Center-to-Limb Variation of Deprojection Errors in SDO/HMI Vector Magnetograms

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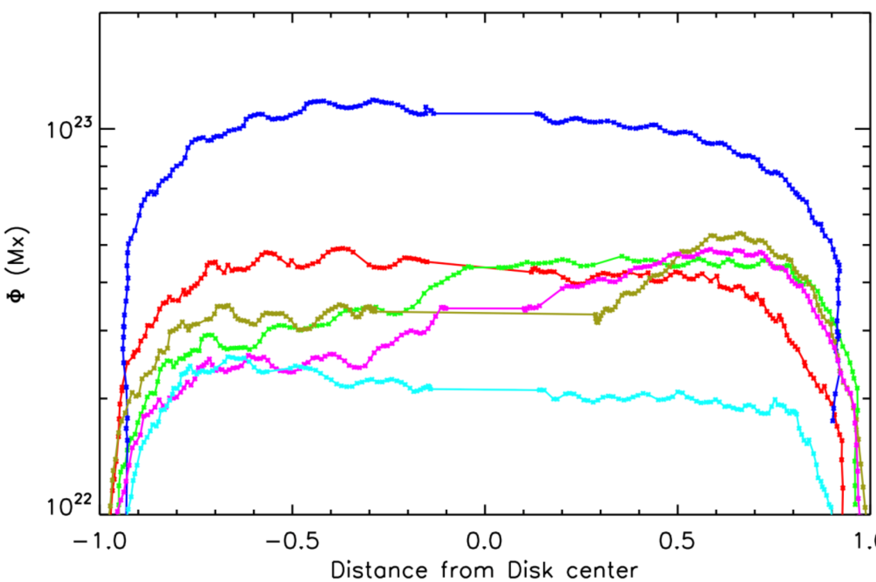
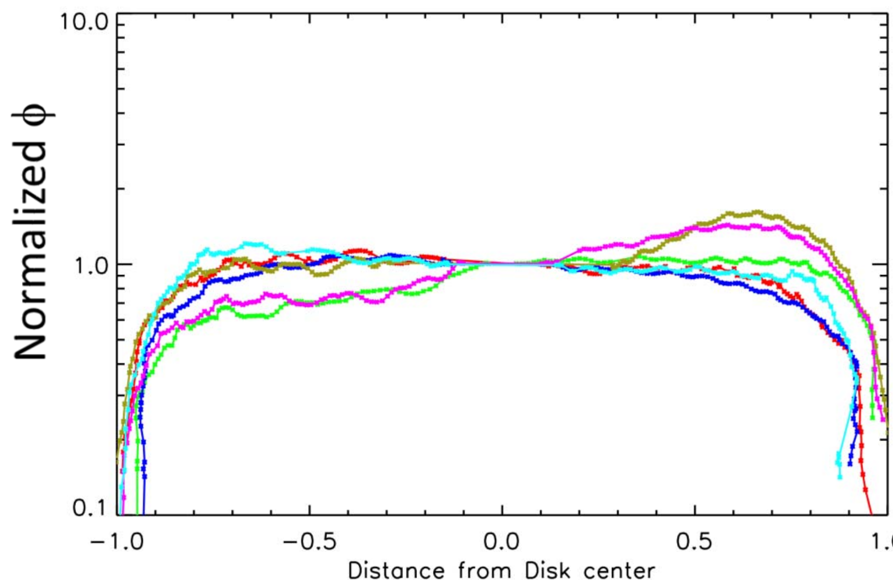
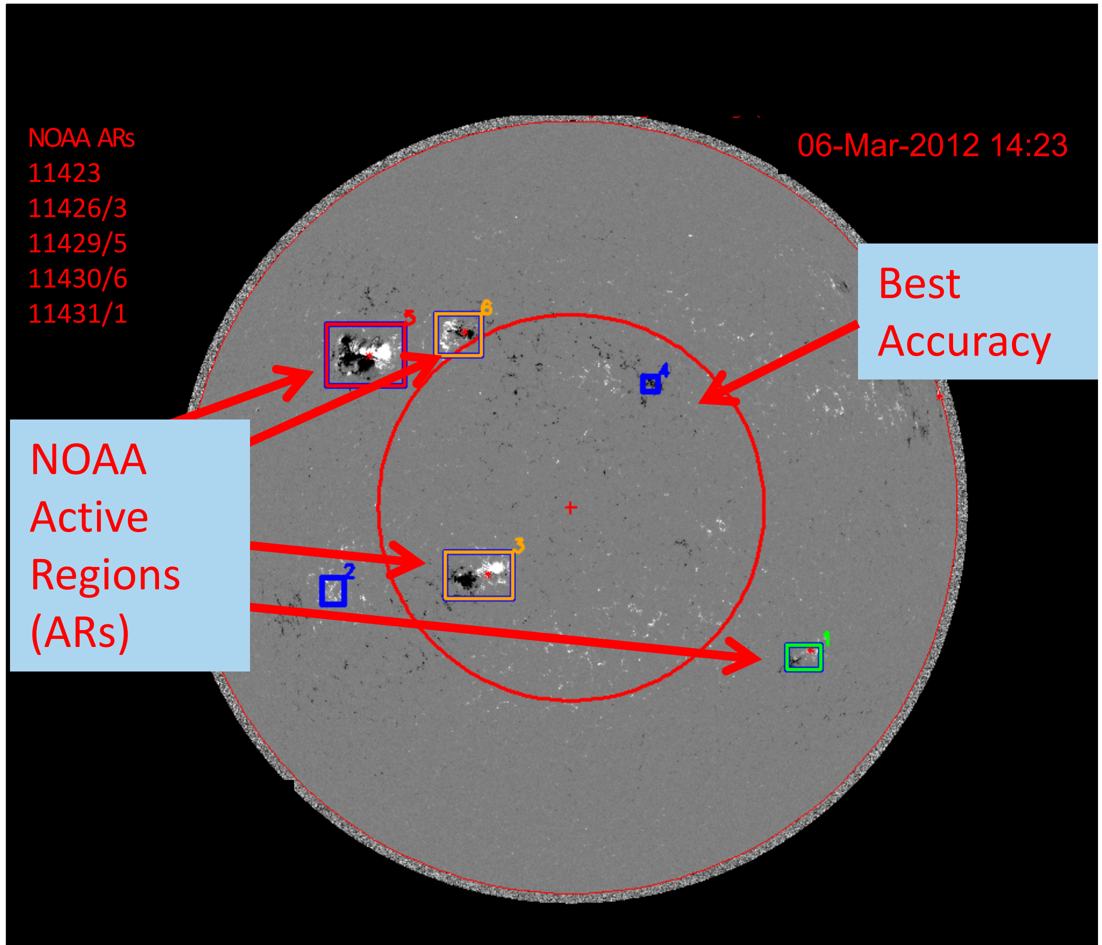




Need to go Vector

- Magnetograms are spatial maps of the magnetic field strengths
- They come in two basic types
  - line-of-sight (right)
  - vector magnetograms
- Free-energy proxies can be measured for Active Regions (areas with sunspots) from either type of magnetogram
- Line-of-sight magnetograms suffer reduced accuracy further from disk center

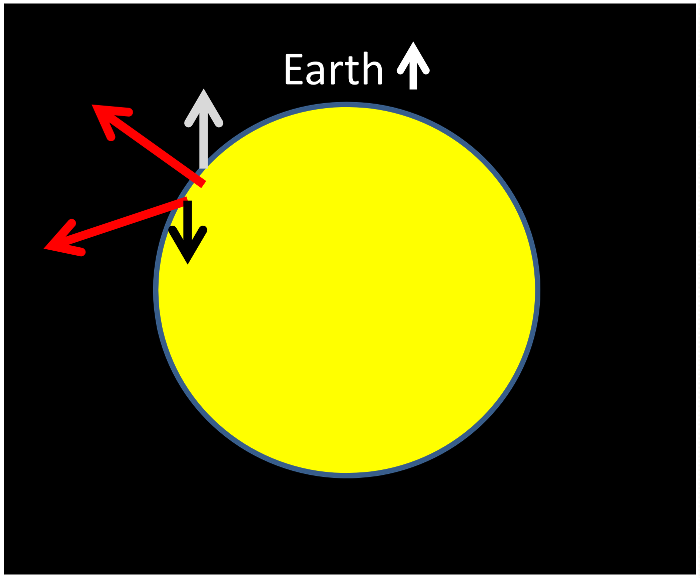
Magnetograms & identify ARs



A full-disk line-of-sight magnetogram of the Sun, from SDO/HMI.

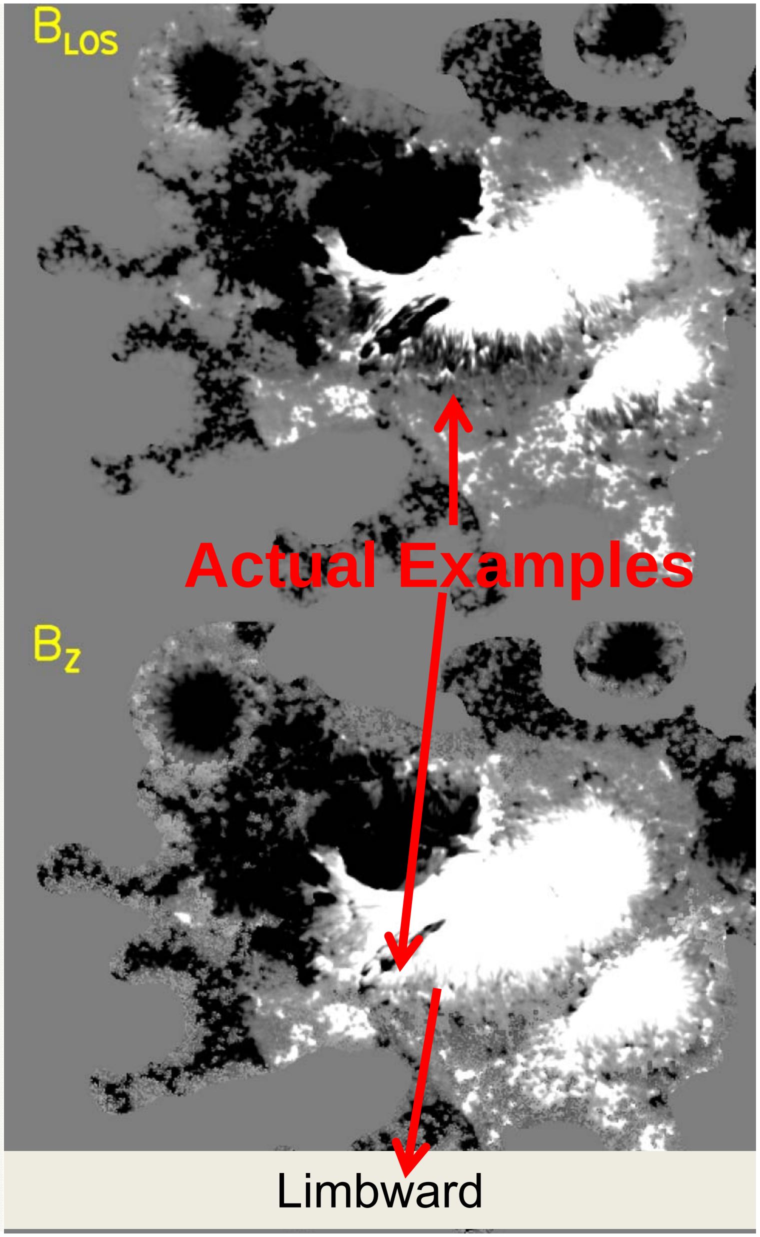
MAG4 Improvements: Vector Magnetograms

- Both vectors shown in red have positive B_z (magnetic field out of the sun), but have opposite sign B_{LOS} and thus a false (unphysical) neutral line in the line-of-sight (LOS) field.



False Neutral Lines occur on limbward sides of sunspots.

Problem fixed by converting from B_{LOS} and $B_{Transverse}$ to B_Z and $B_{Horizontal}$



Potential Limitations of Deprojection

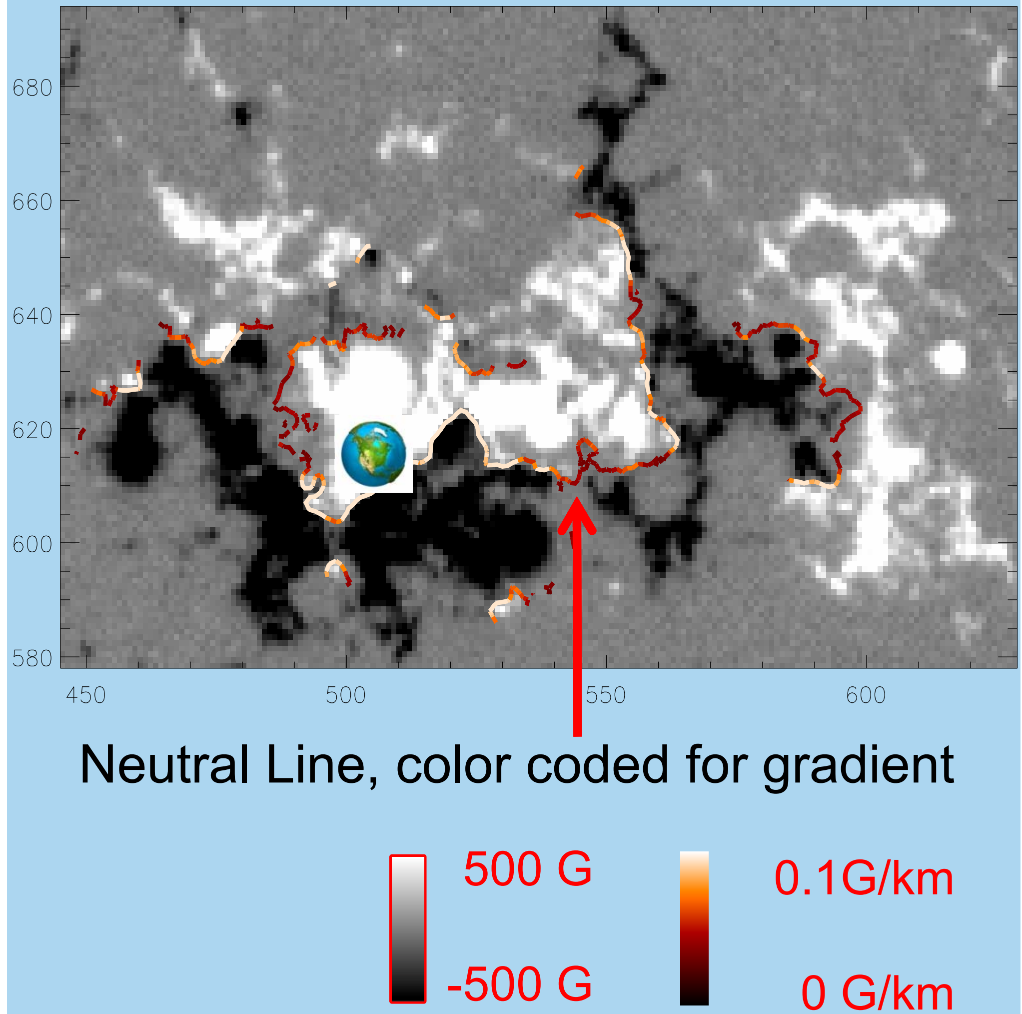
With perfect data, deprojection will work to the limb, of course with real observations, there will be limits. Limits of real observations include:

- Foreshortening (Loss of Resolution near limb)
- Noise in transverse field is large compared to line-of-sight field noise
- Ambiguity resolution
  - This magnifies problems of transverse field towards the limb because the adjacent pixels noise becomes correlated by ambiguity resolution.

Defining AR Magnetic Measures

- $\phi=\int|B_z|da$
- $A=\int da$
- Integral is over pixels with $|B_z|>100$ G
- $WL_{SG}=\int|\nabla B_z|dl$
- $WL_{SS}=\int|\theta_{shear}|dl$
- Where Neutral Line integral is over segments with pbt>100 G.
- R Schrjiver's R
  - Defined as Schrijver et al ??

A magnetogram of an active region

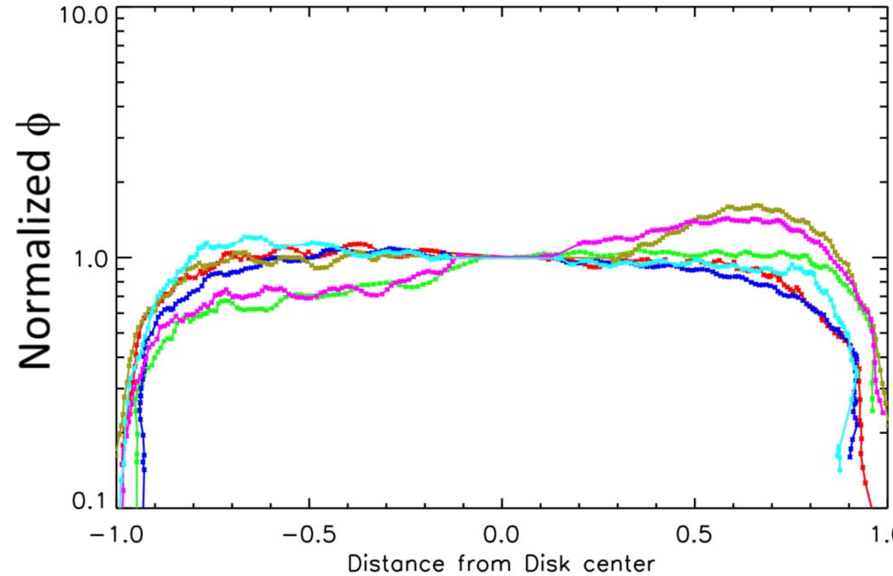


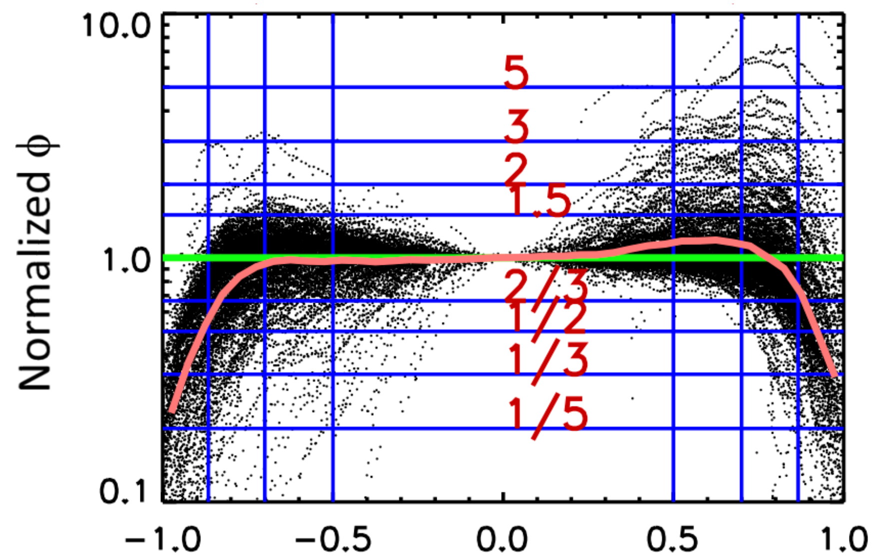
Analysis

1. Assume AR are as likely to grow in a particular magnetic measure as it is too shrink.
2. By looking at the average fractional change of an AR magnetic measure during disk passage.
3. If an AR magnetic measure is constant, and no projection effects there will be no measurable fractional change from unity.
4. Since AR magnetic measures do change, we need to look at the average change (when normalized to unity at central meridian) of a large number of ARs.
5. Where the average significantly departs from unity is the limit of accurate deprojection.

Example Plot Total Magnetic Flux

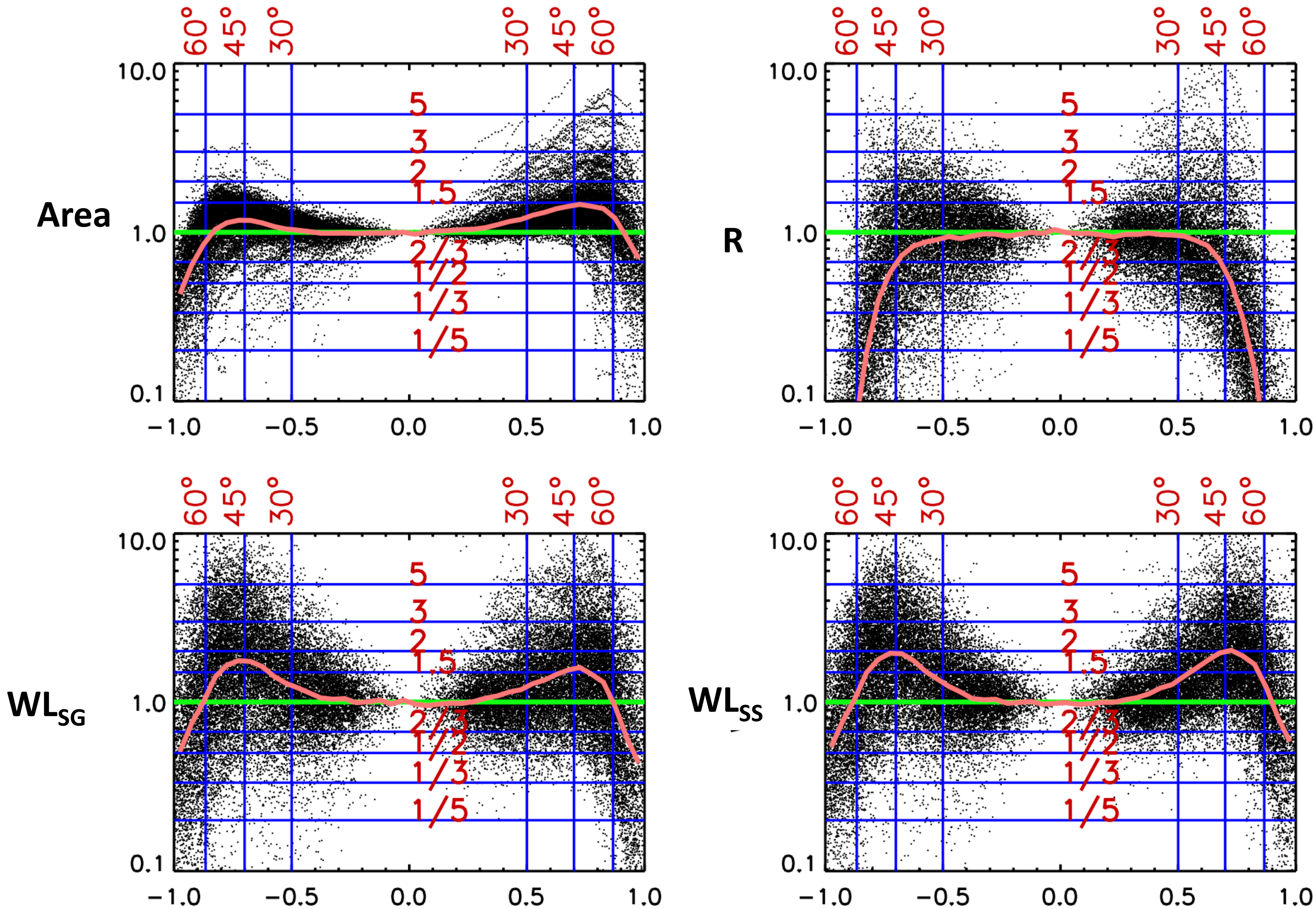
- Each dot is the normalized value relative to central meridian of a single HARP magnetograms.
- Trails of dots are due to a single HARP disk passage.
- The red curve is the average of each bin.
- The green line is the unity line, if their was no deprojection effects.
- Within 60 heliocentric degrees the red curve is within a facto of 1.5 of no deprojection effects.





Distance from Disk Center (R_S)

Other examples



Conclusions

- Projection effects for different measures can be quantified.
- Typically projection effects are negligible to 30 heliocentric degrees, and often manageable to 45-60^o on measure.
- Beyond 60^o problems occur quickly.
- Projection effects due to transverse field noise tends to result in an overestimate of magnetic measures in the 30-60^{o}range.
- Projection effects from foreshortening tends to set in at 45-60^o and result in an underestimate of the magnetic measures.

Application:
CME velocity versus Free-Energy Proxies

- An active region's magnetic measure can be used to predict an upper bound on typical CME velocity.