



Flux Tube Expansion Factor and Solar Wind Speed: Comparison of Current Sheet Source Surface Model and Potential Field Source Surface Model

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PFSS Model

Schatten, Wilcox and Ness 1969

Altschuler and Newkirk 1969

assumptions

- **little current flows between photosphere and source surface**
- **coronal magnetic field can be derived from a potential obeying Laplace's equation**
- **at the source surface all field lines are radial**



PFSS Model: Parameters

- height of source surface
- radius of the inner sphere
- number of multipole components in spherical harmonic expansion: N_{\max}
- $2.5 R_{\text{sun}}$
- $1.0 R_{\text{sun}}$
- $N_{\max} = 9, \dots 90$
WSO data: 22
Kitt Peak: 90



PFSS Model: Limitations

- very sensitive to rapid field evolutions
- magnetic field predicted for mid- and high latitudes does not agree with observations
- potential field approximation not strictly valid for solar corona
- exclusion of current sheet causes severe discrepancies
- location of source surface, $2.5 R_{\text{sun}}$, much lower than Alfvén critical point



Flux Expansion and Solar Wind

Levine, Altschuler and Harvey (1977)

**inverse correlation between SWS
observed at 1 AU and FTE on the
source surface, using PFSS model**



Flux Expansion and Solar Wind

Flux Tube Expansion Factor (FTE)

$$\text{FTE} = R_s/R_{ss} * B_r(\theta_{ss}, ss)/B_r(\theta_s, s) \quad (1)$$

$B_r(\theta_s, s)$ photospheric magnetic field

R_s photospheric radius

$B_r(\theta_{ss}, ss)$ source surface magnetic field

R_{ss} source surface radius



Flux Expansion and Solar Wind

Wang and Sheeley (1990; 1994; 1997)
Confirmed the inverse correlation

Speed	FTE
< 450	> 20
450-550	10-20
550-650	8-10
650-750	4.5-8
> 750	< 4.5



Flux Expansion and Solar Wind

Computation of correlation between FTE and SWS involves:

1. determination of precise location of coronal sources of solar wind

$$0 = R$$

$$0 = R + \omega R_E/V_R \quad (2)$$

2. Identification of photospheric footpoints of these sources by tracing along the magnetic field lines



Discrepancy - Causes

- **quality and resolution of photospheric data**
- **existence of transients not included in the model**
- **stream-stream interaction**
- **inverse mapping of solar wind to its source**
- **limitations of PFSS model itself**



Current Sheet Source Surface Model

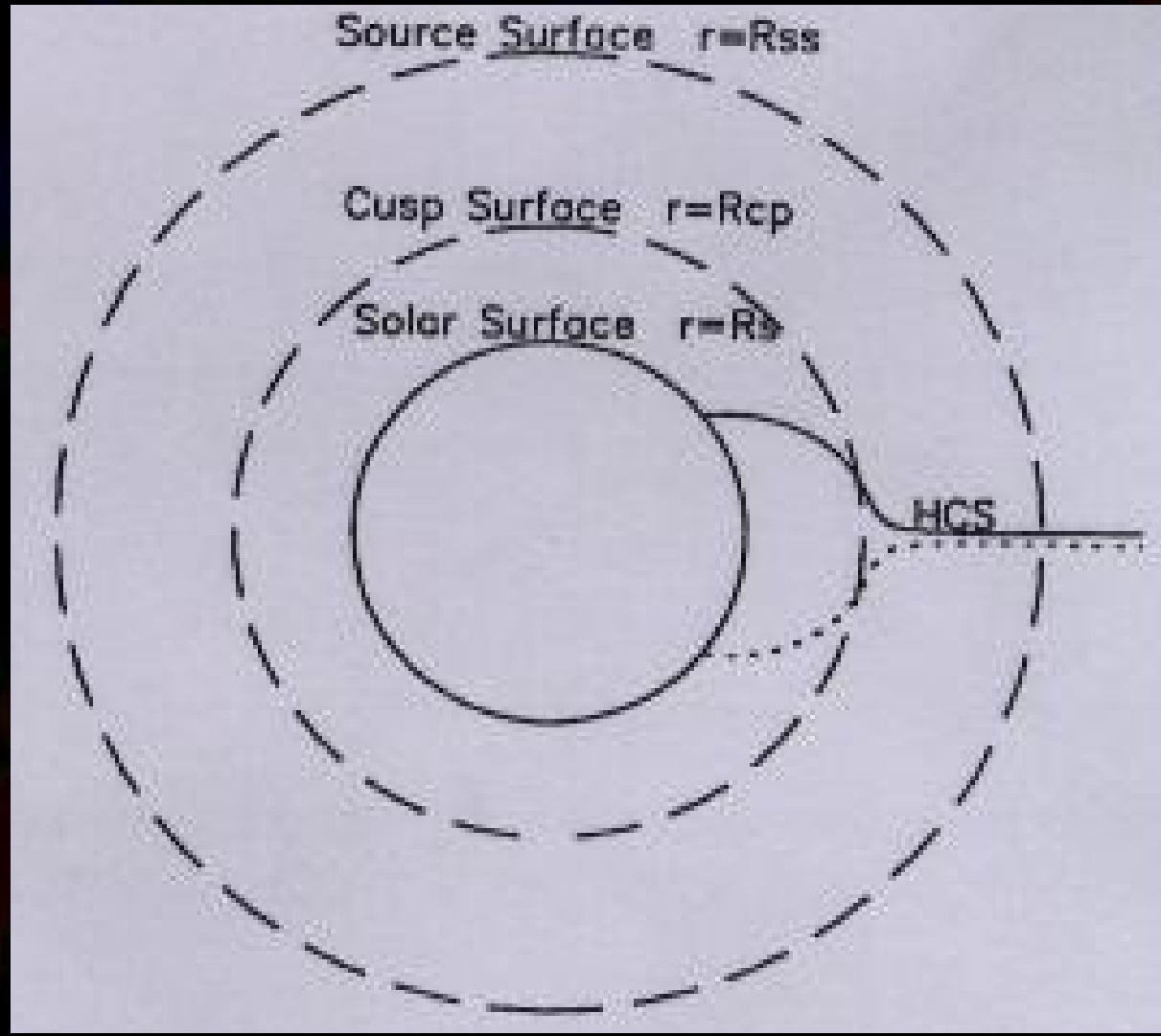
Improvements over SS model

- **cusp surface: field lines are open but not necessarily radial; includes effects of streamer current sheets**
- **source surface: placed near the Alfvén critical point**

uses source surface technique to include effects of volume currents beyond source surface

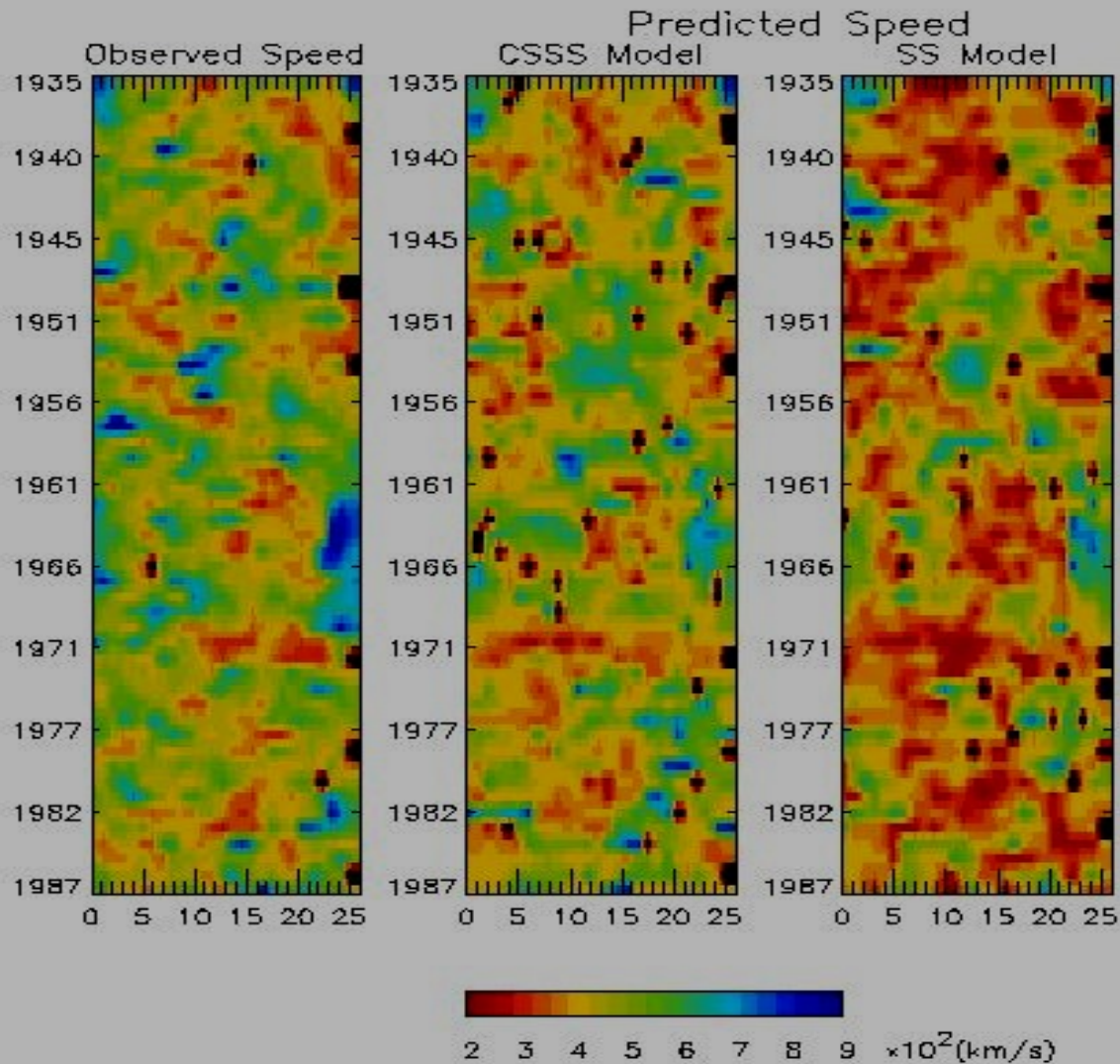


Current Sheet Source Surface Model



Predicted Solar Wind

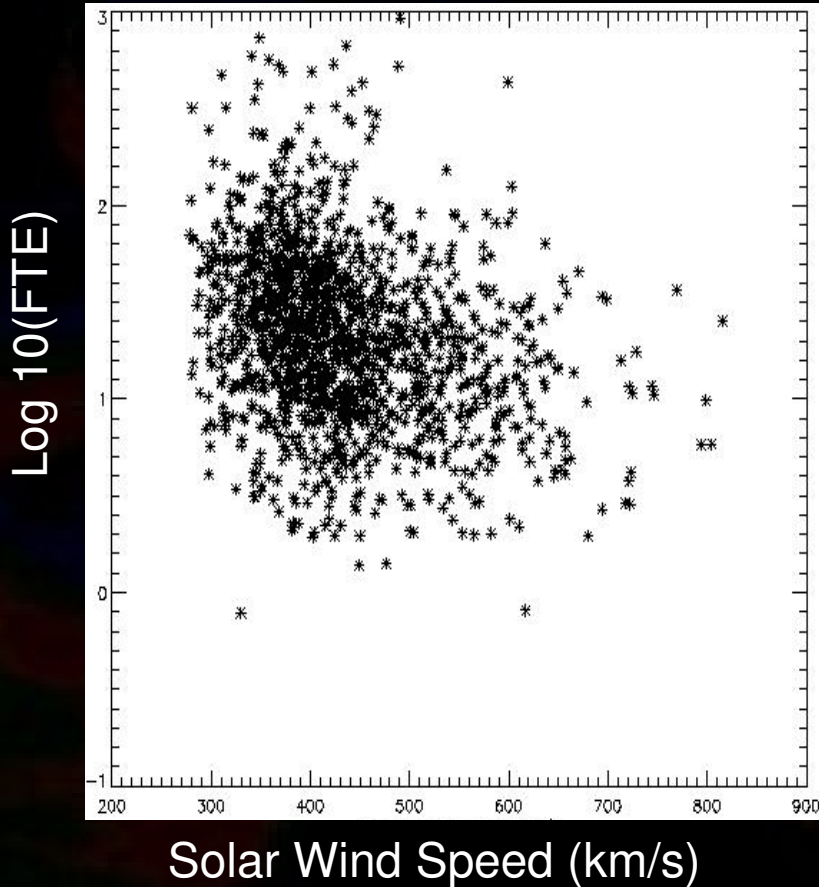
1998–2002 nmax = 22 mapb = 1



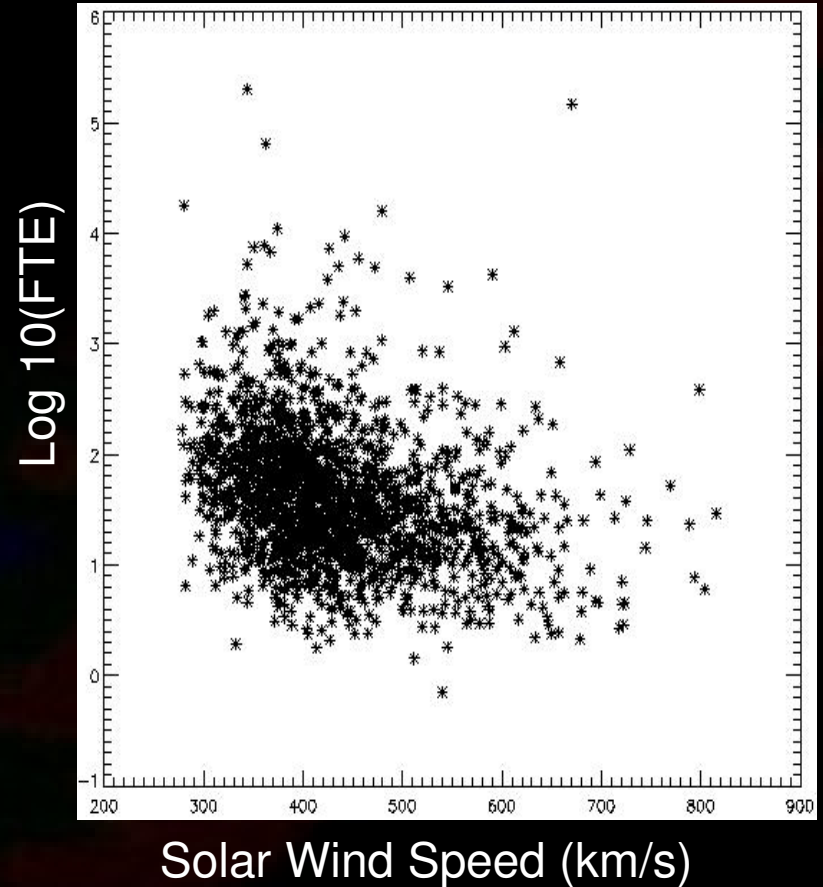


Scatter Plots

CSSS Model



PFSS Model

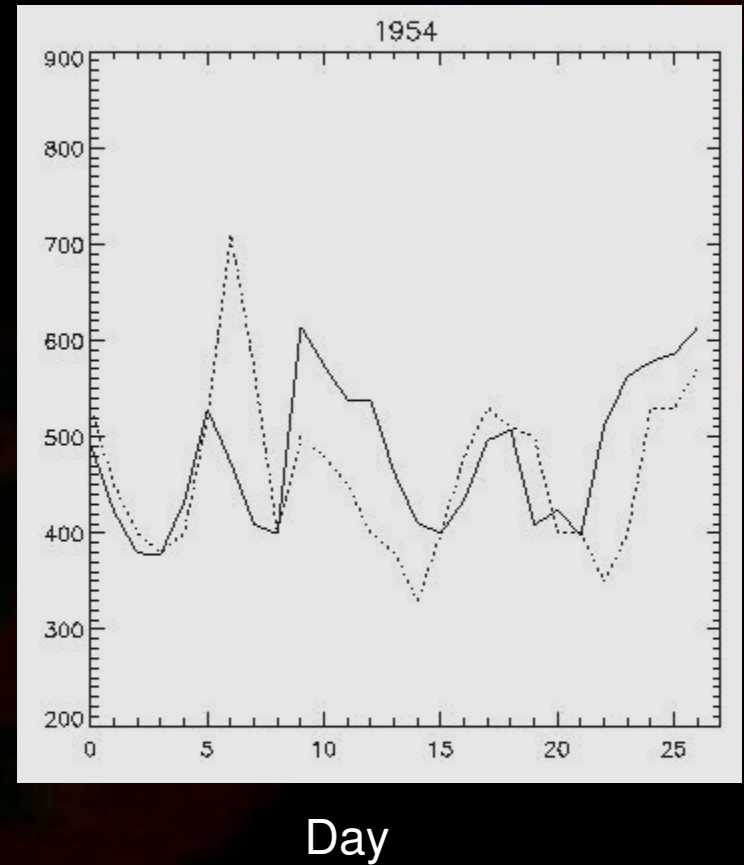
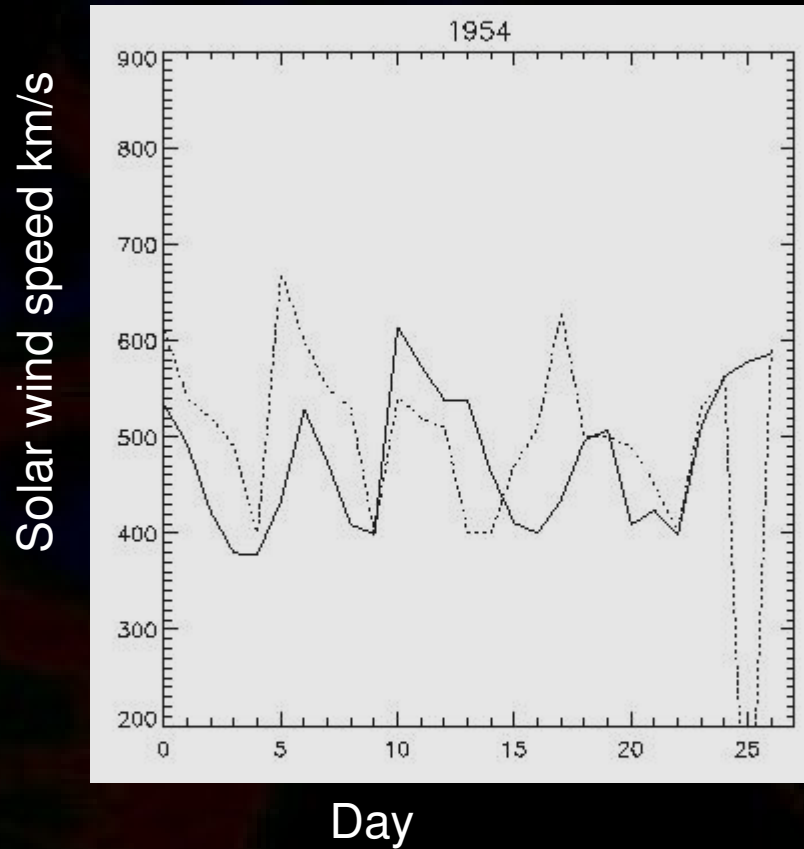




Predicted Solar Wind

Dotted Line: CSSS Model

Dotted Line: PFSS Model





Concluding Remarks

CSSS model appears to predict solar wind speed slightly better than the PFSS model from the present analysis.

This may be due to the fact that CSSS model can trace field lines better than PFSS model.

This work will be extended to other periods of solar activity.

