

# Physics-based Heliospheric Modeling System: Background Solar Wind

Prateek Mayank, Dr. Bhargav Vaidya

Department of Astronomy, Astrophysics and Space Engineering, IIT Indore

## Abstract

Predictions of the solar wind parameters are the core of space weather forecasts. And, structure and dynamics of the heliospheric magnetic field (HMF) are key to understanding the solar wind flow. Typically, line-of-sight observations of a magnetogram is used to derive the HMF structure and then a solar wind model is used for forecasting solar wind parameters. Here, we present an implementation of our physics-based solar wind model aiming to compliment the in-situ measurements at 1 AU.

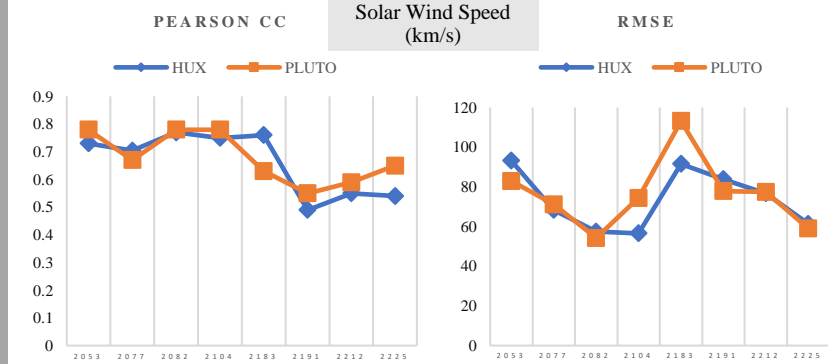
## Velocity Profile at Inner Boundary

$$V = v_0 + \frac{v_1}{(1 + f_s)^{2/9}} \times \left( \left( 1.0 - 0.8 \exp\left(\frac{-d}{w}\right)^\beta \right)^3 \right)$$

where:  $w = \text{median of } d$

$v_0 = 240 \text{ km/s}$ ;  $v_1 = 675 \text{ km/s}$ ;  $\beta = 1.25$

## 8 Sample CRs for Analysis



## Subdomains and Models

- Low Plasma Beta
- Magnetic field dominates the dynamics

**PLUTO / HUX**  
From 21.5 to 215  $R_0$

**SCS**  
from 2.5 to 21.5  $R_0$

PFSS 0.1 AU

1.0 AU

- High Plasma Beta
- Pressure gradient dominates the dynamics

### PFSS

[Potential Field Source Surface]

- Assumption:  $J = 0$
- Source surface at  $\sim 2.5$  solar radius
- Field is radial at source surface

### PLUTO / HUX

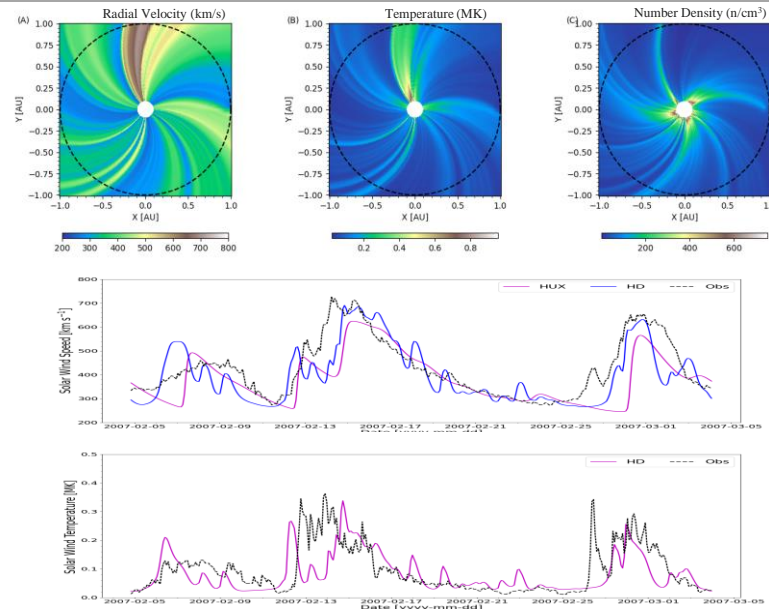
- HUX is used for 1D stream extrapolation
- PLUTO code is a framework that is used for physics module
- We have used 2D HD PLUTO

### SCS

[Schatten Current Sheet]

- PFSS output acts as inner boundary condition
- Extends the magnetic field in a radial way

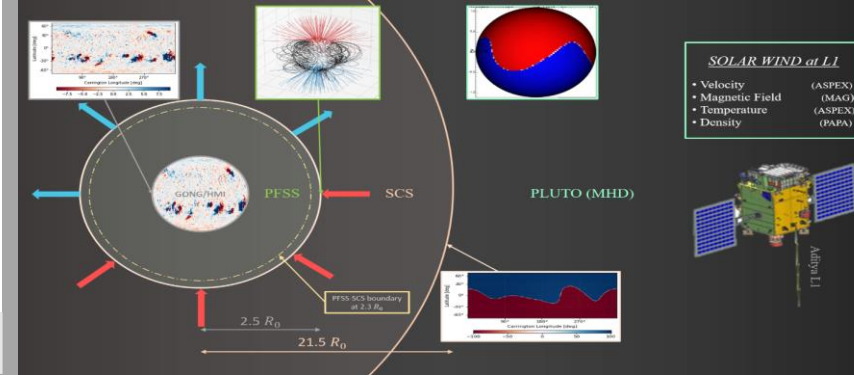
## Model Outputs



Our 2D HD-PLUTO model, which uses modified WSA empirical relation, has been successful in capturing the structure of the solar wind speed and temperature profiles.

## Conclusion

- We used the modified WSA relation as an input for our HUX and PLUTO codes, keeping the values of all parameters constant.
  - Statistical result of all CRs were satisfactory except 2183, which lies outside the solar minima range.
  - PLUTO results were better than HUX for all CRs except 2104 & 2183
- Our aim is to extend this study to 3D MHD model which will complement the upcoming Aditya-L1 mission, in particular ASPEX, PAPA & MAG.



## Acknowledgement

- This work utilizes *pfsspy* python module.
- NSO-GONG magnetograms has been used as an input for Coronal model.
- We used OMNI hourly averaged data to compare the output at L1

## References

- Mignone, A. et al. PLUTO: A Numerical Code for Computational Astrophysics. *ApJS* 170, 228–242 (2007).
- Riley, P., Lionello, R. Mapping Solar Wind Streams from the Sun to 1 AU: A Comparison of Techniques. *Sol Phys* 270, 575–592 (2011).