A Determination of the Value and Variability of the Sun's Open Magnetic Flux using a Global MHD Model
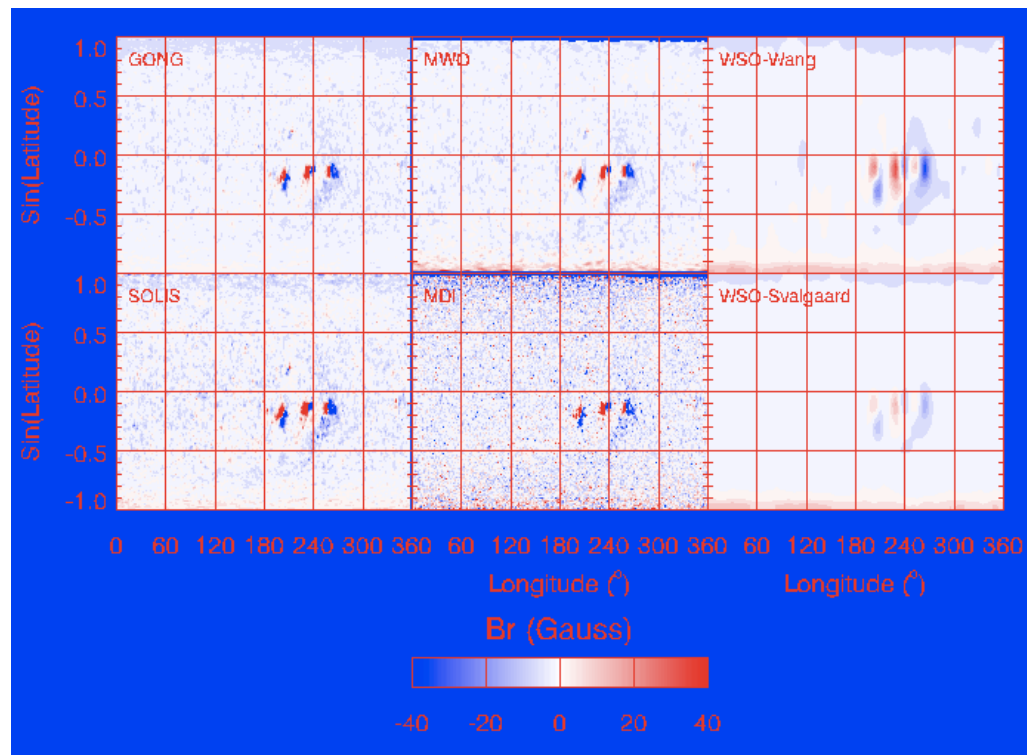
Pete Riley
Zoran Mikic
Jon A. Linker,
SAIC, San Diego, CA.

Jack Harvey
NSO, Kitt Peak, Tucson, AZ

Todd Hoeksema
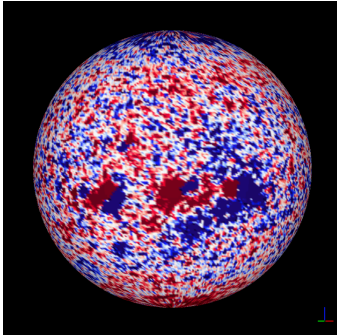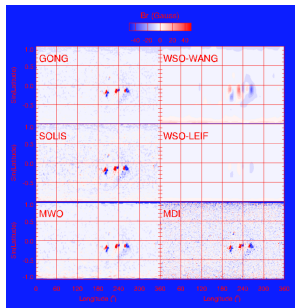**Yang Liu**
Stanford University, Stanford, CA

and

Luca Bertello
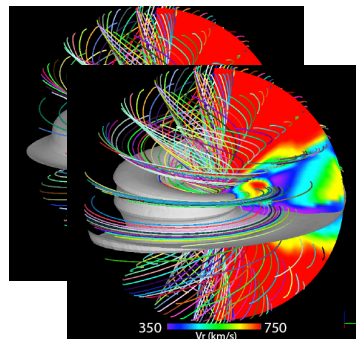UCLA, Los Angeles, CA

This talk explores the sensitivity of different magnetic field inputs into global numerical models

There are currently no "ground truth" observations of the radial photospheric magnetic field.

Often, there isn't a simple relationship between photospheric magnetic fields from different observatories.

Different inputs produce substantial differences in the computed structure of the solar corona and heliosphere, and the open flux, in particular.
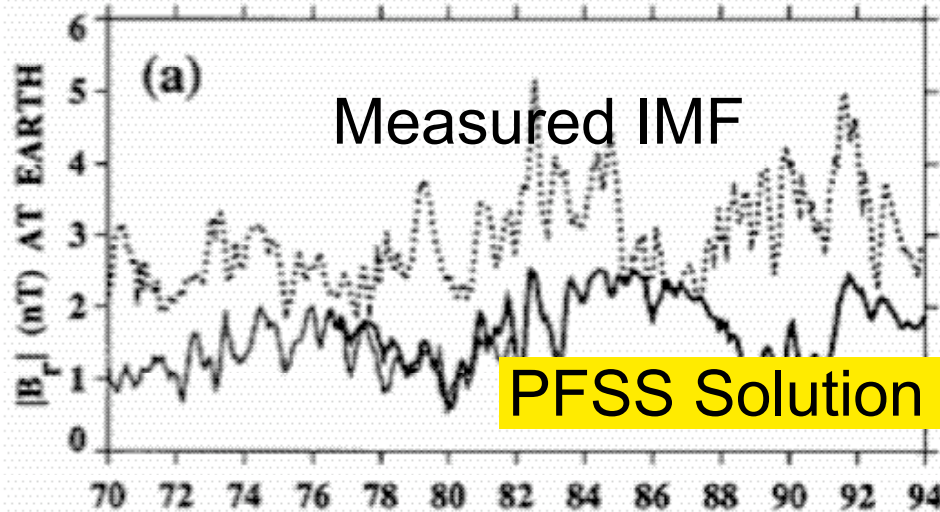
Potential Field Source Surface Models
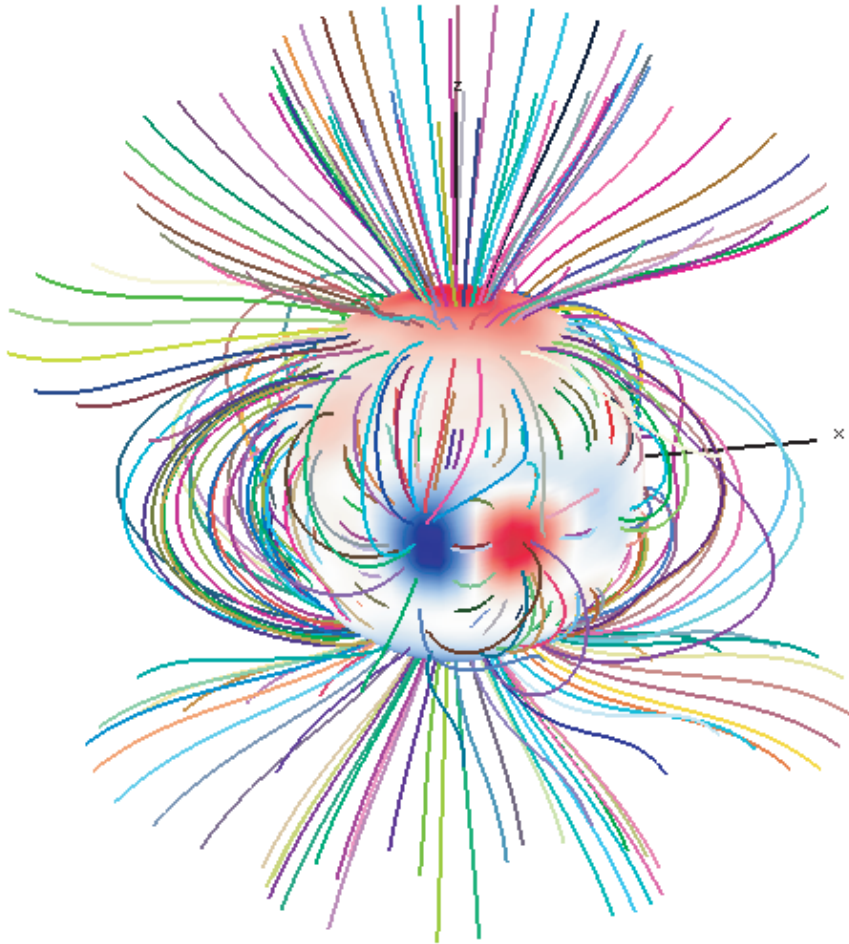
Between Rs and 2.5Rs, field is current free:

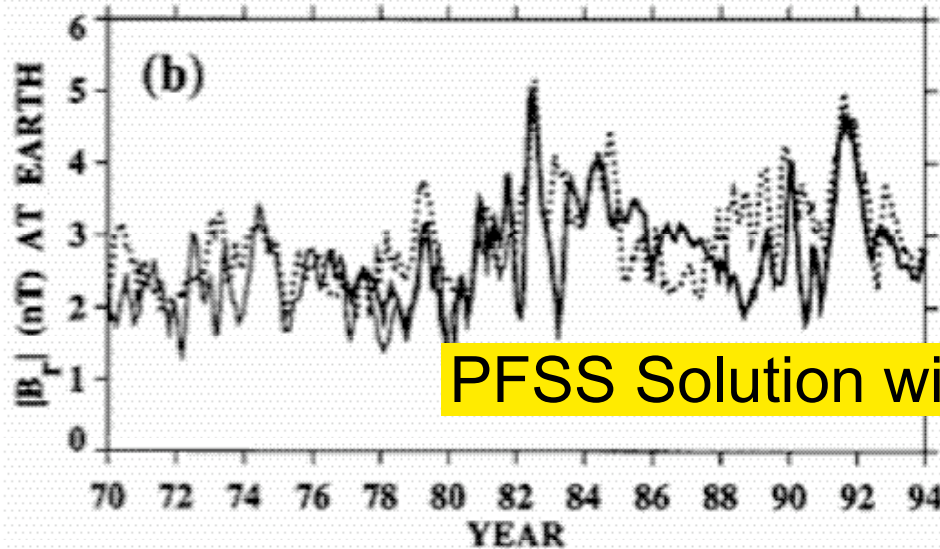$$\nabla \times \mathbf{B} = \mathbf{0}$$

$$\nabla^2 \chi = 0$$

At 2.5Rs, field is forced to become radial

Wang and Sheeley argue that using the Wilson correction factor on WSO data improves the match with 1 AU data.

Measured IMF

$g_{Wilcox} = 1.8$ (or 1.86)
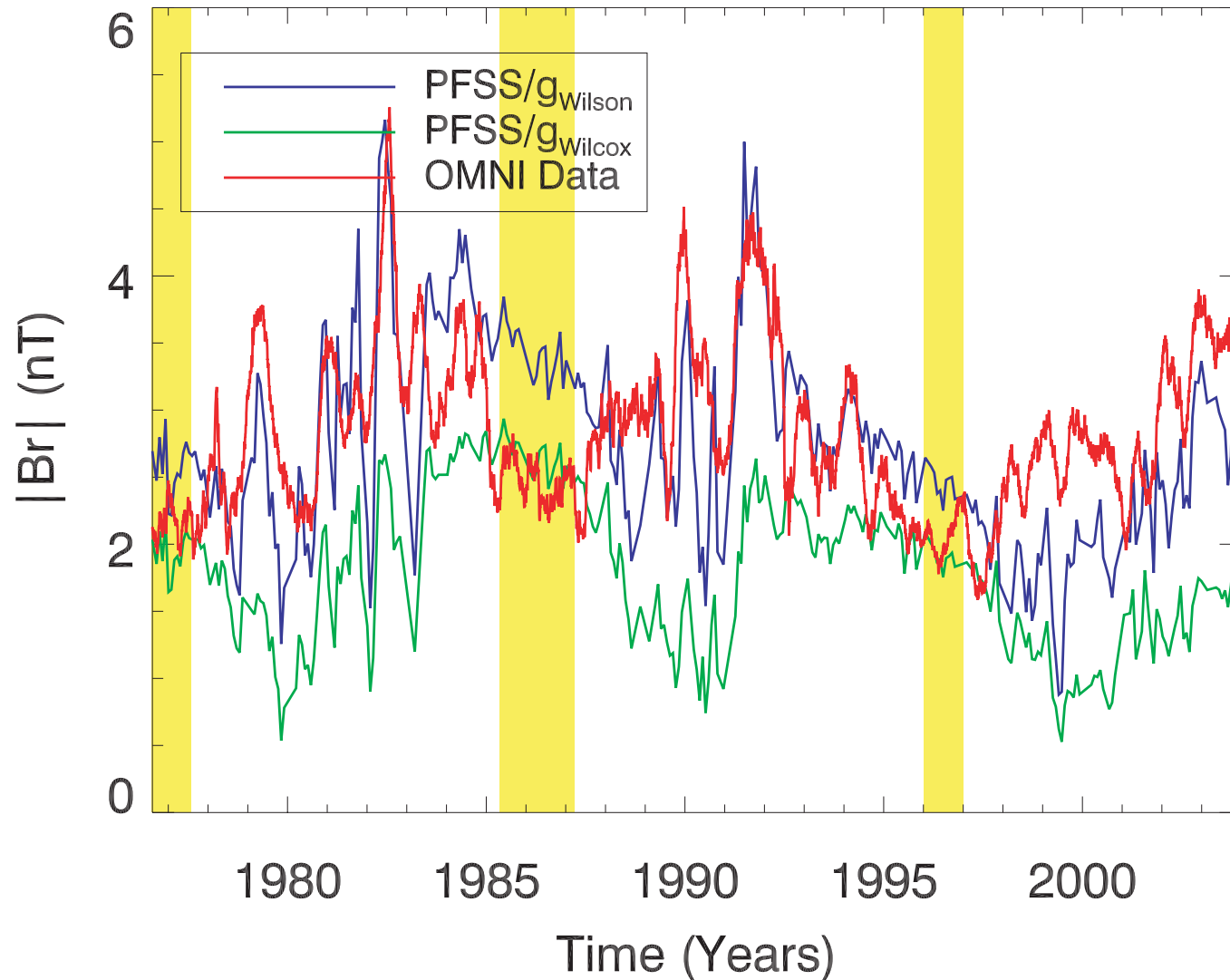
Svalgaard

PFSS Solution with "Wilcox" factor

$g_{Wilson} = 4.5 - 2.5 \sin^2(L)$

Wang and Sheeley

PFSS Solution with "Wilson" factor

Wang and Sheeley (1995)

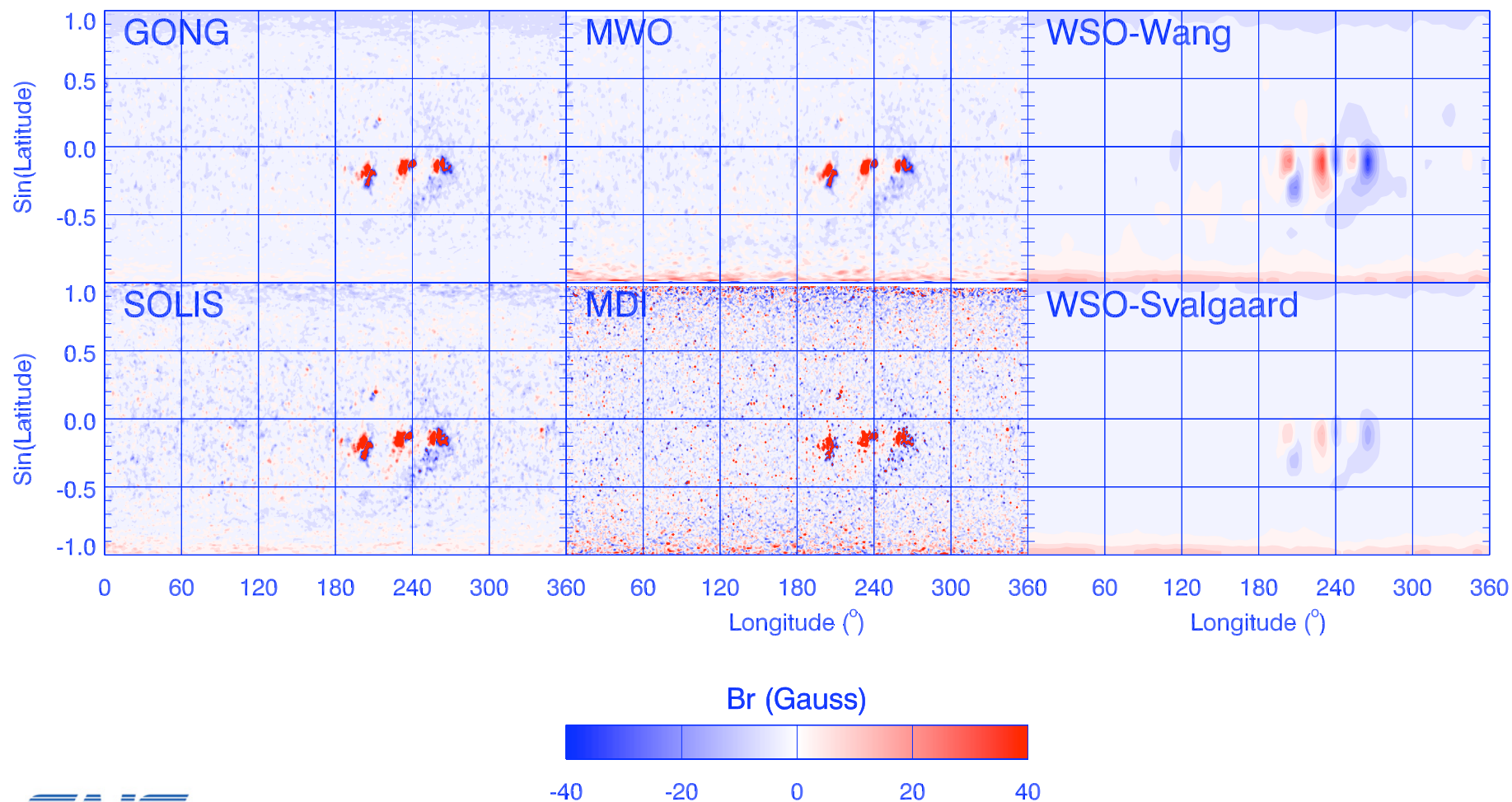# Our independent PFSS calculations match the Wang and Sheeley result.

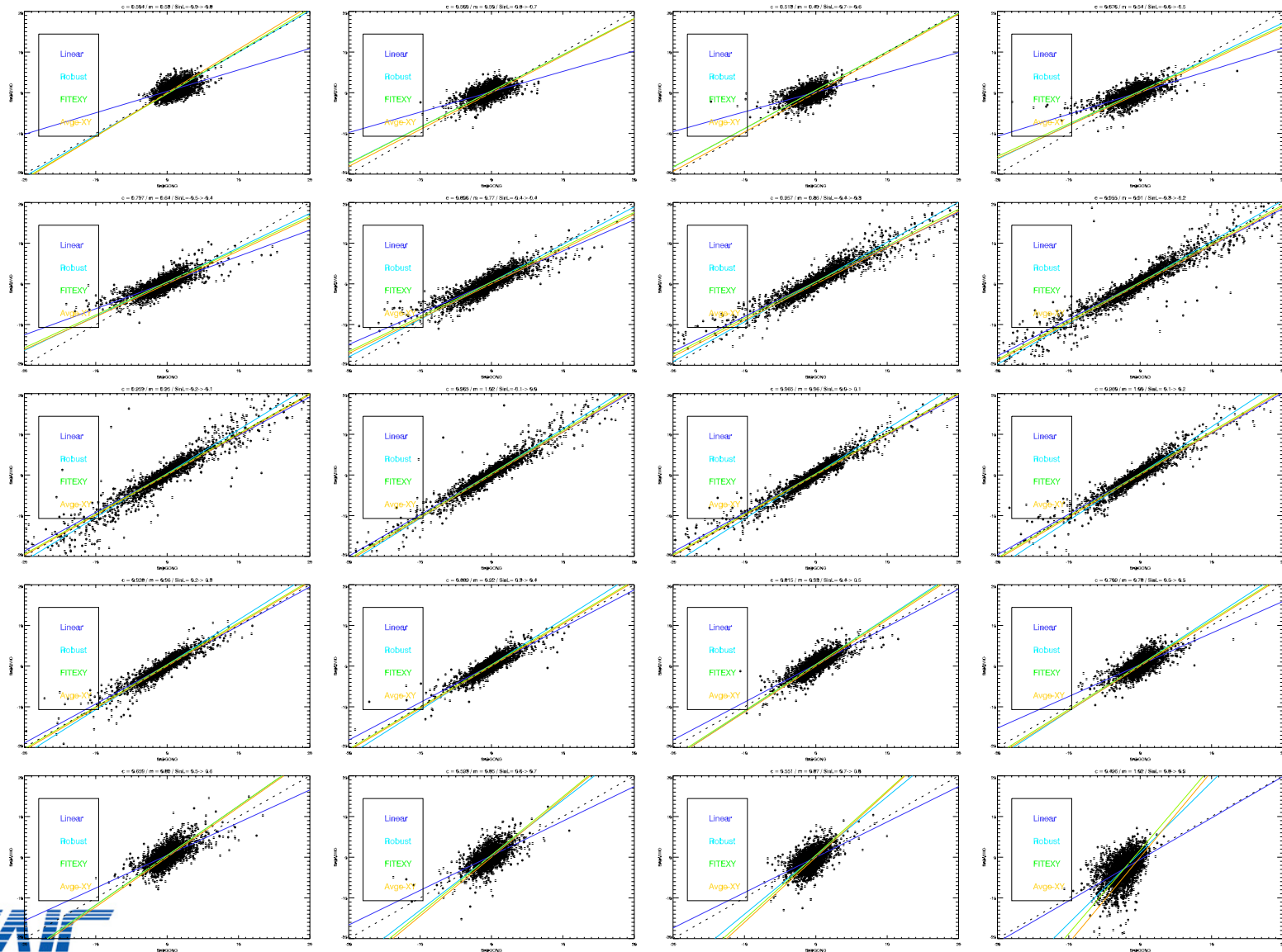# In situ observations can be interpreted as being composed of a background flux contribution + a contribution from ICMEs.
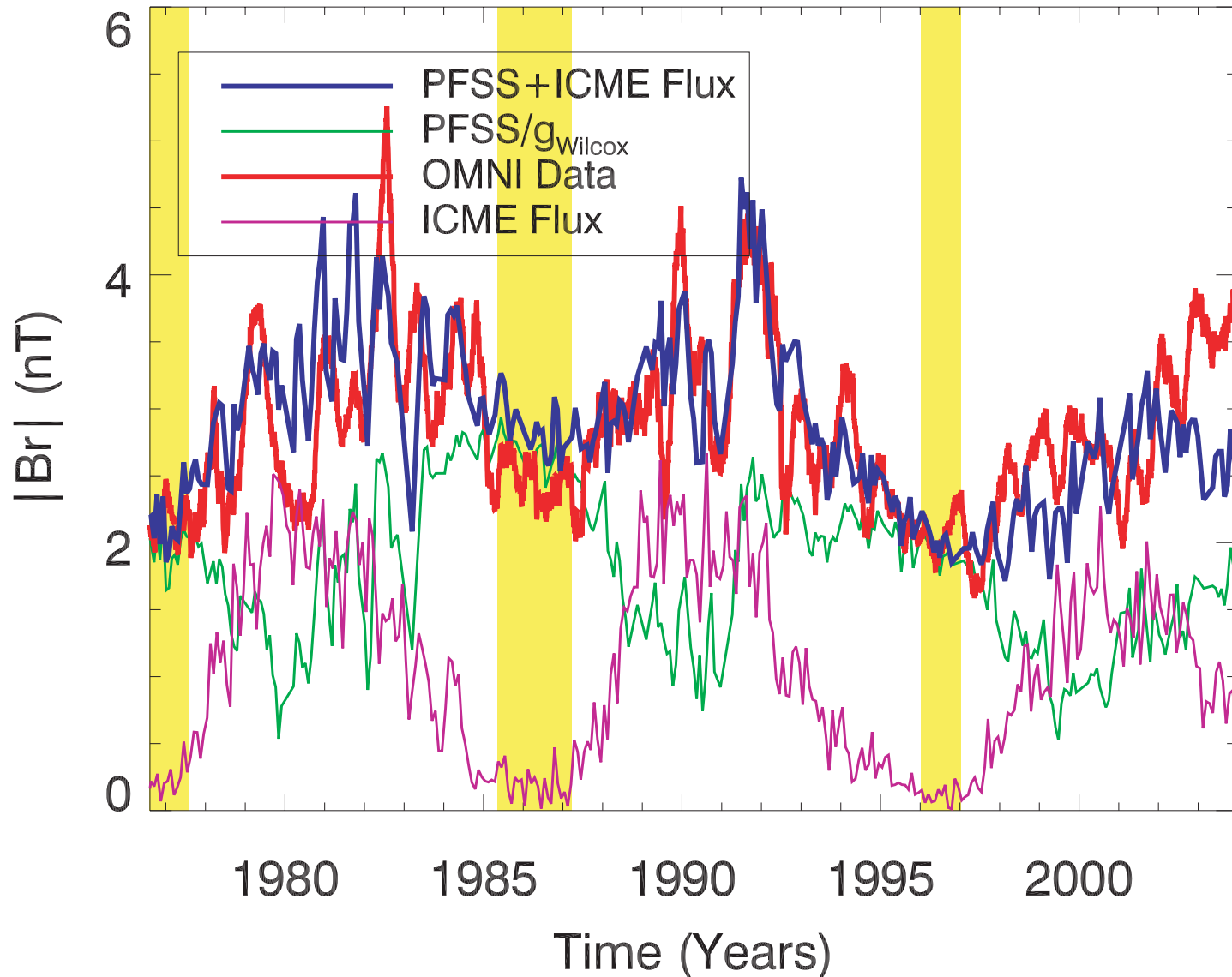
Synoptic maps from 5 observatories for CR2068 compare qualitatively well on the large-scale, but important differences exist between them.

Correlation of GONG and MWO as a function of bins in latitude (CR 2047).

Best-fit slope to MWO/GONG data is 1.0. Correlation coefficient > 0.96 near equator (CR2047).
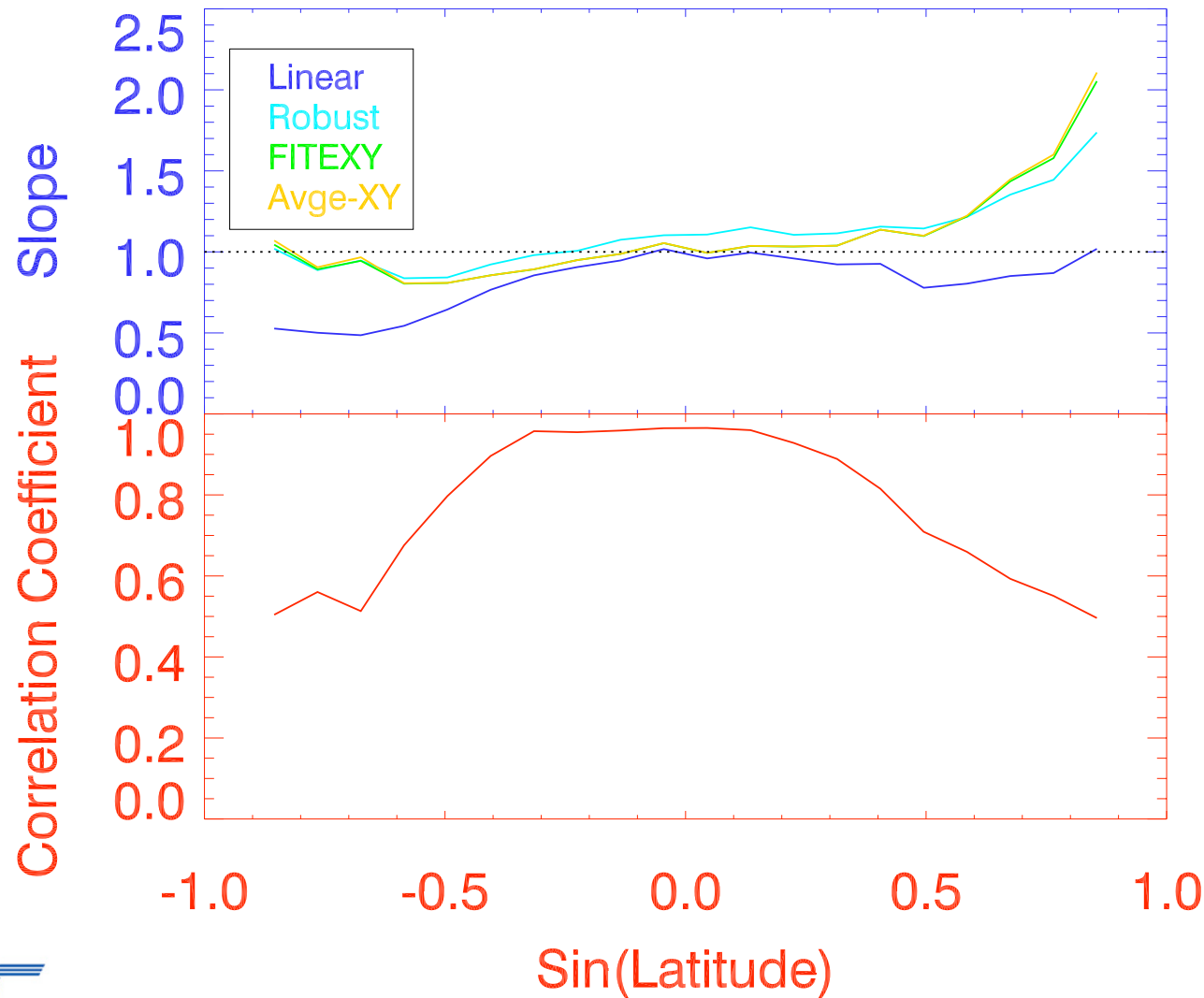
Correlation analysis of SOLIS/GONG: SOLIS offset from GONG diachronic maps by up to ~2.5 Deg.

GONG(top) and SOLIS(bottom)/CR2068

Cross Correlation Function

UNSHIFTED Corr. Coeff.=0.33

SHIFTED Corr. Coeff.=0.83
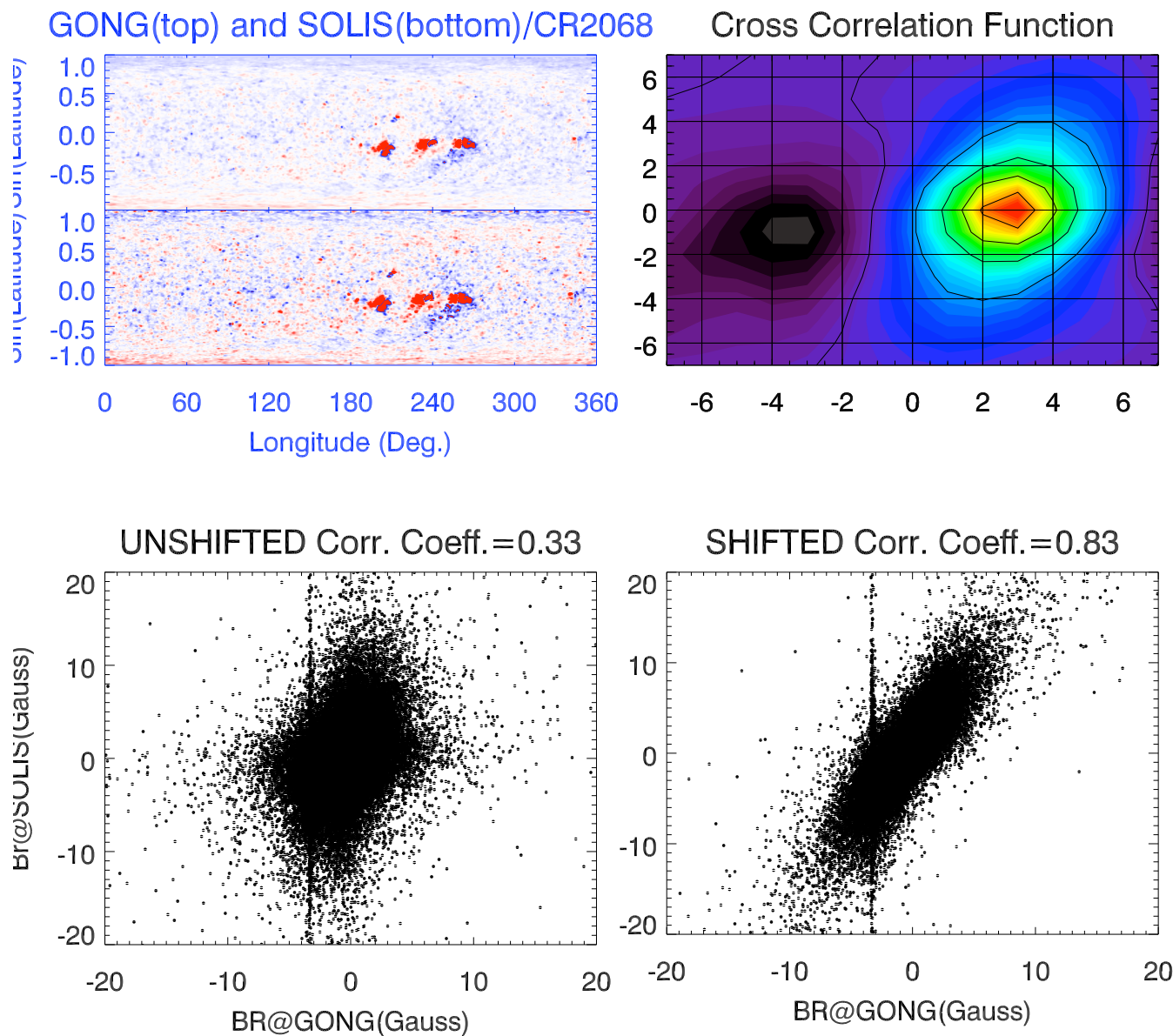
The error in SOLIS data is likely due to an approximation in the computation of the instantaneous longitude of the observation.

Longitudinal Errors in SOLIS Synoptic Maps
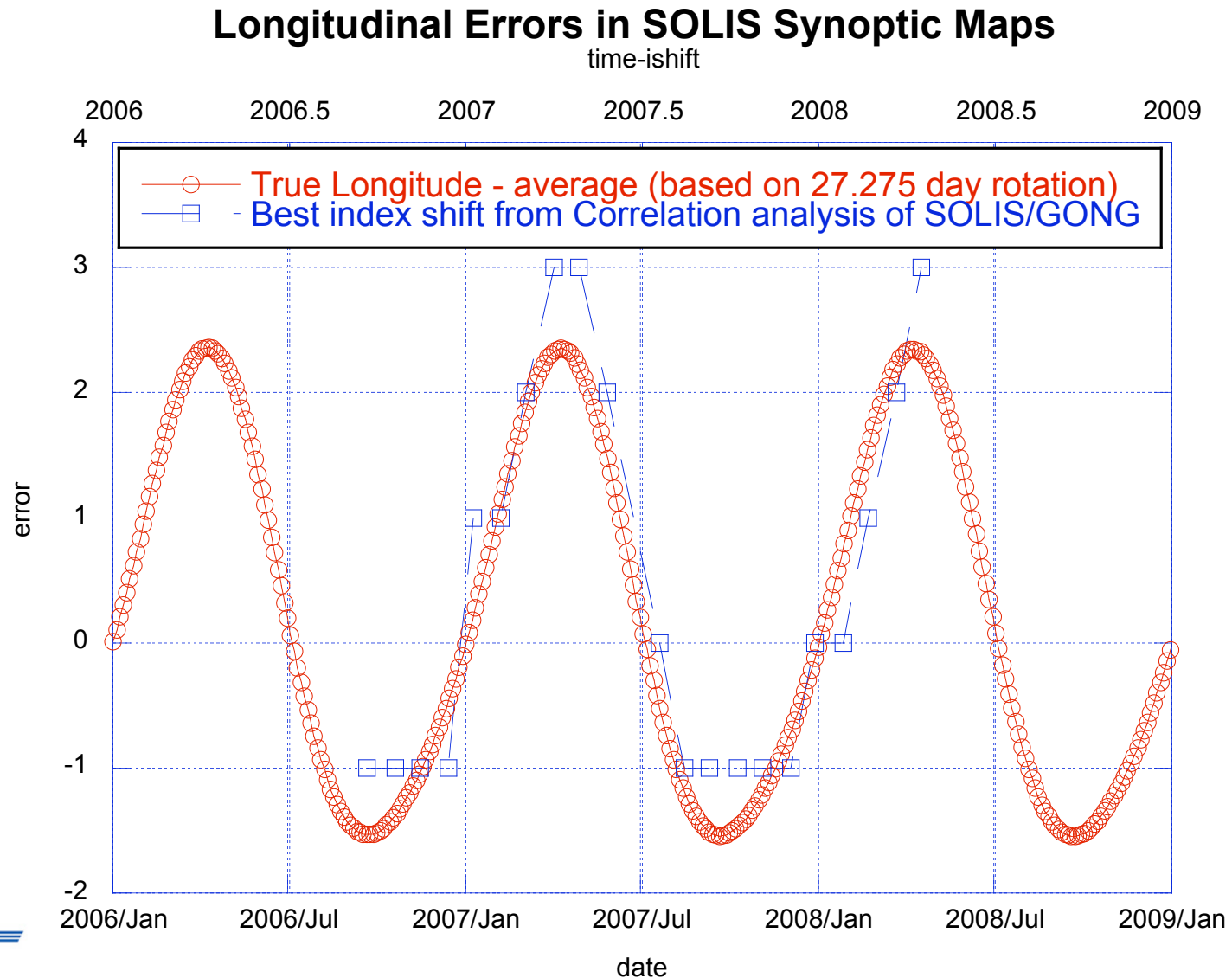
SOLIS/WSO correlation analysis for CR2047 does not show any evidence for a sin^2(lat) dependence in the correction factor.

$$g_{Wilson} = 4.5 - 2.5 \sin^2(L)$$

Wang and Sheeley

Linear
Robust
FITEXY
Avge-XY

Slope

Correlation Coefficient

Sin(Latitude)
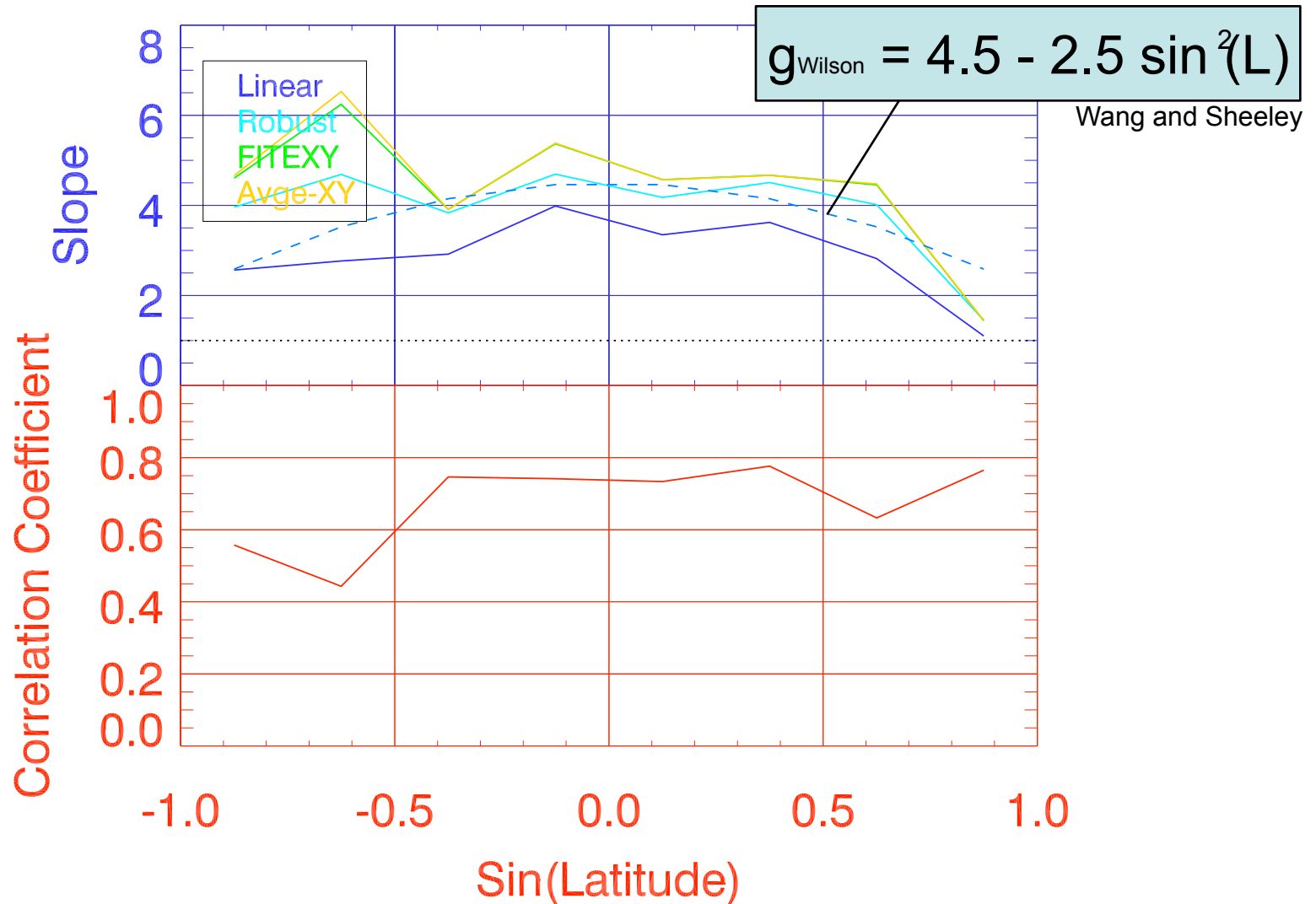
Similarly, WSO/GONG correlation analysis for CR2047 does not show any evidence for a sin^2(lat) dependence in the correction factor.
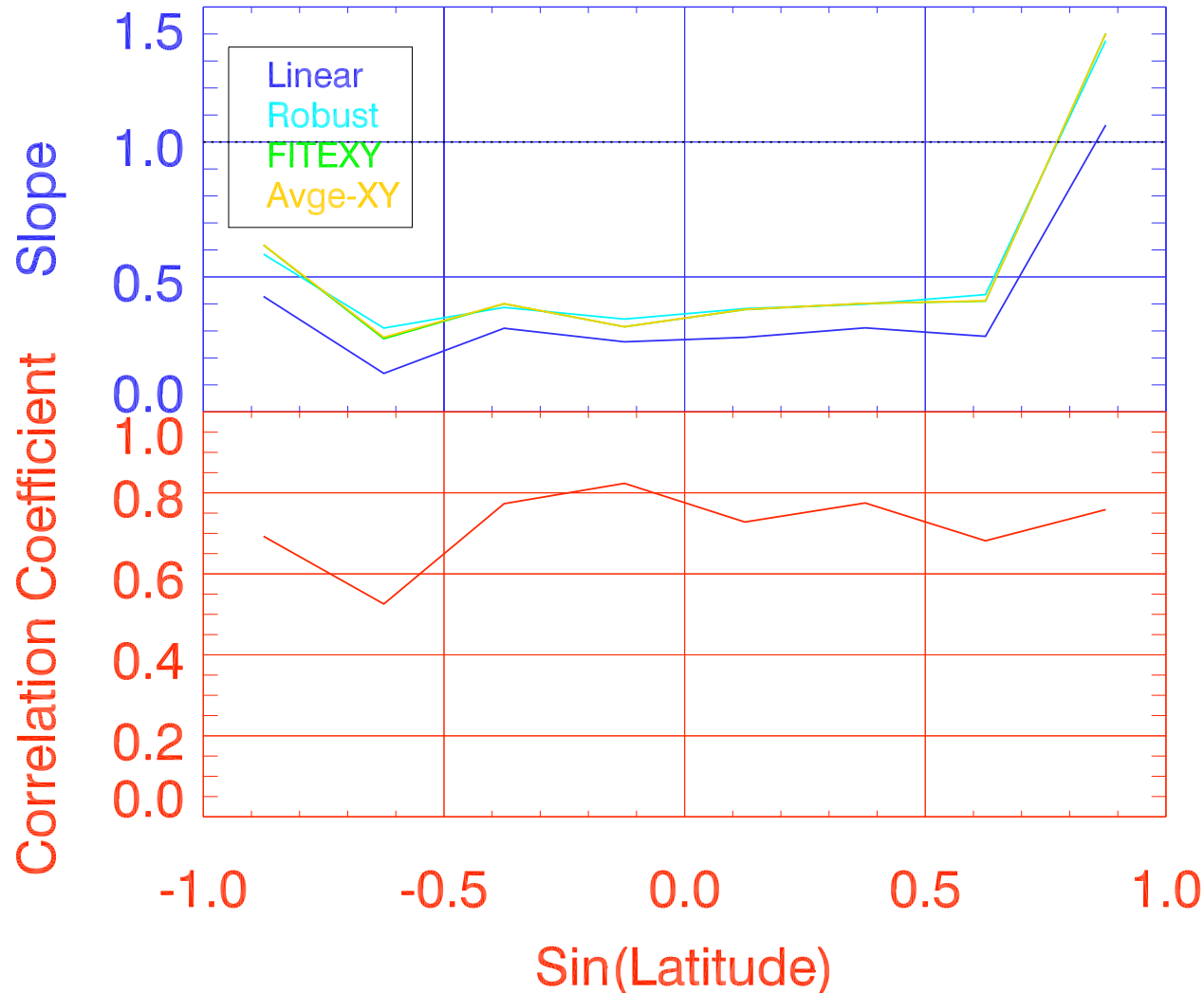
Inferred correction factors for CR 2047 show that MWO and GONG match very well (corr. coeff ~ 0.93). Correlation coefficients > 0.75 for others, except MDI.

	WSO	SOLIS	GONG	MWO	MDI
WSO	1	0.21	0.36	0.38	-
SOLIS	4.8	1	1.94	2.1	-
GONG	2.8	0.52	1	1.0	-
MWO	2.6	0.48	1.0	1	-
MDI	-	-	-	-	1

SOLIS

Re-gridded SOLIS

WSO

BR@SOLIS

Br@WSO
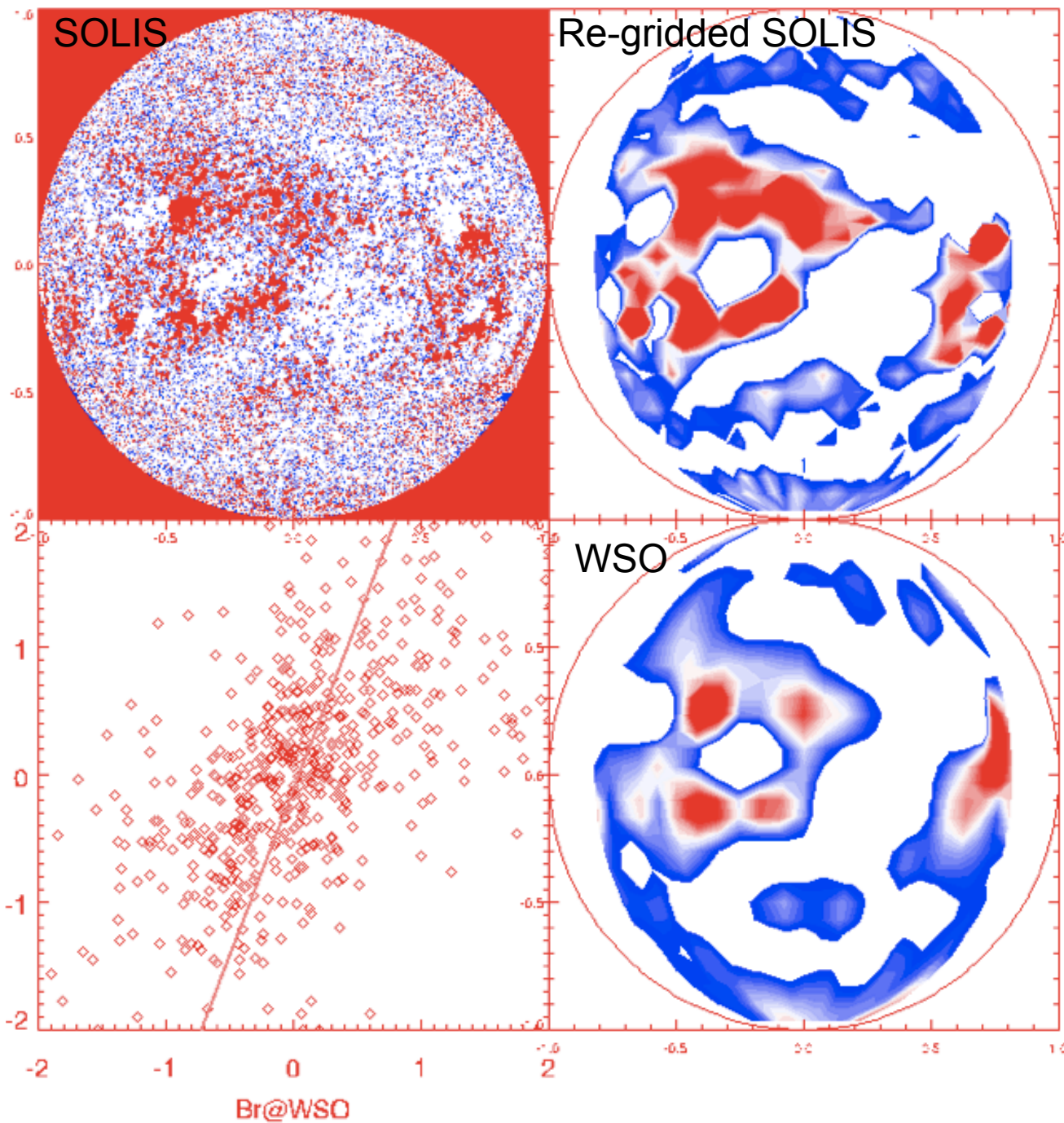
Disk comparisons from team members do not converge!

Pete Riley:

From 2004/07/06
SOLIS = -0.11 + 2.634*WSO

From 2008/03/31:
SOLIS = -0.012 + 4.345*WSO

From 2007/12/31:
SOLIS = -0.063 + 3.814*WSO

Yang Liu:

From 07/21/04 17:00:
SOLIS = 0.04 + 0.699*MDI
MWO = -0.1 + 0.944*MDI

From Aug. 2006/June 2007
WSO = 0.045 + 0.227*MDI

MDI~4.4*WSO and SOLIS~0.7*MDI.
Leading to: SOLIS~3.0*WSO

Jack Harvey:

SOLIS/WSO magnetogram comparison for Jan 13, 2008:
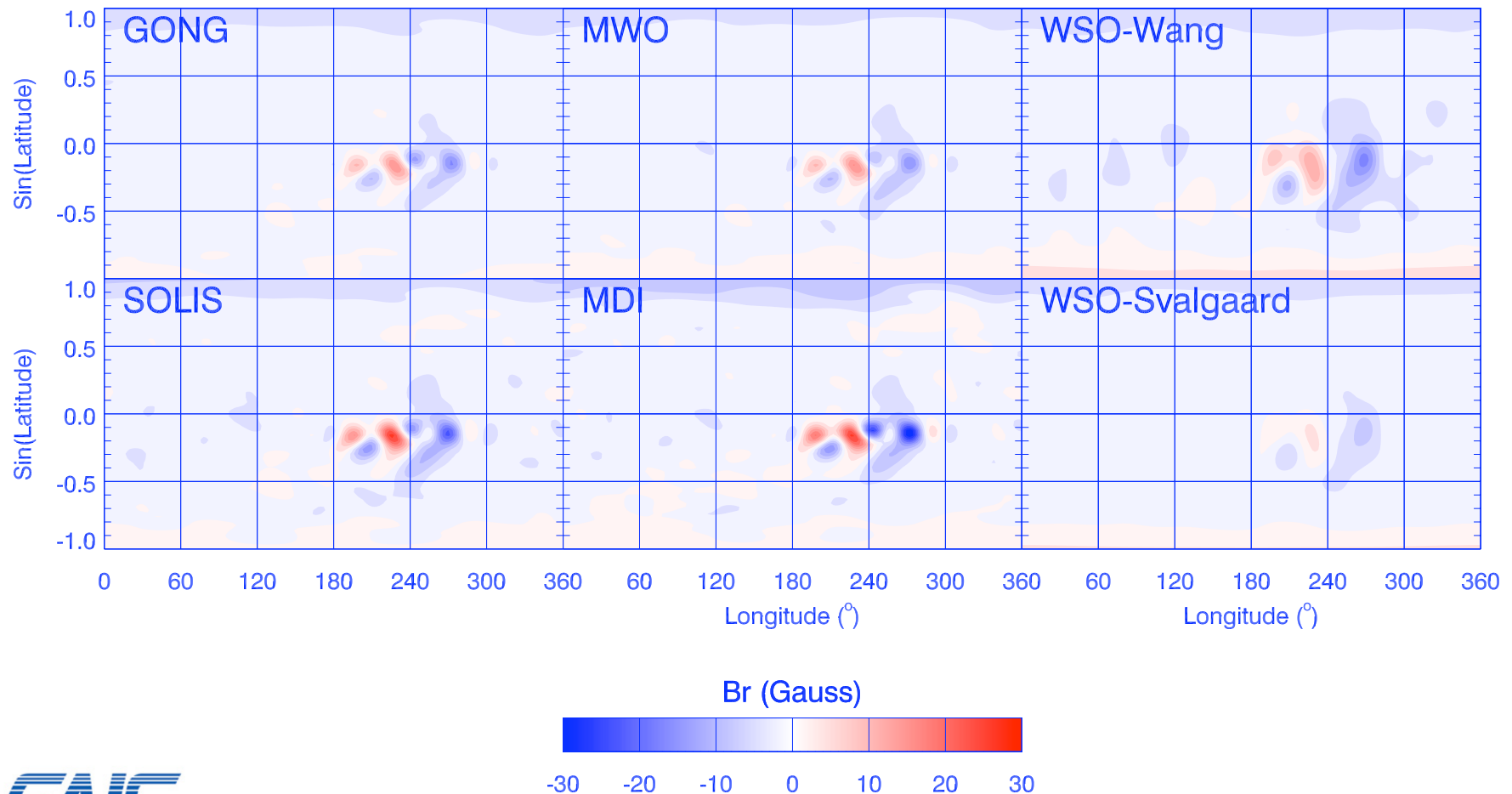SOLIS6301 = 0.11 + 2.032 * WSO +/- 0.4
SOLIS6302 = 0.10 + 2.097 * WSO +/- 0.4

For 24 April 2008:
SOLIS6301 = 0.14 + 1.821 * WSO
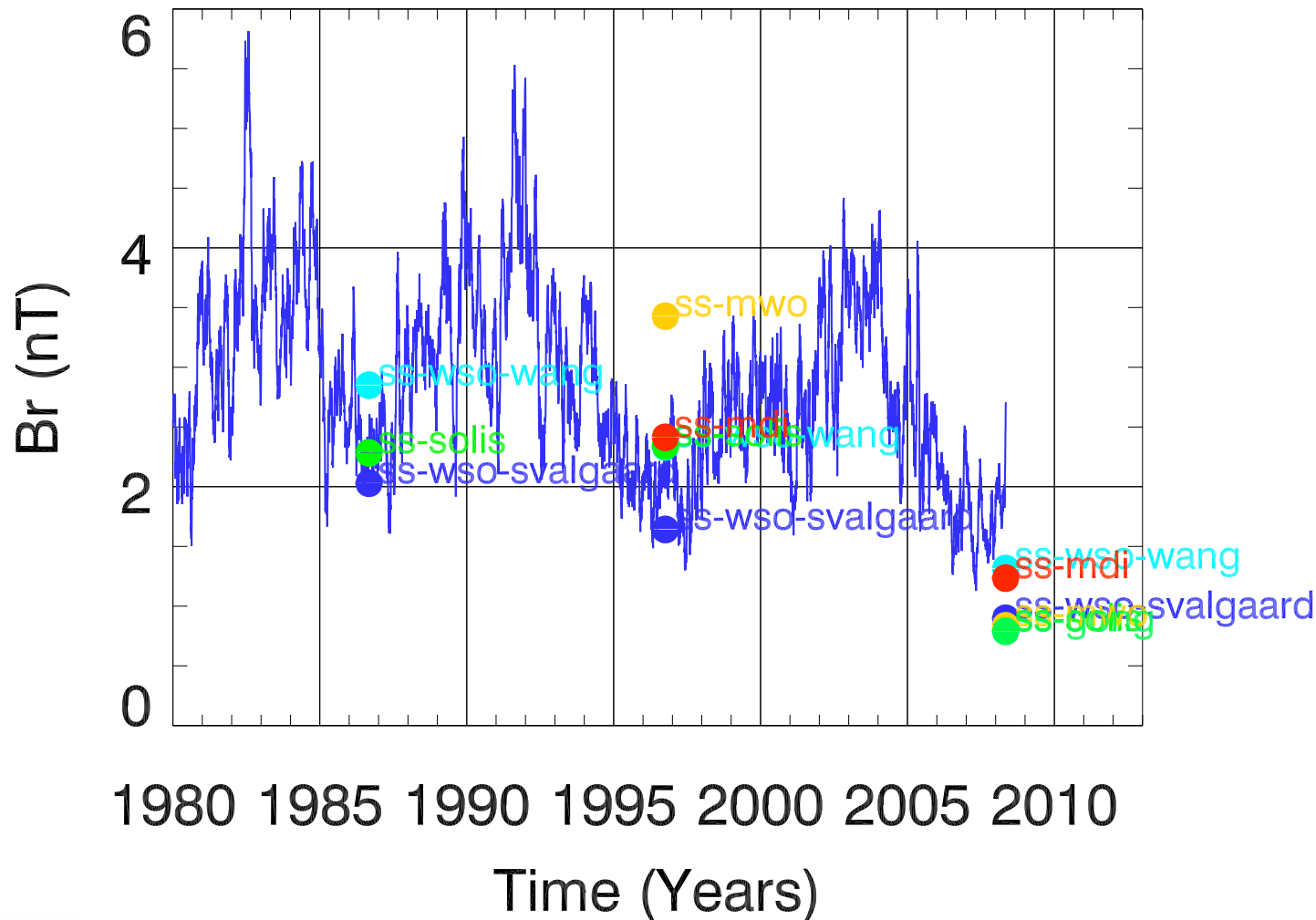SOLIS6302 = 0.10 + 1.669 * WSO

GONG/WSO comparisons show large offset, the origin of which
remains unknown.

Processing all synoptic maps in the same way leads to model inputs that more closely resemble one another. Here are 6 maps for CR 2068.

Comparison of open flux computed with PFSS model and observations of open flux at 1 AU.

Summary

- **Diachronic maps match to varying degrees:**

  - GONG/MWO match remarkably well
  - WSO should be multiplied by 4.4 (2.7) to match SOLIS (GONG)
  - SOLIS maps may need to be shifted by up to 2.5 Deg. longitude

- **Disk magnetogram comparisons confuse issue:**

  - WSO = 1.6*SOLIS to 4.3*SOLIS

- **Isolated comparisons of PFSS results at solar minimum do not resolve issue:**

  - Complete solutions over entire observatory range (1975 - present) are required
  - Limitations in PFSS model may require running MHD model on all maps

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SAIC
From Science to Solutions

Questions?