Medium-l Global Helioseismology with MWO Dopplergrams

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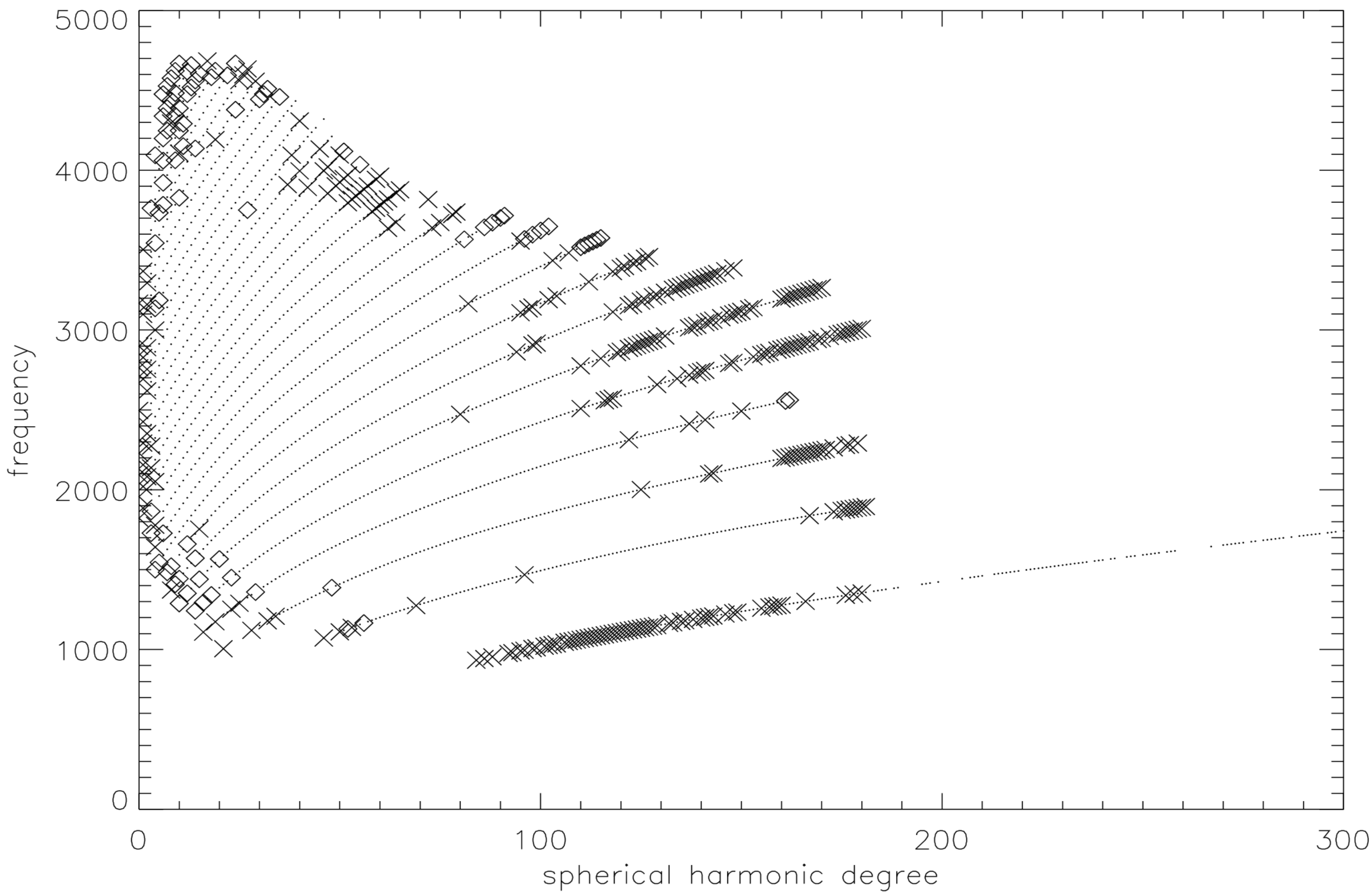
The 60-foot solar tower at Mount Wilson Observatory took high resolution dopplergrams at a cadence of one minute between the summers of 1988 and 2006. Because this instrument overlaps with GONG and MDI, it provides a unique opportunity to extend the inferences of those two projects backwards in time to solar cycle 22. Furthermore, access to the MWO data has been facilitated by its ingestion at the Joint Science Operations Center (JSOC) at Stanford. For this initial study we choose for our analysis a single summer in which MDI was also operating. By running the MWO data through the same processing pipeline and comparing with the results from MDI, we are able to determine how accurately the two datasets can be combined. In future we will be able to use the MWO data to compare the torsional oscillation during solar cycles 22 and 23.

The Data

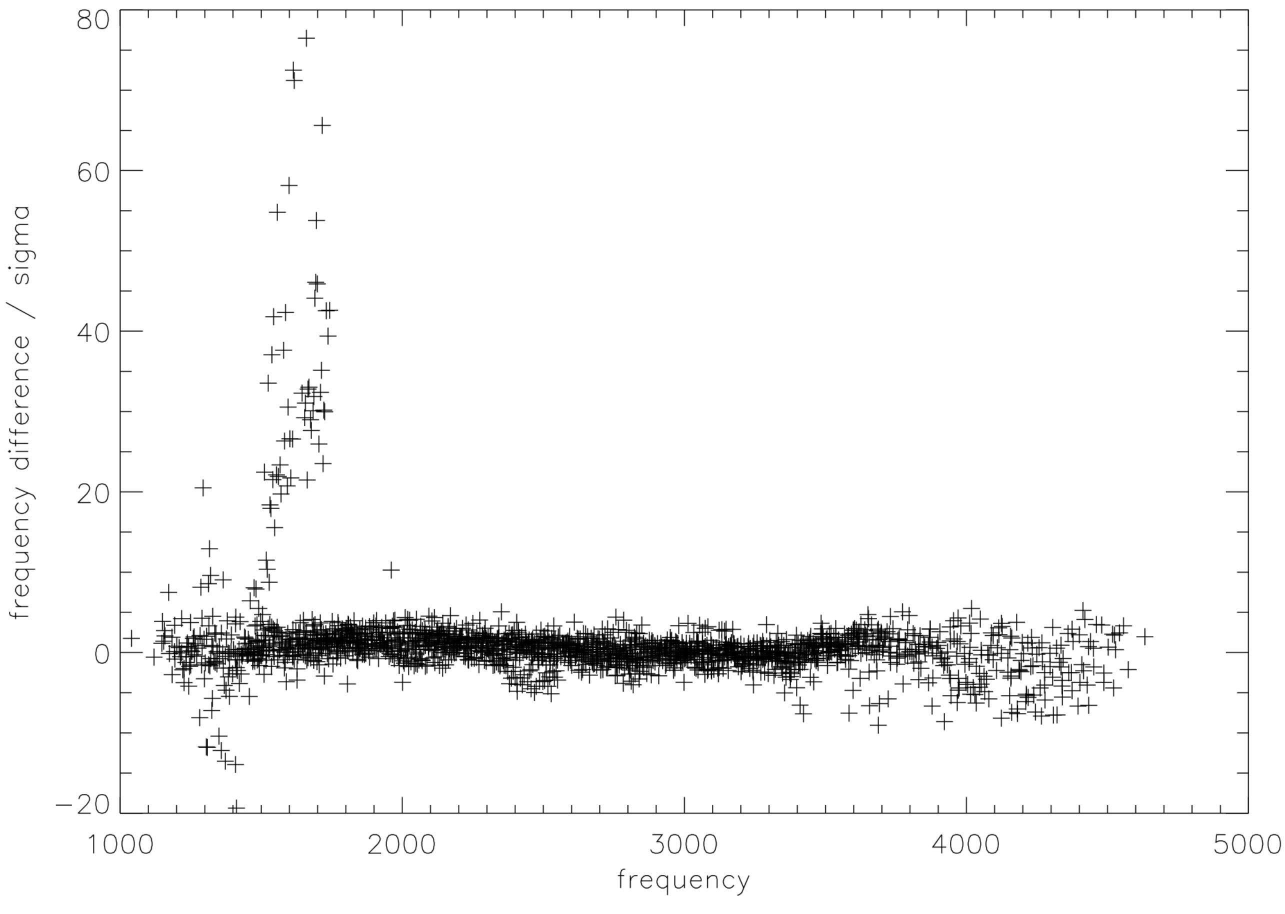
From May to August the 60-foot tower was able to complete full-day observation runs. To maximize the MWO duty cycle, we chose the summer with the highest number of observations, which is 1996. Our timeseries span the 122 days beginning May 1, 1996. Over this interval the MWO duty cycle was 28.9% before gapfilling and 34.3% after. The MDI duty cycle was 90.9% before gapfilling and 92.5% after.

Needless to say, we were able to fit many more modes for the MDI data. However, we suspect this may be due in part to rejection criteria based on MDI data. To give the MWO data the benefit of the doubt, we refrained from applying the final rejection criteria, and instead rejected all modes with any outliers greater than 8 sigma. The MDI data was weeded as usual.

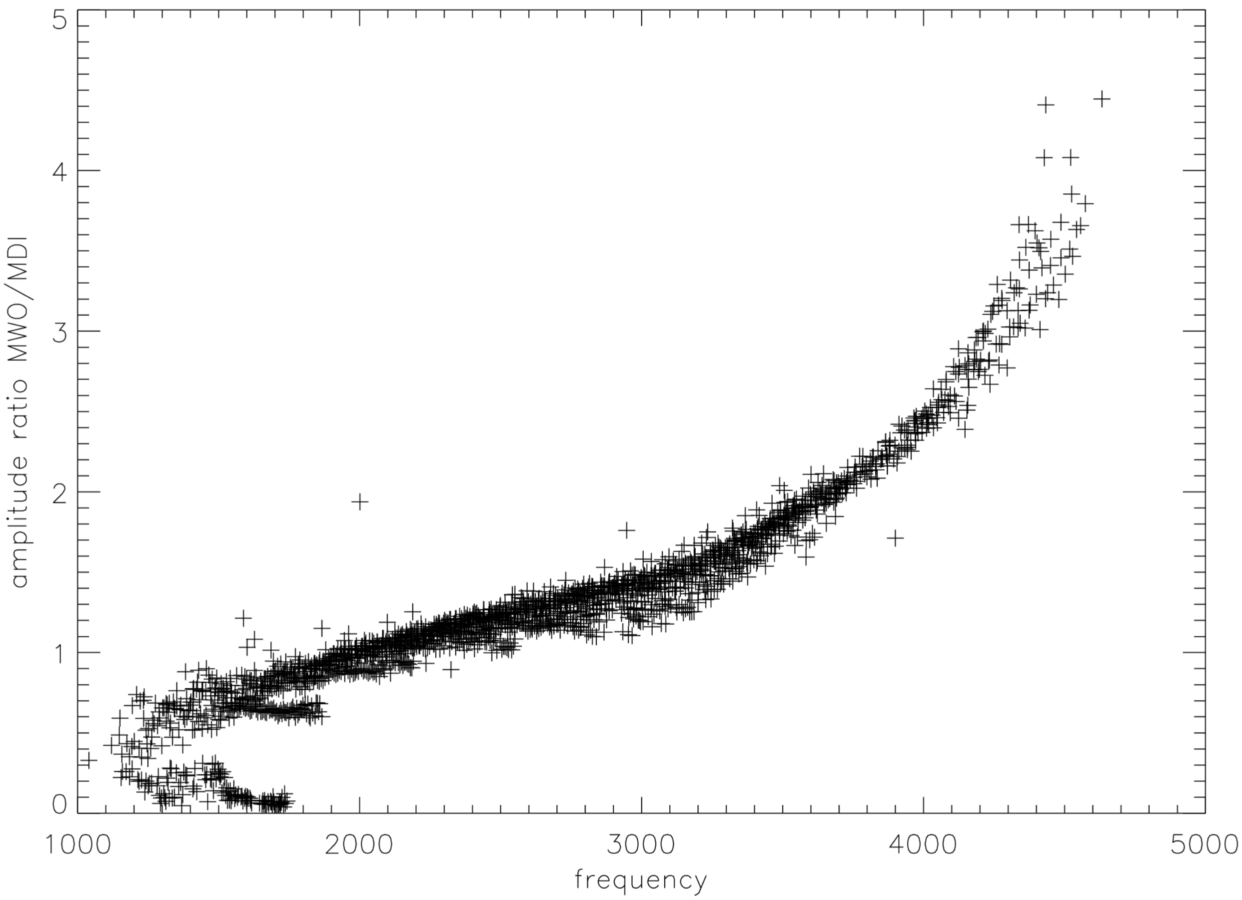
The l-nu diagram below shows the mode coverage of this run. Dots represent modes fitted in both MDI and MWO data, X’s were fitted only for MDI, and diamonds were fitted only for MWO. Some of the latter can be attributed to the relaxed rejection criteria.



The two datasets agree reasonably well in frequency, with the notable exception of the f-mode. A plot of the differences in background show even more drastic differences for the f-mode, which perhaps explains why it is so difficult to fit.



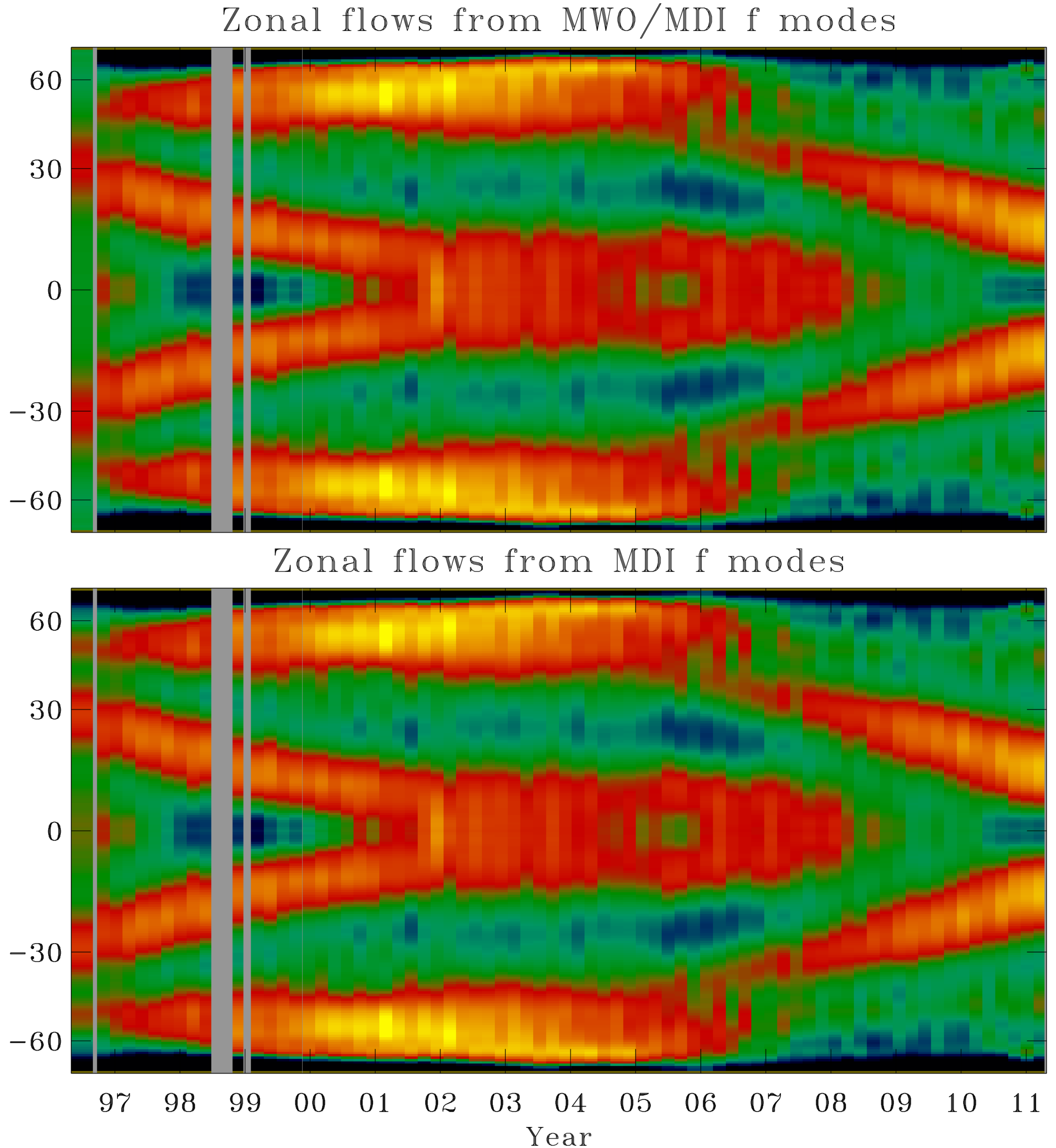
The difference in amplitude is unsurprising since the two instruments observe different spectral lines: MDI uses the 6768 Ni line, MWO uses the 5896 Na line.



Discussion

For the most part we found good agreement between the two instruments for p-modes. In spite of the difficulties in fitting the f-mode, the data still have something to tell us, as the plots below show. The two of them are the same except for the first column (122 days wide instead of the usual 72). Essentially the MWO data seems to have less resolution in latitude.

Clearly further study is needed to understand the differences between the two instruments. One known source of error is a half-pixel offset in the X0, Y0 keywords of the MWO data. Another is in the determination of the P-angle. We also intend to analyze the MDI data with the MWO window function in an attempt to distinguish the effects of the duty cycle from that of the other instrumental differences.


Zonal flows from MWO/MDI f modes
60
30
0
−30
−60
Zonal flows from MDI f modes
60
30
0
−30
−60
97
98
99
00
01
02
03
04
05
06
07
08
09
10
11
Year