Three-Dimensional Tomographic Reconstruction and MHD Modeling of WHPI target rotations CR-2219 and CR-2223

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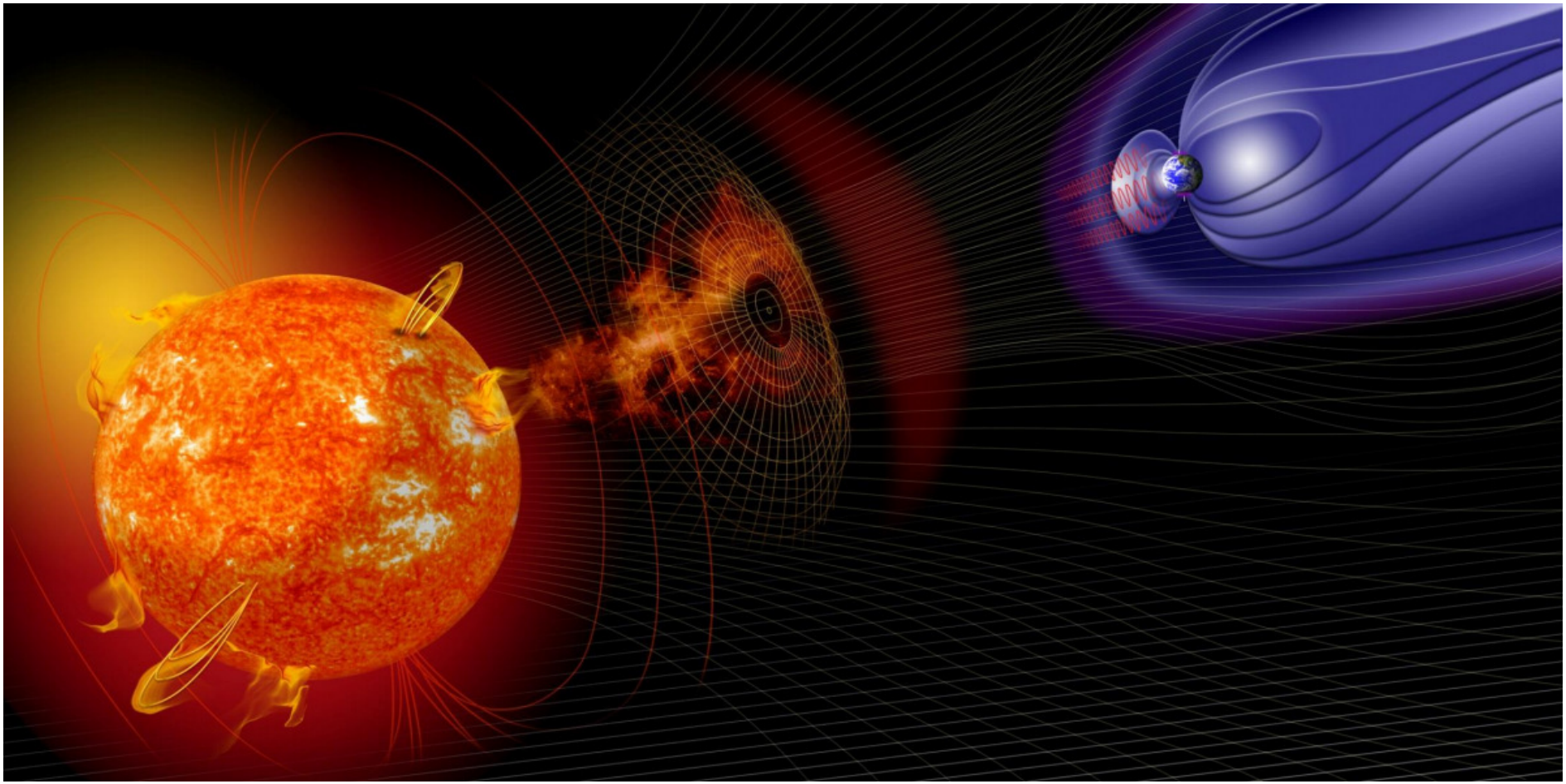
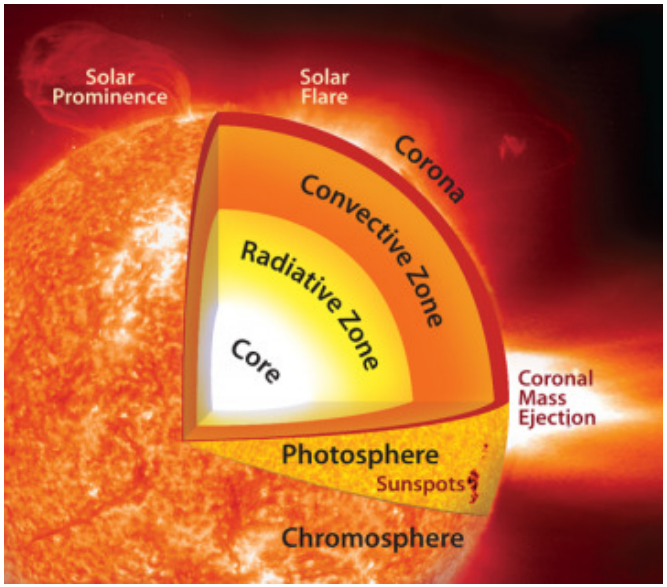
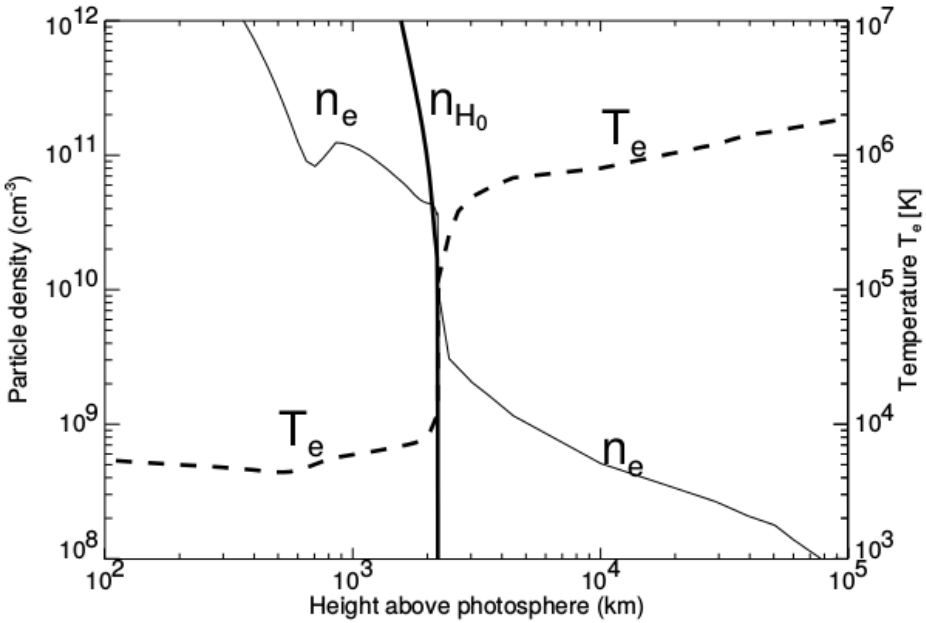
Solar Corona and Sun-Earth relation



Being the region where the solar wind is heated and accelerated, and impulsive events as solar flares and coronal mass ejections are released, observation and modeling of the Solar Corona is of great relevance to advance our understanding of the Sun-Earth environment.

Solar Corona

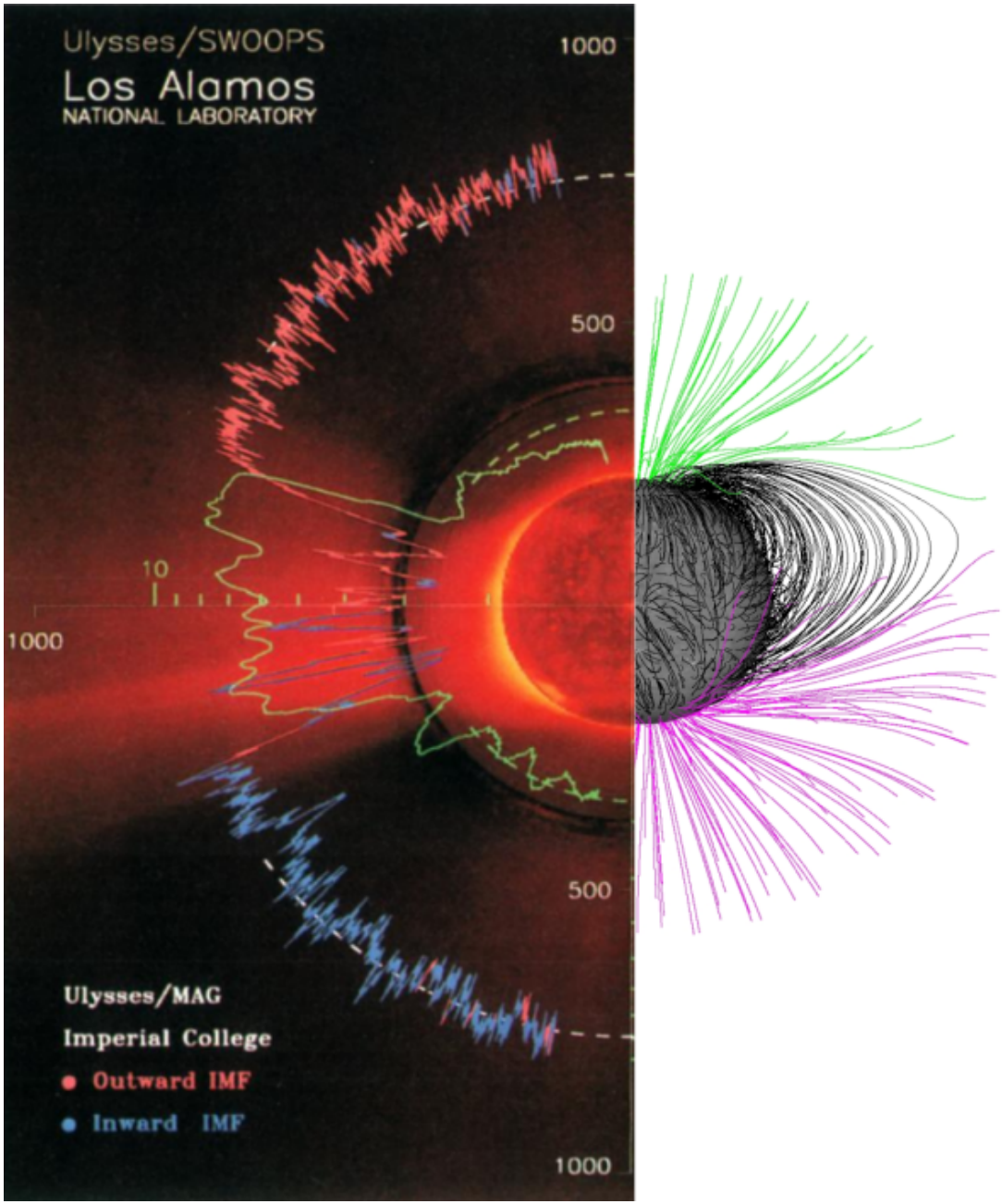




Corona ($T \approx 1 - 10$ MK, $n \approx 10^{10-7}\ \mathrm{cm}^{-3}$)

- The corona is optically thin in the UV, EUV, X, VL ranges.
- Images are thus 2D projections of the underlying 3D emitting structure.
- Advancement of physical models is in need of 3D information of the coronal fundamental parameters **B**, N_e, T_e and chemical abundances.

Solar Wind



- The plasma flows along open magnetic lines
- High-latitude open lines exhibit a fast and low-density regime
- Near-streamer open lines exhibit a slow and high density regime

McComas et al. 2000
(Journal of Geophys. Res.)

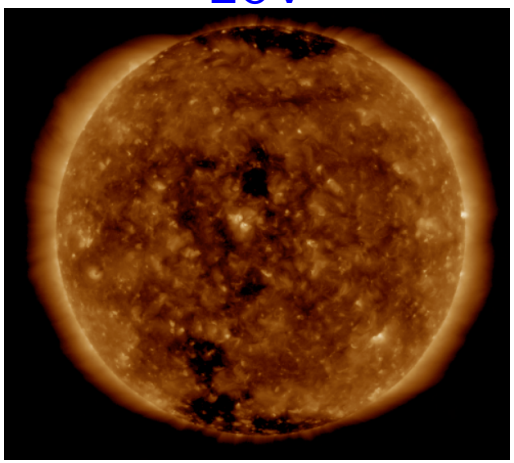
Suess et al. 2009
(Journal of Geophys. Res.)

Solar Rotational Tomography (SRT)

The object of study is the solar corona.
The solar rotation provides the necessary 360°view angles.

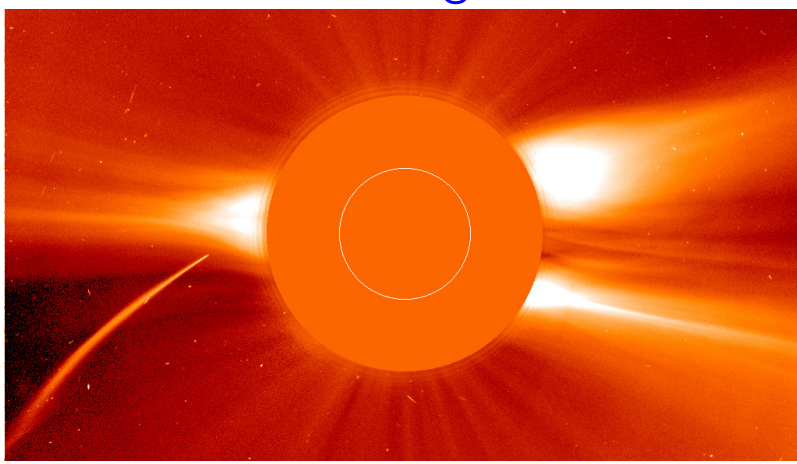
- Corona-E: True coronal emission by ions UV, EUV and X.
- SRT-EUV $\rightarrow$ 3D EUV emissivity $\rightarrow$ 3D $\langle N_e^2 \rangle$ and $\langle T_e \rangle$
- 1st SRT-EUV: Vásquez et al. 2009; Frazin et al. 2009

EUV



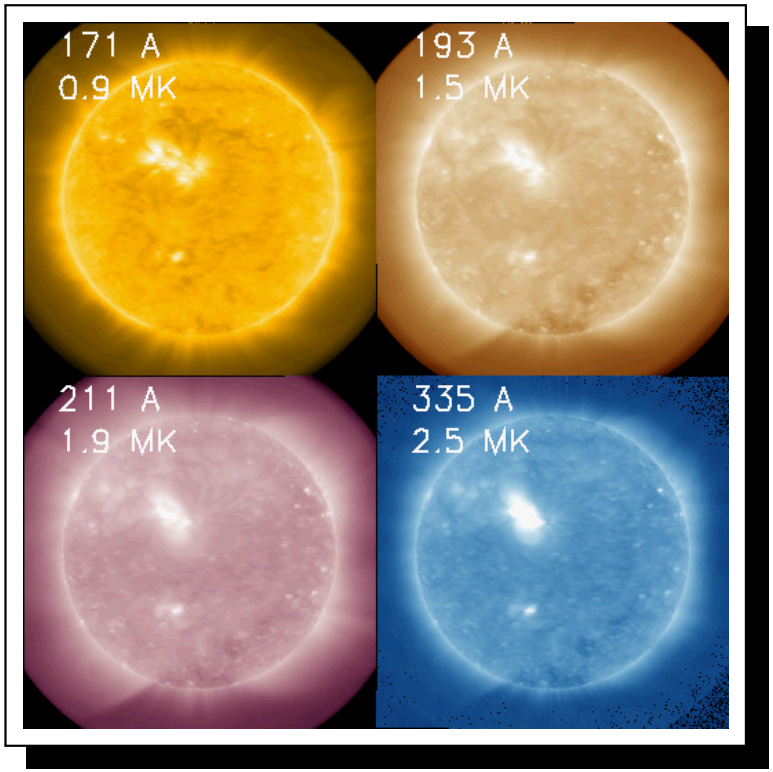
- Corona-K: Thomson scattering of photospheric visible light (VL).
- SRT-VL $\rightarrow$ 3D $\langle N_e \rangle$.
- 1st SRT-VL: Altschuler & Perry (1972)

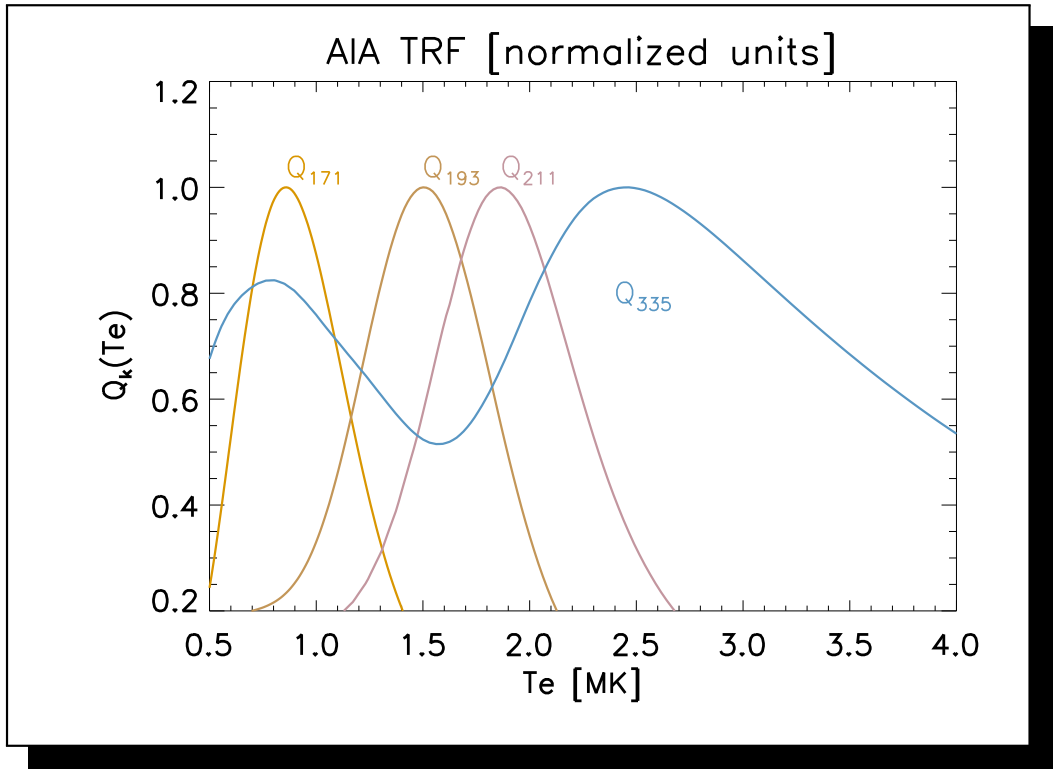
Visible Light



Characteristic Temperatures of the Solar Corona

AIA/SDO 4 bands: 0.5-4.0 MK

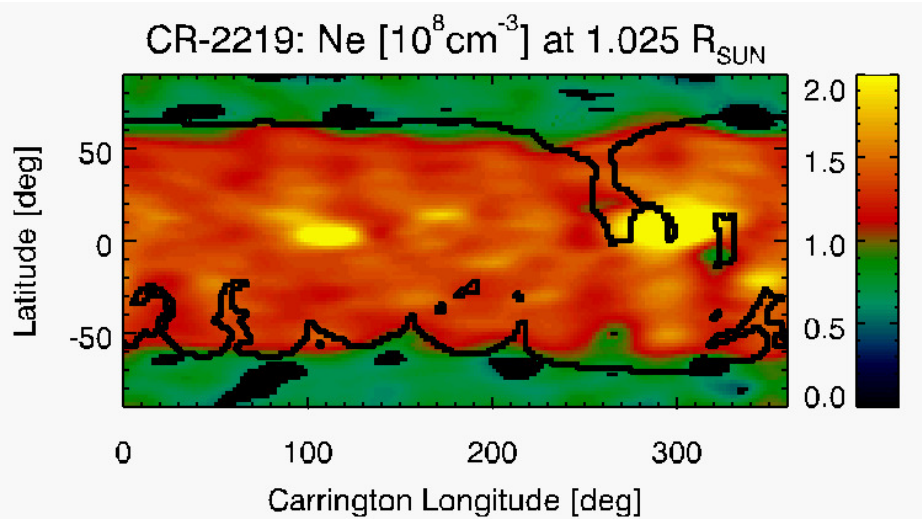


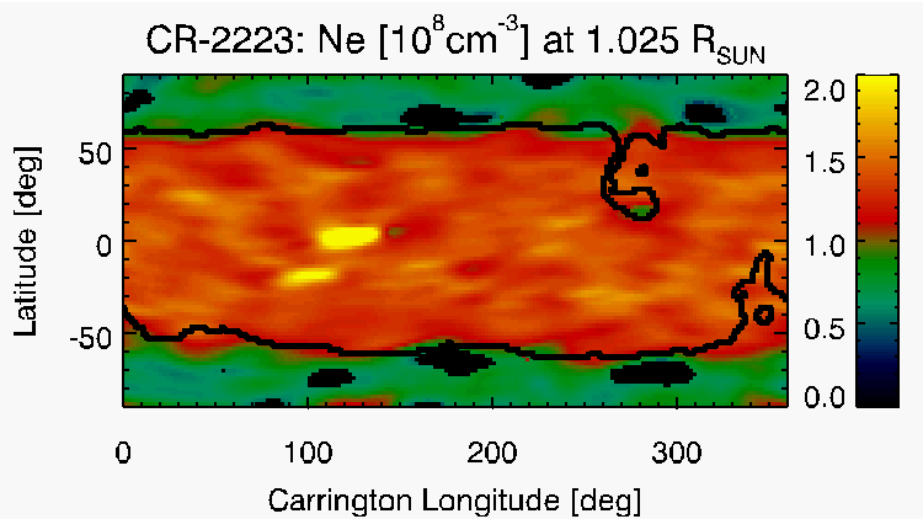


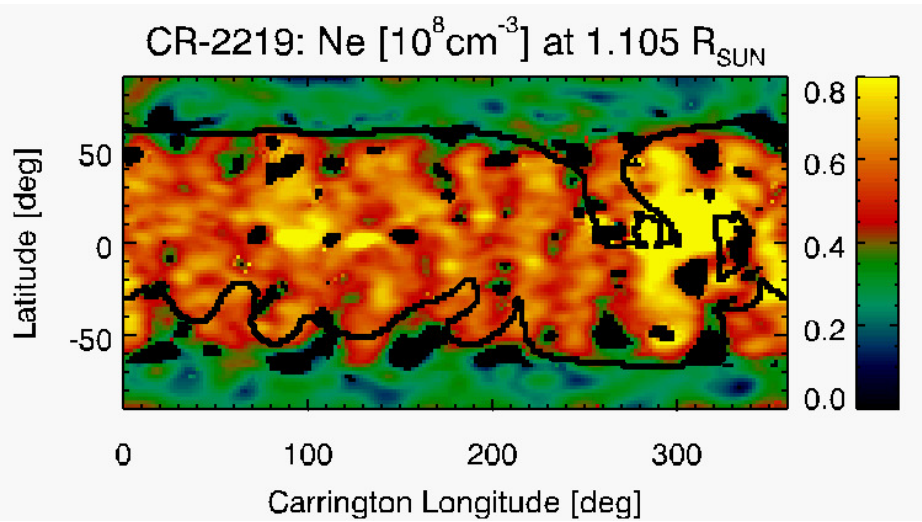
- $I_b = \int_{LDV} dI$ **E_b**
- $E_b = \int dT\ R_b(T)$LDEM(**T**) $\rightarrow \langle N_e^2 \rangle = \int dT$ LDEM(**T**)
  $\rightarrow T_m = \frac{1}{\langle N_e^2 \rangle} \int dT\ T$ LDEM(**T**)

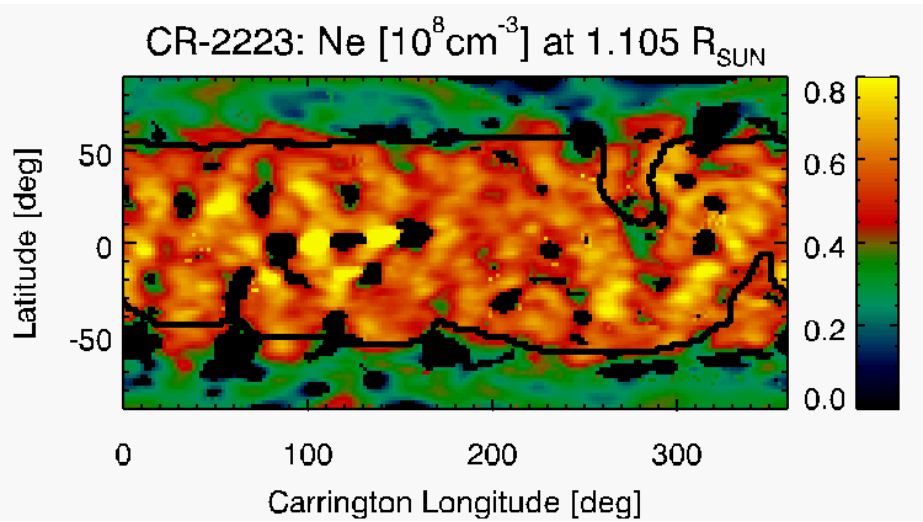
(Nuevo et al. 2015, ApJ)

Tomographic results



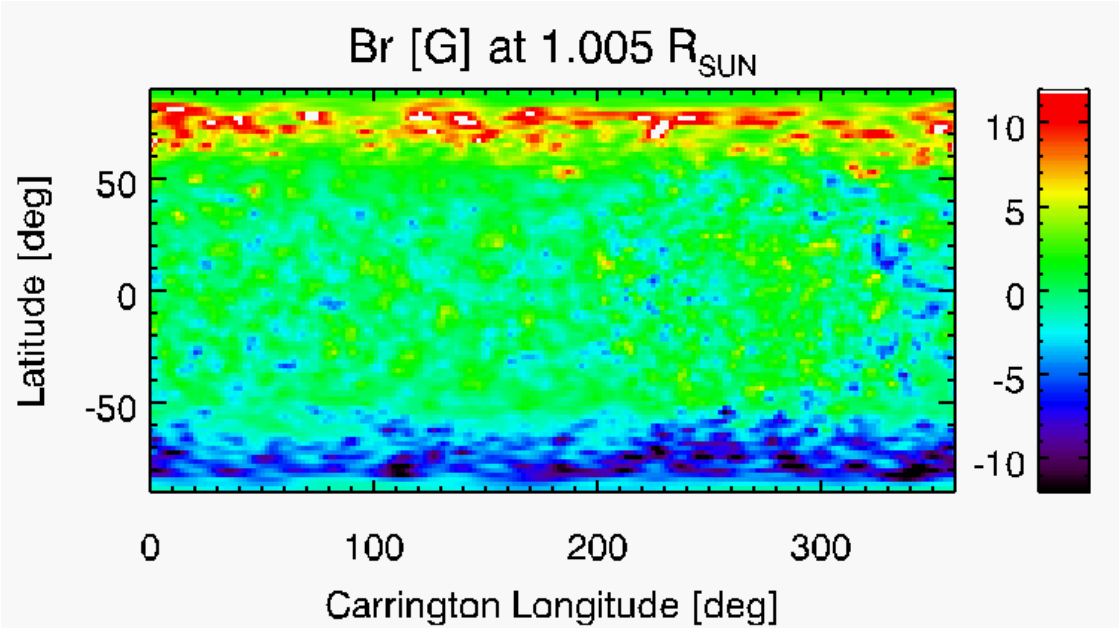






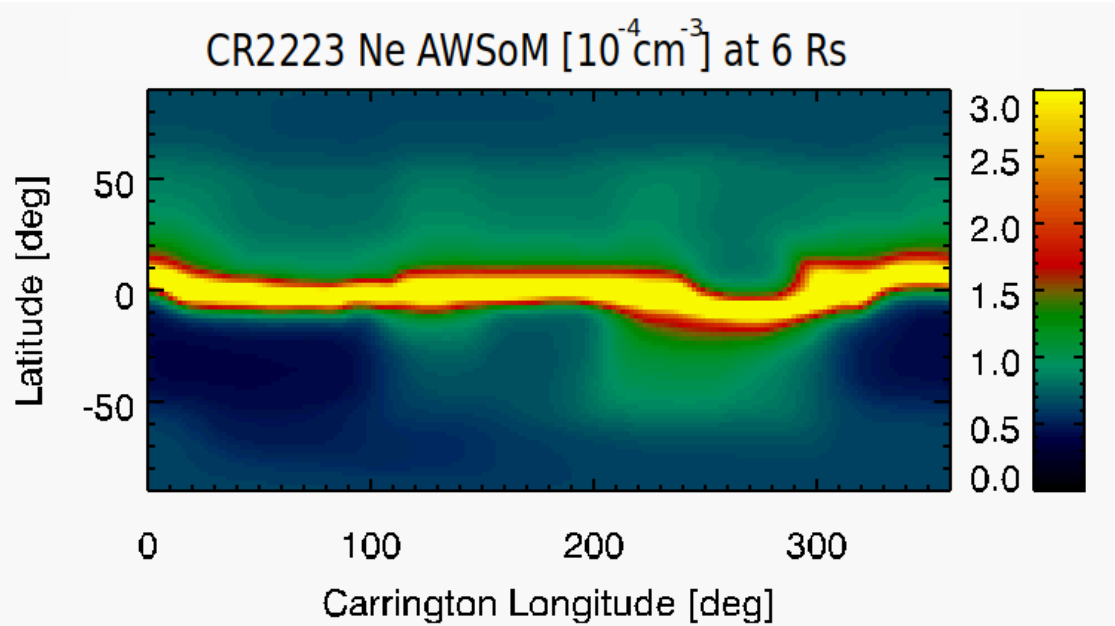
MHD-3D AWSoM model

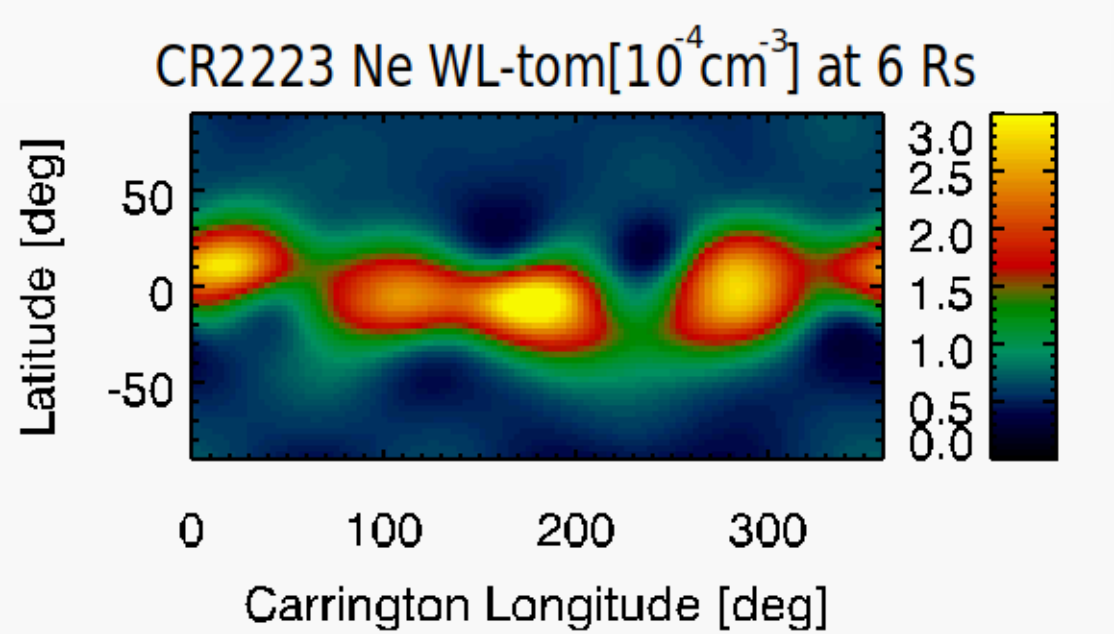
- MHD-3D: Alfvén Wave Solar Model (AWSoM), within Space Weather Modeling Framework (SWMF)
- Coronal heating given by dissipation of Alfvén waves (van der Holst et al., 2014)
- Covers from the chromosphere up to 1 AU
- Synoptic Magnetogram as Boundary Condition (ADAPT-GONG)



Sachdeva et al. 2019, Apj.
Lloveras et al. 2020, SolPhys.

Validating AWSoM runs with VL-Tomography

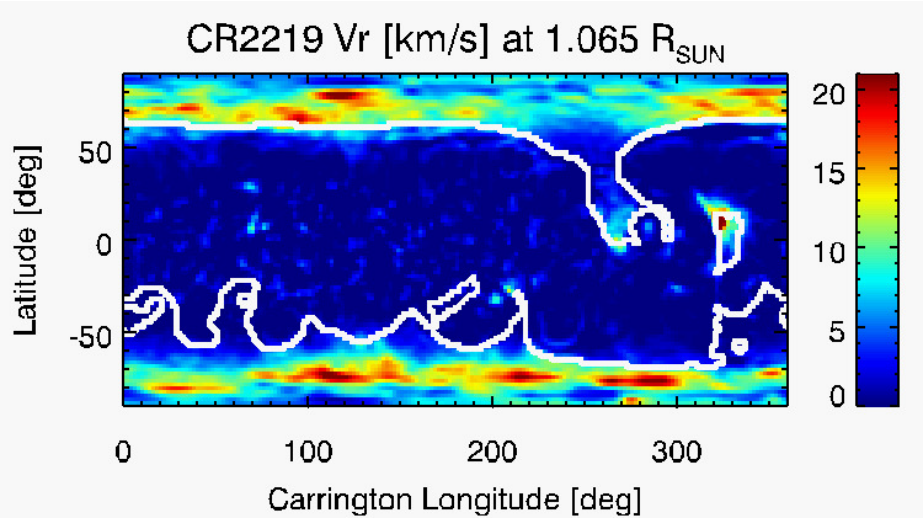


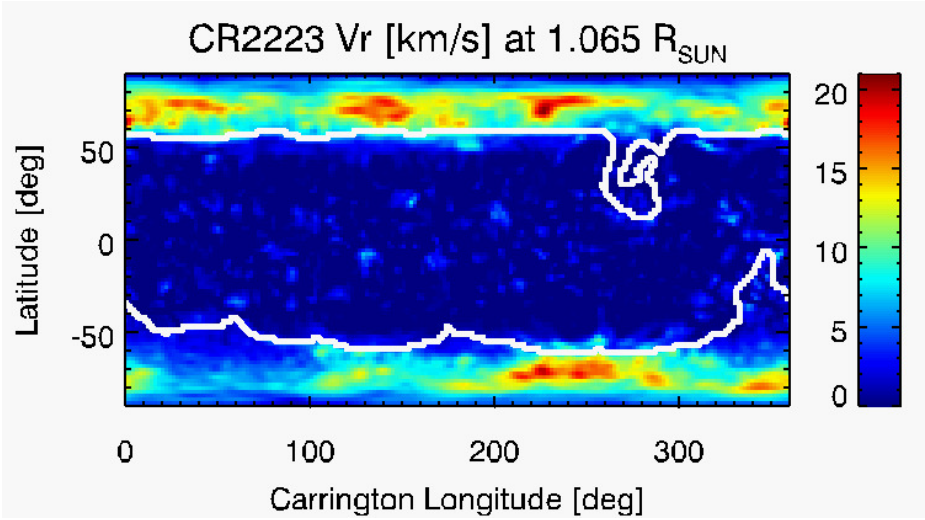


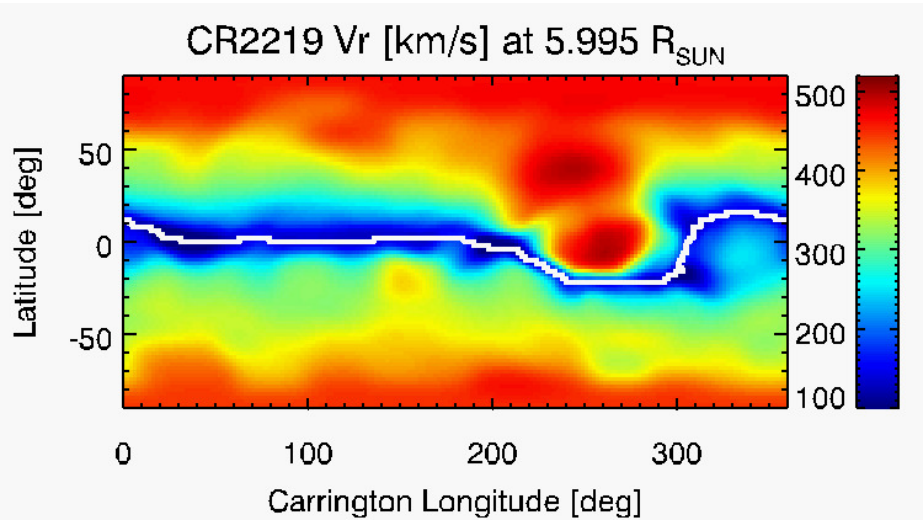
Arge et al. (2010)

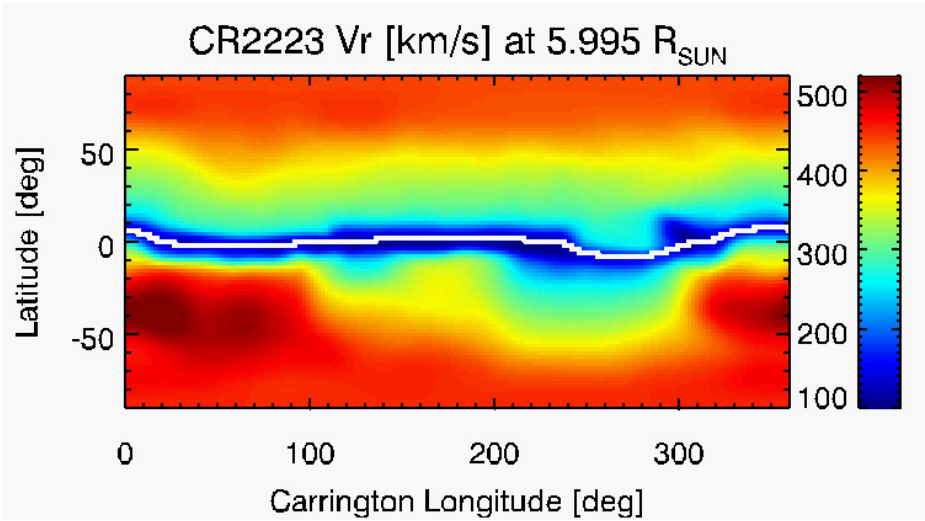
Hickmann et al. (2015)

Solar Wind - AWSoM



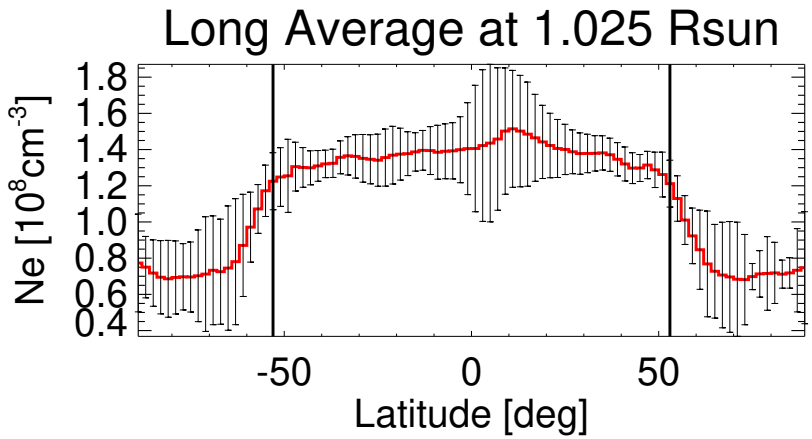


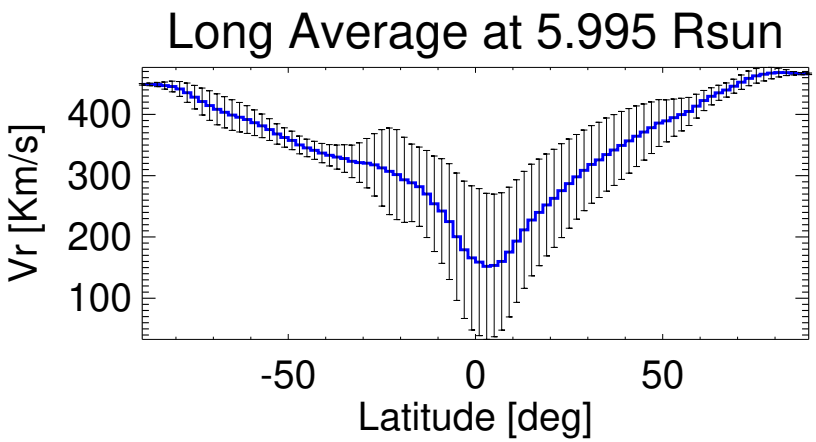




Avg Latitudinal Variation: DEMT and AWSoM

CR2219





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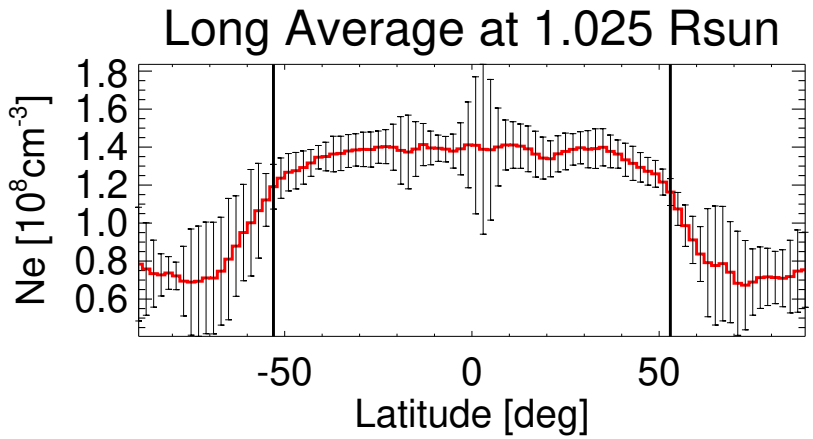
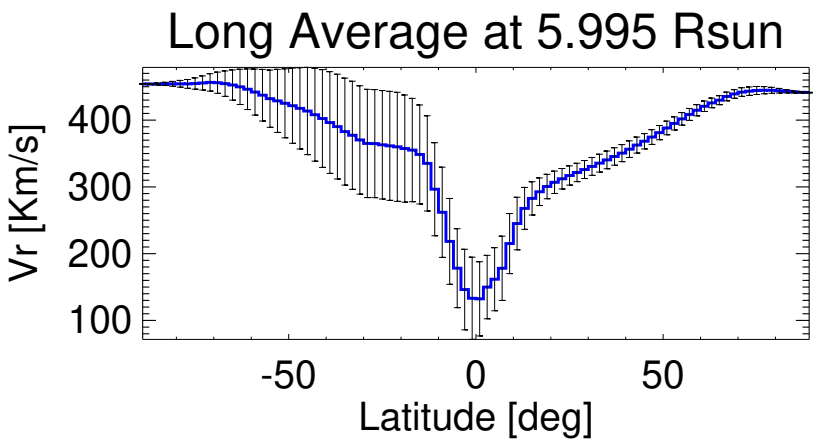
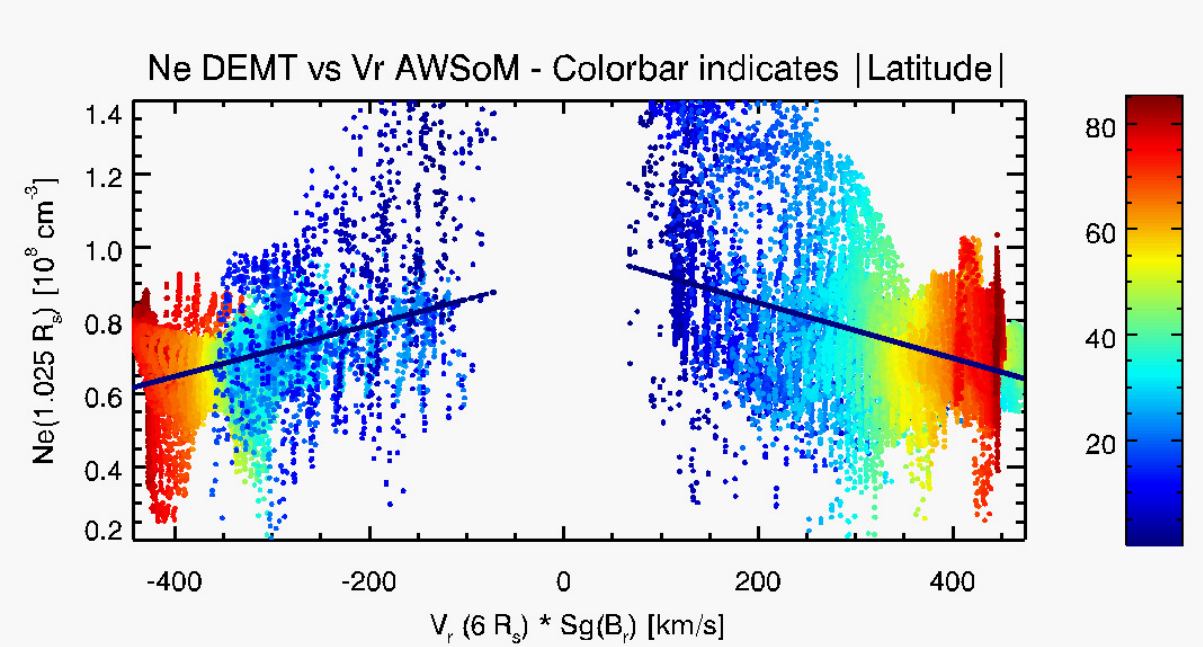




CR2219



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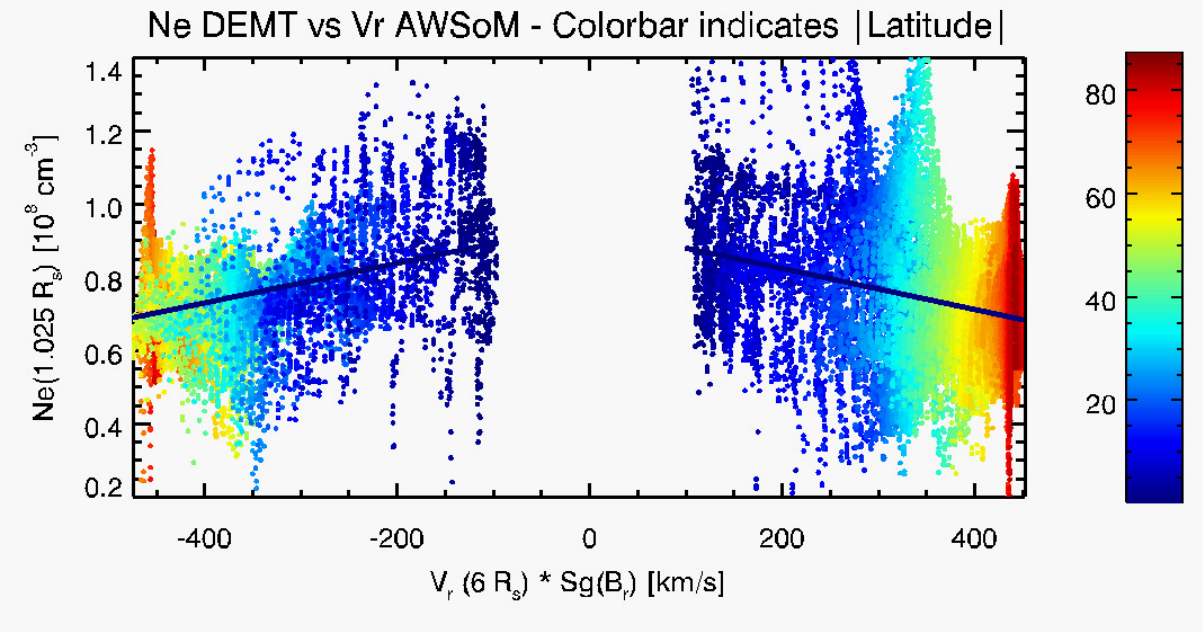

Final comments

- Solar Rotational Tomography is currently the only observational technique that allows construction of global 3D maps of Ne and Te
- The MHD-3D model was validated with VL and EUV tomography
- By tracing the results we were able to correlate the physical properties at the coronal base obtained with the tomography with the fast/slow components of the solar wind given by the MHD model for each magnetically open line.
- For the first time, basal properties of both components of the SW were quantitatively determined using tomography.

- We will carry out the same type of statistical analysis along field lines comparing their model terminal properties at 1 AU with their tomographic results in the inner corona.