Global-Mode Analysis of Full-Disk Data from MDI and HMI

(stuff from my thesis)

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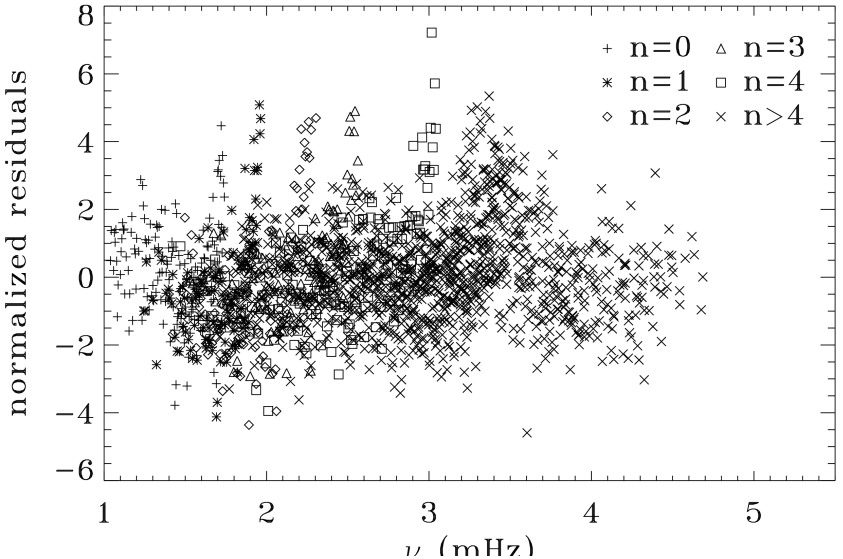
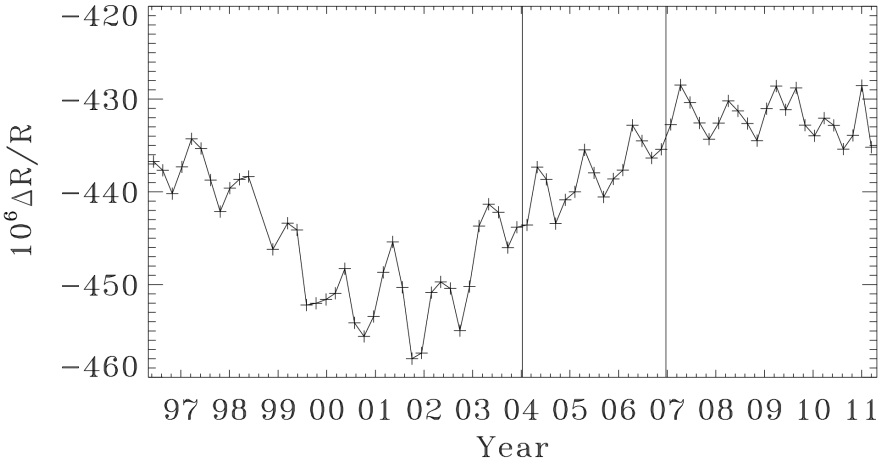
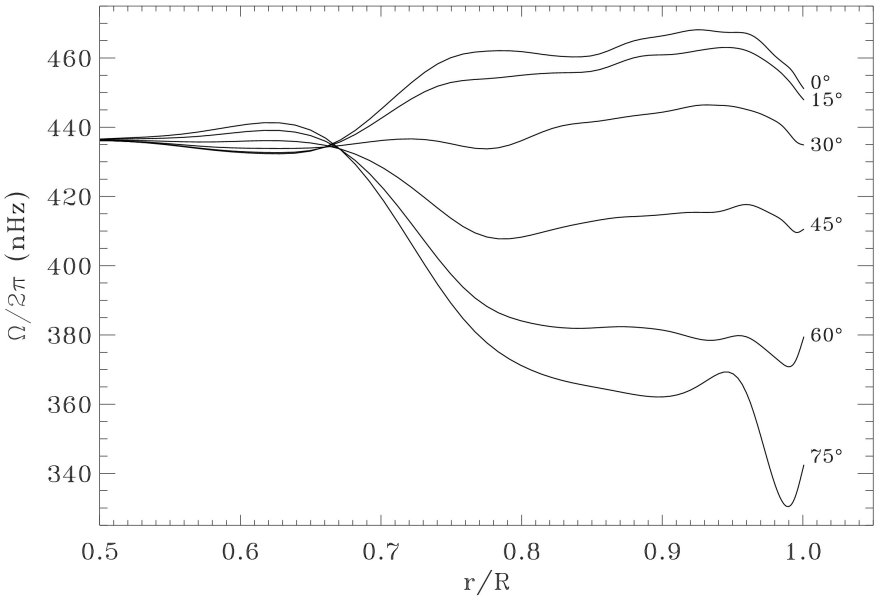
Review:
Problems with the MDI vw_V Data







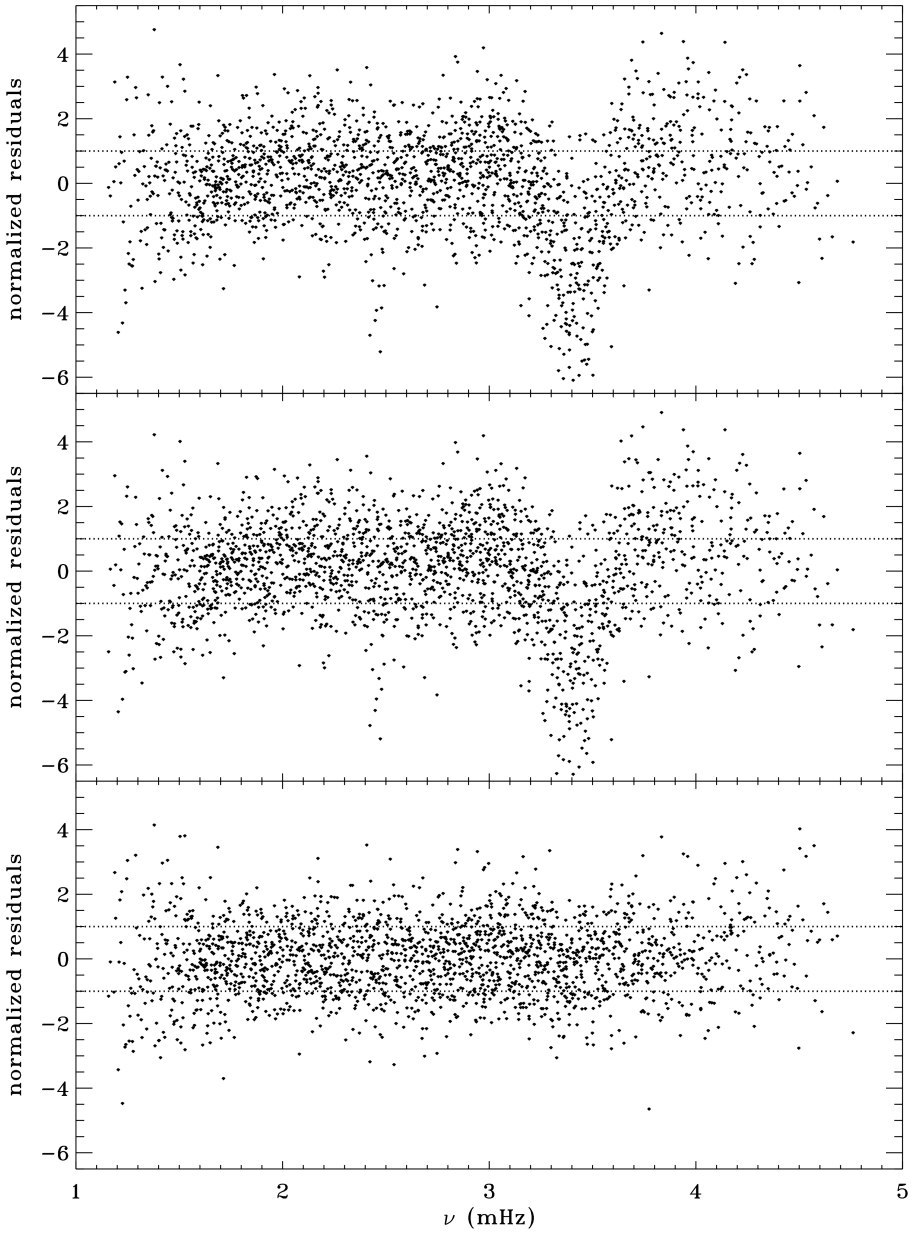
Bump Horns

Jet Annual Period

tried 10 different corrections

Progress:	eliminated horns,
	reduced annual period
No progress:	bump,
	jet,
	six month period

Comparison with Full-Disk



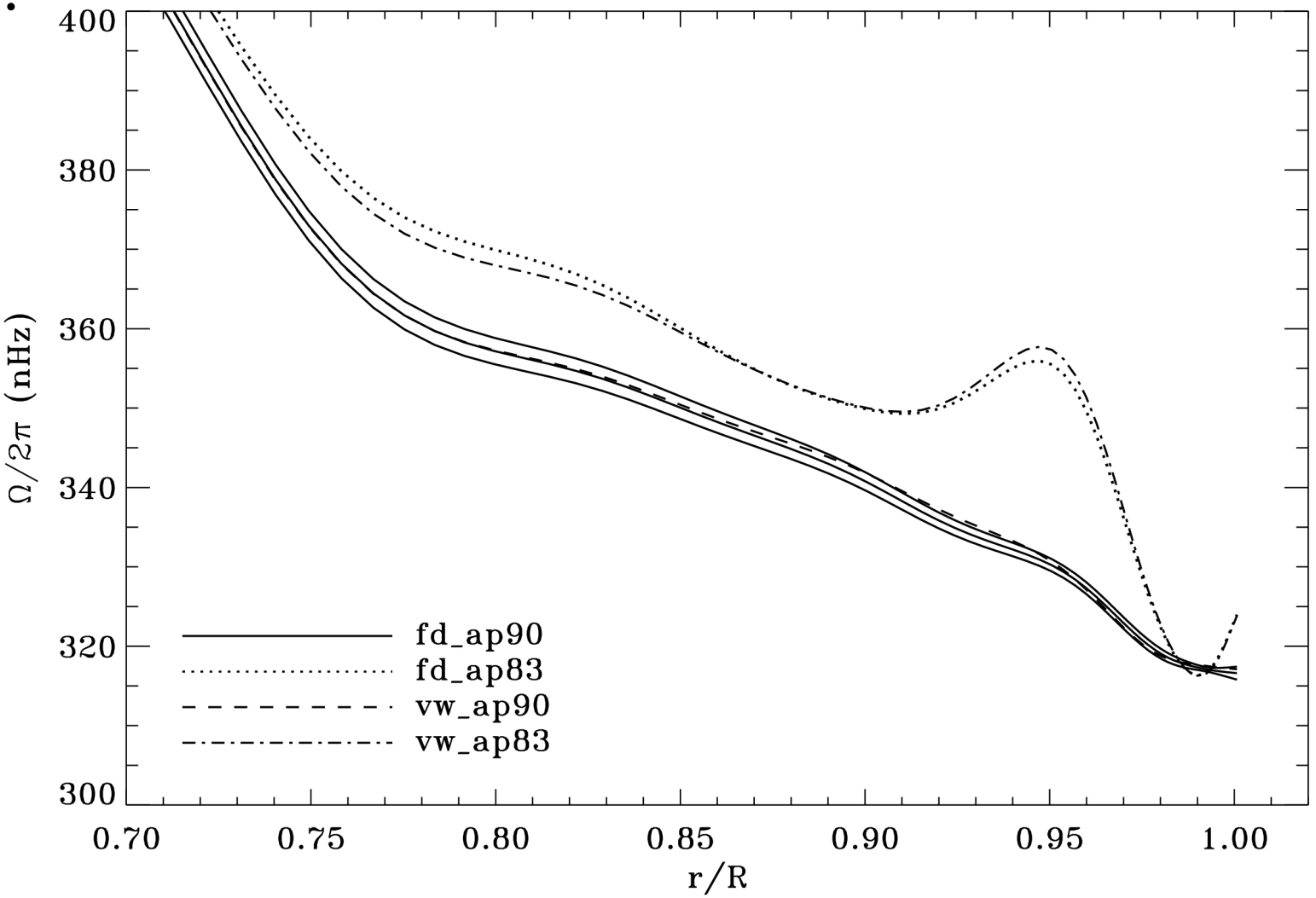
vw_V

full-disk with vw_V apodization

regular full-disk

Above plots are for an average over dynamics runs. For 1998, we could use full-disk apodization on reconstructed vw_V. Resulting rotation rate at 75° latitude:

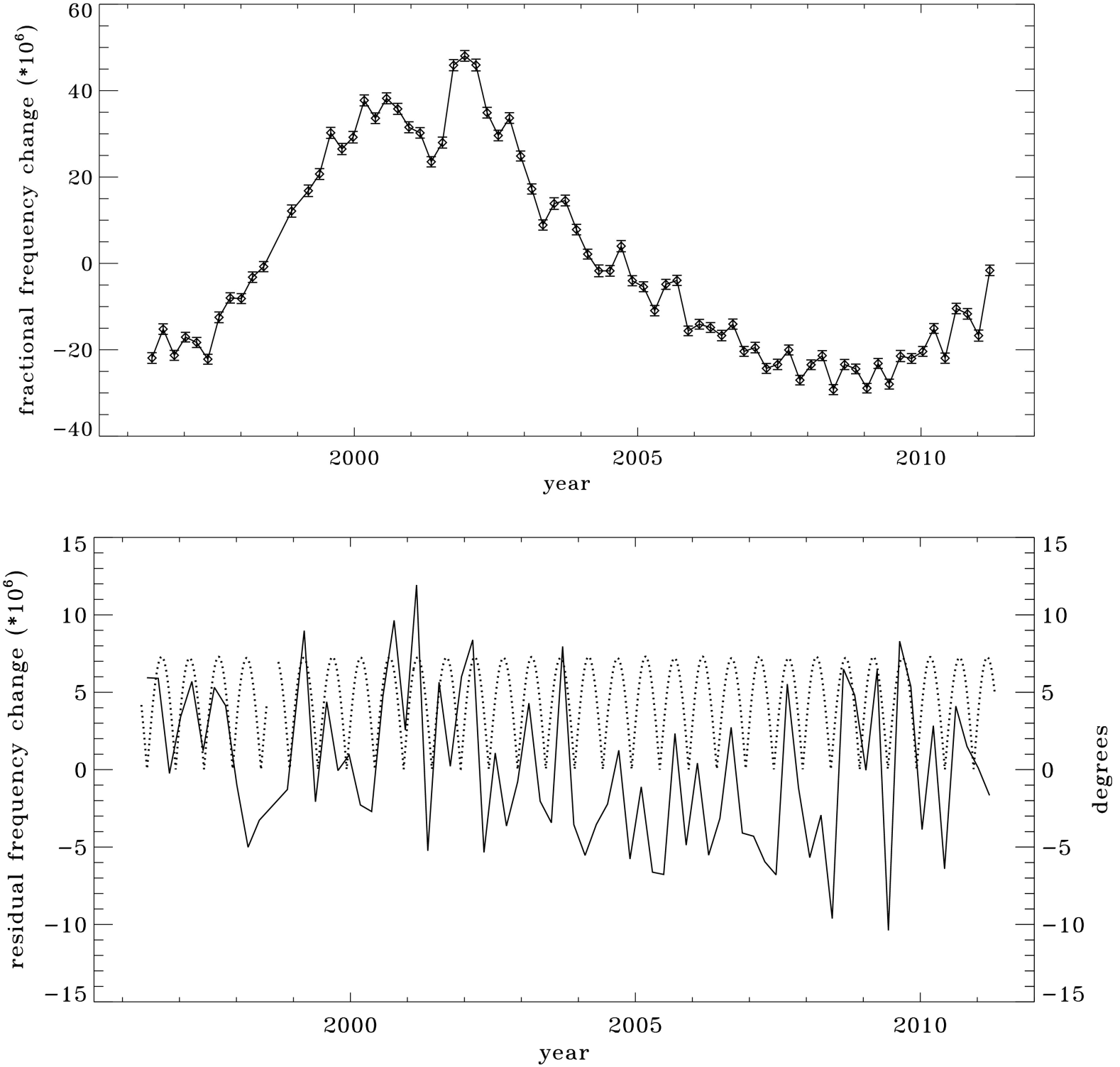
Solid lines show regular full-disk analysis and its errors; errors for the other analyses were similar.

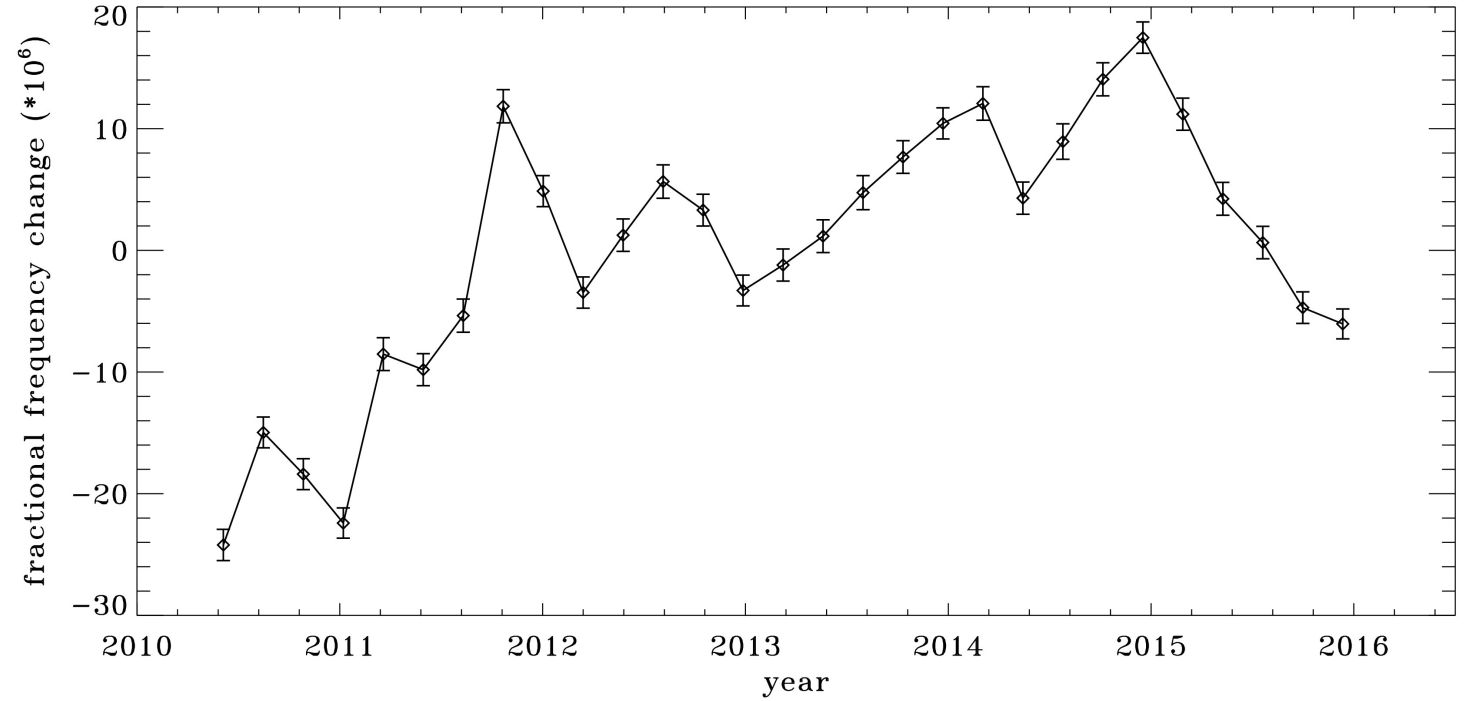


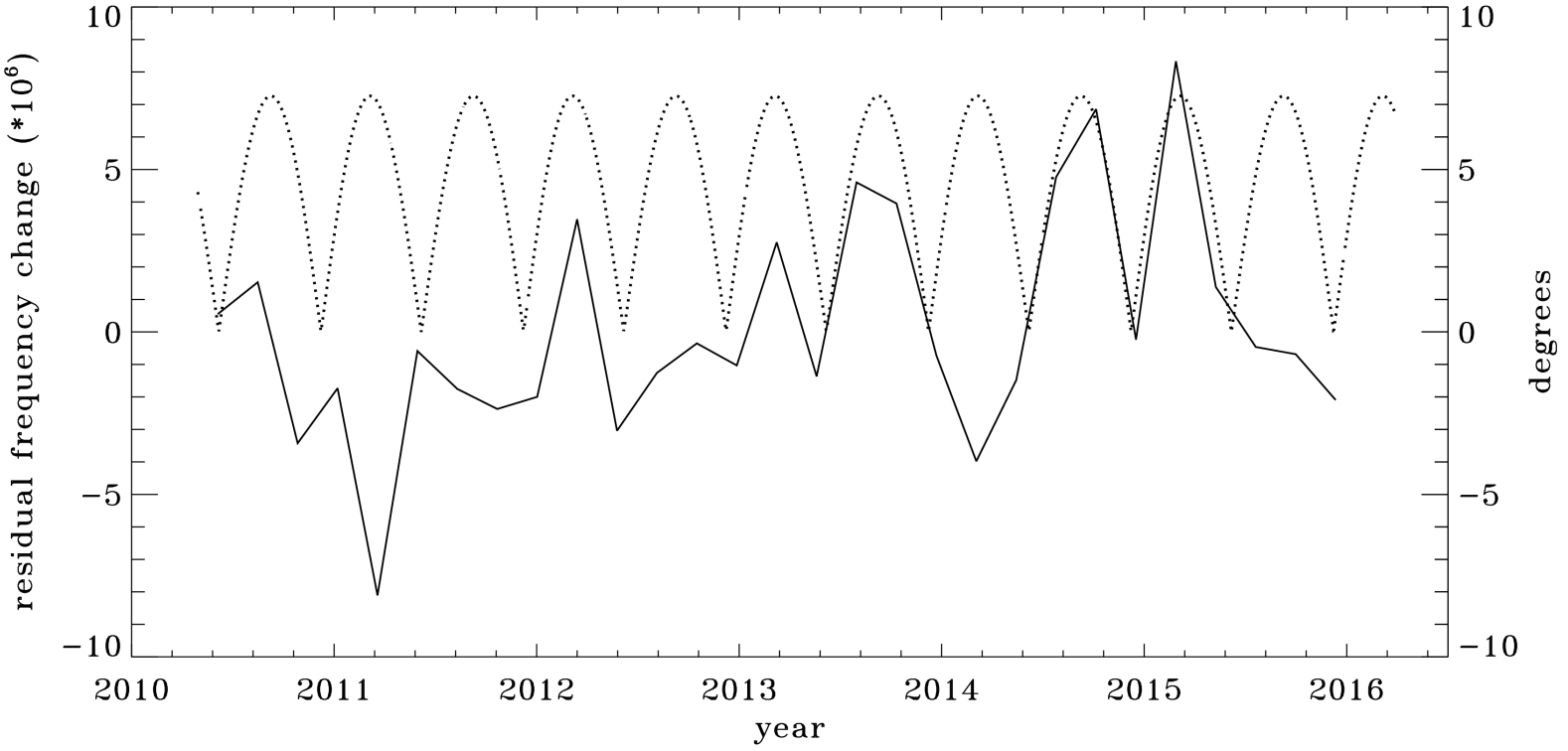
Periodicity

First plot below shows the shift in f-mode frequencies using the updated analysis. We fit this to the average rms of the corresponding magnetograms. Second plot shows result after subtraction, with $|B_0|$ overplotted.

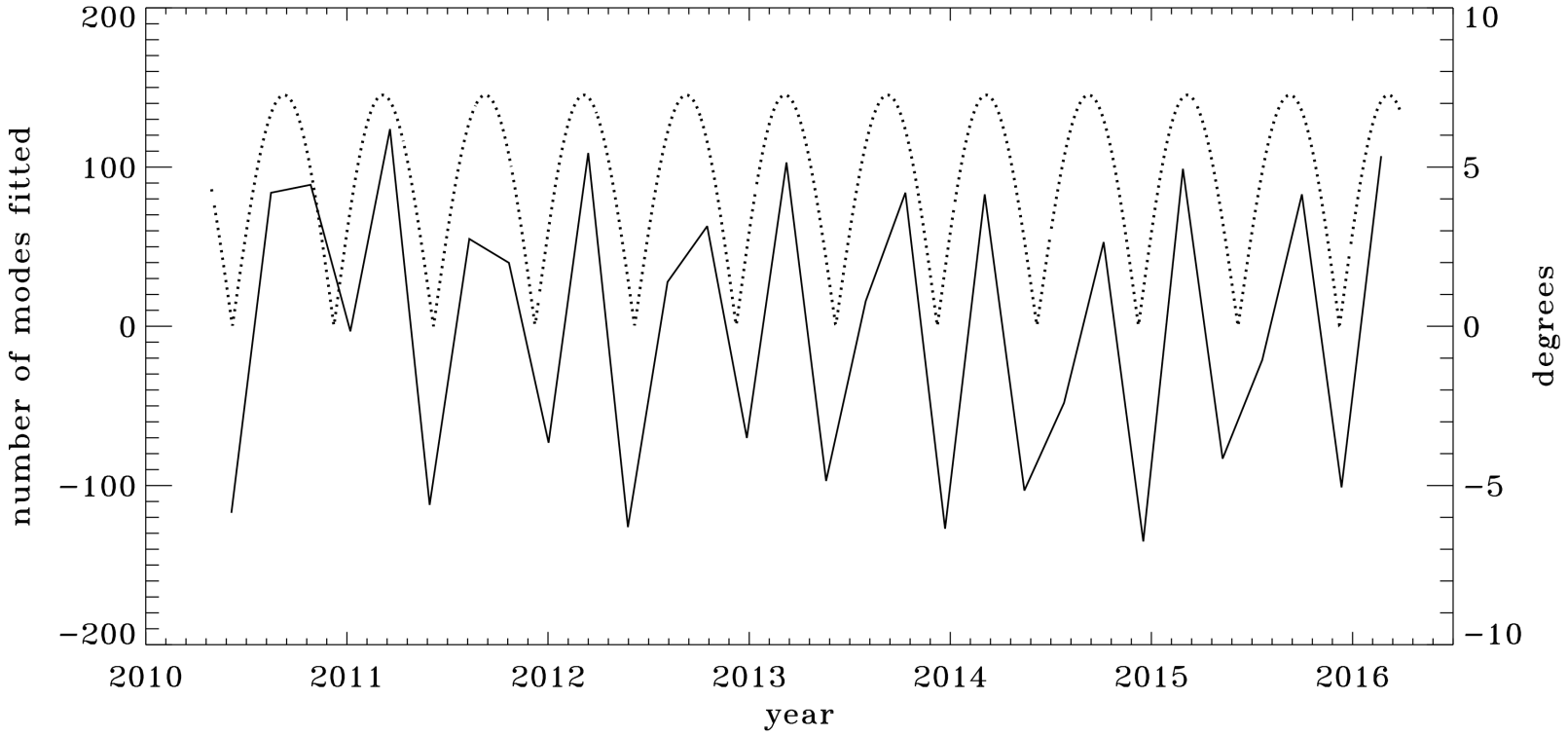
Next two plots show the same thing for a vw_V proxy made from HMI data.


fractional frequency change (*10^6)
60
40
20
0
−20
−40
2000
2005
2010
year
residual frequency change (*10^6)
15
10
5
0
−5
−10
−15
degrees
2000
2005
2010
year


fractional frequency change (*10^6)
20
10
0
−10
−20
−30
2010
2011
2012
2013
2014
2015
2016
year

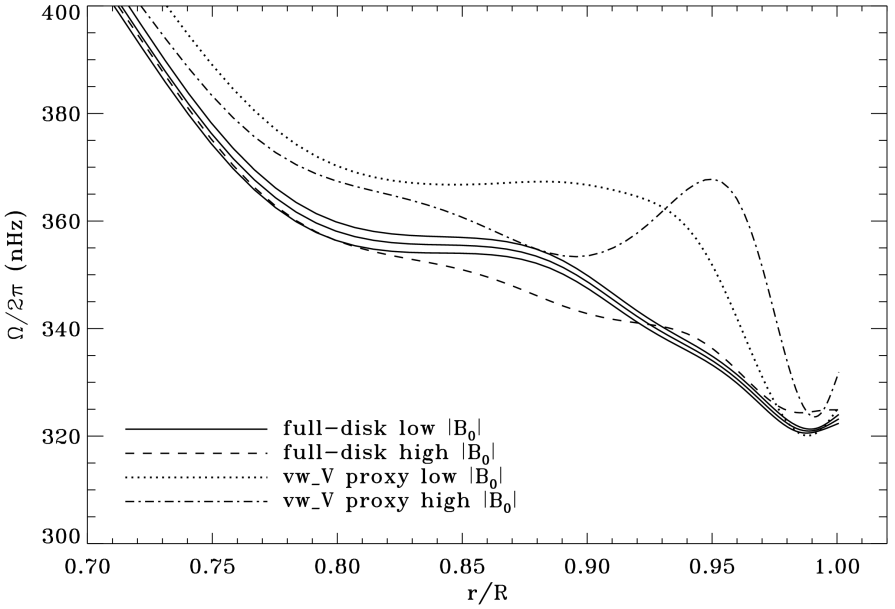

residual frequency change (*10^6)
10
5
0
−5
−10
degrees
2010
2011
2012
2013
2014
2015
2016
year

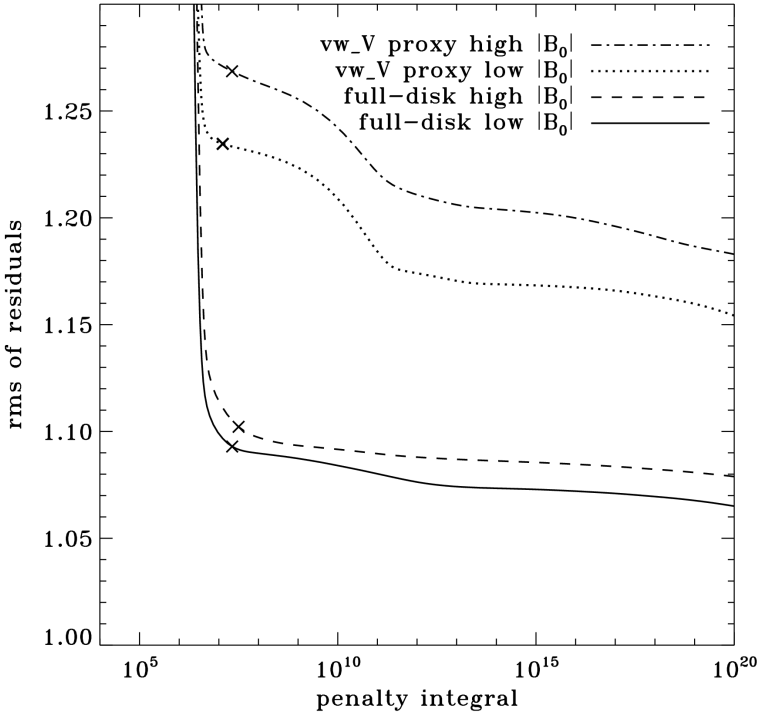
For MDI, the peaks line up. For HMI, we have only six years and not such good correlation. But how about the number of modes fitted for the vw_V proxy? The correlation coefficient between this and $|B_0|$ is 0.95.



What?!?!

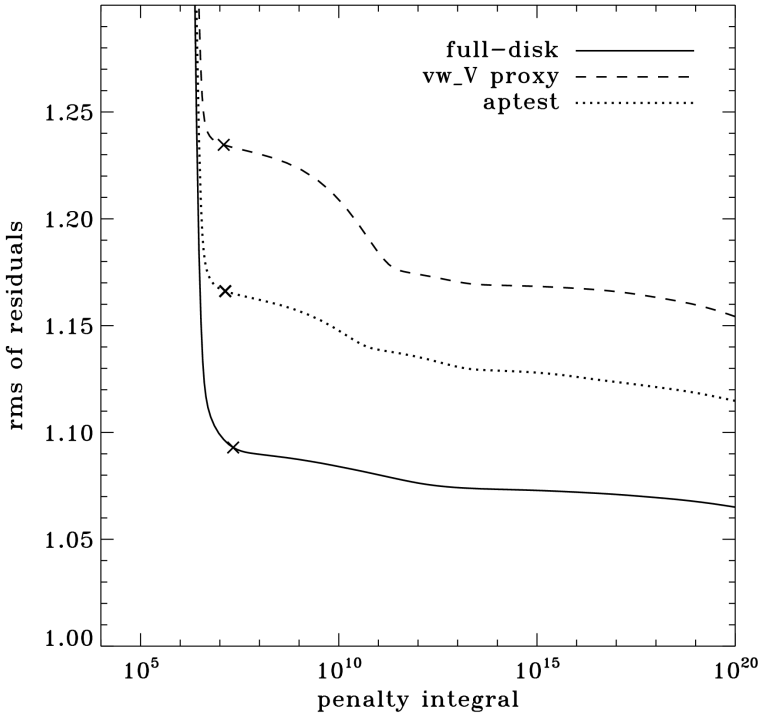
The leakage matrix is calculated assuming B_0=0. Why in the world would we fit *more modes* when the leakage matrix is *most incorrect*? As the plots below show, we later discovered that the high-latitude inversion results depend on B_0 as well.



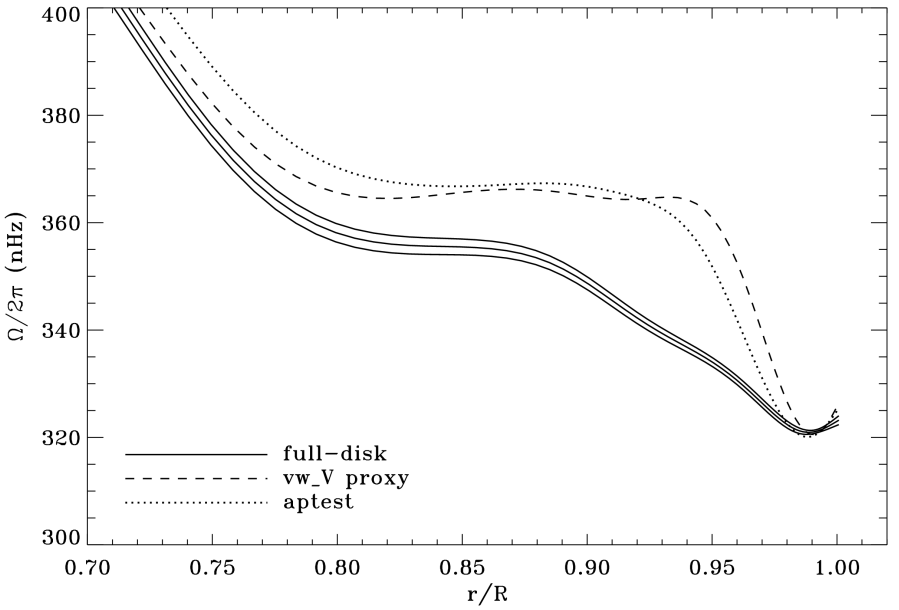


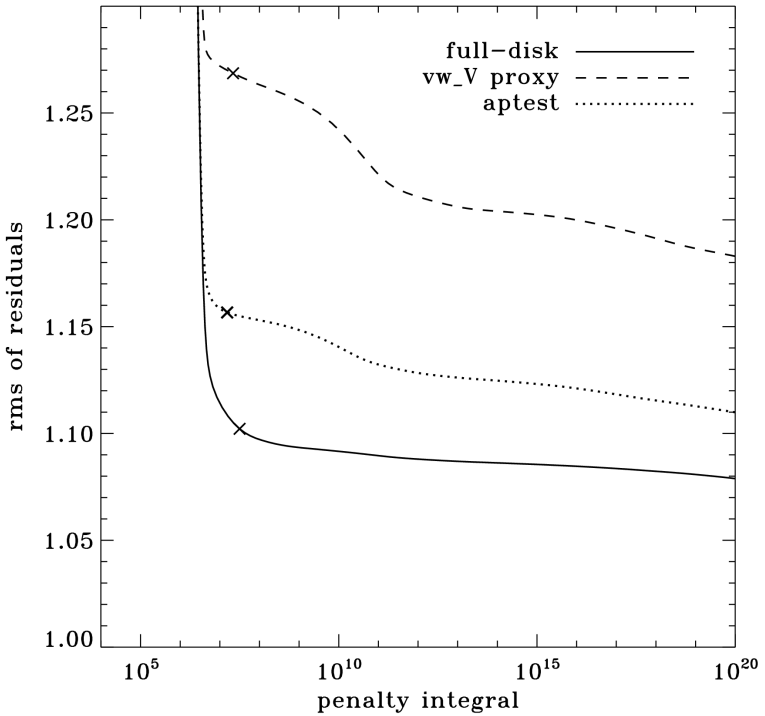
New Apodization

Although we fit more modes for high $|B_0|$, the tradeoff curves were lower for low $|B_0|$. In both cases, the high-latitude rotation rate differed significantly between the two apodizations. I therefore constructed a new one: apodized with a cosine in longitude from 56.10° to 60.46° with a hard cutoff in latitude at 60°. This roughly mimics the extent of the vw_V apodization. The following plots show the resulting tradeoff curves and rotation rates.

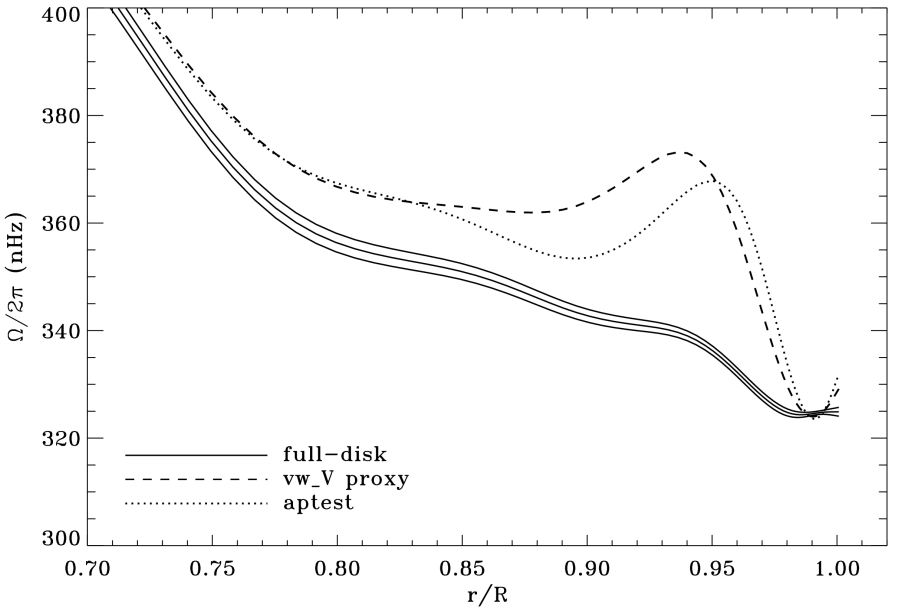


Low $|B_0|$

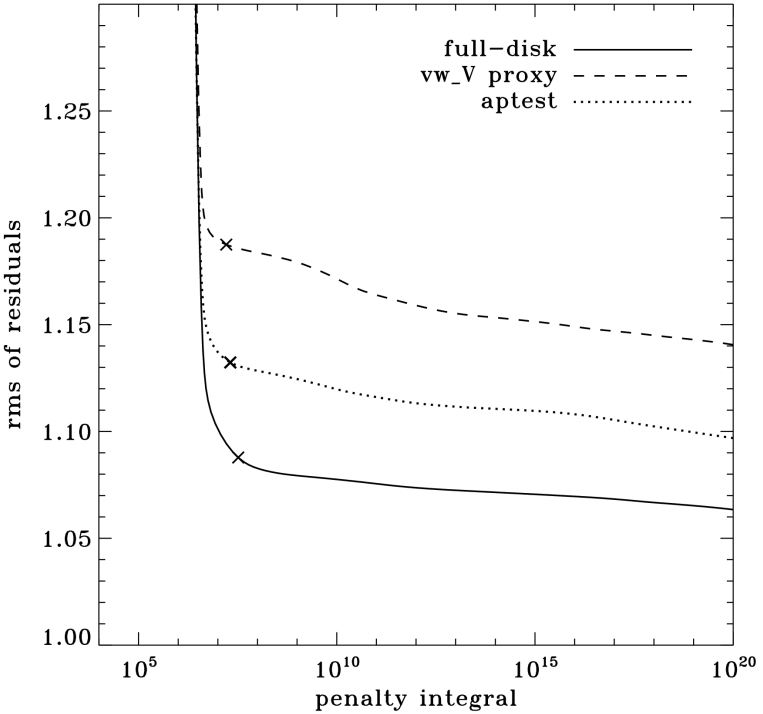


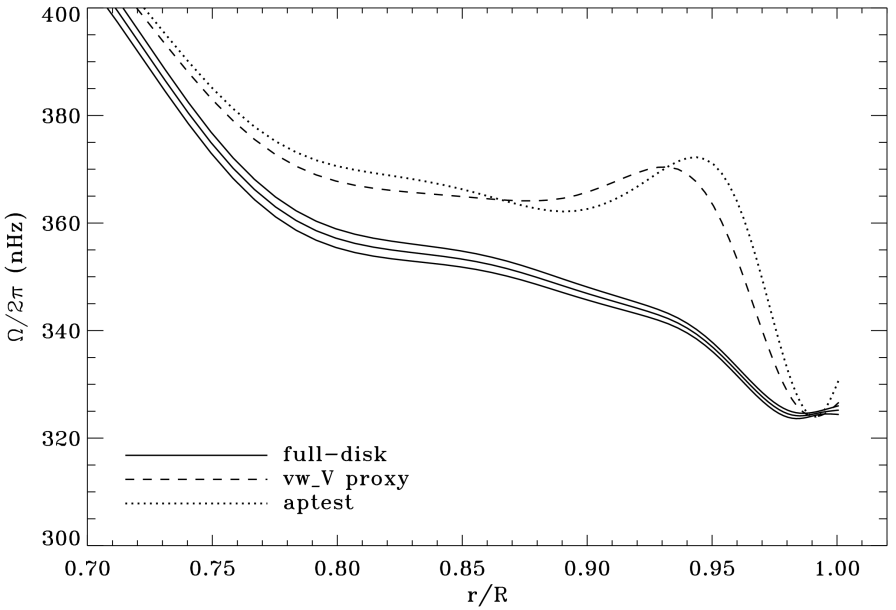


High $|B_0|$

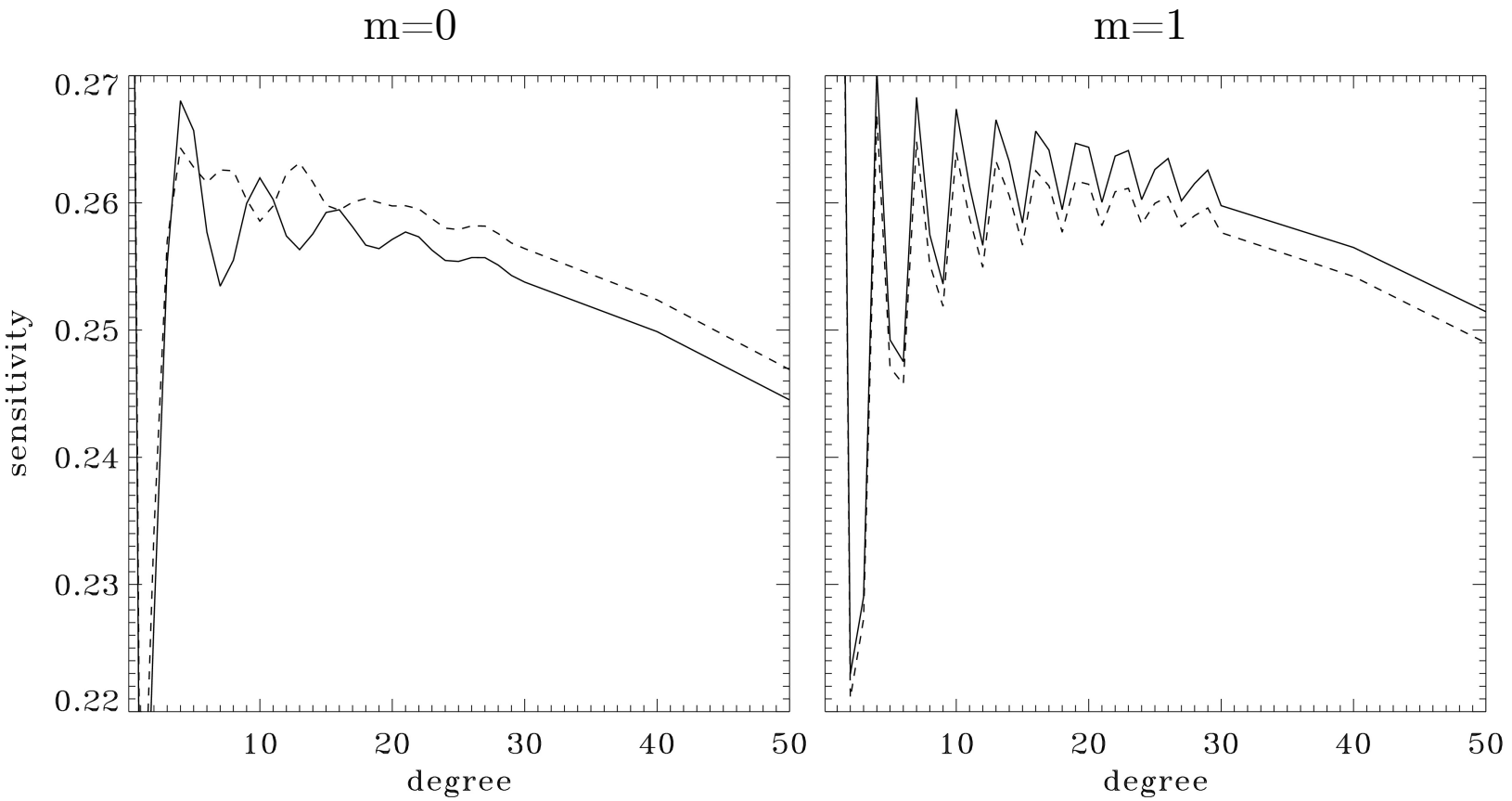


The residuals for the new apodization were much reduced relative to original vw_V. The shape of the tradeoff curves were closer to those of the full-disk, indicating the bump was also reduced. As a final variation, I repeated the analysis of the last interval with leakage matrices calculated for B_0=-6.79.

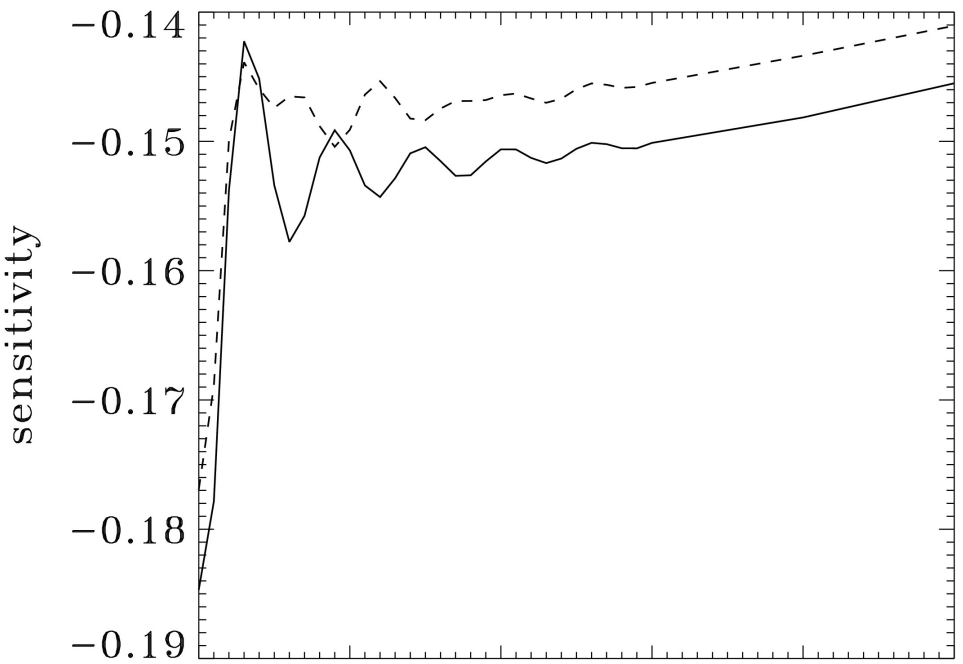




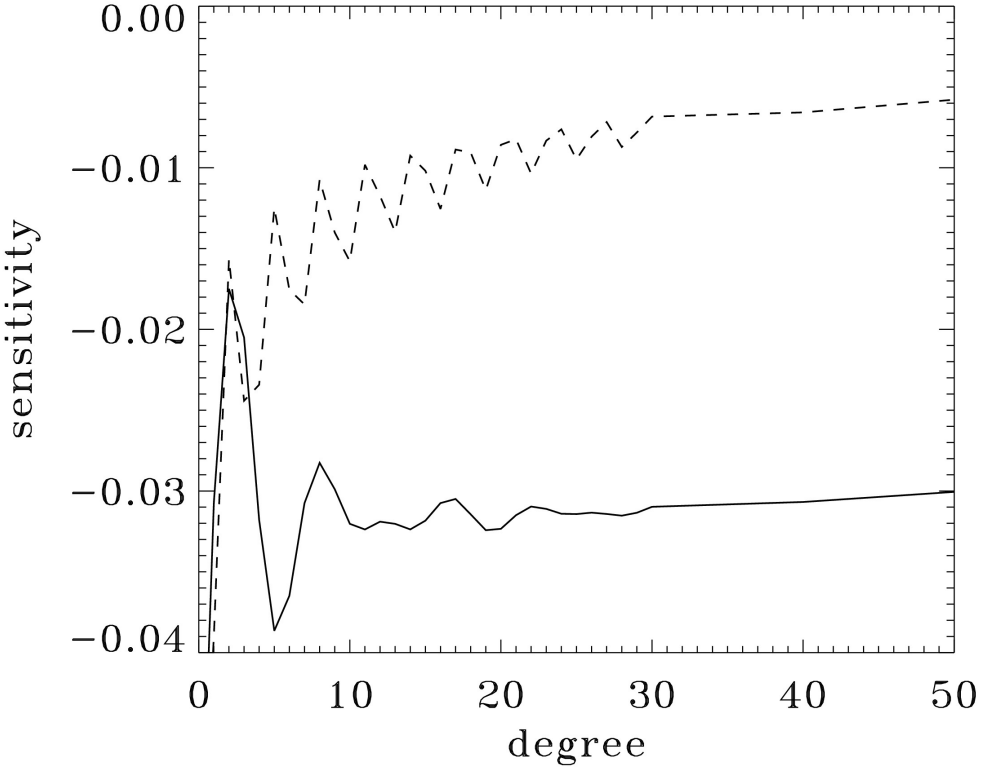
Although the tradeoff curves are the lowest and have the best shapes in the preceding plot, I must emphasize that the results are not necessarily any more correct, because in all cases the code neglects leaks from $\Delta l + \Delta m$ odd, which arise from north-south asymmetry. The following plots show cuts through the leakage matrix using the regular vw_V apodization for both values of B_0. In all cases the differences become smaller as the degree increases.



Sensitivity to target mode. Solid lines show original leakage matrix, dashed lines show leaks calculated for high $|B_0|$.



Leaks for m=0 and $\Delta l=2$, $\Delta m=0$. Solid line shows original, dashed line shows leaks for high $|B_0|$.



Leaks for high $|B_0|$, $\Delta l=1$, $\Delta m=0$. Solid line shows m=0, dashed line shows m=l. Original leaks are identically zero.

Summary

I found that the jet, unlike the bump, is not a constant feature of the inversions. In the vw_V proxy, it appears only for high |B0|. On the other hand, when |B0| is low, the full-disk analysis shows an upturn in the rotation rate near the surface, which is otherwise absent.

The results using the new apodization are somewhat encouraging. One hopes that the results will improve even more once an apodization in latitude is added.