A Study of Solar Polar Field Using SOHO/MDI and Hinode Observations

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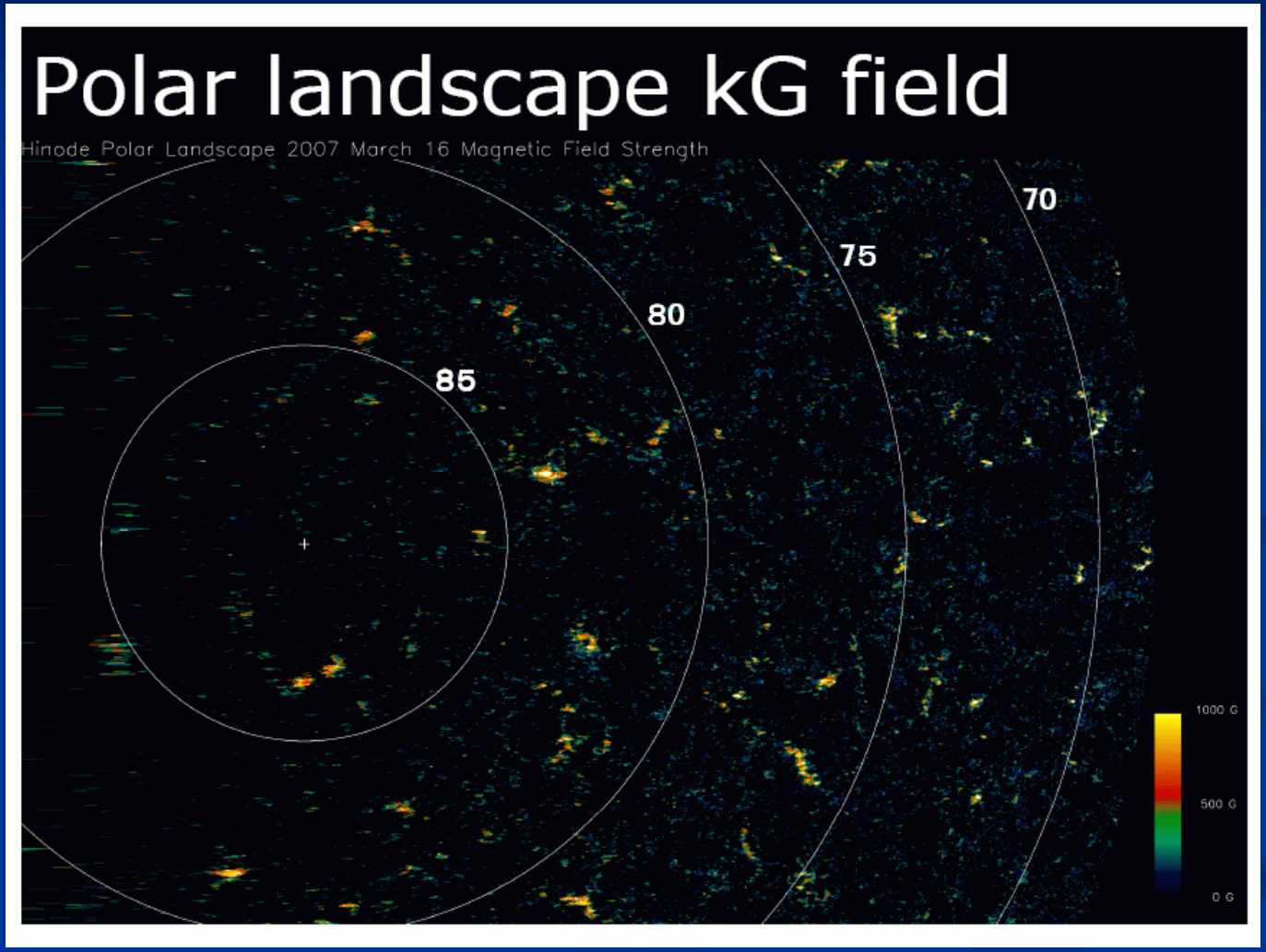
Motivation



Tsuneta et al. 2008

Motivation

MDI observation taken in March 2007

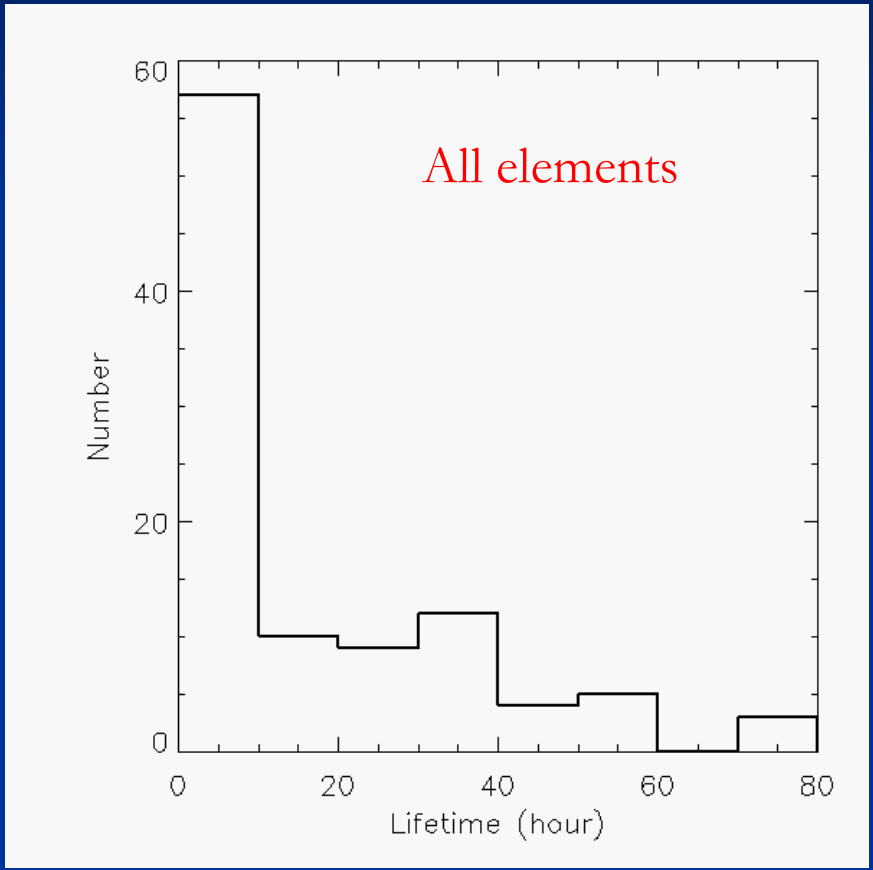
Motivation

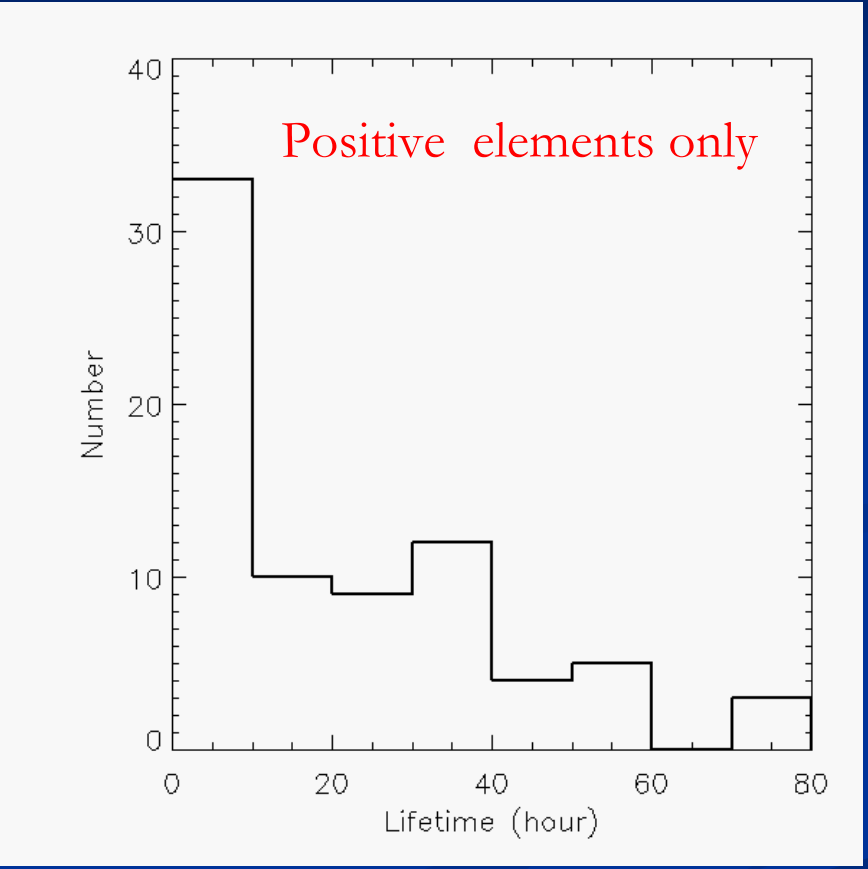
- Lifetime of magnetic elements in polar regions:
  - Deng et al. (1999), after tracking 1300 elements in high latitude, found that the lifetime of elements varies from several hours to more than 58 hours;
  - Varsik et al. (1999) reported the lifetime of elements ('knots') is longer than 7 hours but shorter than 24 hours;
  - Benevolenskaya (2007) found ``the polar magnetic elements have a tendency to be present for about 1-2 days'';
  - Thus, it is useful to give a statistical estimate of lifetime.
- Solar rotation rate in high latitude:
  - Many publications with various methods. Junwei Zhao suggests, with this set of data, it's better to use image cross-correlation method.

1. Method for lifetime estimate

- Manually track each magnetic elements to measure the lifetime of this element.

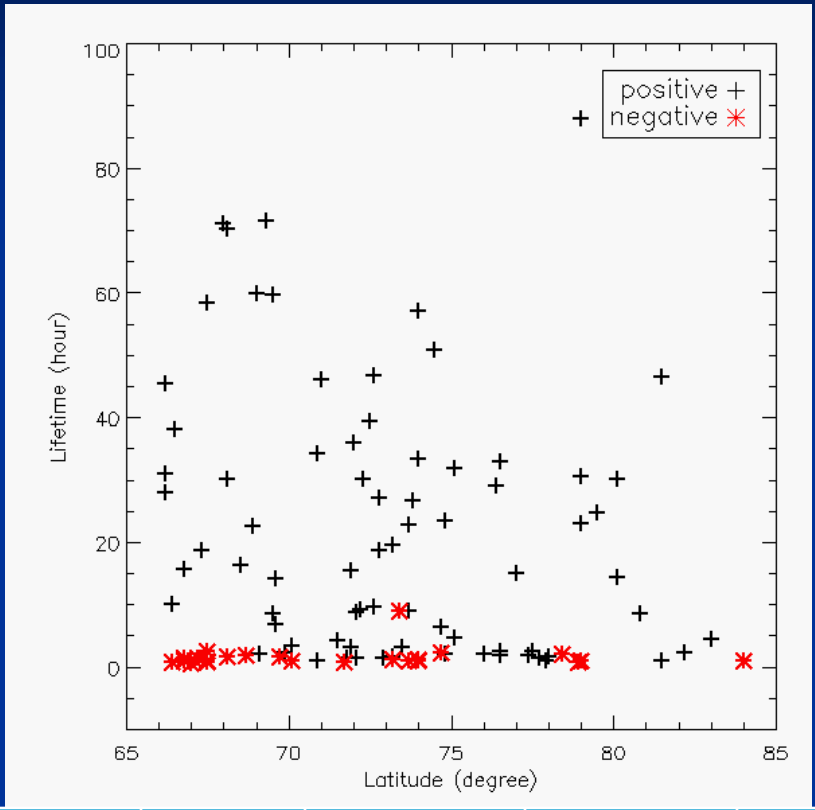
Lifetime of magnetic elements

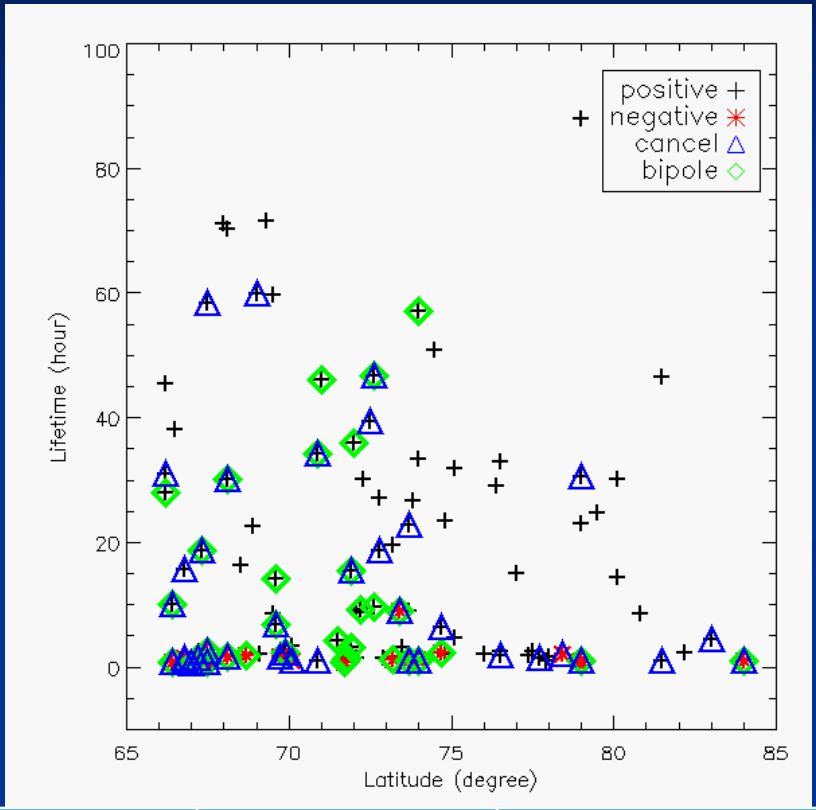




	Positive	Negative	All
Percentage	76%	24%	100%
Lifetime (h)	21.8±17.0	1.6±0.8	17.0±16.3

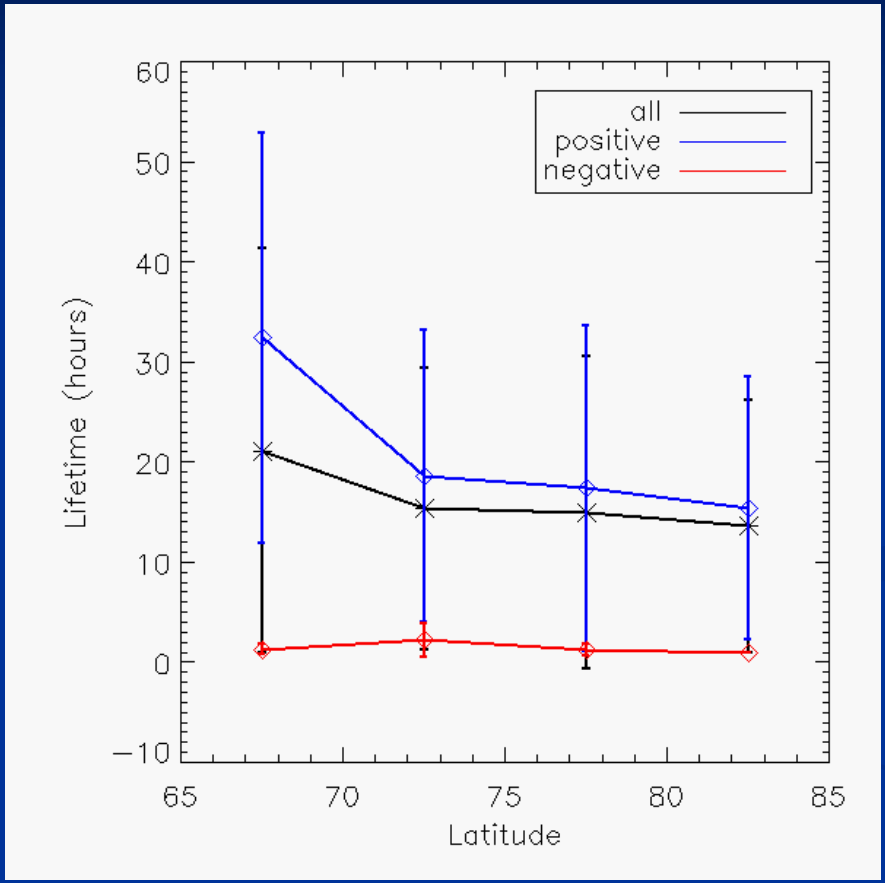
Lifetime (more detail)





	all	positive	negative	lifetime(all)	lifetime(pos)	lifetime(neg)
cancellation	38%	30%	67%	12.5±13.3	19.9±15.1	1.7±1.0
bipole	33%	25%	63%	11.8±12.2	19.7±14.7	1.8±1.1
non-can-bip	47%	57%	13%	21.6±18.0	23.0±17.9	1.0±0.2
all	100%	76%	24%	17.0±16.3	21.8±17.0	1.6±0.8

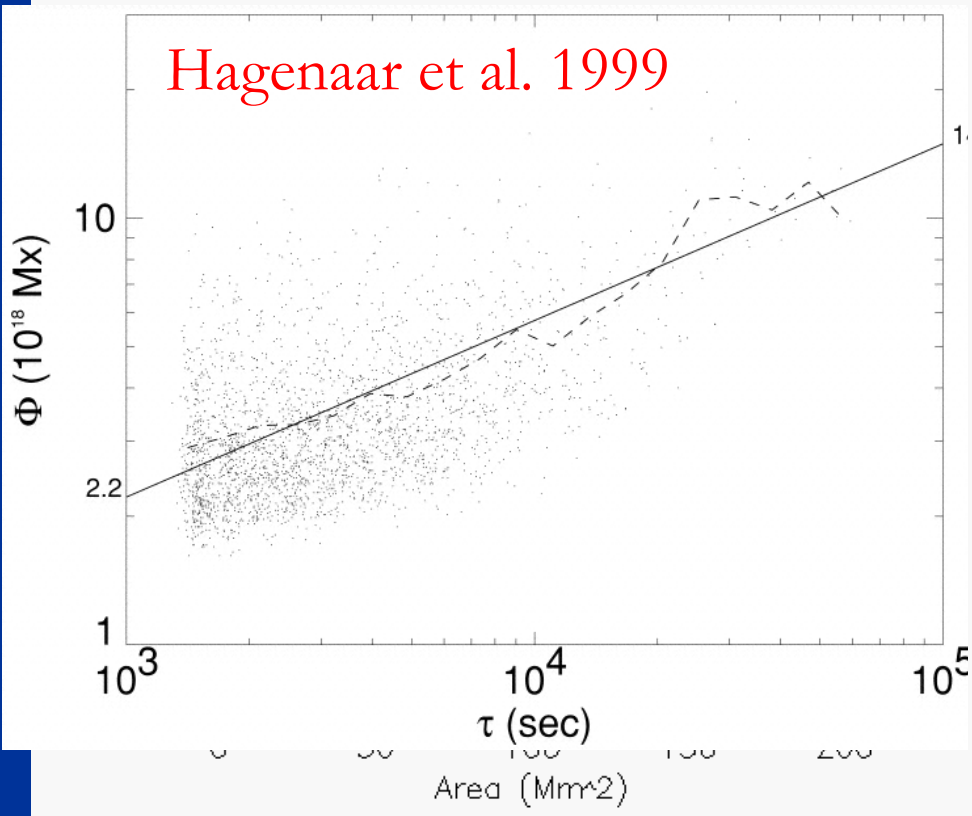
Lifetime versus latitude

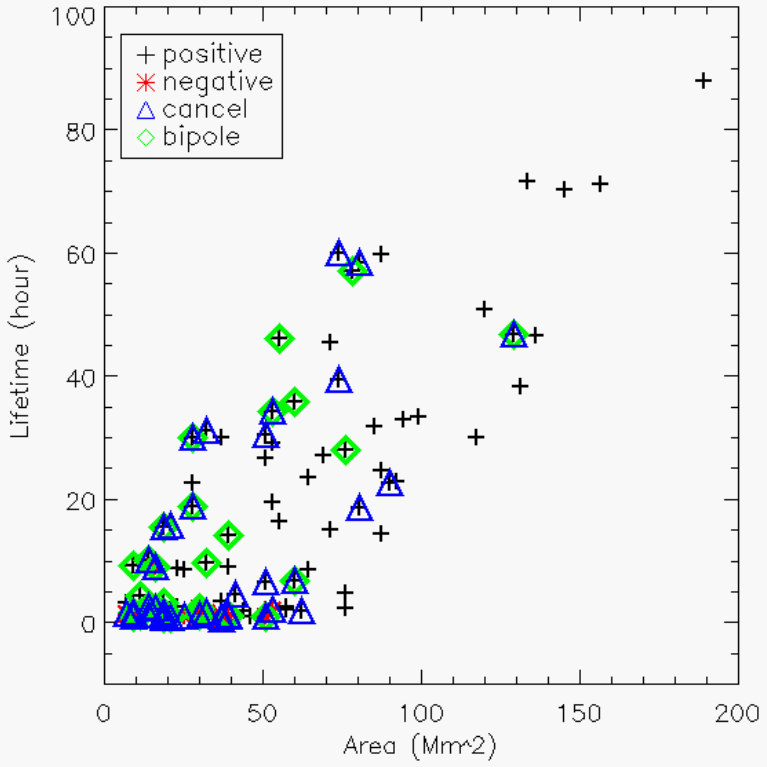


Latitude	67.5	72.5	77.5	82.5
all	21.1±20.1	15.3±14.1	14.9±15.6	13.6±12.6
positive	32.4±20.5	18.6±14.6	17.5±16.3	15.4±13.1
negative	1.3±0.5	2.2±1.7	1.2±0.6	1.0±0.0

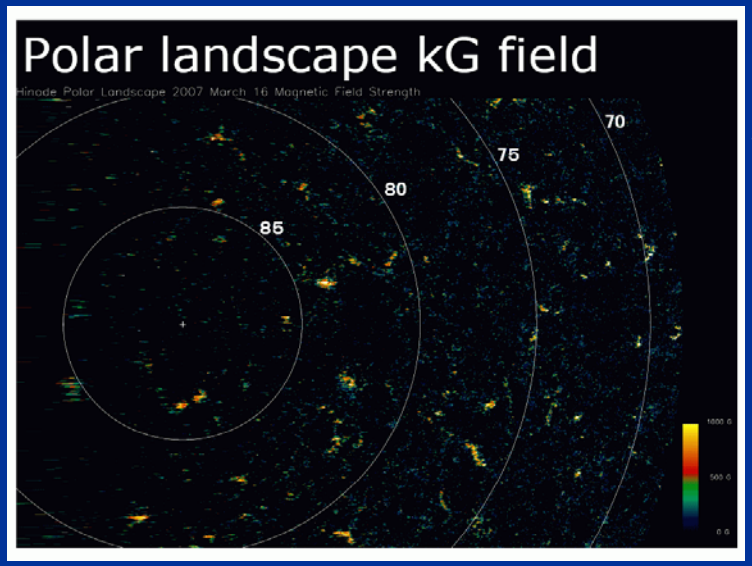
Lifetime versus flux

- Cancelled flux is about 28% of total flux (29% of total area, 38% of total elements).

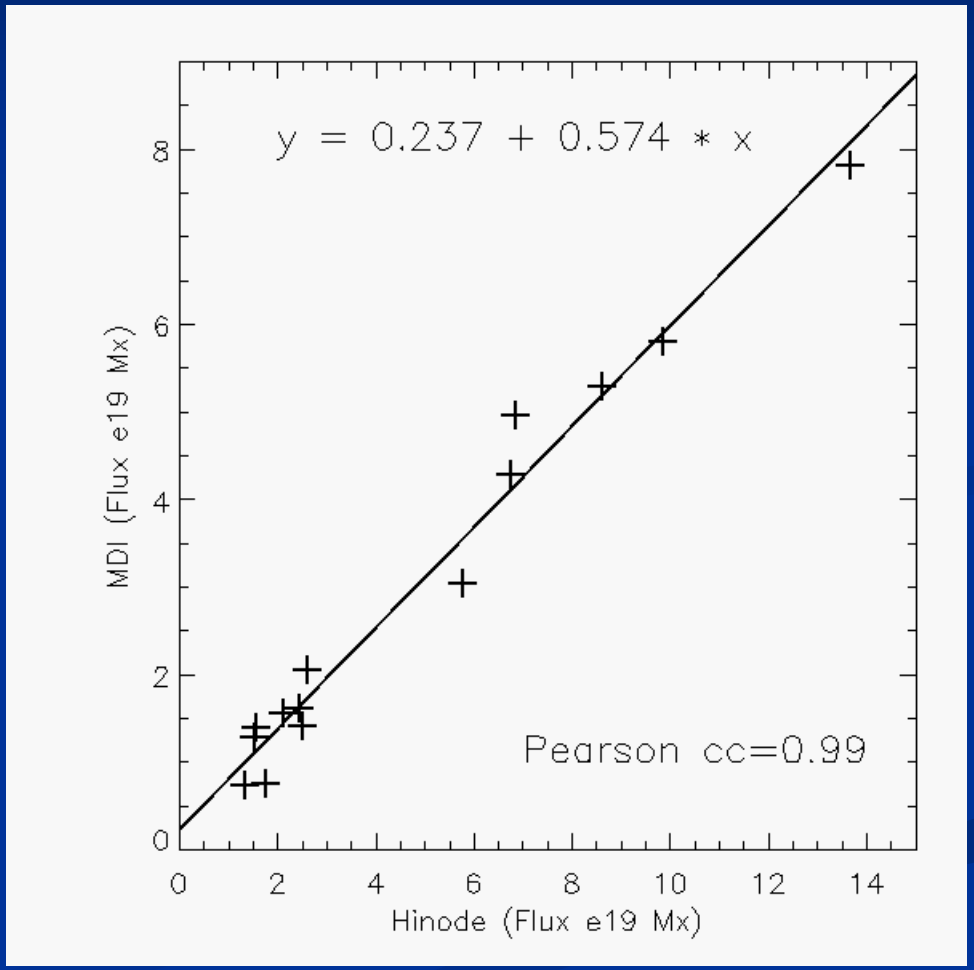




Comparison between MDI and Hinode



30 magnetograms averaged at a center of 13:52:30



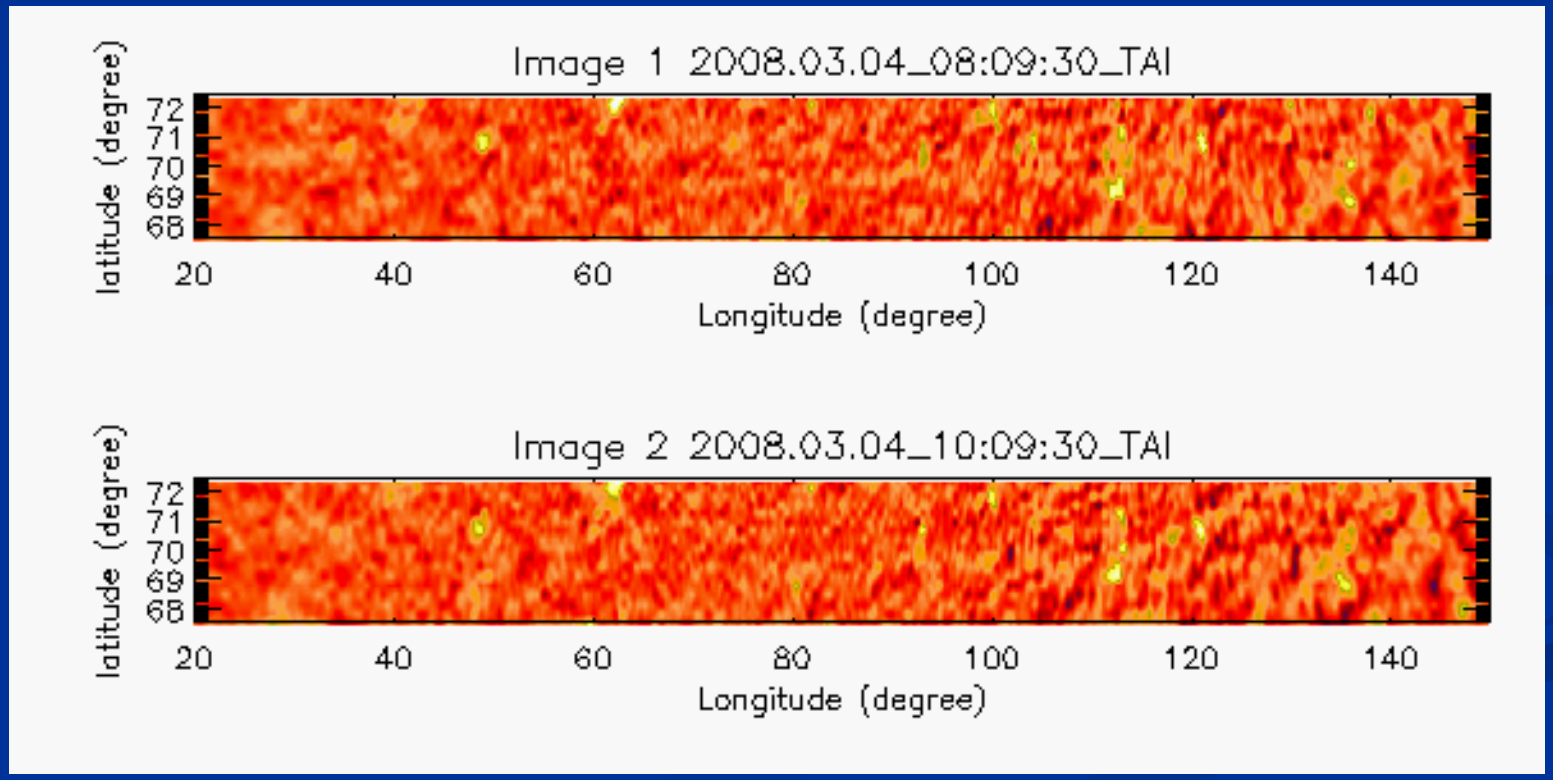
Data taken from 12:02:19-14:55:48 (Tsuneta et al. 2008)

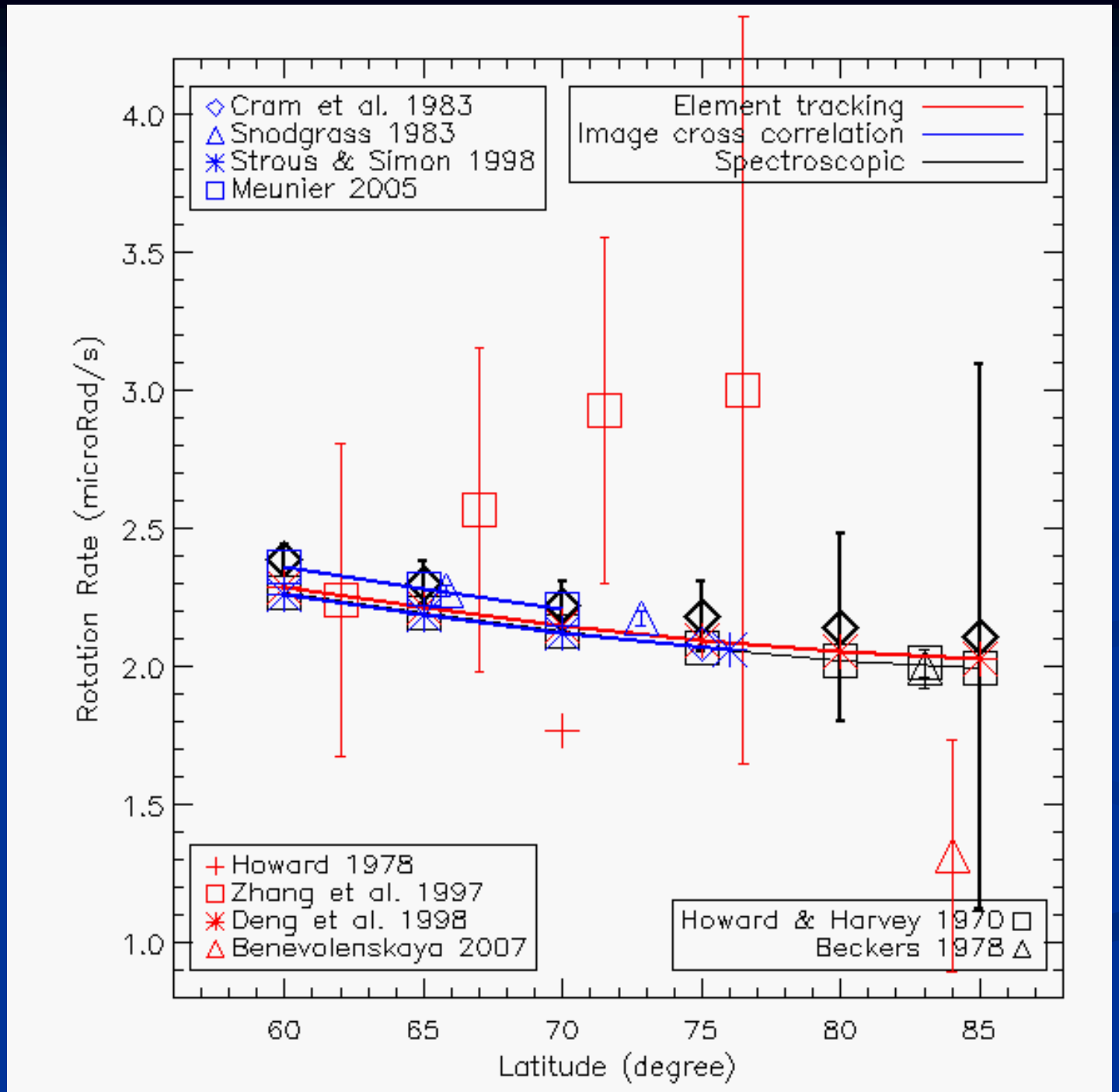
2. Method for rotation rate at high latitude (image cross-correlation)

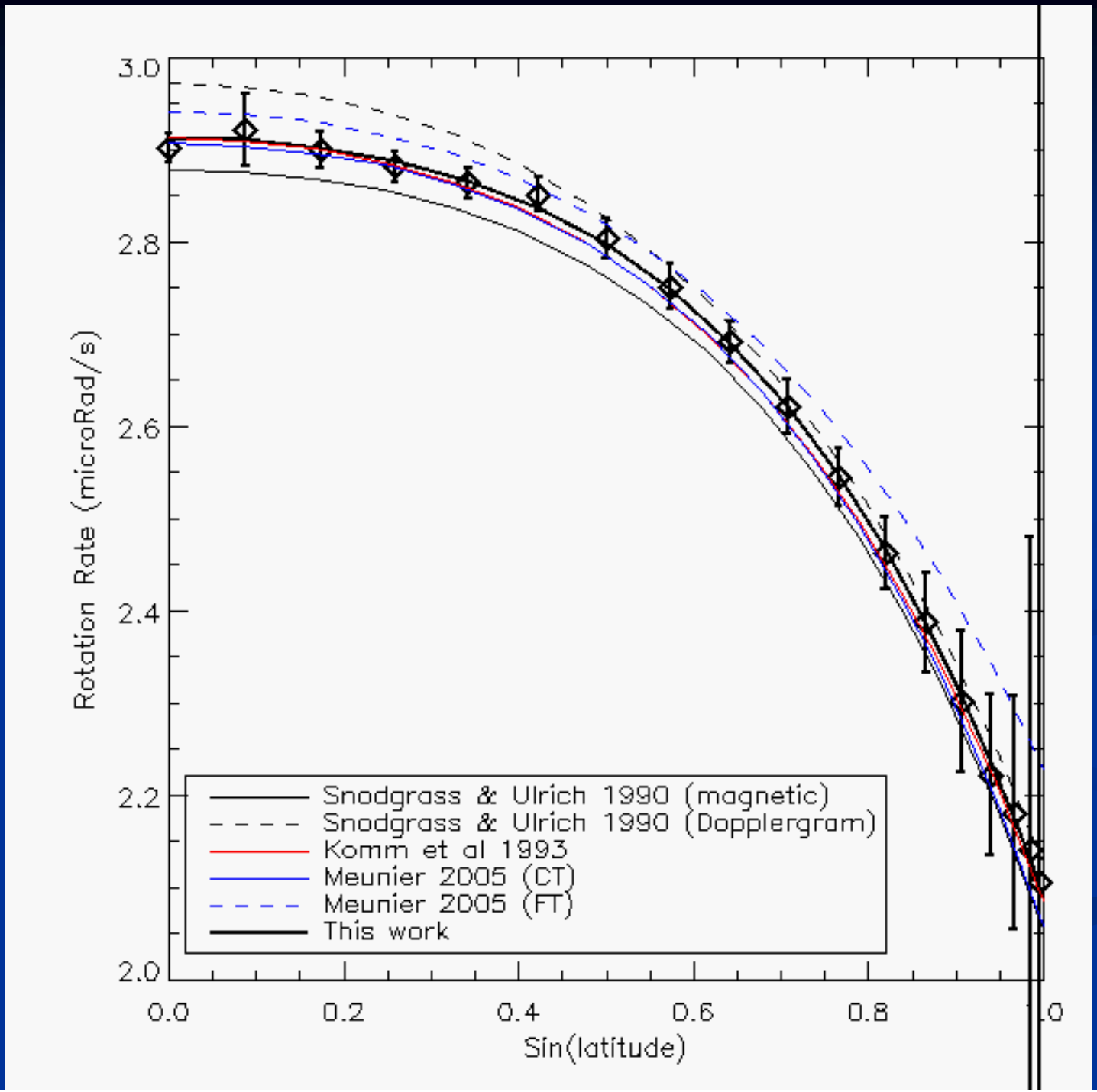
- Remap magnetograms onto Carrington coordinates;
- Average certain number of remapped images to beat down noise (here we average 60 mags);
- Divide the average image into strips along the latitude with a bin size of 5 degree;
- Correlate the corresponding strips from a pair of remapped magnetograms with a certain time lag between them (here we choose a 2-hours lag). The cross correlation code, cross_cor_taylor.pro, developed by G. H. Fisher at Berkeley, allows sub-pixel shifts to find the position of the maximum.

Methodology

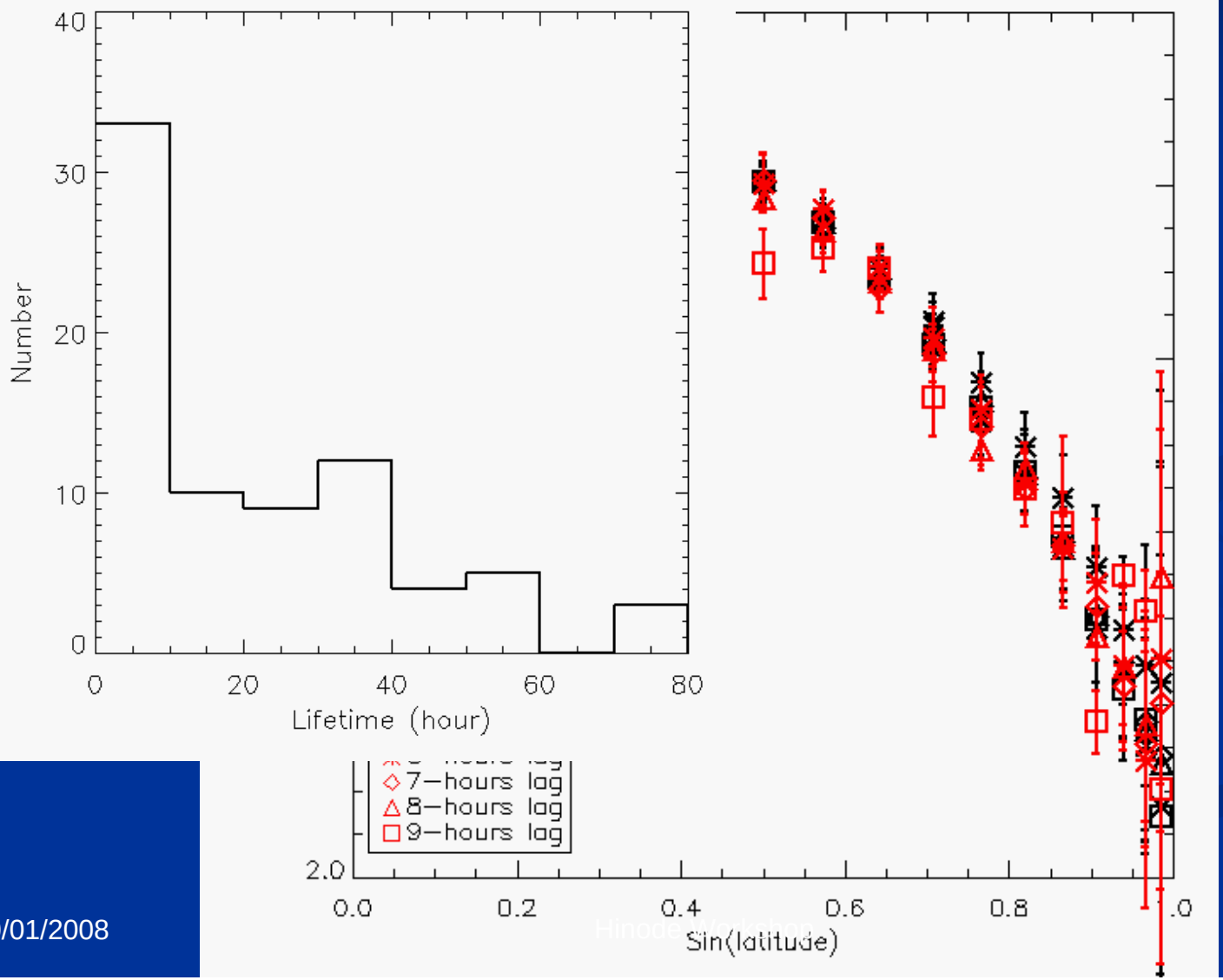
- An example of a pair of strips to be correlated.

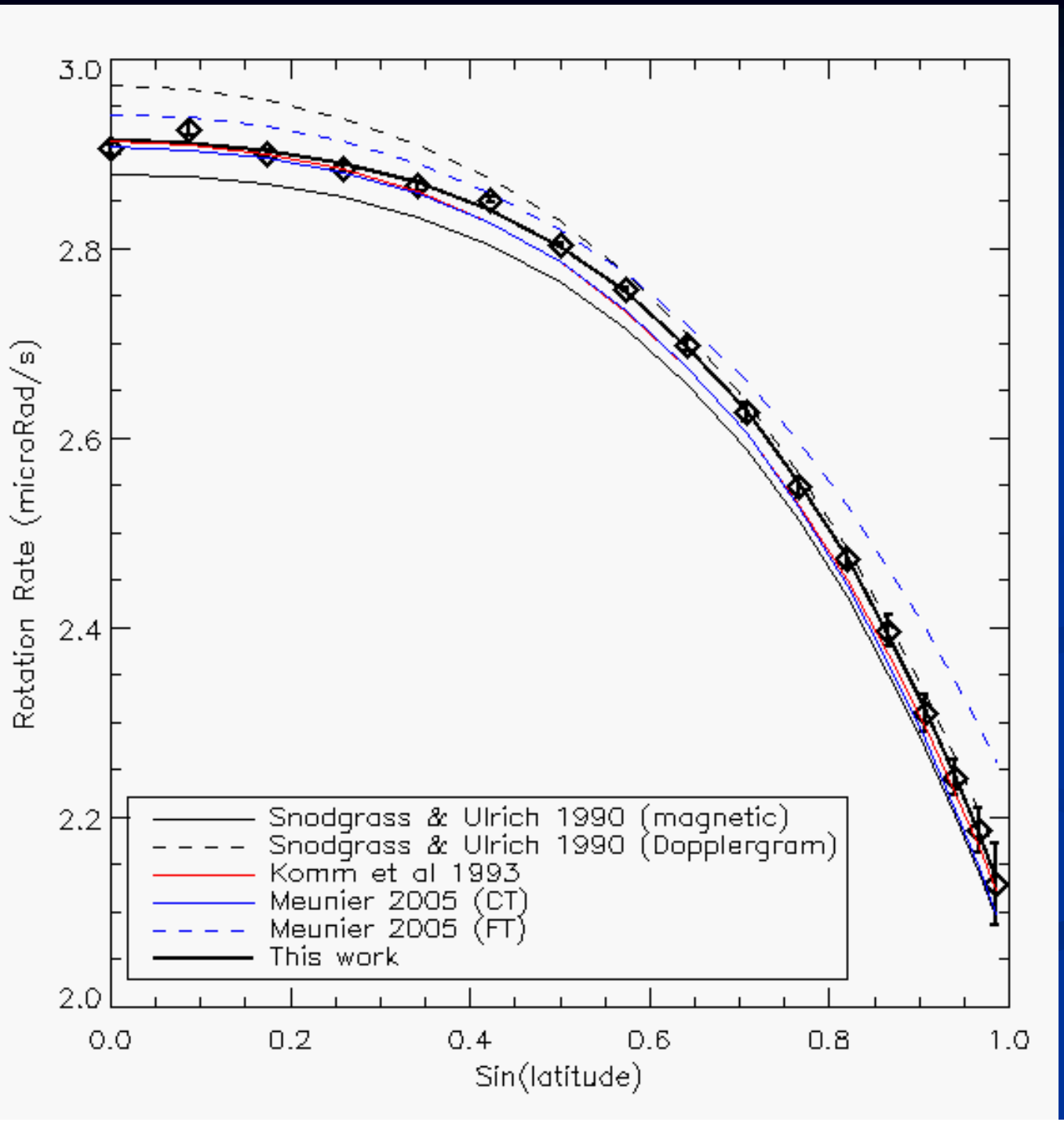



Cram et al. 1983
Snodgrass 1983
Strous & Simon 1998
Meunier 2005
Element tracking
Image cross correlation
Spectroscopic
Howard 1978
Zhang et al. 1997
Deng et al. 1998
Benevolenskaya 2007
Howard & Harvey 1970
Beckers 1978
Rotation Rate (microRad/s)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
60
65
70
75
80
85
Latitude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


3.0
2.8
2.6
2.4
2.2
2.0
Rotation Rate (microRad/s)
0.0
0.2
0.4
0.6
0.8
1.0
Sin(latitude)
Snodgrass & Ulrich 1990 (magnetic)
Snodgrass & Ulrich 1990 (Dopplergram)
Komm et al 1993
Meunier 2005 (CT)
Meunier 2005 (FT)
This work

Solar rotation (different lags)




3.0
2.8
2.6
2.4
2.2
2.0
Rotation Rate (microRad/s)
0.0
0.2
0.4
0.6
0.8
1.0
Sin(latitude)
Snodgrass & Ulrich 1990 (magnetic)
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Komm et al 1993
Meunier 2005 (CT)
Meunier 2005 (FT)
This work

Summary

- Magnetic elements in high latitude during solar minimum
  - Average lifetime of dominant polarity elements is 21.8 hours, and 1.6 hours for opposite polarity elements;
  - 63% of elements with a sign opposite to the dominant polarity appear as a bipole, and 67% disappear during cancellation;
  - Lifetime of elements is found to be related with the size of the elements– this agrees with lifetime of the elements in quiet Sun found by Hagenaar et al. (1999).
- Solar rotation rate at high latitude:
  - The result from this work agree with the results derived using cross-correlation and spectroscopic methods, and also agree with results from some element tracking work when the sample of tracked elements is large (e.g. Deng et al. 1999).