Three-Dimensional Tomographic Reconstruction of CR-2219 and CR-2223

D.G. Lloveras[1] **A.M. Vásquez[1]** **F.A. Nuevo[1]**
N. Sachdeva[2] **W. Manchester IV[2]** **B. Van der Holst[2]**
R.A. Frazin[2] **P. Lamy[3]** **H. Gilardy[3]**

[1]Instituto de Astronomía y Física del Espacio (IAFE)
CONICET – University of Buenos Aires, Buenos Aires, Argentina

[2]Department of Climate and Space Sciences and Engineering (CLaSP),
University of Michigan, Ann Arbor, MI, USA

[3]Laboratoire Atmosphéres, Milieux et Observations Spatiales, CNRS & UVSQ, Guyancourt, France

WHPI-Workshop — September 14th, 2021

Summary

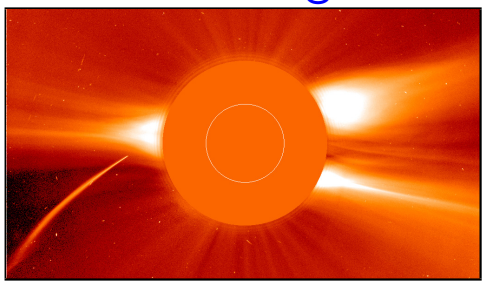
- Interest in predicting space weather conditions constantly pushes the advance of state-of-the-art of 3D-MHD models, which need to be validated with observational data.
- Solar rotational tomography (SRT) provides a 3D empirical description of the inner solar atmosphere in a global fashion.
- We carry out SRT reconstructions of two WHPI targets:
  - CR-2219 (Total Solar Eclipse Campaign)
  - CR-2223 (PSP/STEREO-A Closest Approach)
- Using AIA images (in 171, 193 and 211 Å), we apply DEM-Tomography to reconstruct N_{e} and T_{e}, in the range of heights $\approx 1.0 - 1.25\ \mathrm{R}_{\odot}$.
- Using LASCO-C2 images, we apply VL-Tomography reconstruct N_{e}, in the range of heights $\approx 2.5 - 6.0\ \mathrm{R}_{\odot}$.
- We also ran steady-state simulations of both periods using the SWMF/AWSoM model (Univ. of Michigan).

Solar Rotational Tomography (SRT)

The object of study is the Solar Corona.
Solar rotation provides the multiple viewpoints.

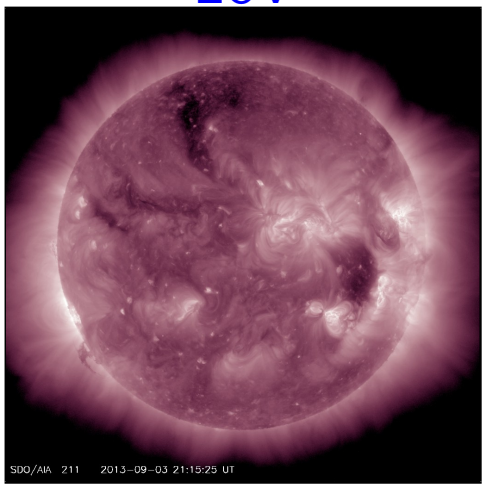
- K-Corona: Thomson scattered VL.
- SRT-VL $\rightarrow$ 3D N_{e}.
- 1st SRT-VL: Altschuler & Perry (1972)

Visible Light



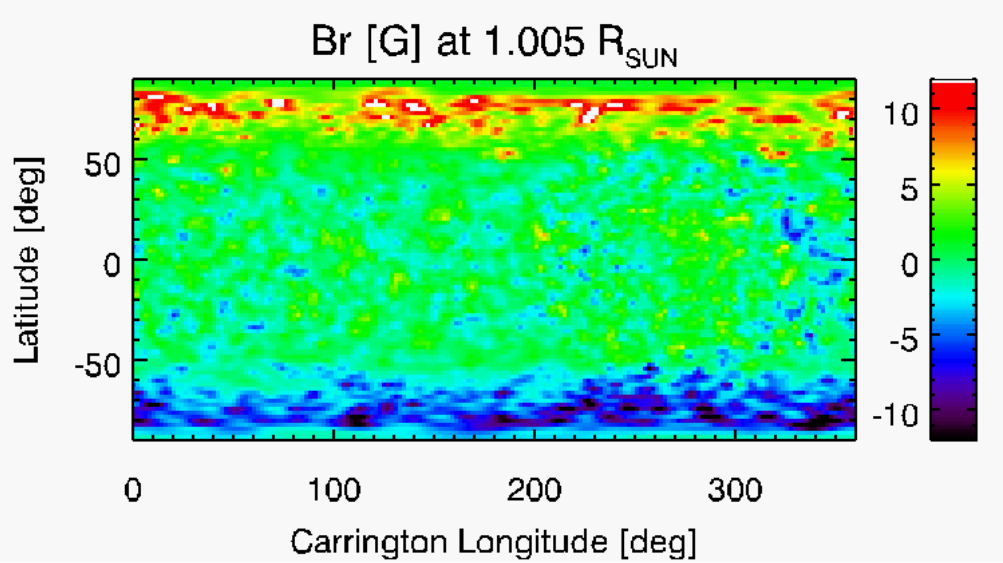
- E-Corona: coronal emission: UV, EUV.
- SRT-EUV $\rightarrow$ 3D EUV emissivity $\rightarrow$ 3D Differential Emission Measure $\rightarrow$ 3D N_{e} y T_{e}
- 1st SRT-EUV (or DEM-Tomography): Frazin, Vásquez & Kamalabadi (2009) Vásquez, Frazin & Kamalabadi (2009)

EUV



MHD-3D AWSoM model

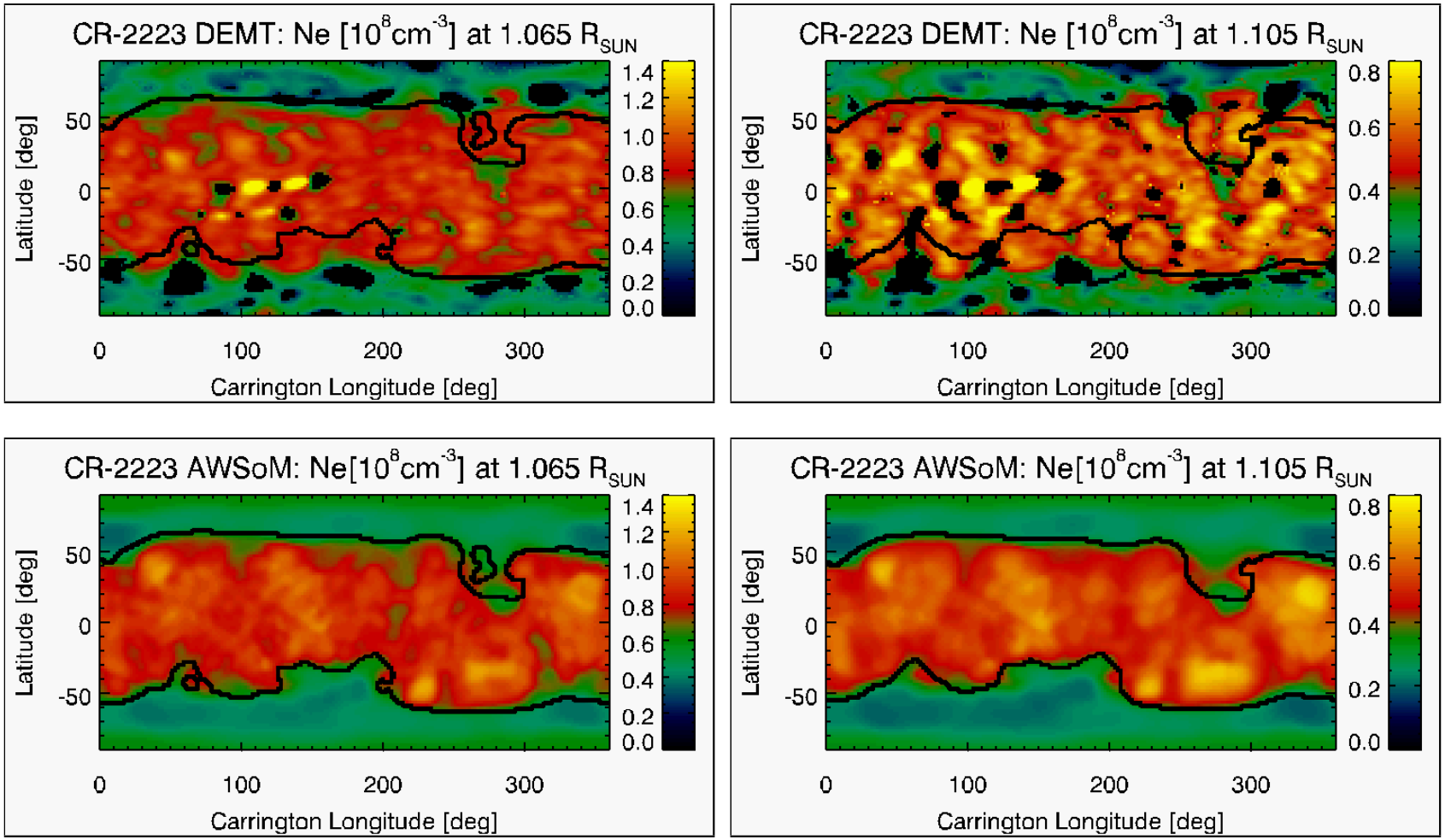
- MHD-3D: Alfvén-Wave driven Solar wind Model (AWSoM), within the Space Weather Modeling Framework (SWMF).
- Coronal heating given by dissipation of Alfvén waves (van der Holst et al., 2014).
- Spans from the chromosphere up to 1 AU.
- Synoptic Magnetogram as Boundary Condition (ADAPT-GONG).



Sachdeva et al. (2019), ApJ

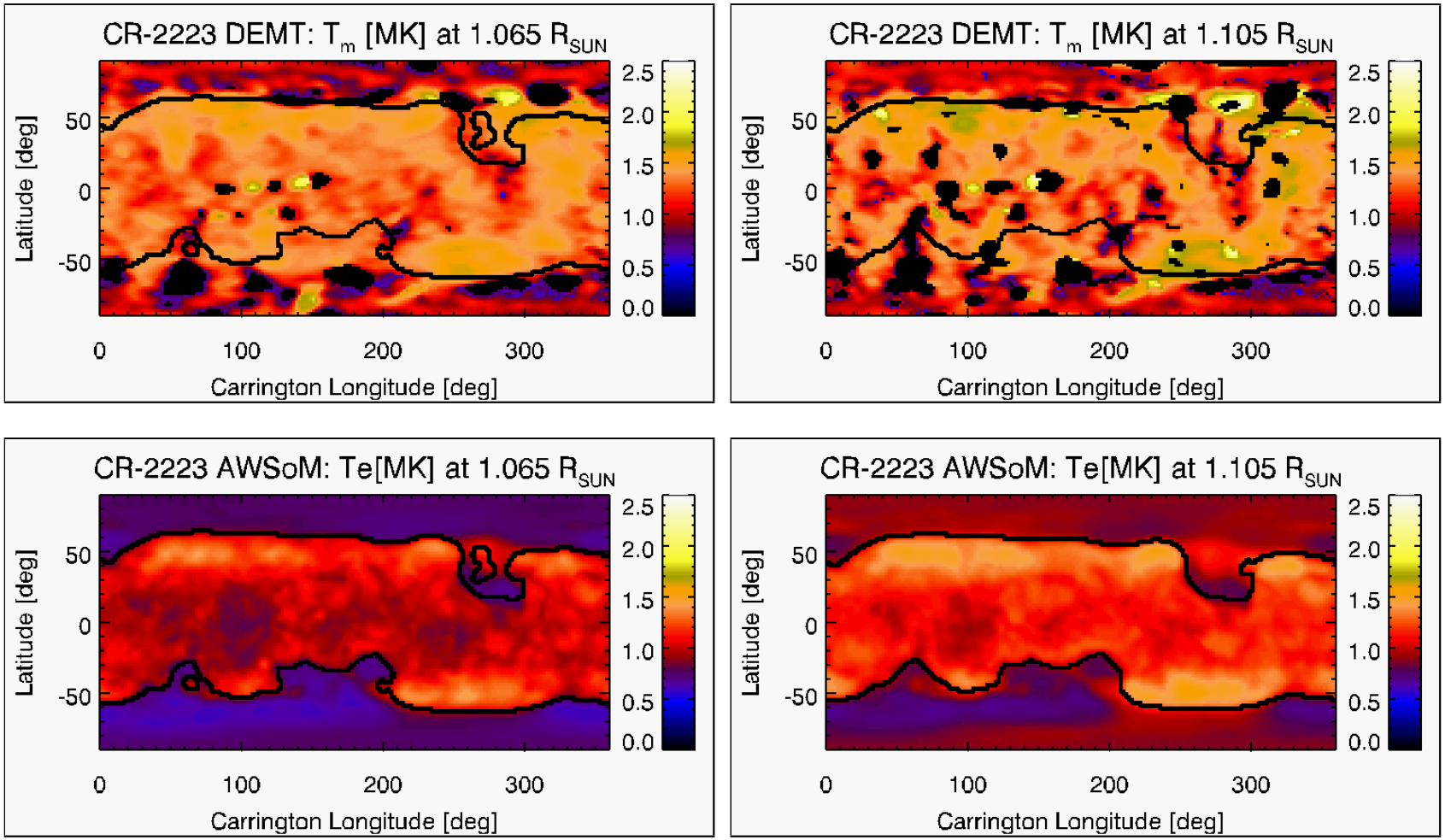
Lloveras et al. (2017, 2020), Sol.Phys.

N_e: DEMT versus AWSoM



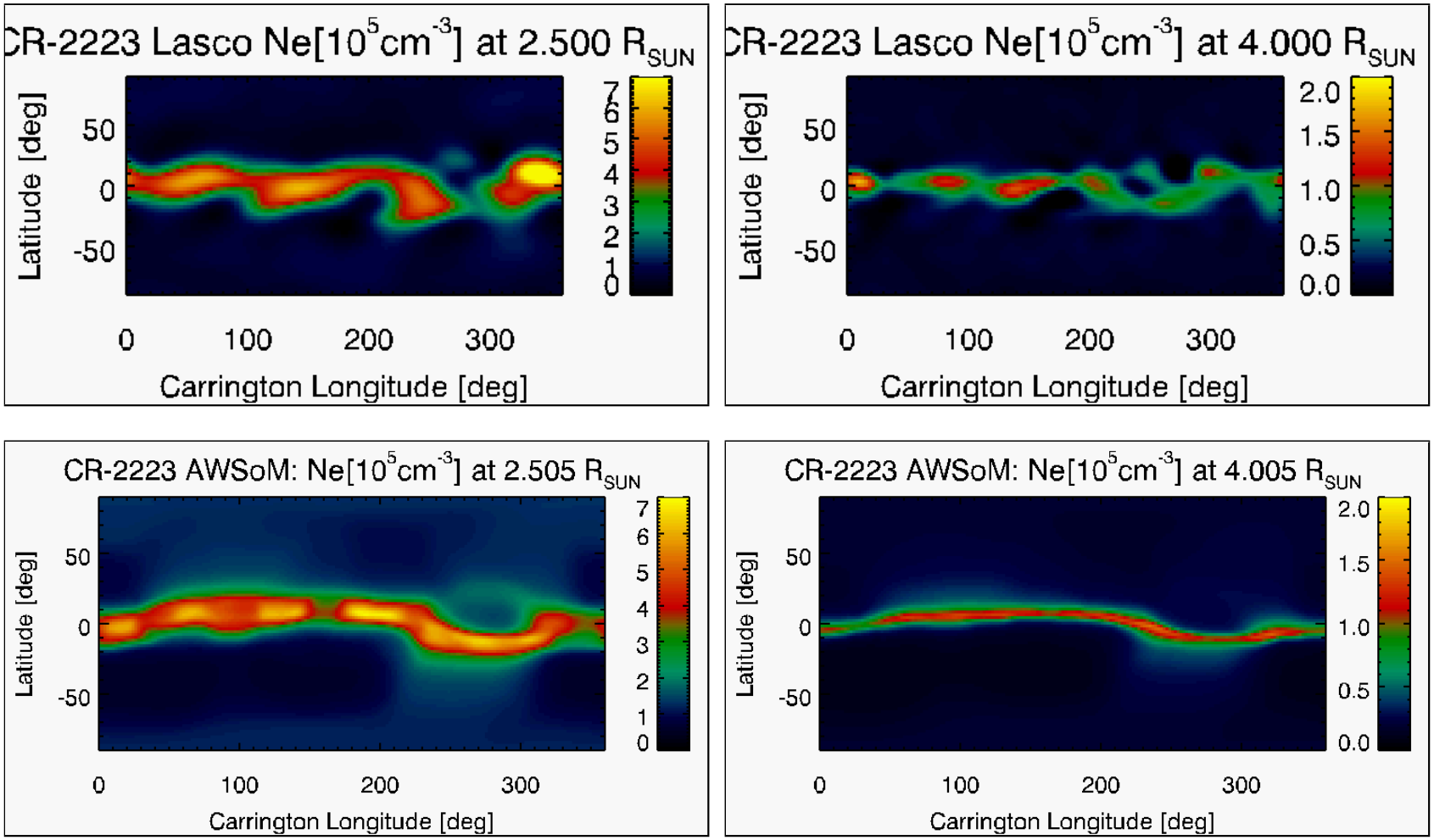
Latitude/longitude maps of N_e at two sample heights from **DEMT** (top) and **AWSoM** (bottom).

T_e: DEMT versus AWSoM



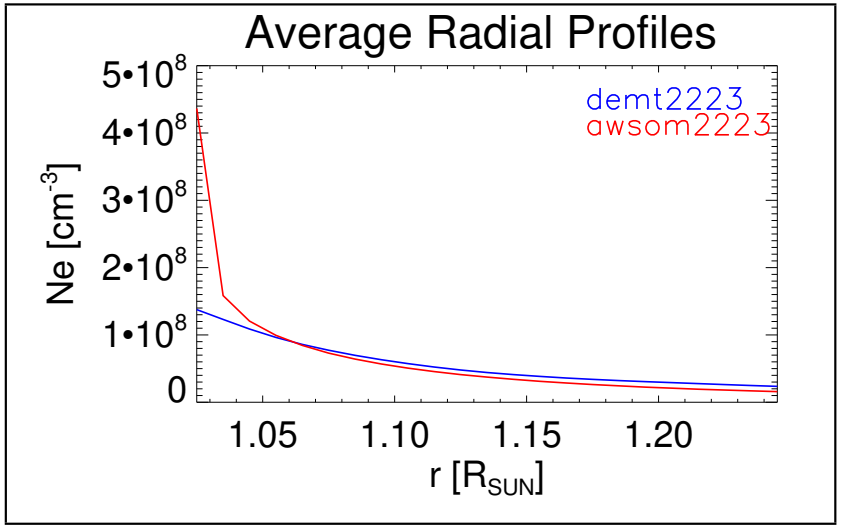
Latitude/longitude maps of T_e at two sample heights from **DEMT** (top) and **AWSoM** (bottom).

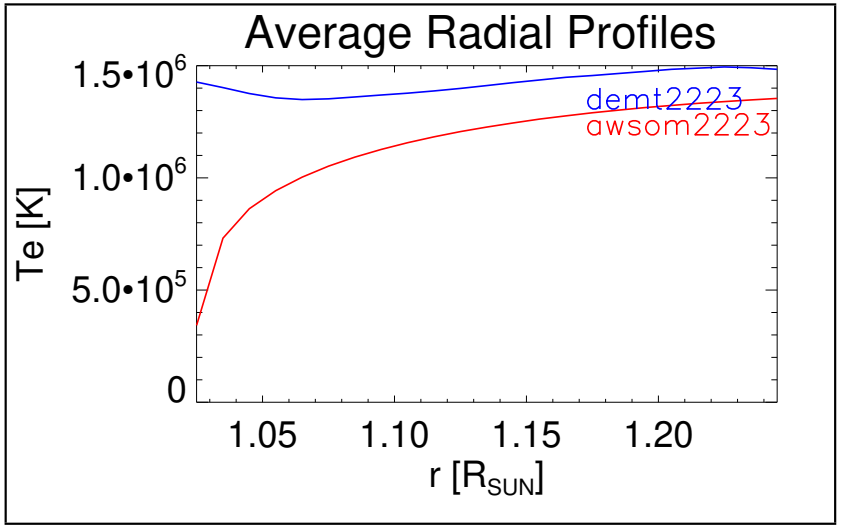
N_e: SRT-WL versus AWSoM

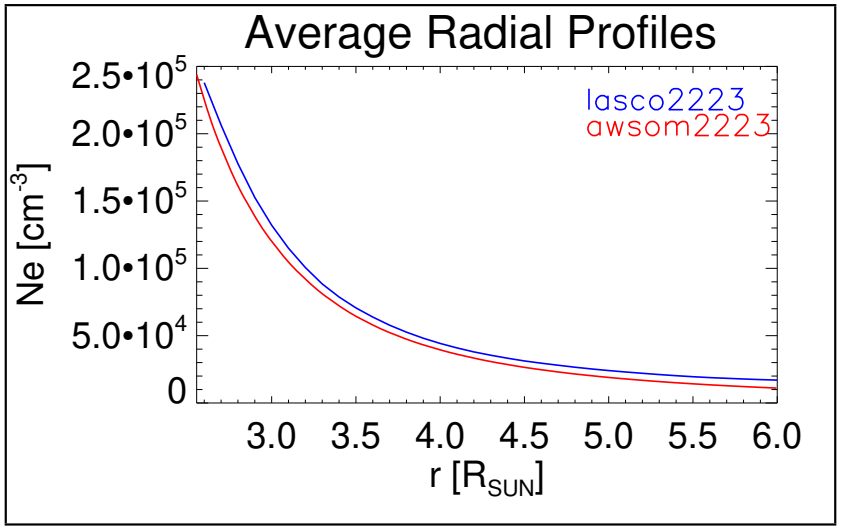


Latitude/longitude maps of N_e at two sample heights from **SRT-WL** (top) and **AWSoM** (bottom).

Streamer Average Radial Profiles

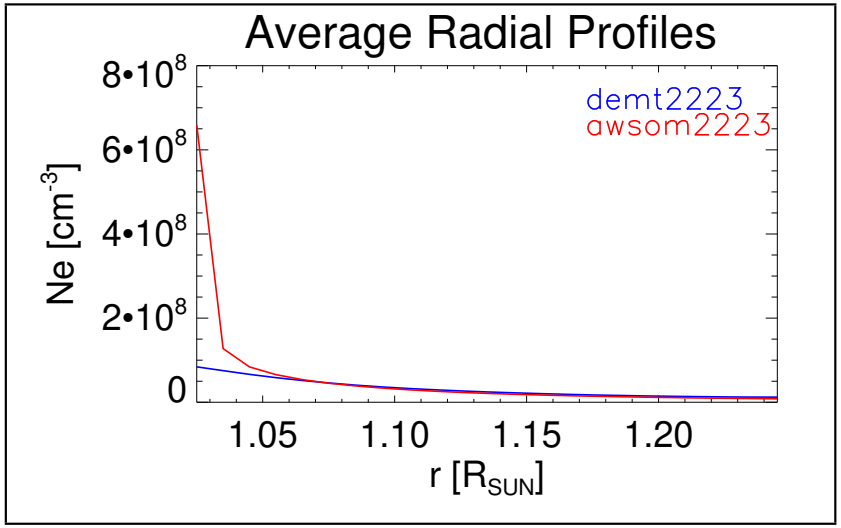


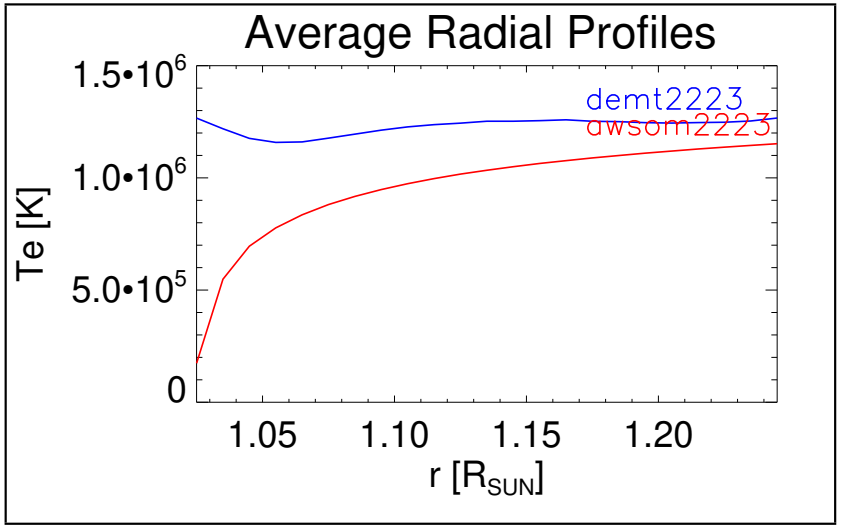


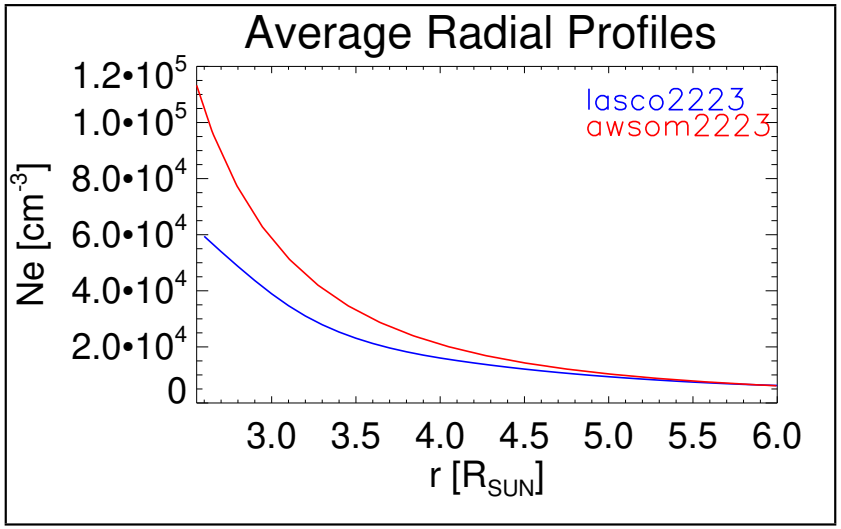


$N_e(r)$ and $T_e(r)$ from **DEMT** and **AWSoM** (top).
$N_e(r)$ from **SRT-WL** and **AWSoM** (bottom).

CHs Average Radial Profiles







$N_e(r)$ and $T_e(r)$ from **DEMT** and **AWSoM** (top).
$N_e(r)$ from **SRT-WL** and **AWSoM** (bottom)

DEMT of CR-2081 (2008-2009)

Comparative Coronal Study of CR-1915 and CR-2081

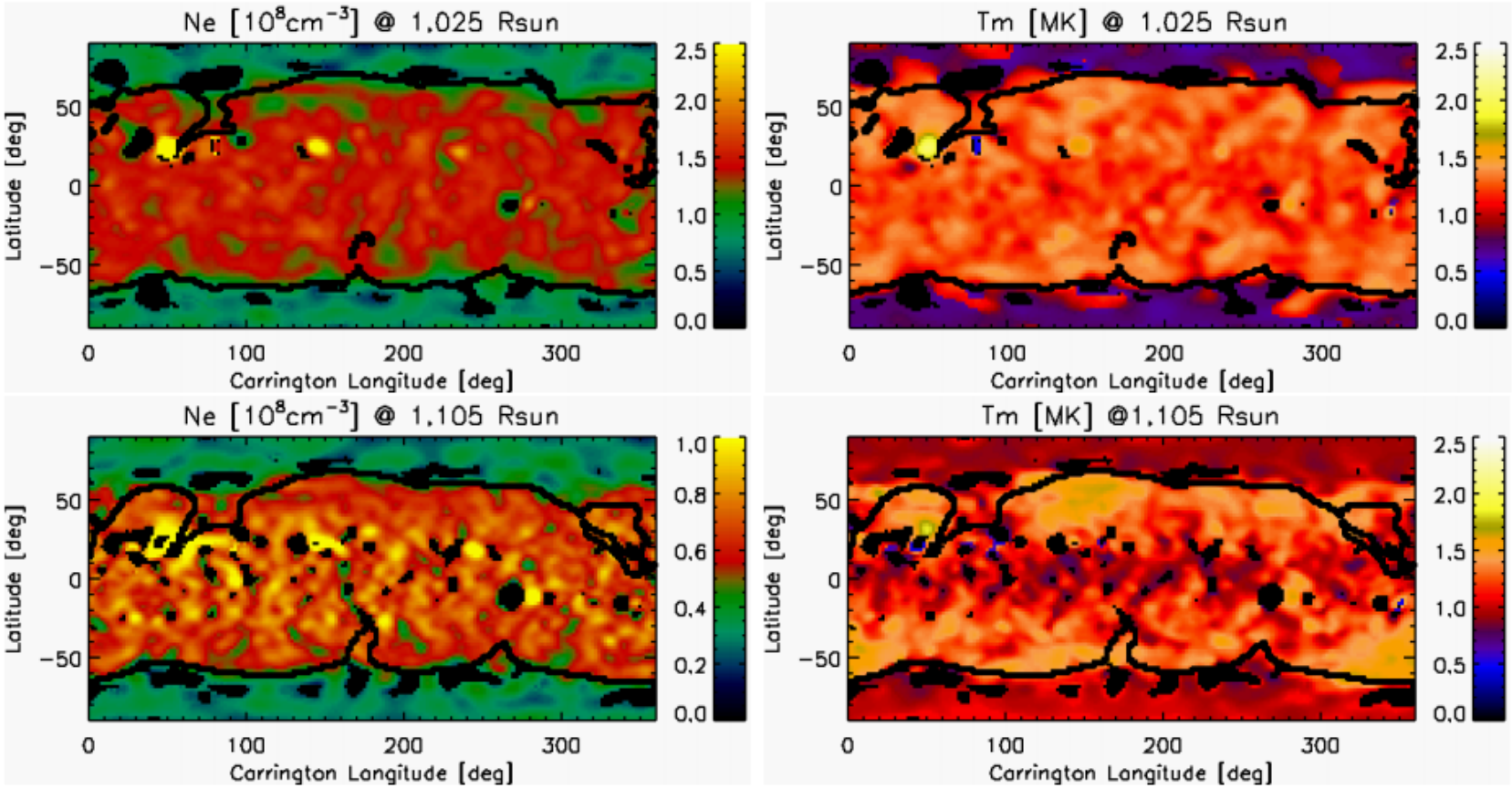
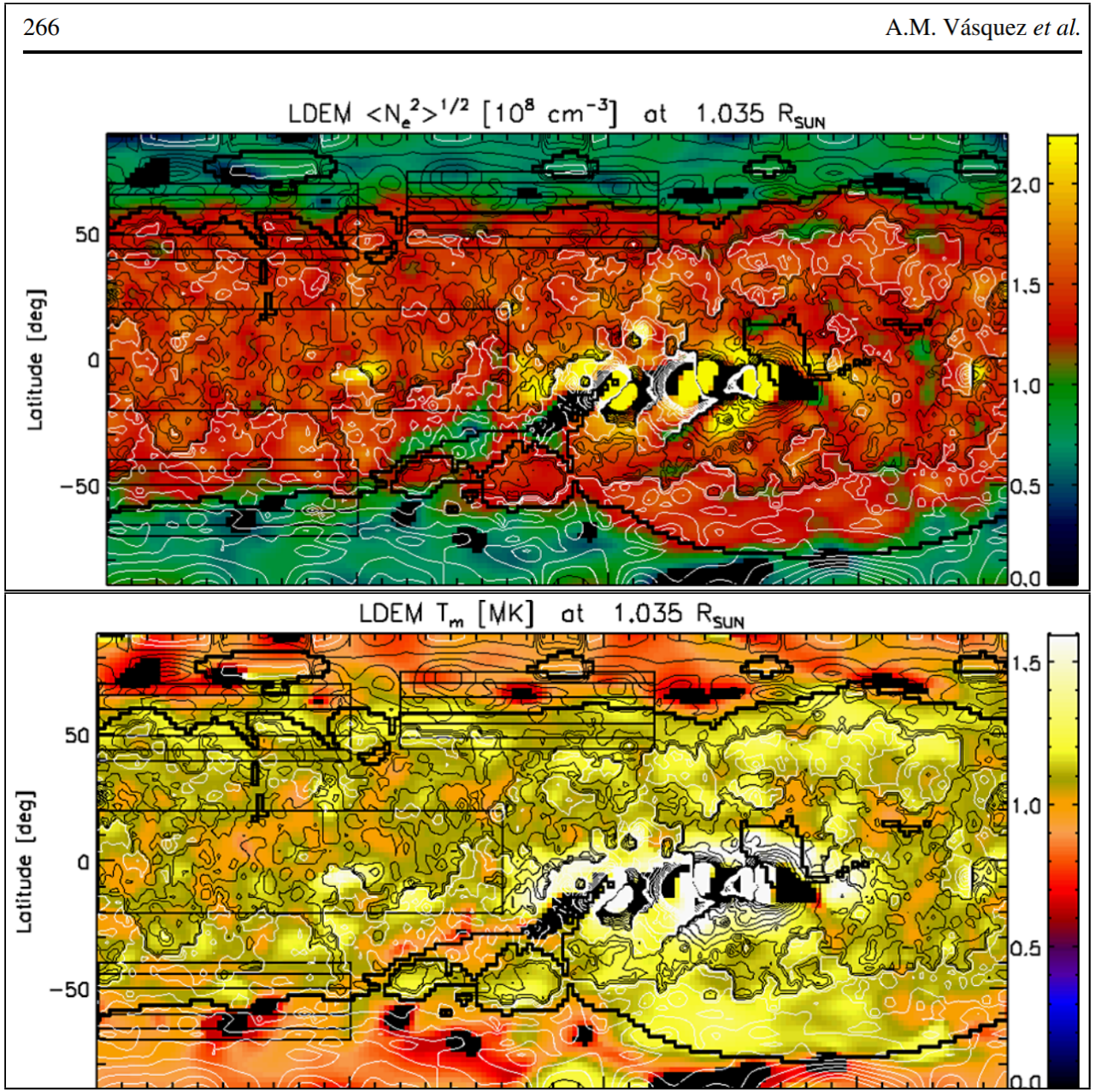
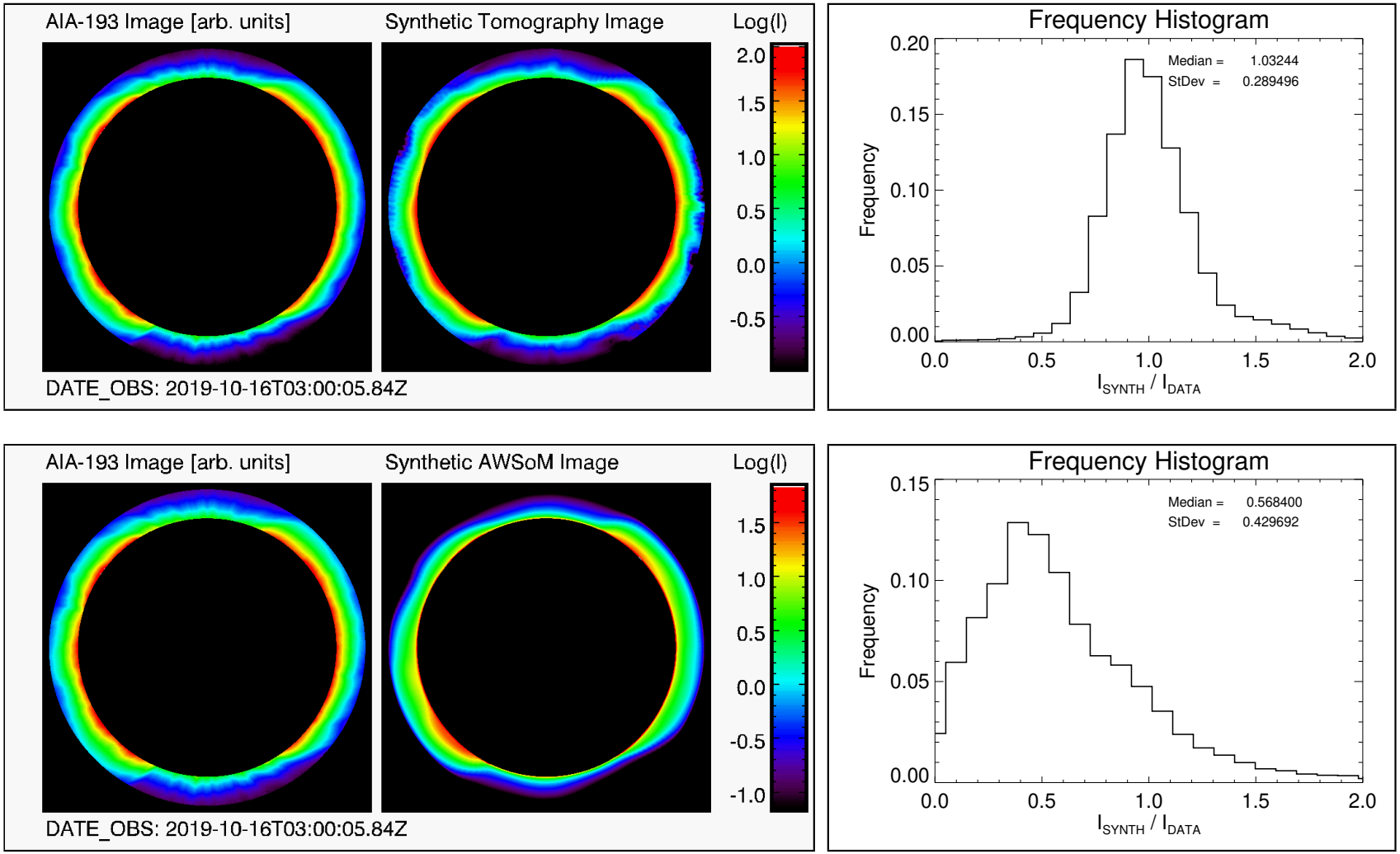


Figure 4. Same as Figure 3, but for CR-2081.

DEMT of WHI


266
A.M. Vásquez et al.
LDEM <N_e^2>^1/2 [10^8 cm^-3] at 1.035 R_SUN
Latitude [deg]
50
0
−50
2.0
1.5
1.0
0.5
0.0
LDEM T_m [MK] at 1.035 R_SUN
Latitude [deg]
50
0
−50
1.5
1.0
0.5
0.0

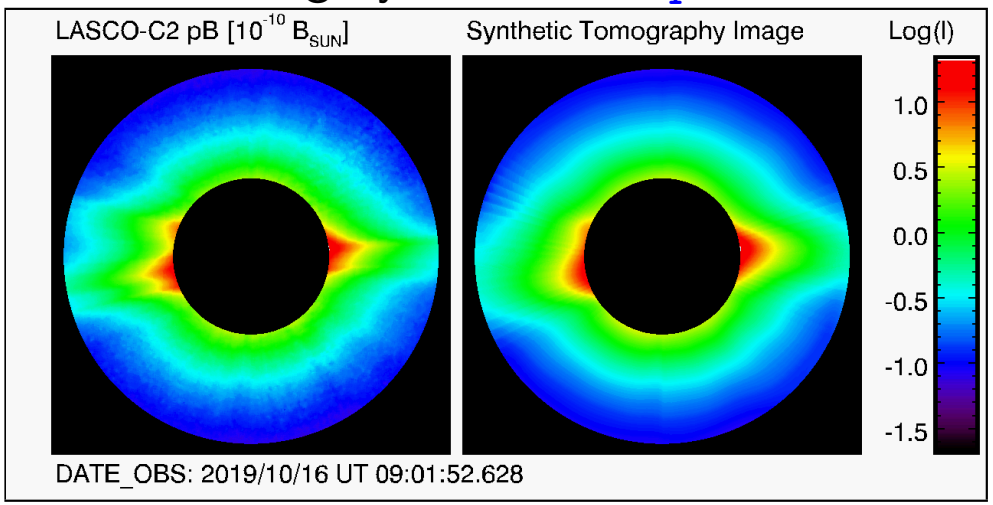
CR-2223 EUV Images: Data versus Synthetic

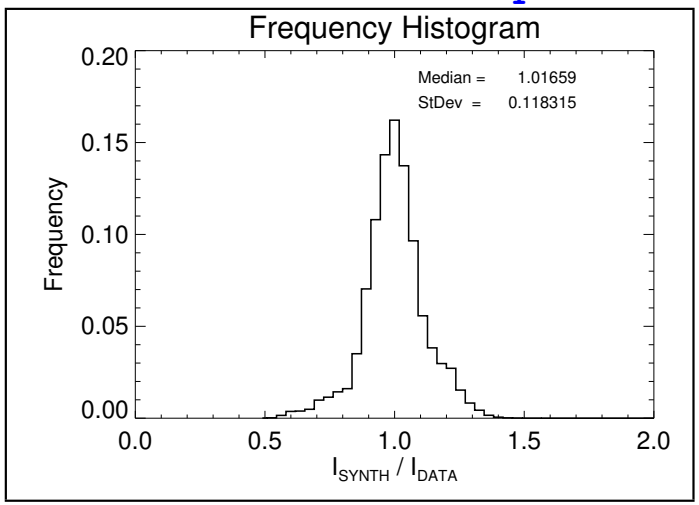


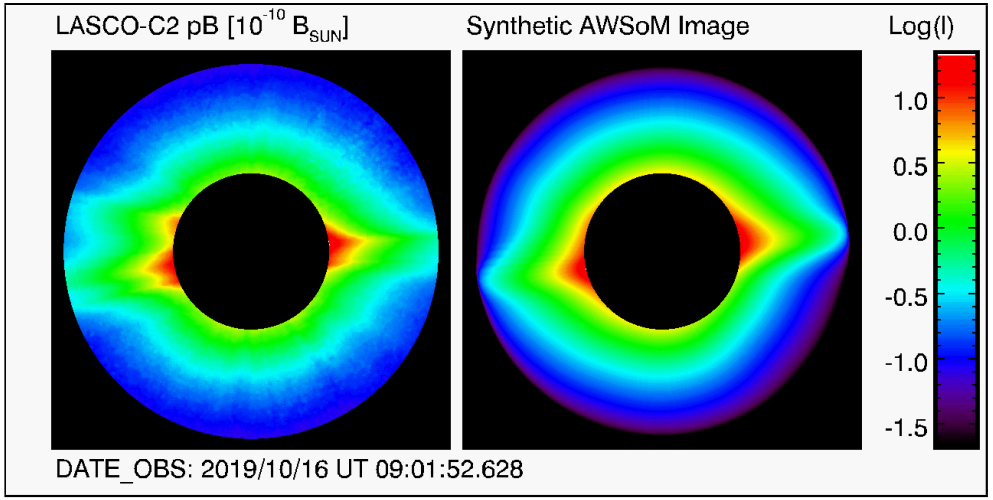
AIA 193 Å and corresponding synthetic image, plus intensity-ratio histogram, from **Tomography** (top) and from the **AWSoM** model (bottom).

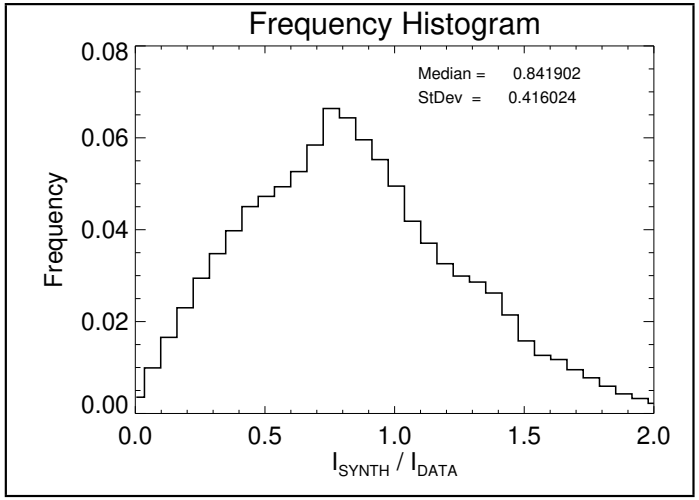
CR-2223 VL Images: Data versus Synthetic

LASCO-C2 Legacy Archive http://idoc-lasco-c2-archive.ias.u-psud.fr









LASCO-C2 and corresponding synthetic image, plus intensity-ratio histogram, from **Tomography** (top) and from the **AWSoM** model (bottom).

Conclusions

- Characteristic values of $N_{\rm e}$ and $T_{\rm e}$ in the AWSoM model are consistent with the tomographic reconstrucions.

- **Streamer:** within the FoV of AIA the model $N_{\rm e}(r)$ agrees very well with the tomographic reconstructions, while the model $T_{\rm e}(r)$ is $\approx 15\%$ smaller than in the reconstructions. **HCS:** within the FoV of LASCO-C2, the model $N_{\rm e}(r)$ agrees very well with the reconstructions.

- **CHs:** within the FoV of AIA the model $N_{\rm e}(r)$ agrees very well with the tomographic reconstructions, while the model $T_{\rm e}(r)$ is $\approx 15\%$ smaller than in the reconstructions. Within the FoV of LASCO-C2, the model tends to overestimate $N_{\rm e}(r)$ and underestimate its scale height.

- As a test for both the tomographic reconstructions and the AWSoM model, we synthesize images from both and compare them with the AIA and LASCO-C2 data. As expected, tomographic reconstructions are able to reproduce images with much finer detail than the model.

- An upcoming publication will include a detailed quantitative analysis for both CR-2223 and CR-2219, similar to Lloveras et al. (2020), Sol.Phys. 295, 76.

DATA PRODUCT we are sharing through HSO Connect

Shared with me > WHPI_Tomography

Name	Owner	Last modified	File size
README.txt	me	9 Sept 2021 me	748 bytes
read_tomography.pro	Federico Nuevo	9 Sept 2021 me	4 KB
Te_EUV-Tomography_CR2219_rmin1.02_rmax1.25	me	9 Sept 2021 me	1.4 MB
Te_EUV-Tomography_CR2223_rmin1.02_rmax1.25	me	9 Sept 2021 me	1.4 MB
Ne_EUV-Tomography_CR2223_rmin1.02_rmax1.25	me	9 Sept 2021 me	1.4 MB
Ne_EUV-Tomography_CR2219_rmin1.02_rmax1.25	me	9 Sept 2021 me	1.4 MB
Ne_VL-Tomography_CR2219_rmin2.45_rmax6.05	me	9 Sept 2021 me	1,013 KB
Ne_VL-Tomography_CR2223_rmin2.45_rmax6.05	me	9 Sept 2021 me	1,013 KB