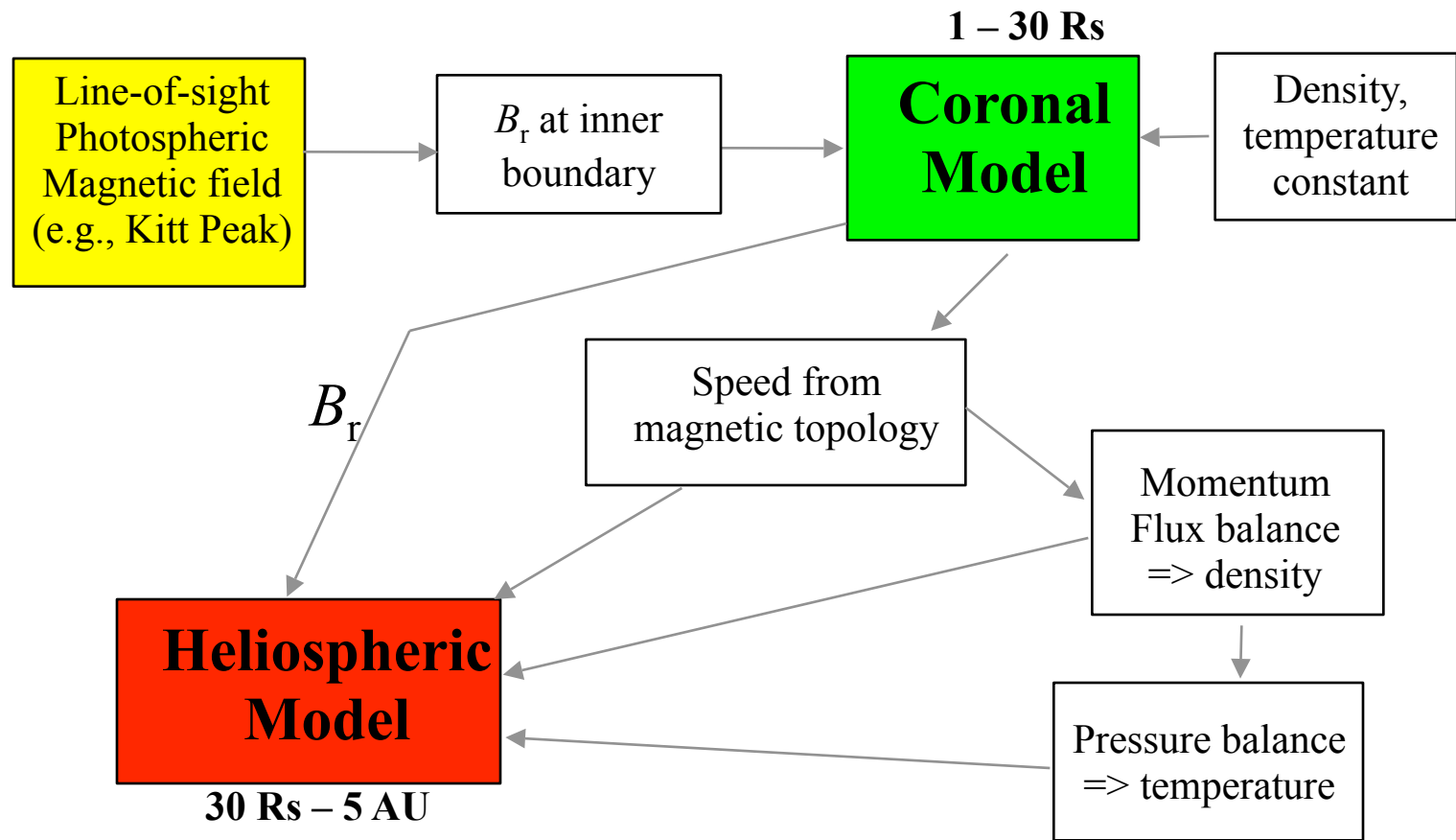
The 'old' version of MAS at the CCMC relies on a polytropic relationship

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

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

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

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

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

$$\gamma = 1.05.$$

Schematic of how corona/heliospheric solutions are computed in the 'old' MAS

| Line-of-sight Photospheric Magnetic field (e.g., Kitt Peak) | → | B_r at inner boundary | → | **1 – 30 Rs** **Coronal Model** | ← | Density, temperature constant |

Schematic of how corona/heliospheric solutions are computed in the 'old' MAS
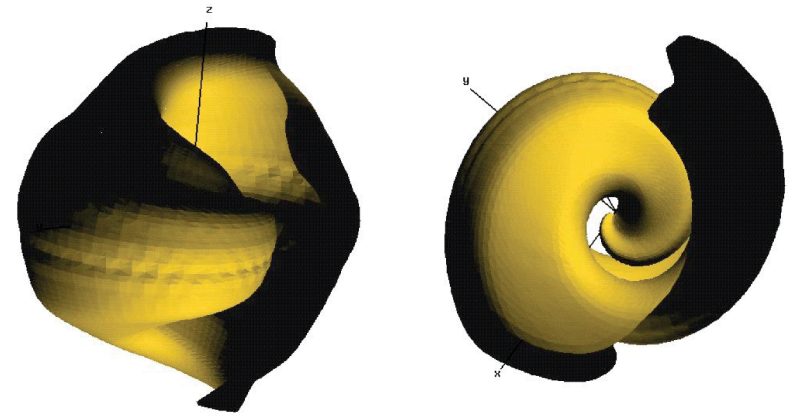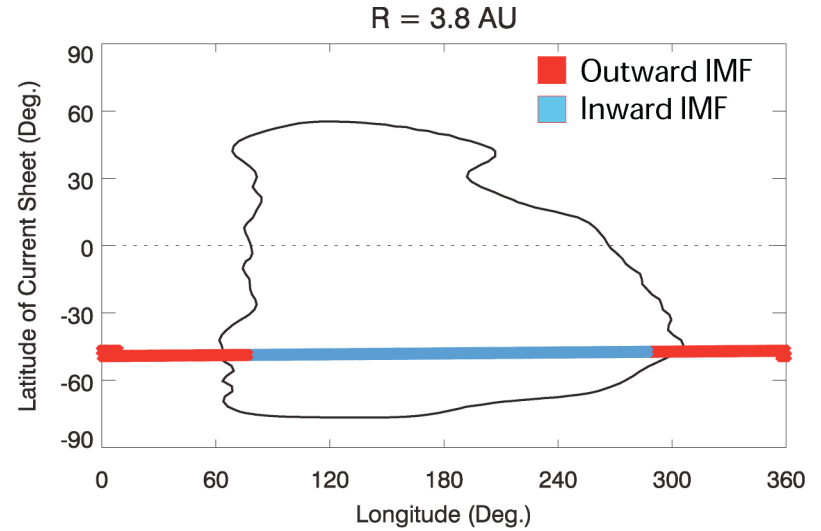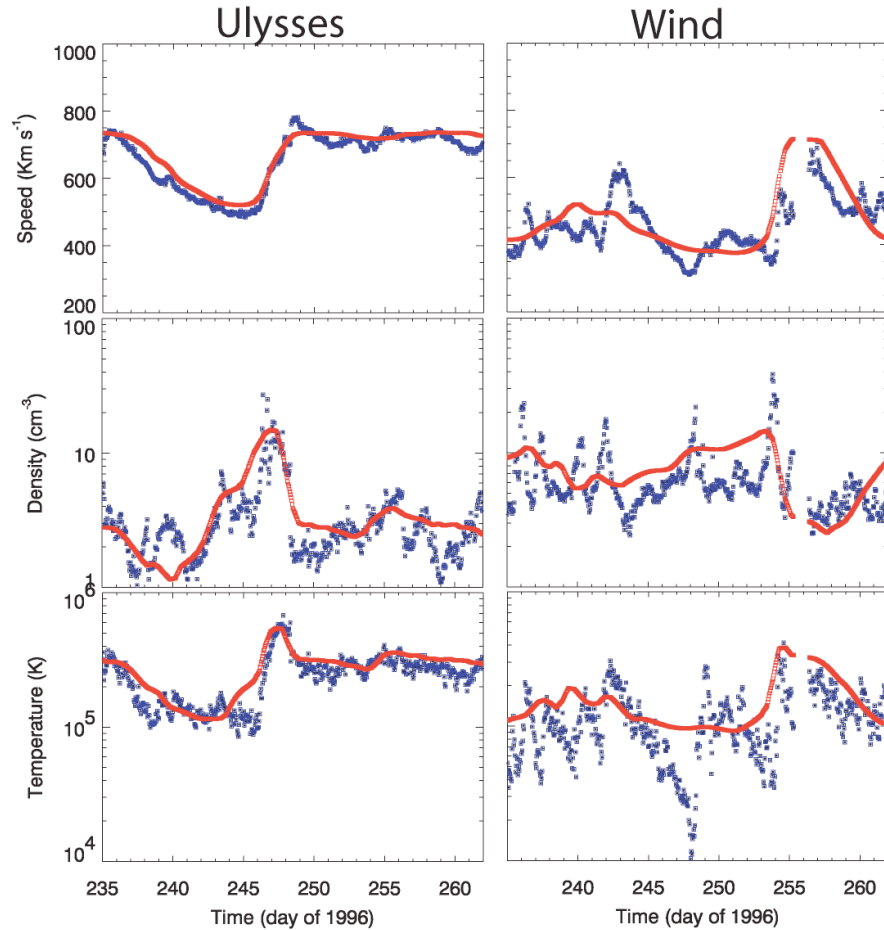
The old MAS code provides robust solutions for the solar corona and inner heliosphere

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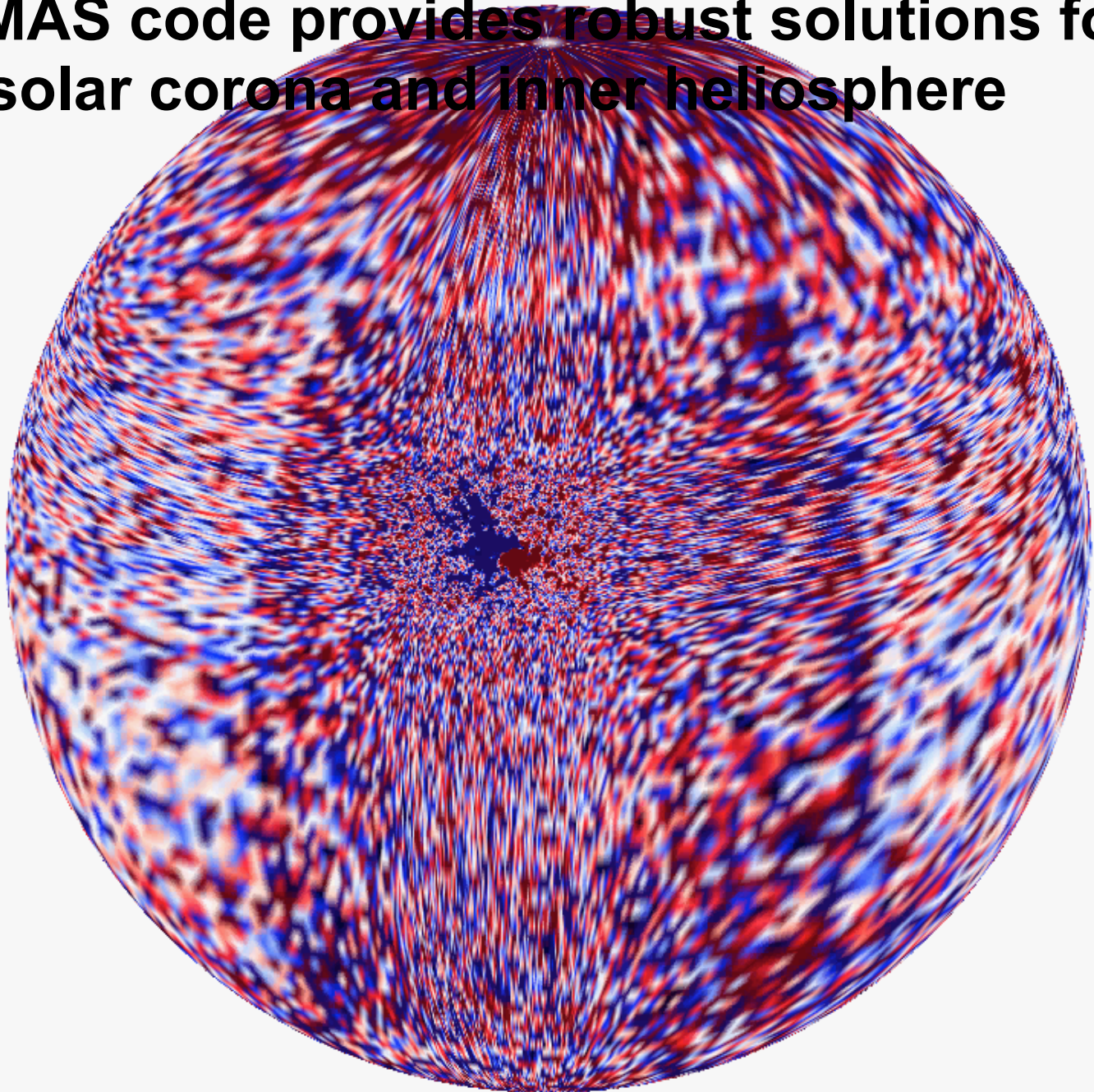
Comparisons with in situ data demonstrate that that the model can reproduce essential observations

The latest version of MAS includes energy transport processes

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

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

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

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

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

$$\frac{\partial p}{\partial t} + \nabla\cdot(p\mathbf{v}) = (\gamma - 1)\left(-p\nabla\cdot\mathbf{v} - \nabla\cdot\mathbf{q} - n_e n_p Q(T) + H\right)$$
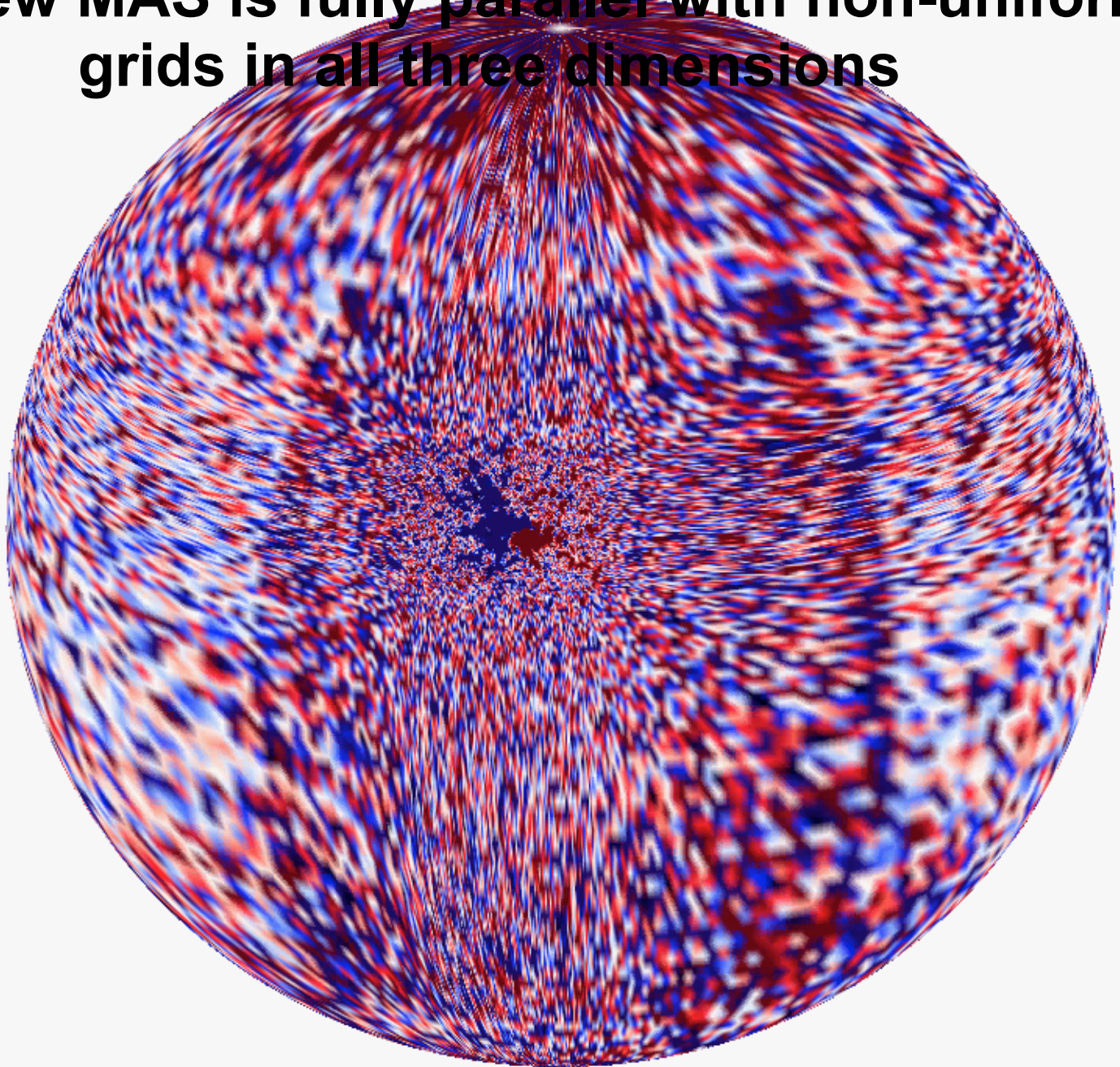
$$\gamma = 5/3$$

$$\mathbf{q} = -\kappa_\parallel \hat{\mathbf{b}}\hat{\mathbf{b}}\cdot\nabla T \qquad \text{(Close to the Sun, } r \lesssim 10 R_S\text{)}$$

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

+ 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 is fully parallel with non-uniform grids in all three dimensions
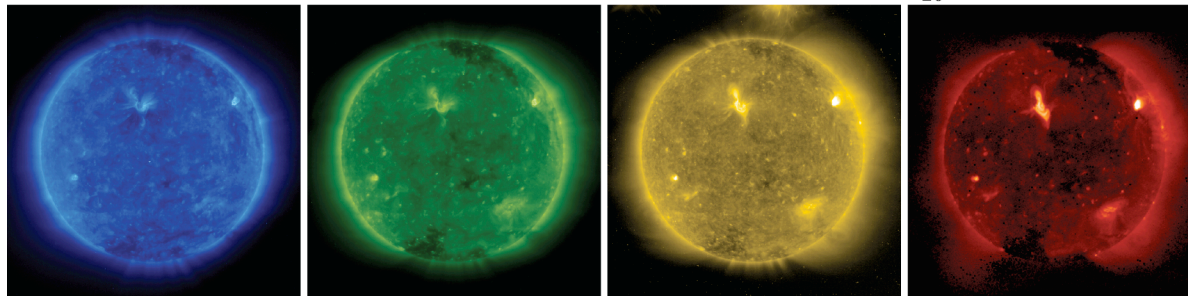
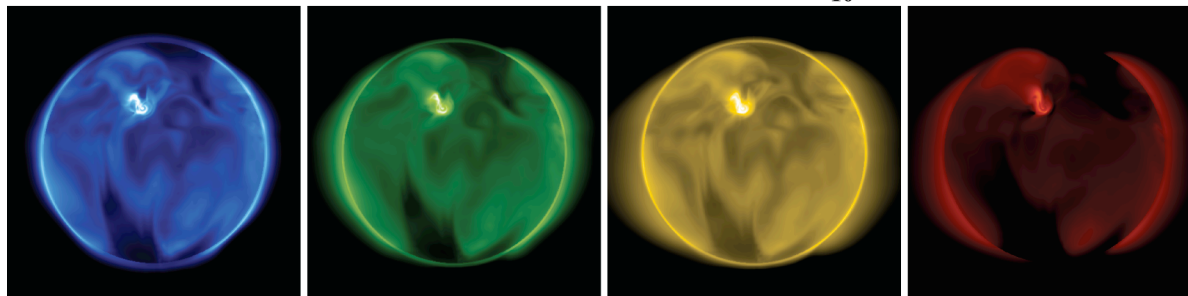# The new MAS can reproduce white-light and emission measurements

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

Predicted Field Lines | Predicted Polarization Brightness | Eclipse Image from Egypt
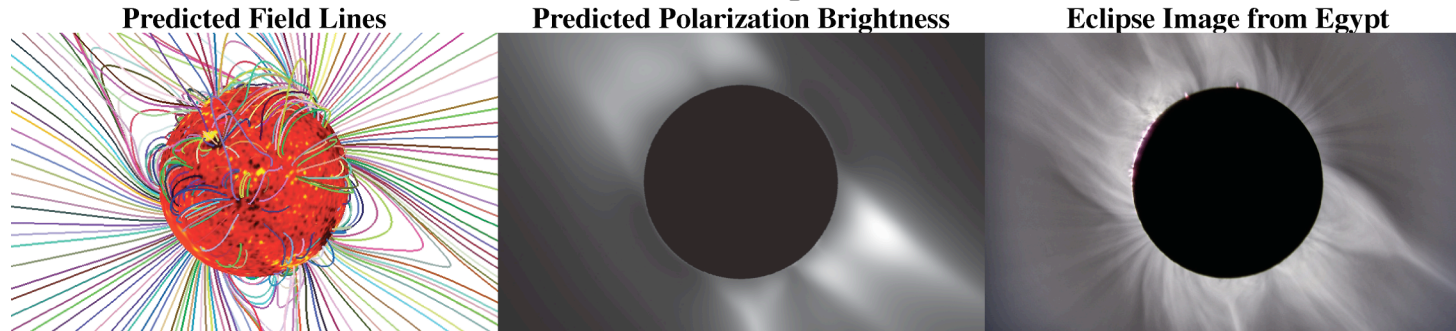
Observed Emission on May 11, 1997 near 01:00UT [$Log_{10}DN/s$]

Simulated Emission on May 11, 1997 [$Log_{10}DN/s$]
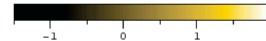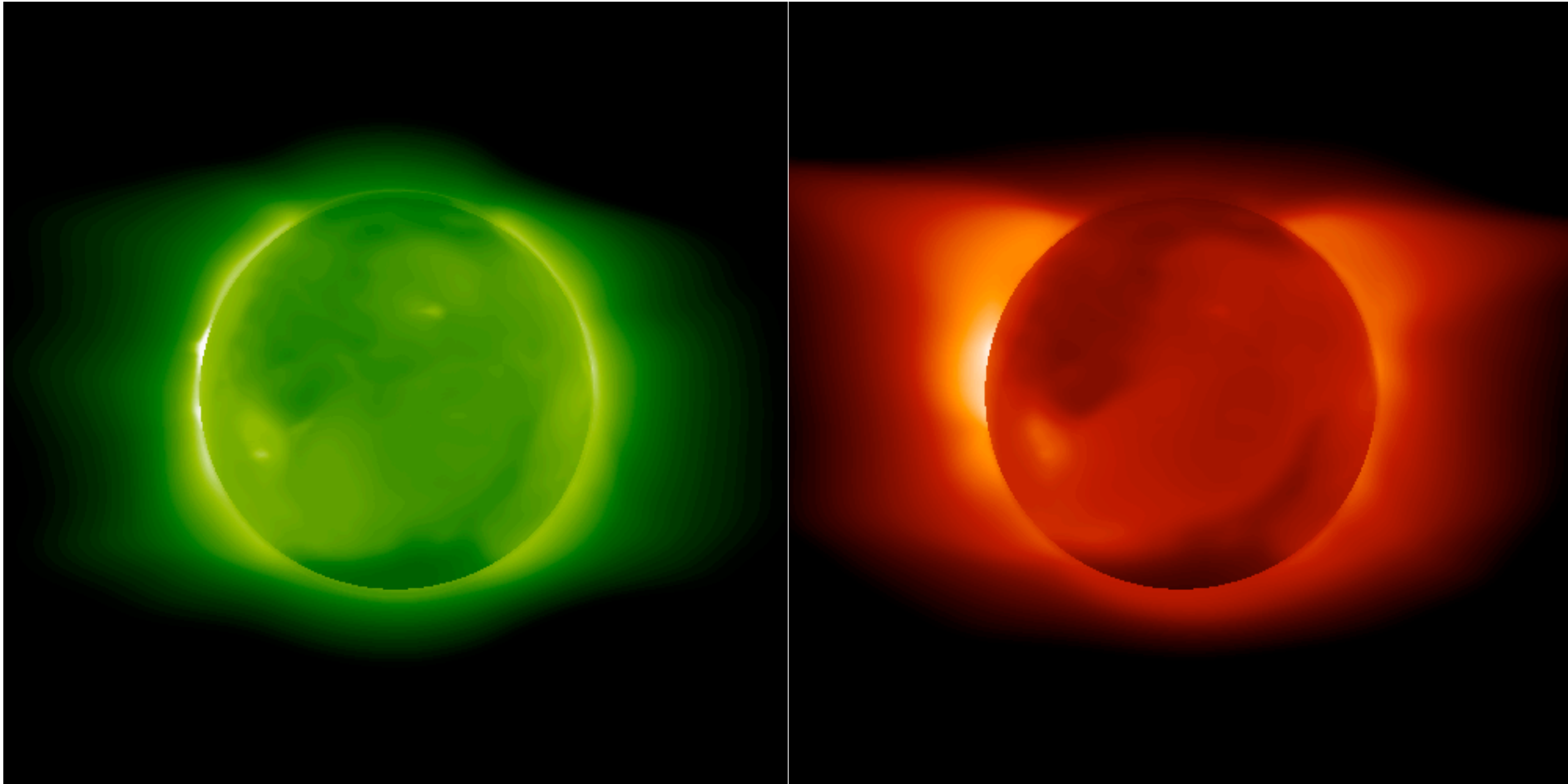
EIT 171Å | EIT 195Å | EIT 284Å | SXT Composite Filter

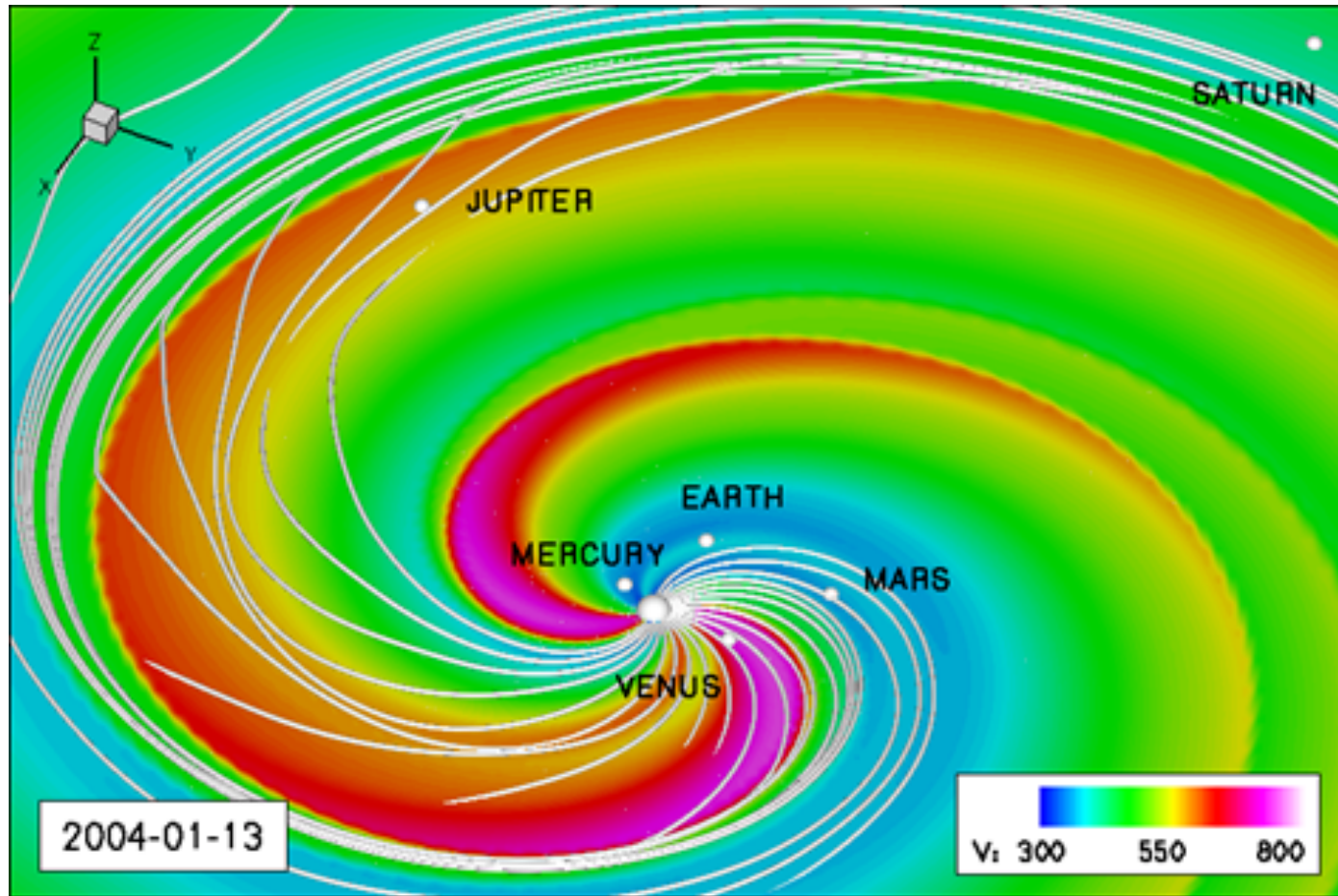# The new MAS provides 3-D views of the solar corona

The new MAS provides 3-D views of the solar corona

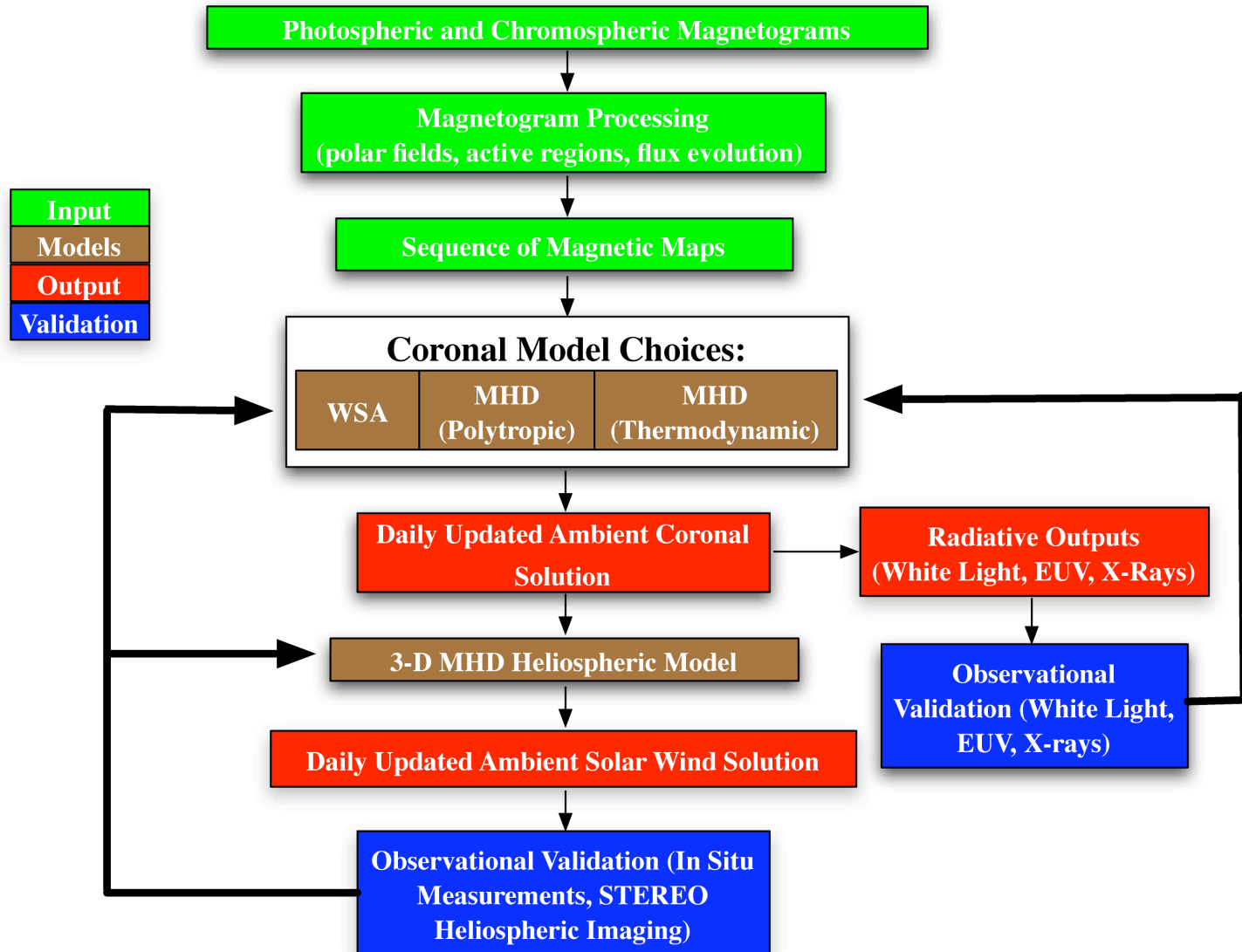# The new version of MAS will require multi-processor cluster capabilities

The NSF-funded CISM program is developing an ambient coronal/heliospheric model (CORHEL)

An SAIC-led LWS Strategic Capability will ultimately provide a near-real time SW model

A Next-Generation Model of the Corona and Solar Wind

In summary, we are very pleased with our interactions with the CCMC and look forward to delivering ever-more sophisticated coronal models

Improved physical processes
- Thermal conduction
- Radiation
- Coronal heating
- Alfven Waves

Fully parallel code
- Runs Columbia, Datastar, & clusters
- Higher resolution
- Non-uniform meshes

Structure of the Corona on May 12, 1997

Radial Flow Velocity

Plasma Temperature

Photospheric Radial Magnetic Field

Magnetic Field Lines

CME Source Active Region

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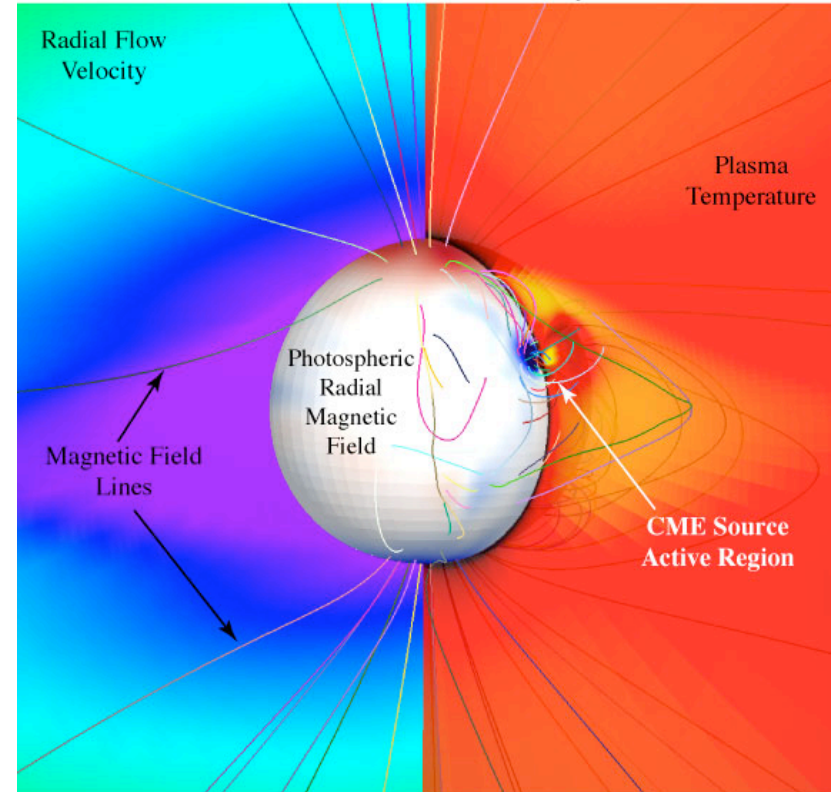
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SAIC
From Science to Solutions

Questions?