AWSoM

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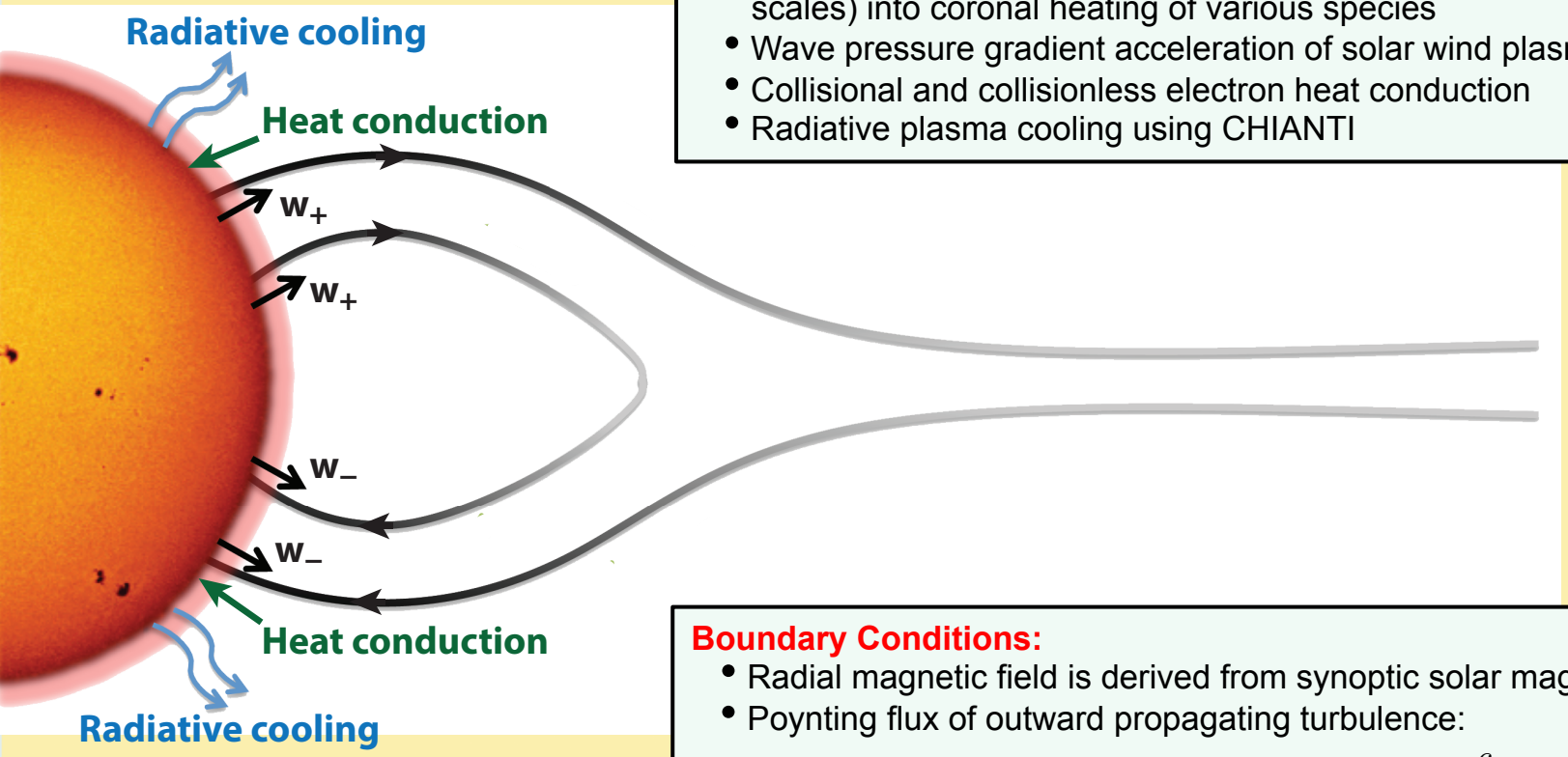
Alfvén Wave Solar Model (AWSoM)

B. van der Holst et al. ApJ **782**, 81 (2014).

Extended MHD physics:

- Two (T_i, T_e) or three ($T_{i||}$, $T_{i\perp}$, T_e) temperatures
- Equations for parallel and antiparallel propagating turbulence ($w_\pm$)
- Physics-based reflection of $w_\pm$ results in turbulent cascade
- Physics-based apportioning of turbulence dissipation (at the gyro-radius scales) into coronal heating of various species
- Wave pressure gradient acceleration of solar wind plasma
- Collisional and collisionless electron heat conduction
- Radiative plasma cooling using CHIANTI

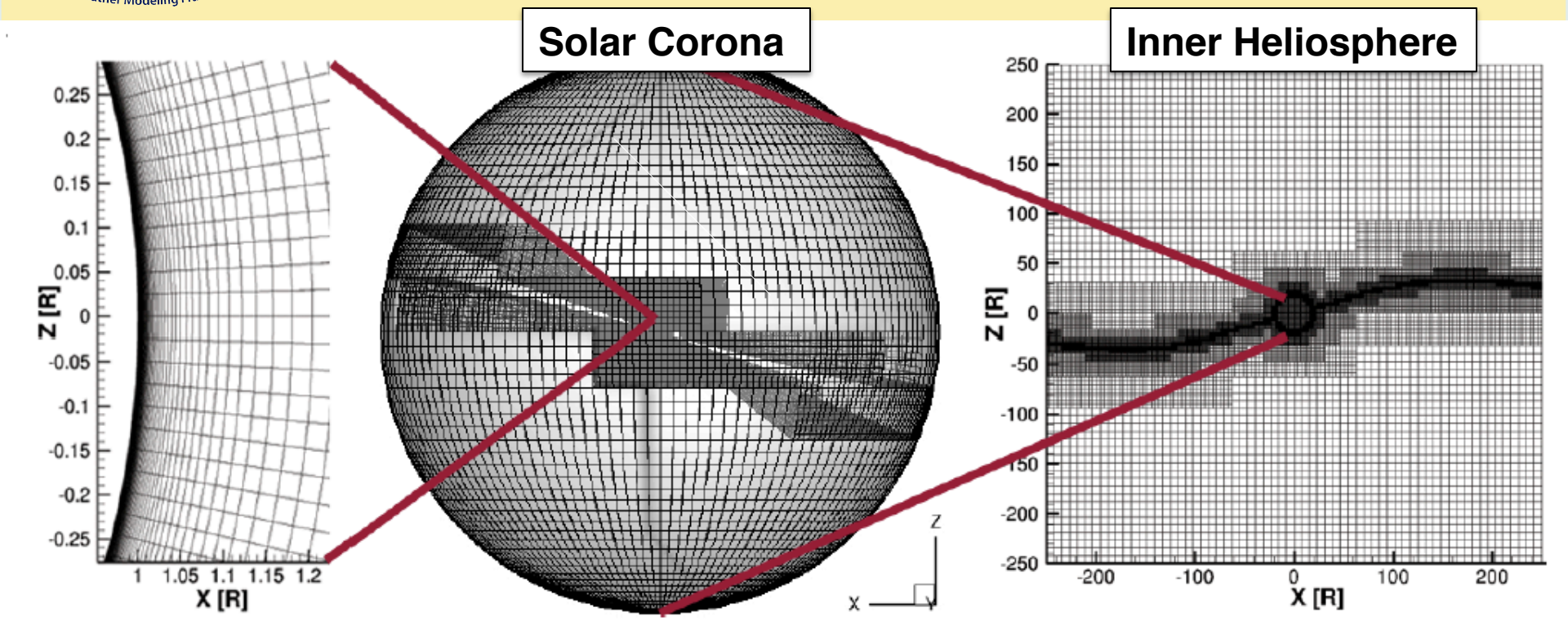


Boundary Conditions:

- Radial magnetic field is derived from synoptic solar magnetograms
- Poynting flux of outward propagating turbulence:

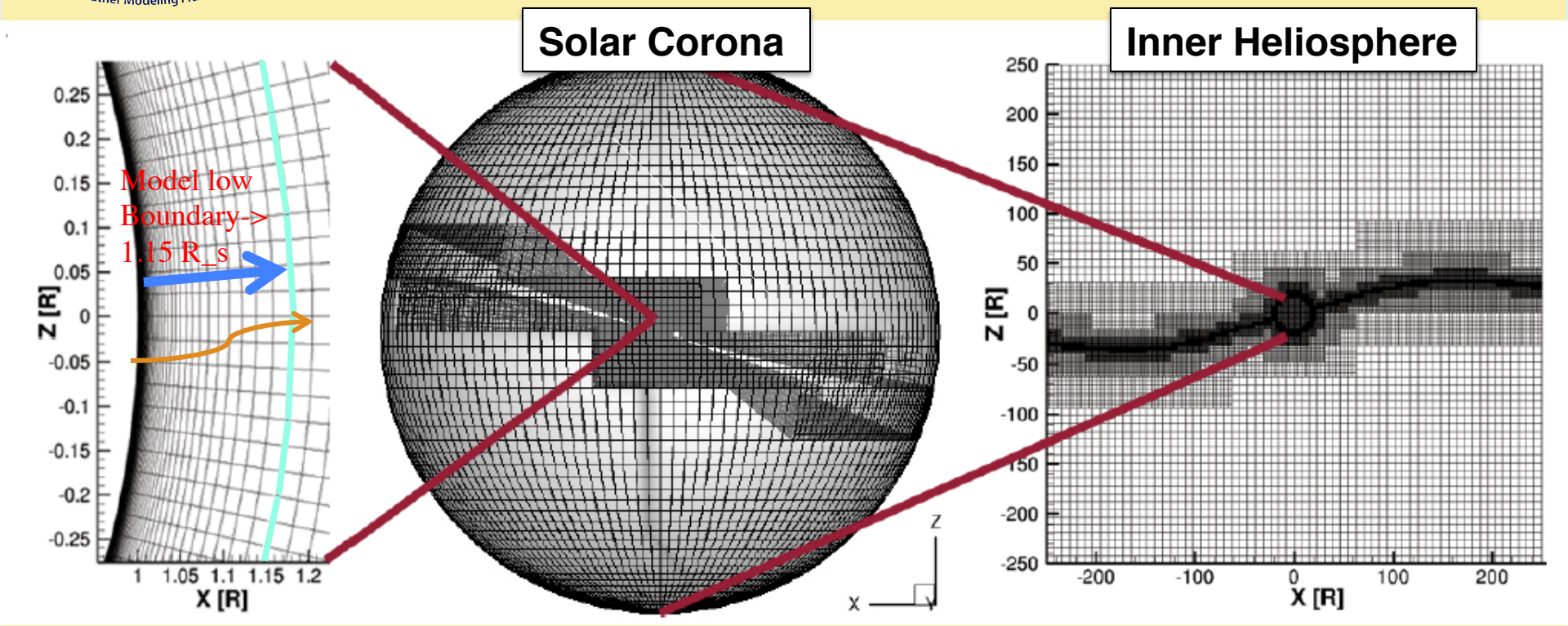
$$(S_A/B)_\odot = 1.1 \times 10^6 \ \mathrm{W\,m^{-2}\,T^{-1}}$$

Computational Grid: AWSoM



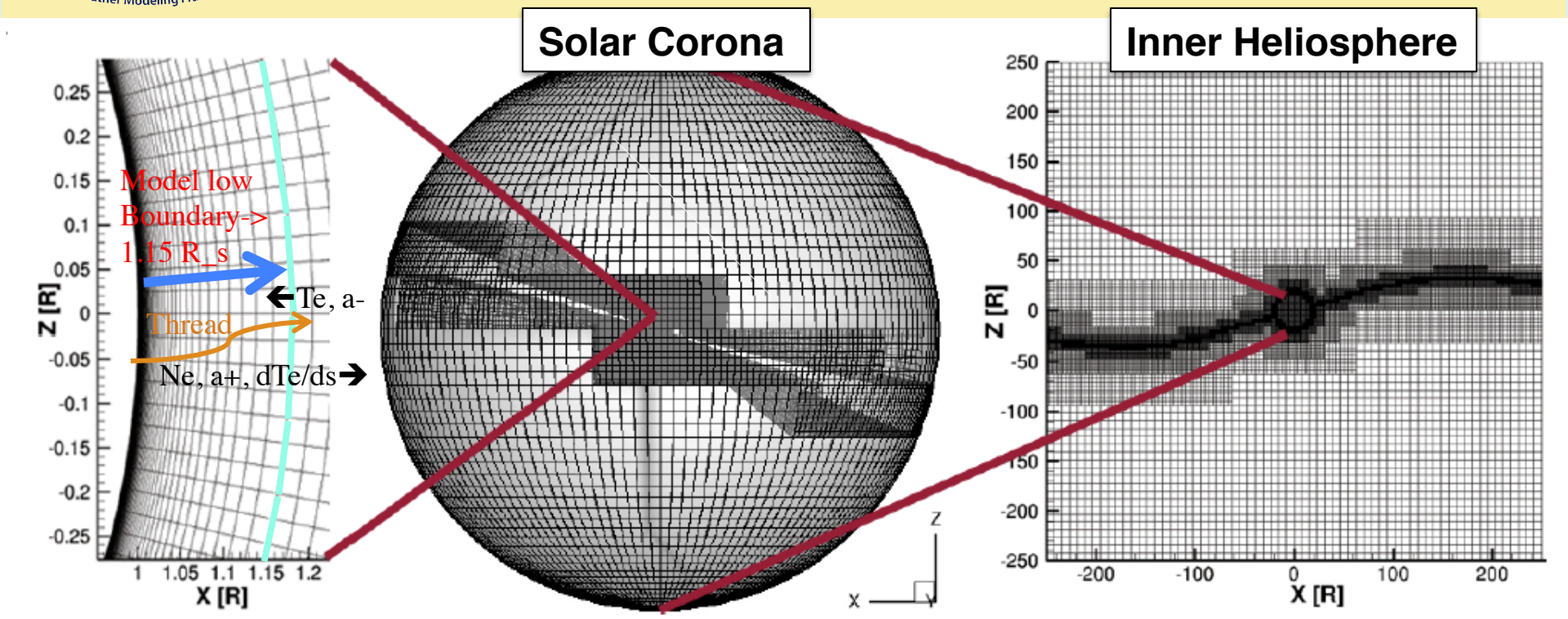
- AWSoM is split in two coupled framework components: stretched spherical grid for solar corona, cartesian grid for inner heliosphere
- Significant grid stretching to grid resolve the upper chromosphere and transition region in addition to artificial transition region broadening
- Due to the very high resolution below $1.15R_{sun}$ AWSoM is too slow to achieve faster than real-time.

AWSoM-R: Upshift the Inner Boundary



- We use the lower boundary of the AWSoM-R model at R = 1.15R_s
- We apply 1D thread solutions along PFSS model field lines to bridge the AWSoM-R model to the chromosphere through the transition region.

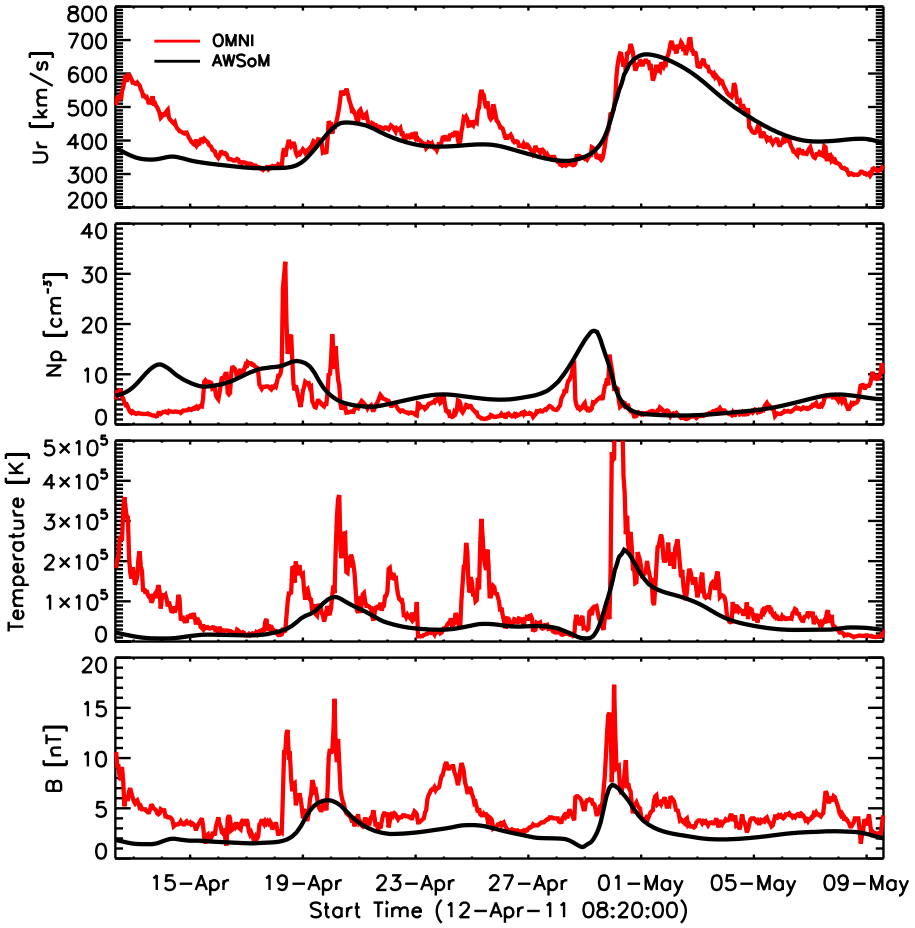
Apply 1D Thread Solution



- Recognize that between $1R_s$ and $1.15R_s$ $u \parallel B$ and $u \ll V_{slow}, V_A, V_{fast}$
- Quasi-steady-state mass, momentum, energy transport and wave turbulence transport is solved along the connecting field line implicitly (1D equations!)
- The speed-up of AWSoM-R is about a factor 200 compared to AWSoM

Validation: MHD Quantities at 1AU

CR2109



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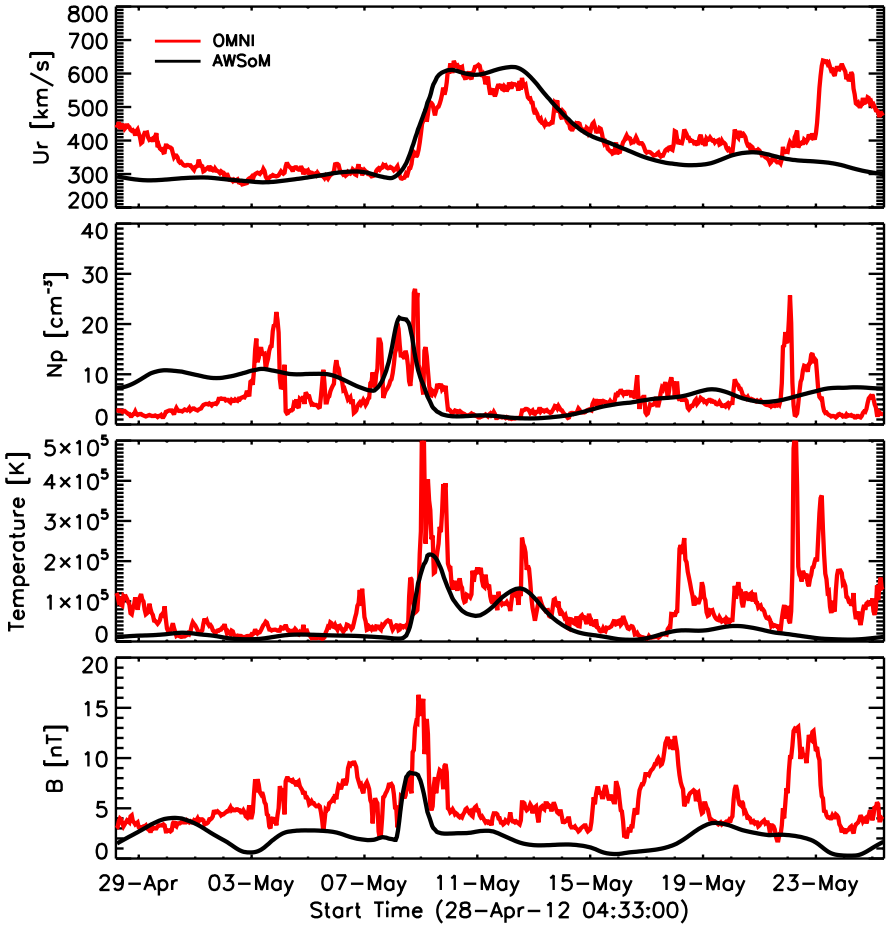
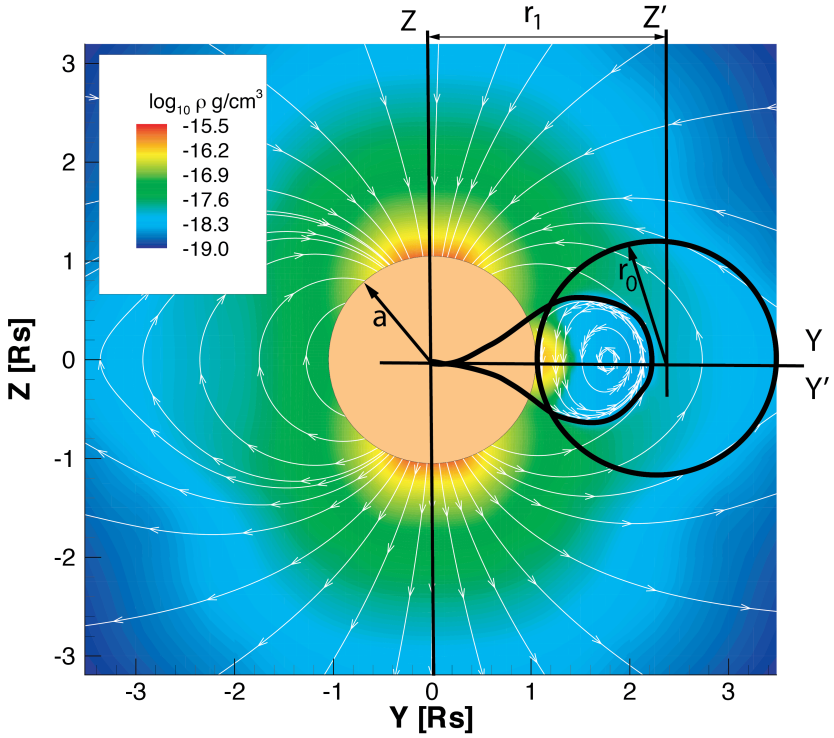
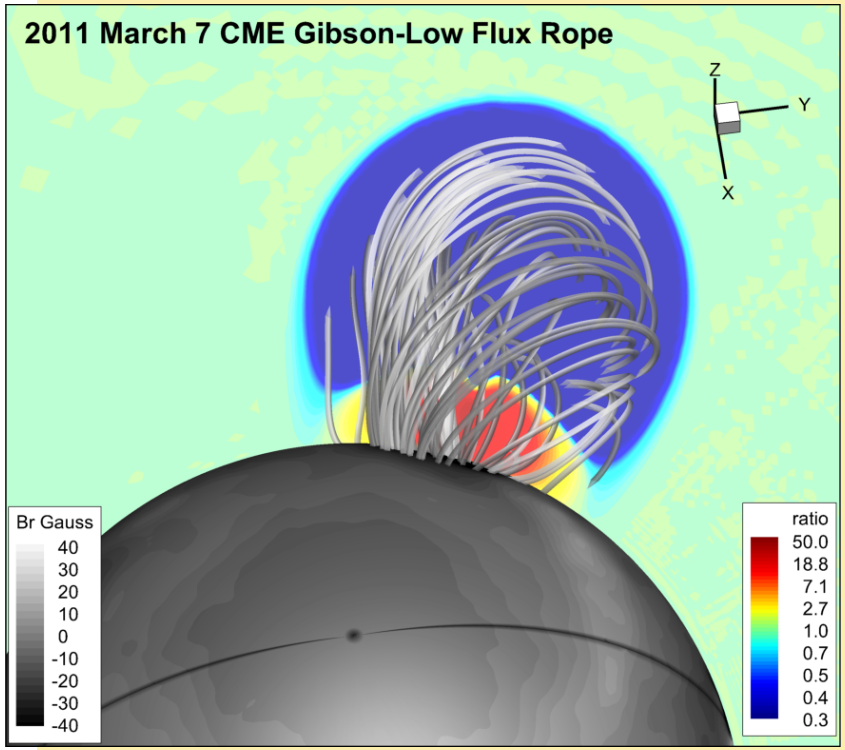


Gibson-Low Flux Rope

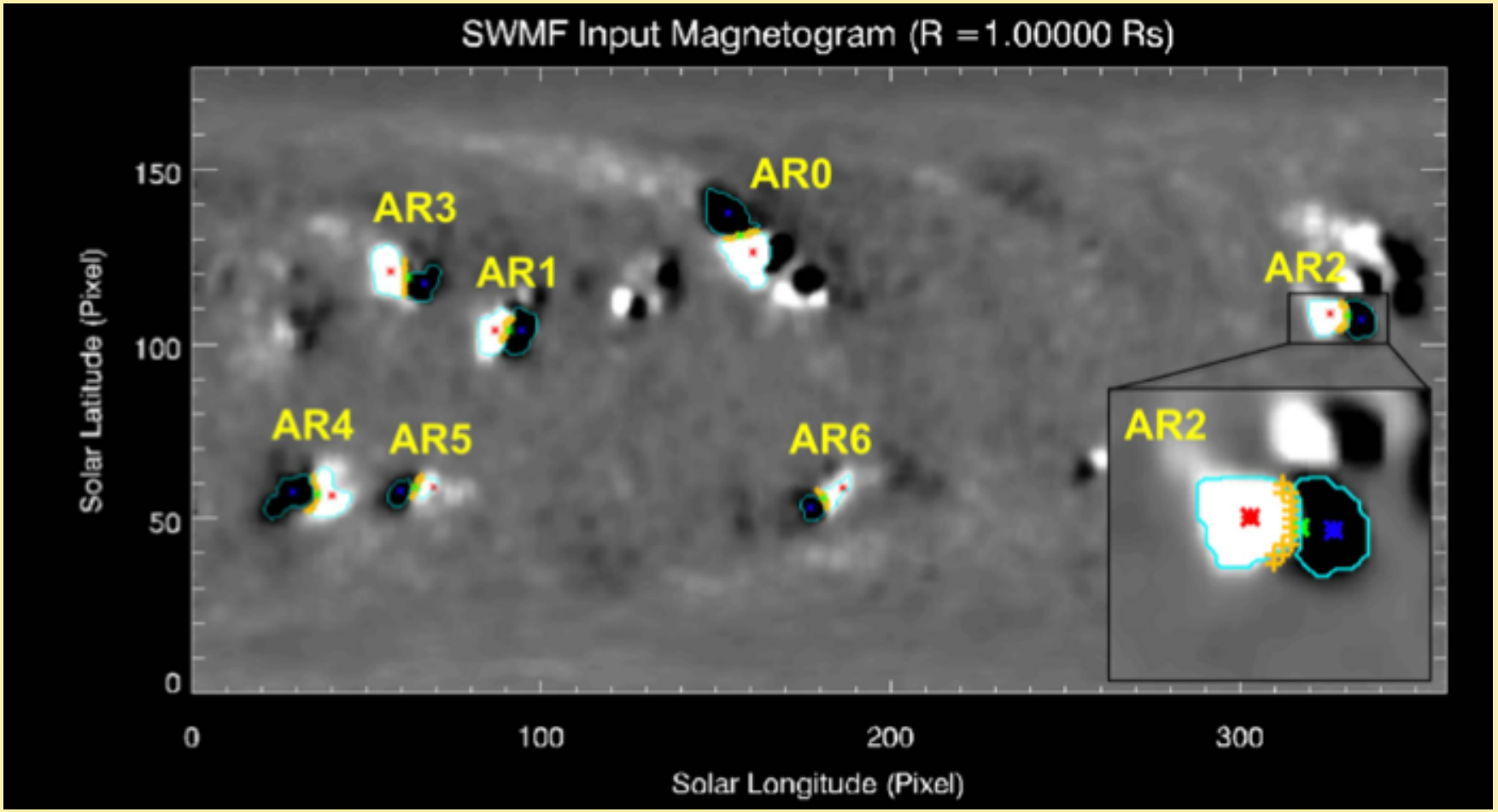




- **Self-similar Gibson-Low flux rope (Gibson & Low, ApJ 493, 460, 1998) to initiate CME in background solar wind**
- **Input parameters:**
  - Location, orientation, field strength, size of flux rope
  - Helicity is derived from hemispherical preference (Liu et al., 2014)
- **How to determine the parameters from observations ?**

Eruptive Event Generator Gibson Low (EEGGL)

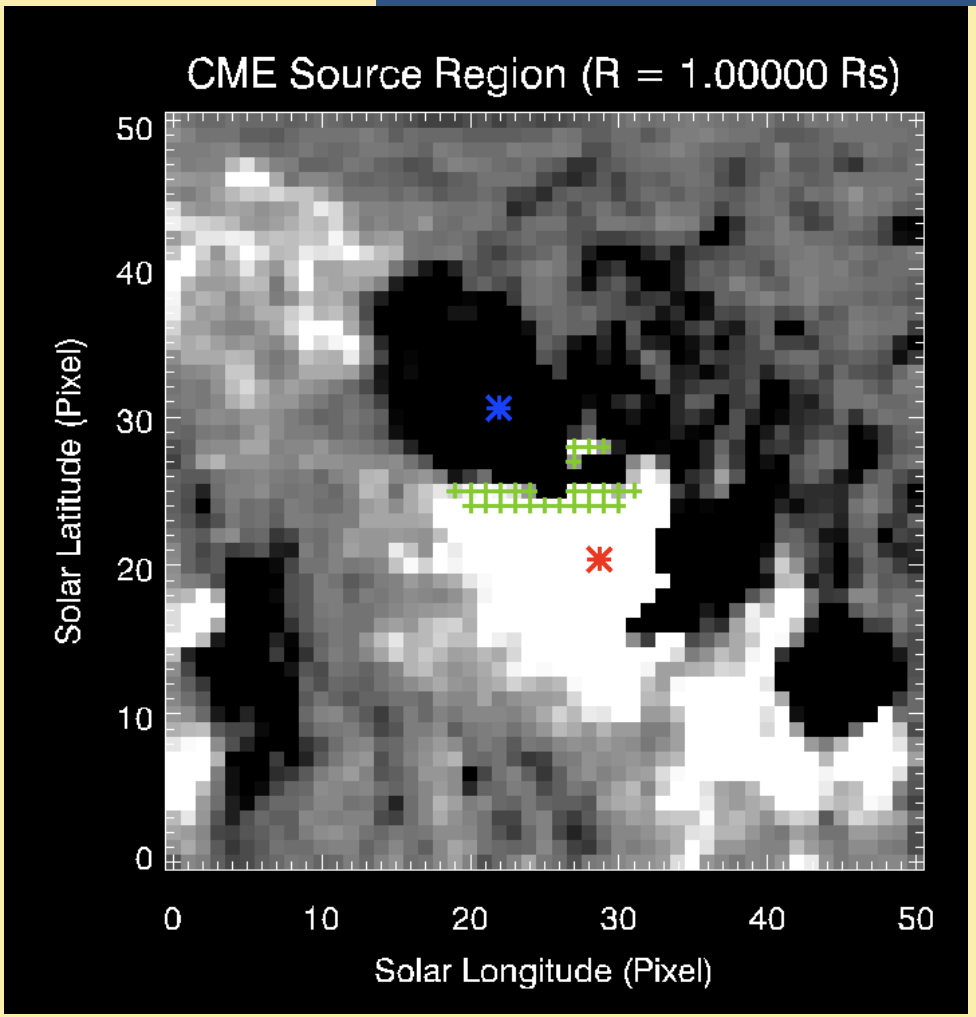
Jin et al. ApJ 2017, 834, 173



Weighted center determined via $\mathrm{sum}(\mathbf{r}Br)/\mathrm{sum}(Br)$ limited to a polarity of active region

C. Schrijver (2007) algorithm for polarity inversion lines (GONG data)

Eruptive Event Generator Gibson Low (EEGGL)



Blue: Weighted Center of Negative Polarity

Red: Weighted Center of Positive Polarity

Green: Polarity Inversion Line

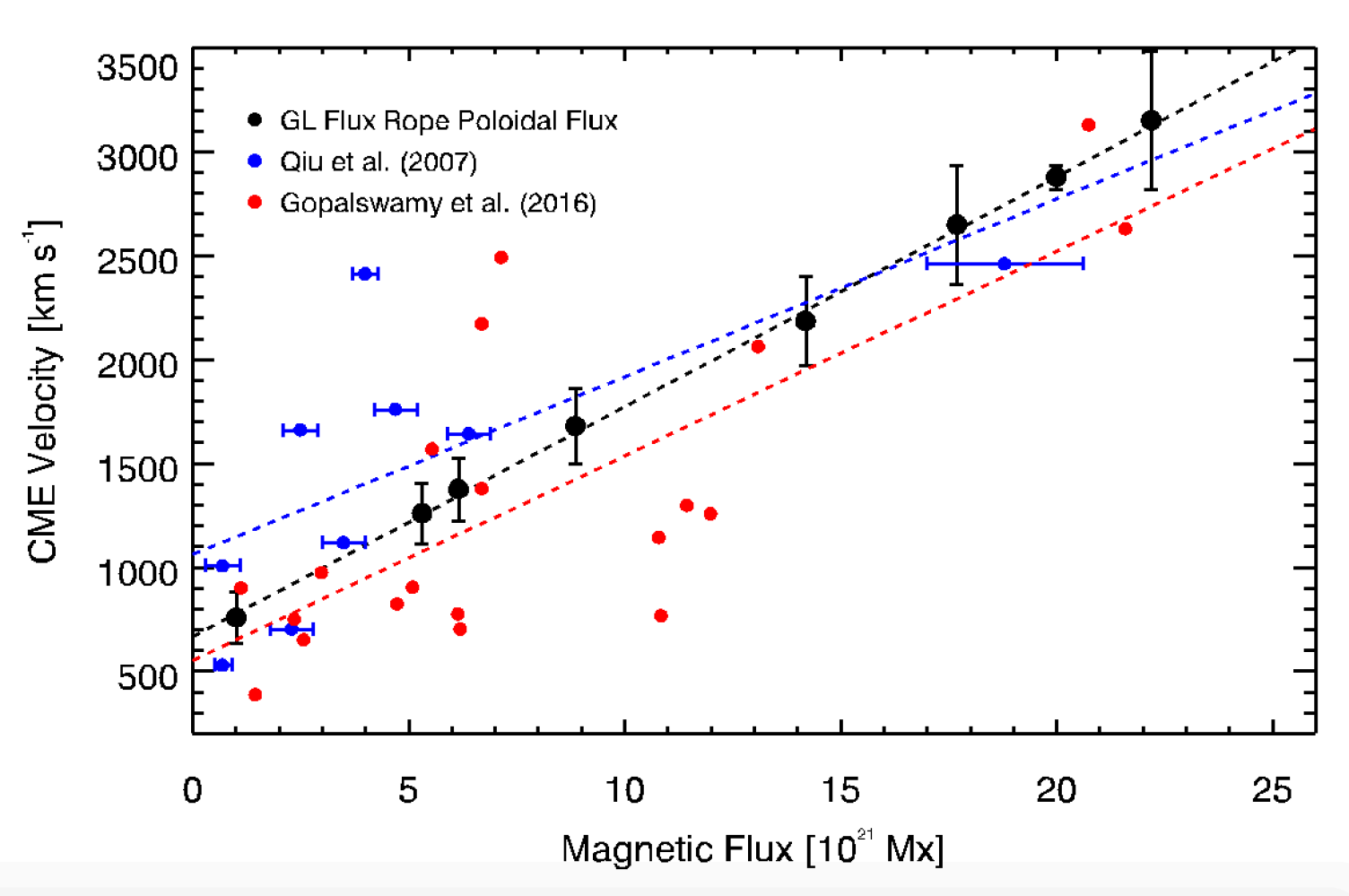
Recommended Parameters

```
==========================================
The Recommended GL FLux Rope Parameters
==========================================
          Latitude:          27.46
         Longitude:         158.00
       Orientation:         276.67
            Radius:           0.80
         Bstrength:           2.25
  Stretch (FIXED):            0.60
  Distance (FIXED):           1.80
------------------------------------------
```

Weighted center determined via $\mathrm{sum}(\mathbf{r}Br)/\mathrm{sum}(Br)$ limited to a polarity of active region

C. Schrijver (2007) algorithm for polarity inversion lines

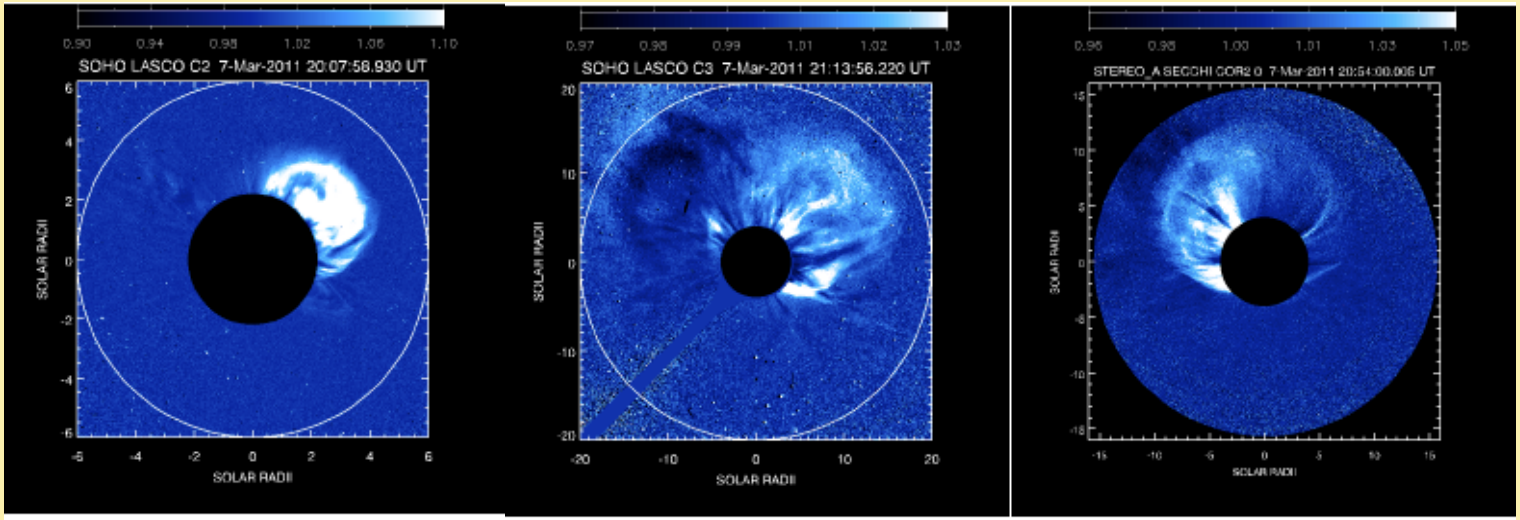
Poloidal Flux vs. Velocity



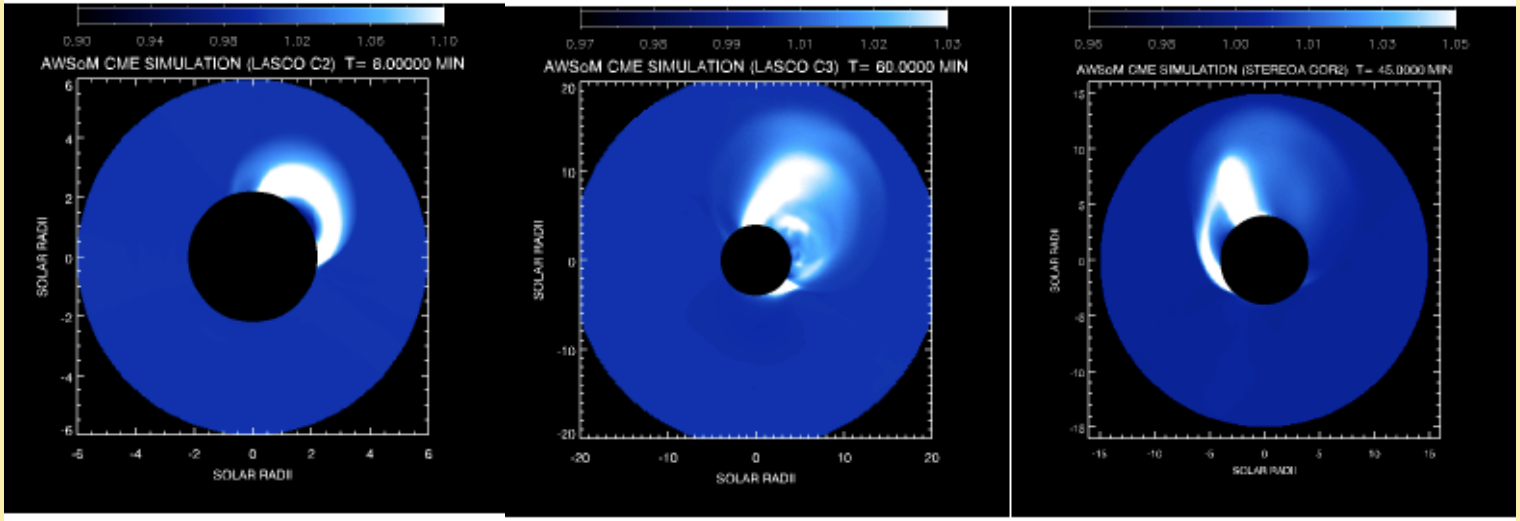
- Coronagraph determines CME speed (from height-time)
- Speed sets reconnected magnetic flux of flux rope
- Low speeds (<1500) most likely impacted by wind speed and density variation

White Light Images

LASCO C2 | LASCO C3 | STEREO A COR2

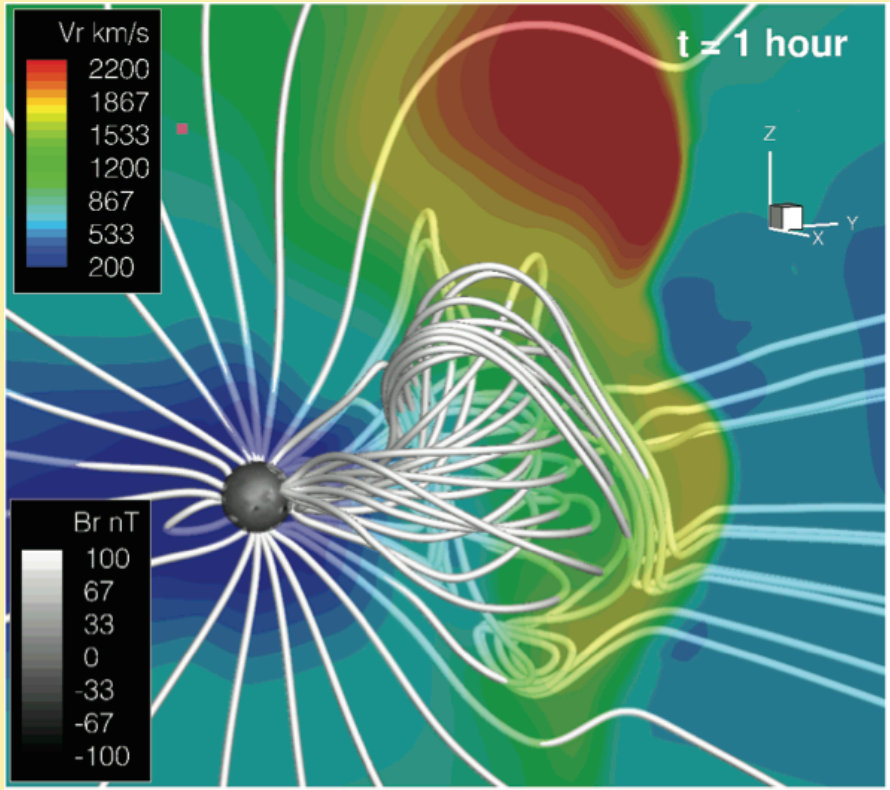


Observation



Simulation

1 AU Comparison



- Time shifted by 10 hours to show agreement with magnetic signatures at 1AU (but not the arrival time)