Comparative analysis of the open and closed field topologies reconstructed by different coronal models

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1. MOTIVATION

The coronal magnetic field topology is an essential input to heliospheric space weather models. However, regardless of whether one employs a simplified or a full-MHD coronal model, current research has shown that simulated open flux strongly underestimates both, the values measured at 1au and those associated to coronal holes (CHs), which until recently were considered as the primary source of open fields (*Linker et al., 2017*).

- Do coronal models of different complexity, physical or numerical, agree well with each other?
- If yes, how well do they agree or disagree to observations of open field areas in EUV?

2. DATA & METHODOLOGY

Models used:

1. Wang-Sheeley-Arge (WSA)-PFSS
2. EUHFORIA – PFSS
3. MULTI-VP (employing WSA solution)
4. Predictive Science Inc (PSI) PFSS model
5. PSI MHD model.

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Models initiated with 2 types of HMI ADAPT global magnetic field **(GMF)** maps:

- One that includes active regions (ARs) added retrospectively
- One without ARs added retrospectively

Each of these map types consists of 12 realisations generated by the ADAPT model (*Arge et al., 2010*).

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We simulated the solar coronal for 3 consecutive dates 2010–09–18 18:00 UT, 2010–09–19 18:00 UT, and 184 2010–09–20 18:00 UT, a period when the coronal hole (CH) shown in ***Figure 1***, and which we already studied in *Linker et al. 2021* was at the centre of the solar disc in the field of view of Earth.

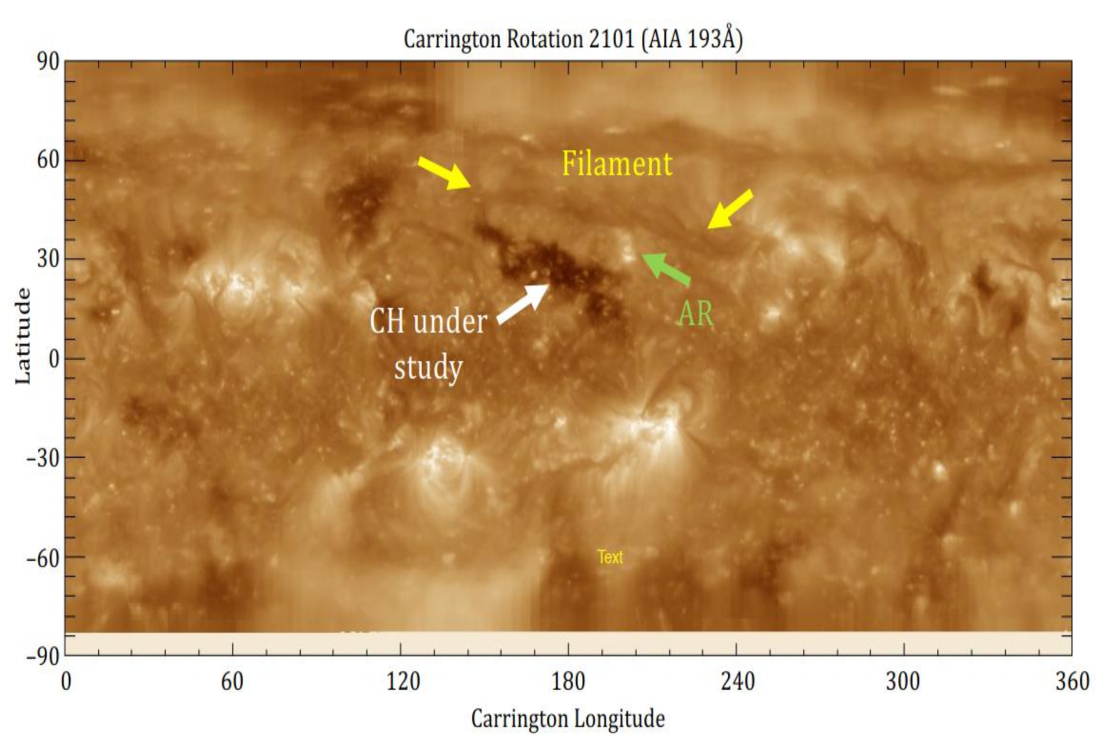

Figure 1: EUV synoptic map for CR2101 using AIA 193Å. The CH under study (white arrow) is surrounded by a filament channel (yellow arrows) and an evolving AR (green arrow).

In our analysis we compared the open magnetic field topology maps generated by each of the 5 models. Our aim was to assess the impact on the modelled open-closed field topology by the:

- input GMF maps in terms of model output generated by:
  - Different HMI ADAPT realisations (for details check QR-code)
  - The 2 GMF map types, with or without ARs added retrospectively (for details check QR-code)
- the simulation set up in terms of model output generated:
  - After smoothing the GMF maps (for details check QR-code)
  - By different source surface heights (for details check QR-code)
  - By the different PFSS models (for details check QR-code)
  - By PFSS vs MHD model **(Section 3 in this poster)**

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To complement our work, we also compared the observed CH area, studied in *Linker et al. 2021*, with the modeled open field associated with it **(Section 4 in this poster)**.

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3. HOW DOES THE PFSS MODEL OUTPUT COMPARES TO THE FULL-MHD ONE

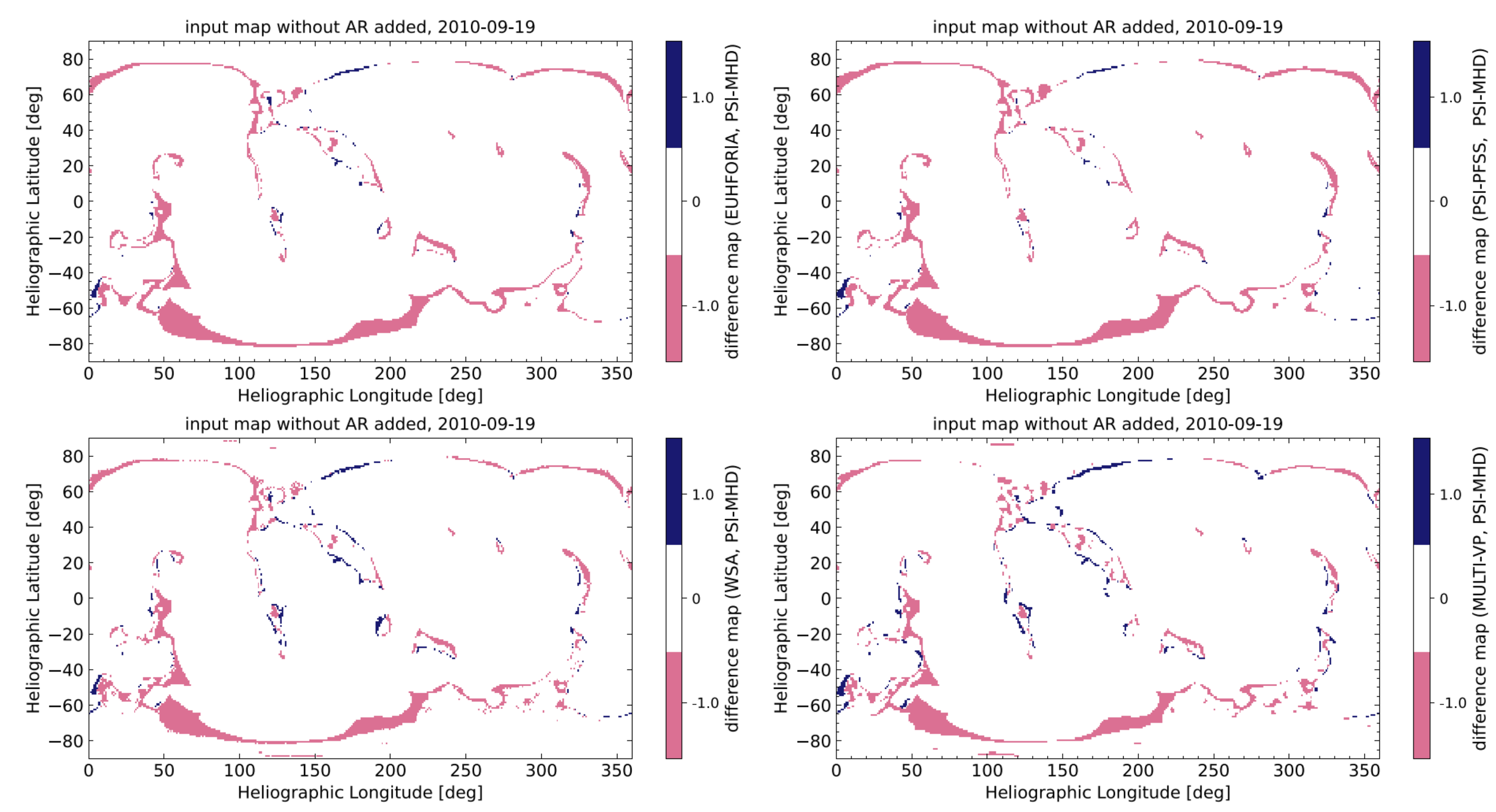

Figure 2: Difference maps between the model output from the full-MHD model and each of the PFSS based models.

4. HOW DOES THE MODEL OUTPUT COMPARES TO THE CH UNDER STUDY

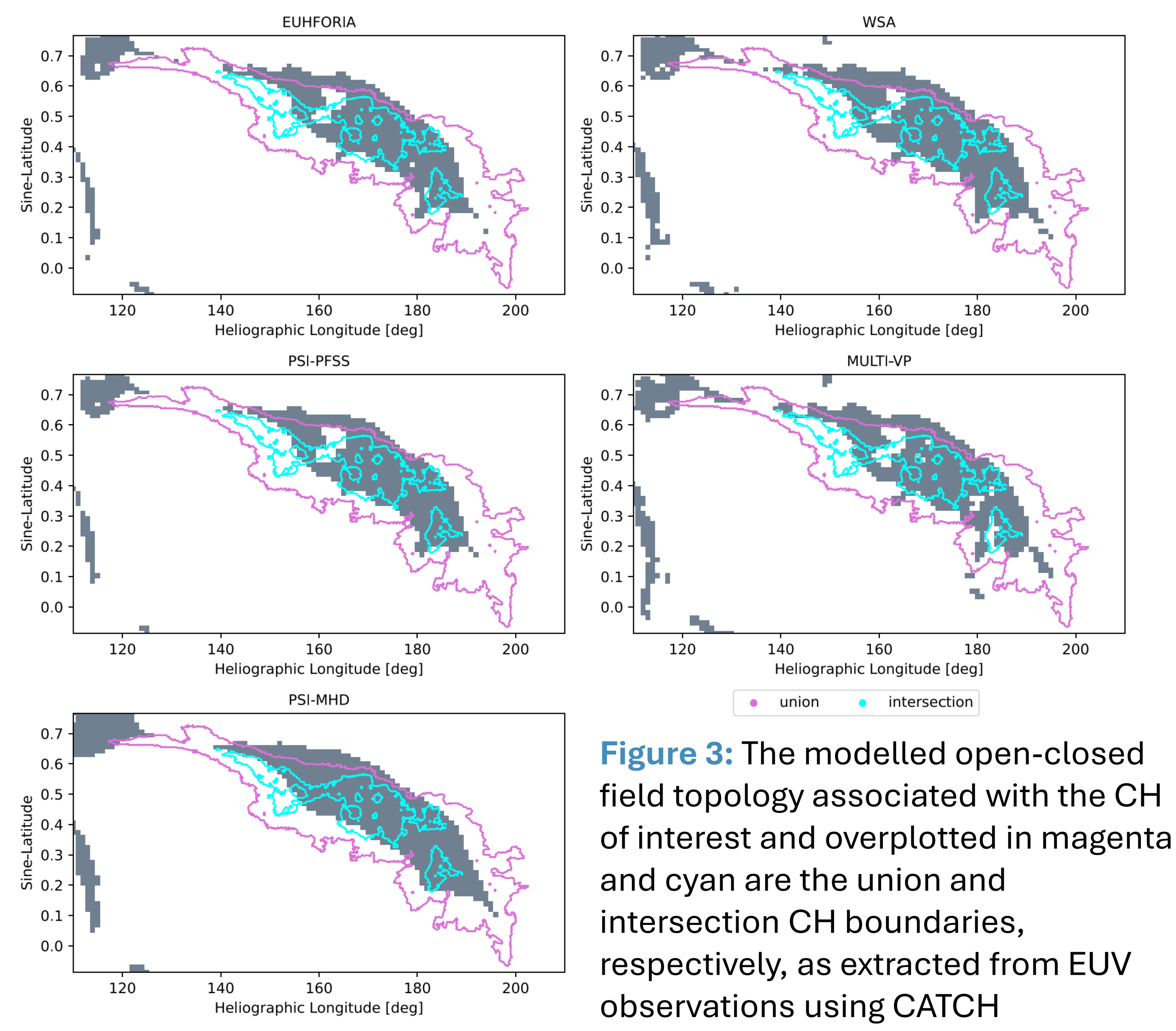

Figure 3: The modelled open-closed field topology associated with the CH of interest and overplotted in magenta and cyan are the union and intersection CH boundaries, respectively, as extracted from EUV observations using CATCH (*Heinemann et al., 2019*). For more details see (*Linker et al., 2021*).

5. CONCLUSIONS

This analysis revealed that all models considered here produce very comparable open and closed field topologies and neither the selected input GMF maps nor the numerical implementation scheme affected the generated open-field topology considerably. However, this does not mean that the observed changes in the topology are not of great importance. We also found, in consistence with previous studies, that modelled open-closed field topologies do not compare well to EUV observations of CH.

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References
» Arge et al., 2010, doi: doi: 10.1063/1.3395870
» Heinemann et al., 2019, doi: 10.1007/s11207-019-1539-y
» Linker et al., 2017, doi: 10.3847/1538-4357/aa8a70
» Linker et al., 2021, doi: 10.3847/1538-4357/ac090a