Analysis of NOAO AR 11093 using HMI and GONG data

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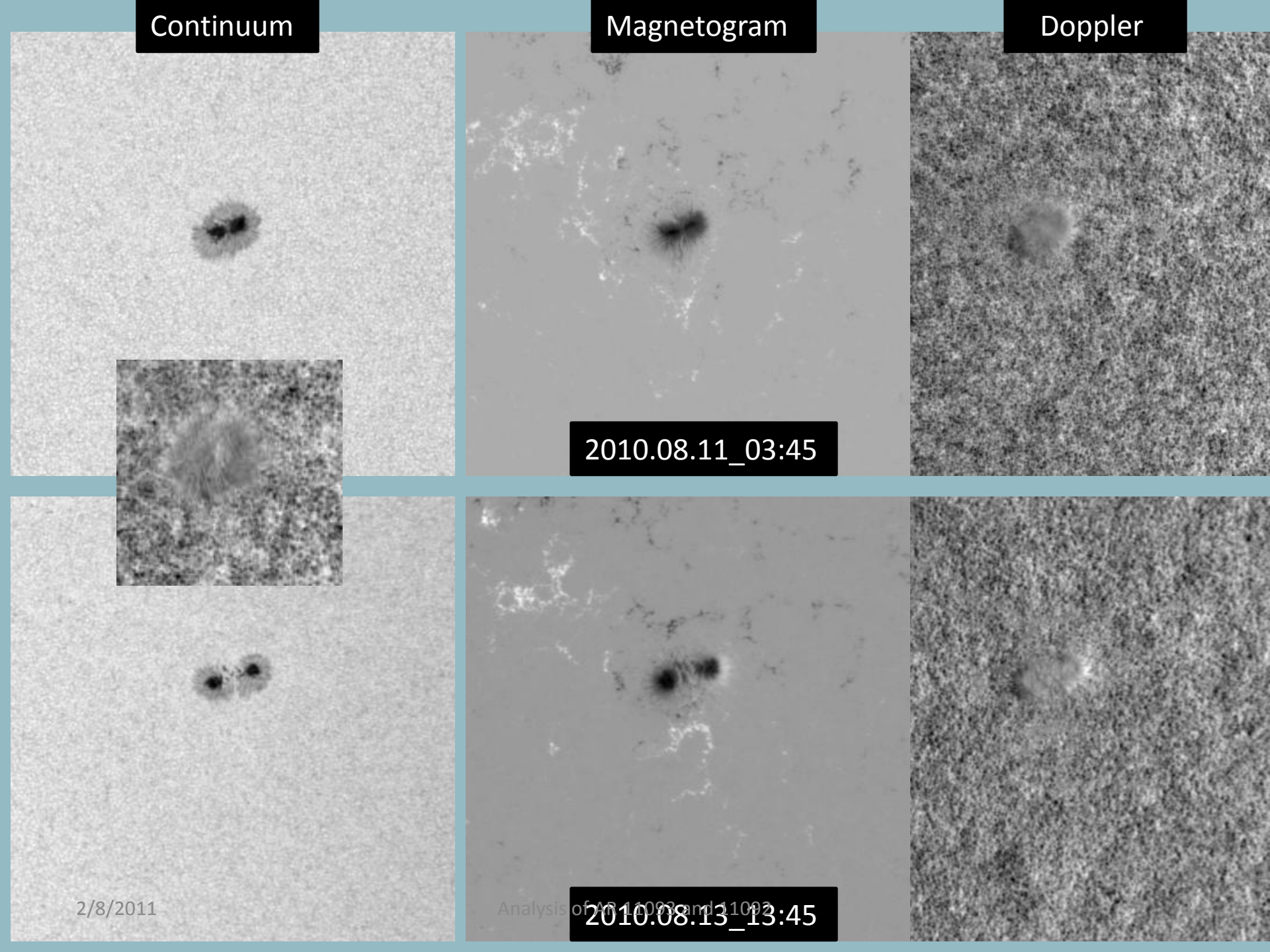
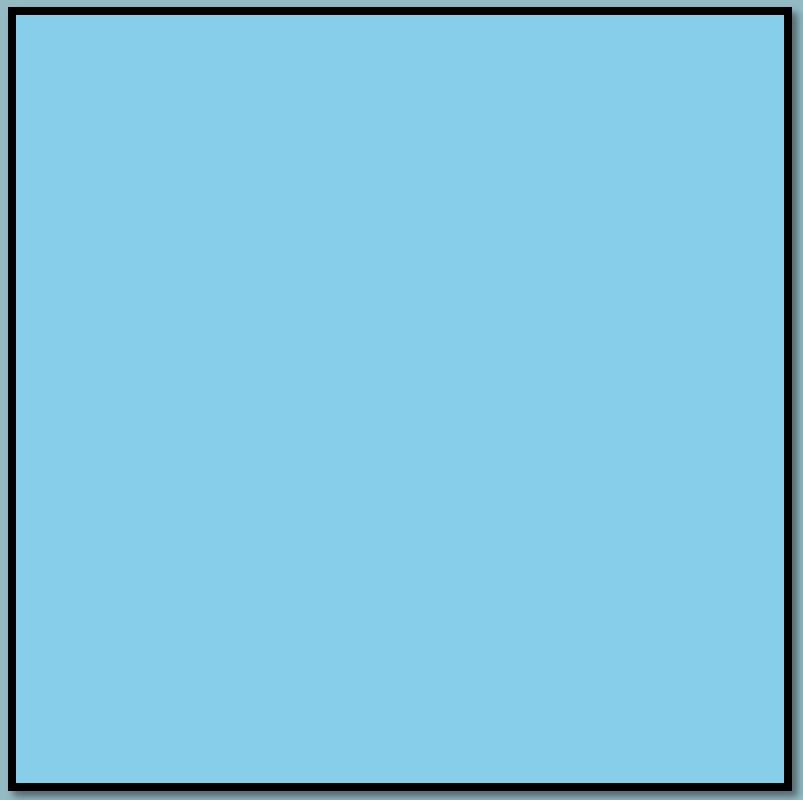
Introduction

- We study the evolution of AR NOAO 11093 during its disk passage from August 6 to 14, 2010 (CR Longitude 354^{o})
- GONG and HMI data are processed through the GONG ring-diagram pipeline
- A quiet region is chosen on Aug 6 (CR LON 35^{o})
- The sunspot umbra separates into two spots on 13th but the beginning of the process is seen earlier


Continuum
Magnetogram
Doppler
2010.08.11_03:45
2010.08.13_13:45



Breaking of the sunspot into two separate spots on 13th August 2010.

Motivation

- Do we see any signature of the breaking of the sunspot in the flow pattern ?
- How does the flow pattern vary between different patch sizes ?
- How does the mode and flow parameters compare between HMI and GONG observations and HMI and GONG pipelines?

Notes on GONG R-D pipeline

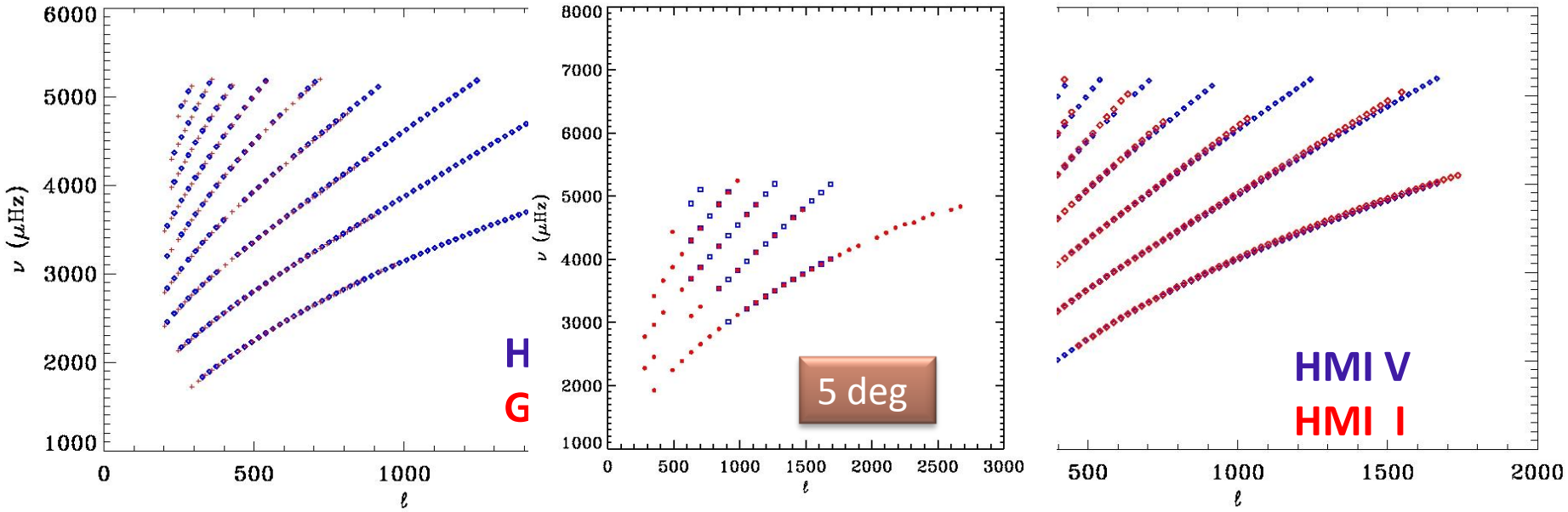
- uses Symmetric Lorentzian model profile to fit the power spectrum

$$P = \frac{A\Gamma}{(\omega - \omega_0 + k_x U_x + k_y U_y)^2 + \Gamma^2} + \frac{b_0}{k^3}$$

- Normally fits up to radial order n = 6 but we have extended it up to n = 9

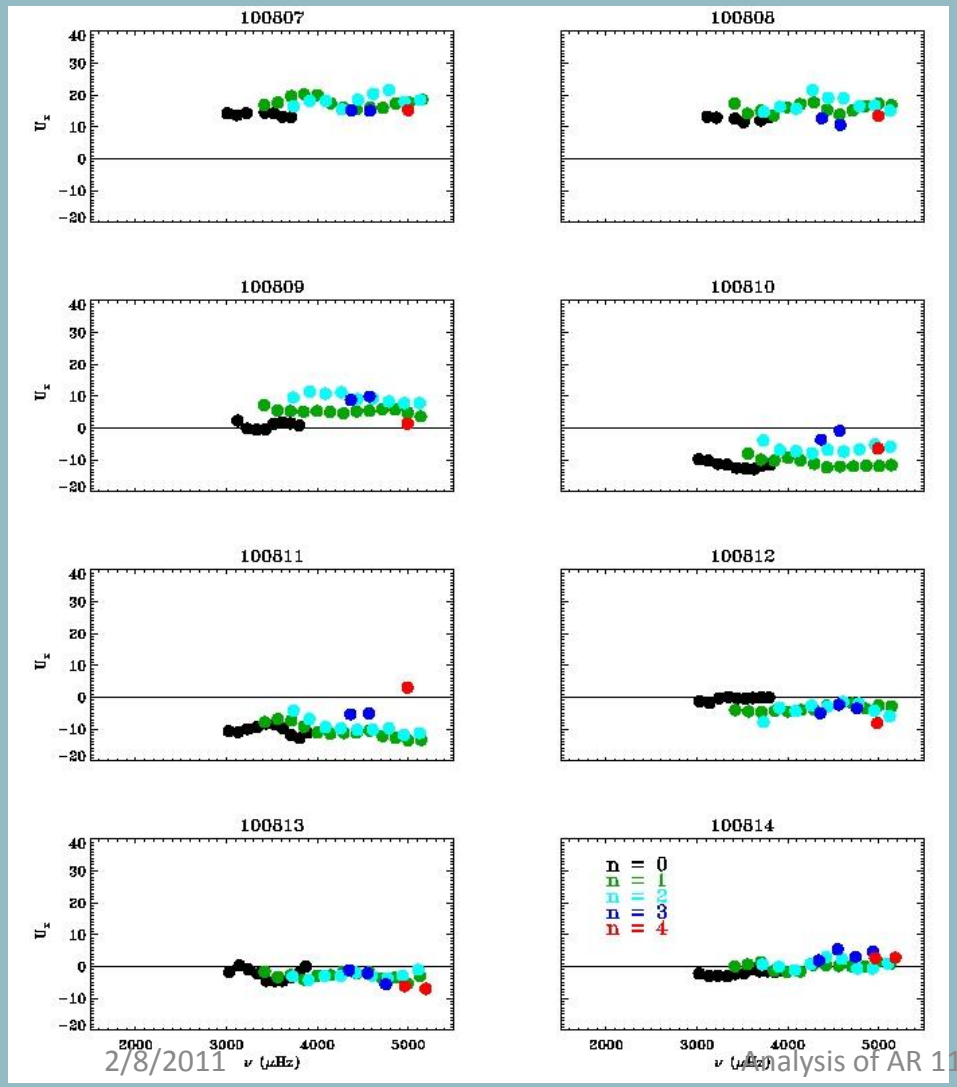
- Uses the new guess table from Deborah to be consistent with HMI pipeline

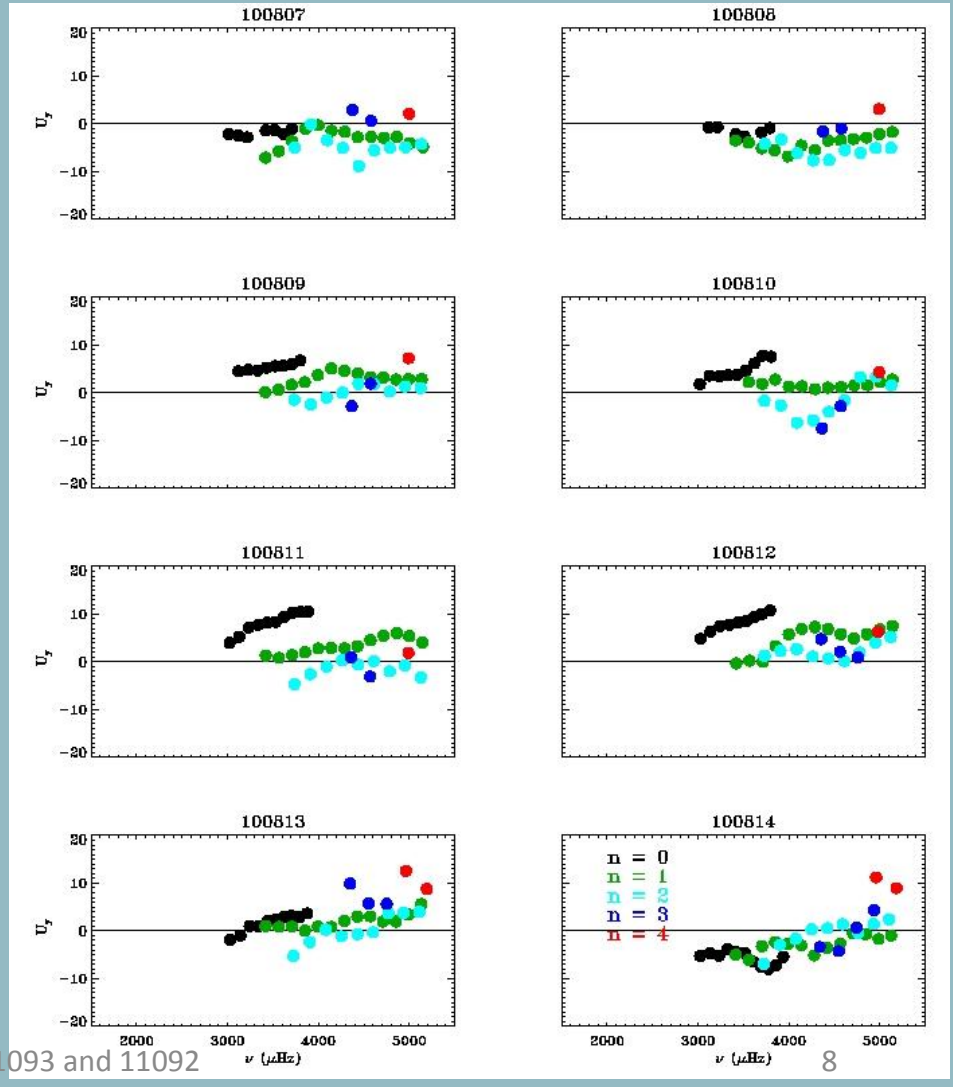
The diagnostic diagram



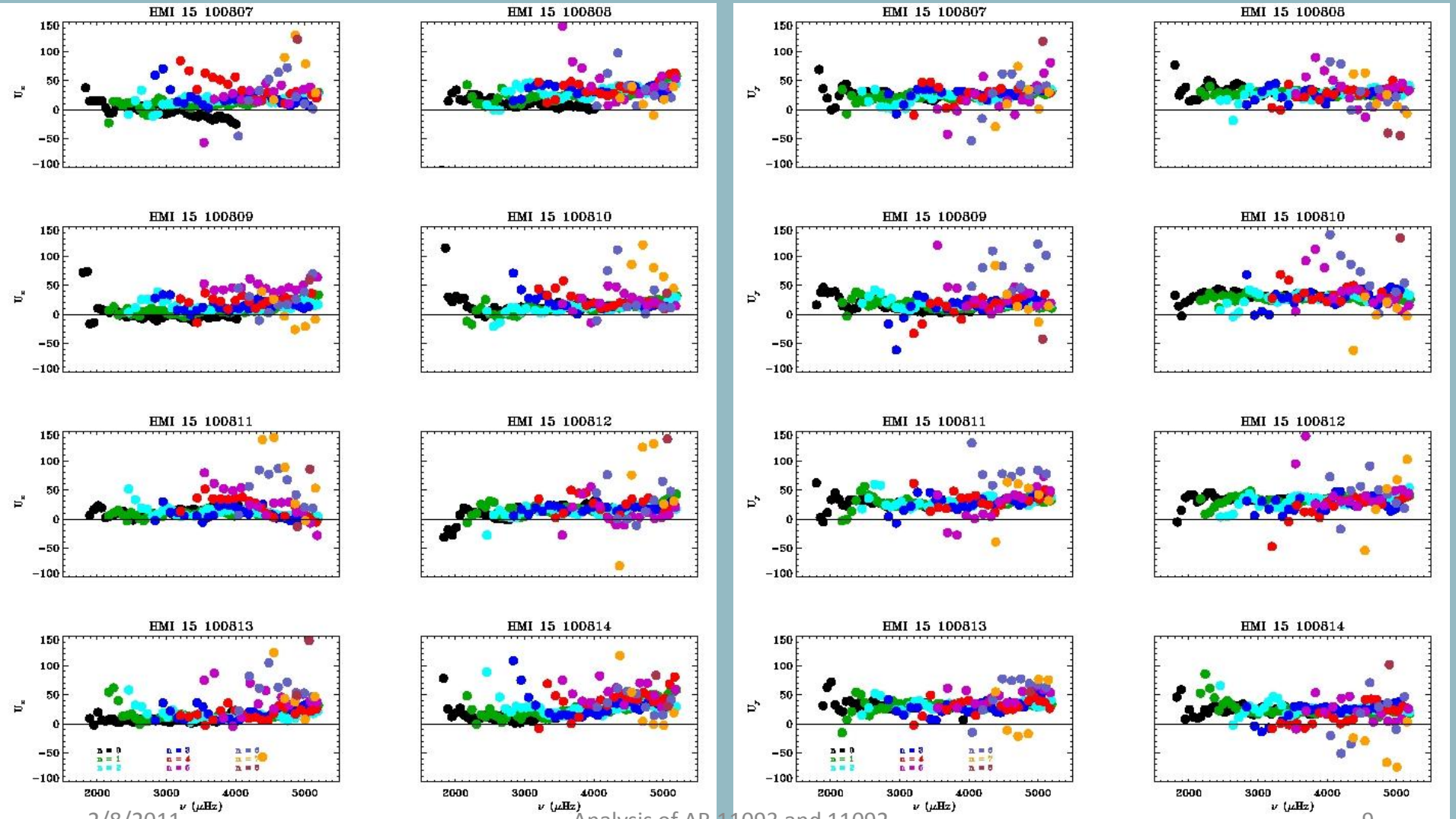
No of modes fitted:
HMI 15^o (384x384 pixels): 400 (320)
HMI 5^o (128x128 pixels): 60 (40)
GONG 15^o (128x128 pixels): 320 (200)

Variation of zonal and meridional component of velocity (HMI 5^{o})

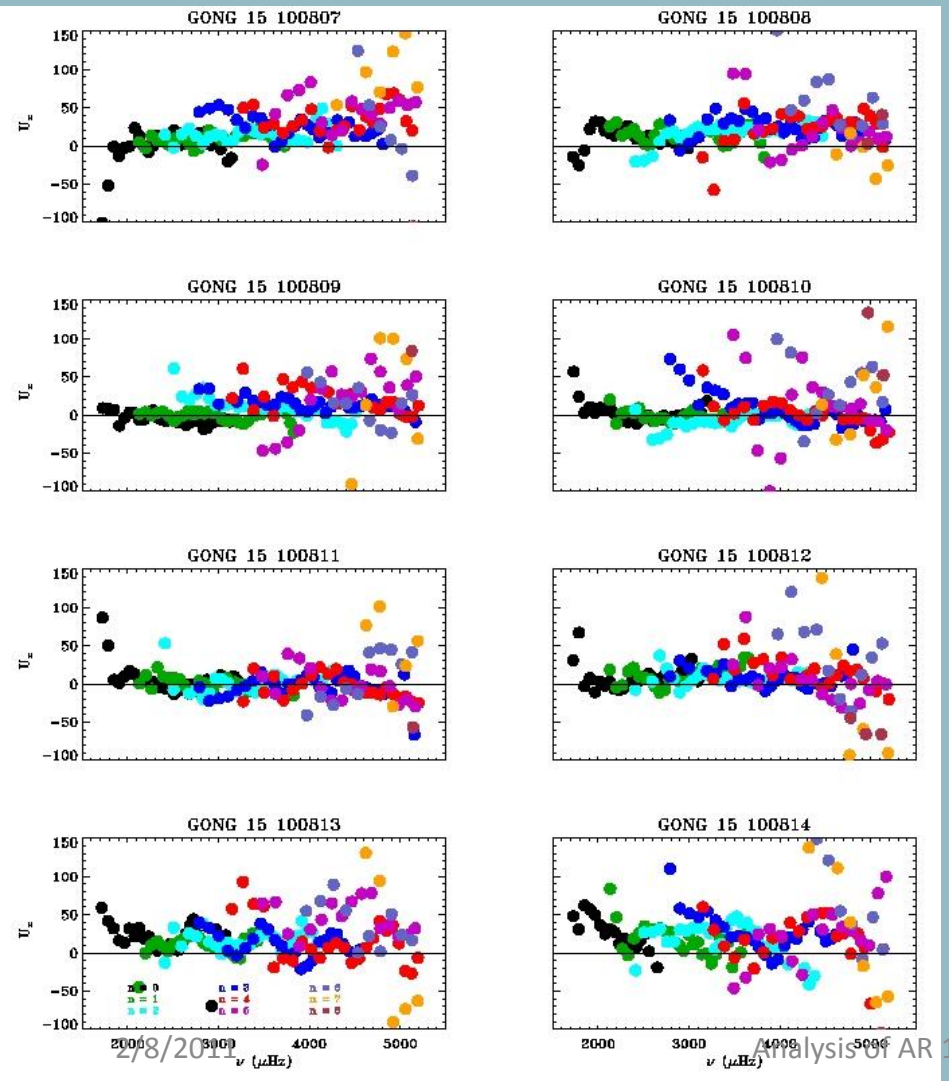


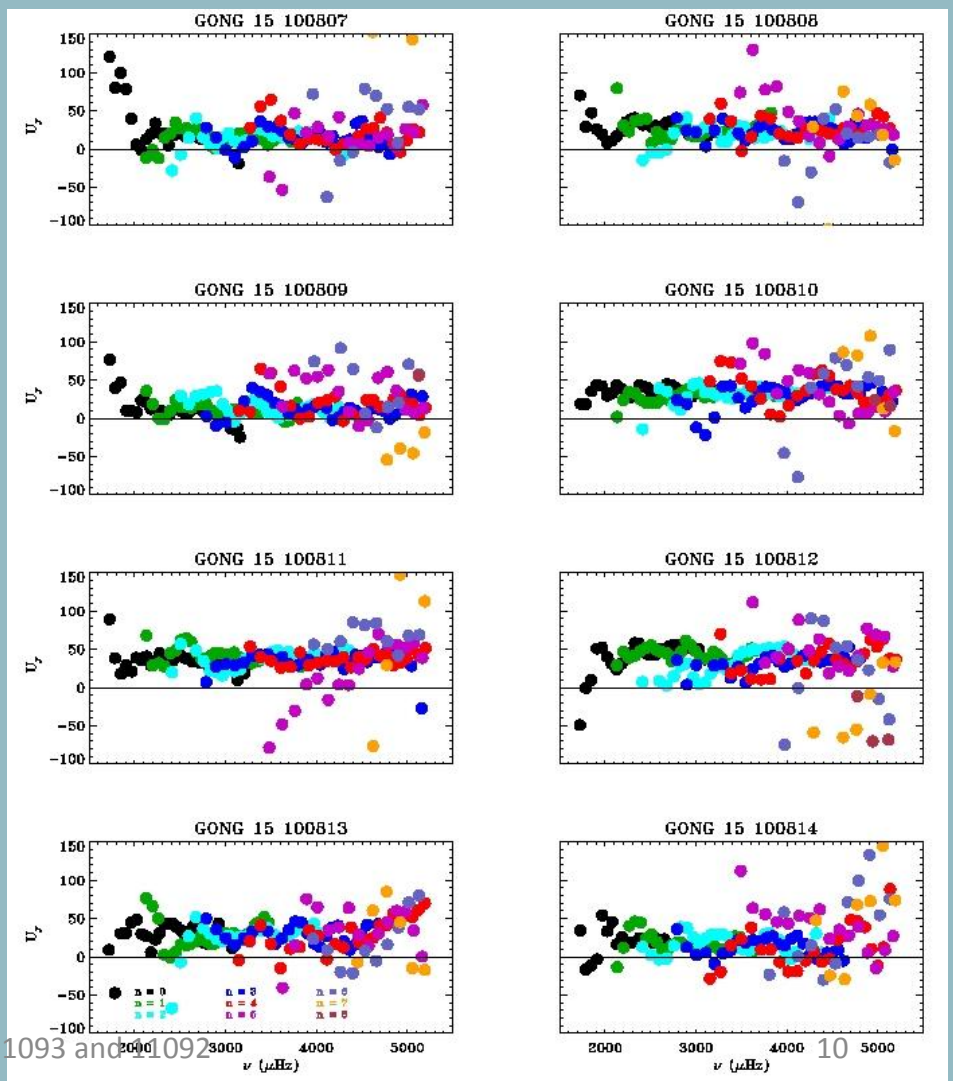


Variation of zonal and meridional component of velocity (HMI 15°)

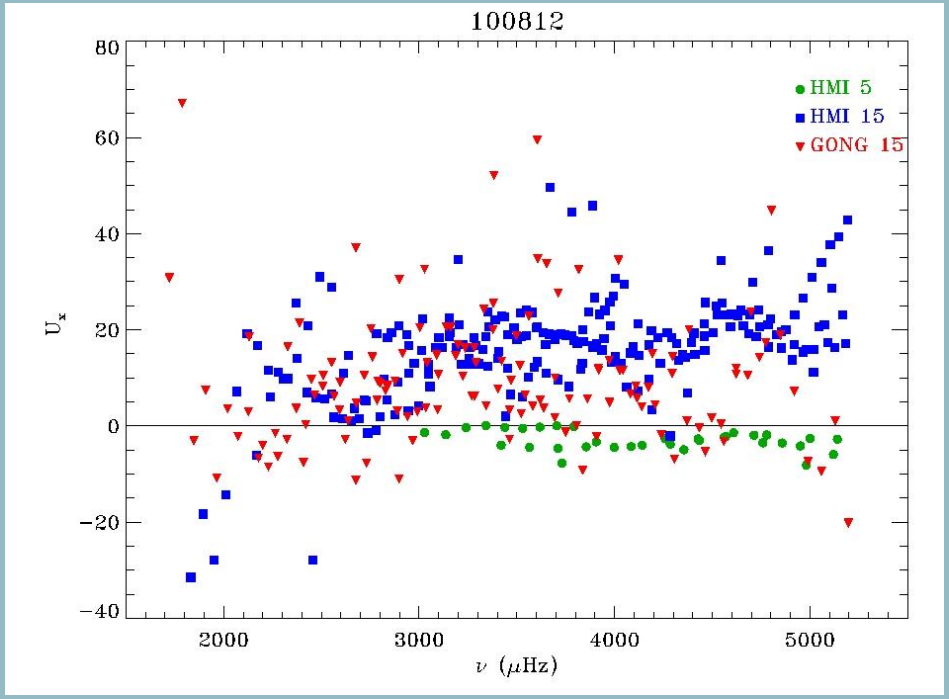


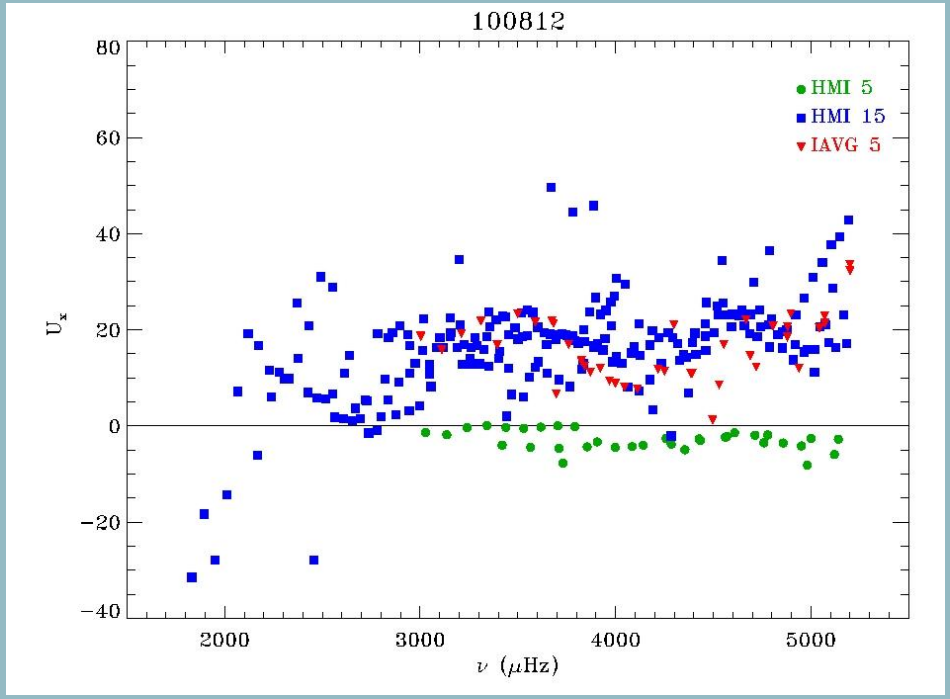
Variation of zonal and meridional component of velocity (GONG 15^{o})





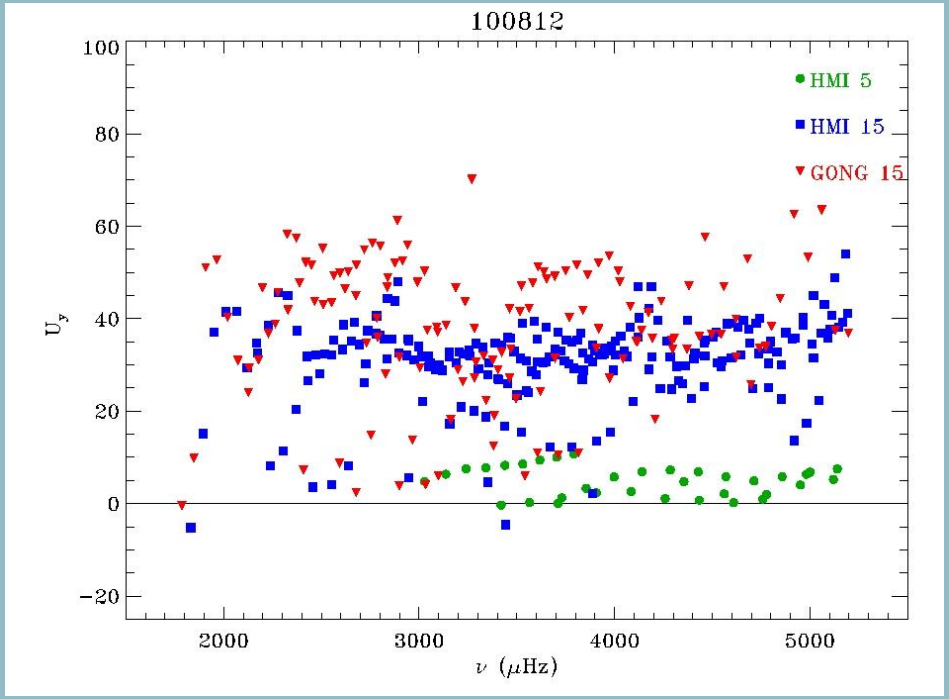
Comparison of zonal component between patches of different sizes

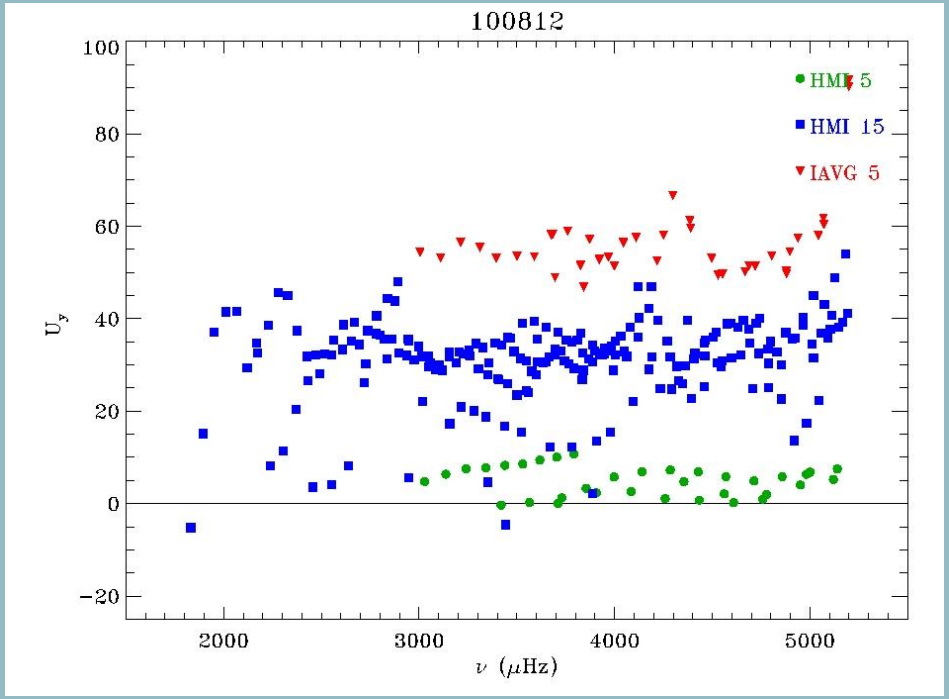




Zonal component of the velocity of 5^o are smaller (and even of opposite sign) compared to 15^o patches. However, when 9 patches of 5^o are averaged, the velocities are comparable.

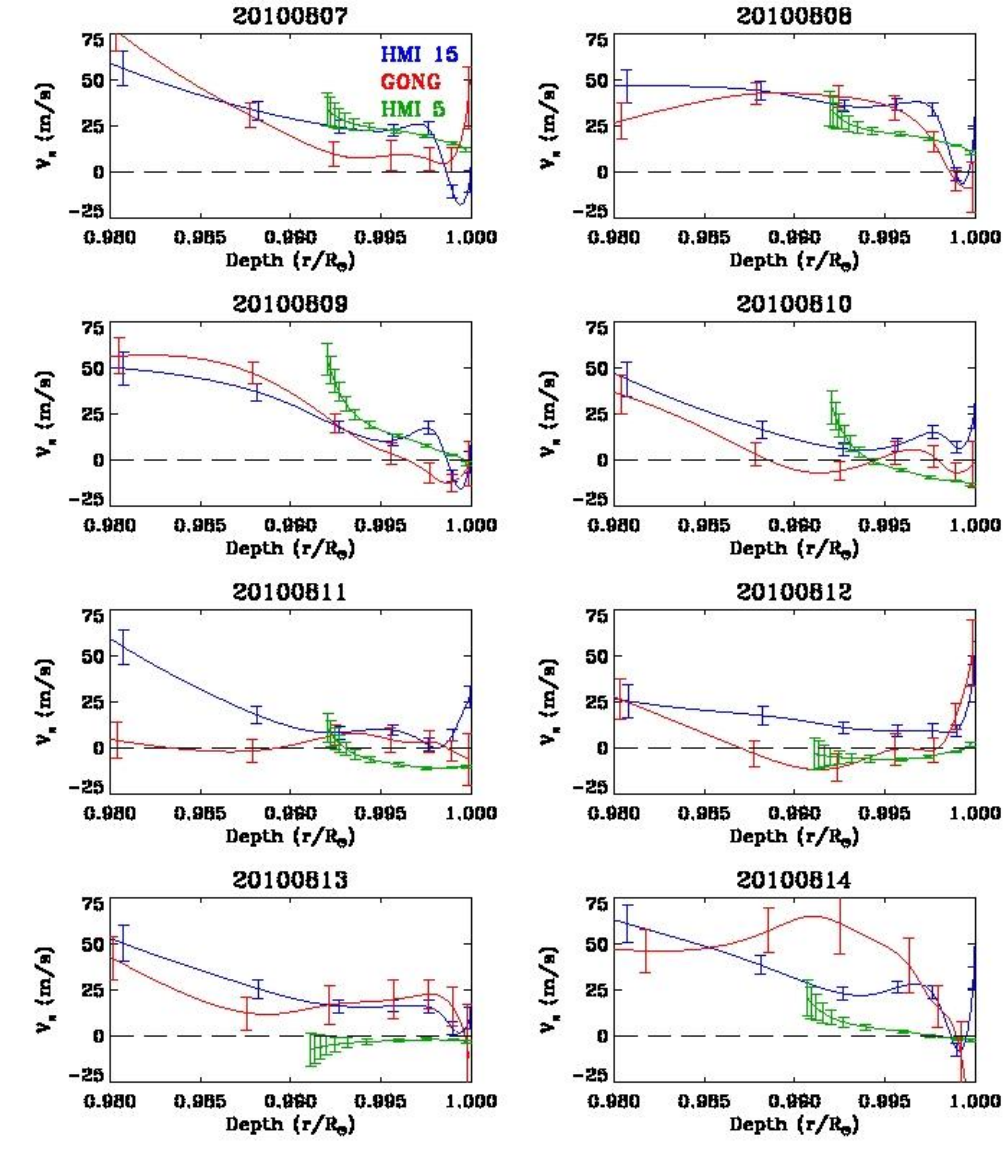
Comparison of meridional component between patches of different sizes





Meridional component of the velocity of 5^o are smaller (and even of opposite sign) compared to 15^o patches. However, when 9 patches of 5^o are averaged, the velocities are comparable.

Zonal component of sub-surface flows

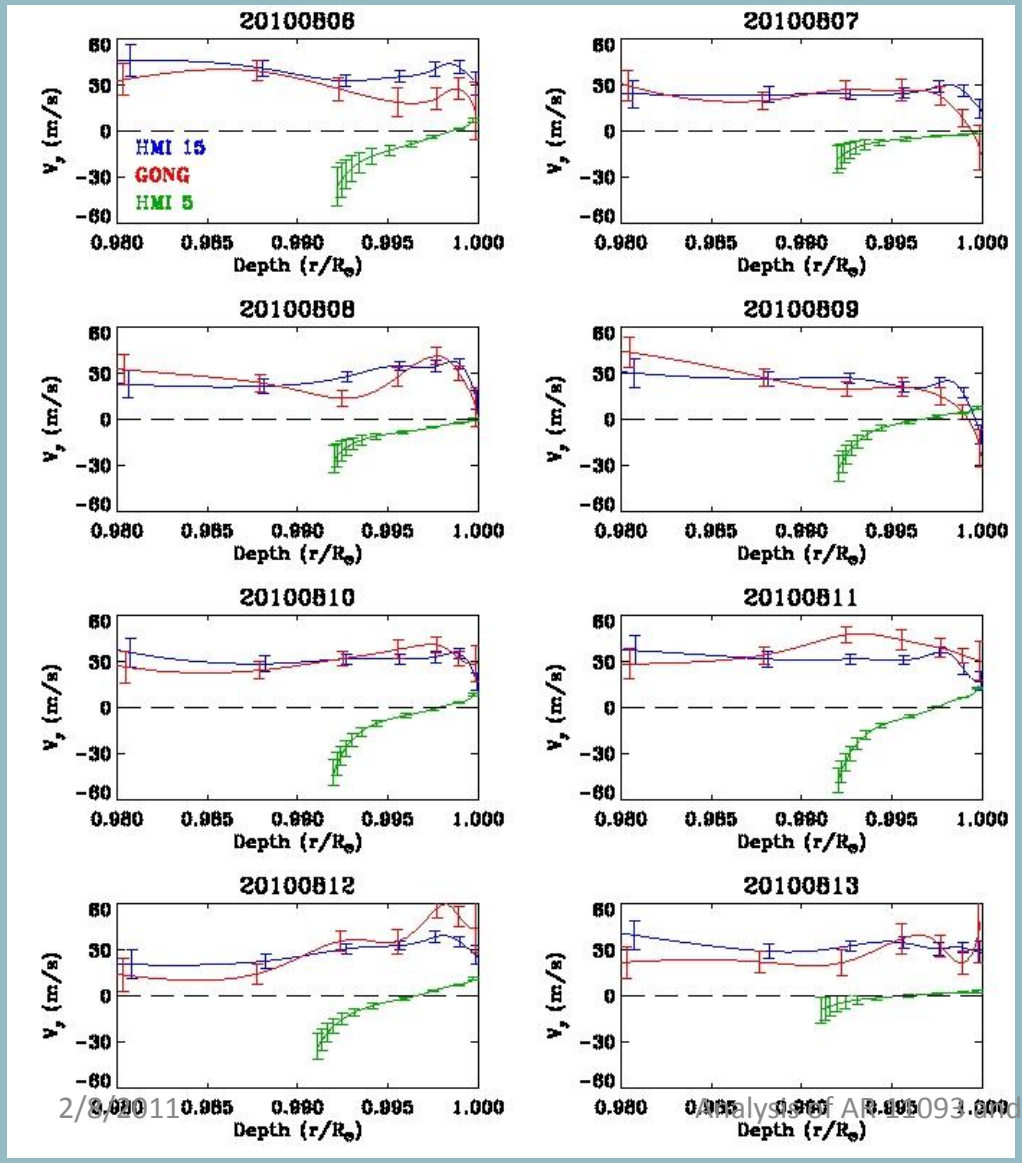


The flow pattern is similar between GONG and HMI data.

There is a daily variation and we will be analyzing these variations.

The flow pattern of 5^o patches shows a variation which is different from 15^o patches. The effect of magnetic field is stronger for the smaller patches.

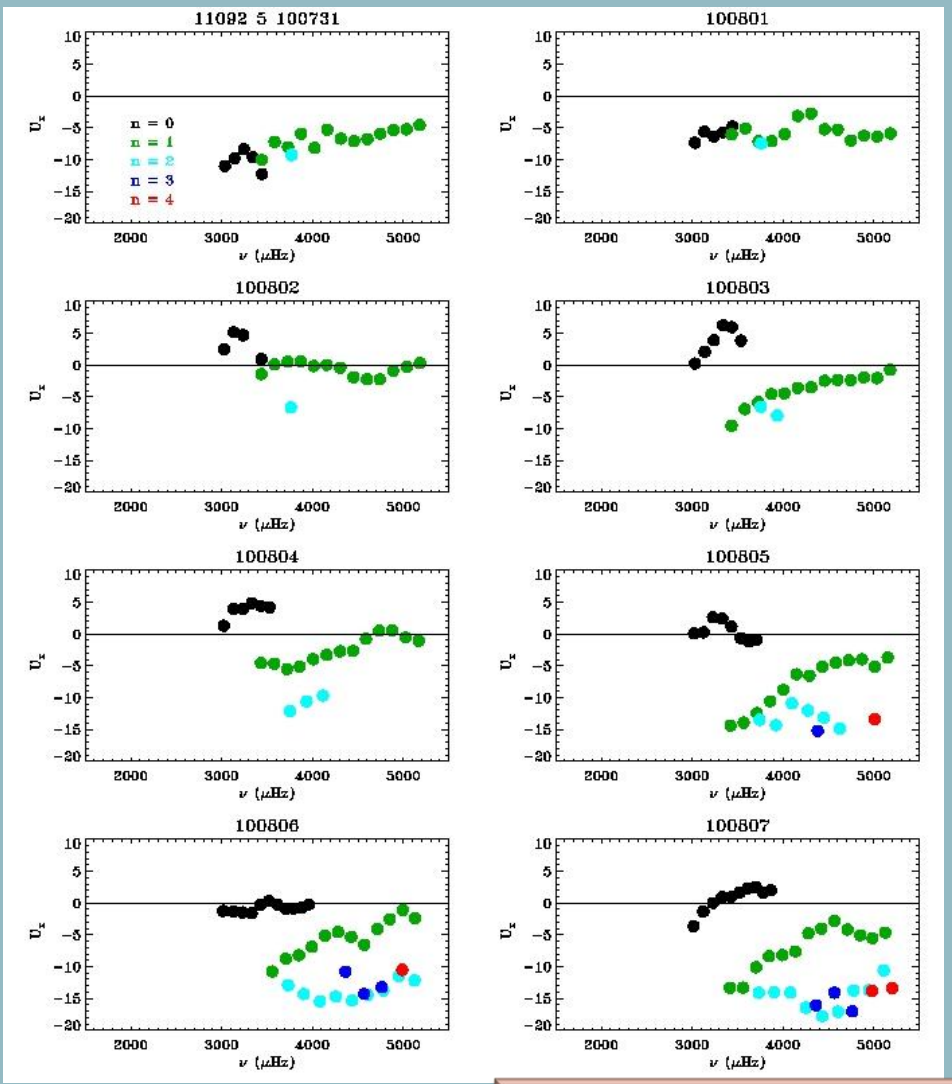
Meridional component of sub-surface flows

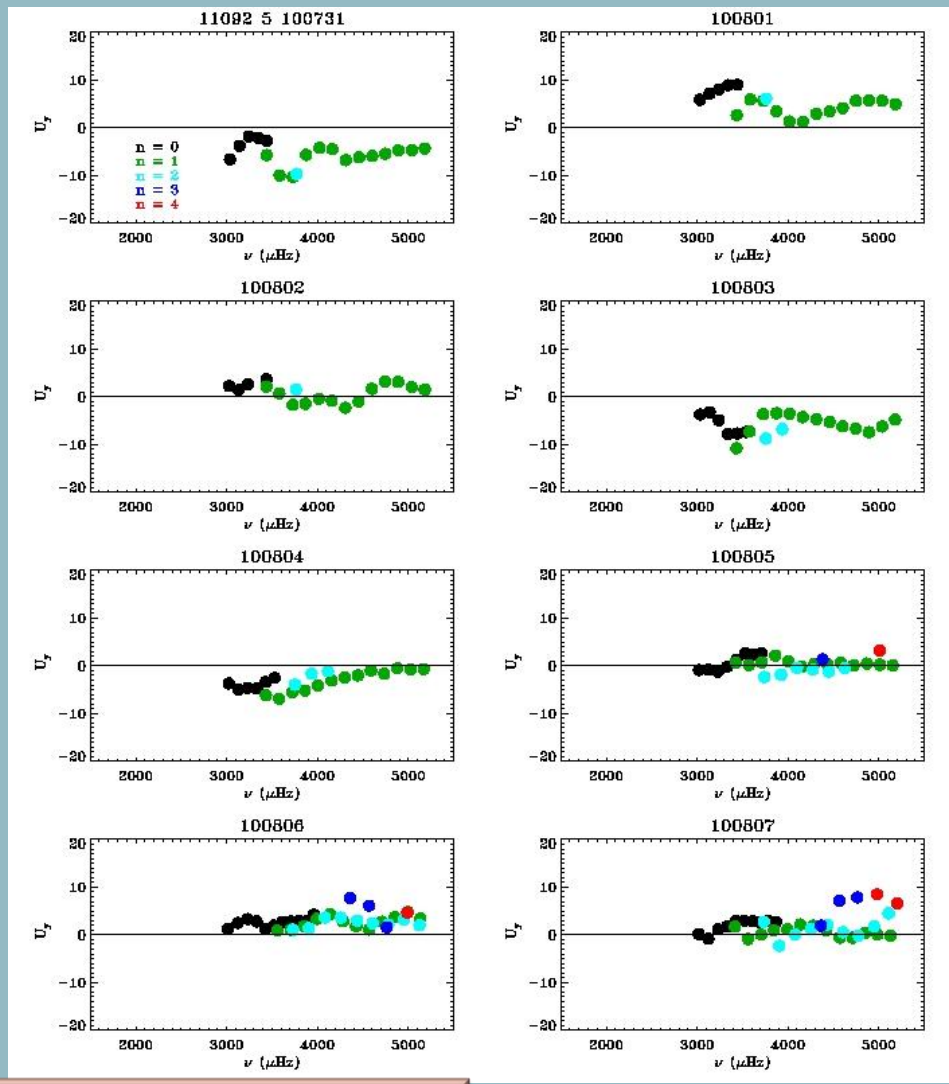


The flow pattern of 5^o degree patches are different than 15^o patches.

ANALYIS OF AR NOAA 11092

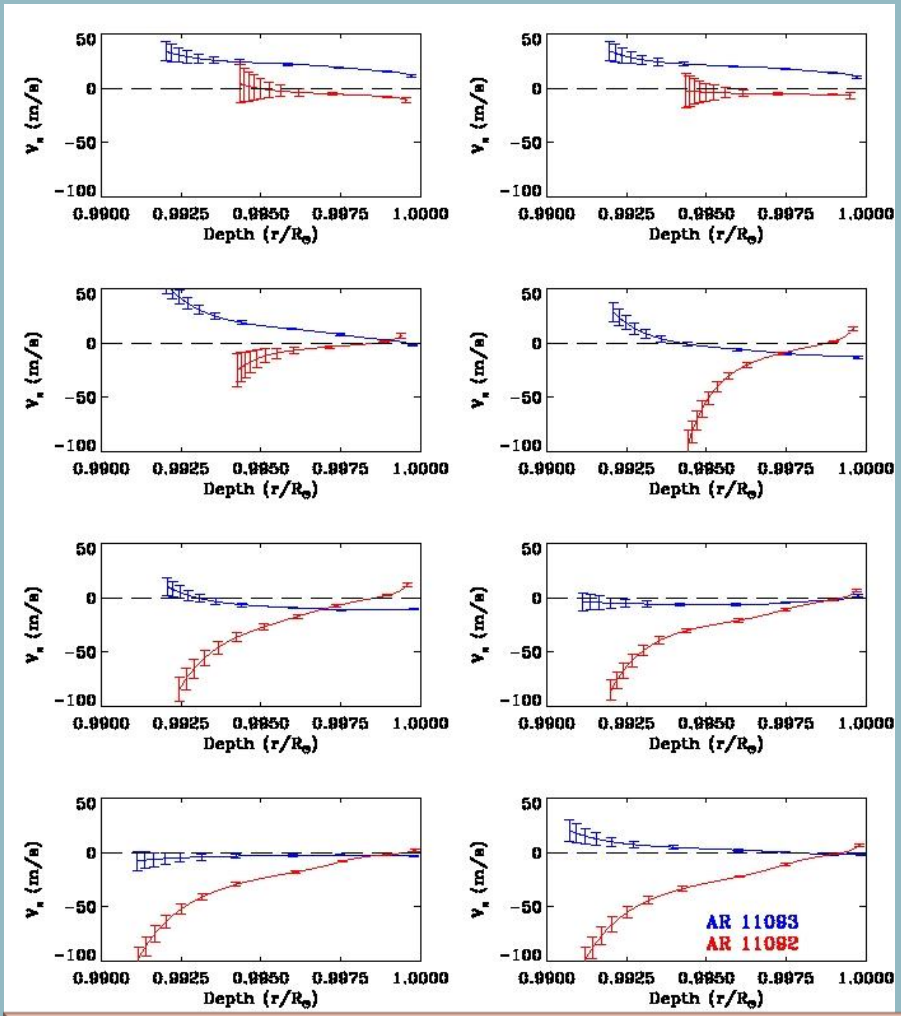
Variation of zonal and meridional component of velocity (AR 11092; 5^{o})



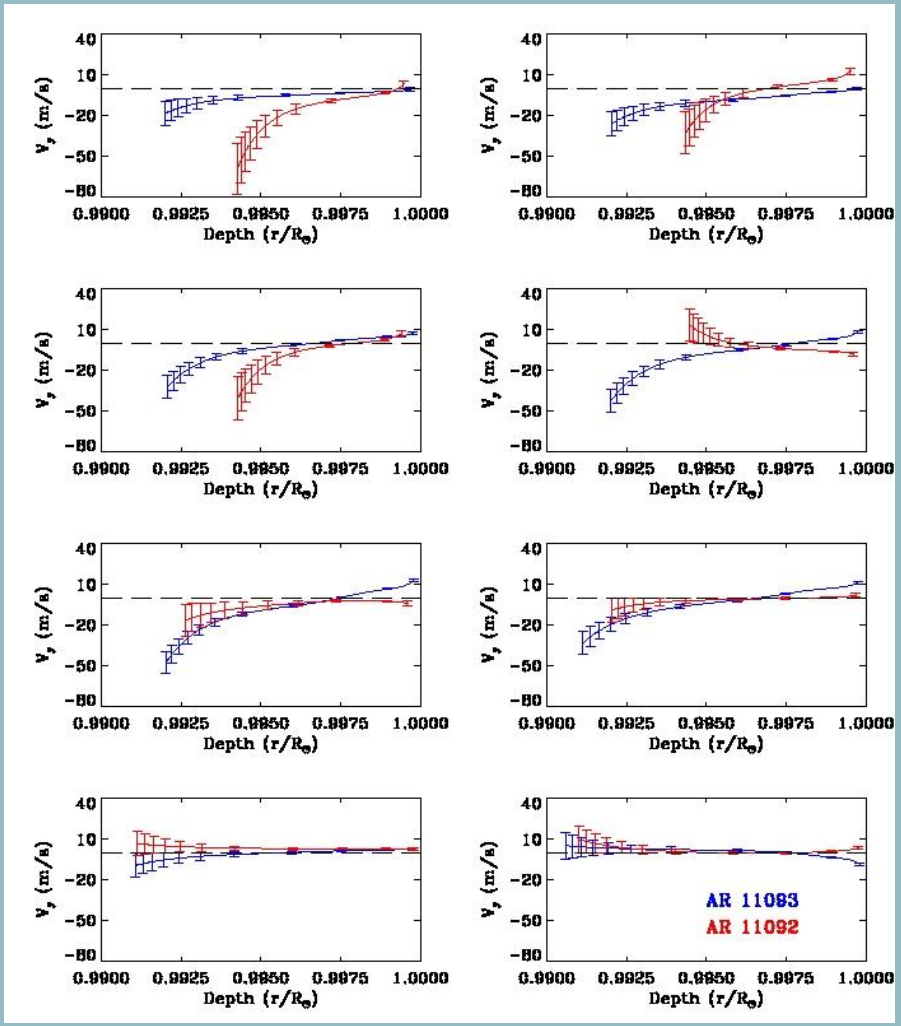


No systematic trend is visible

Comparison between AR 11092 and 11093



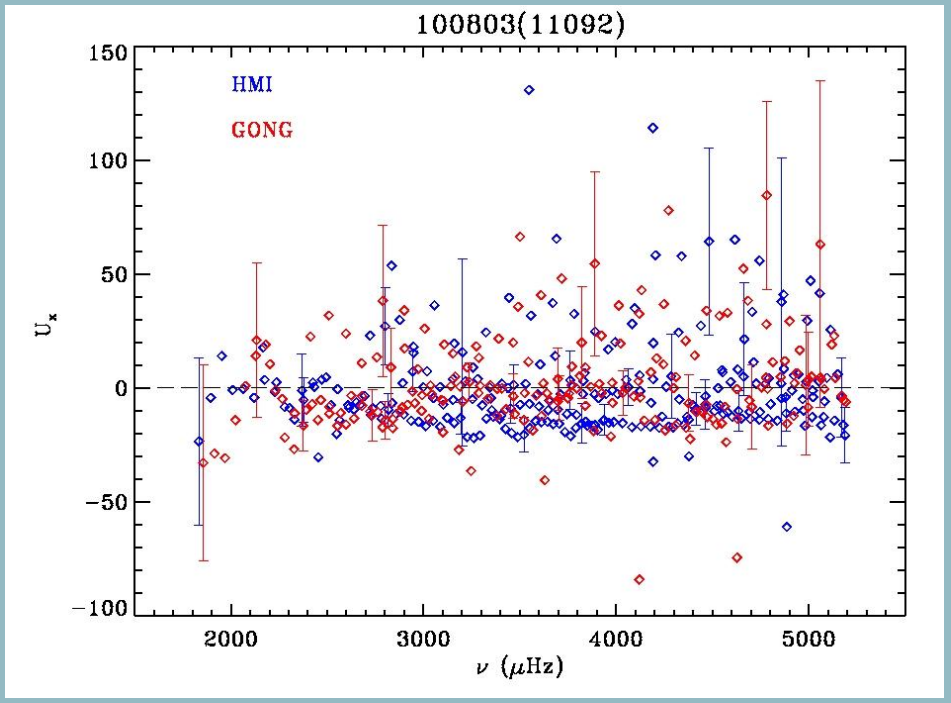
The zonal flows are different specially when the sunspot starts to break

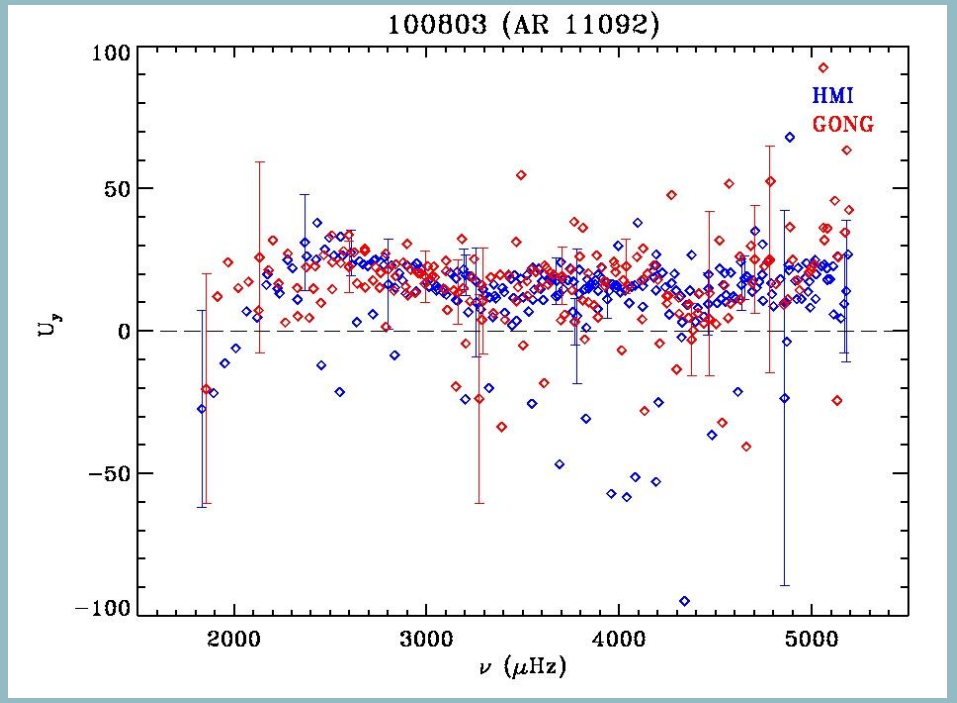


The meridional flows are similar

COMPARISON BETWEEN HMI AND GONG PARAMETERS

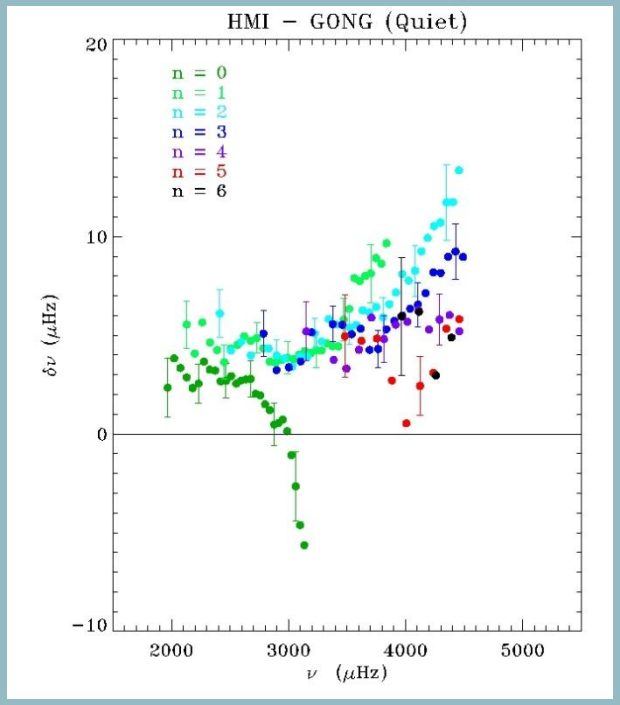
Comparison between HMI and GONG (AR 11092)

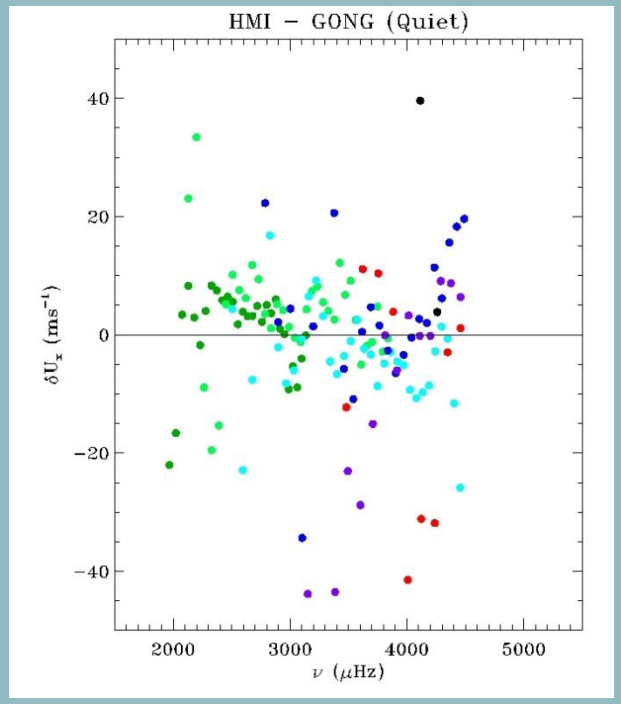


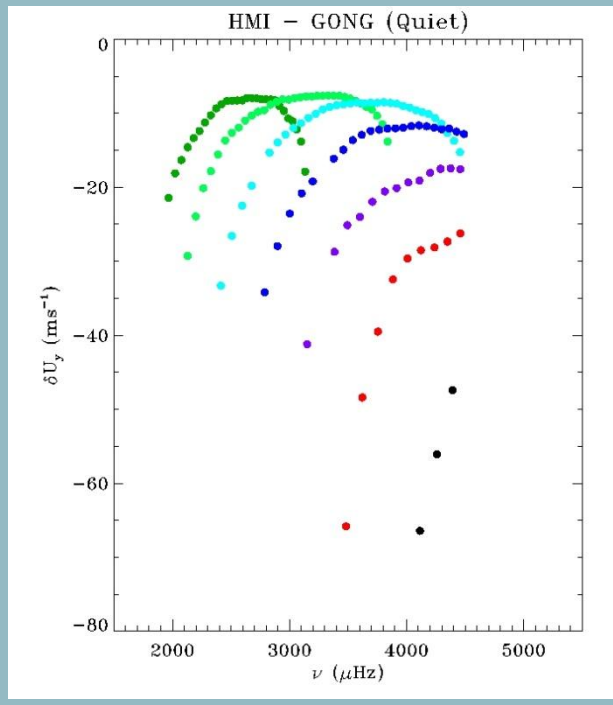


The flows are more consistent compared to AR 11093

Comparison between GONG and HMI (quiet region)

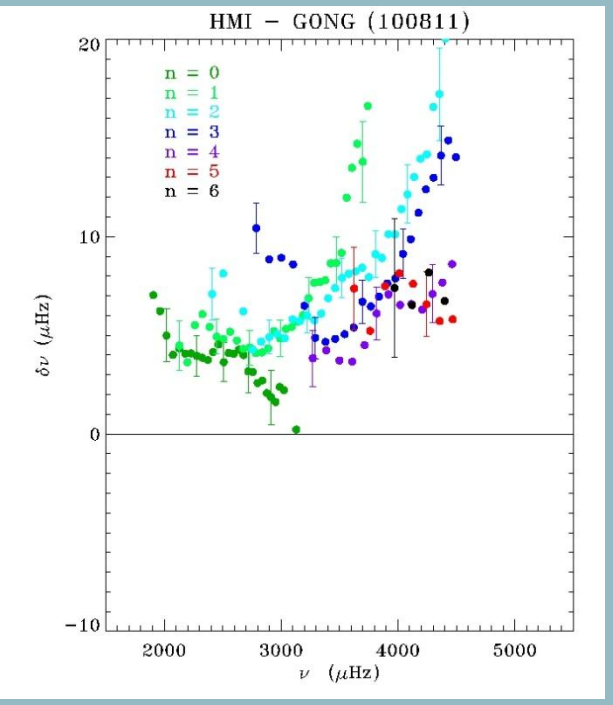


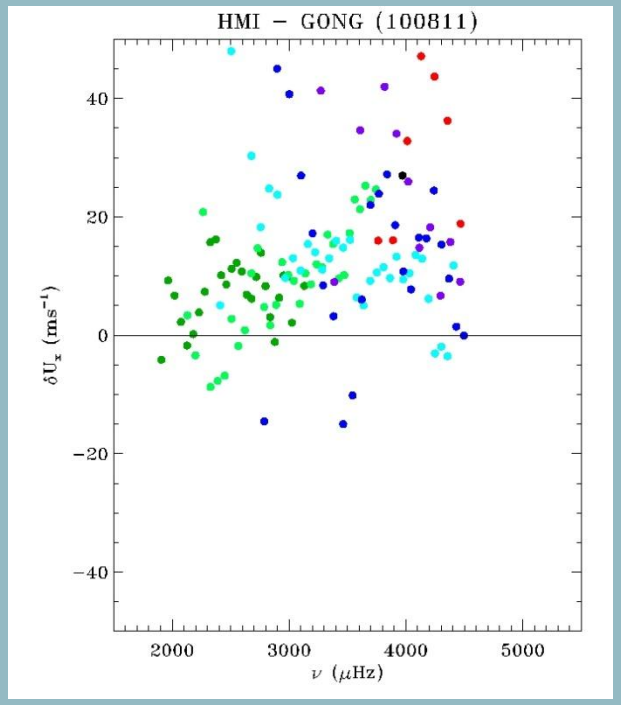


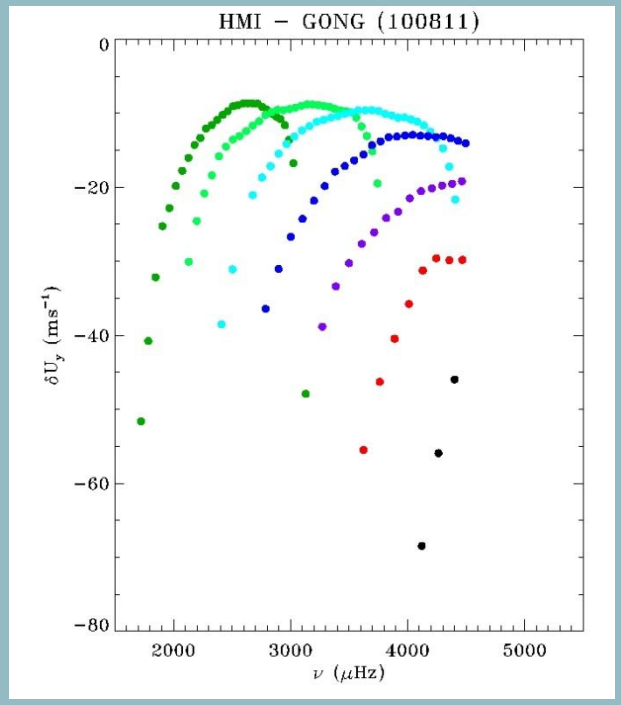


What surprises is the difference in meridional component of the Velocity

Comparison between GONG and HMI (Active Region)



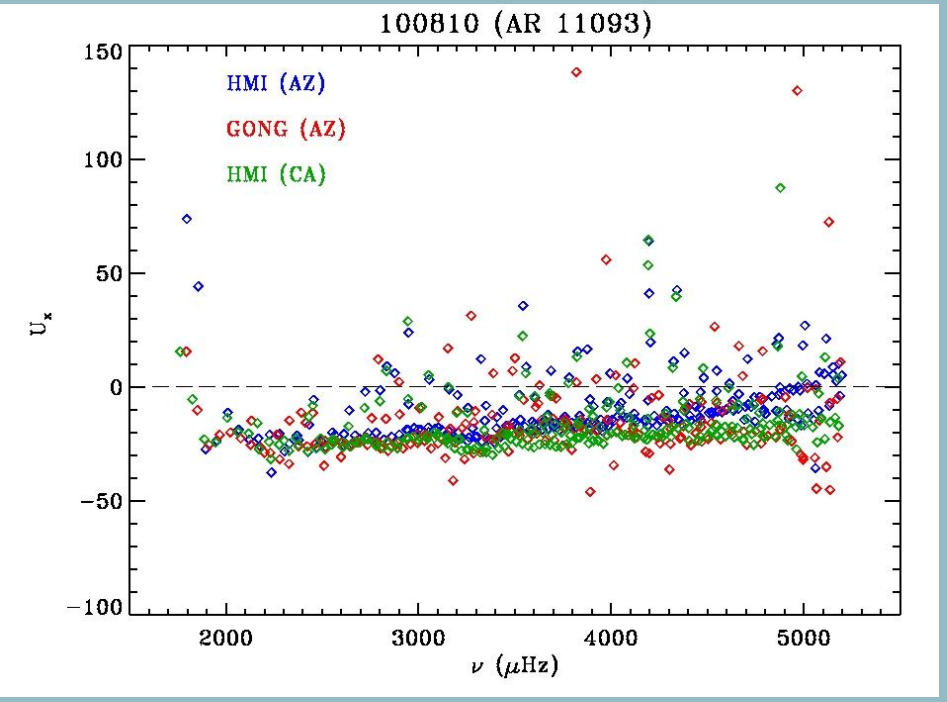


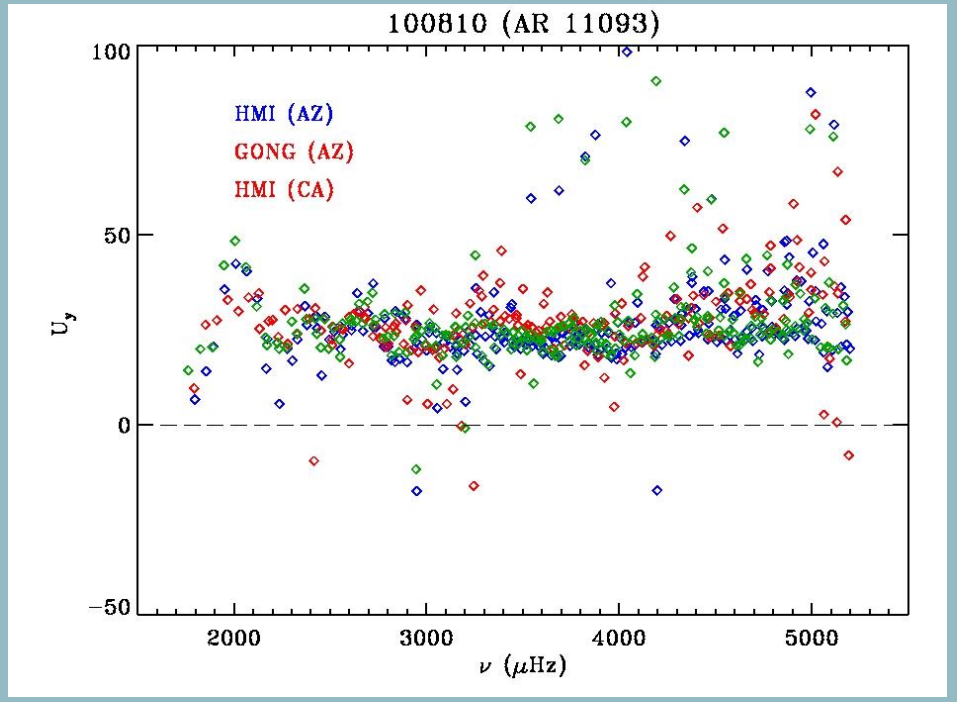


What surprises is the difference in meridional component of the Velocity

COMPARISON BETWEEN HMI AND GONG PIPELINES

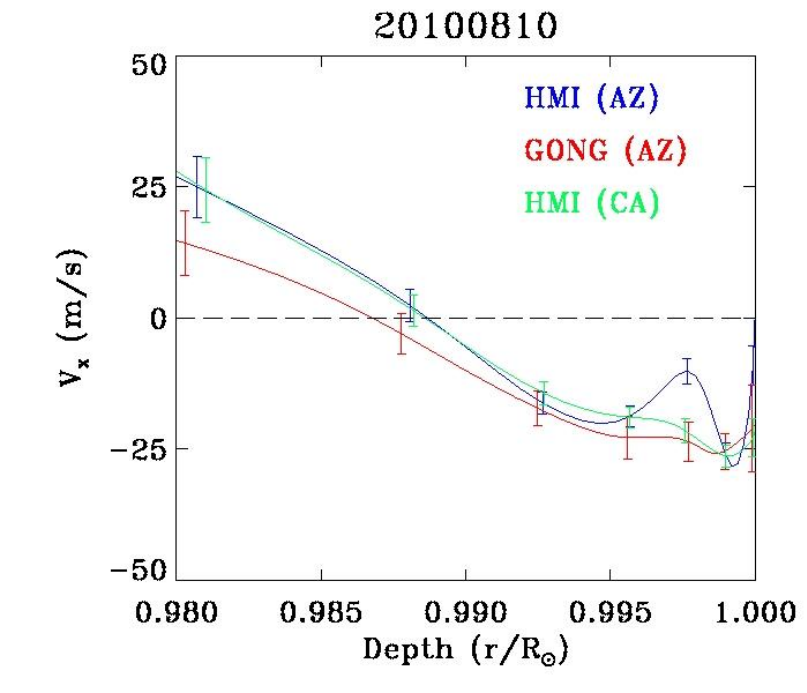
Comparison between HMI and GONG pipelines (surface flows)

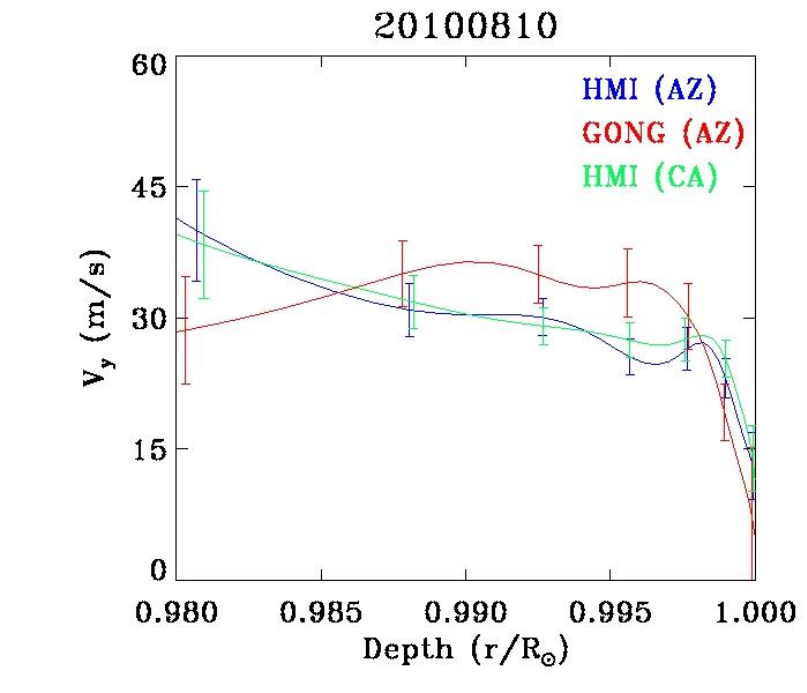




The surface zonal and meridional flows are in agreement between the two pipelines

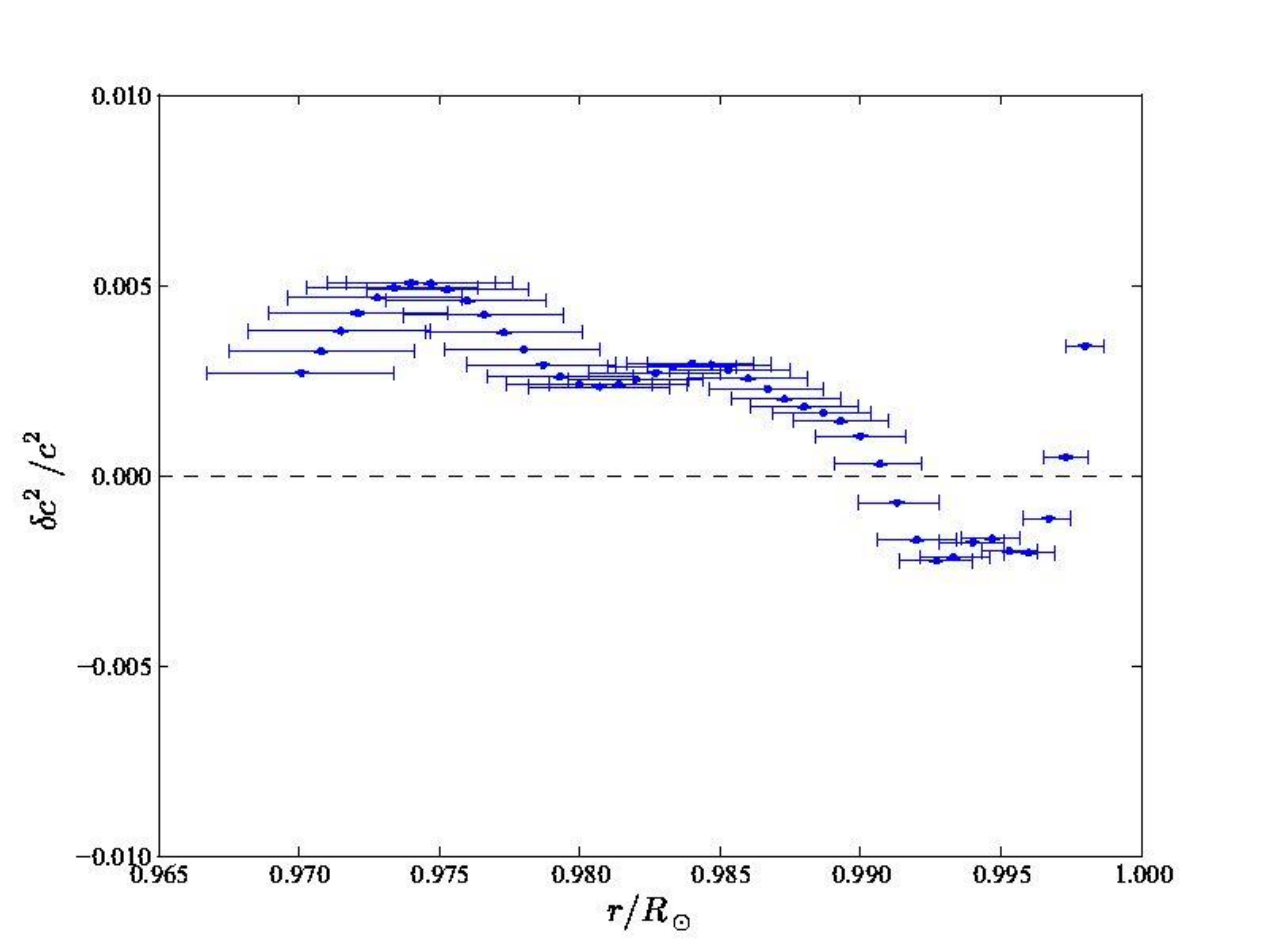
Comparison between HMI and GONG pipelines (sub-surface flows)





The sub-surface zonal and meridional flows within error estimates are in agreement between the two pipelines

Sound speed inversion



The regions are tracked at Carrington rate for a period of 3-days (Aug 9-11).

The preliminary sound speed profile is similar to those obtained for other ARs using MDI data.

Courtesy of C. Baldner

What have we learned !!

- It is better to analyze sunspot regions using HMI observations and smaller tiles (5^o). But effort is required to fit more modes.
- The flow velocities seen in smaller tiles are real (when we average over similar 15^o tiles, we get the same answer)
- There is some evidence that the flow patterns change before the sunspot bifurcates in AR NOAA 11093 but more detailed analysis is required.

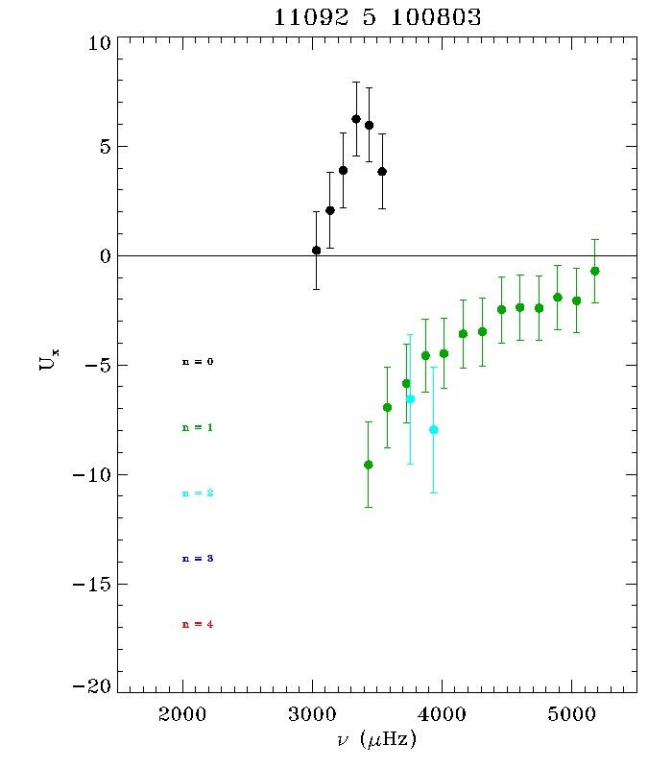
What have we learned !!

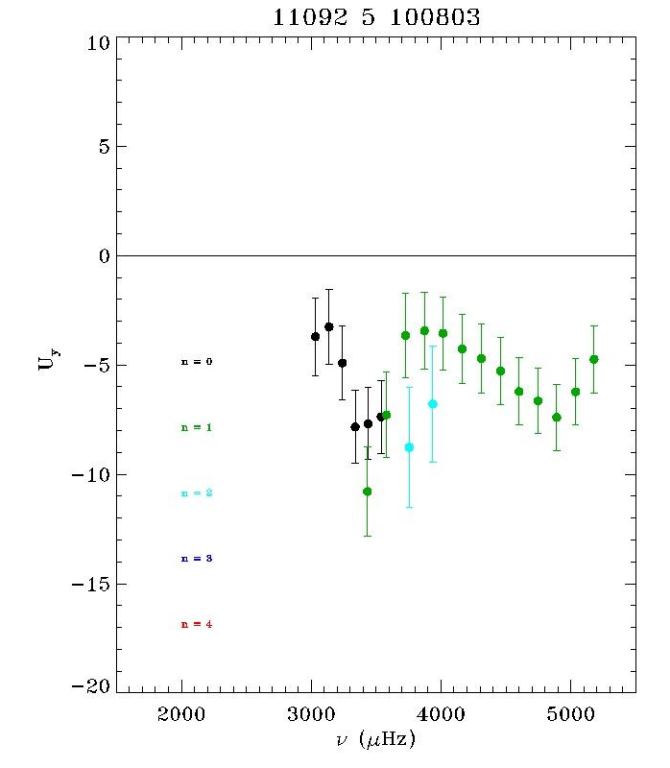
- Frequency calculated from HMI data are higher than those obtained from GONG observations (height dependency ? Different spectral line ?)

- In general, the velocities calculated between HMI (AZ), GONG(AZ) and HMI(CA) are in agreement, but there is a small frequency dependent difference in the surface meridional component between HMI (AZ) and GONG (AZ).

Thank You

Ux and Uy errors for 5 degree patch





AR 11092: FLOW (5degree)