MHD Simulations of Stream Interaction Regions

- Modeling Carrington Rotations 2109 & 2123

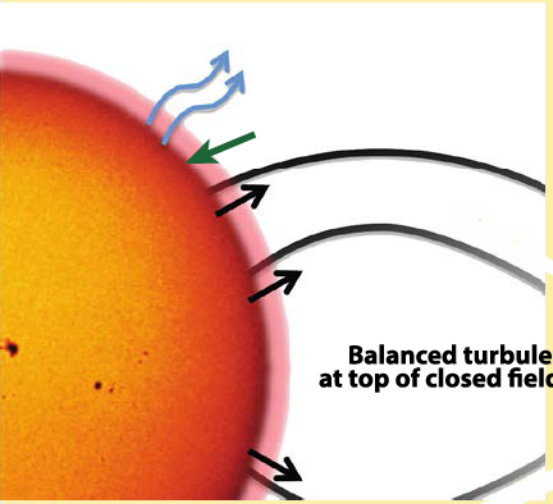
- *Chip Manchester & Bart van der Holst*

Alfvén Wave Solar Model (AWSoM)

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

XMHD physics:

- Separate $T_{p\|}$, $T_{p\perp}$ and T_e
- WKB equations for parallel and antiparallel propagating turbulence ($w_\pm$)
- Non-WKB physics-based reflection of $w_\pm$ results in turbulent cascade
- Correction for presumed uncorrelated waves $w_\pm$ in the balanced turbulence near apex of closed field lines
- 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



mbalanced turbulence
on open field lines

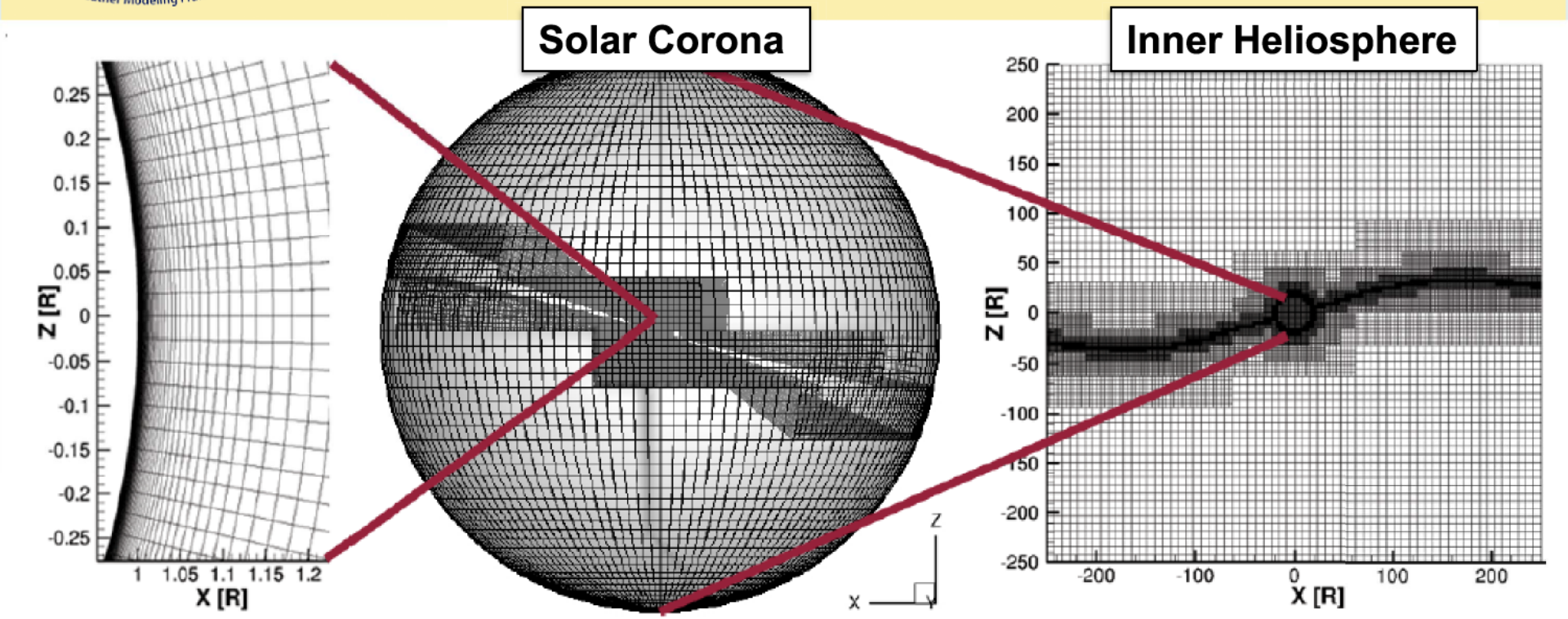
Boundary Conditions:

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

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

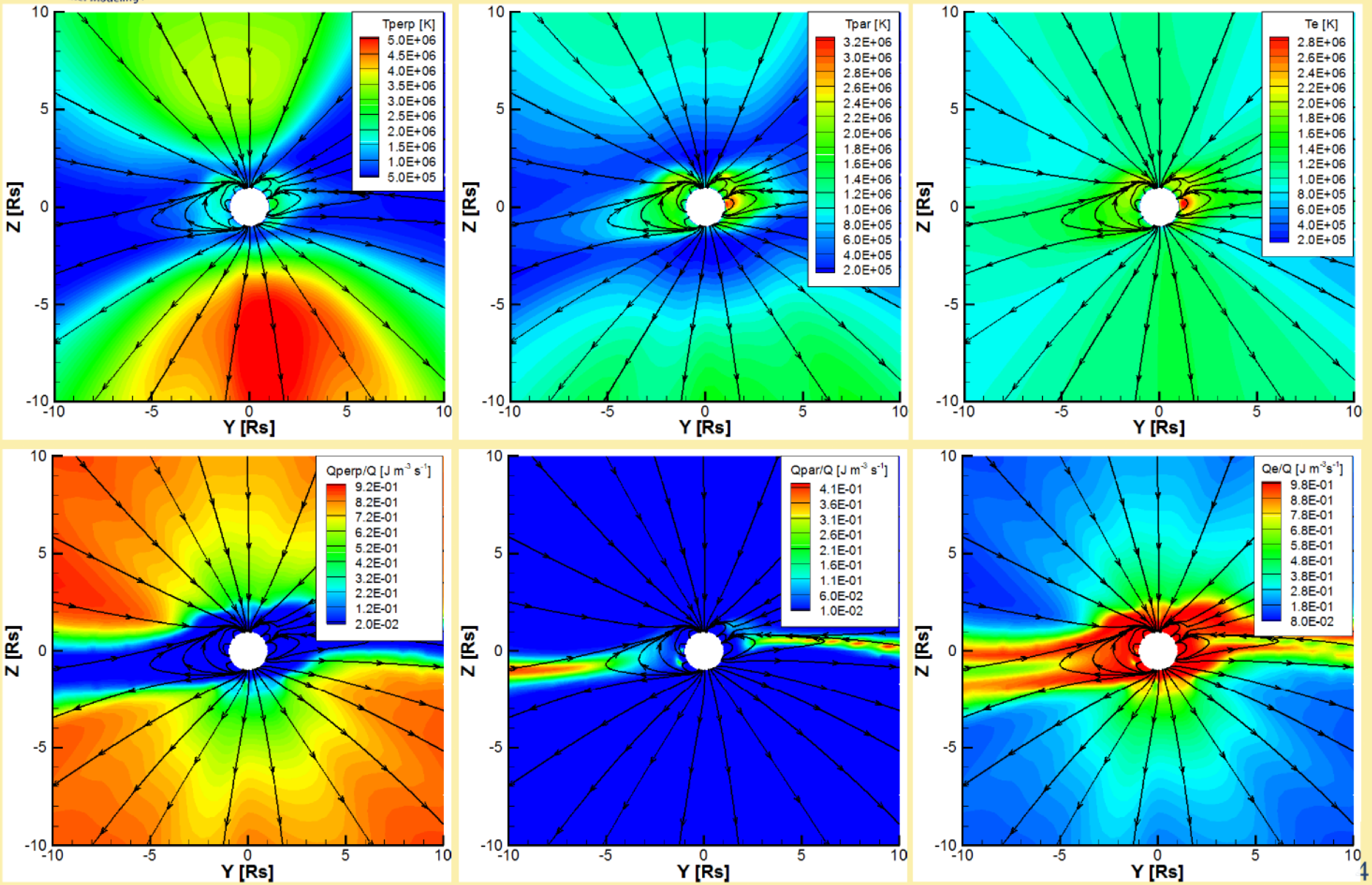
(This Poynting flux is based on Hinode observations by B. De Pontieu)

Computational Grids



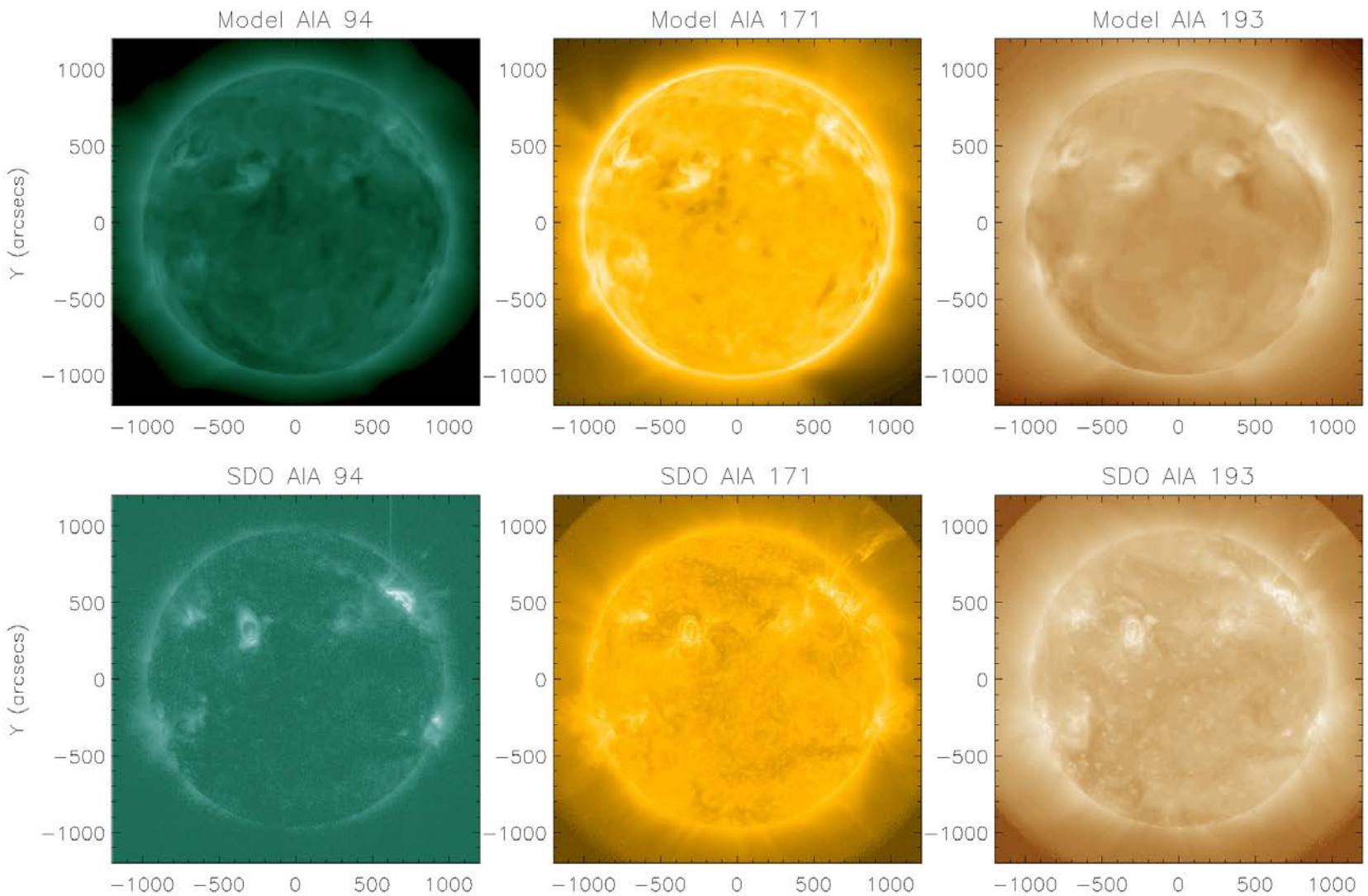
- Significant grid stretching to grid resolve the upper chromosphere and transition region in addition to artificial transition region broadening (Lionello et al. 2009, sokolov et al. 2013)

Heat Partitioning



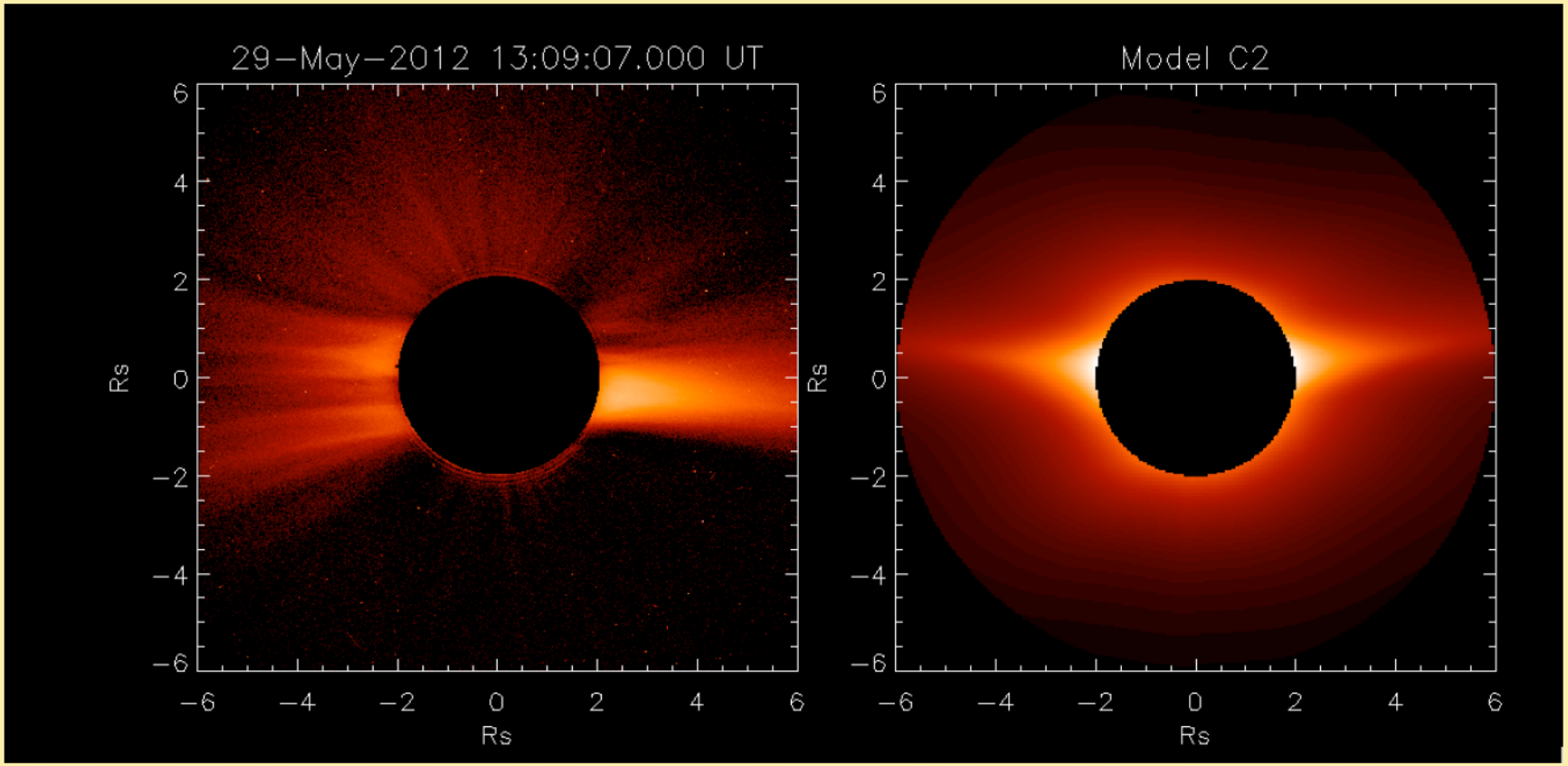
LOS EUV images for CR2107

Wave turbulence heating capable of reproducing EUV emission

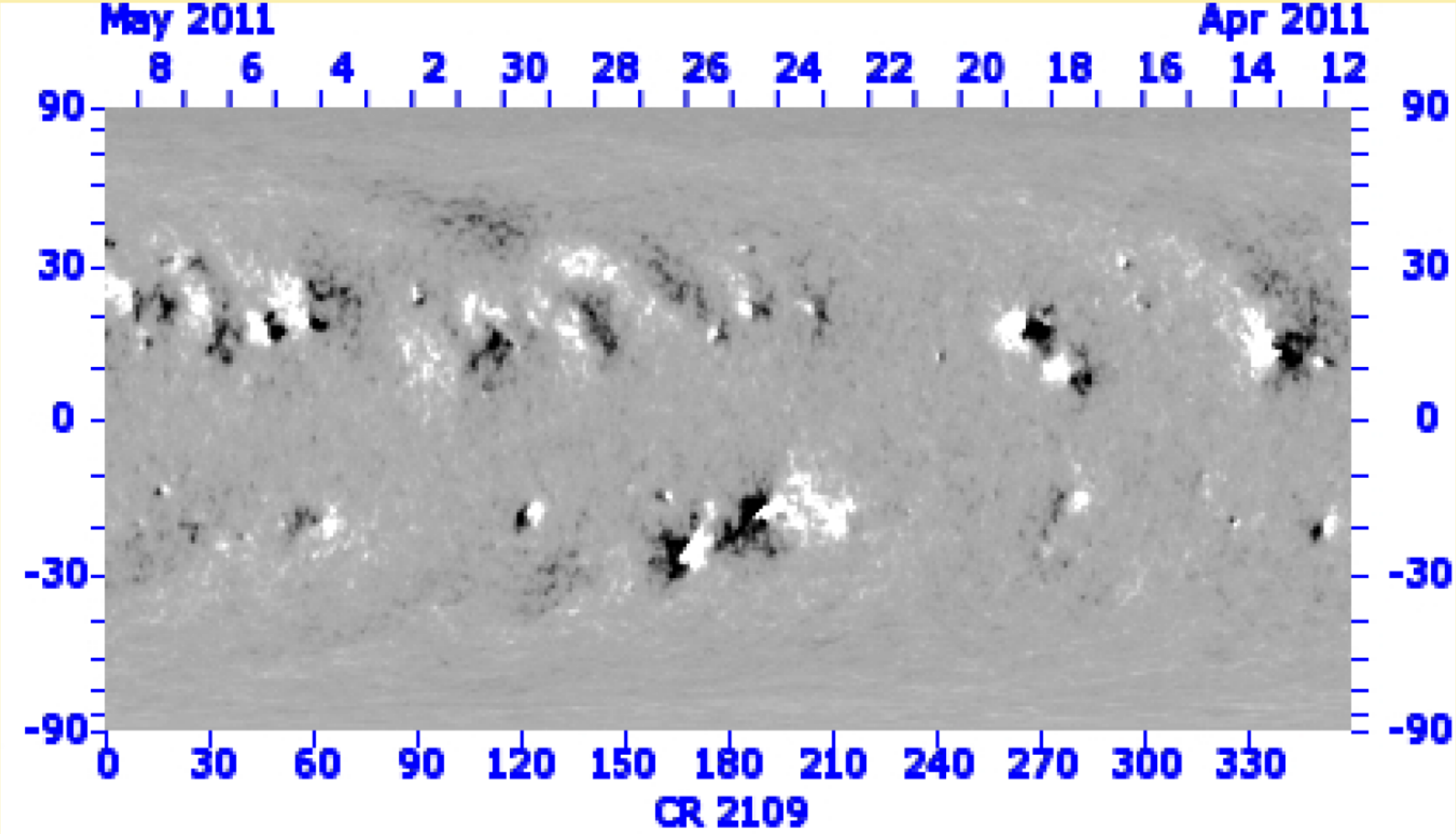


Synthesized Images

- Wave turbulence capable of reproducing coronal electron density



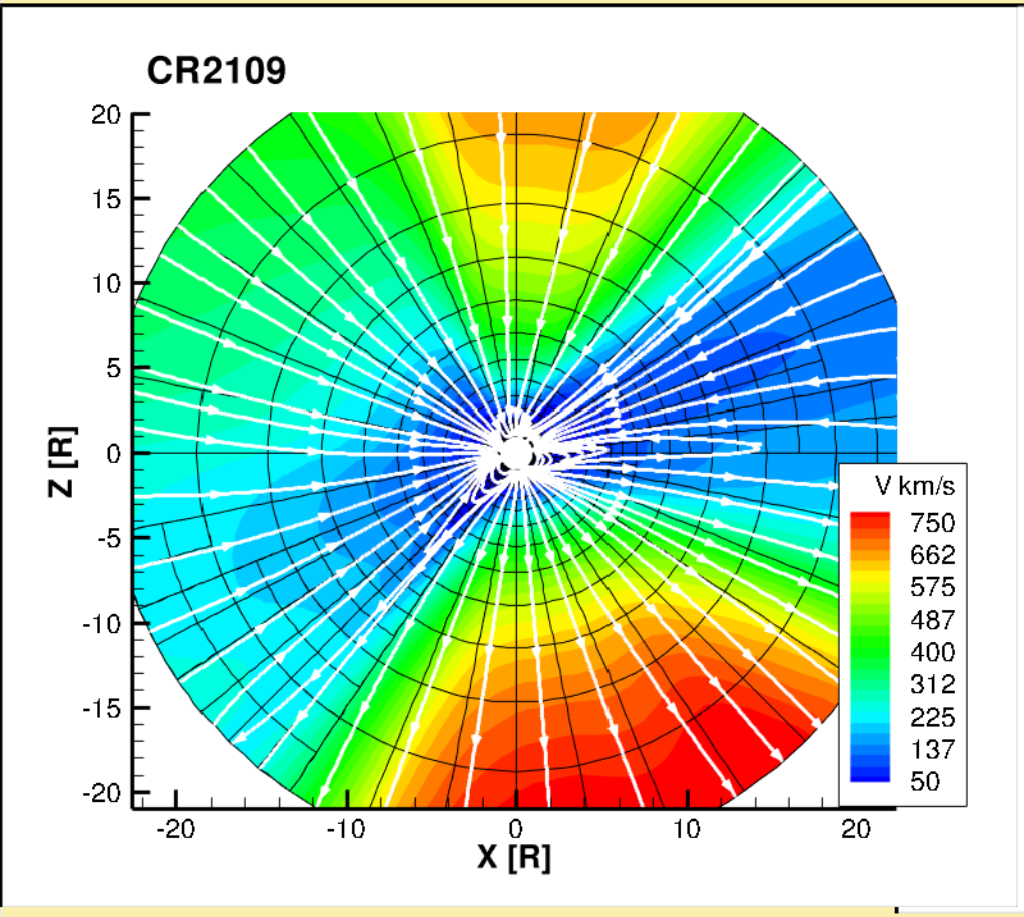
GONG Synoptic Magnetogram for CR2109

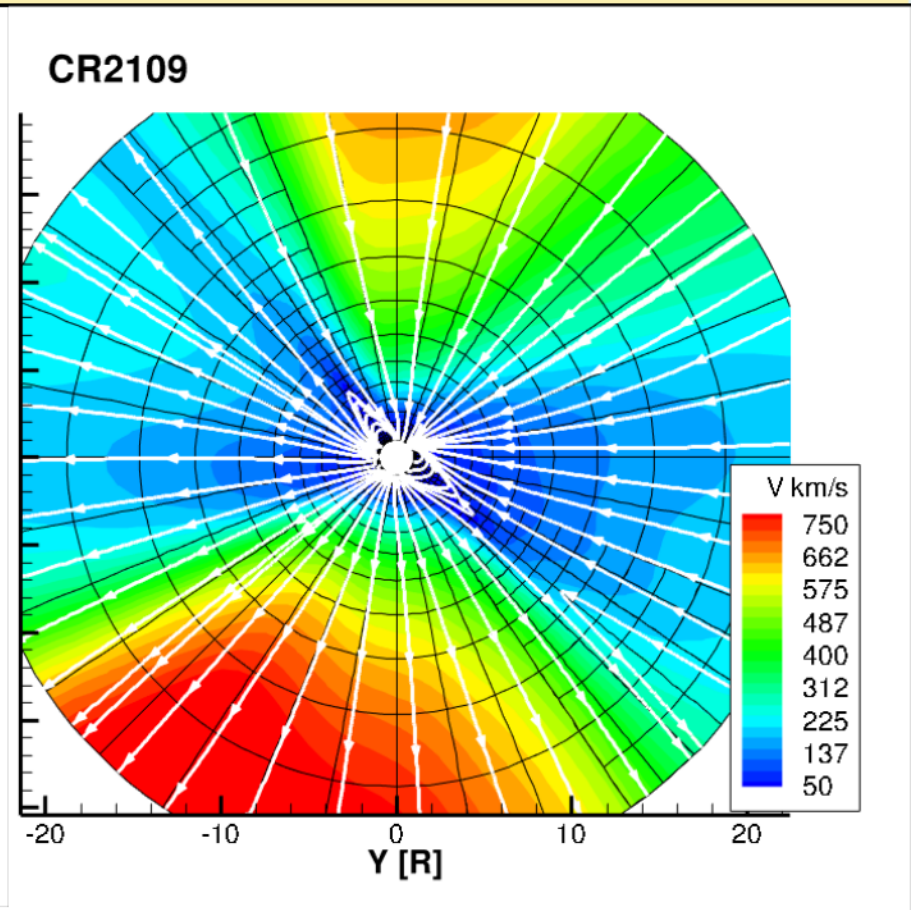


CR2109: SC Highly Inclined Current Sheet

High Speed Wind Extends from Coroal Holes

Current Sheet Inclination Leads to Strong Stream Interaction





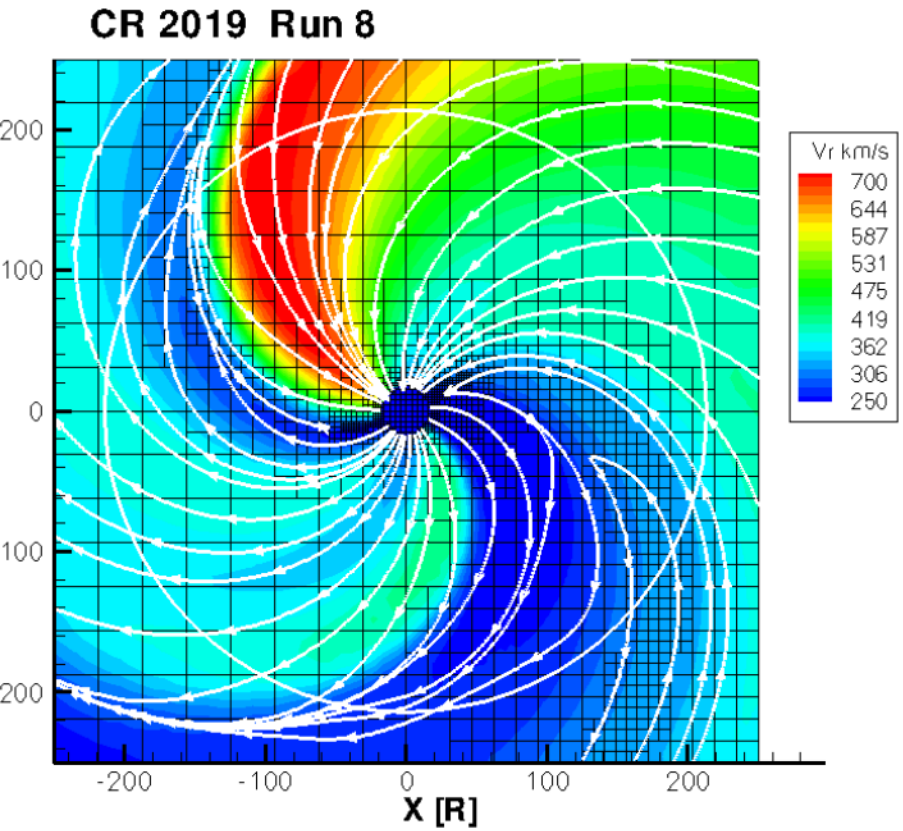
CR2109: SC Highly Inclined Current Sheet

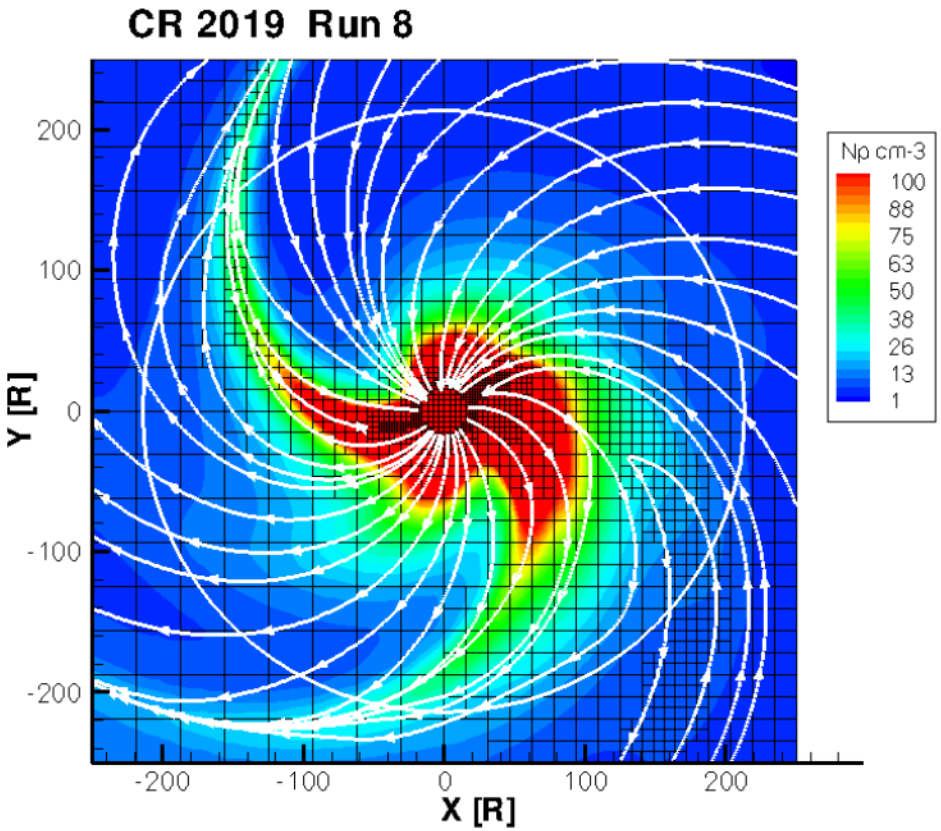
CR2109: Stream Interaction Regions

Radial Velocity and Density in the IH on the Equatorial Plane

HSSs Impact Slow Streams to Form Compressions

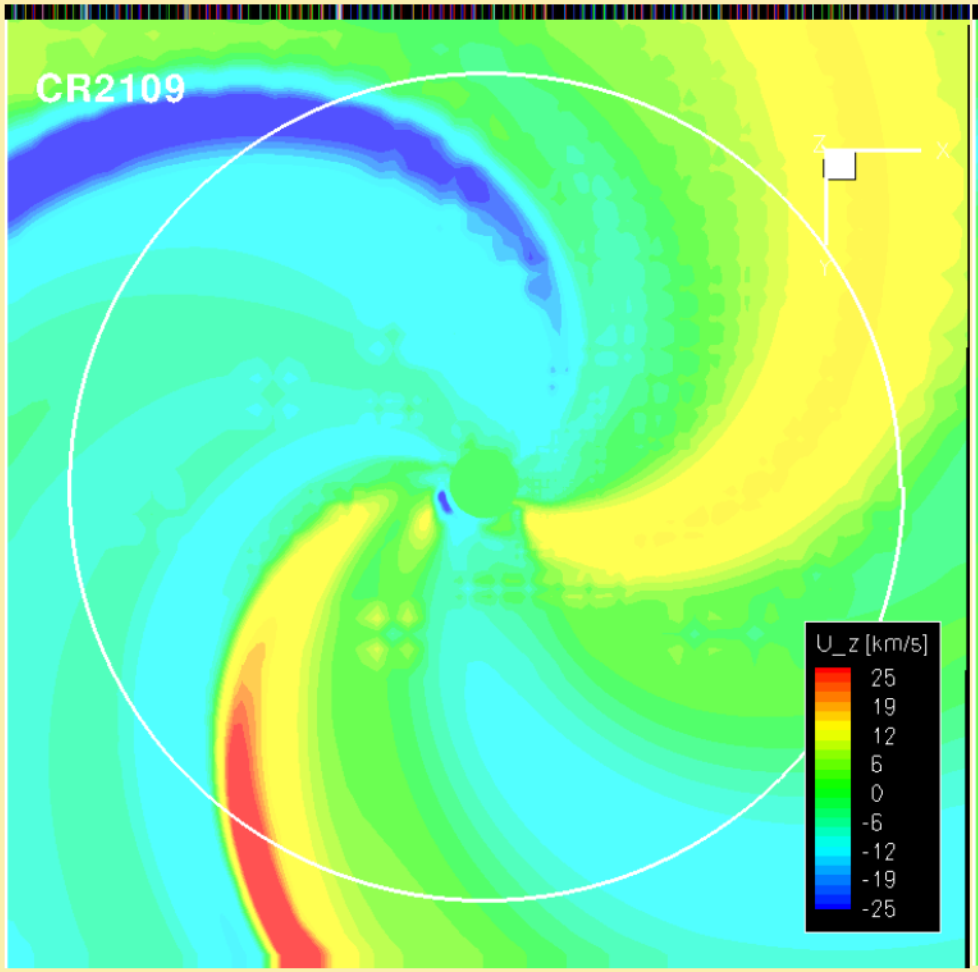
AMR allow for 10 Re resolution at Earth

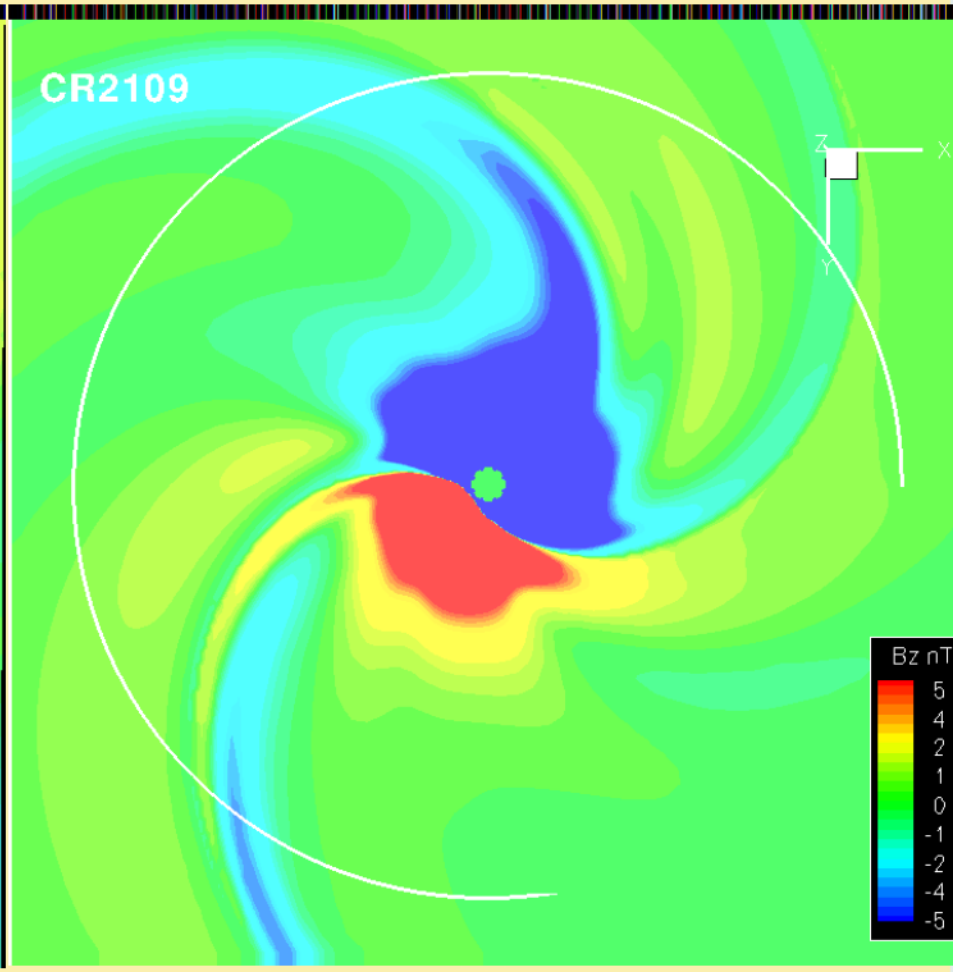




CR2109: Stream Interaction Regions

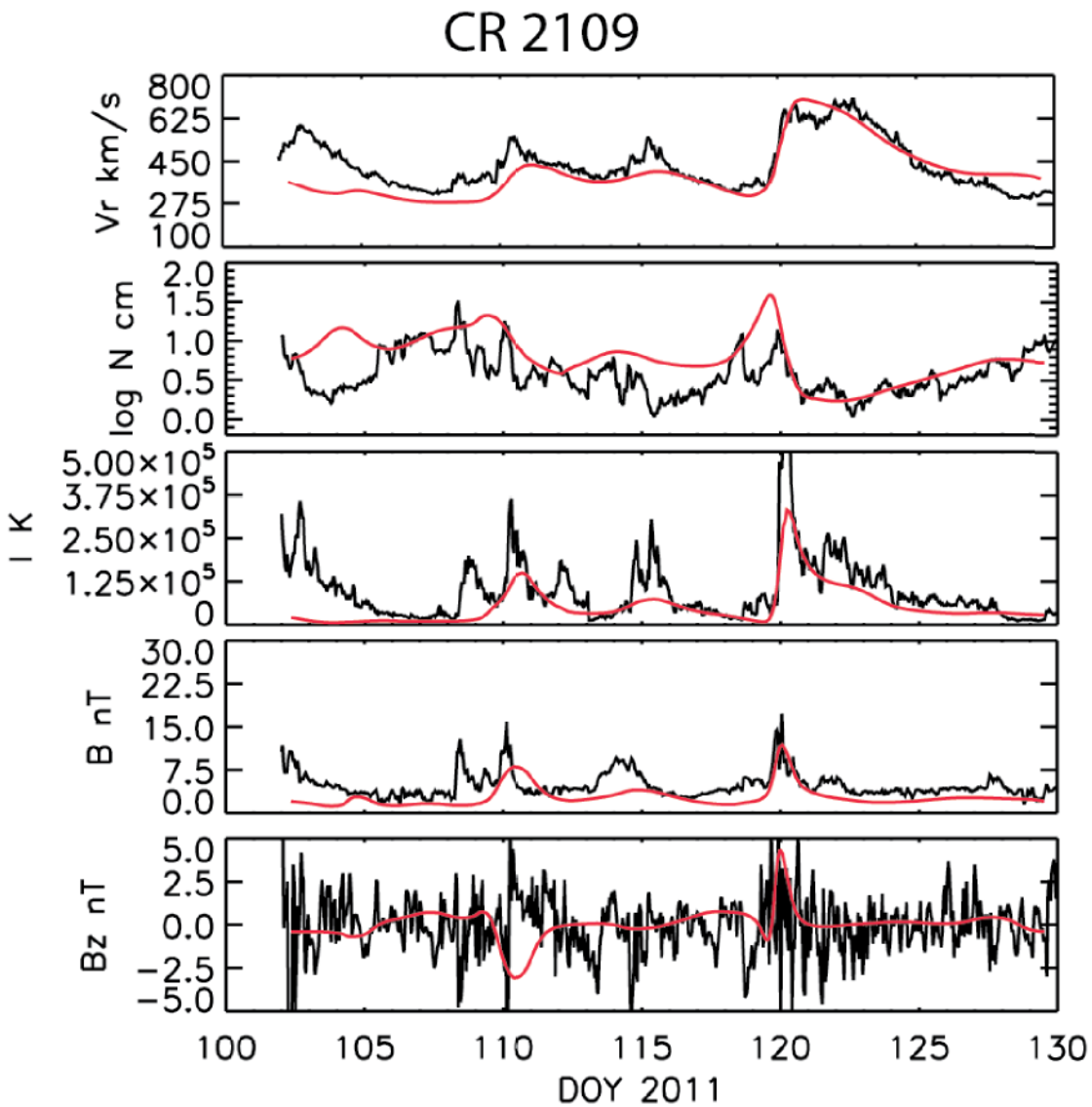
Uz and Bz enhancements at SIRs boundaries



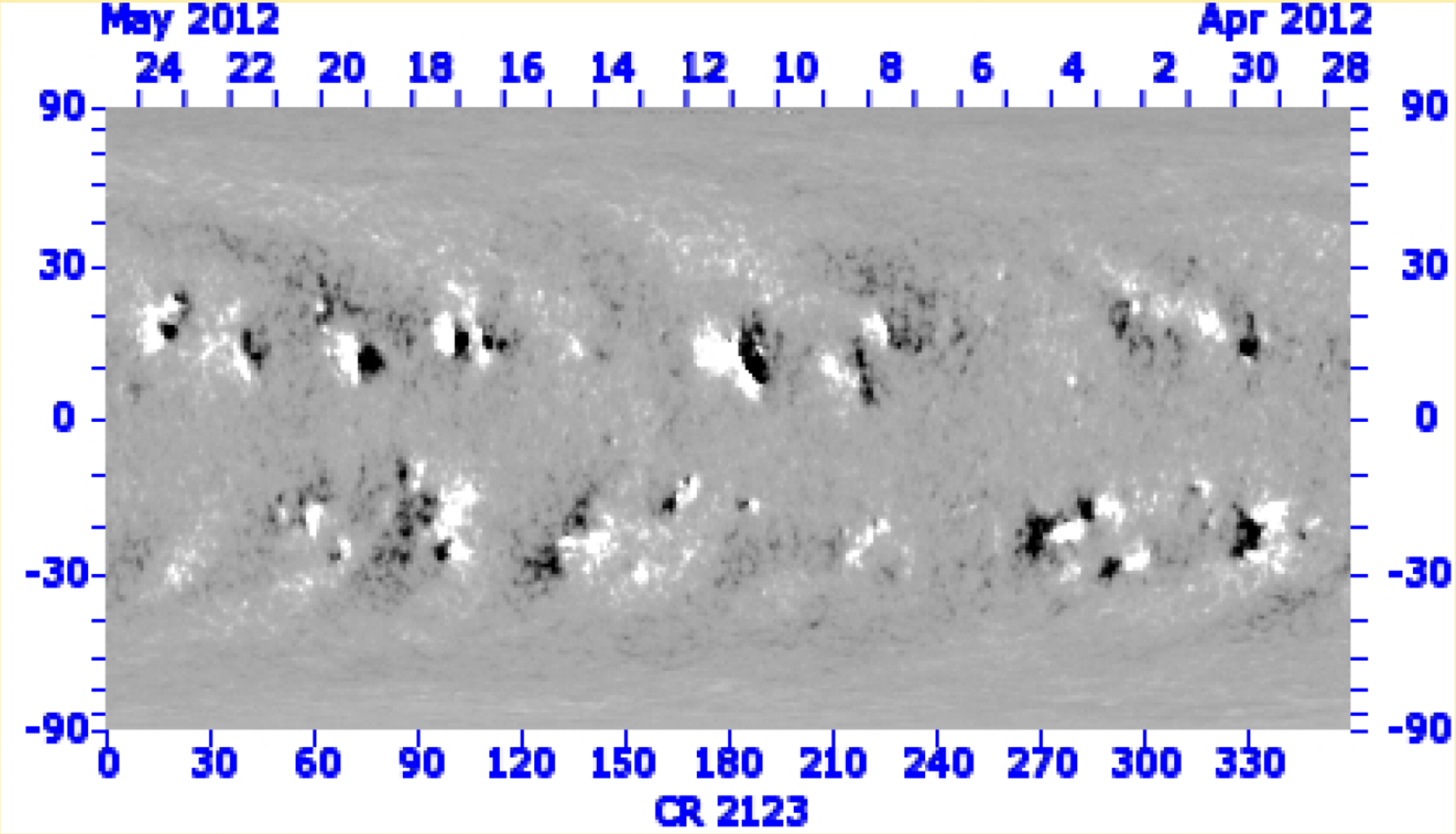


CR2109: Prediction of MHD Quantities at Earth

- All quantities are well predicted
- More variability in Bz than in other quantities

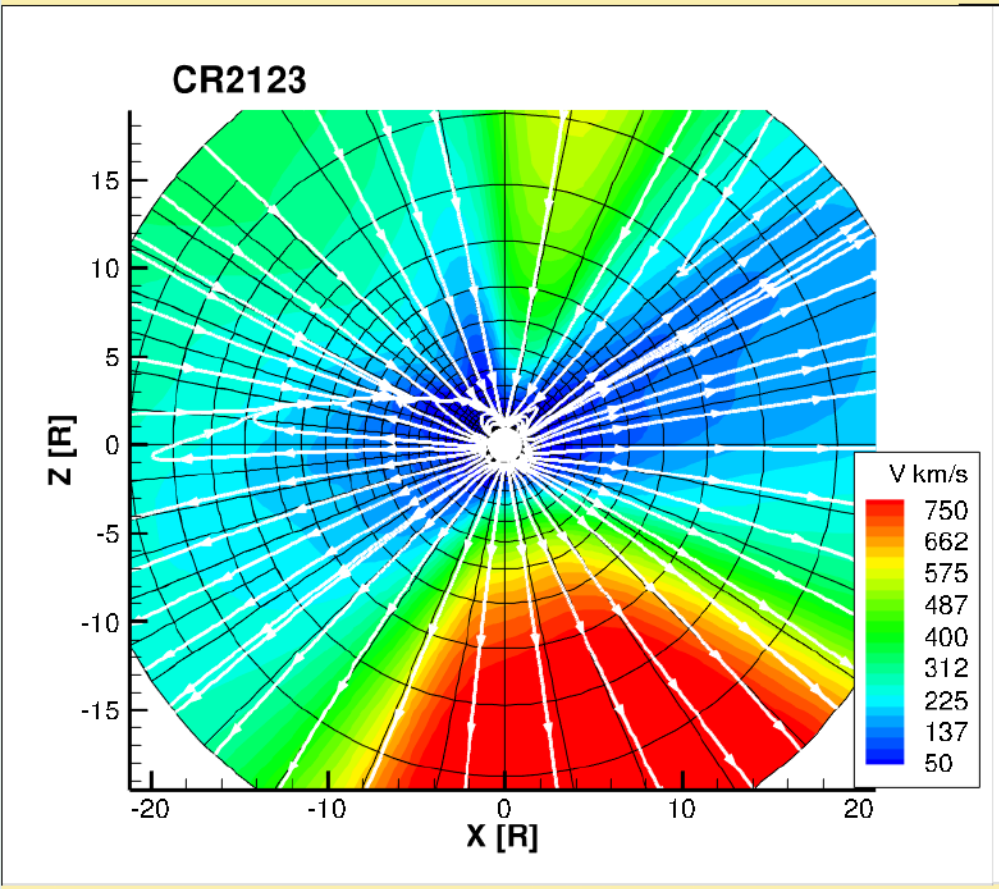


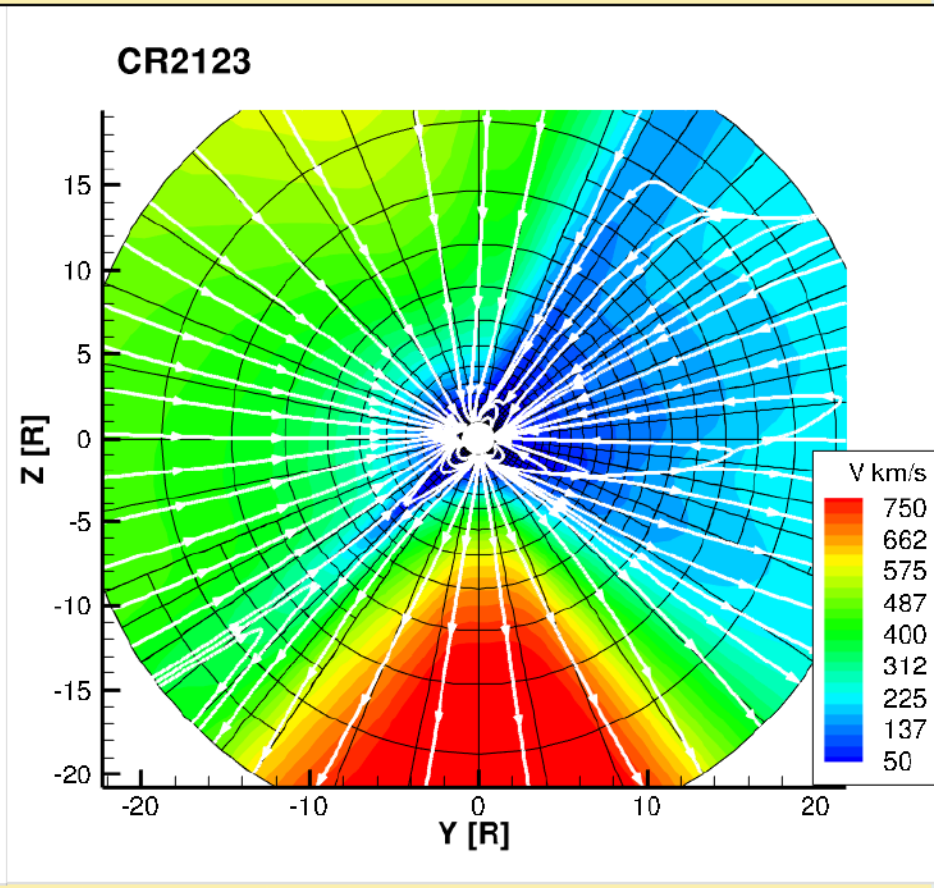
GONG Synoptic Magnetogram for CR2123



CR2123: SC Highly Bent Current Sheet

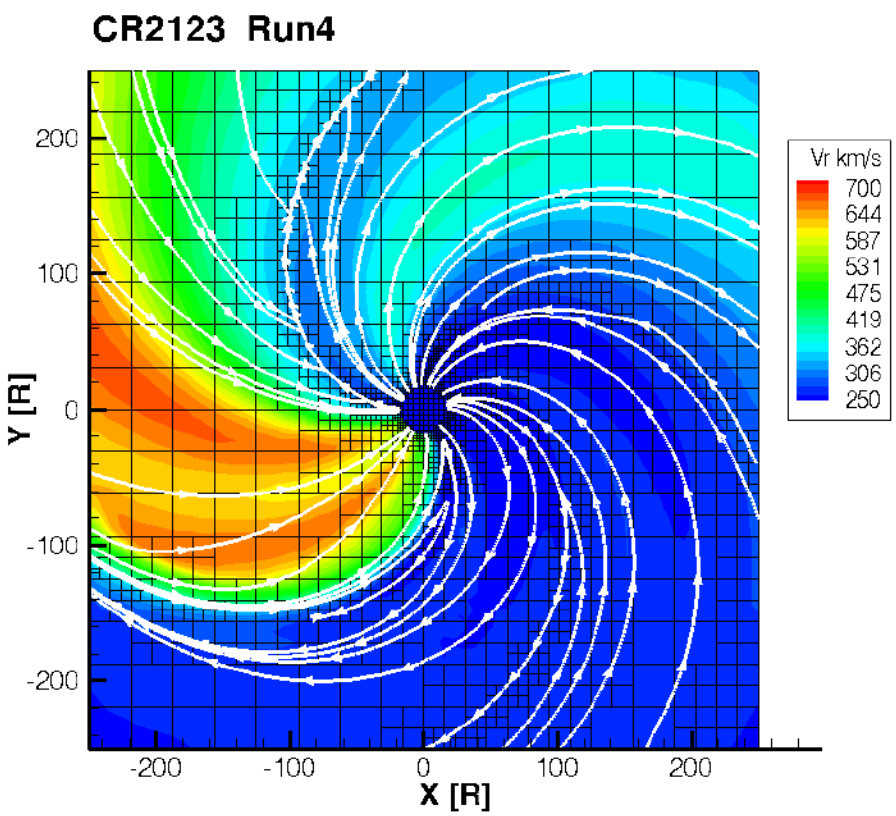
Bent Sheet Leads to Strong Stream Interaction

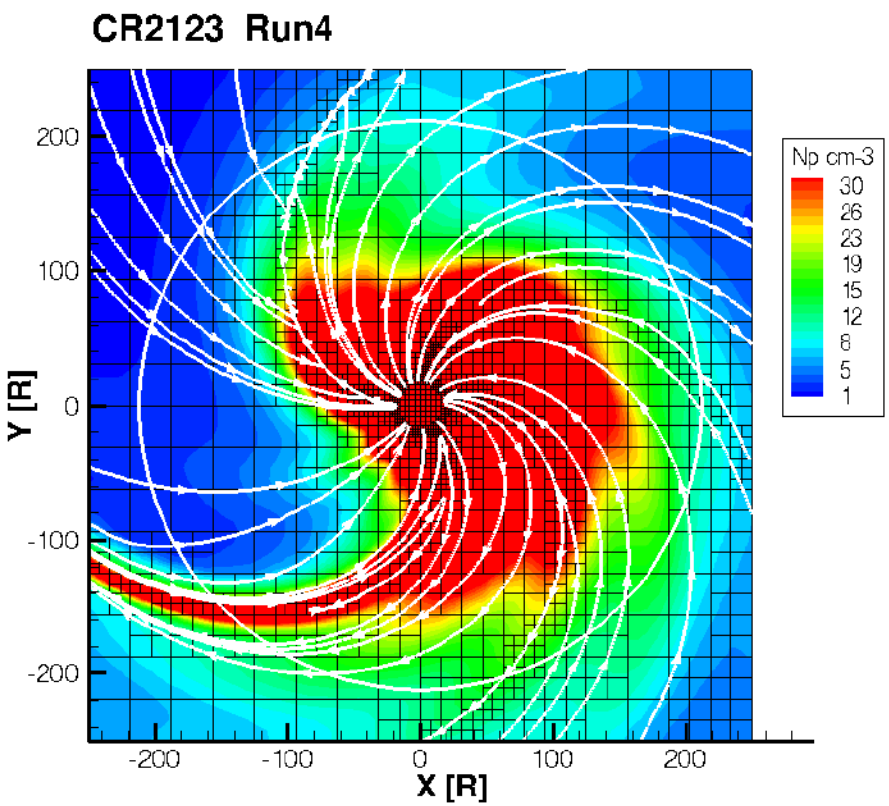




CR2123: SC Highly Bent Current Sheet

CR2123: Stream Interaction Regions





CR2123: Prediction of MHD Quantities at Earth

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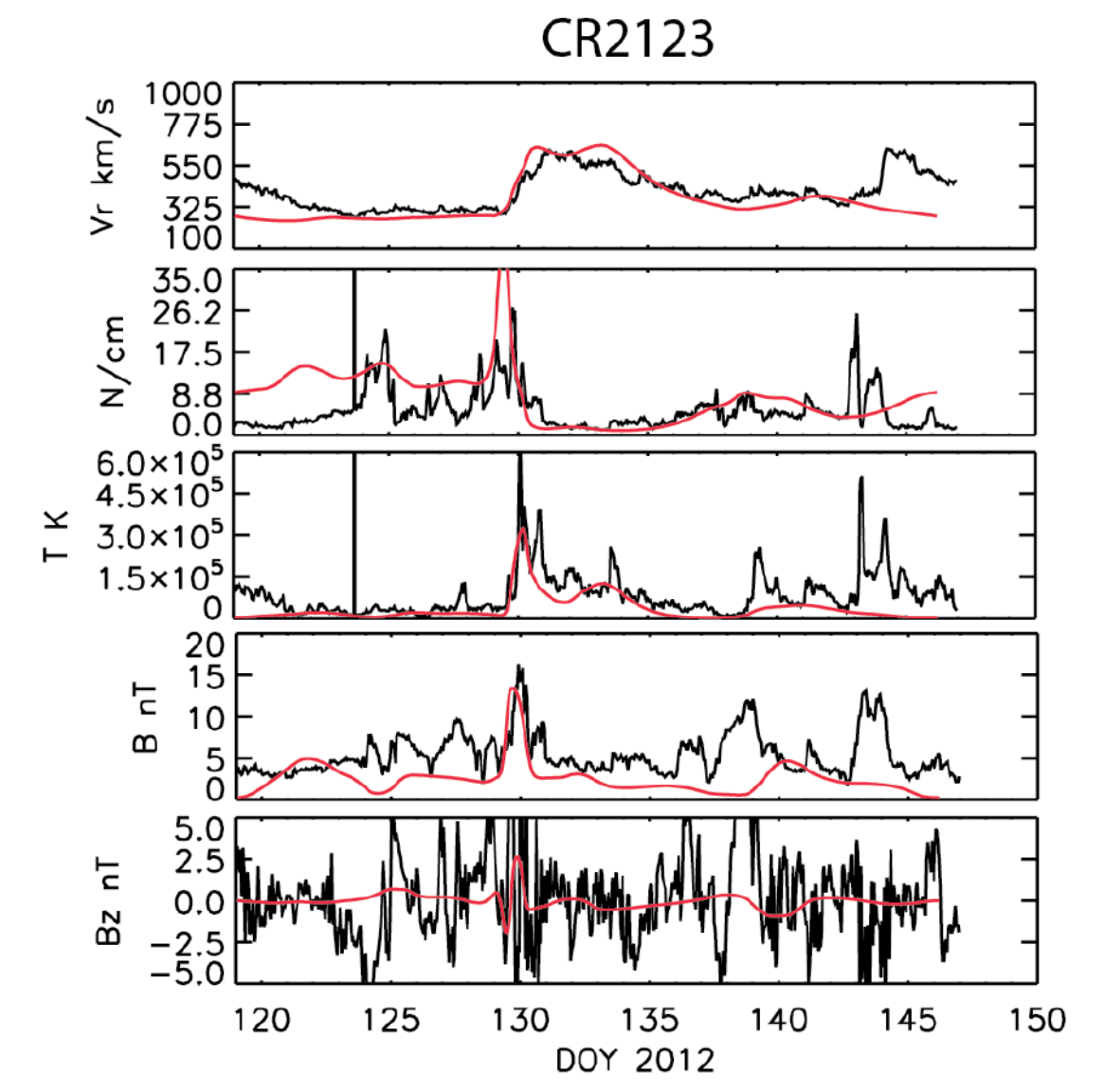
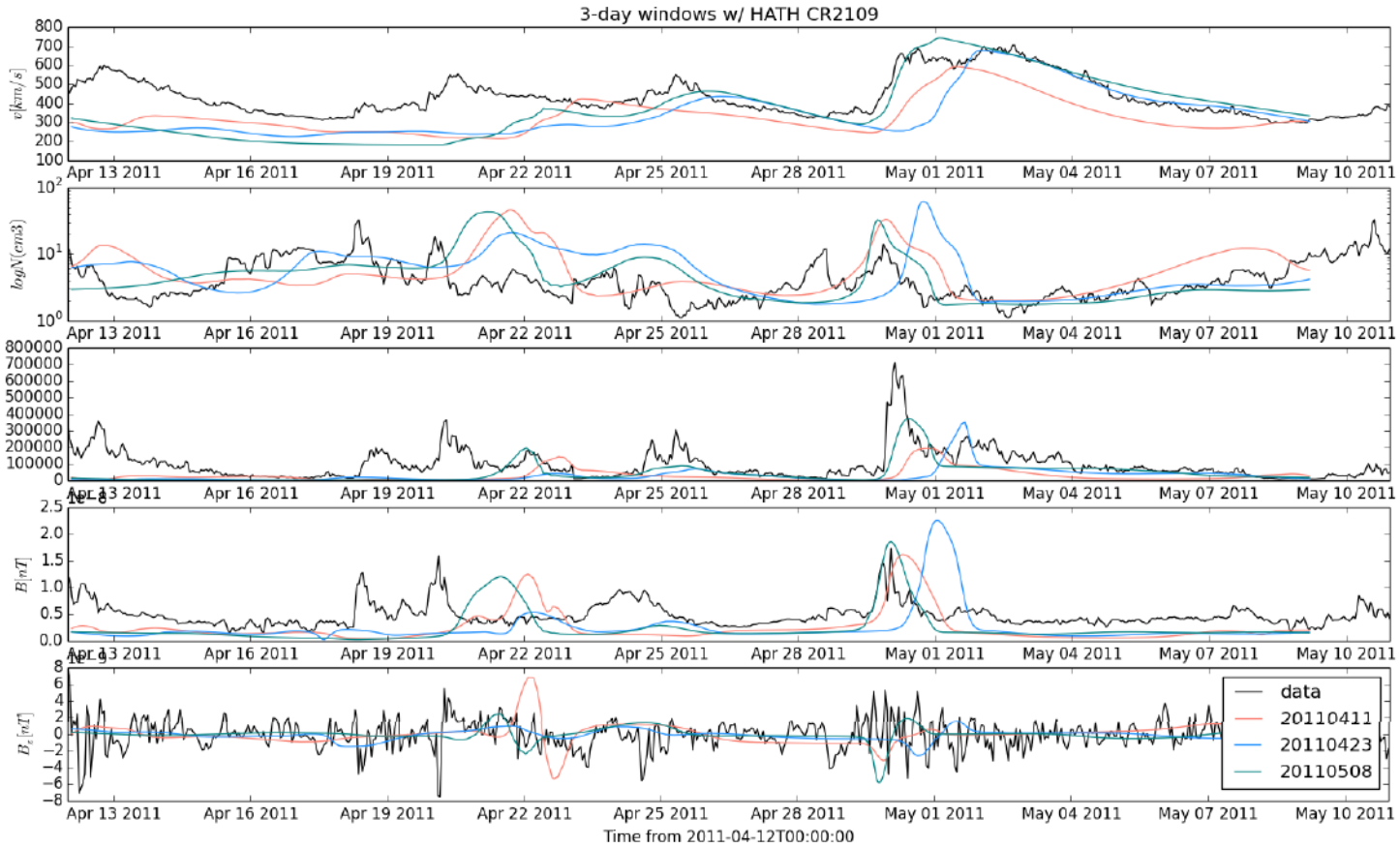
- More variability in Bz than in other quantities



Synchronic Maps: Results for CR2109

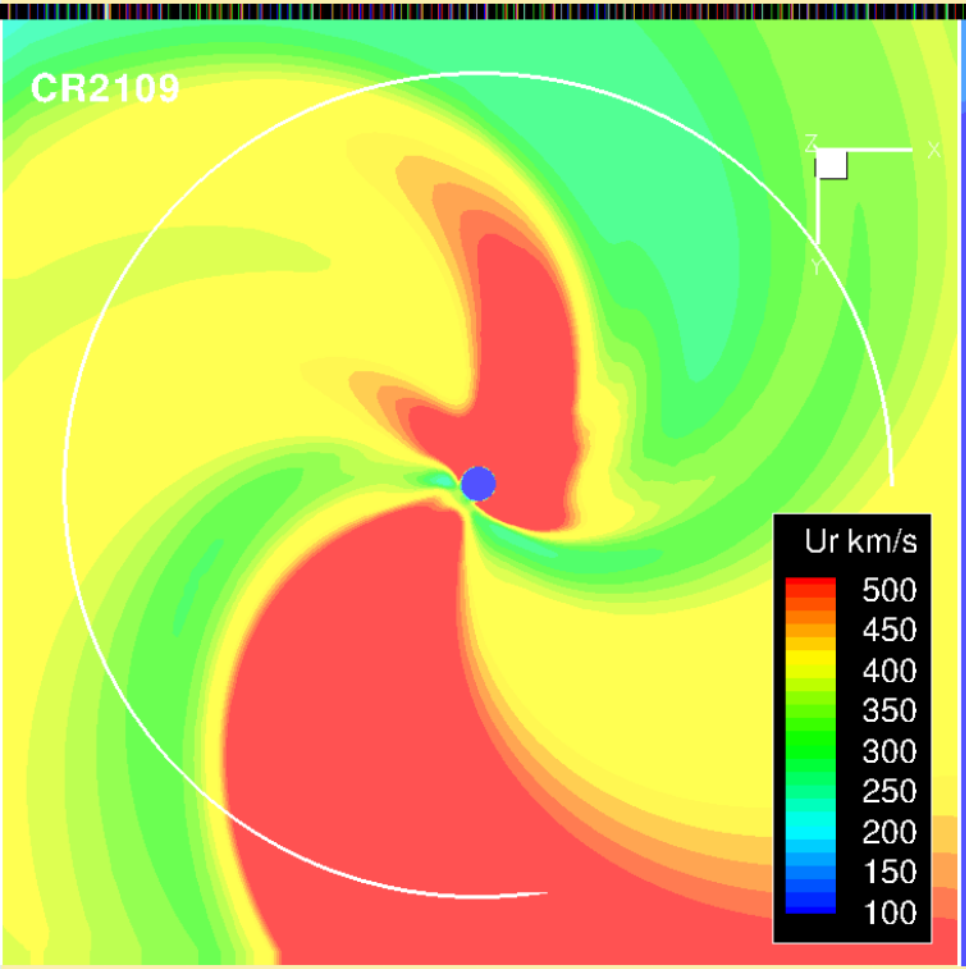
MHD quantities show significantly better fit with the data

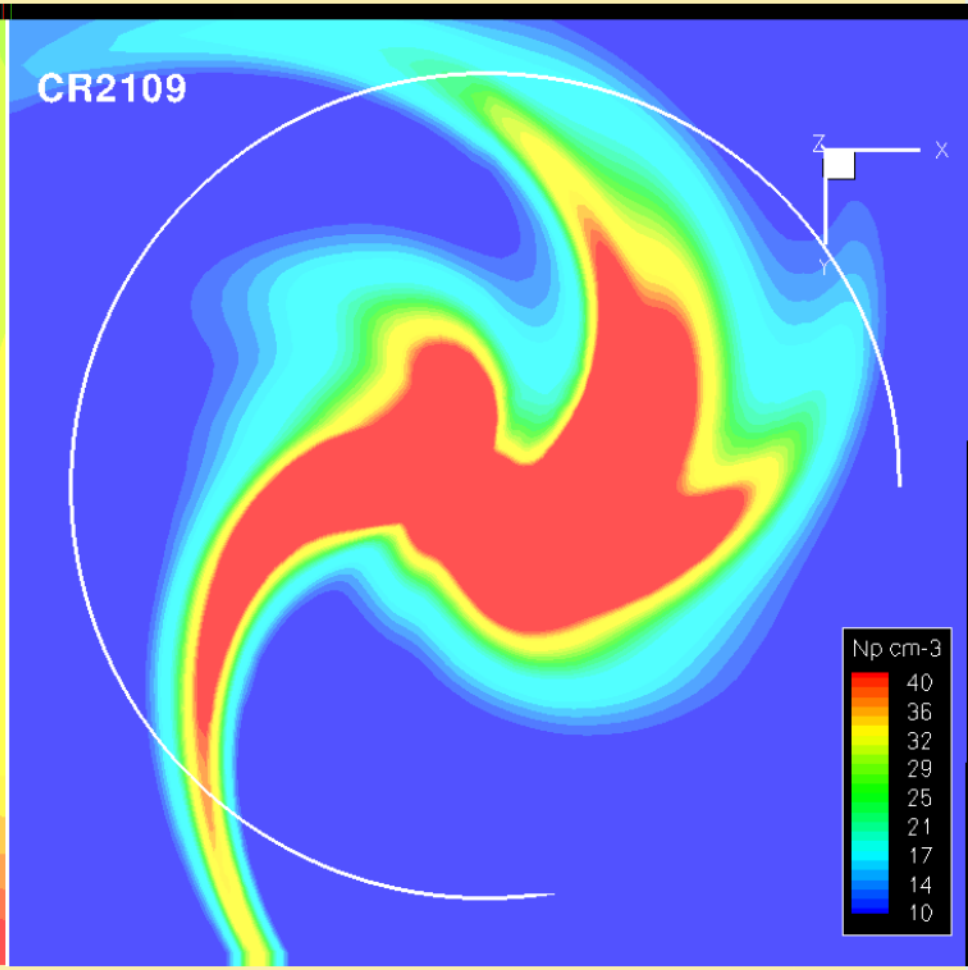


Summary

- **Modeling Steady State Wind and Stream Interaction Regions**
  - AWSoM Alfven wave-driven 2-3T MHD coronal model with field aligned heat conduction upper transition region
  - Data input: GONG synoptic magnetogram CR2109 & 2123
  - AMR to resolve the heliospheric current sheet and SIRs to 10 Re
- **Results**
  - Model MHD quantities at 1 AU & capture SIRs
  - Make predictions of stream structure over a rotation period
  - Results diverge from observations at the beginning and end of the Carrington Rotation
  - Bz show large variations that the model cannot capture, Alfvenic Turbulence as well as small scale advected structures
- **Current Work**
  - Apply Synchronic Maps to provide better fits at the endpoints of the Carrington Rotation
  - Time Accurate Runs with code speed up by a factor of 100

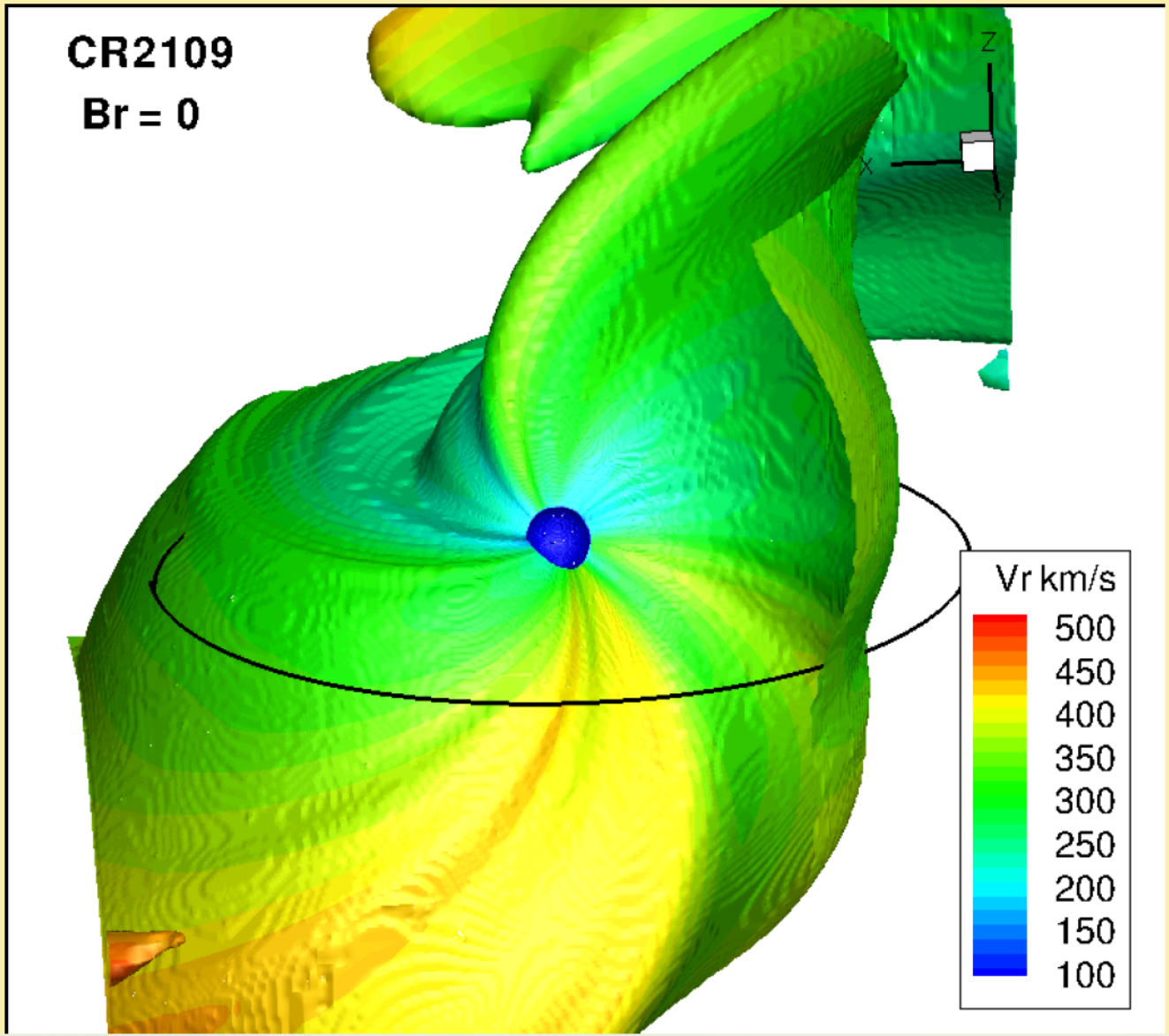
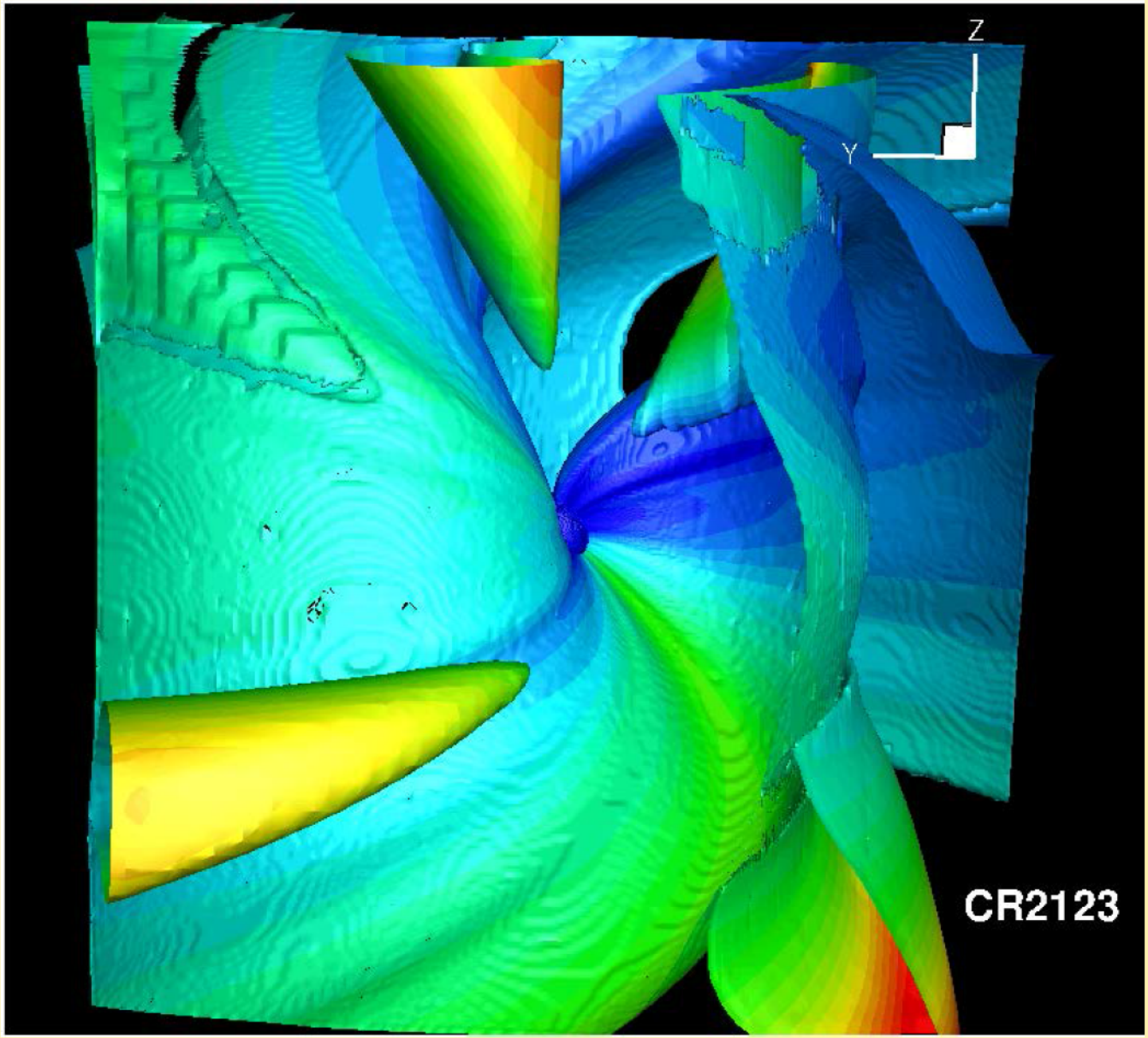
CR2109: Stream Interaction Regions





CR2109: Heliospheric Current Sheet

Br = 0 iso-surface



CR2123: Heliospheric Current Sheet