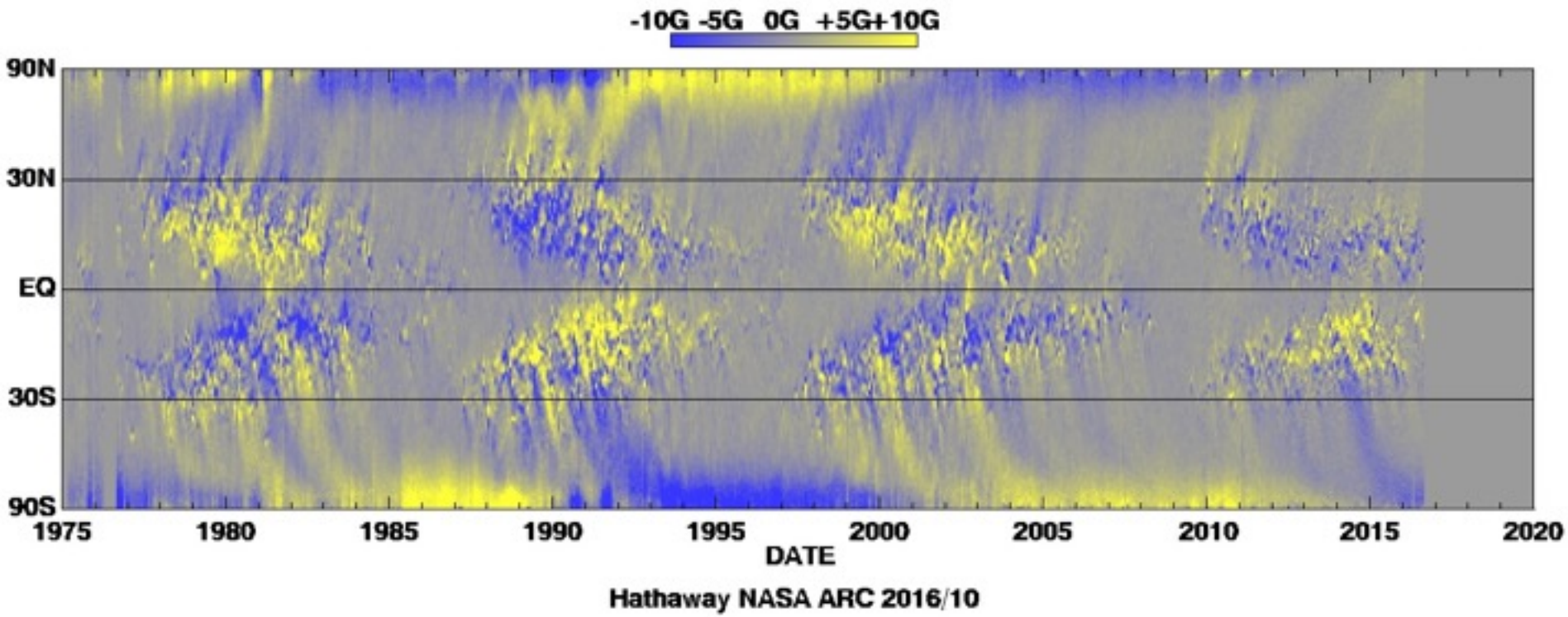
SDO — DKIST Synergies

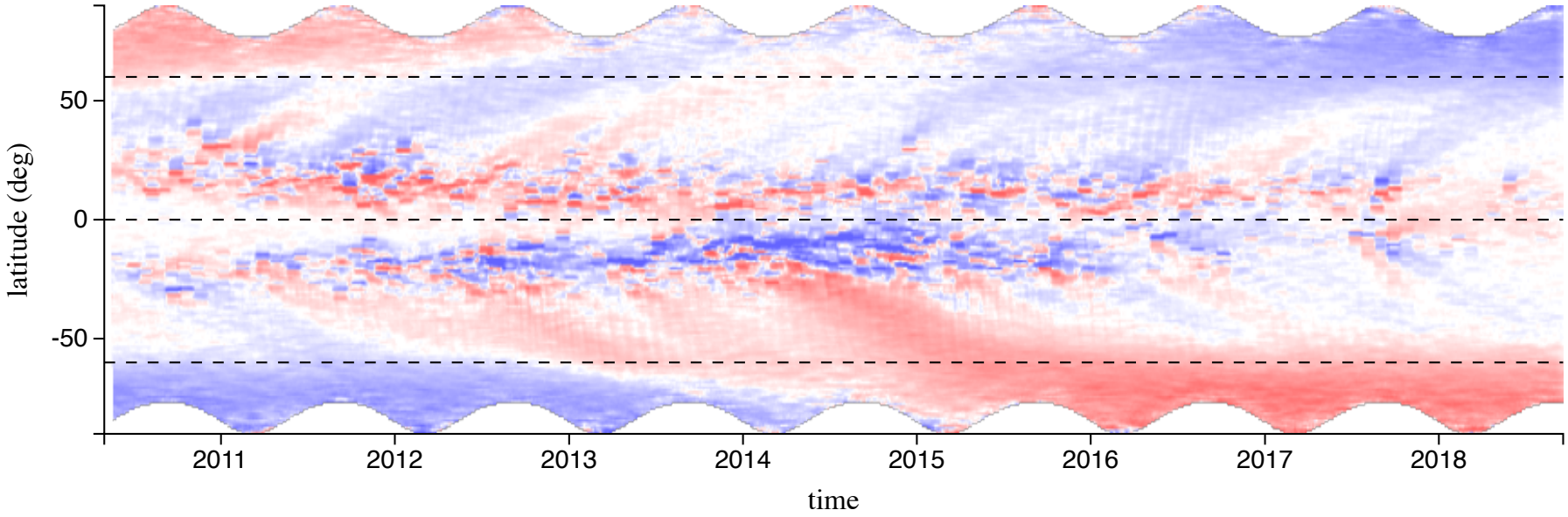
Yang Liu and HMI Team

Long-Term Studies



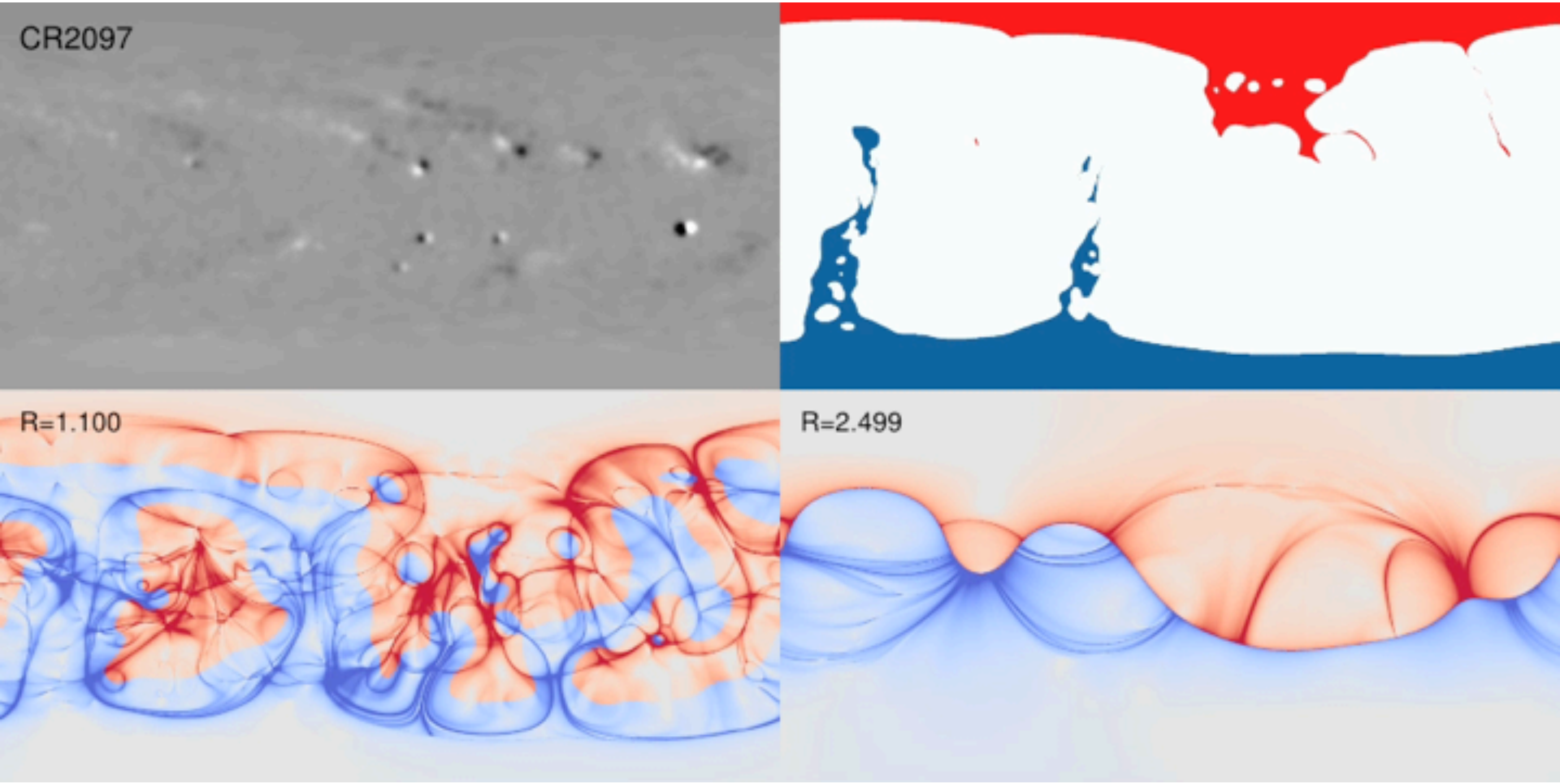
Credit: D. Hathaway

Long-Term Studies



SDO Era: HMI Observation

Long-Term Studies



Credit: X. Sun

Long-Term Studies: Surface Flux Transport Model

$$\frac{\partial B_r}{\partial t} = -\omega(\theta)\frac{\partial B_r}{\partial \phi} - \frac{1}{R\sin\theta}\frac{\partial}{\partial \theta}\left[v(\theta)B_r\sin\theta\right] + \frac{\kappa}{R^2}\left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial B_r}{\partial\theta} + \frac{1}{\sin^2\theta}\frac{\partial^2 B_r}{\partial\phi^2}\right)\right] + S(\theta,\phi,t)$$

Differential Rotation

Meridional Flow

Diffusion coefficient

Source function

Long-Term Studies: Surface Flux Transport Model

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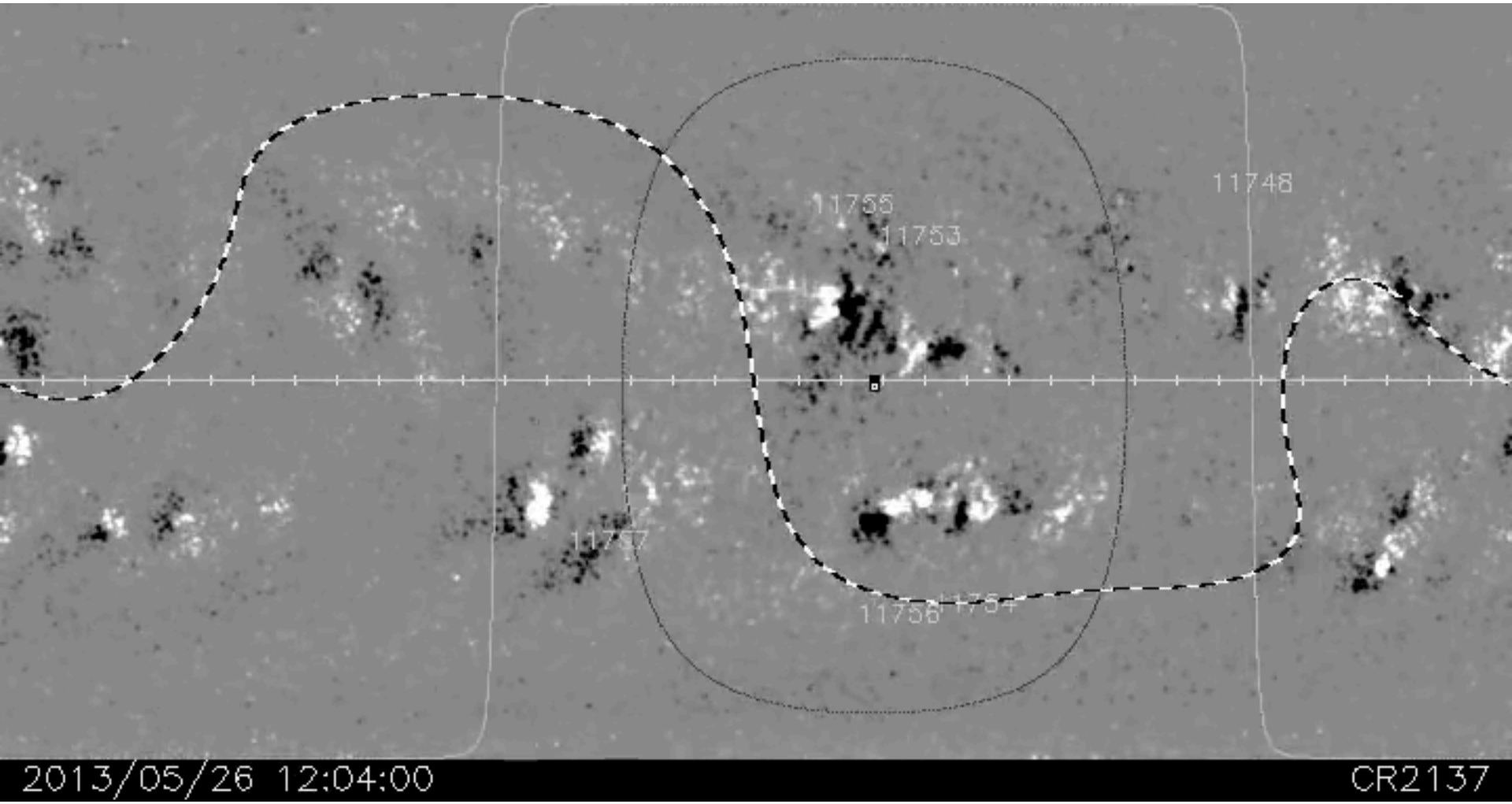

From M. DeRosa

Long-Term Studies: Surface Flux Transport Model

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Long-Term Studies: Differential Rotation at High Latitude

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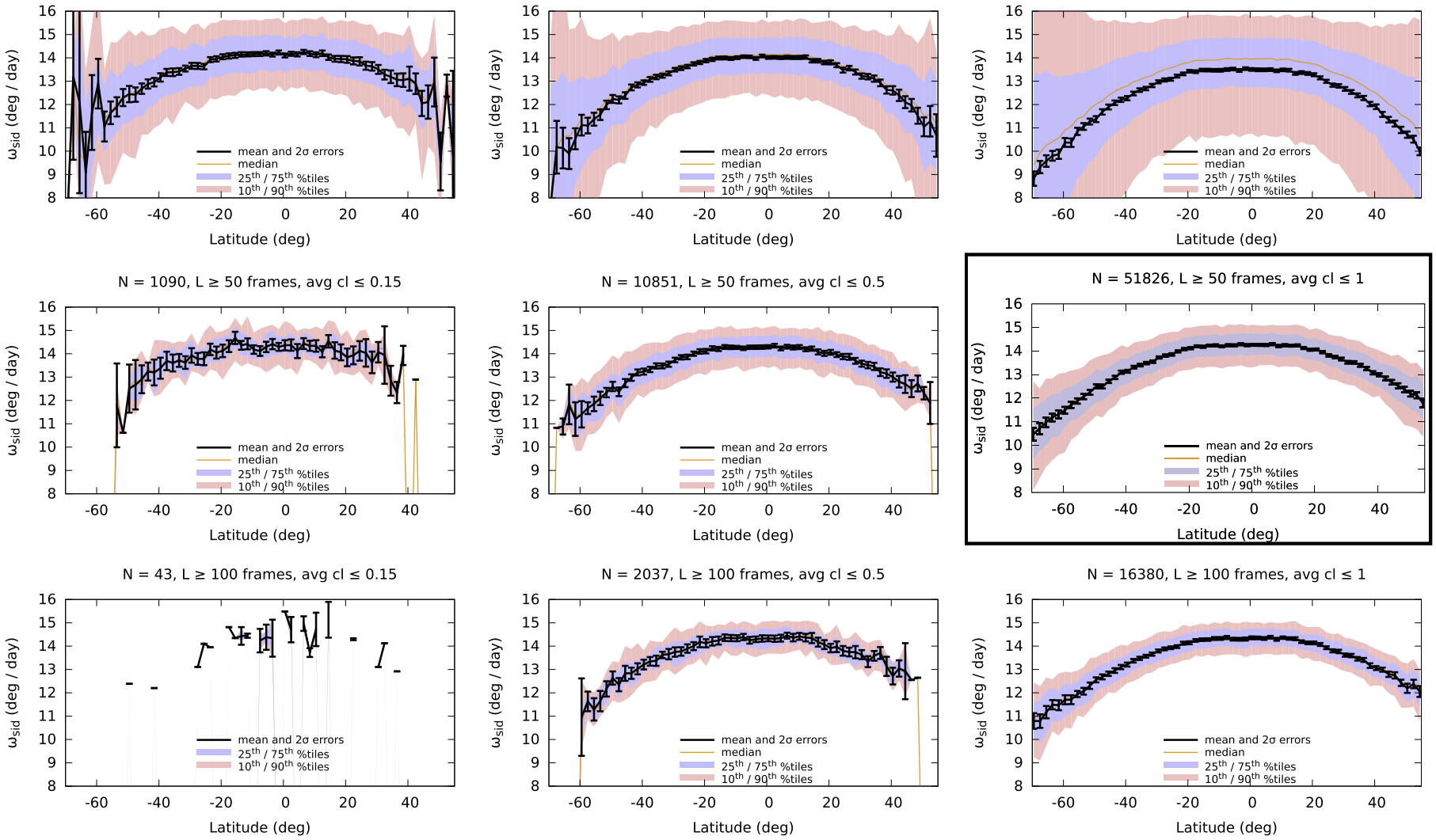
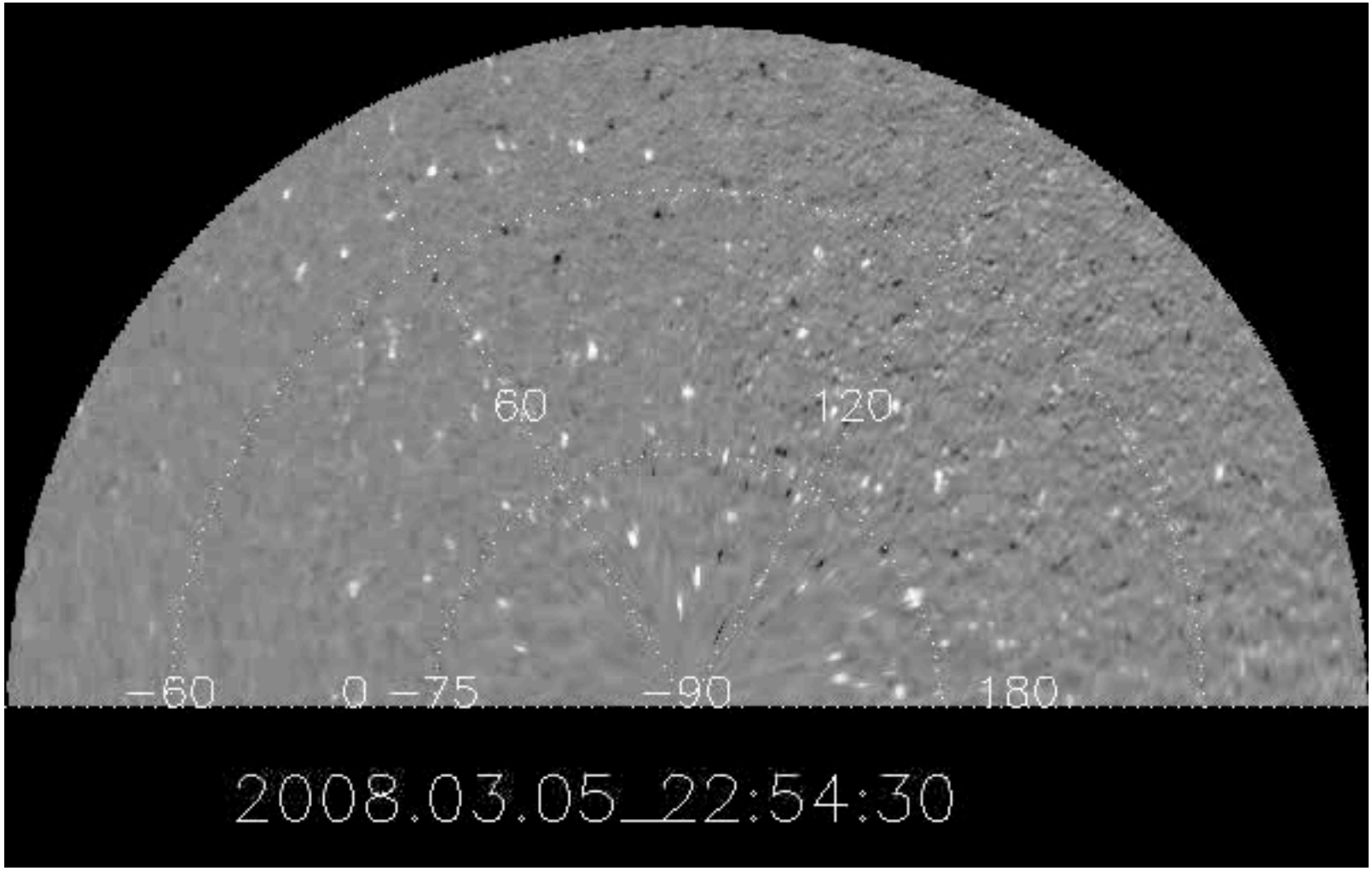
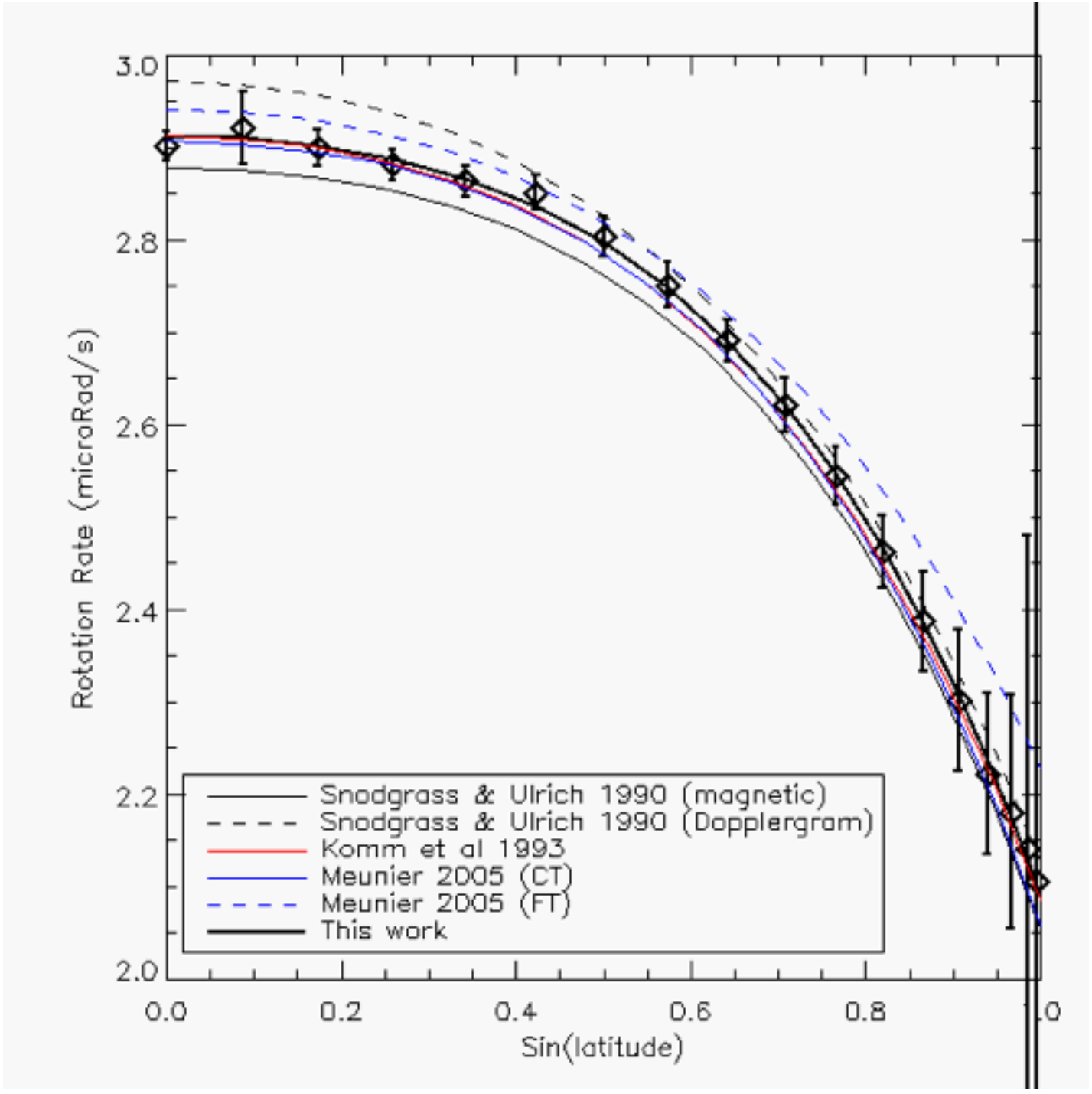


Figure 3. Rotational motion for lifetime (rows; top to bottom: 10, 50, 100) and average closeness parameters (columns; left to right: 0.15, 0.50, 1.00). The latitudinal bin size in all plots is 2°. The combination of the lifetime and average closeness parameters strongly affects the smoothness of the mean profiles and the width and symmetry of the distributions in the latitudinal bins. I use the boxed plot for the rotational profile analysis in the remainder of the paper.

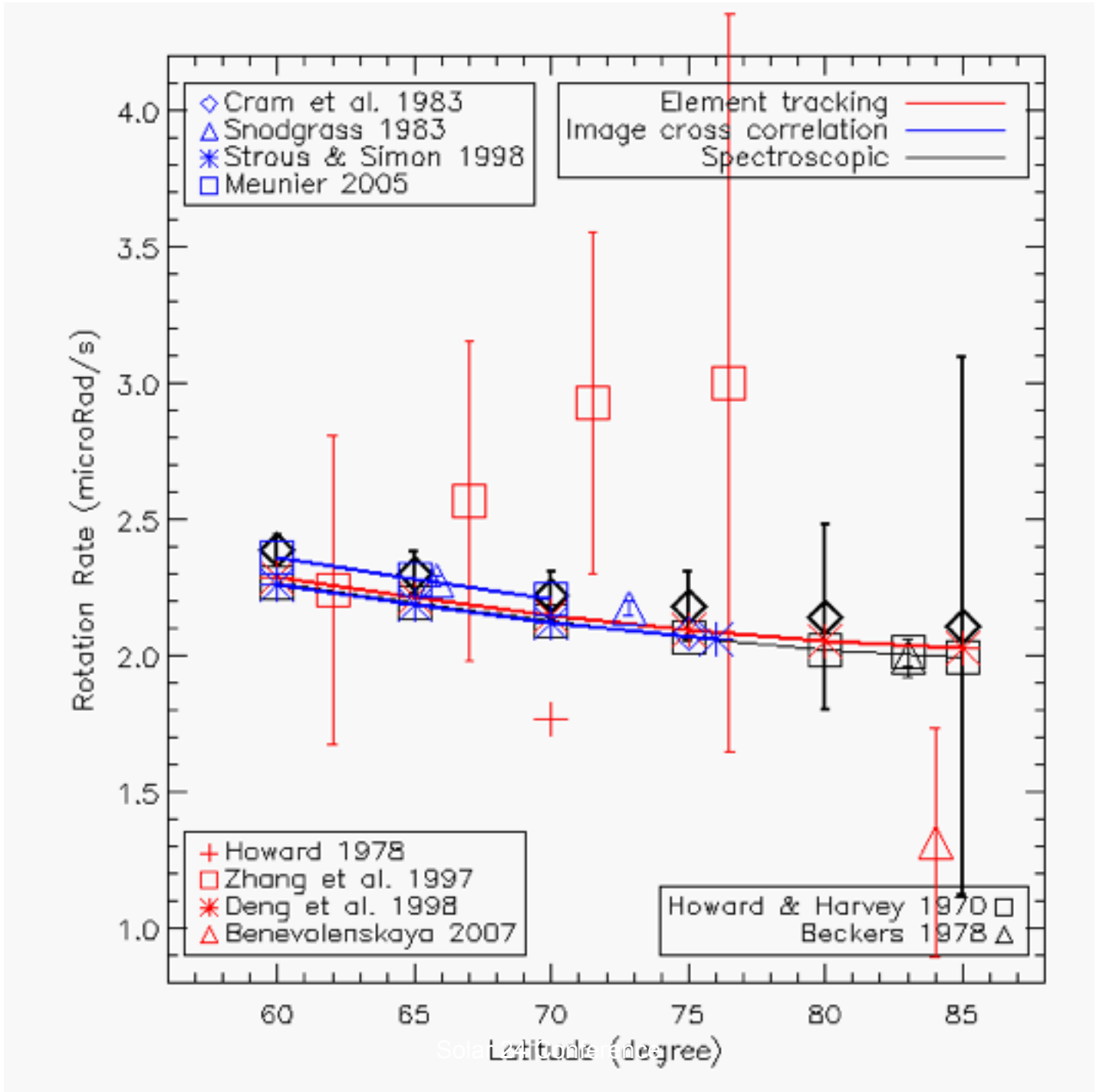
Lamb 2017

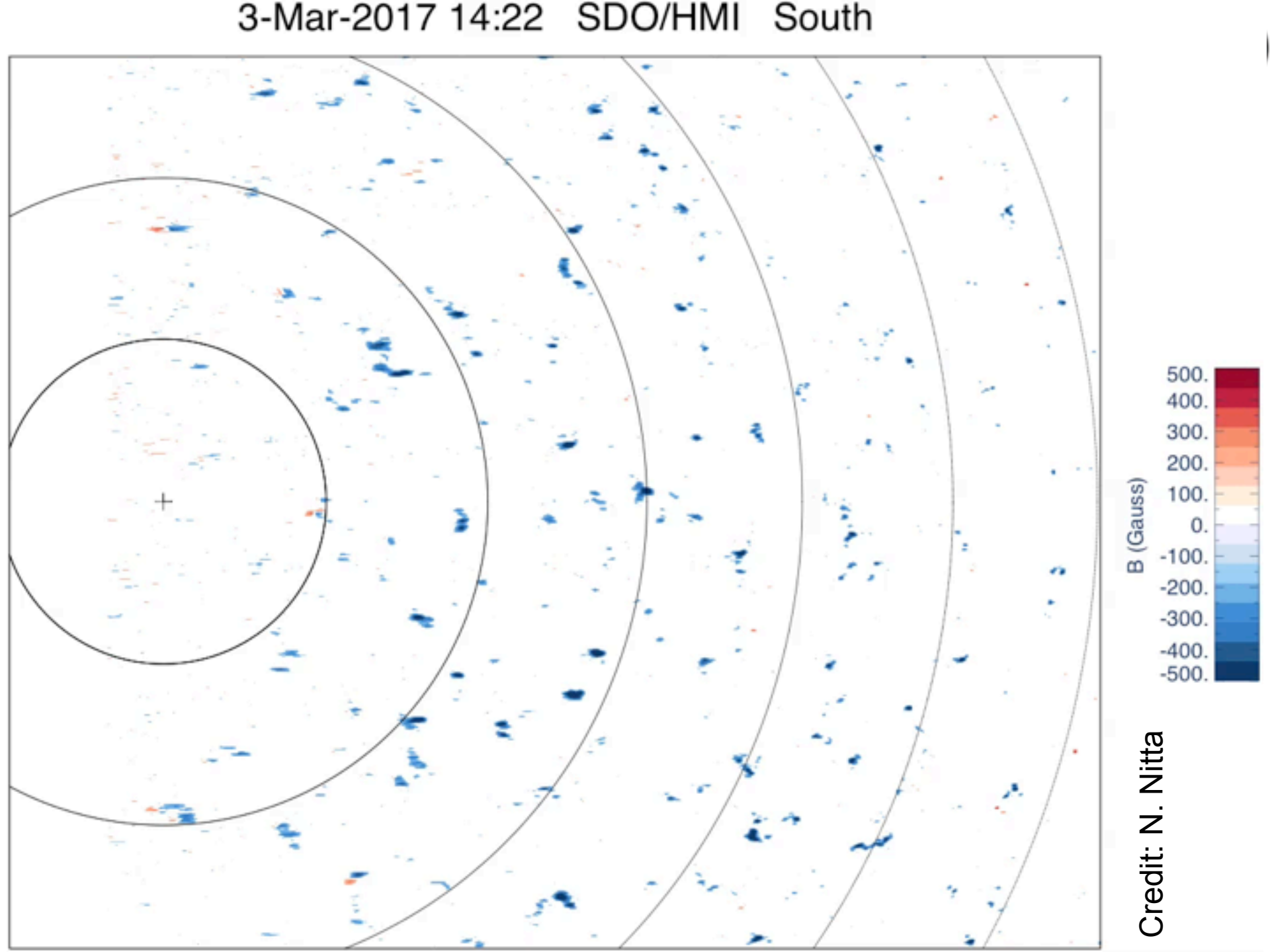
Long-Term Studies: Differential Rotation at High Latitude



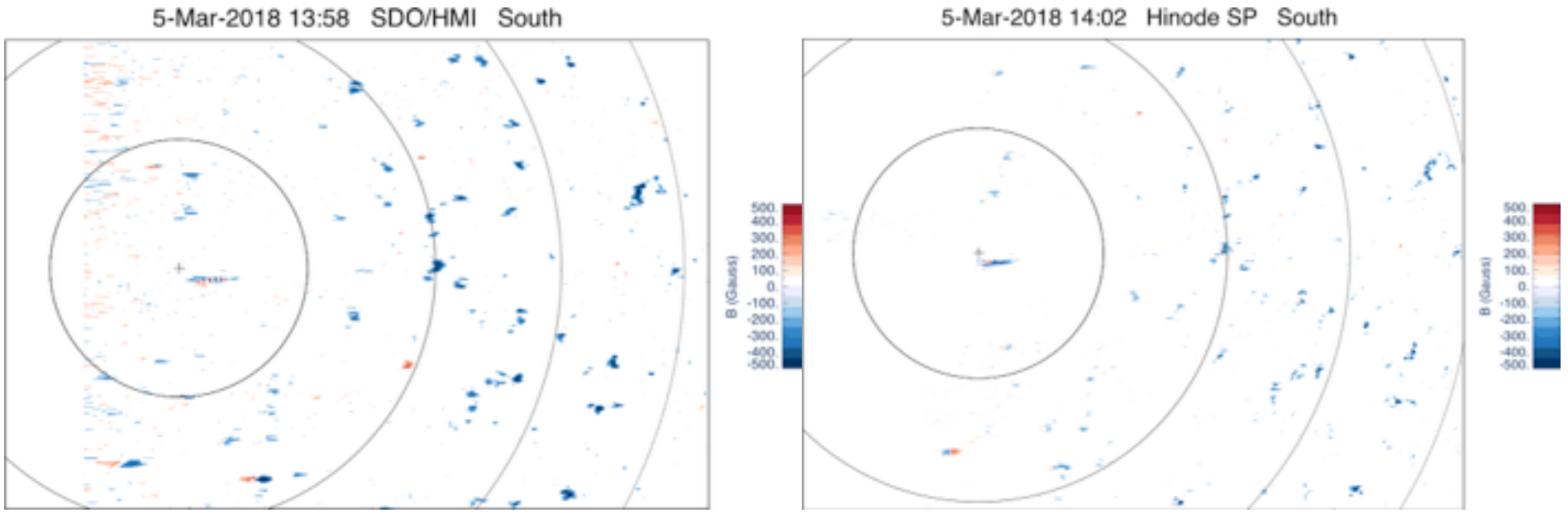


Liu & Zhao, 2009


Cram et al. 1983
Snodgrass 1983
Strous & Simon 1998
Meunier 2005
Element tracking
Image cross correlation
Spectroscopic
Howard 1978
Zhang et al. 1997
Deng et al. 1998
Benevolenskaya 2007
Howard & Harvey 1970
Beckers 1978
Rotation Rate (microRad/s)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
60
65
70
75
80
85
Latitude (degree)


3-Mar-2017 14:22 SDO/HMI South
B (Gauss)
500.
400.
300.
200.
100.
0.
-100.
-200.
-300.
-400.
-500.
Credit: N. Nitta

Long-Term Studies: Differential Rotation at High Latitude



Credit: N. Nitta

Long-Term Studies: Meridional Flow

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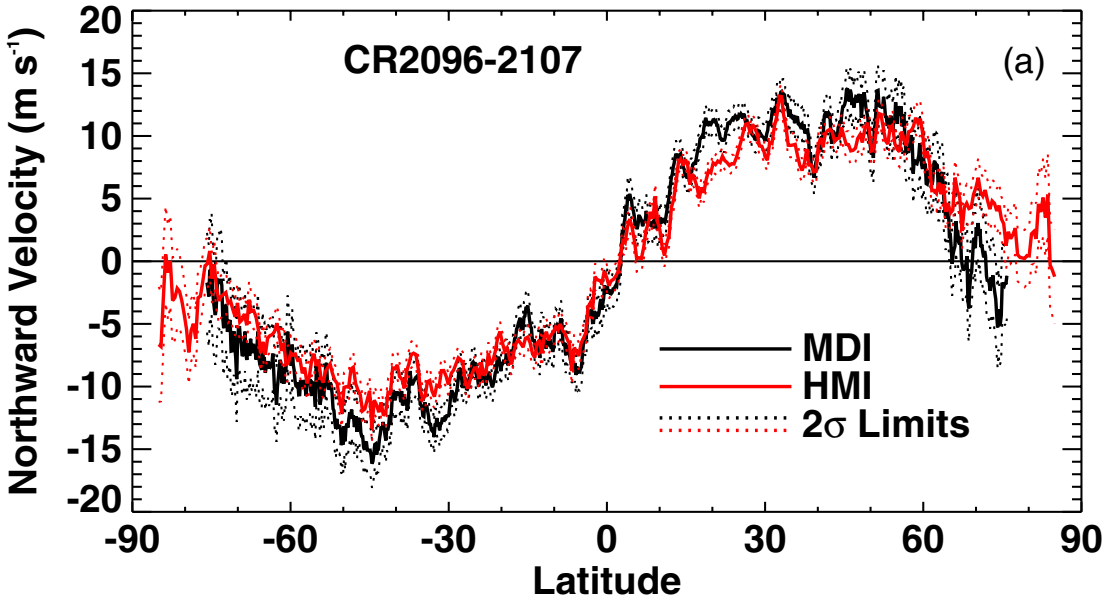
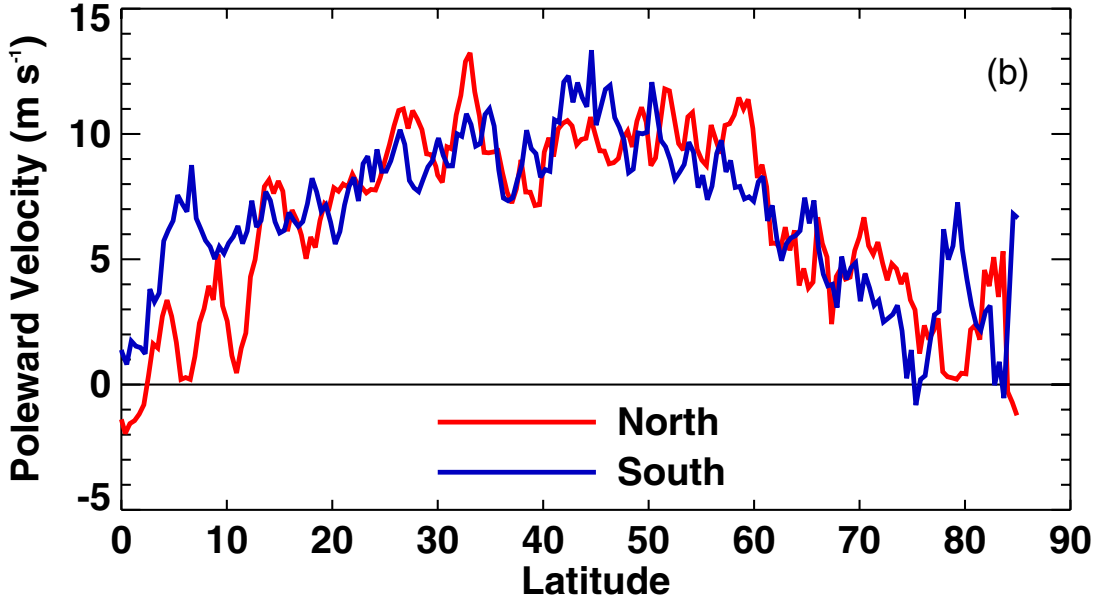
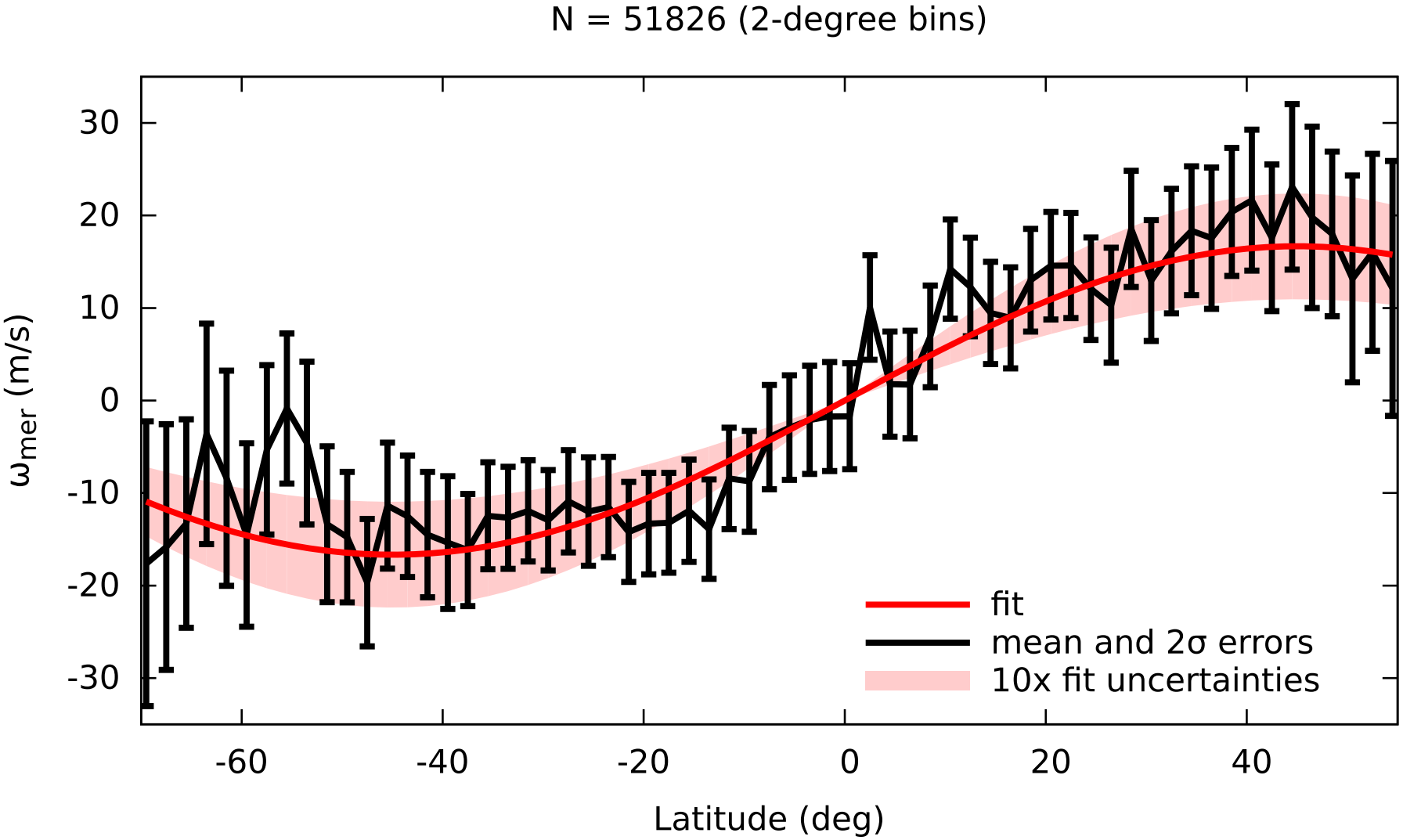




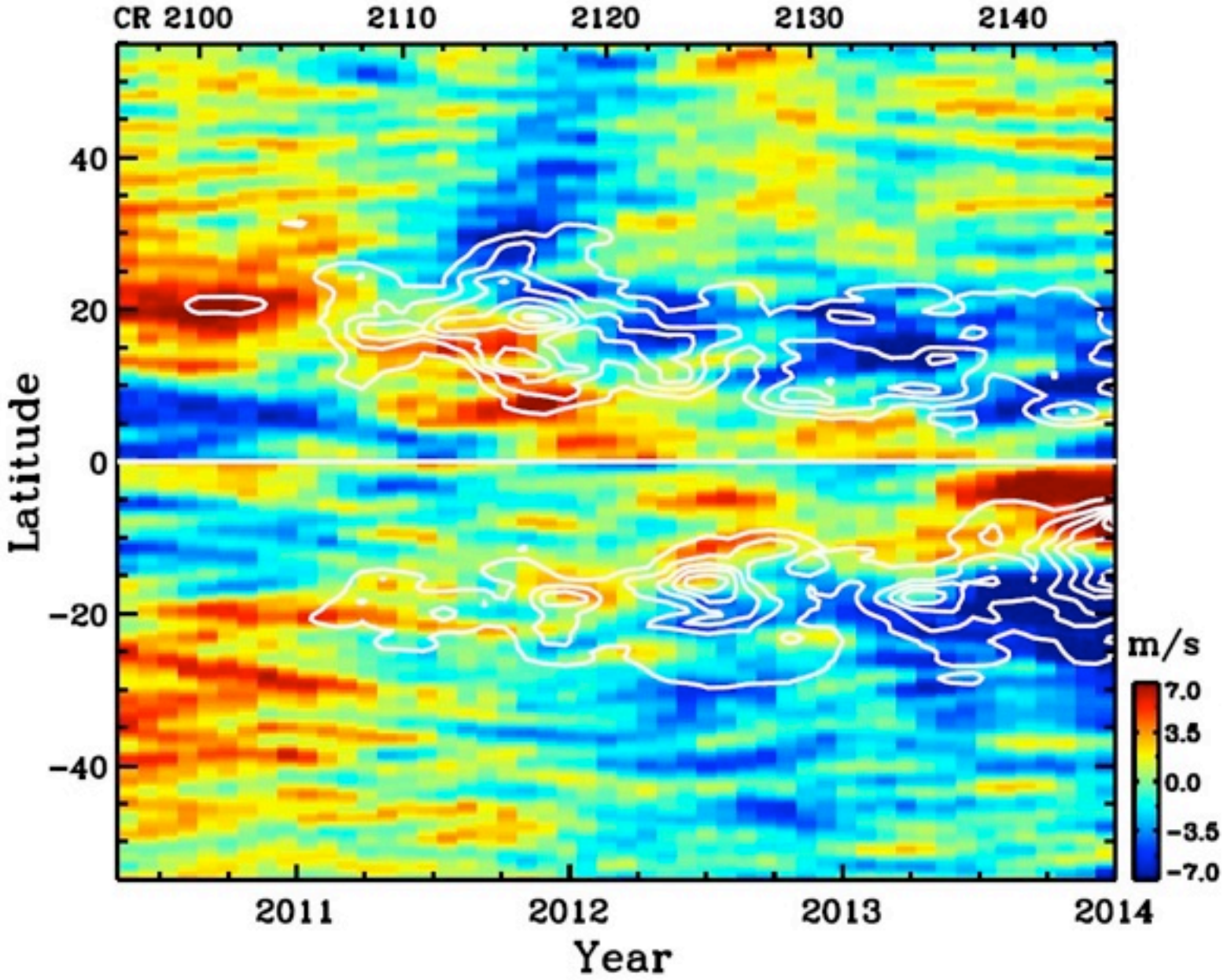
Rightmire-Upton et al. 2012

Long-Term Studies: Meridional Flow



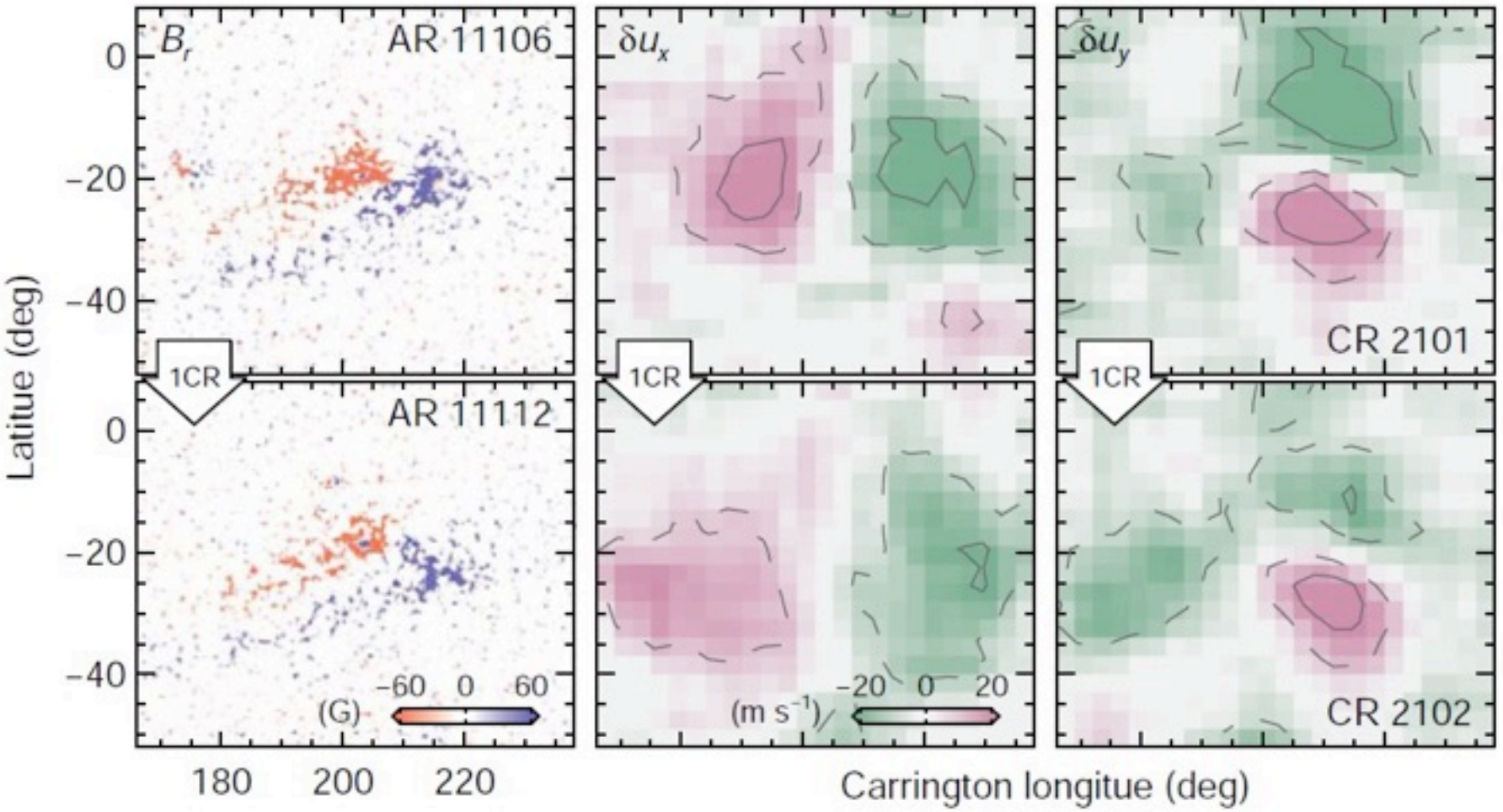
Lamb 2017

Long-Term Studies: Meridional Flow



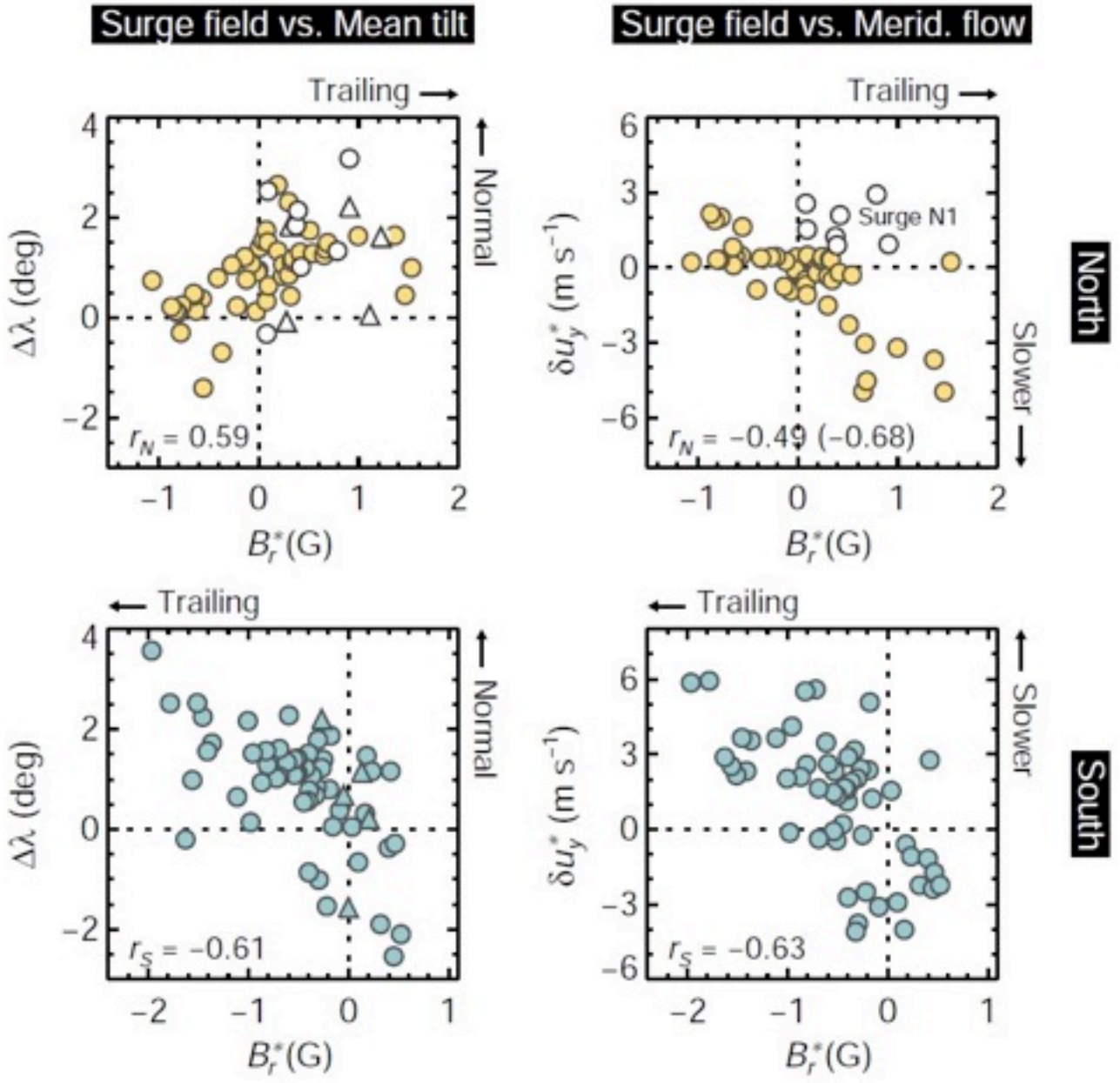
Zhao et al. 2014

Long-Term Studies: Meridional Flow



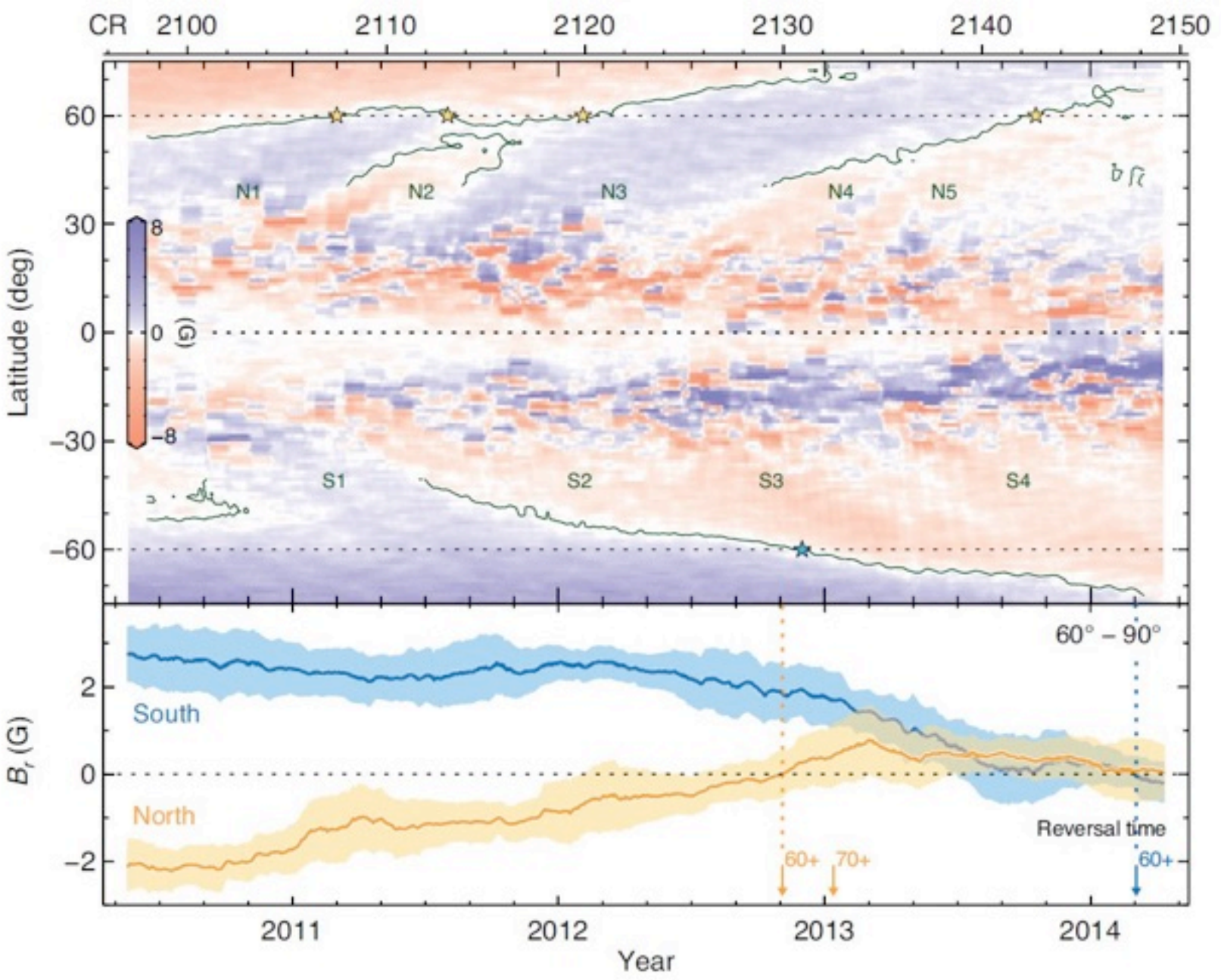
Sun et al. 2014

Long-Term Studies: Meridional Flow

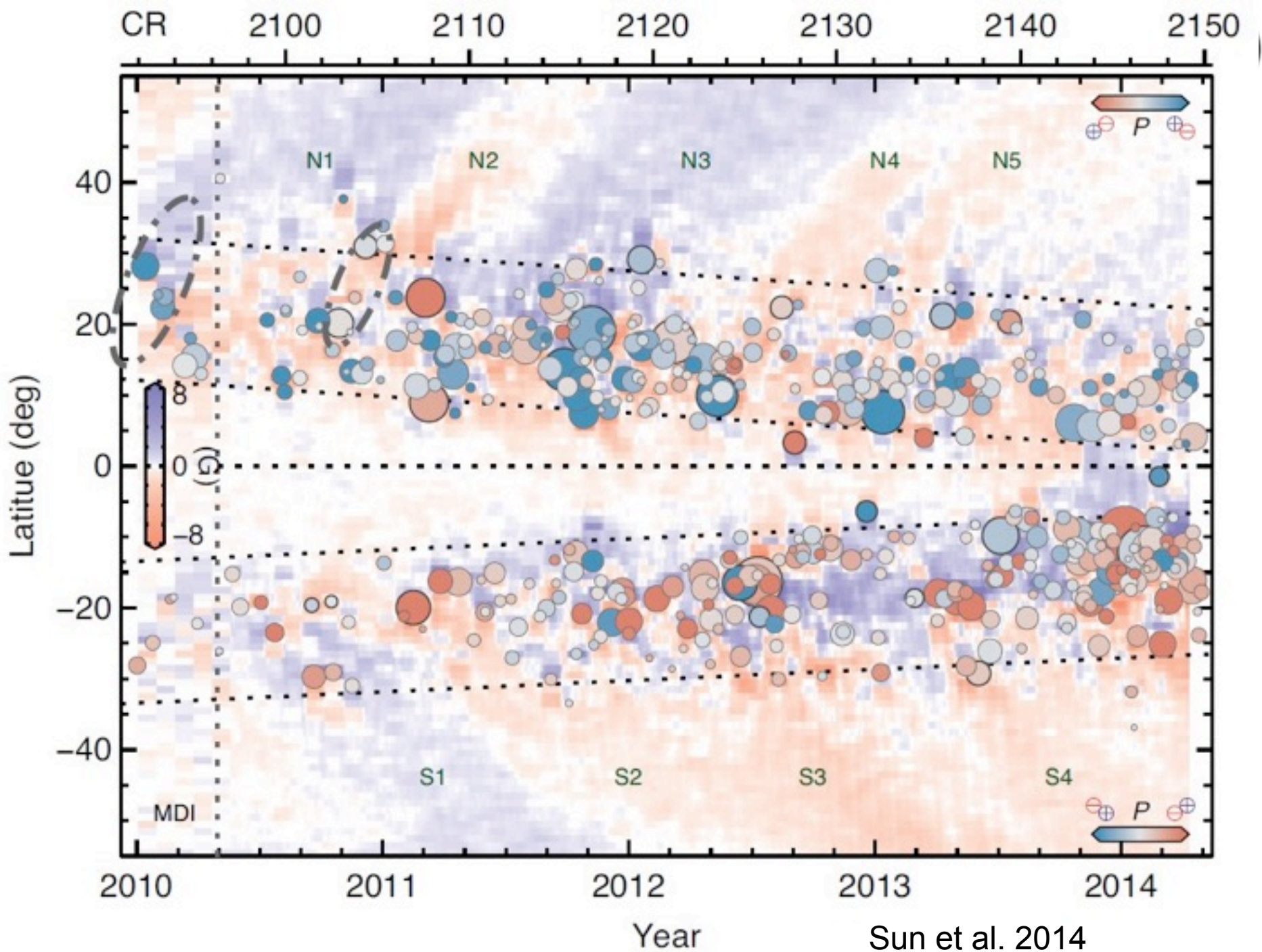


Sun et al. 2014: Meridional flow & AR properties

Long-Term Studies: Meridional Flow

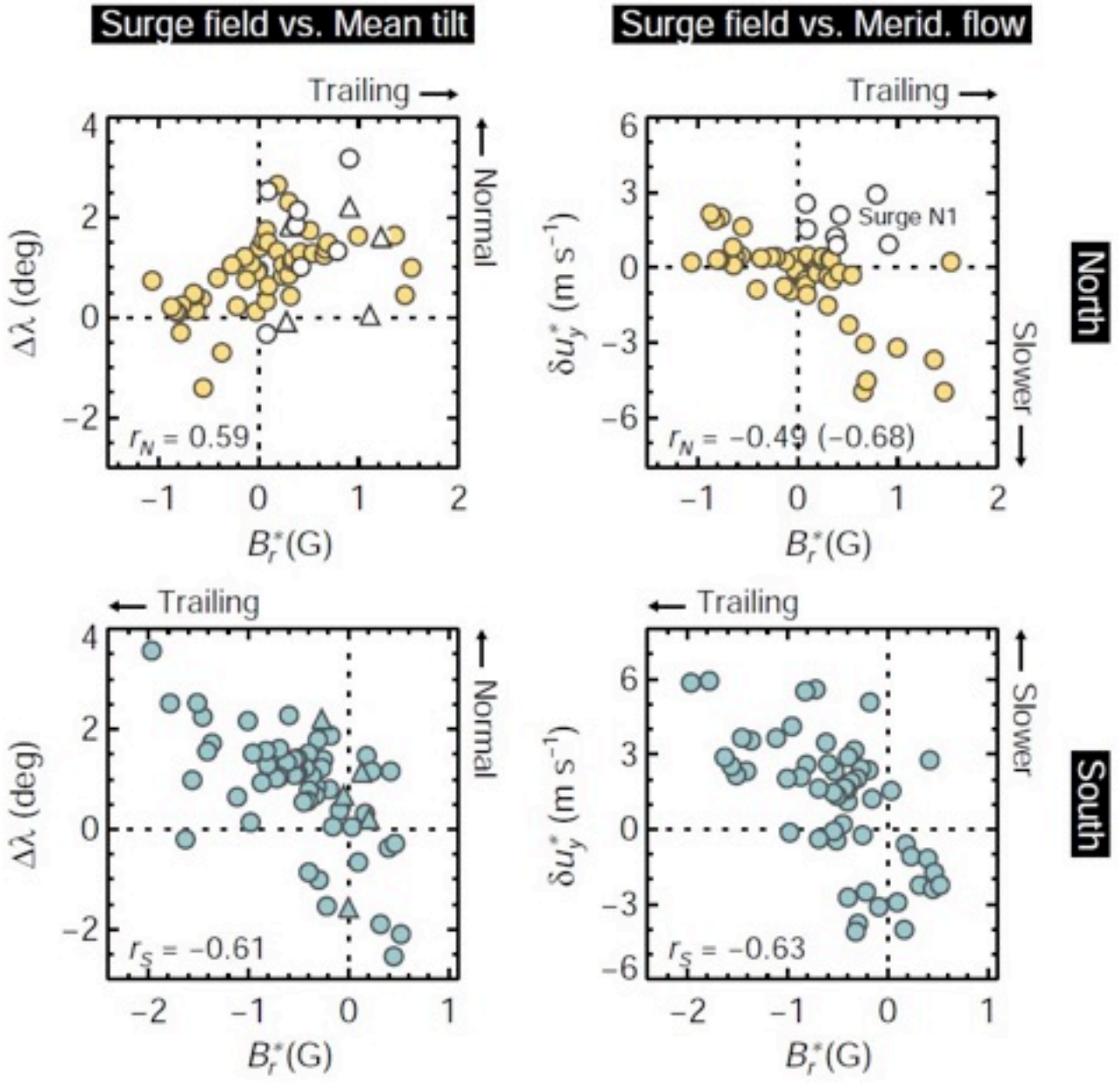


Sun et al. 2014



Sun et al. 2014

Long-Term Studies: Meridional Flow



Sun et al. 2014: Meridional flow & AR properties

Long-Term Studies: Diffusion Coefficient

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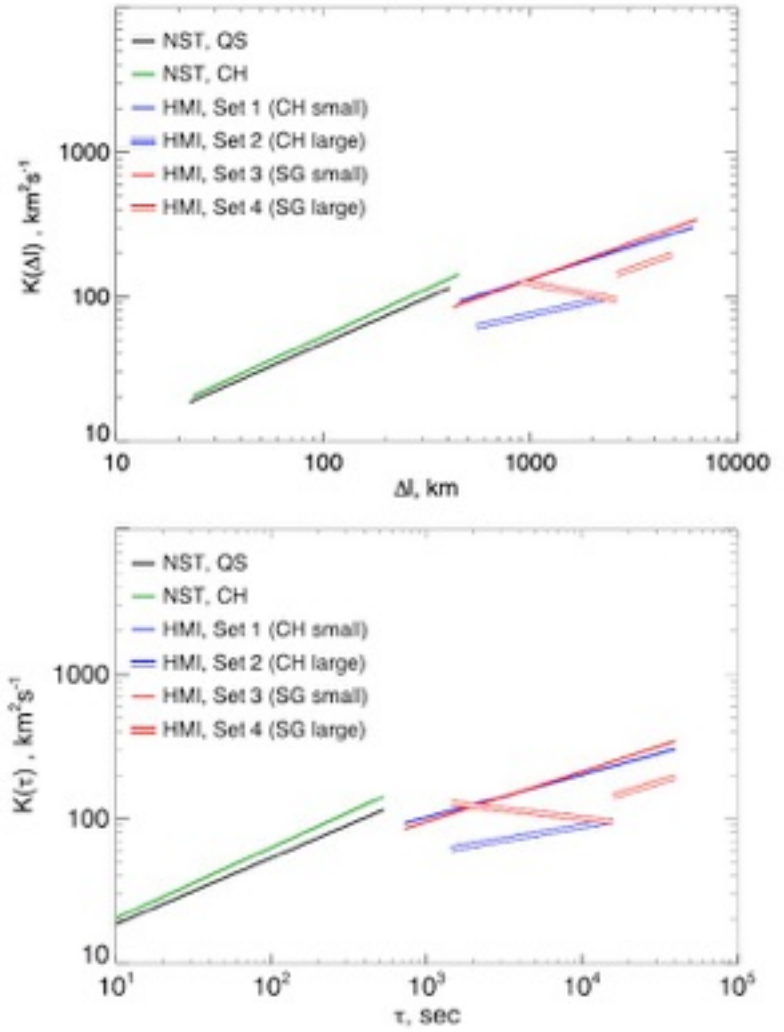
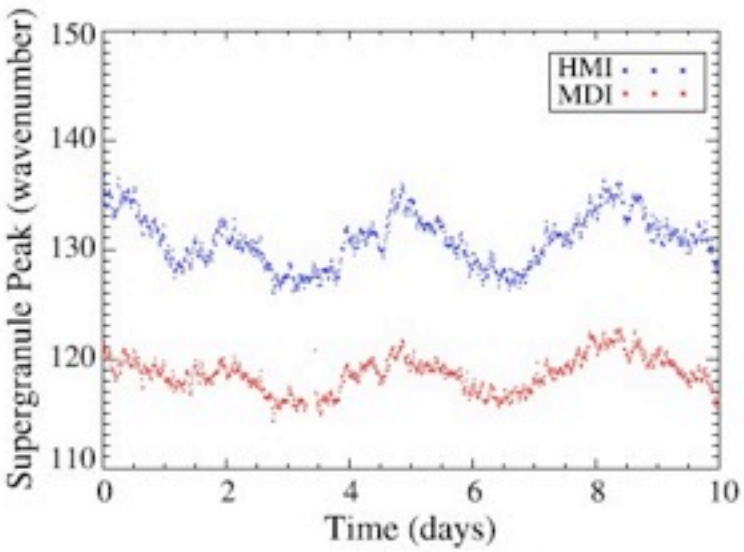
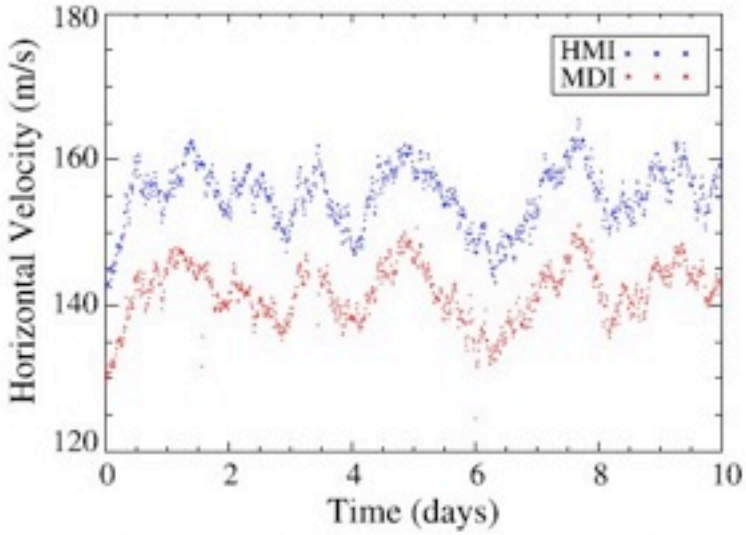
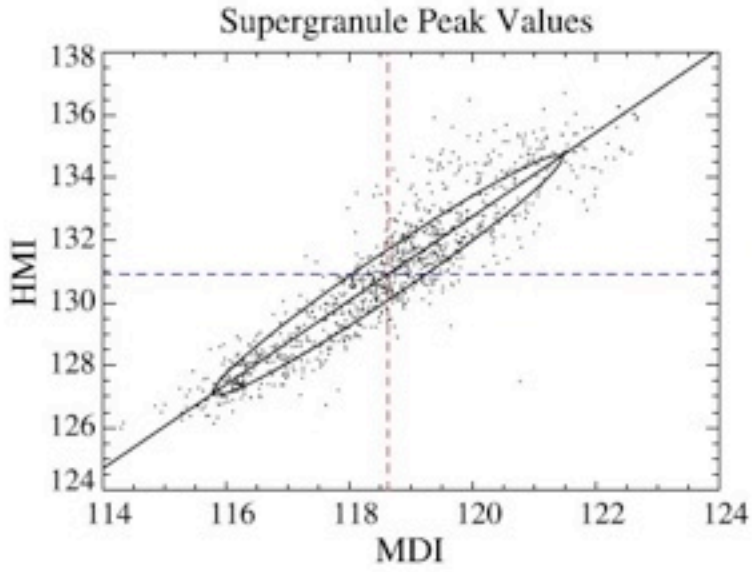


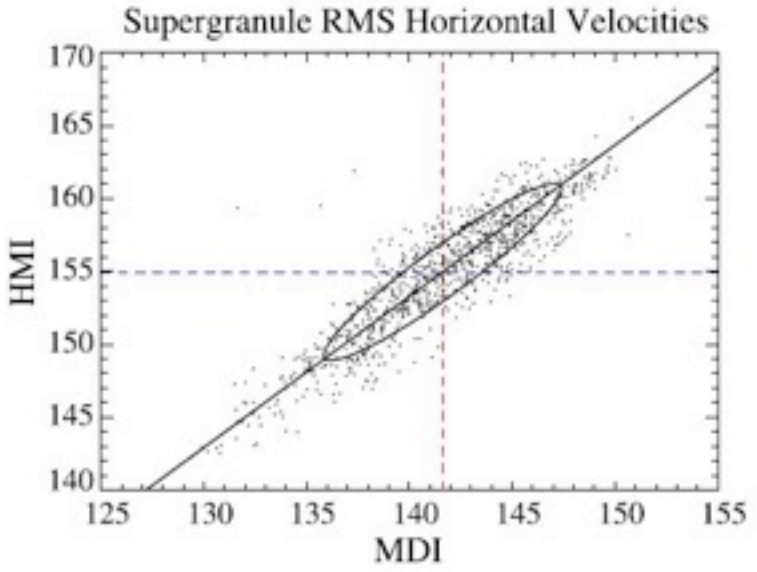
Abramenko (2017): diffusion coefficient depends on spatial and temporal scales of magnetic features in quiet Sun regions.

Long-Term Studies: Diffusion Coefficient



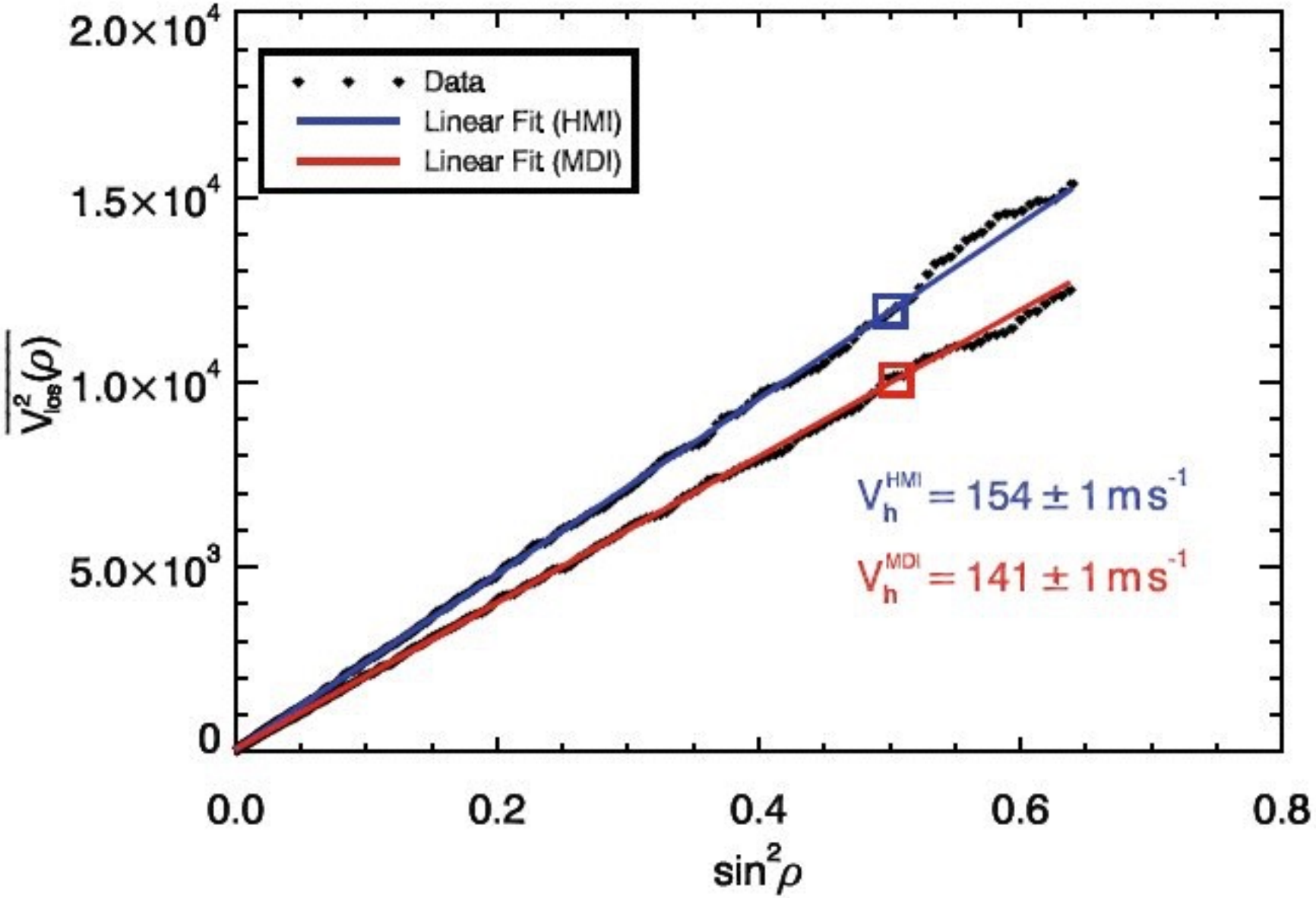






Williams et al. 2014

Long-Term Studies: Diffusion Coefficient



Williams et al. 2014

Long-Term Studies: Source Function

Long-Term Studies: Surface Flux Transport Model

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Differential Rotation

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SDO & DKIST can make progress in understanding Sun's long-term variability.

Long-Term Studies: Several Other Things

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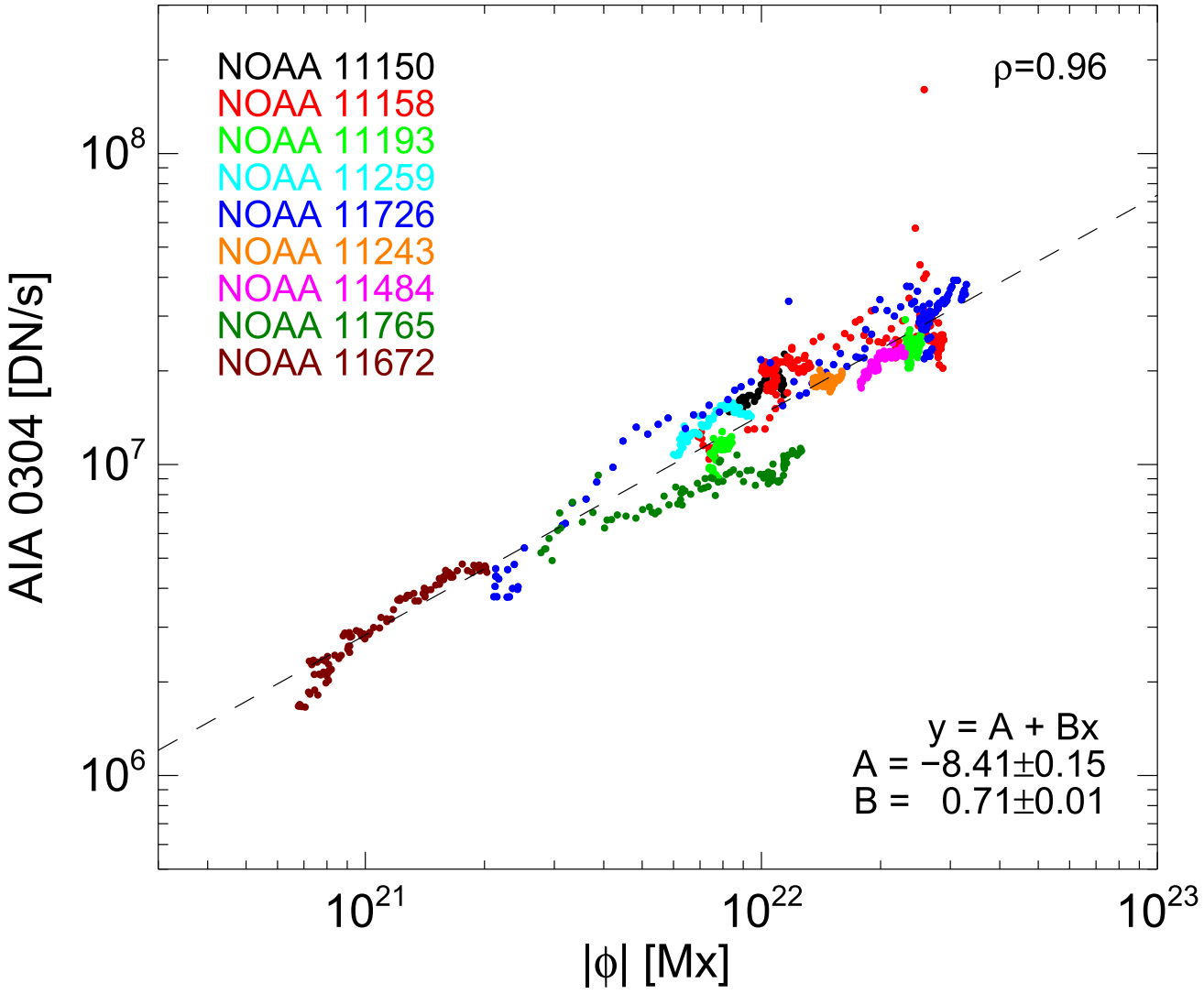


Recover far-side magnetic flux. Ugarto-Urra et al. 2015

Long-Term Studies: Several Other Things

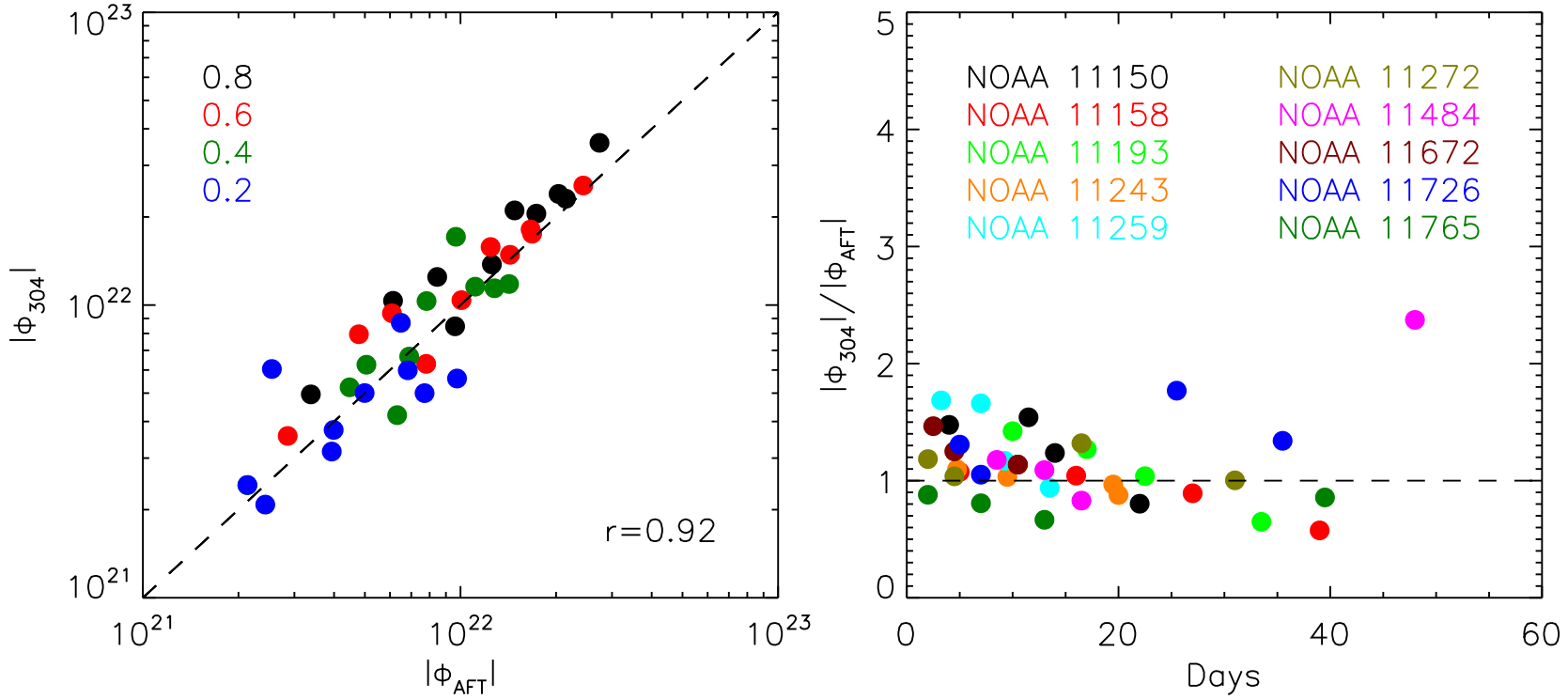
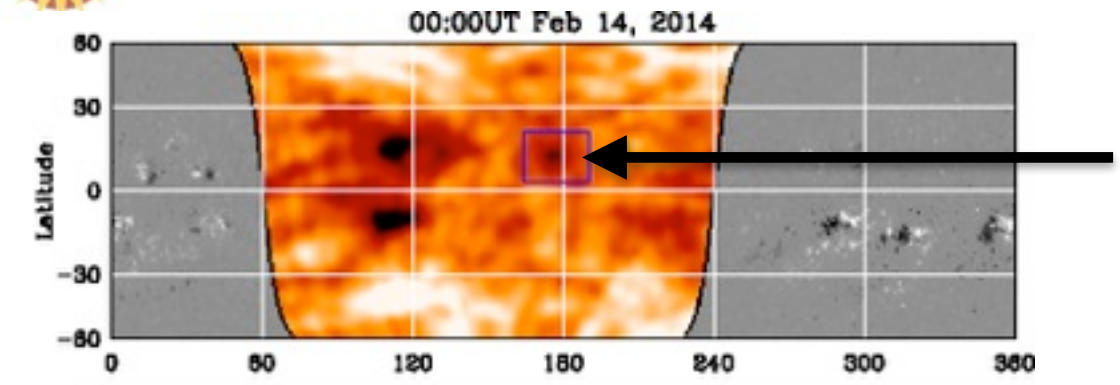


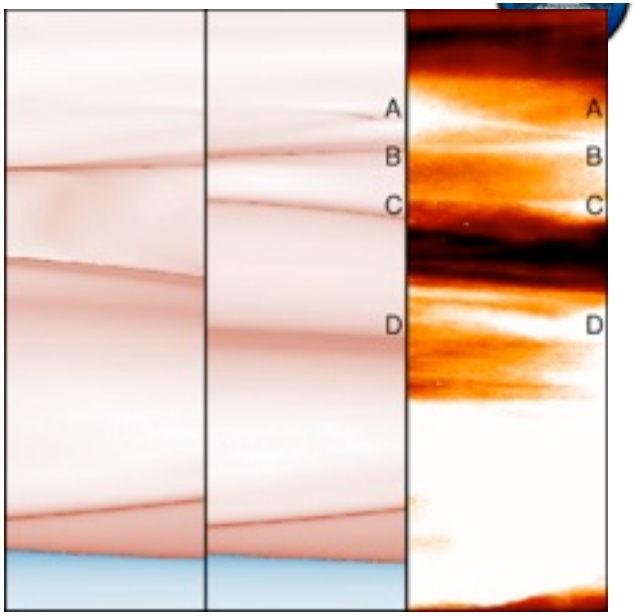
Figure 6. Left: comparison of total unsigned flux for the 304 Å and AFT curves for times when $|\phi_{304}|$ reaches a fraction of the peak flux. Fractions are denoted by the colors. *r* is the Pearson's correlation coefficient. Right: ratio of both fluxes as a function of time for the same instances. Those times and fluxes are highlighted with circles in Figure 4. Dashed lines indicate expected values for the same flux.

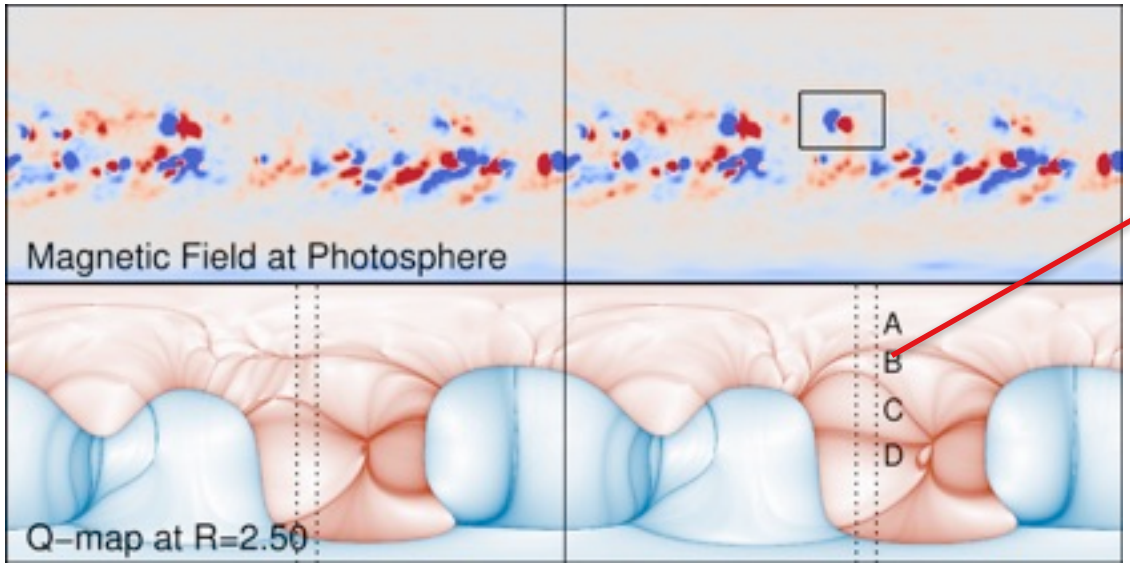
Recover far-side magnetic flux. Ugarto-Urra et al. 2015

Long-term Studies: Synoptic Map by Near-side obs.+ Far-side Images.



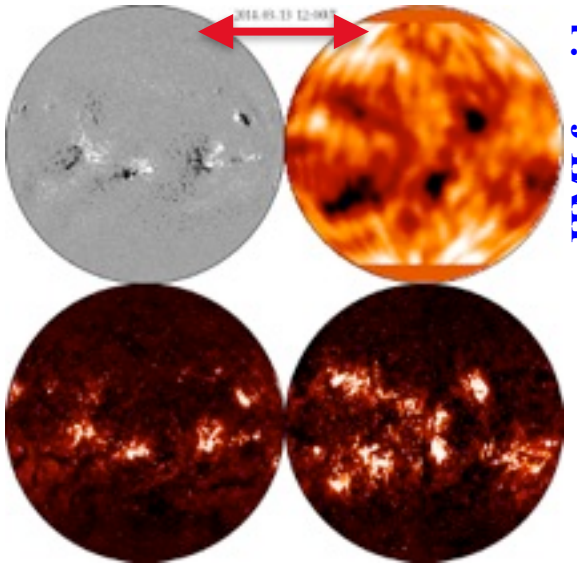
AR emerges at far-side





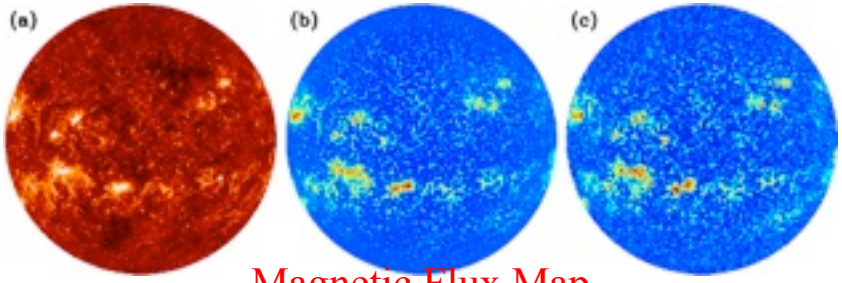
HMI near-side mag

HMI far-side img



AIA near-side 304A

Stereo far-side 304A

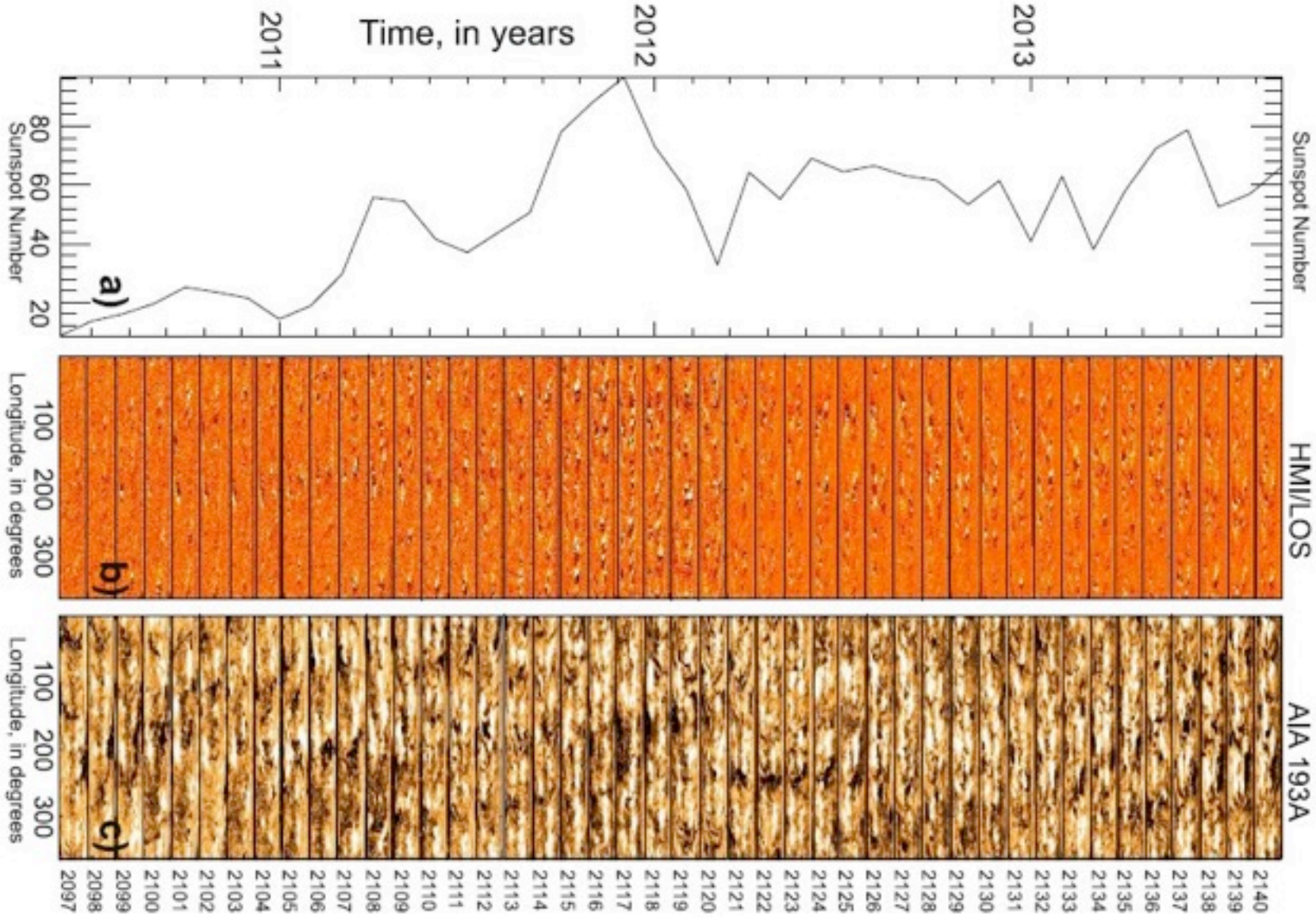


AIA 304Å Img

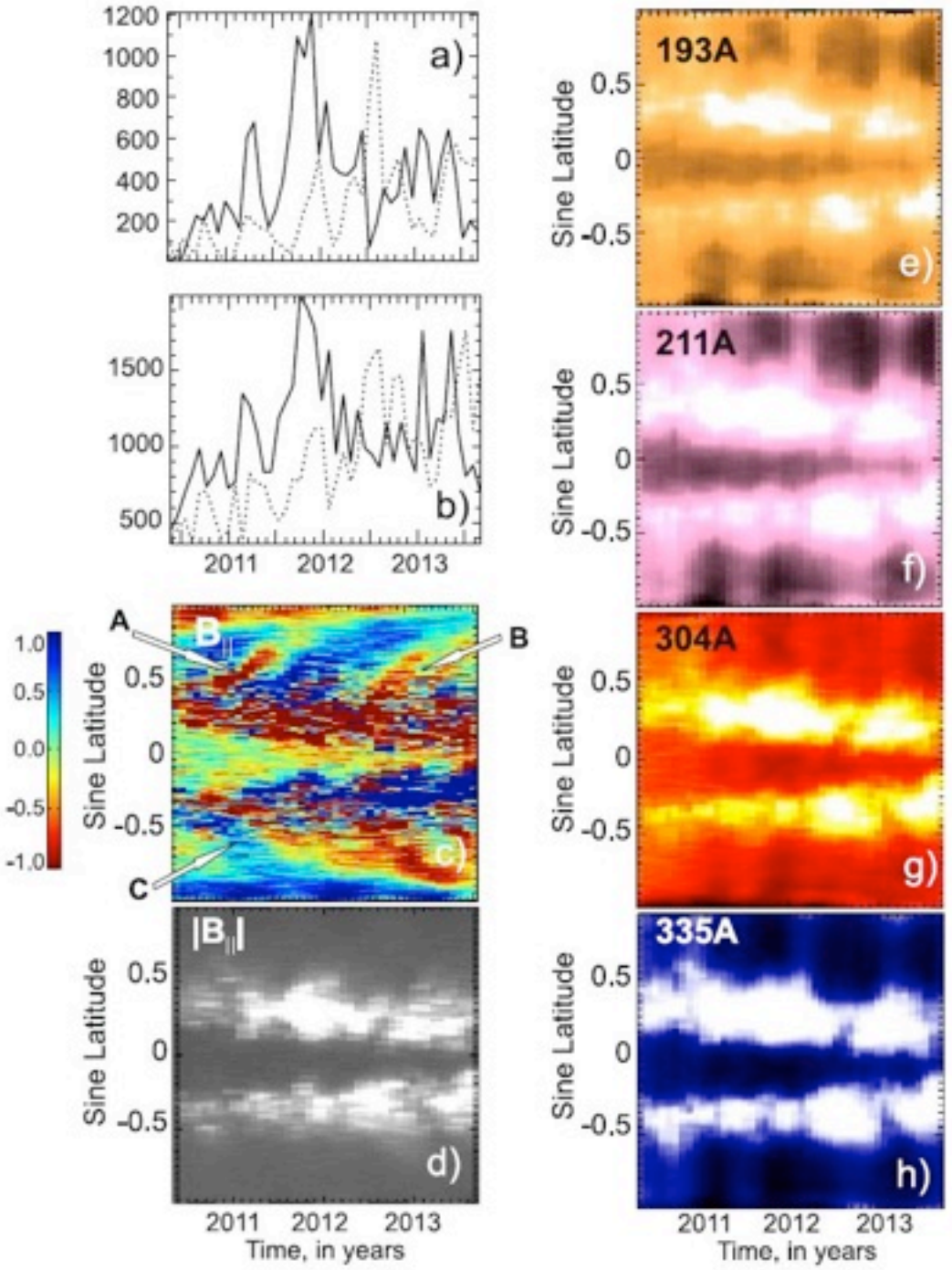
Magnetic Flux Map from AIA 304Å

HMI Mag

Long-Term Studies: Solar Atmosphere



Benevolenskaya 2014



Benevolenskaya 2014

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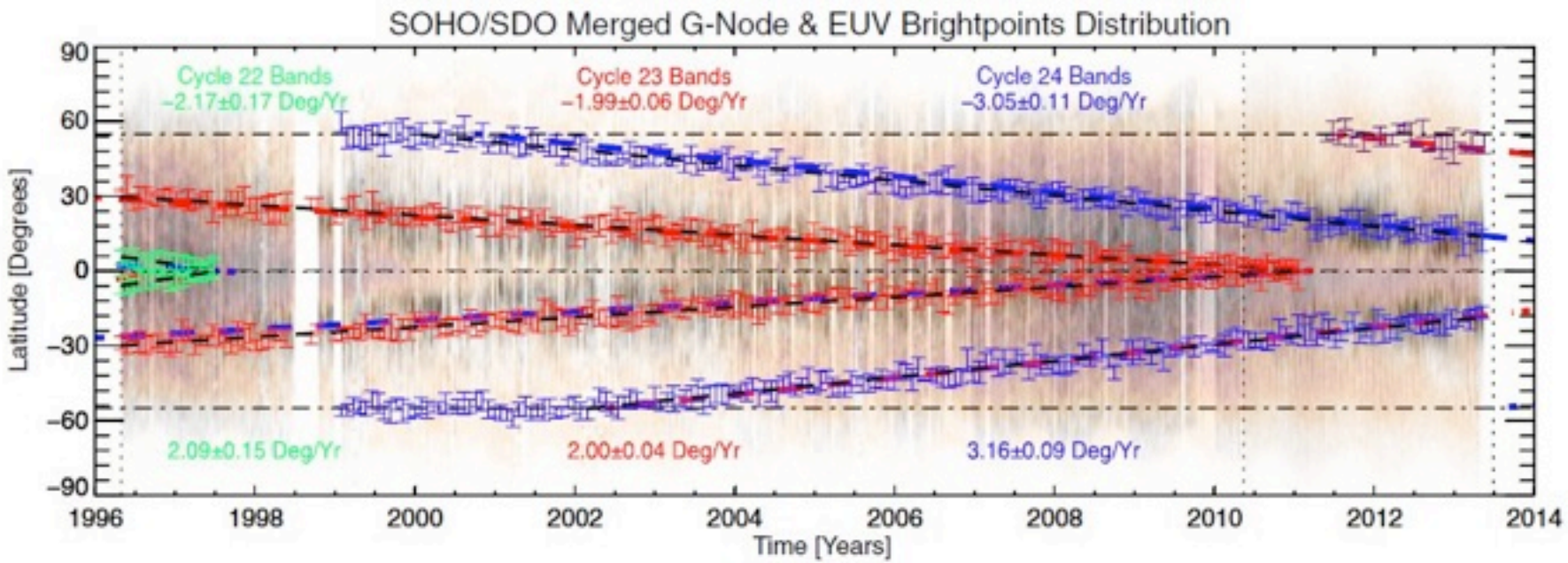
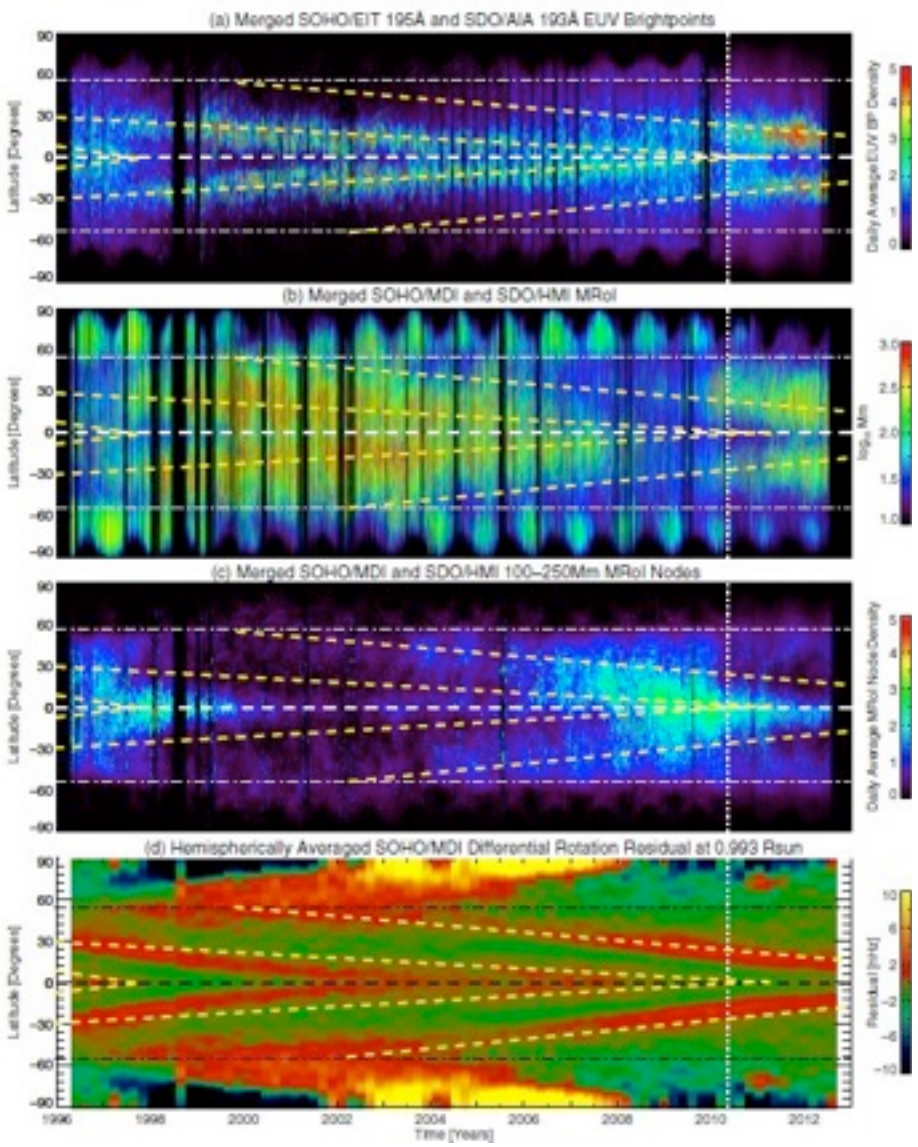
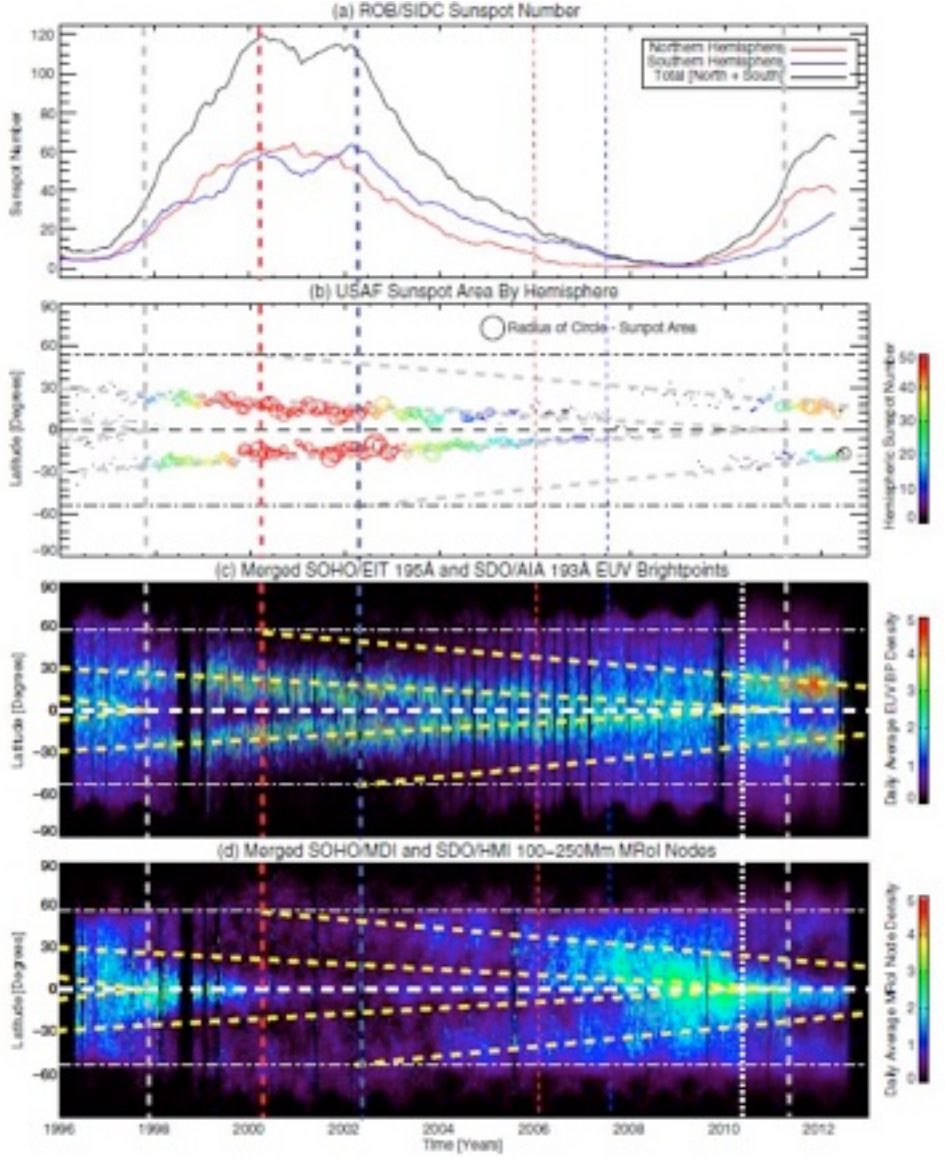


Figure 4. Fitting the BP and g-node bands terminating in 1997 (green), 2011 (red), and the current bands (blue) from the combined g node and BP latitude–time distributions. Each bar on the plot is determined as shown in Figure 3 and the results are assumed to describe a linear migration of the activity band with time. The linear fit to each band is shown as a black dashed line and the gradient fits are as shown on the plot. The vertical dotted lines mark the beginning and end of the observation sample.

McIntosh et al. 2014

Long-Term Studies: Solar Atmosphere





McIntosh et al. 2014

Long-Term Studies