Potential Field Source Surface Model and Solar Wind Prediction

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Solar wind Prediction

Arge and Pizzo (2000)

$$V_{sw} = 267.5 + 410.0/f^{(1.0/2.5)} \qquad (3)$$

f => FTE calculated using PFSS model

Prediction not always agree with observation

Potential Field Source Surface 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
  - 2.5 R_{sun}
- radius of the inner sphere
  - 1.0 R_{sun}
- number of multipole components in spherical harmonic expansion: N_{max}
  - N_{max} = 9, ... 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_{sun}, much lower than Alfvén critical point

Background

Levine, Altschuler and Harvey (1977)

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

Background

Flux Tube Expansion Factor (FTE)

$FTE = R_s/R_{ss} * B_r(\theta_{ss},\Phi_{ss})/B_r(\theta_s,\Phi_s)$ (1)

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

R_s photospheric radius

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

R_{ss} source surface radius

Background

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

Inverse Mapping

Computation of correlation between FTE and SWS involves:

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

$$\Theta_0 = \Theta_R$$

$$\Phi_0 = \Phi_R + \omega R_E / V_R \qquad (2)$$

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

How to improve?

Arge and Pizzo (2000)

improved photospheric field data and allowed stream-stream interaction

discrepancies still exist

What Next?

Look at calculation of FTE

we investigated the sources of errors caused in FTE computation using PFSS model

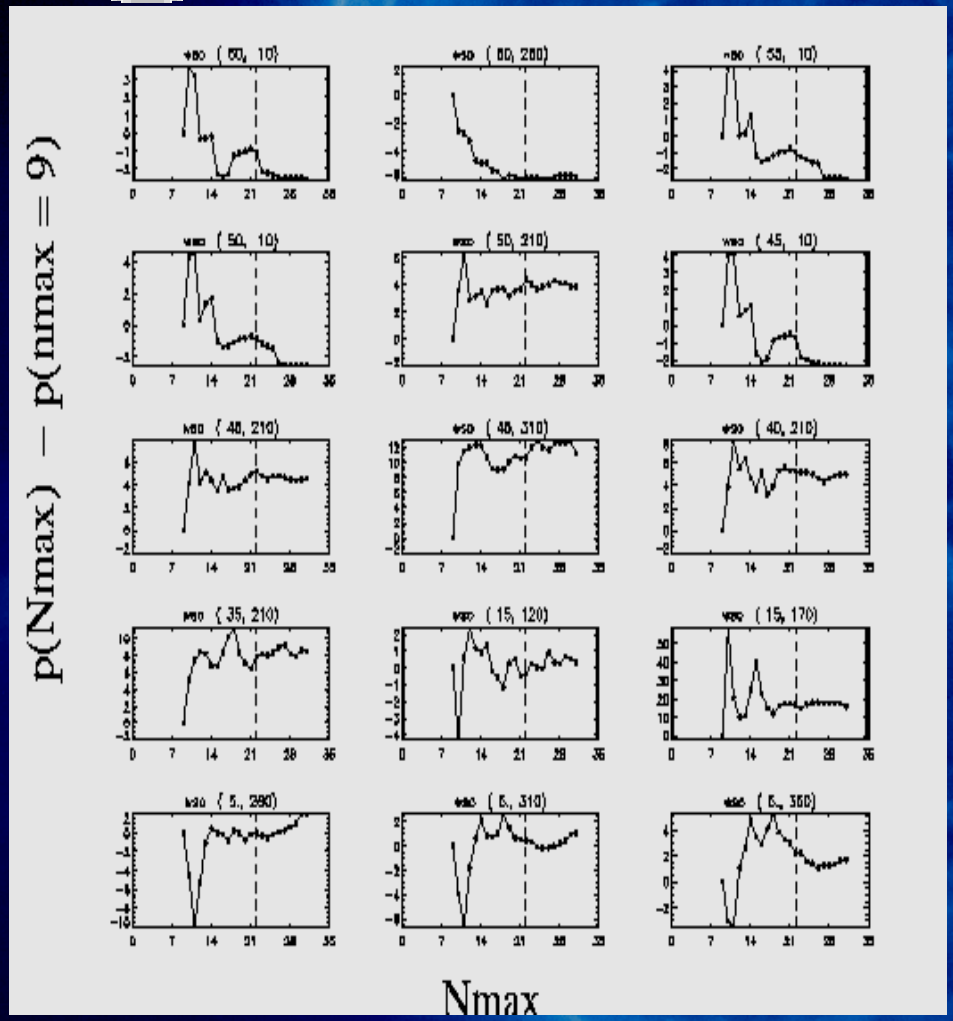
Current Sheet Source Surface Model

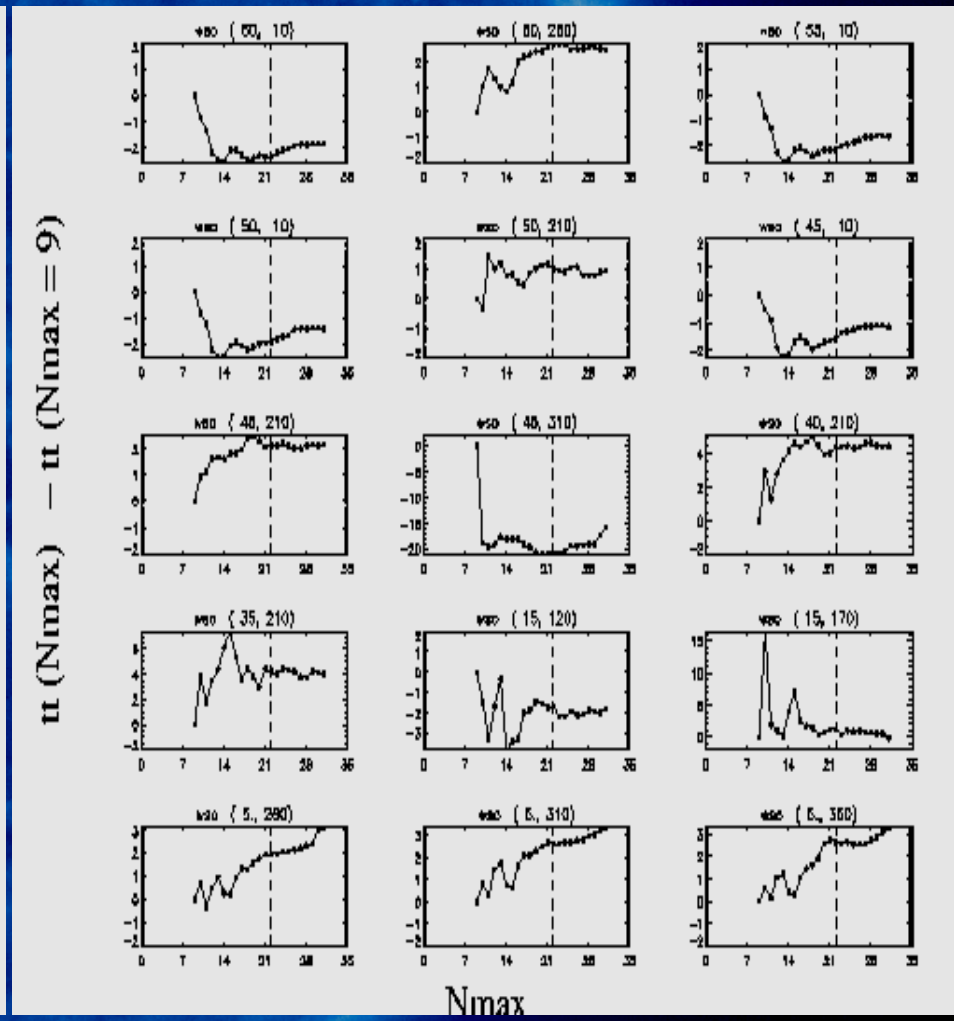
Improvements over SS model

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

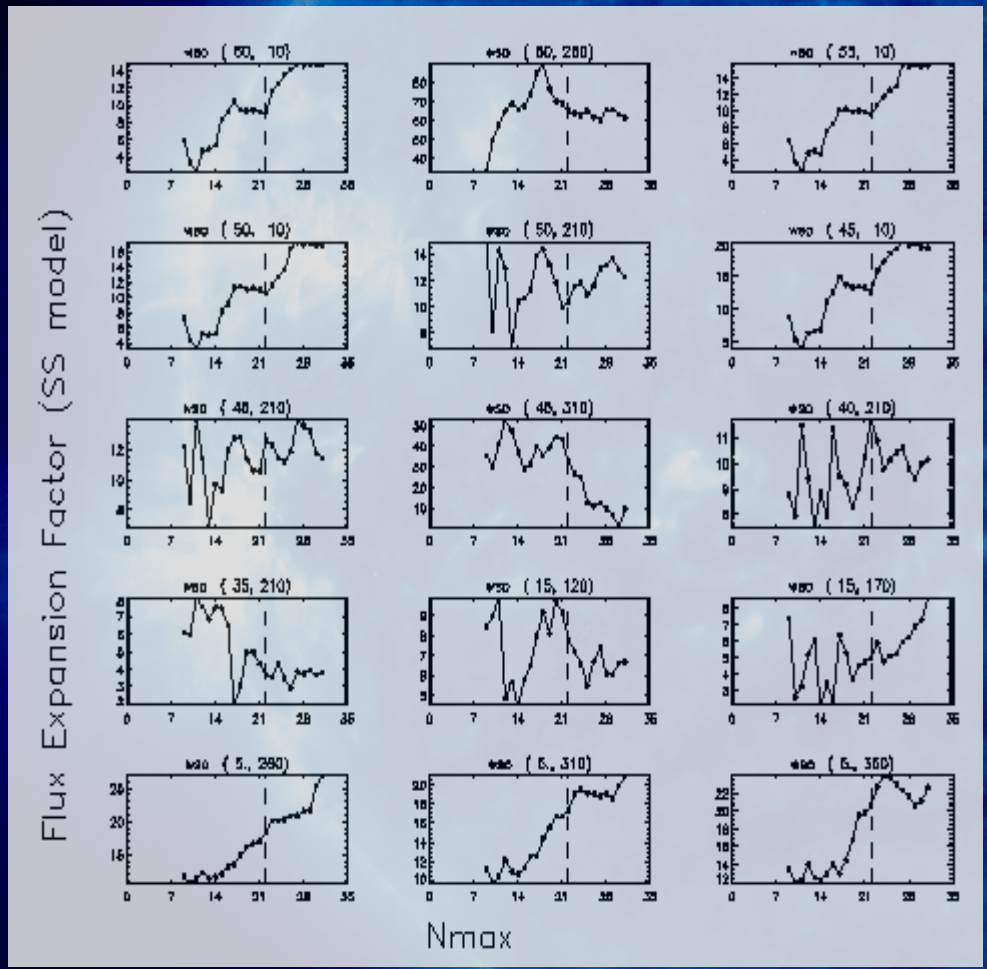
uses source surface technique to include effects of volume current beyond source surface

Foot point and Nmax

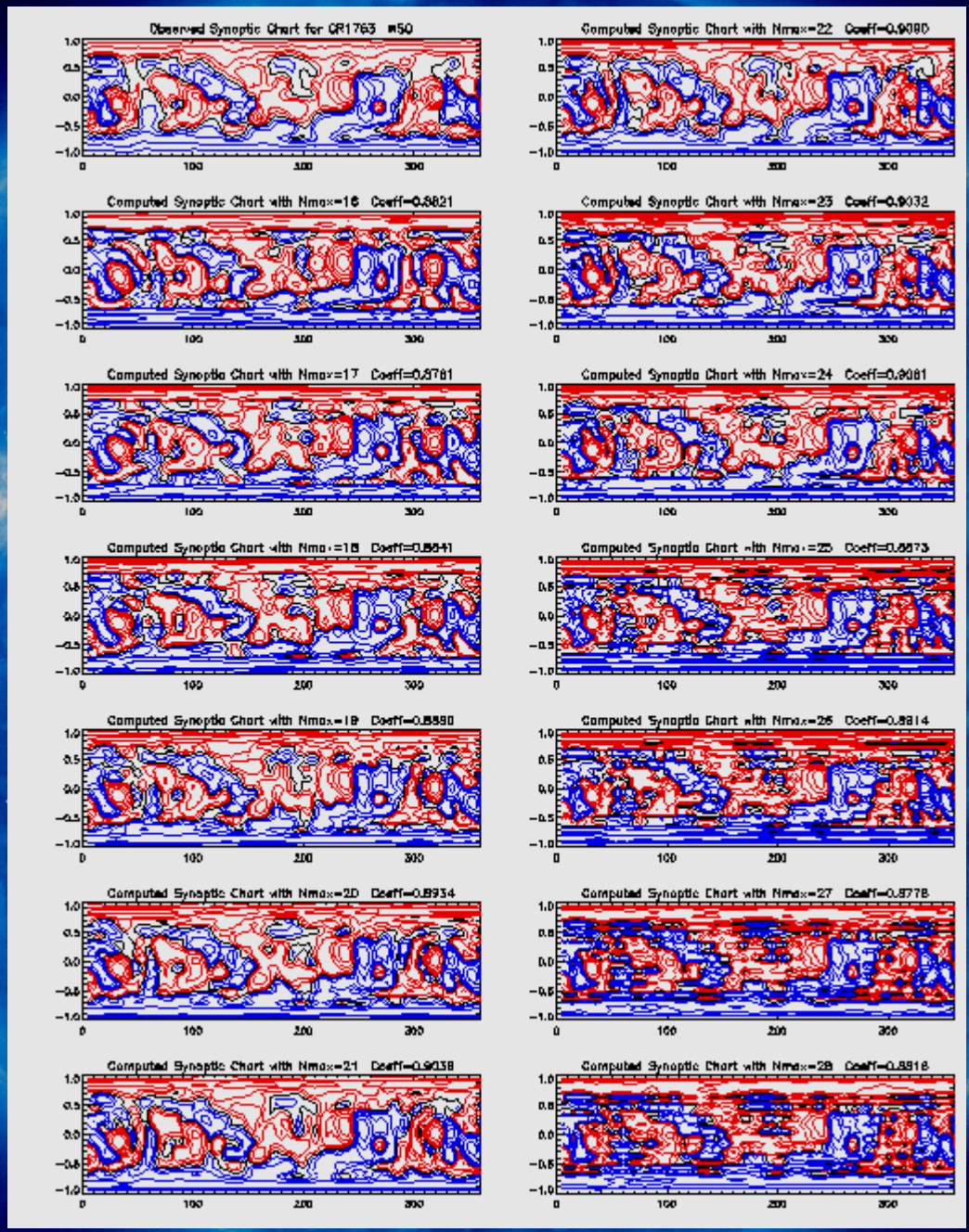


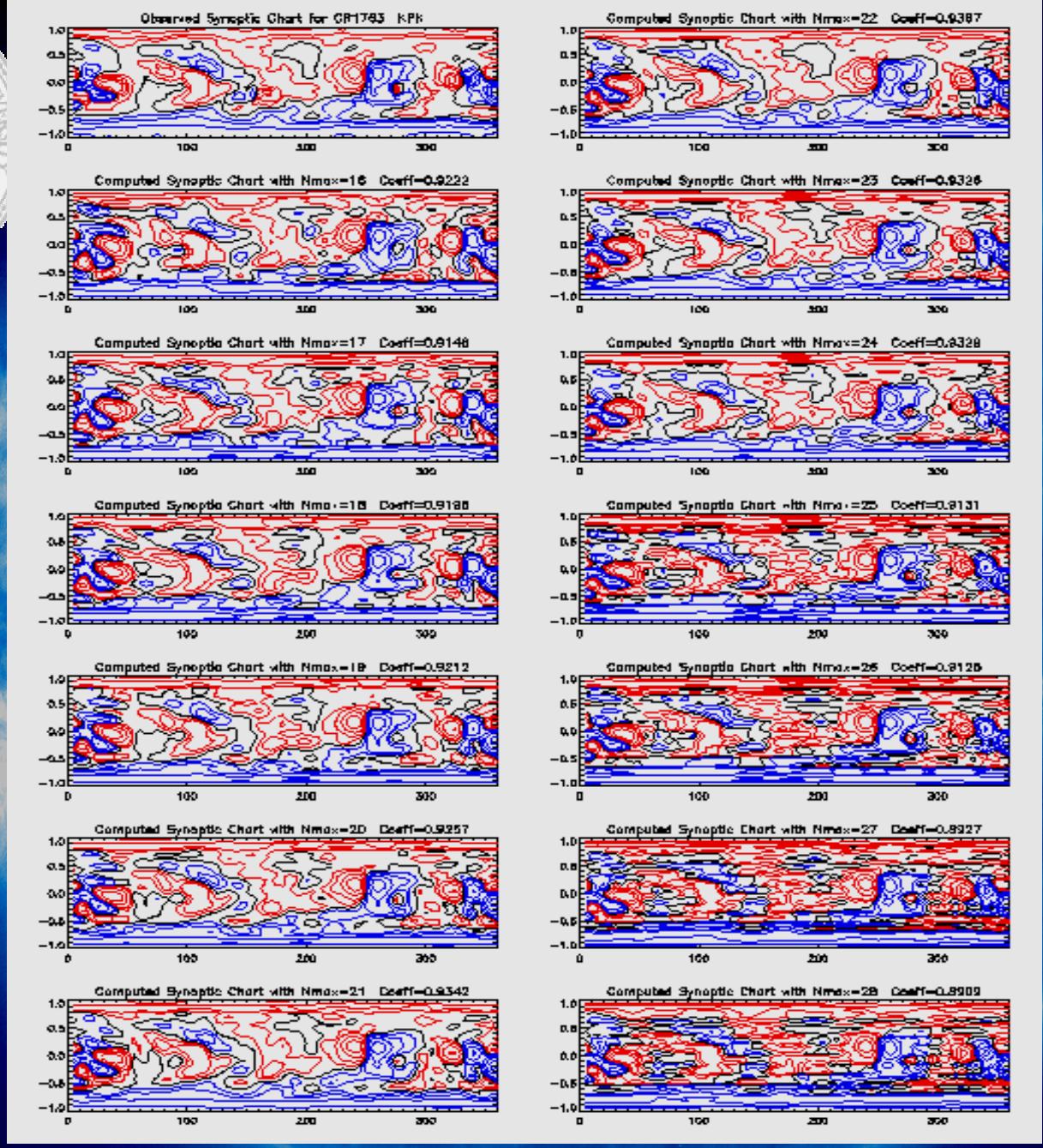


FTE and Nmax

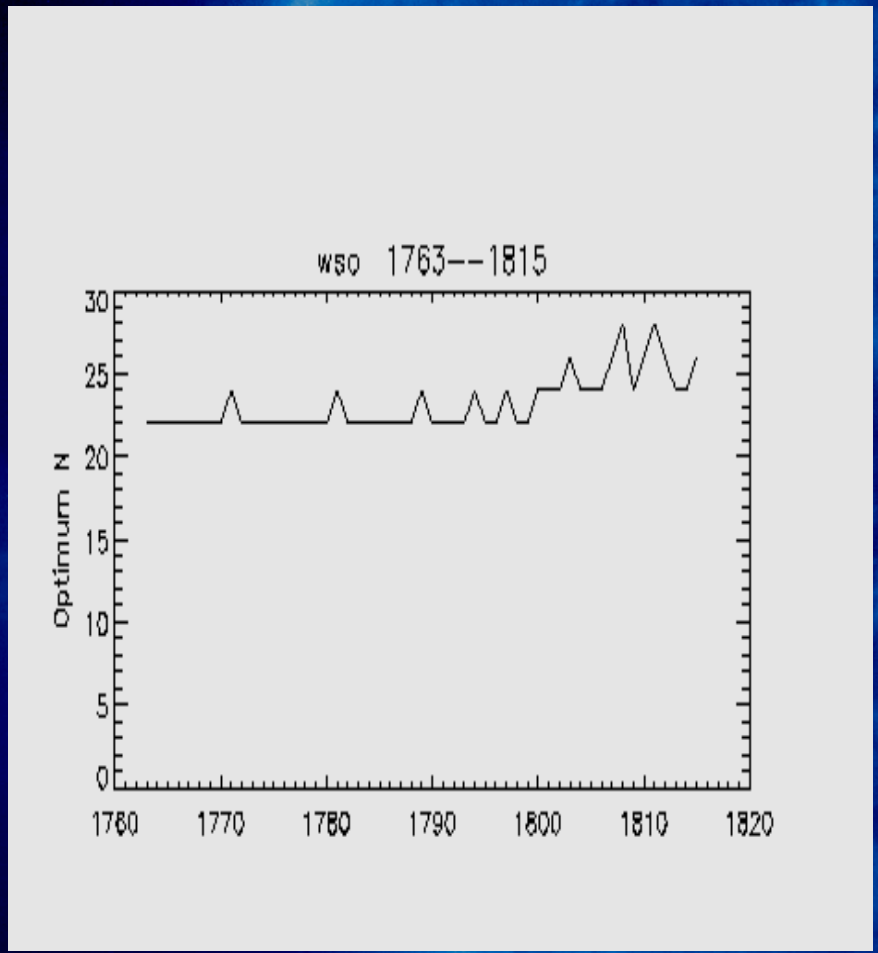


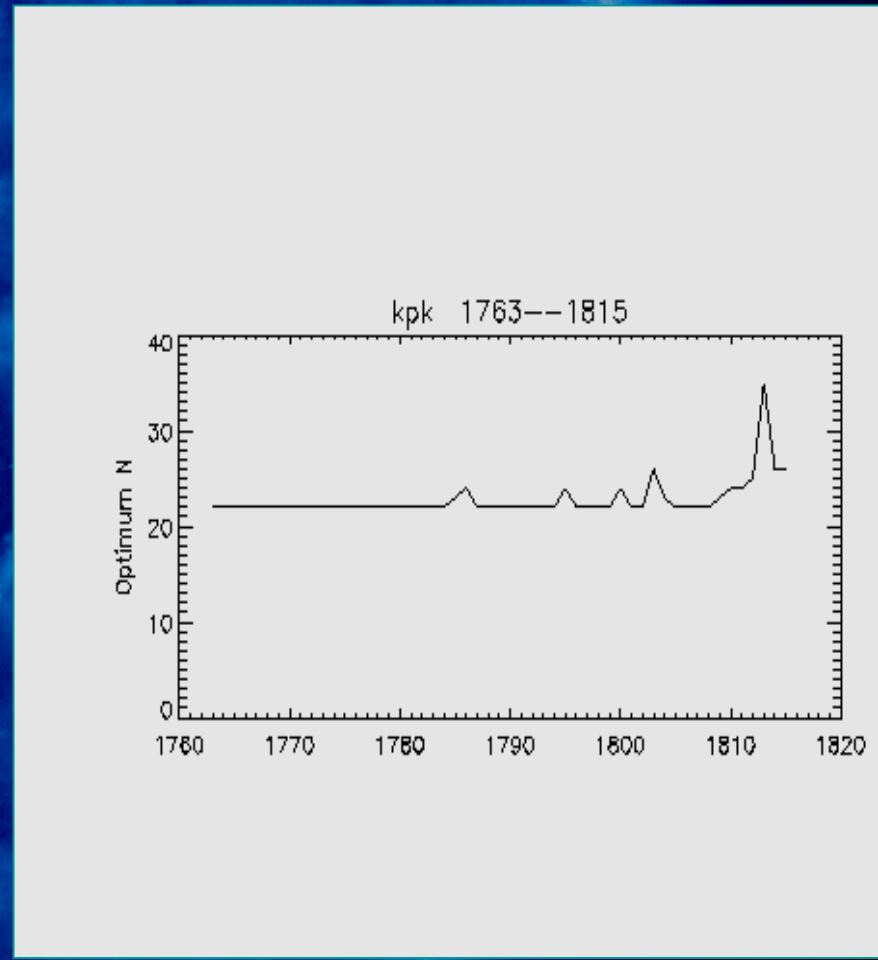
- Variation of FTE with Nmax used in PFSS model


Observed Synoptic Chart for CR1763 m50
Computed Synoptic Chart with Nmax=22 Coeff=0.9080
Computed Synoptic Chart with Nmax=16 Coeff=0.8821
Computed Synoptic Chart with Nmax=23 Coeff=0.9032
Computed Synoptic Chart with Nmax=17 Coeff=0.8781
Computed Synoptic Chart with Nmax=24 Coeff=0.9081
Computed Synoptic Chart with Nmax=18 Coeff=0.8841
Computed Synoptic Chart with Nmax=25 Coeff=0.8873
Computed Synoptic Chart with Nmax=19 Coeff=0.8890
Computed Synoptic Chart with Nmax=26 Coeff=0.8814
Computed Synoptic Chart with Nmax=20 Coeff=0.8934
Computed Synoptic Chart with Nmax=27 Coeff=0.8778
Computed Synoptic Chart with Nmax=21 Coeff=0.9038
Computed Synoptic Chart with Nmax=28 Coeff=0.8818


Observed Synoptic Chart for CR1793 KPk
Computed Synoptic Chart with Nmax=22 Coeff=0.9387
Computed Synoptic Chart with Nmax=16 Coeff=0.9222
Computed Synoptic Chart with Nmax=23 Coeff=0.9326
Computed Synoptic Chart with Nmax=17 Coeff=0.9148
Computed Synoptic Chart with Nmax=24 Coeff=0.9328
Computed Synoptic Chart with Nmax=18 Coeff=0.9188
Computed Synoptic Chart with Nmax=25 Coeff=0.9131
Computed Synoptic Chart with Nmax=19 Coeff=0.9212
Computed Synoptic Chart with Nmax=26 Coeff=0.9125
Computed Synoptic Chart with Nmax=20 Coeff=0.9257
Computed Synoptic Chart with Nmax=27 Coeff=0.9227
Computed Synoptic Chart with Nmax=21 Coeff=0.9342
Computed Synoptic Chart with Nmax=28 Coeff=0.9309

Optimum Nmax





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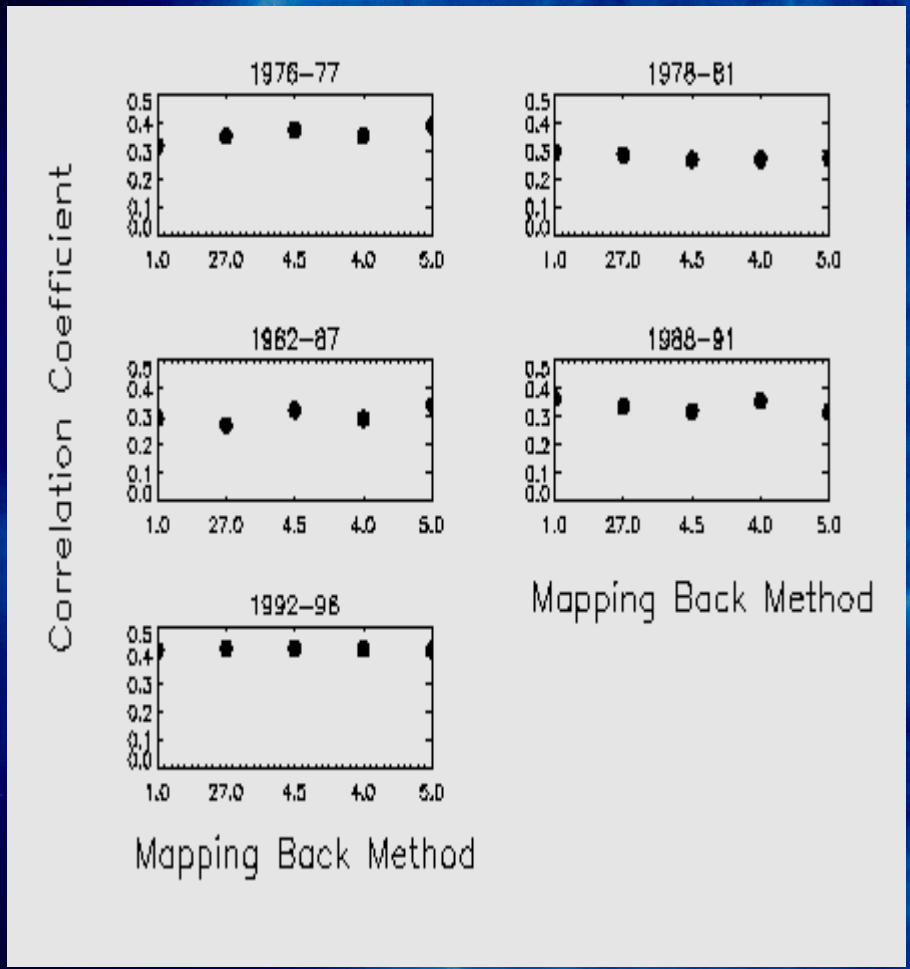
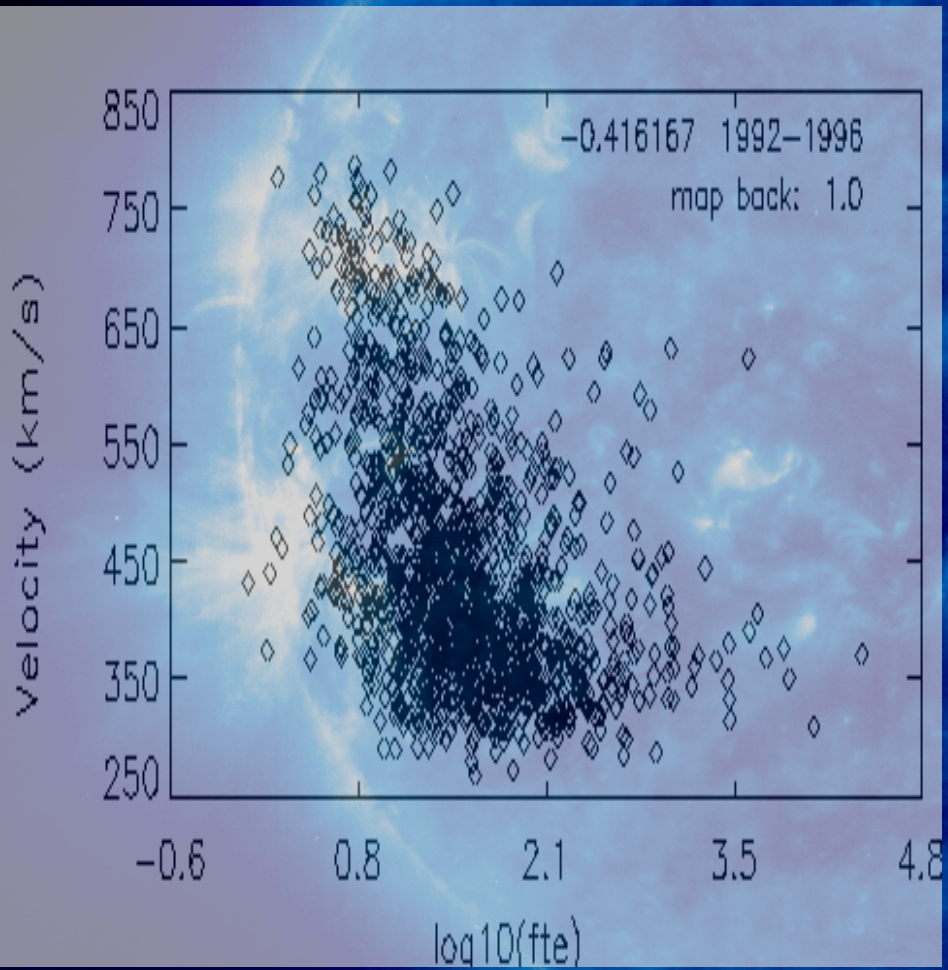
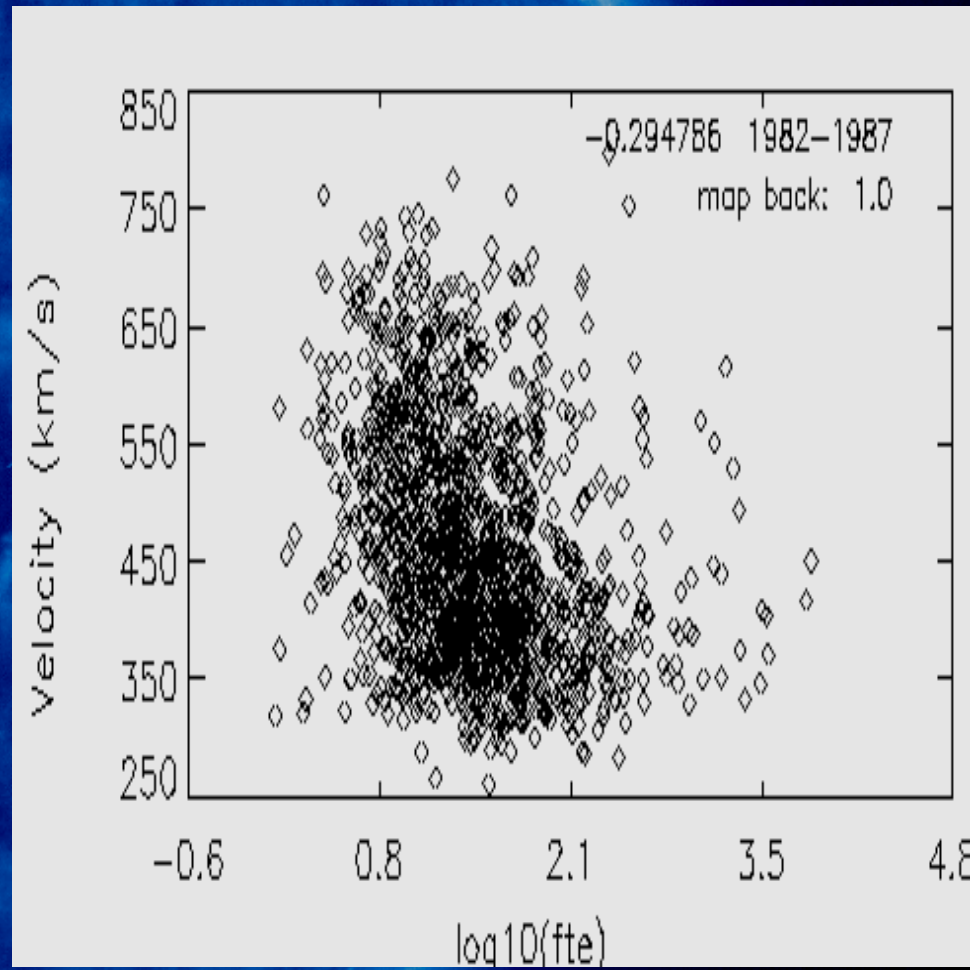
Inverse Mapping - Correlation Coefficient



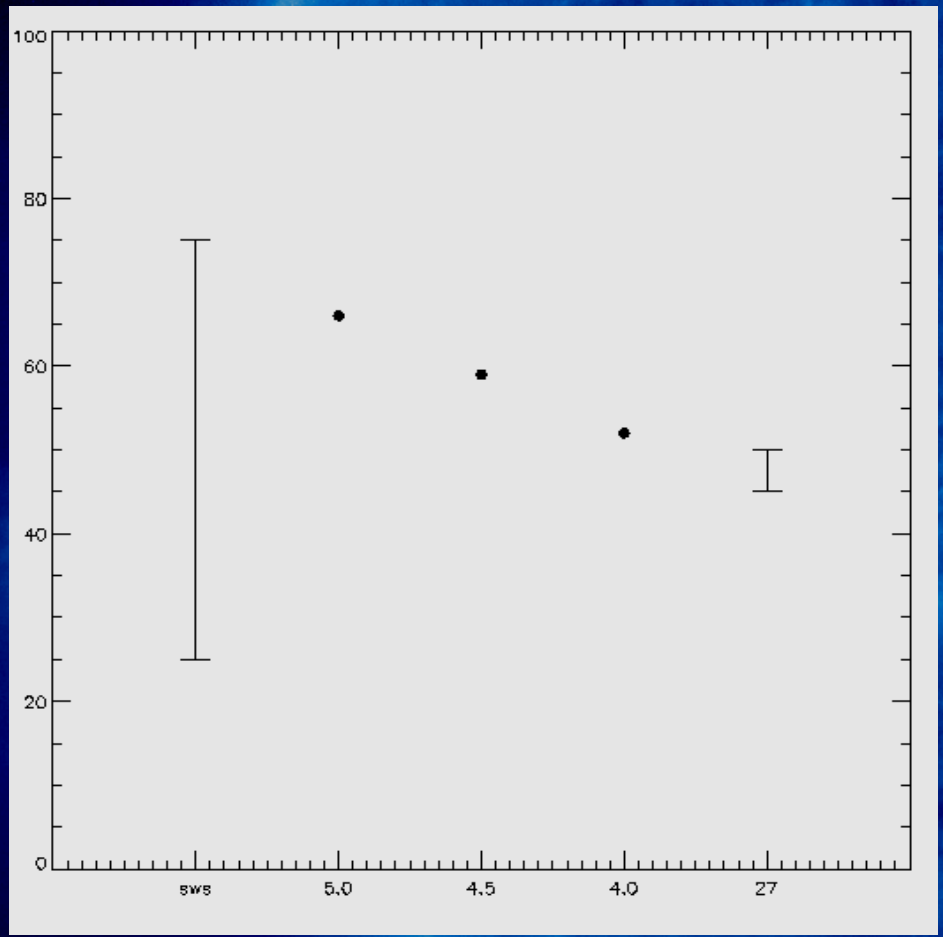
- variation of correlation coefficient with different values of solar wind transit time adopted in the inverse mapping technique

Scatter Plot - FTE vs SWS





Inverse Mapping: Longitude Range



- sws: observed daily averaged values
- 5.0: constant speed of 5 days
- 4.5: constant speed of 4.5 days
- 4.0: constant speed of 4 days
- 27: running average

Histogram: "Error" in Longitude