Investigating the Solar Wind with Parker Solar Probe

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1. Introduction

- The **solar wind** is a highly conducting plasma expanding outwards from the Sun at supersonic speeds.
- The Earth is protected from the solar wind by its magnetic field. However, sometimes particles can make it through this barrier, driving space weather at Earth. This has the potential to destroy power grids, GPS and communications.

- It is extremely important that we understand how the solar wind is formed and accelerates towards Earth.
- This provided NASA with the motivation to launch the **Parker Solar Probe (PSP)** in August, 2018.

2. Background Physics

- The solar wind is split according to velocity into slow (~400 km/s) and fast (>600km/s). Slow solar wind is thought to originate in **active regions** - areas of particularly strong magnetic fields - whereas fast solar wind originates from **coronal holes**.

- **Alfvén waves** travel along the Sun's magnetic field lines and fluctuate transverse to the field direction.
- The source of Alfvén waves is currently debated, with popular theories suggesting that they are a due to **magnetic reconnection** at coronal hole edges, and in active regions.

3. Modelling the Sun

- Wanted to predict the solar wind conditions that PSP would measure.
- Ran a simulation which used a solar magnetic map and the **Wang-Sheeley-Arge model** [1] to provide the boundary conditions for a **magnetohydrodynamic** code (**Enlil**).
- We have assumed that the solar wind shown in Figure 1 is static, which is reasonable at **solar minimum**.

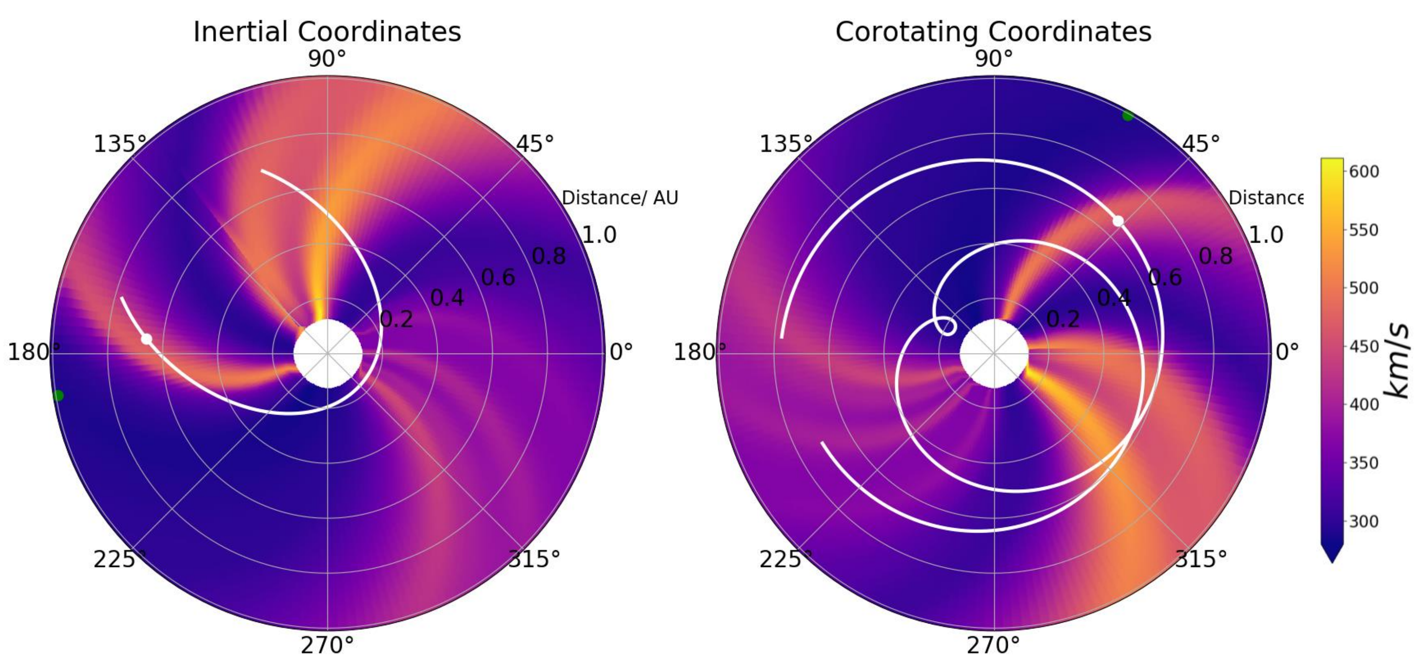

Figure 1: A snapshot of the solar wind velocity (colour gradient) at a constant latitude, with the white dot being the position of PSP along the full orbit described by the white line.

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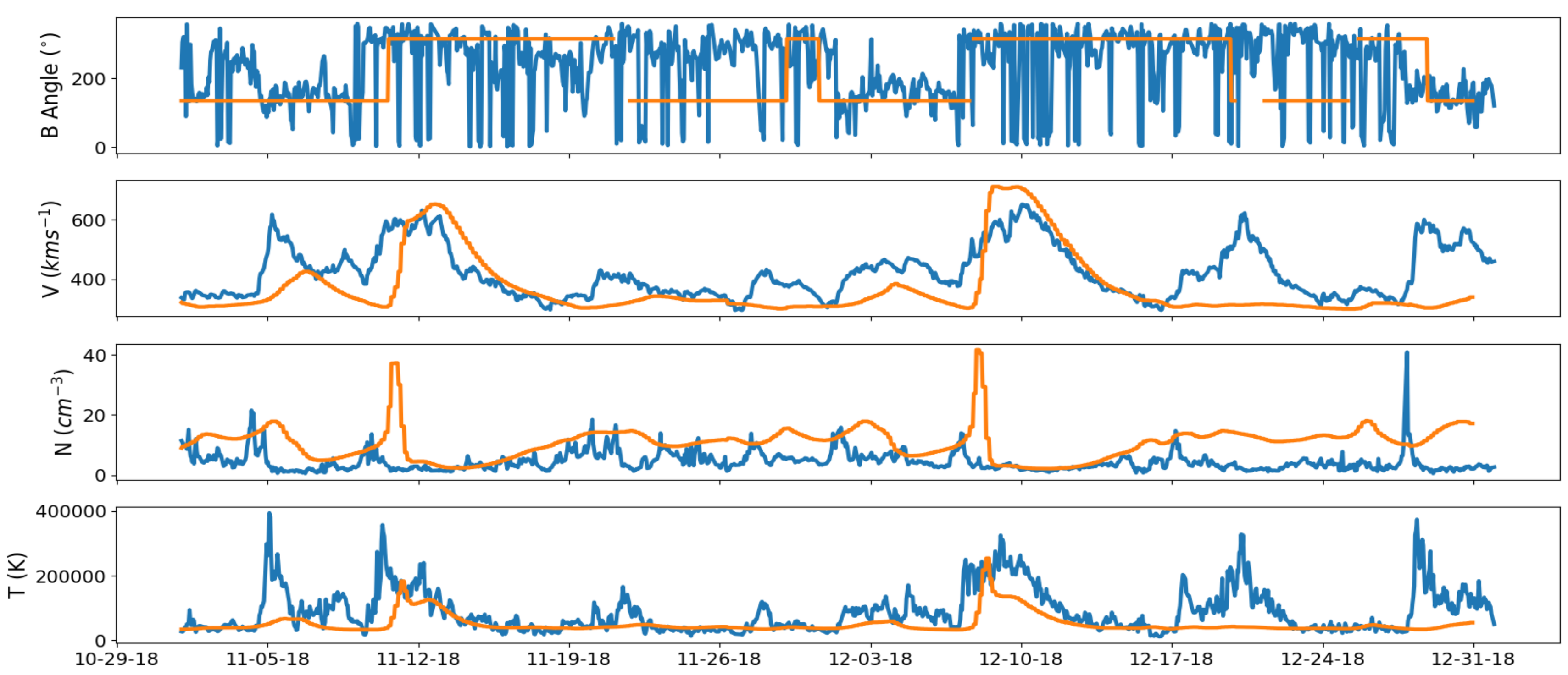

Figure 2: Solar wind conditions measured by ACE at Earth are shown in blue. The predicted conditions at Earth are shown in orange, with good agreement for all but magnetic field.

- Have checked these predictions against solar wind data taken from the ACE satellite ahead of Earth (see Figure 2). They are consistent in velocity, density and temperature but the magnetic field is unclear.

4. Connecting In Situ Data to Features on the Sun

- To address the static Sun assumption above we have used the hourly **Potential Field Source Surface model (PFSS)** [2]. (See bottom of Figure 3).
- Calculated the magnetic field lines connecting to the spacecraft along its orbit, with the PFSS model.

- Using magnetic field data from PSP we identified Alfvénic streams and tracked them back to the corona using the PFSS model to determine the source of each one.
- 3 sources of Alfvénic streams were identified and analysed, 1 from an active region and 2 from coronal holes.
- The processes that create the Alfvénic peaks occur on timescales of **~10 minutes** with each peak lasting for an average of **30 – 60 seconds**.

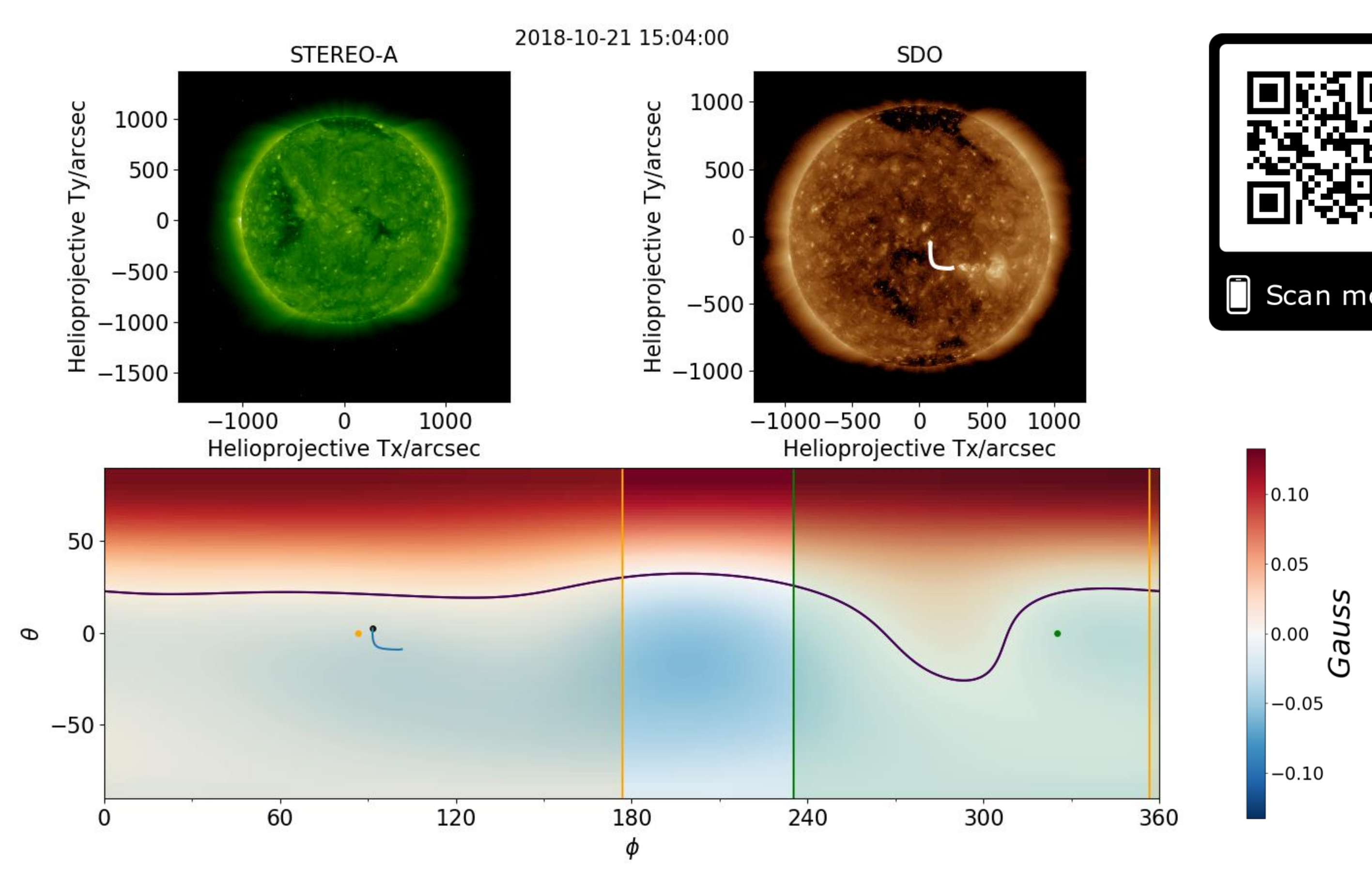

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Figure 3: Shows how magnetic field lines from the Sun connect to PSP (the black dot), highlighting the source region of the solar wind.

5. Conclusion

- Have now identified the source regions for different parts of the in situ magnetic field data.
- Can test theories regarding the generation and acceleration of the solar wind from different types of regions on the Sun.
- Can repeat these methods for the next perihelion in April.

References

[1] V. Pizzo, G. Millward, A. Parsons, D. Biesecker, S. Hill, and D. Odstrcil, "Wang-Sheeley-Arge-Enlil cone model transitions to operations," *Sp. Weather*, vol. 9, no. 3, 2011.
[2] E. Marsch, "Kinetic Physics of the Solar Corona and Solar Wind," *Living Rev. Sol. Phys.*, vol. 3, no. 1, p. 1, 2006.