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FLUXPipe: Automated Fluxon Modeling of the Solar Wind from Magnetograms

SOUTHWEST RESEARCH INSTITUTE

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Overview

FLUX[1,2,3] is a coronal forward-model which creates Fluxons then relaxes them to a linear force-free state.

Fluxons are equal-flux tracers of the magnetic field that follow field lines. This approach allows for multi-scale modeling of the corona, simulating plasma parameters along Fluxons and interpolating between them only if necessary.

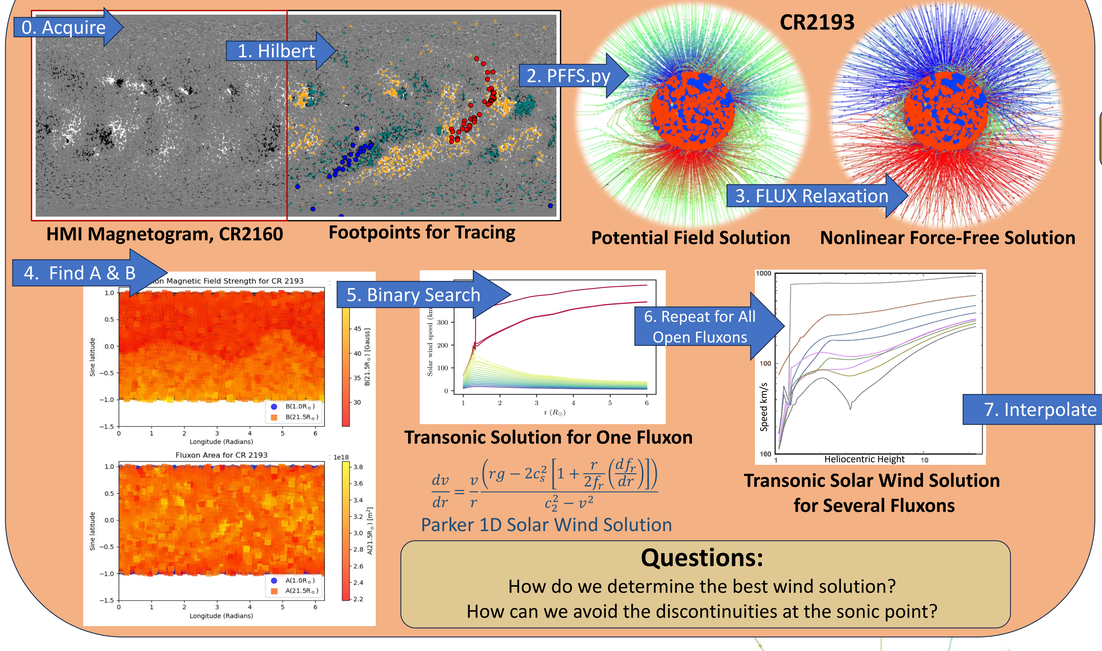
FLUXPipe is a new pipeline which automates the individual steps from magnetogram to solar wind speed values.[3]

The **solar wind speed** along the open fluxons is determined iteratively by finding the transonic solutions.

PUNCH Objectives of Relevance

- **Objective 1:** Understand how coronal structures become the ambient solar wind.
  - ***1A:*** *Global solar wind flow*
    - Determine large-scale flow context necessary to relate coronal structure to in-situ measurements
    - Characterize the global solar wind conditions through which transient structures propagate.
  - ***1C:*** *Alfven Zone*
    - Determine the height where the solar wind exceeds the fast MHD speed

FLUXPipe Steps



$$\frac{dv}{dr} = \frac{v}{r}\frac{\left(rg - 2c_s^2\left[1 + \frac{r}{2f_r}\left(\frac{df_r}{dr}\right)\right]\right)}{c_2^2 - v^2}$$

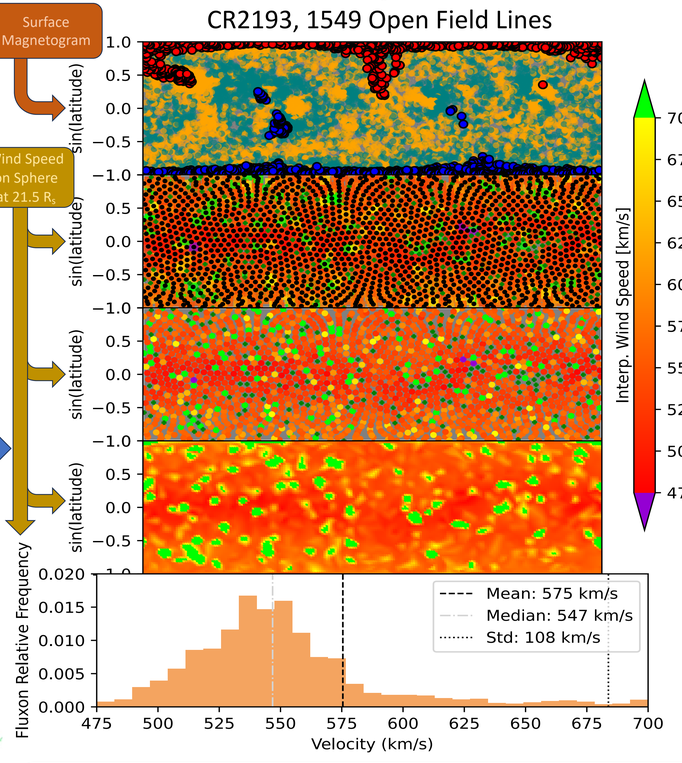
Questions:

How do we determine the best wind solution?

How can we avoid the discontinuities at the sonic point?

Solar Wind Speed Results

CR2193, 1549 Open Field Lines



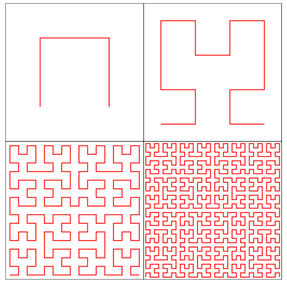
Questions:

Why are there so many outliers?

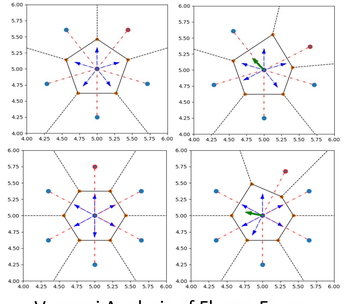
How can we connect source features to wind speed?

Will ADAPT maps converge better than HMI Synoptic?

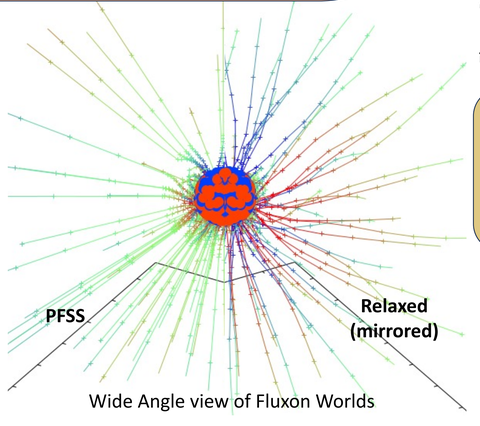
Extra Plots



Example Hilbert Curve



Voronoi Analysis of Fluxon Forces



Wide Angle view of Fluxon Worlds

References

[1] https://github.com/lowderchris/fluxon-mhd

[2] Deforest, Kankelborg 2006

[3] Lowder, Gilly, Deforest 2023