Ring Diagram Analysis of the Structure of Solar Active regions

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(1) Use ring-diagrams to determine the frequency differences between active and quiet regions.

Active and quiet regions chosen to be at same latitude, during the same CR. Tracked when at the CM for 8192 min.

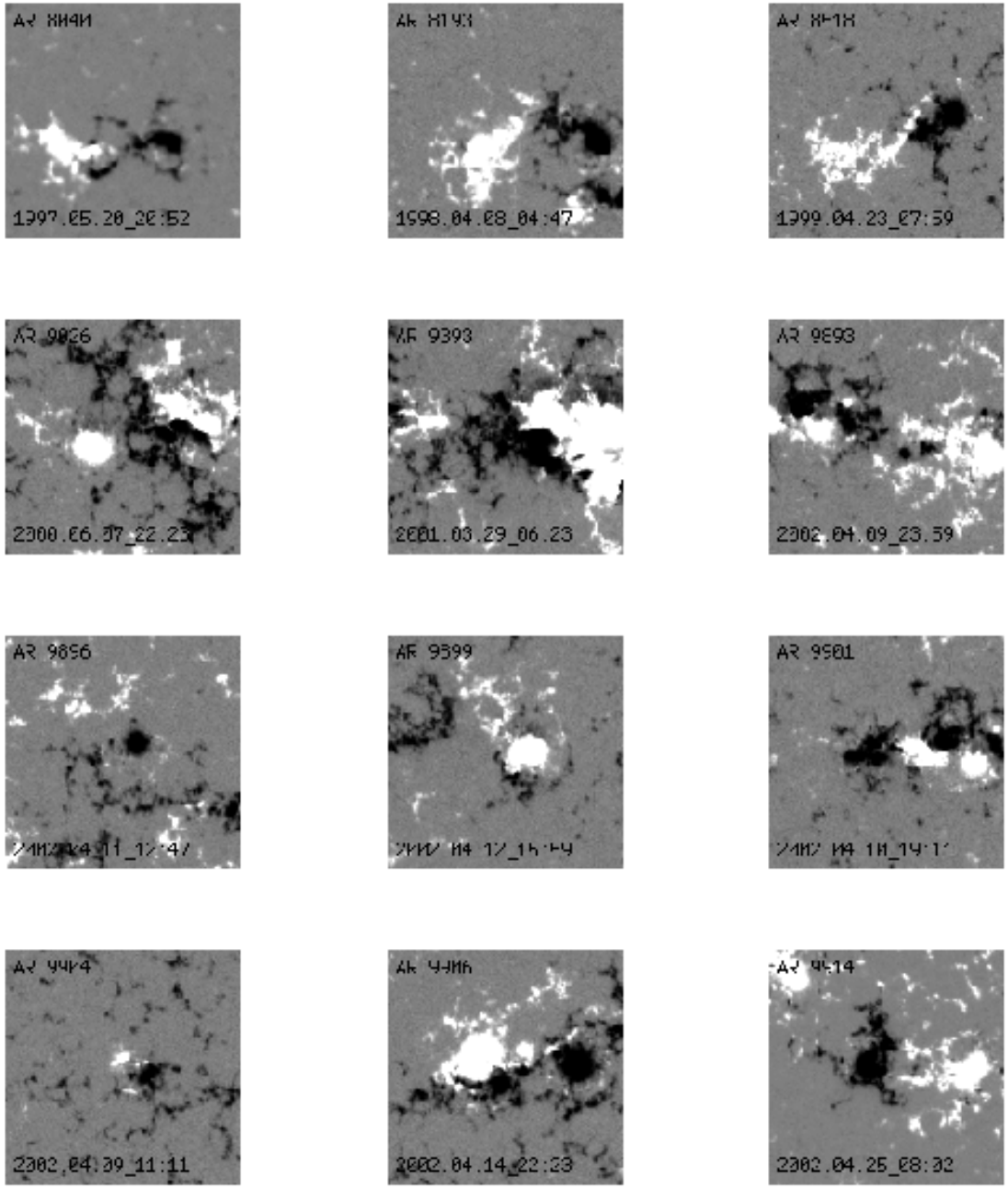
(2) Invert for sound-speed and Γ_1 differences between the two regions.

(3) Compare with activity indices.

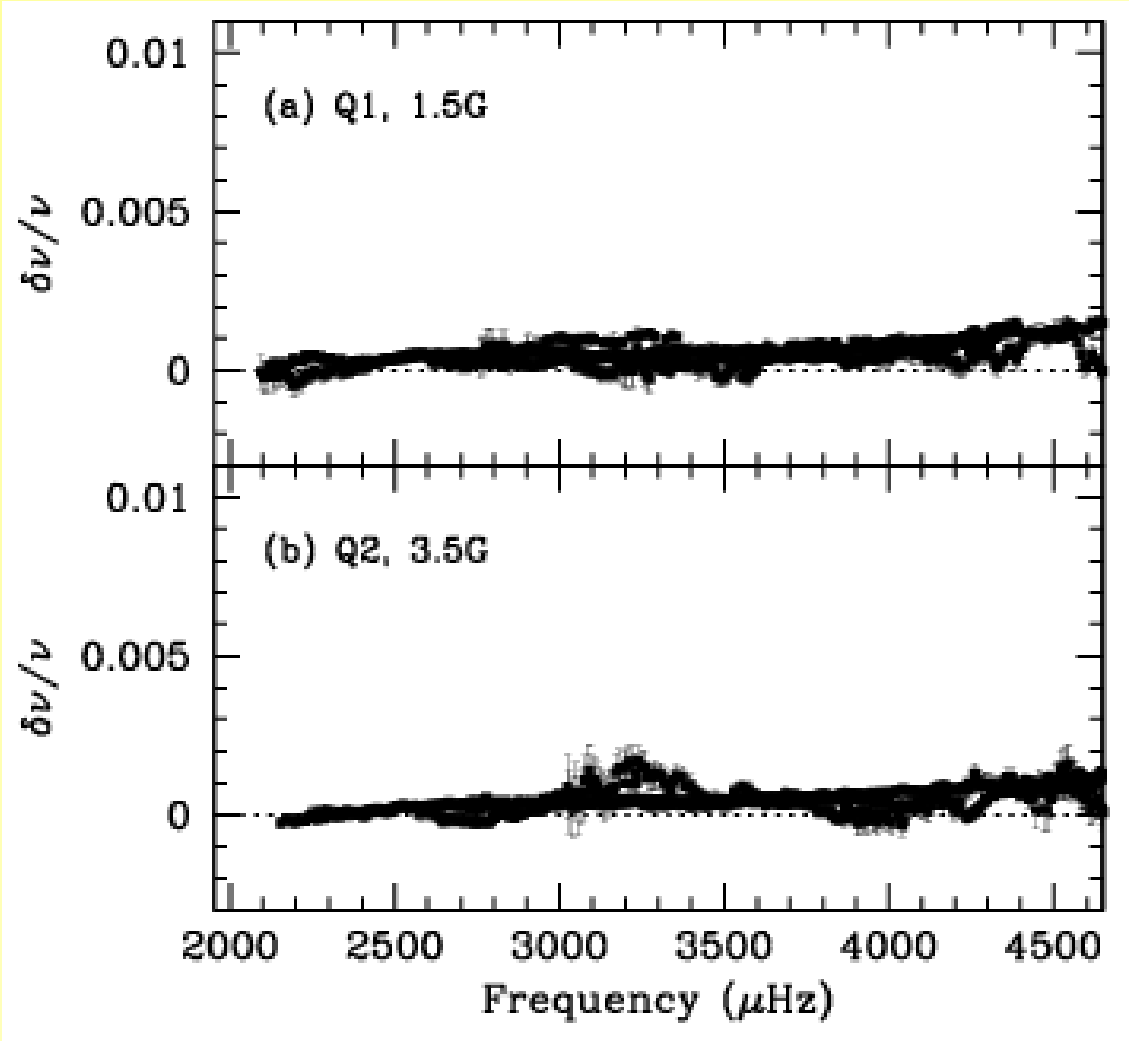
(2)

Region #	CR	Lat. (deg.)	CM Lon. (deg)	Mag. Index (G)	NOAA #	Max. area (millionths)
1	1922	7.0N	16	19.9	8040	150
2			341	0.2		
3	1934	21.0S	82	68.4	8193	290
4			67	0.6		
5	1948	14.0S	105	53.2	8518	170
6			75	0.9		
7	1963	20.0N	71	146.6	9026	820
8			126	0.9		
9			41	4.4		
10	1974	19.0N	147	241.6	9393	2440
11			207	1.2		
12	1988	19.0N	215	81.5	9896	110
13			255	0.7		
14	1988	11.0S	195	26.8	9896	110
15			205	2.0		
16	1988	18.0N	180	56.3	9899	220
17			240	2.2		
18	1988	20.0N	204	108.5	9901	350
19			249	0.7		
20	1988	16.0S	222	23.3	9904	60
21			242	2.7		
22	1988	16.0S	150	125.8	9906	850
23			120	2.8		
24	1988	4.0N	13	86.9	9914	260
25			28	1.1		

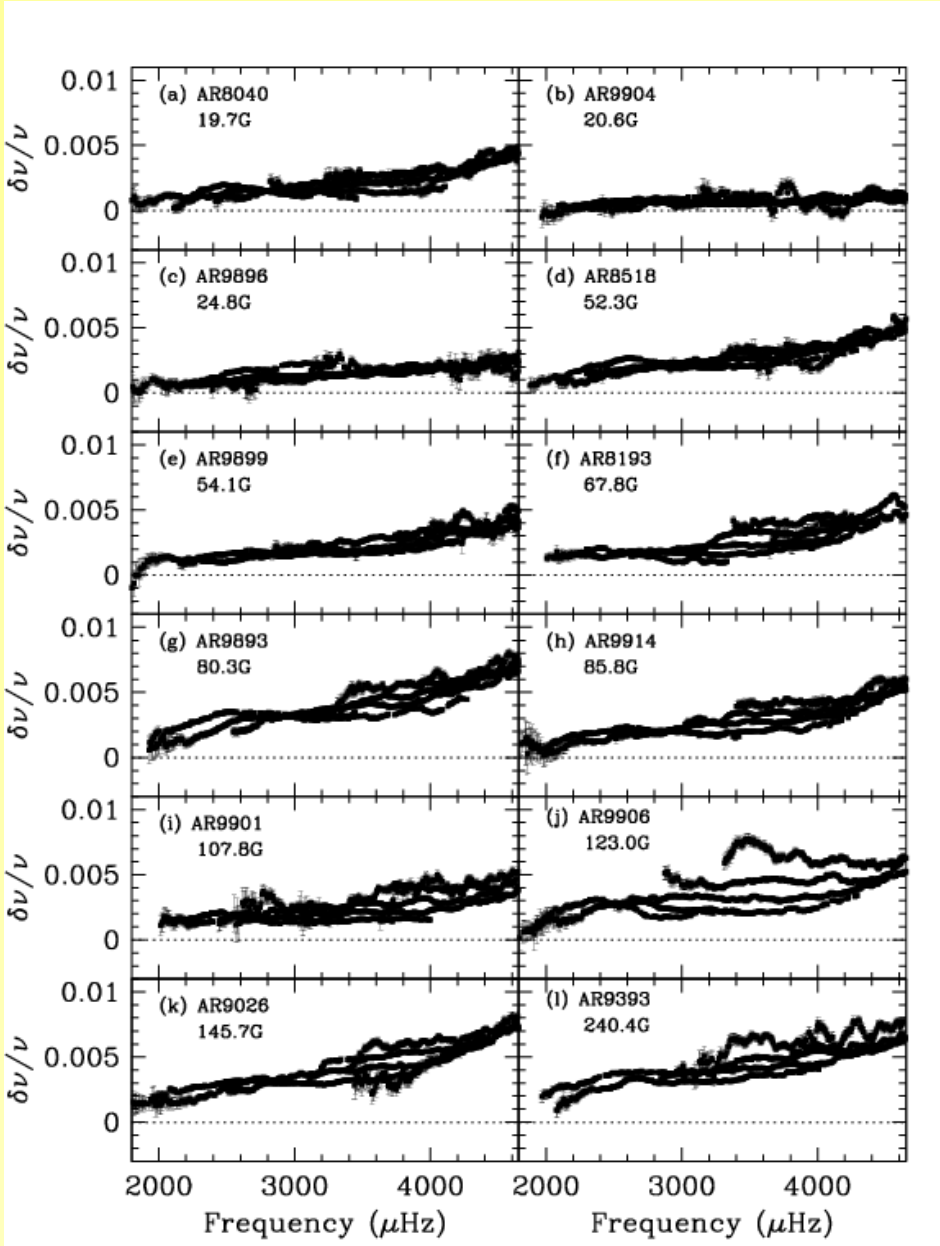
(3)


1997.05.20_20:52
1998.04.08_04:47
1999.04.23_07:59
AR 9026
2000.06.07_22.23
AR 9393
2001.03.29_06.23
AR 9893
2002.04.09_23.59
AR 9896
AR 9599
AR 9501
2002.04.09_11:11
2002.04.14_22:23
2002.04.25_08:32

Frequency differences between quiet regions

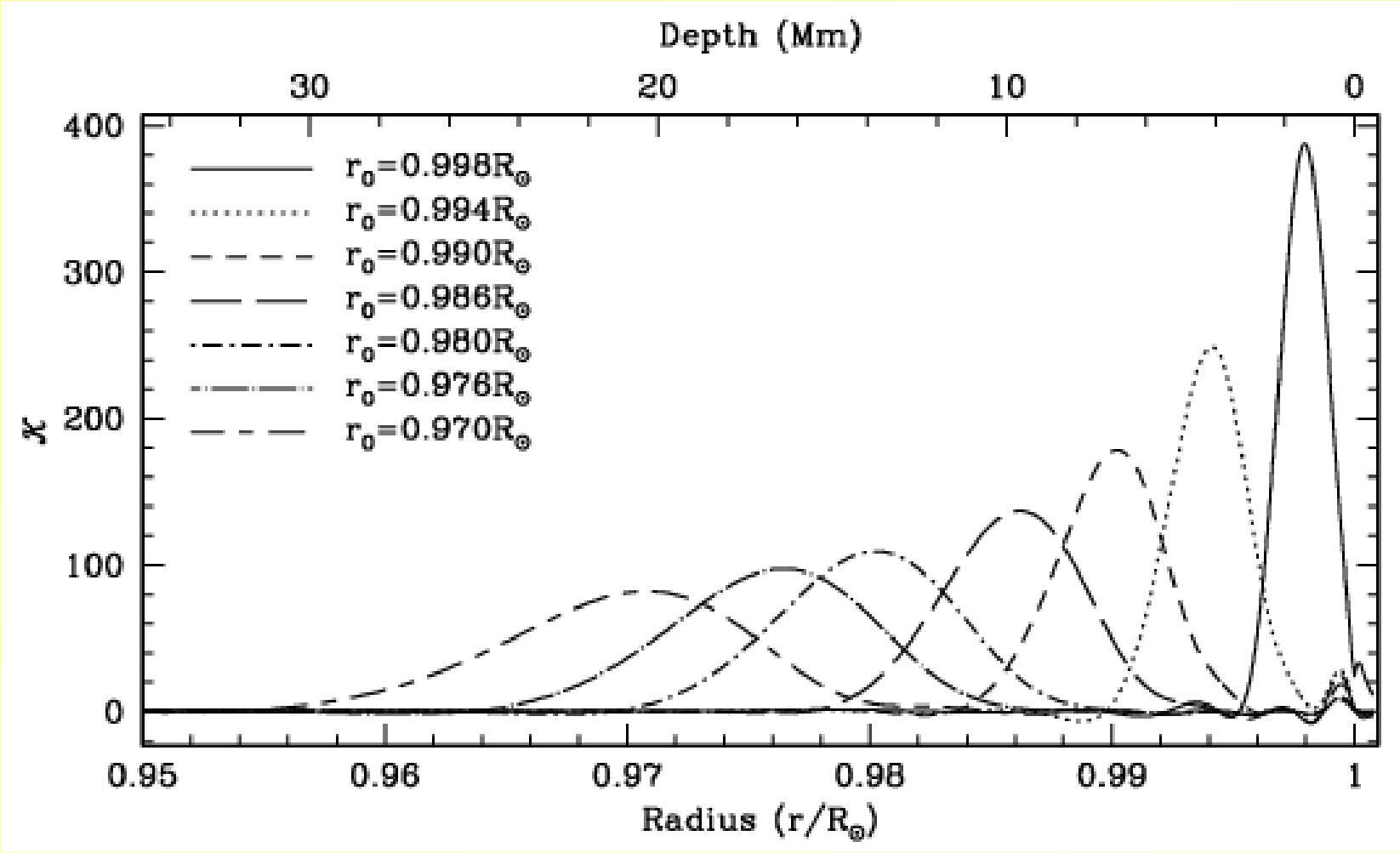


Frequency differences between active and quiet regions



Saturation effect?
(Rajaguru et al.)

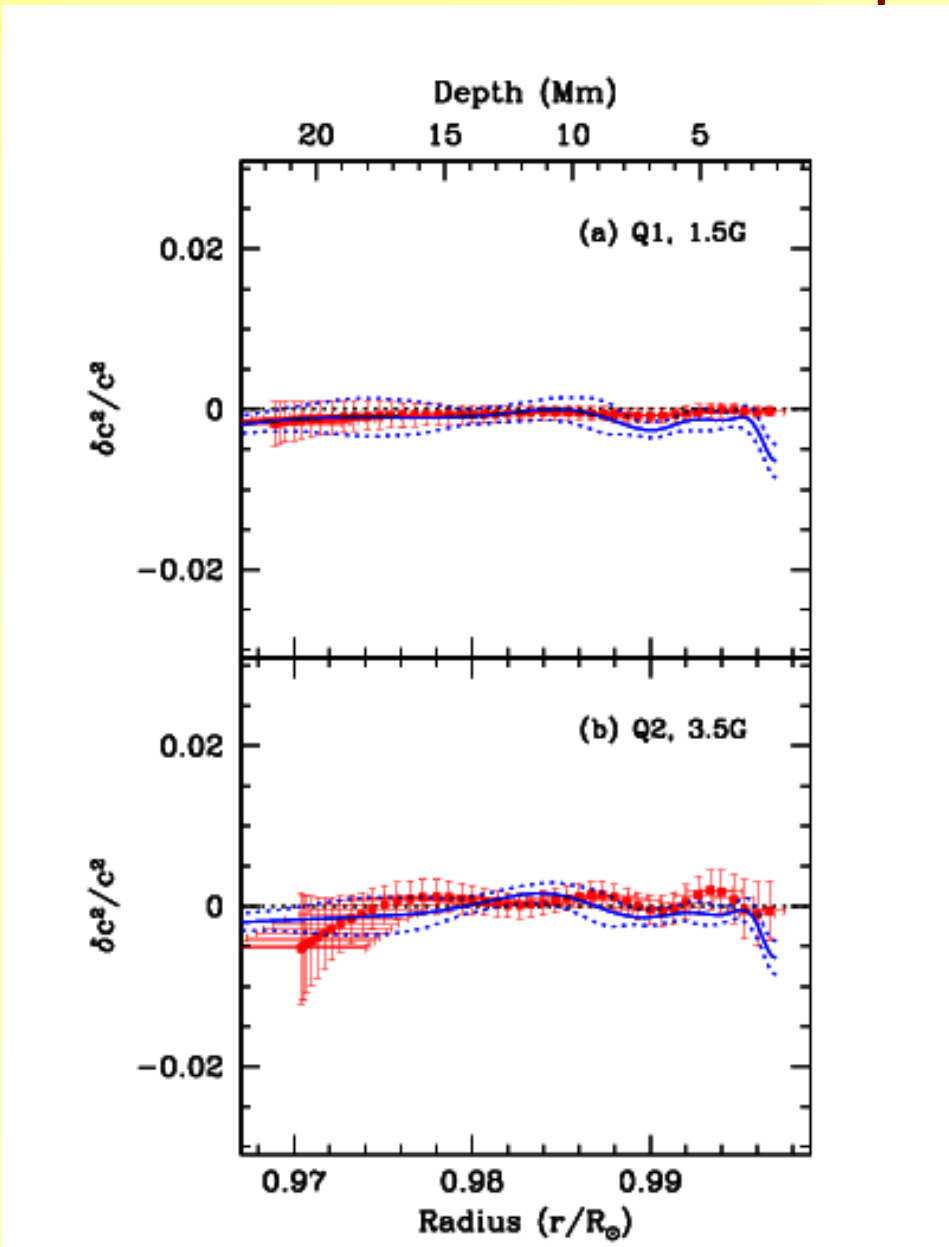
Averaging kernels



Can not trust anything below 0.97 R_sun

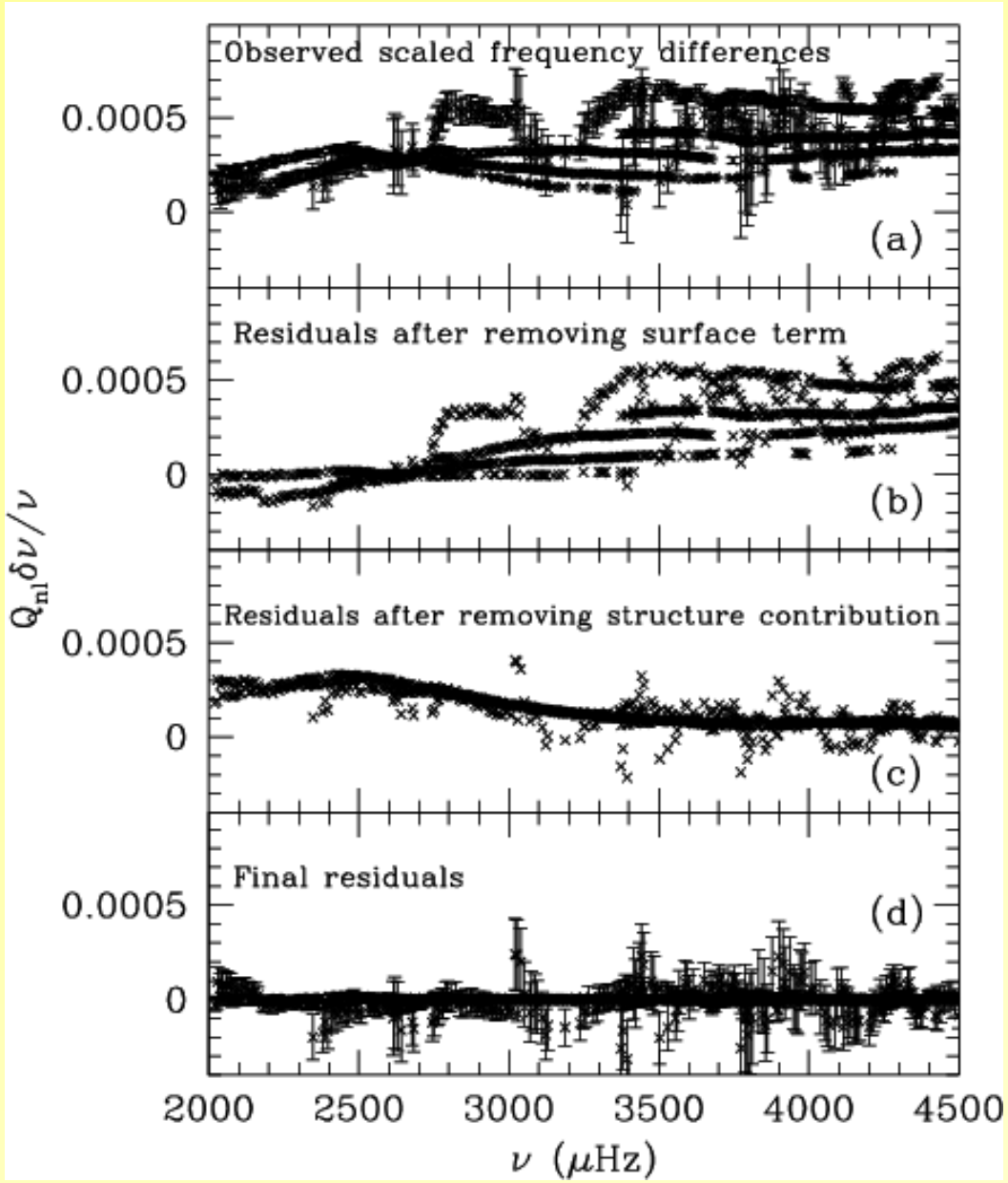
Sound speed differences between quiet regions

Red=SOLA
Blue=RLS

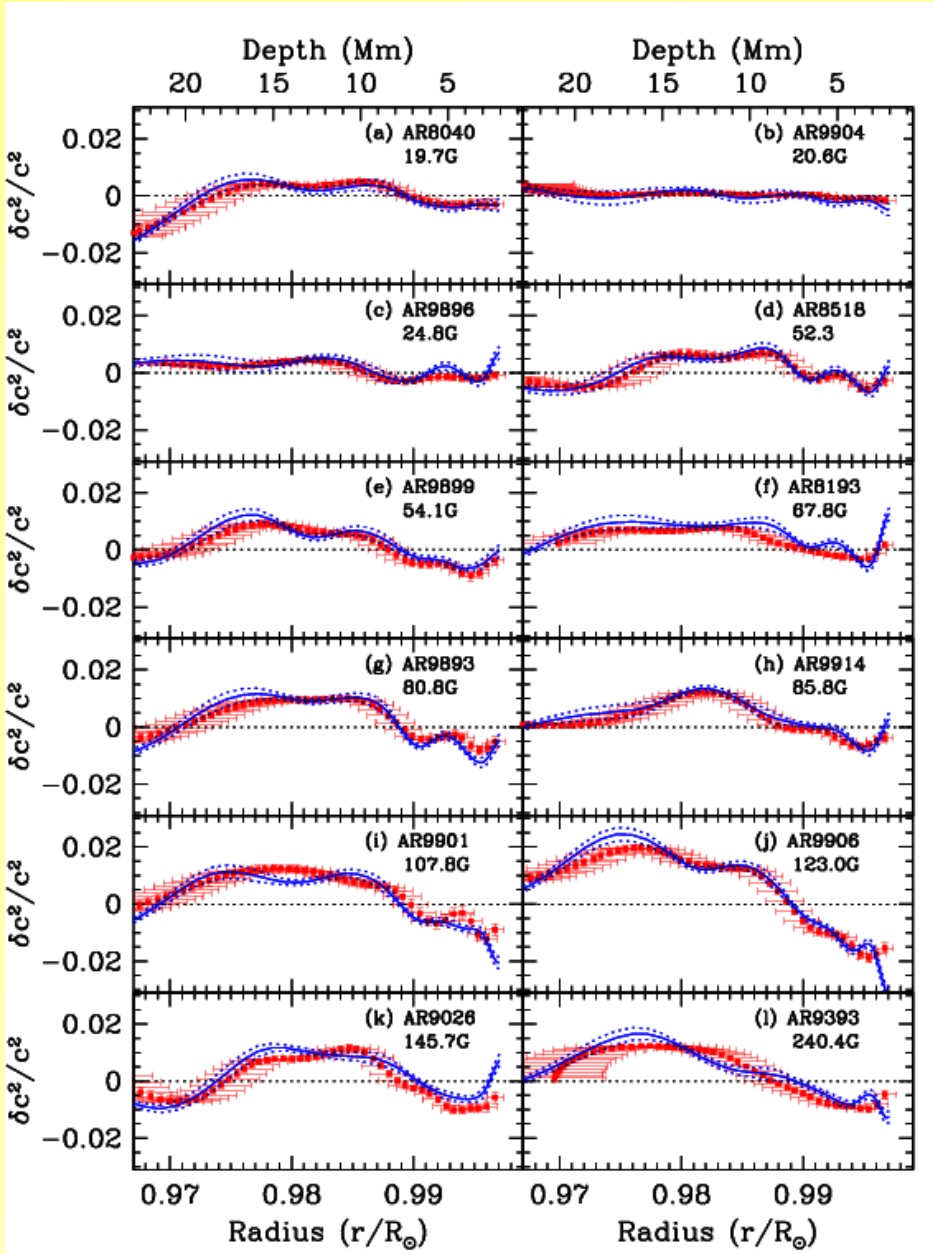


Residuals

(h1)

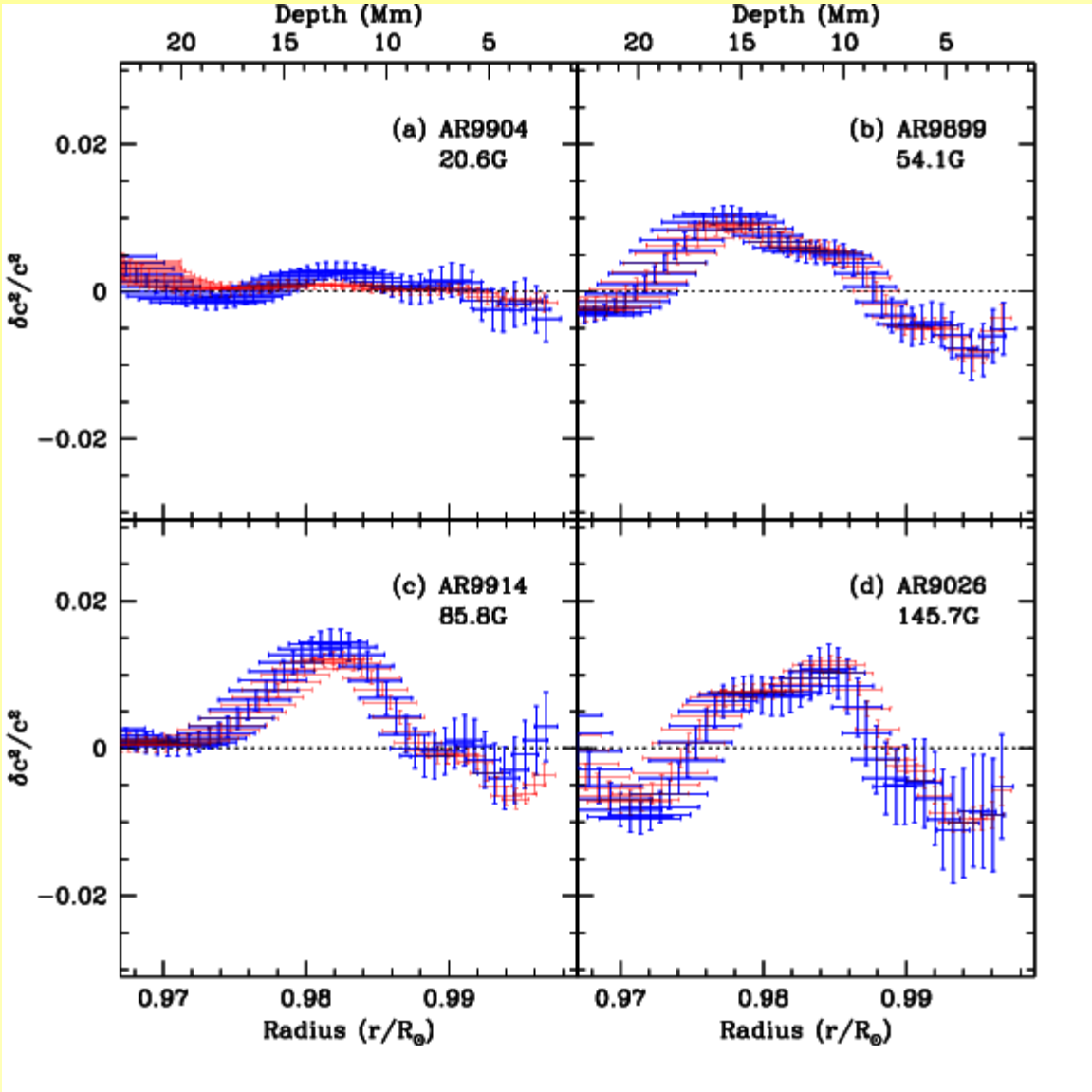


Sound speed differences between active and quiet regions

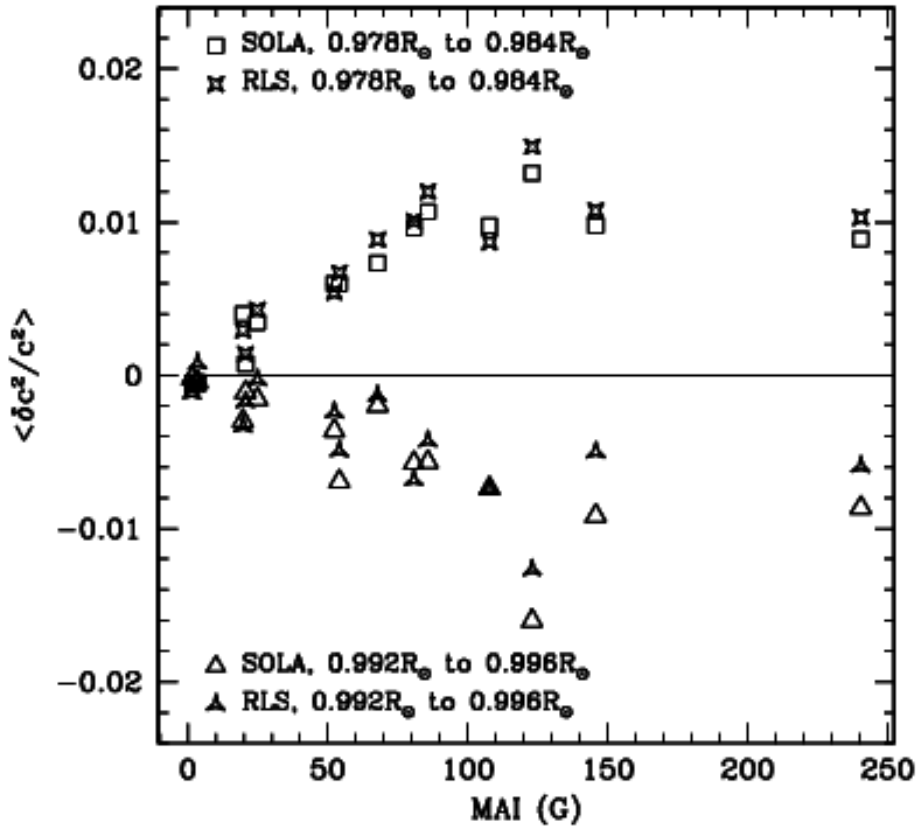


(h2)

2 surface terms?

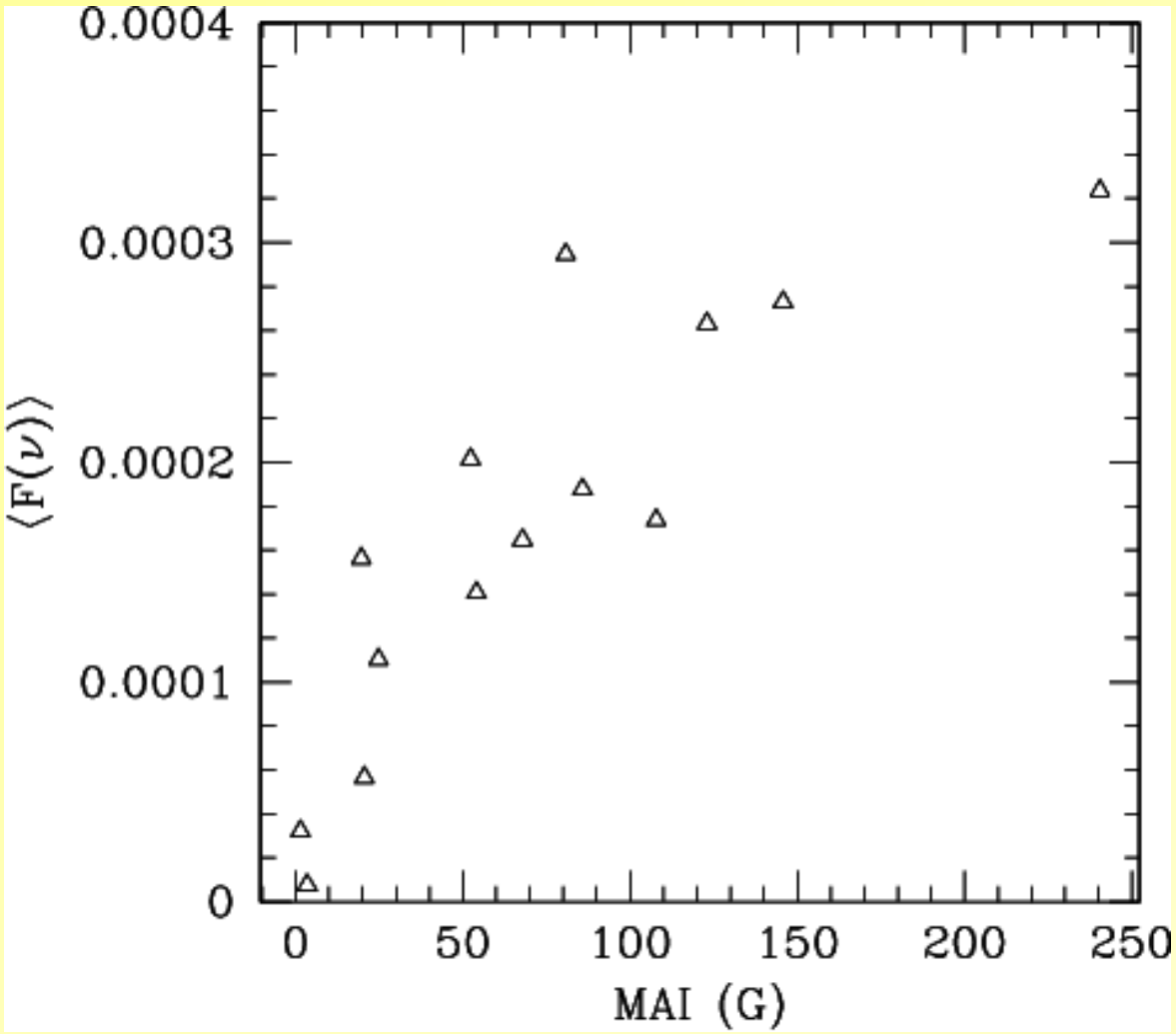


Average c^2 differences

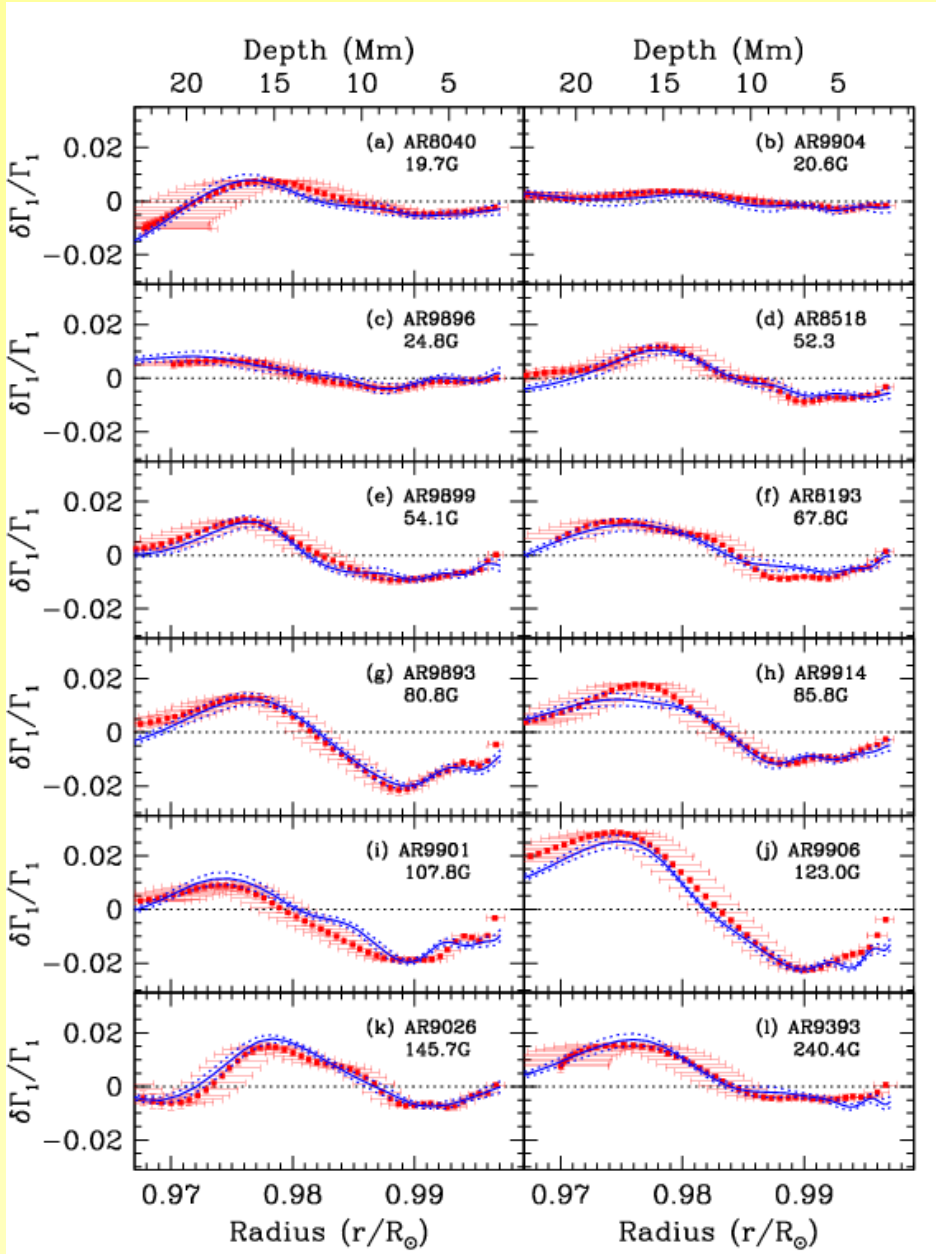


Saturation here too?

Average surface term

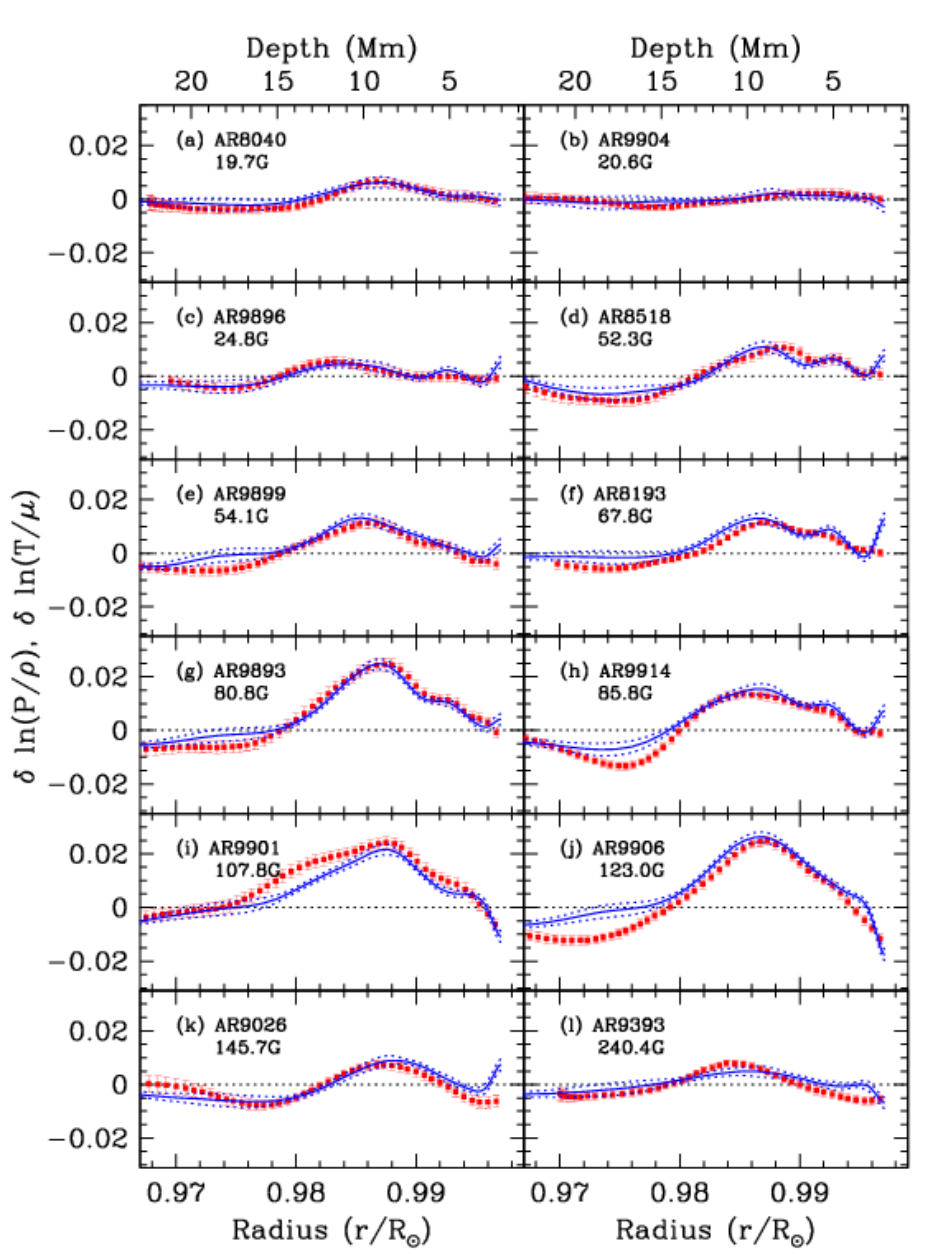


Γ_1 differences



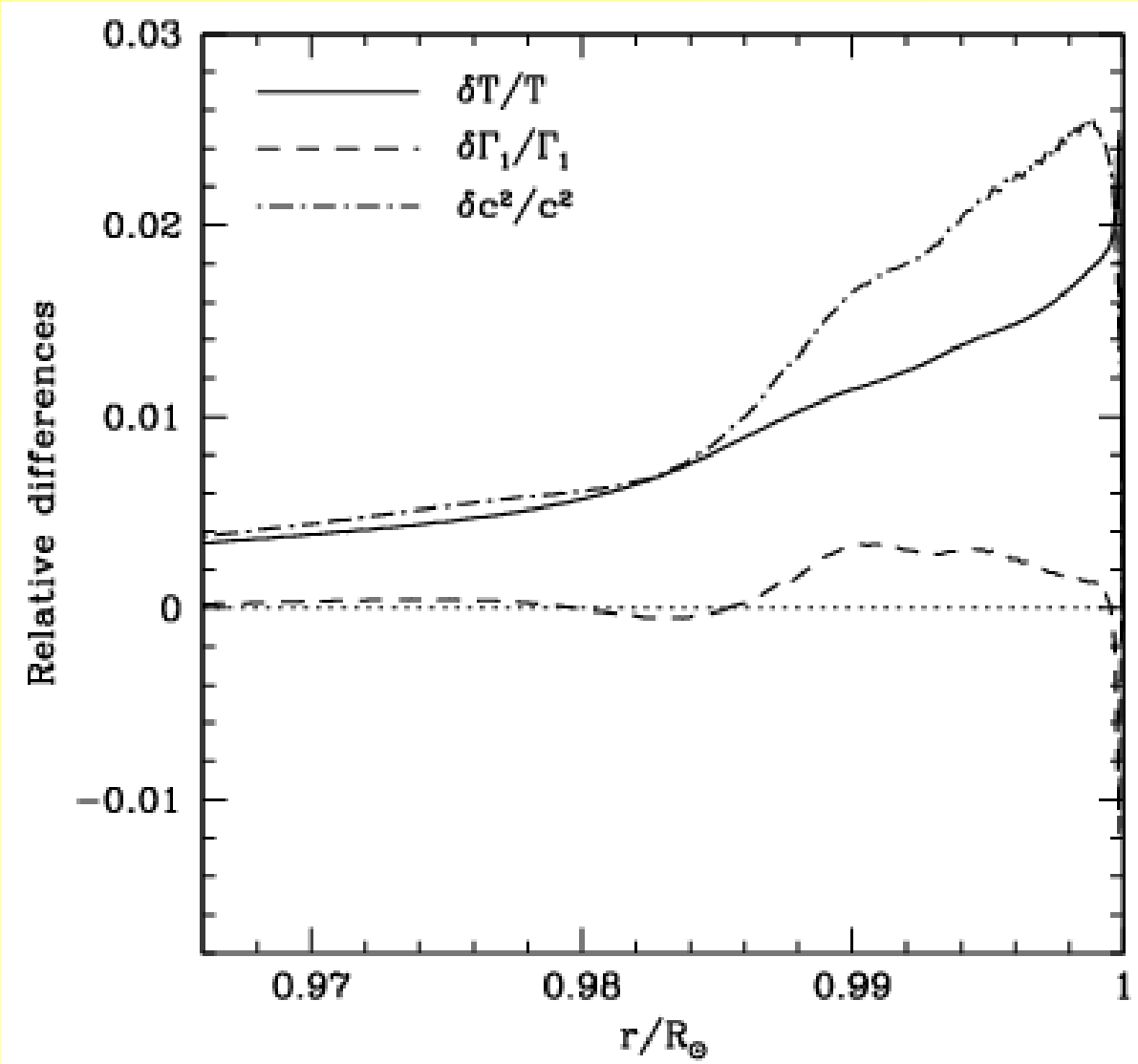
$\delta \ln c^2 - \delta \ln \Gamma_1$ (= $\delta \ln P/\rho$, $\delta \ln T/\mu$)

(12)



Are the changes due to EOS or shifts in ionization fractions, or both?

Changes in Γ_1 due to changes in ionization fraction (and hence changes in μ)



Conclusions

- For the stronger ARs, sound speed close to the surface is lower than that in quiet regions. The sound-speed increases inwards.

- The difference in sound speed between active and quiet regions increses with increase in the magnetic index of the AR. There could be some saturation effect.

- The adiabatic index Γ_1 too is different between active and quiet regions. It appears that although a part of the differences is due to shifts in the ionization zones due to changes in temperature, there is a contribution due to changes in the effective equation of state of the active regions.