From MDI to HMI

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Abstract

With the recent launch of HMI on SDO and the upcoming end of operating MDI on SOHO, it will be necessary to combine the two datasets for any long term studies. In this poster we will compare the two instruments and how their differences might affect our inferences. We will also compare data from the two instruments to determine if there are unexpected differences. Finally we will discuss the implications of the change for the purpose of long term studies.

Background

Since the start of operations of MDI in 1996 we have acquired well over a solar cycle's worth of data. These data have proven invaluable in terms of tracking changes during the solar cycle. If we are to be able to continue these studies it is essential that we can continue to collect data of a comparable or better quality and that we can cross-calibrate the new data with the old data well enough to avoid significant artifacts. With the new solar cycle looking significantly different than the previous one, the quality of such a cross-calibration has become even more important.

The main instrument to take over from MDI will be the recently launched HMI onboard SDO. While HMI is in many ways quite similar to MDI there are significant differences.

For the purpose of allowing the necessary data continuity we have undertaken a comprehensive cross-calibration of MDI and HMI. As part of this we are currently using the last MDI continuous coverage period to repeat the types of observations taken over the MDI mission, while running a standard observing program on HMI.

Below we start with a comparison of the two instruments followed by a comparison of selected quantities.

Comparison of instruments

The table summarizes some of the most significant differences between the two instruments.

Property	MDI	HMI
λ	6768Å	6173Å
D	12.5cm	14cm
Pixels	0.6" (HR)	0.5"
	2.0" (FD)	
λ/D	1.12"	0.91"
Cadence	60s	45s
Coverage	50% (FD/HR)	95%
	99% (VW)	

As can be seen from the table HMI is in essentially all aspects superior to MDI, meaning that it is likely to be possible to degrade the HMI data to MDI quality for continuity and comparison.

In a couple of cases MDI is better than HMI or the instruments are different in ways that may be non trivial to correct. First of all the temporal coverage for MDI Medium-l is better than HMI. This is predominantly caused by the eclipses HMI suffers due to being in Earth orbit.

Another significant difference is which spectral line is used. While the two lines have very similar properties (such as formation height) this may cause significant differences.

Finally the observing schemes and observables calculations are different. The filter profiles are different and HMI uses more positions to accommodate the large orbital velocity of SDO. Also, since all filtergrams are downlinked for HMI we have the ability to use more optimal algorithms for calculating the observables.

The observing cadences are also different. If the Nyquist theorem were satisfied in the temporal domain for HMI, this would not be a problem, but the slight amount of power above the HMI Nyquist frequency could cause problems.

Some Results

Below are figures showing selected properties of HMI and comparisons with MDI.

Figure 1 shows an l-ν diagram illustrating that there are few spectral artifacts. Only a very small amount of aliasing is present at the very highest temporal frequencies.

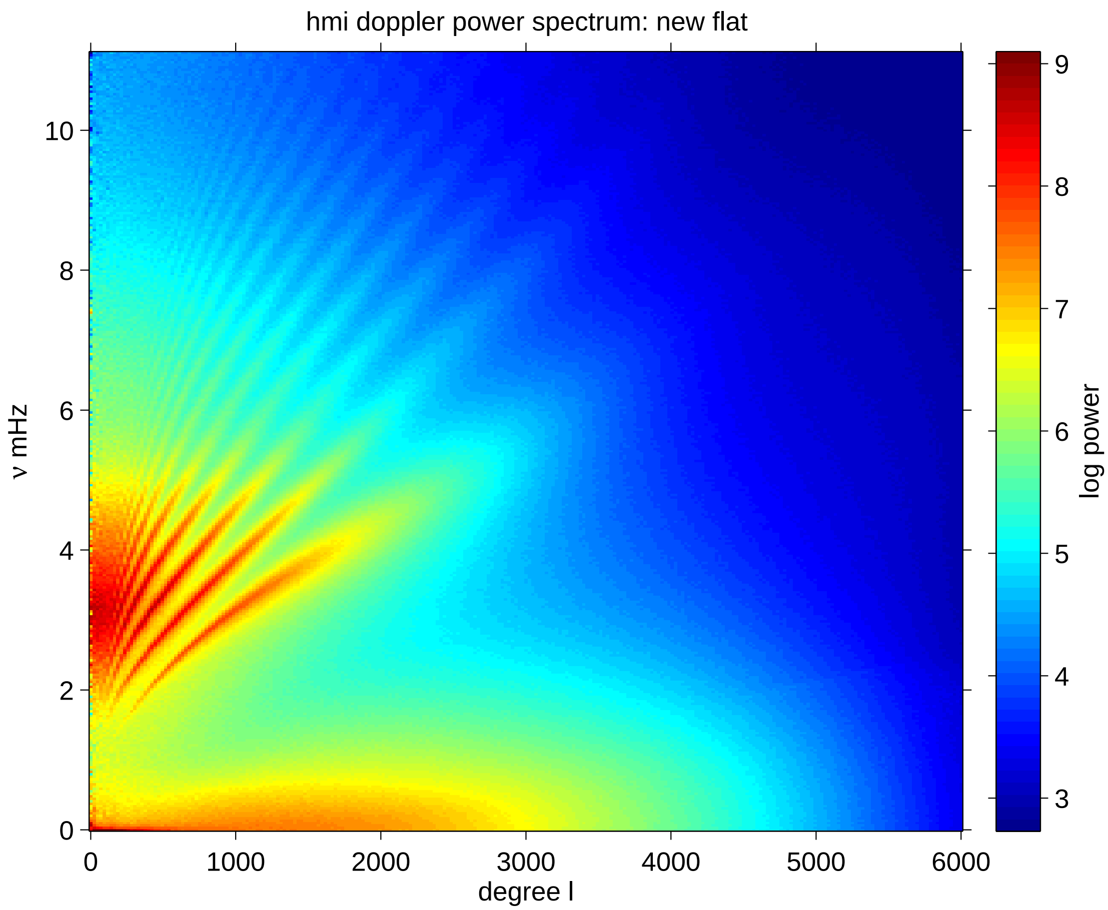

Figure 1: L-nu diagram for HMI. Note that the spatial Nyquist frequency at disk center is close to l=6000.

For comparison Figure 2 shows power spectra for MDI High Resolution (HR) and HMI. As can be seen the increased temporal Nyquist frequency results in significantly less aliasing.

It is at present unclear how significant the differences at low frequencies are and what their origin is.

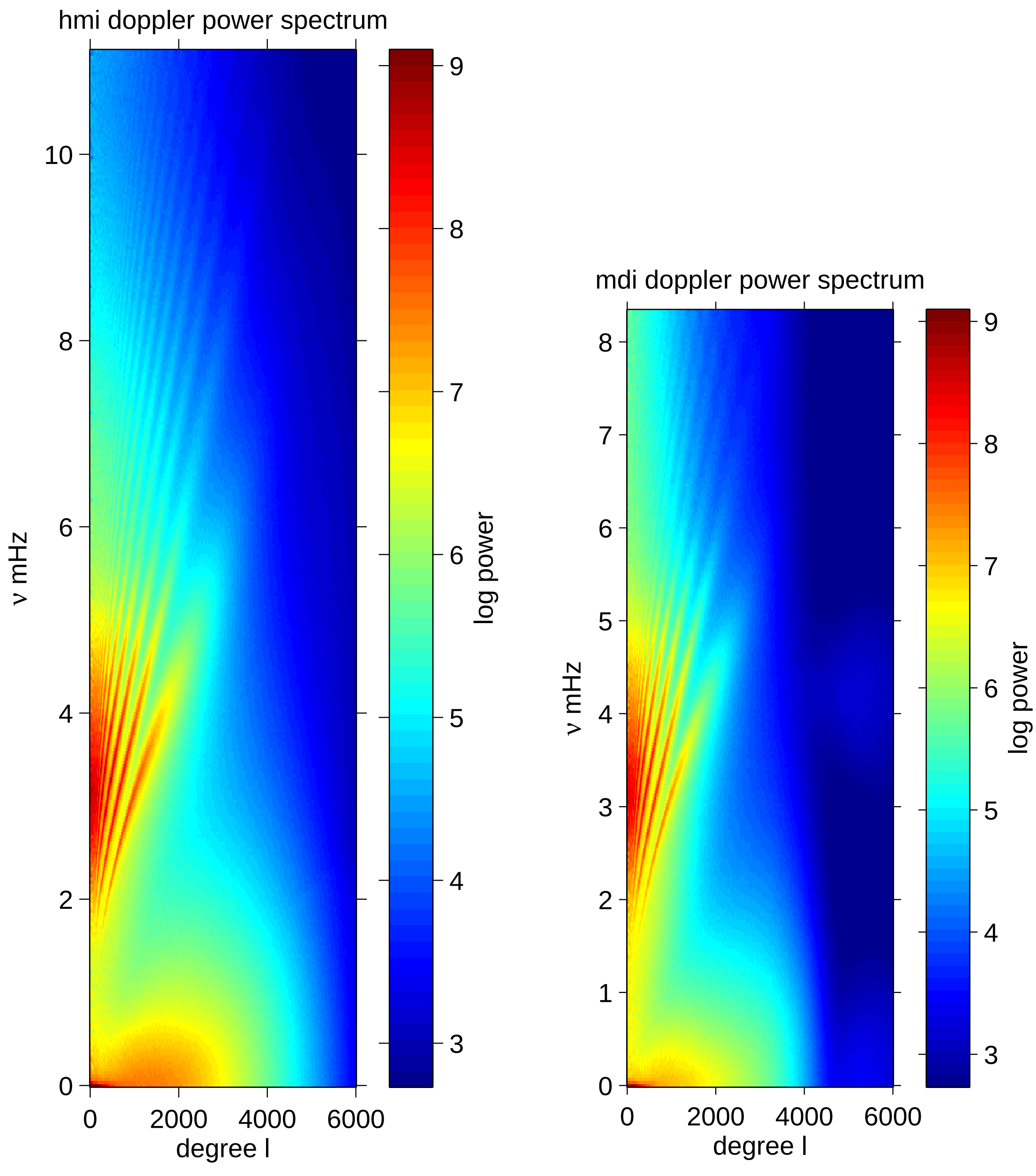

Figure 2: Comparison of power spectra for MDI HR and HMI. Note that the spatial Nyquist frequency for MDI HR corresponds to roughly l=4800.

Figure 3 illustrates the differences at fixed l. Again, the better quality at high frequencies is evident.

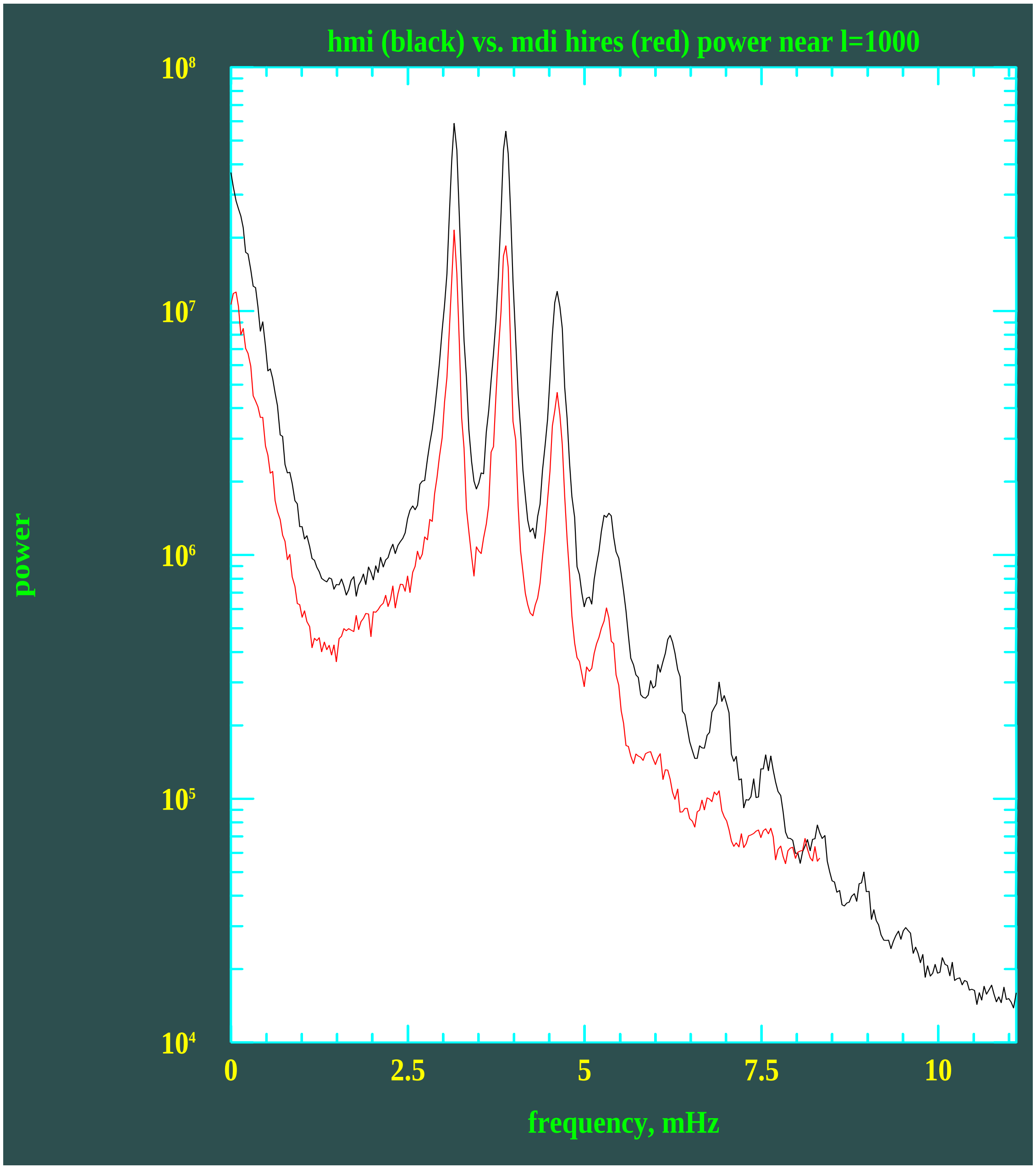

Figure 3: Cuts in Figure 2 around l=1000.

Figure 4 shows the amount of p-mode power as a function of spatial frequency integrated over temporal frequency. This clearly shows that not only can HMI go to higher spatial frequencies, it also has substantially higher sensitivity at moderate frequencies.

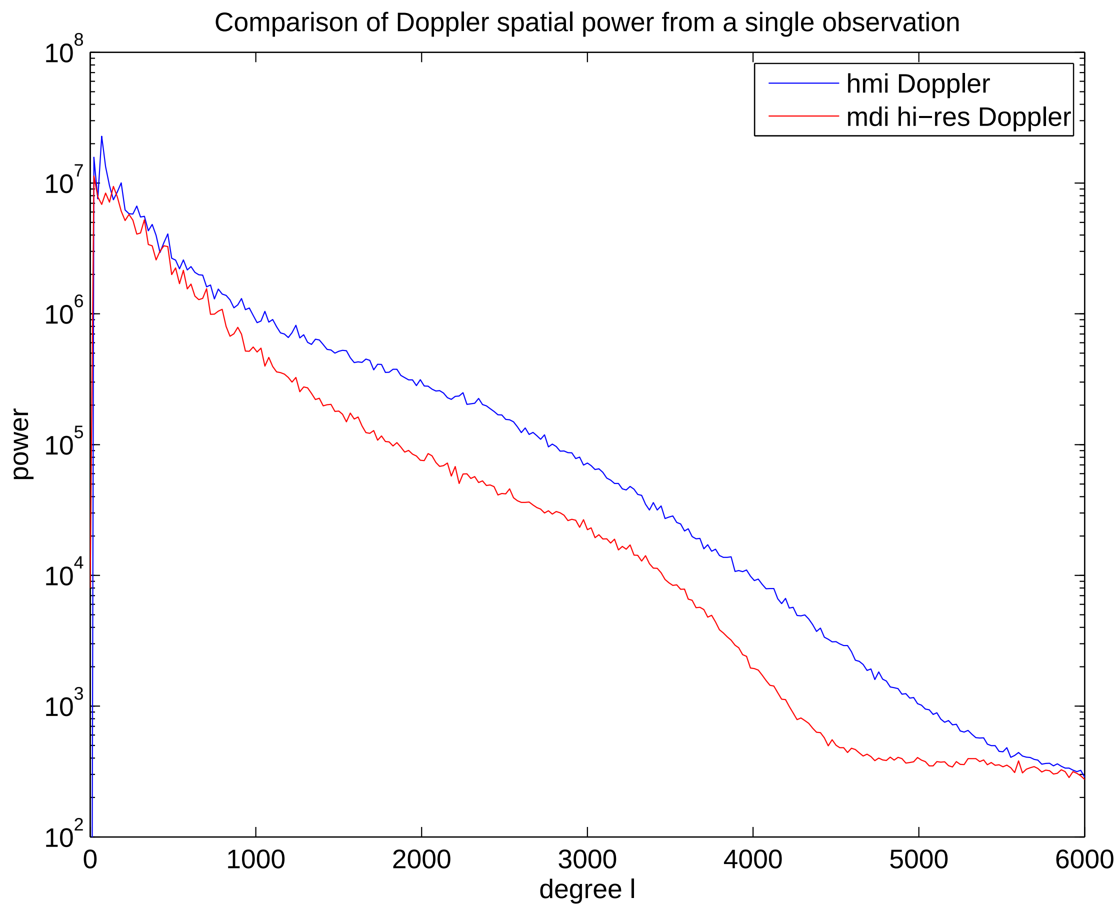

Figure 4: P-mode power as a function of spatial frequency.

Both instruments are also able to measure the line of sight magnetic field. This is illustrated in Figure 5. As can be seen the comparison is fairly good. However, the images were not perfectly aligned or corrected for differences in resolution, so it is, perhaps, not surprising that there is significant scatter.

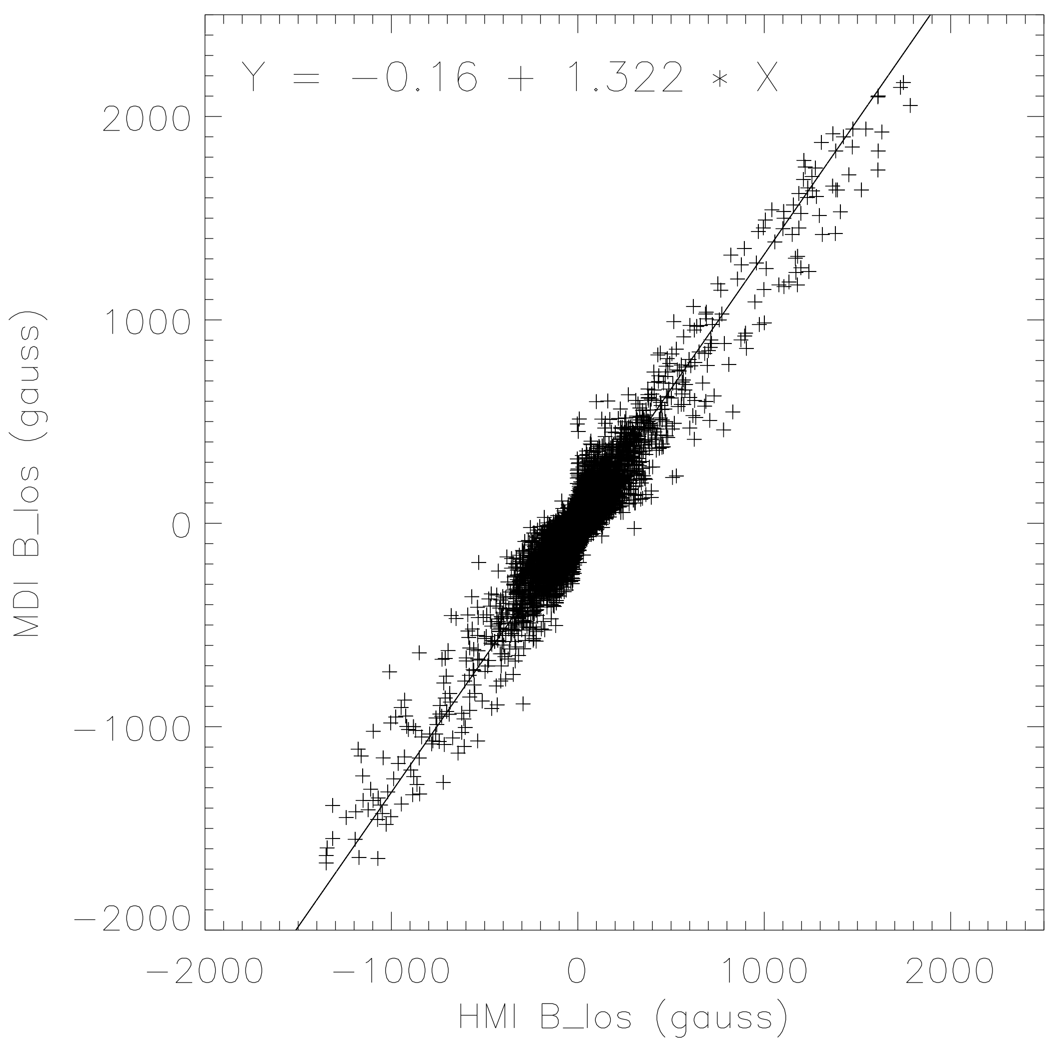

Figure 5: Comparison of MDI and HMI line of sight field measurements from the center part of simultaneous filtergrams. Only crude remappings and MFT corrections were performed.

Figure 6 shows the disk averaged magnetic field from a variety of sources. As can be seen HMI performs quite well. It is worth noting that for MDI a correction for errors in the shutter opening time has to be made, while the HMI results are from uncorrected data.

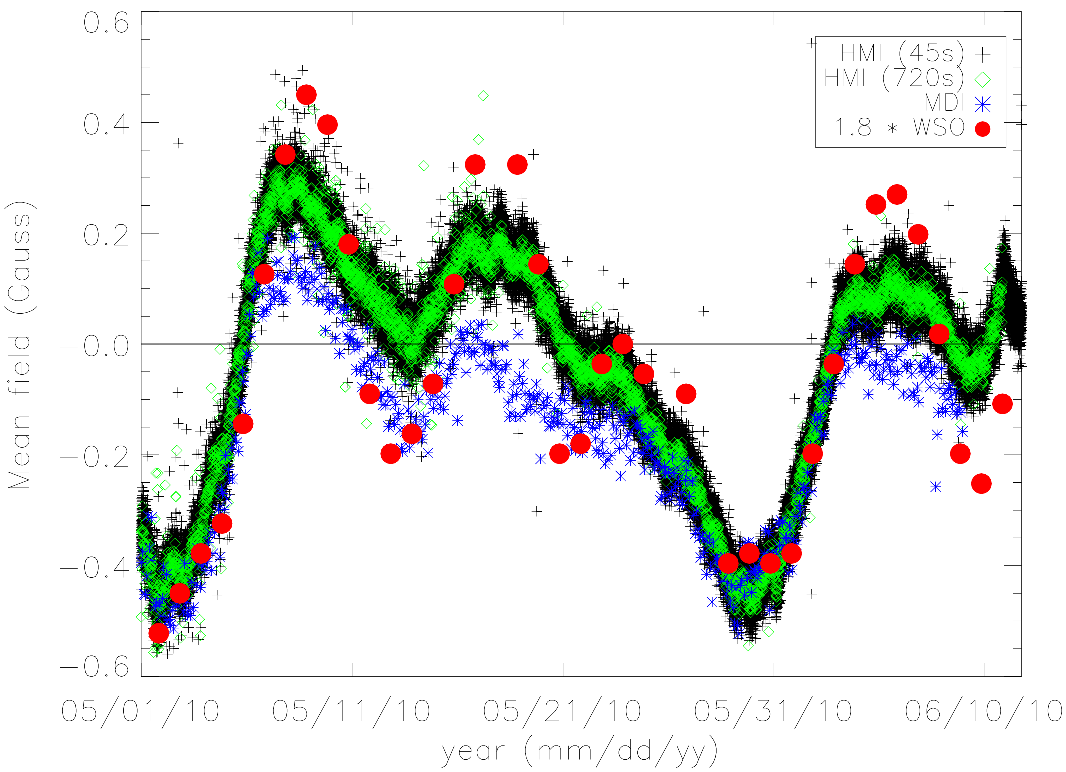

Figure 6: Comparison of the disk averaged (signed) field across the solar disk from various sources. MDI and HMI are integrated over 0.95R.

We have also been able to fit medium degree modes using 36 simultaneous days of data. Results are shown in Figures 7 and 8. As can be seen the results are quite similar. The source of the various differences have not yet been determined. However, it is well known that the MDI calibration is far from perfect.

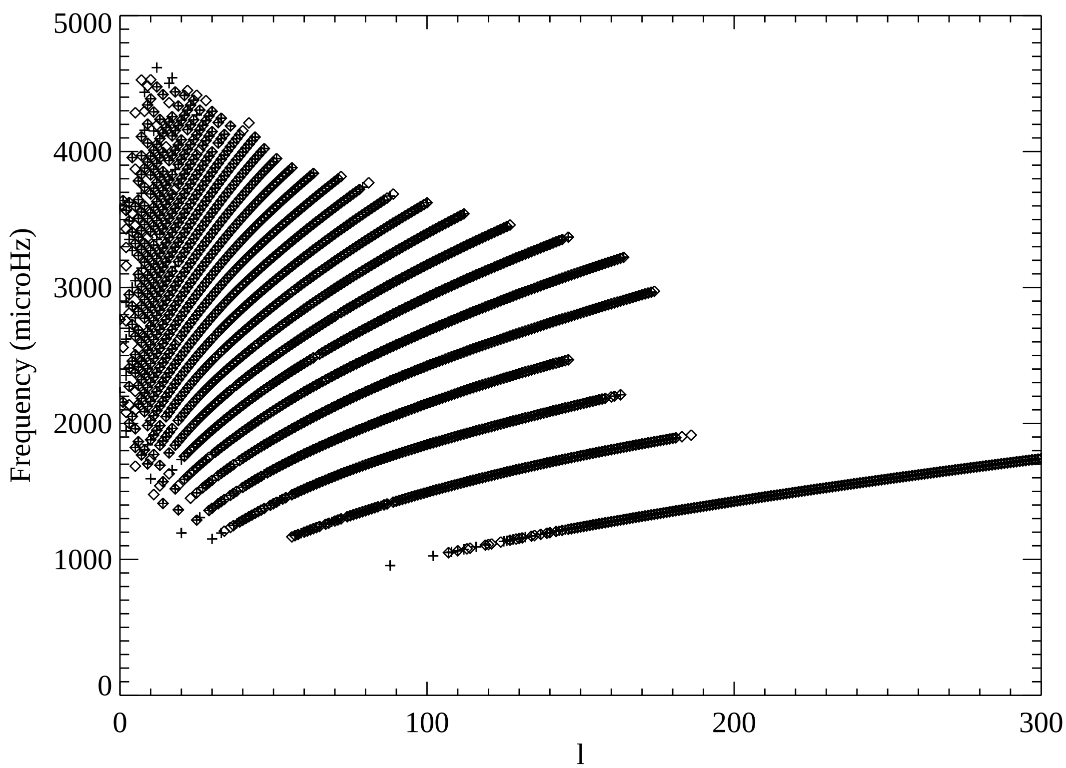

Figure 7: Comparison of mode coverage for MDI FD (plusses) and HMI (diamonds).

The result of an inversion of the f-mode splittings from MDI Medium-l, MDI FD and HMI is shown in Figure 9. As can be seen the results are quite similar. The source of the differences has not been investigated.

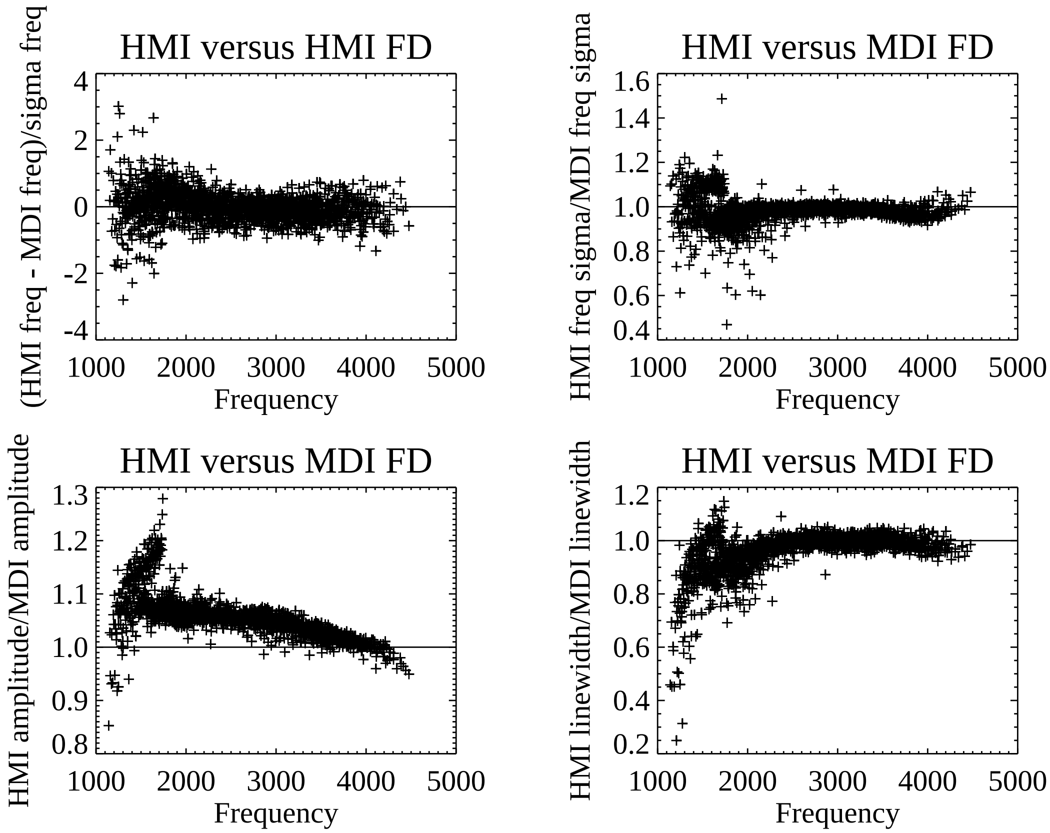

Figure 8: Comparison of various mode parameters for MDI FD and HMI.

Conclusion

It appears that while there are significant differences between MDI and HMI we are likely to be able to extend the measurements from MDI using HMI data. However, it is also clear that significant work remains to cross calibrate the two instruments.

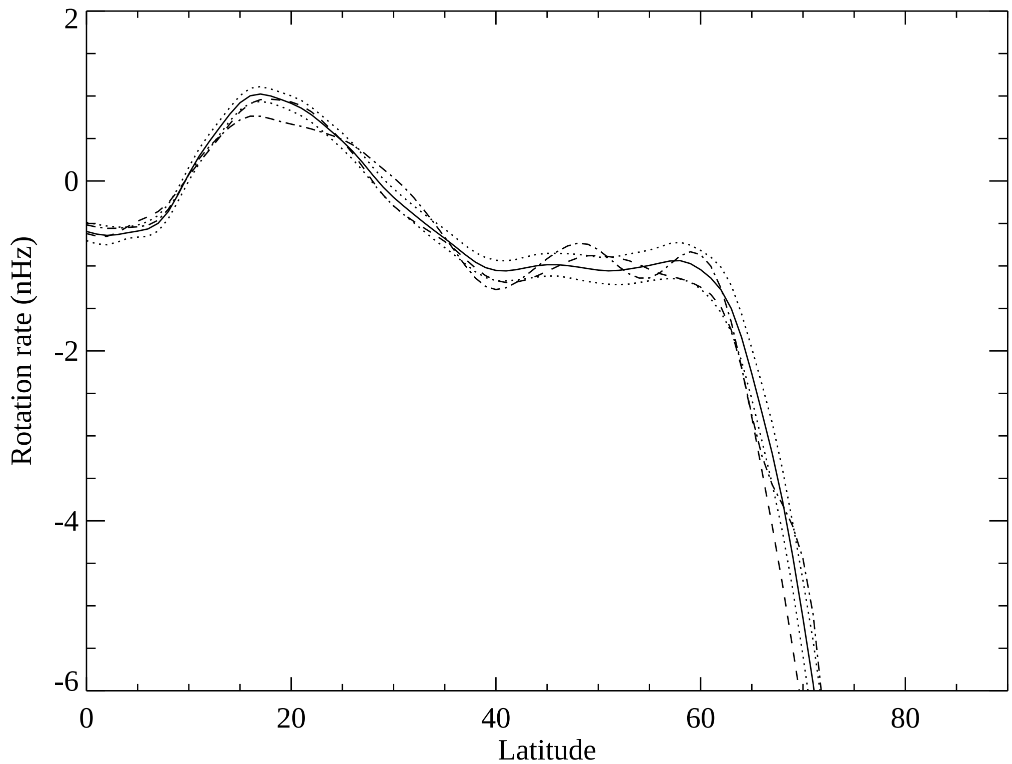

Figure 9: Inversions of f-mode frequency splittings from 36 days of data. Solid is MDI Medium-l, dashed MDI FD and dashed-dotted HMI. Dotted lines are +/-1 sigma on the Medium-l. A smooth mean over the solar cycle was subtracted from all curves.

Acknowledgments

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