

# Mode Frequencies from 17, 15 and 2 Years of GONG, MDI, and HMI Data

GONG-2012/LWS/SDO-3/SOHO-27 (Palm Cove, Queensland)

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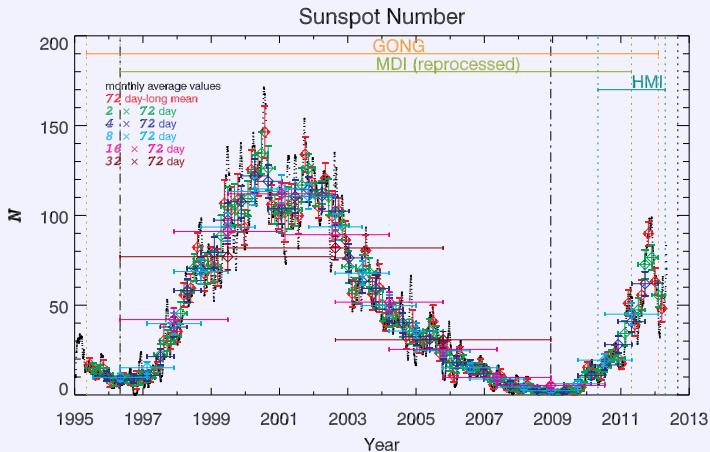
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# Introduction

- ▶ Fitted all available data sets with same fitting procedure *(Korzennik 2005 & 2008a,b)*
- ▶ Data
  - ▶ GONG: all data available so far, or  $171 \times 36$  days (16.85 years),
  - ▶ MDI: the *whole* mission, or  $76 \times 72$  days (14.98 years,  $2 \times 72$  days missing), used sph. harm. coefs computed with *improved* spatial decomposition
  - ▶ HMI: all data (sph. harm. coefs) available so far, or  $10 \times 72$  days (1.97 years,  $5 \times 72$  days overlap with MDI).
- ▶ Fitting Method
  - ▶ Fit individual singlets  $(n, \ell, m)$ ,
  - ▶ Use optimal sine-multitaper spectral estimator, complete leakage matrix, asymmetric profile, ...
- ▶ Fitted time-series of different lengths
  - ▶  $1 \times, 2 \times, 4 \times, 8 \times, 16 \times, 32 \times, 64 \times 72$  day long time-series
  - ▶ ***Trade-off between precision and temporal resolution***
- ▶ Fitted using different leakage matrices
  - ▶  $JS(B_o = 0)$ ,  $SGK(B_o = 0)$ ,  $SGK(B_o = \bar{B}_o)$

# Introduction – Activity

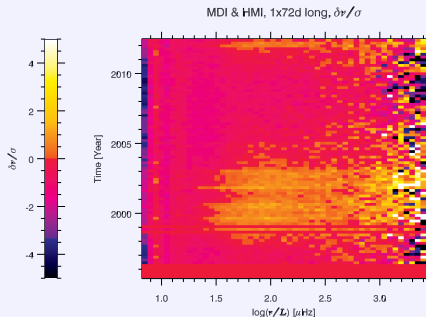
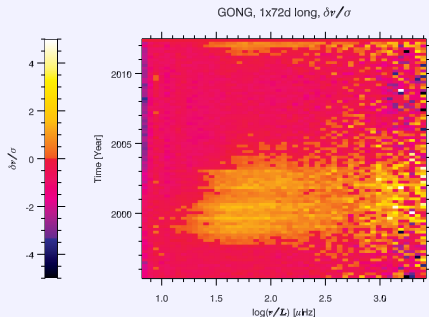


data	leaks	1 ×	2 ×	4 ×	8 ×	16 ×	32 ×	64 × 72d
GONG	$JS(B_0 = 0)$	85	84	40	19	8	3	1
	$SGK(B_0 = 0)$				19			
MDI	$JS(B_0 = 0)$	76	75	37	19	8	3	1
	$SGK(B_0 = 0)$		75	37	19	8	3	1
	$SGK(B_0 = \bar{B}_0)$		75	37				
HMI	$JS(B_0 = 0)$	10	9	3	1			

# Comparisons

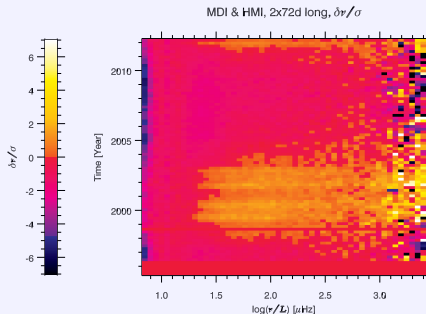
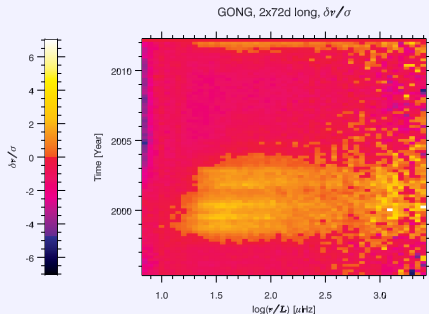
- ▶ Same fitting method
  - ▶ Same time intervals
  - ▶ Low attrition rate
- 
- ▶ GONG & MDI vs activity (time)
  - ▶ GONG vs MDI
  - ▶ MDI vs HMI
  - ▶ Different leakage matrix

# Changes with Activity



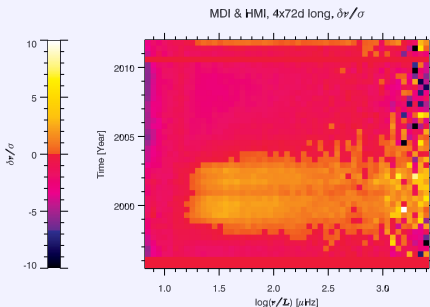
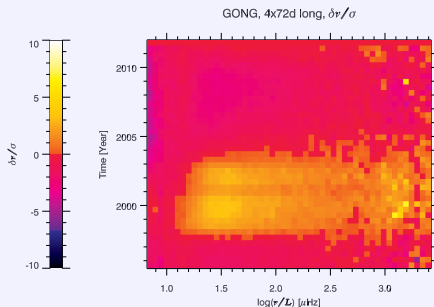
1x72d, GONG & MDI & HMI

# Changes with Activity



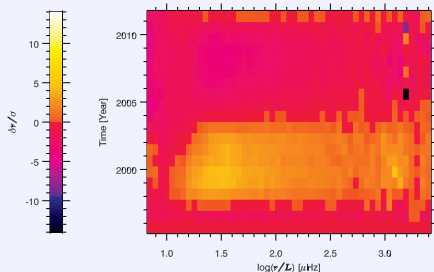
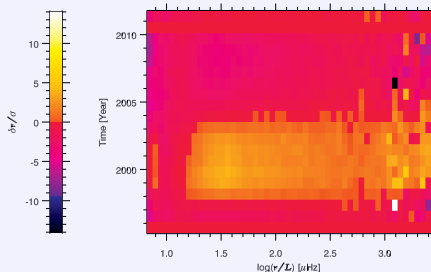
2x72d, GONG & MDI & HMI

# Changes with Activity



4x72d, GONG & MDI & HMI

# Changes with Activity

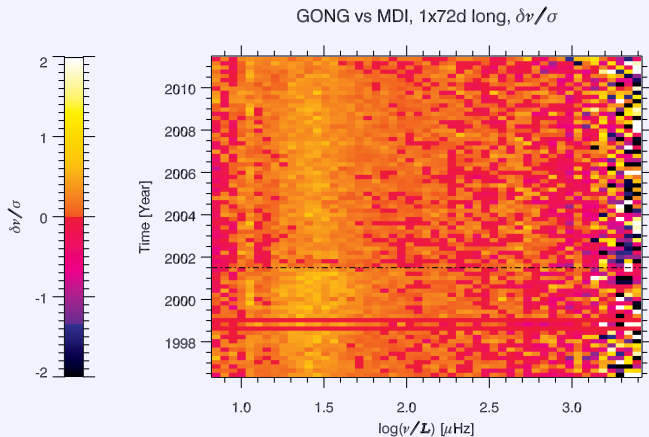
GONG, 8x72d long,  $\delta r/\sigma$ MDI & HMI, 8x72d long,  $\delta r/\sigma$ 

8x72d, GONG & MDI & HMI

[back to 1x72d](#)

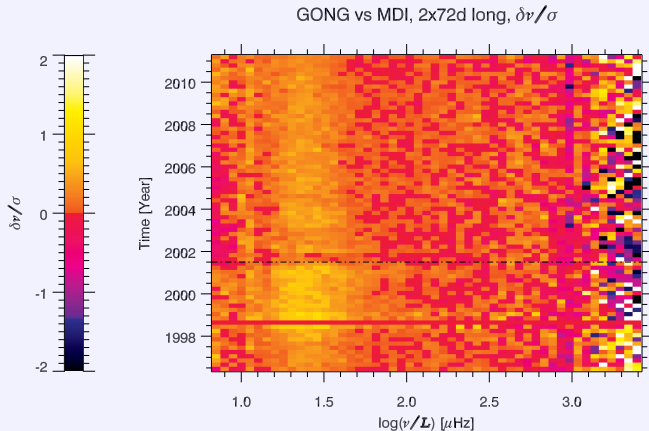


# Compare GONG to MDI



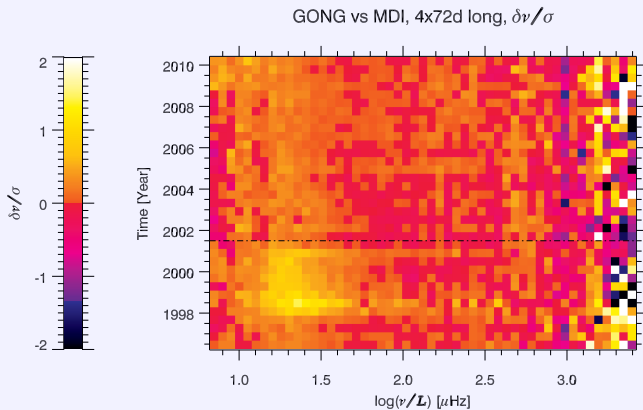
1 × 72d

# Compare GONG to MDI



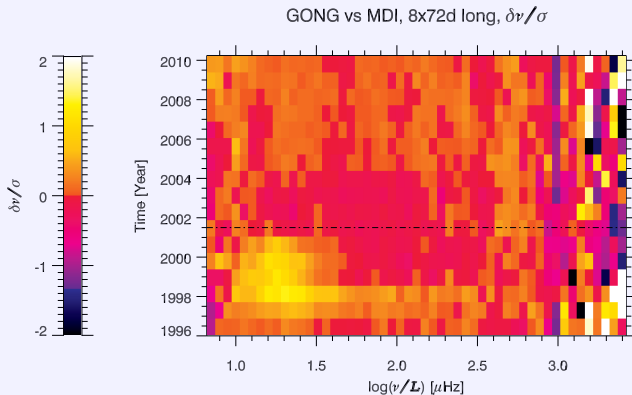
2×72d

# Compare GONG to MDI



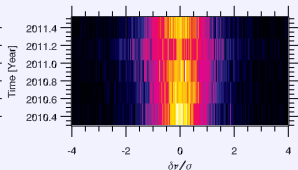
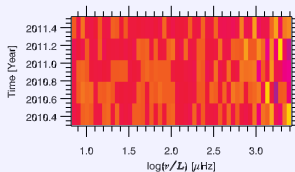
4×72d

# Compare GONG to MDI



8x72d

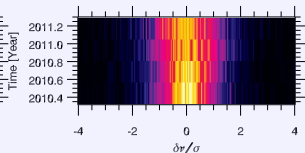
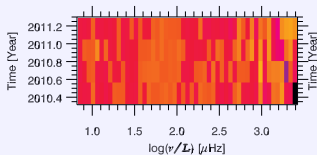
# Compare MDI to HMI



1x72d

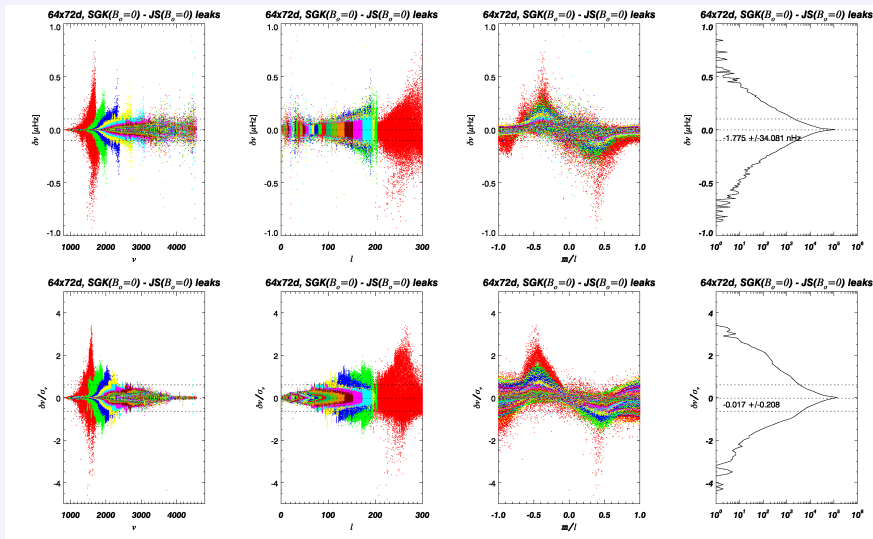
MDI vs HMI, 2x72d long,  $\delta\nu/\sigma$

MDI vs HMI, 2x72d long, histogram

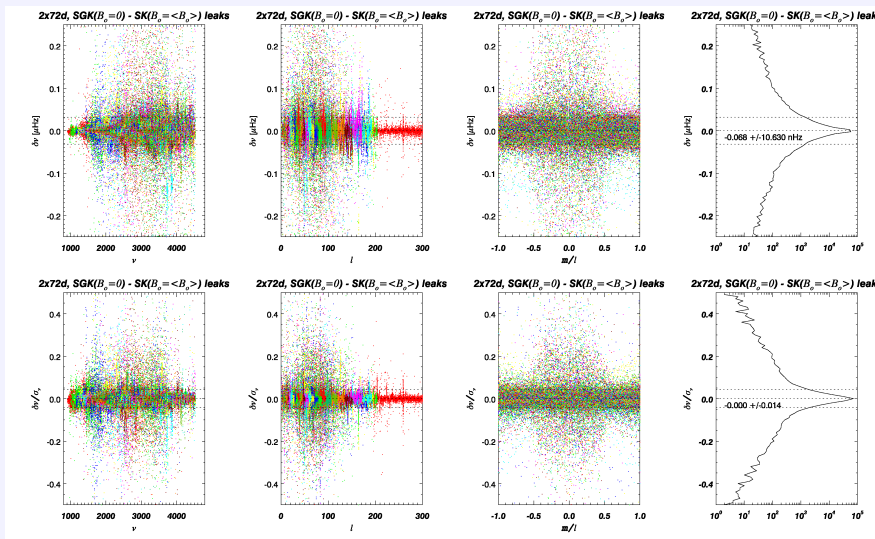


2x72d

# Compare leaks: JS vs SK



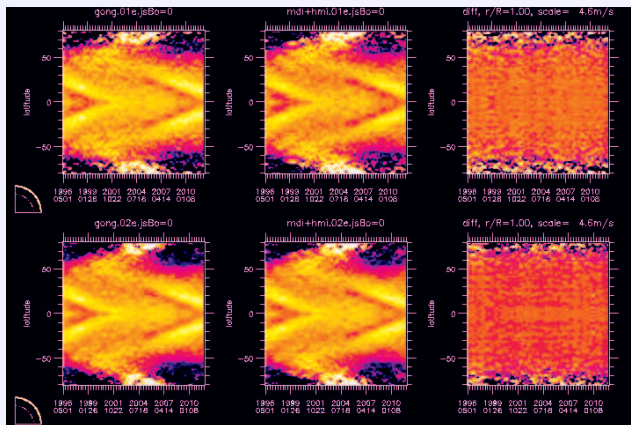
64x72d (singlets)

Compare leaks:  $B_0 = 0$  vs  $B_0 = \bar{B}_0$ 

2x72d (singlets)

# Solar Rotation Variation - Cuts at constant radius

$$\Omega(t, r, \theta) - \bar{\Omega}(r, \theta)$$

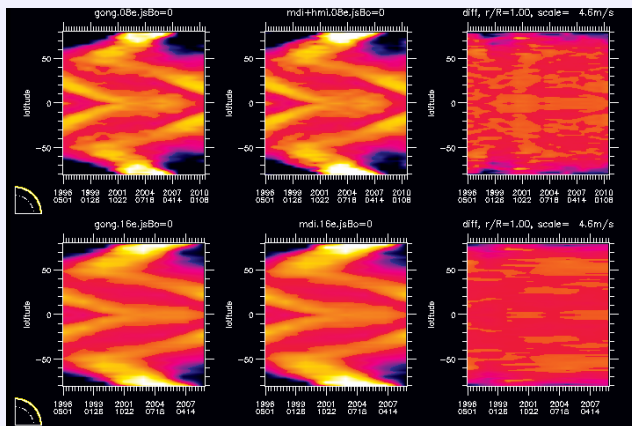


GONG & MDI & HMI for  $1 \times 72d$  &  $2 \times 72d$  cases



# Solar Rotation Variation - Cuts at constant radius

$$\Omega(t, r, \theta) - \bar{\Omega}(r, \theta)$$



GONG & MDI & HMI for 8x72d & 16x72d cases





# Conclusions

- ▶ Consistent set of frequencies across 3 instruments
- ▶ Comparisons
  - ▶ GONG to MDI: upgrade to GONG+, at the  $1\sigma$  level (relatively high)
  - ▶ MDI to HMI: nothing systematic, at the  $2\sigma$  level (surprisingly high)
  - ▶ Different leaks: small effects, at the  $0.1\sigma$  to  $2\sigma$  level
- ▶ Rotation:
  - ▶ High latitude branch visible (significant) when using longer time series
  - ▶ Deeper layers ???

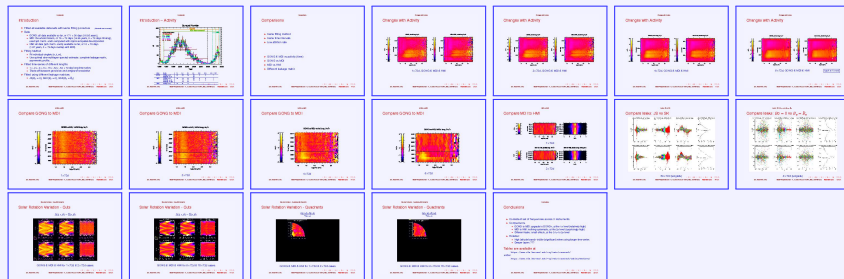
## Tables are available at

<https://www.cfa.harvard.edu/~sylvain/research/>

under

<https://www.cfa.harvard.edu/~sylvain/research/tables/MediumL/>

## The End

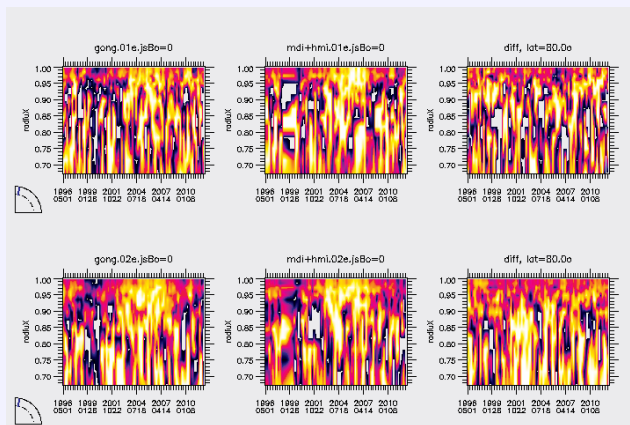


ADV – See Also Poster:

▶ [Korzennik et al, Accurate Characterization of High-Degree Modes using MDI data](#)

# Solar Rotation Variation - Cuts at constant latitude

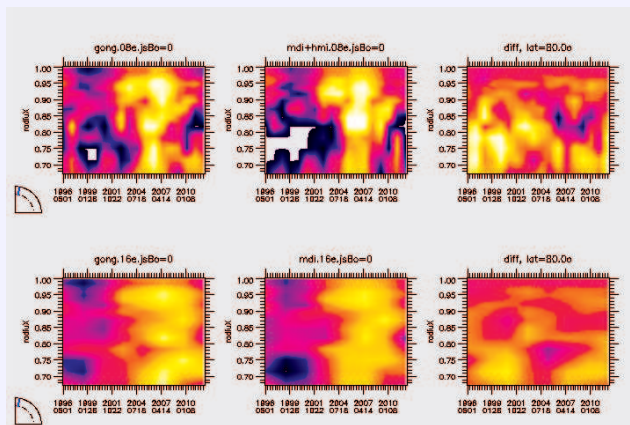
$$\Omega(t, r, \theta) - \bar{\Omega}(r, \theta)$$



GONG & MDI & HMI for 1×72d & 2×72d cases

# Solar Rotation Variation - Cuts at constant latitude

$$\Omega(t, r, \theta) - \bar{\Omega}(r, \theta)$$



GONG & MDI & HMI for 8x72d & 16x72d cases