Are short-term variations in solar oscillation frequencies the signature of a second dynamo?

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BiSON The Birmingham Solar Oscillations Network

Introduction

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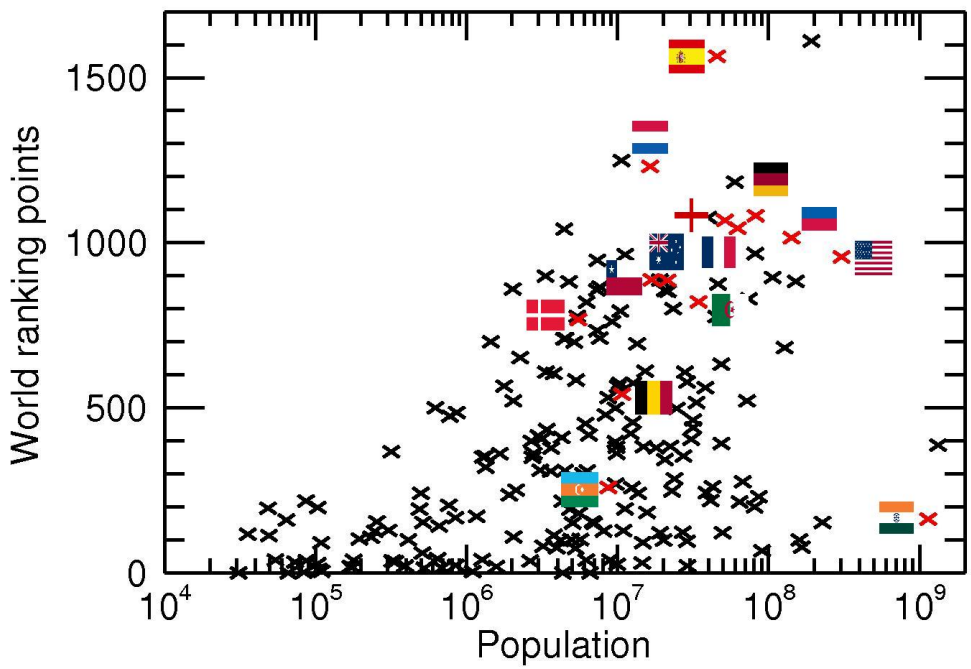
- Significant (quasi-periodic) variability in solar activity is also observed on shorter timescales.
- We have investigated a quasi-biennial signal that is observed in BiSON, GOLF (see arXiv:1006.4305) and VIRGO data.

Take care when comparing data

- Pearson's $\rho = 0.068$, $\text{significance} = 17\%$



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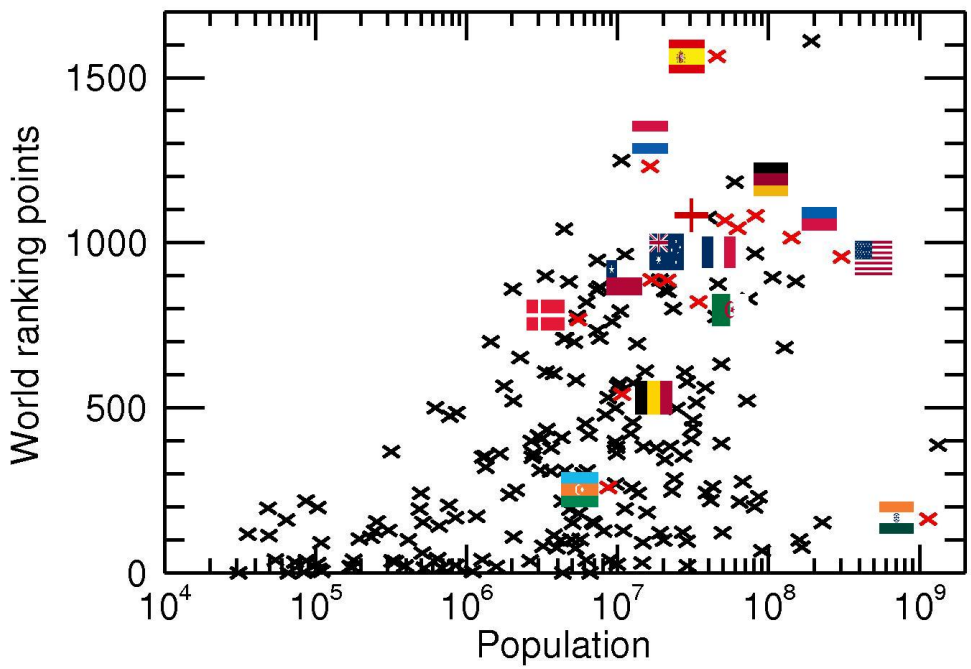

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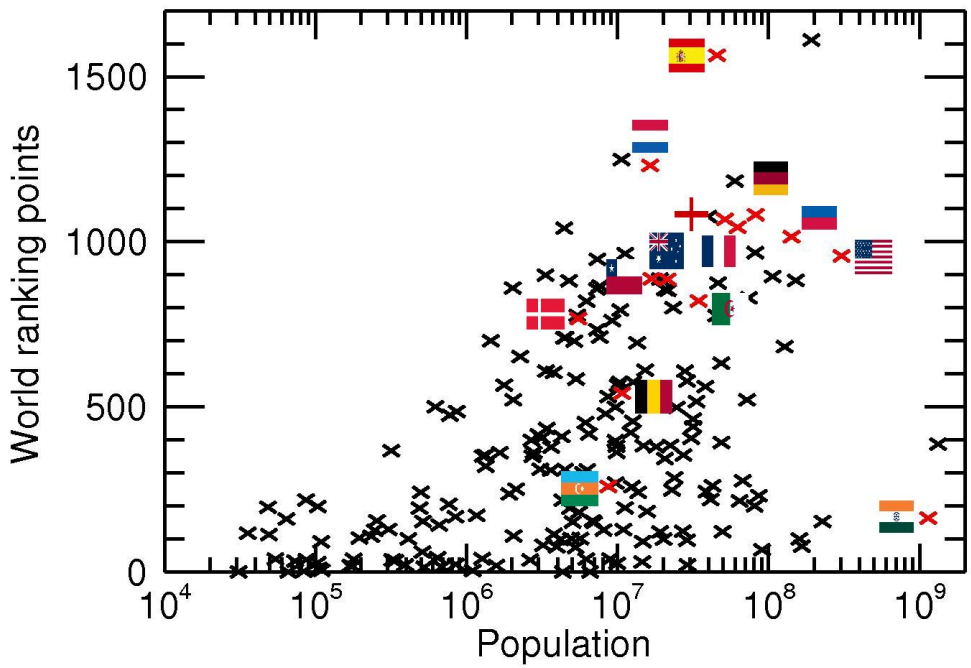
- When using log(population): Pearson's $\rho = 0.471$, $\text{significance} \lll 1\%$



The data

- BiSON, GOLF and VIRGO make Sun-as-a-star observations:
  - They observe low-degree p modes (here used $\ell \leq 2$).
- We have analysed
  - BiSON data from 1986 onwards.
  - GOLF and VIRGO data from 1996 onwards.
- We have split the data into short 182.5 d independent subsets.

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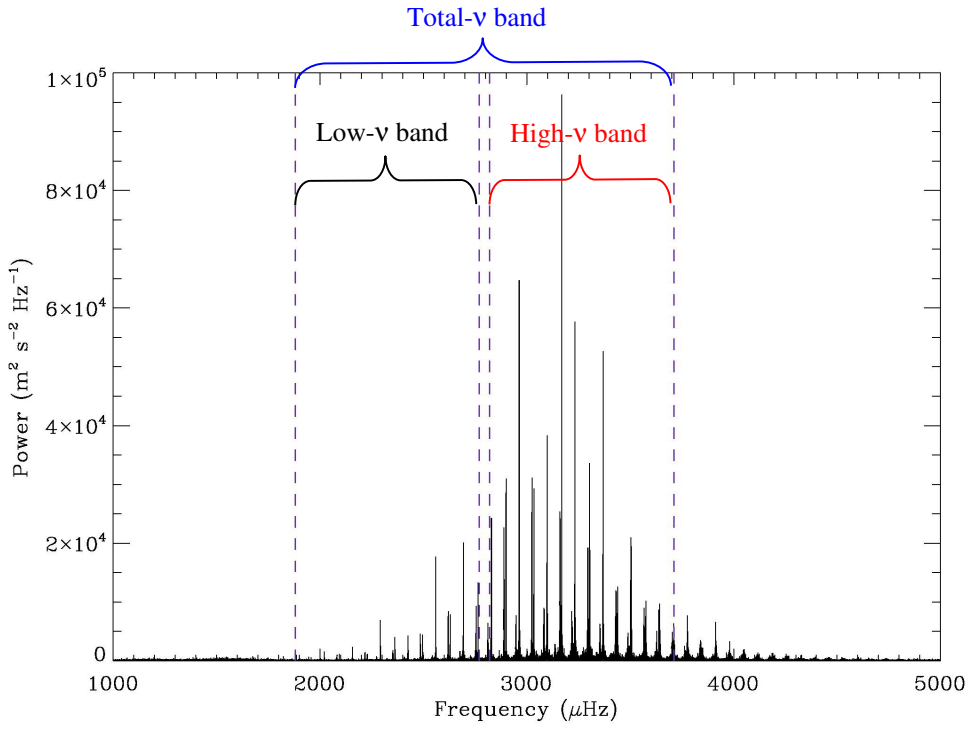
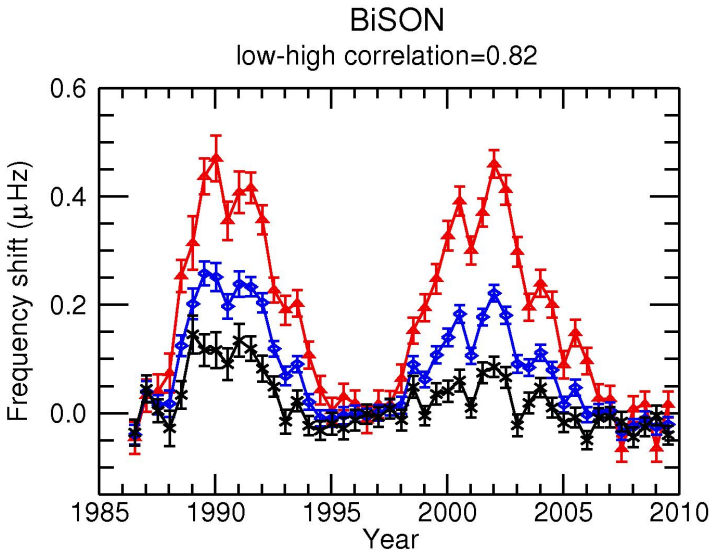
- For each 182.5 d segment we determined a weighted mean of the individual frequency shifts with respect to this reference set.

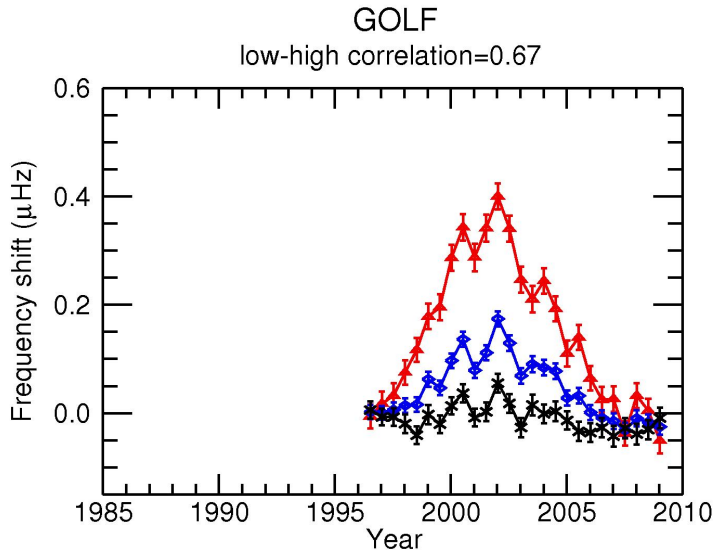
Examining different frequency ranges

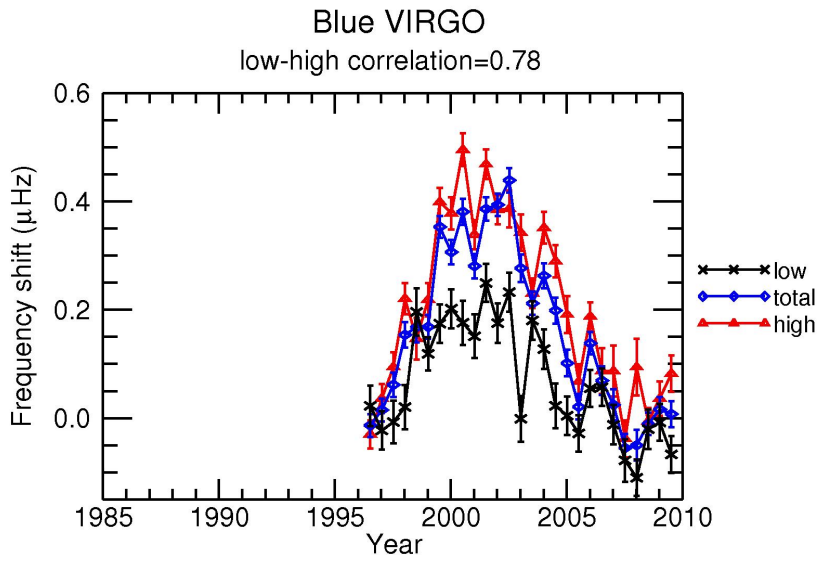
- We considered three frequency bands.
  - A "*total*" frequency range: 1.88-3.71 mHz.
  - A "*low*" frequency range: 1.88-2.77 mHz.
  - A "*high*" frequency range: 2.82-3.71 mHz.



The observed frequency shifts

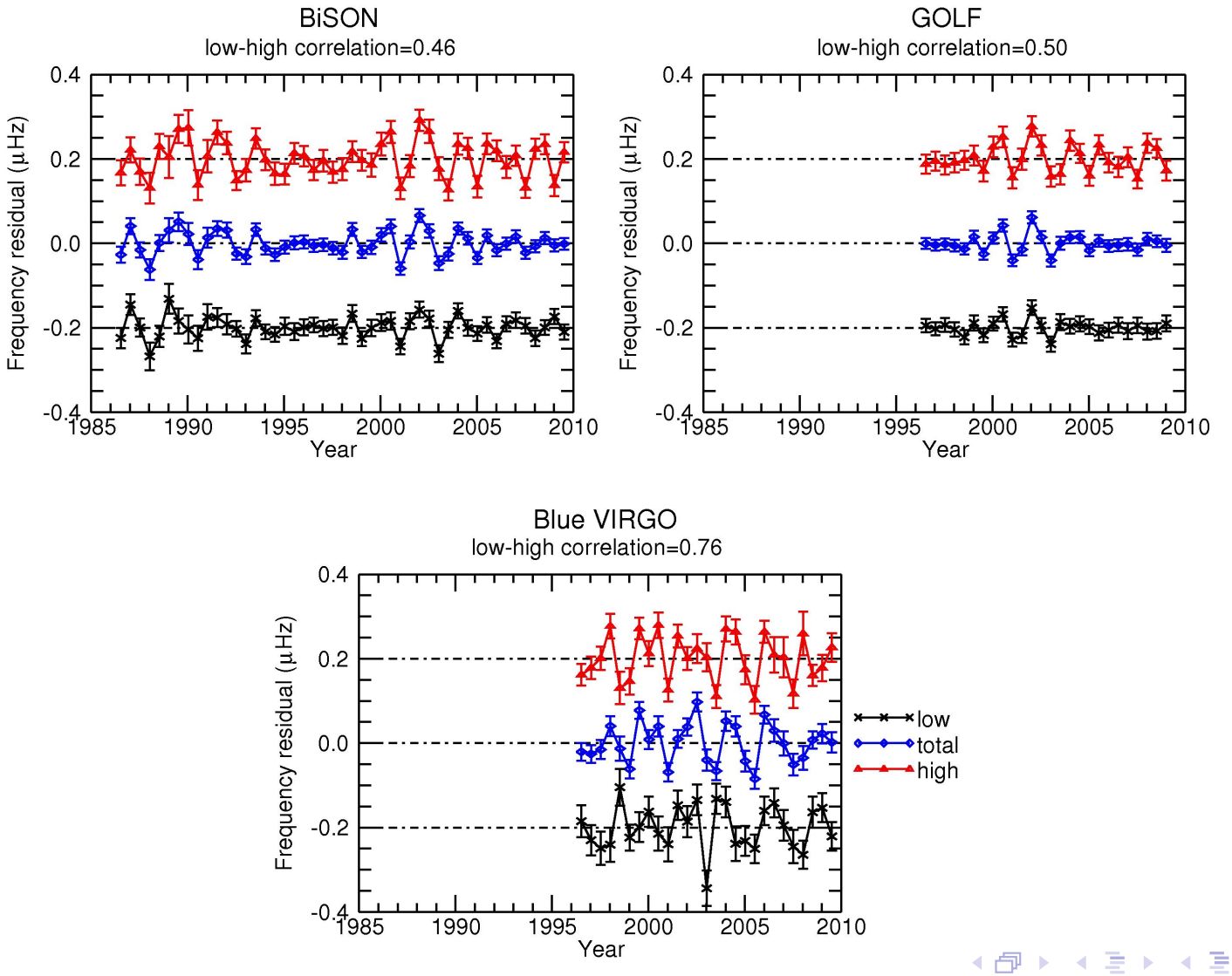




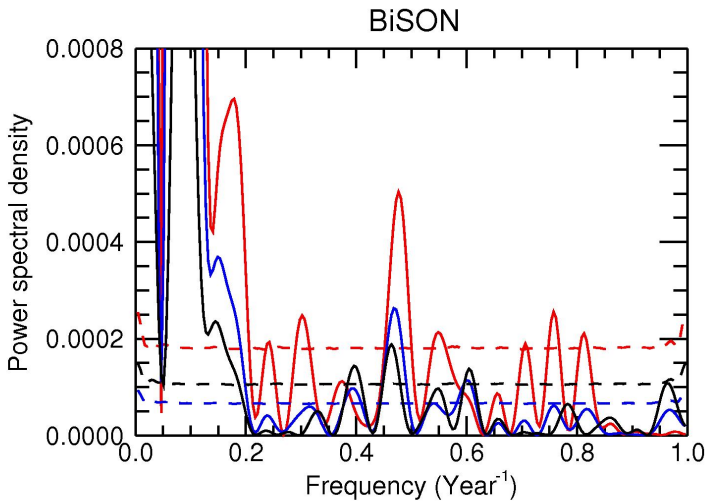


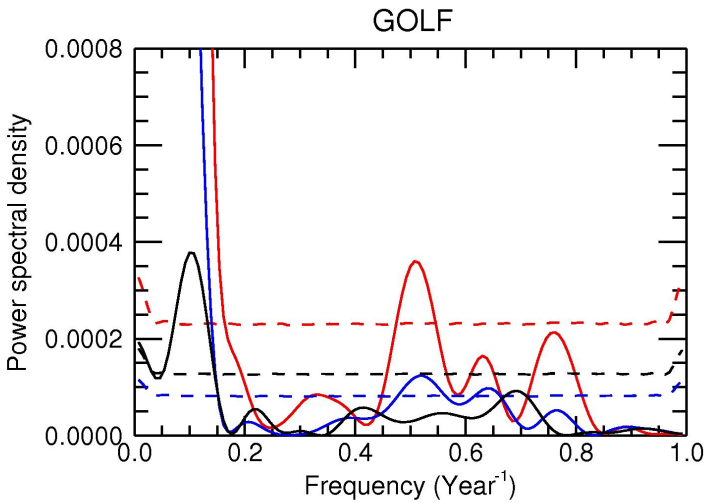
The quasi-biennial signal

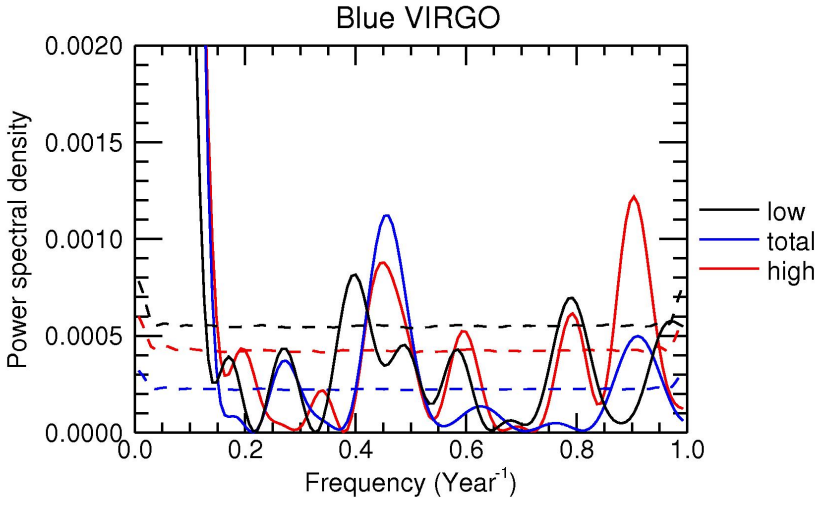
- BiSON-GOLF correlations are significant to less than 1%.



Periodograms of the frequency shifts







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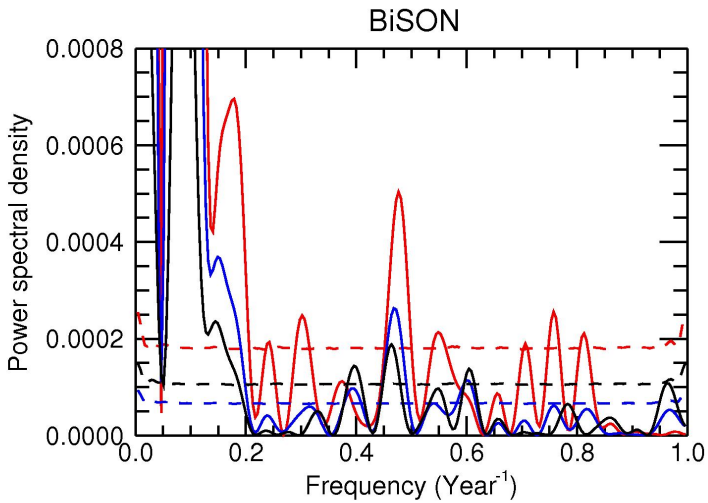

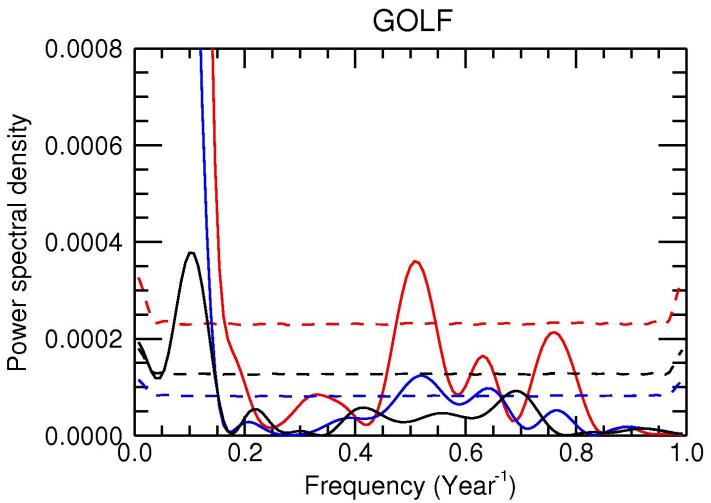

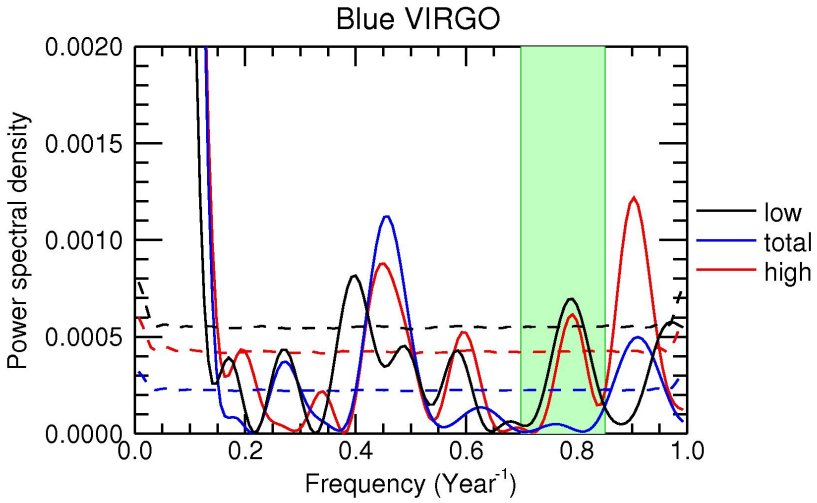

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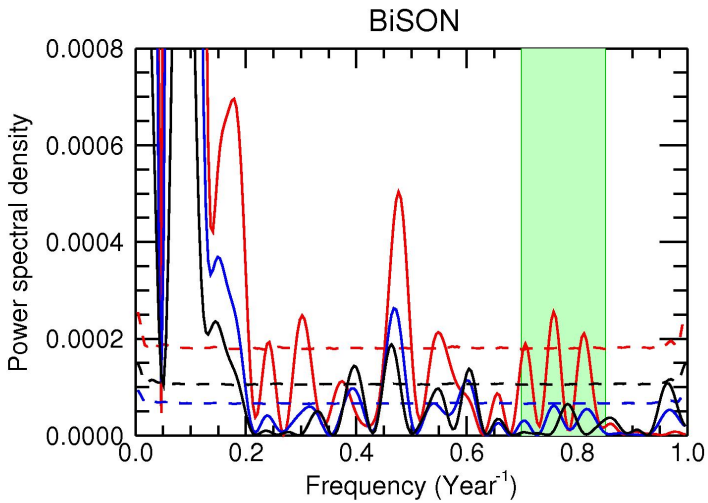

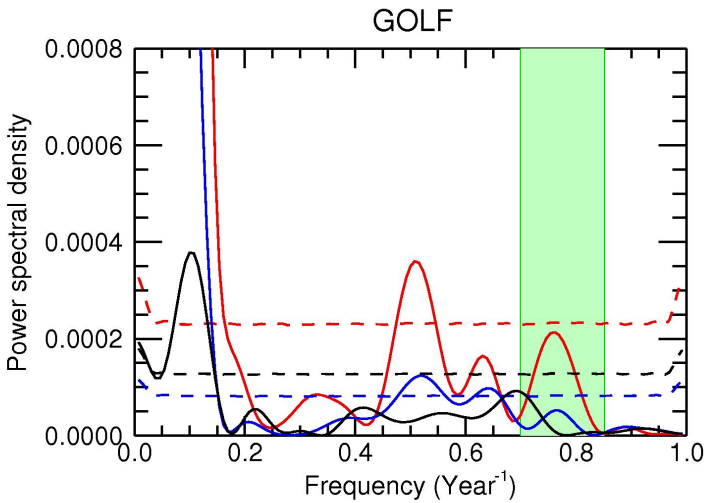

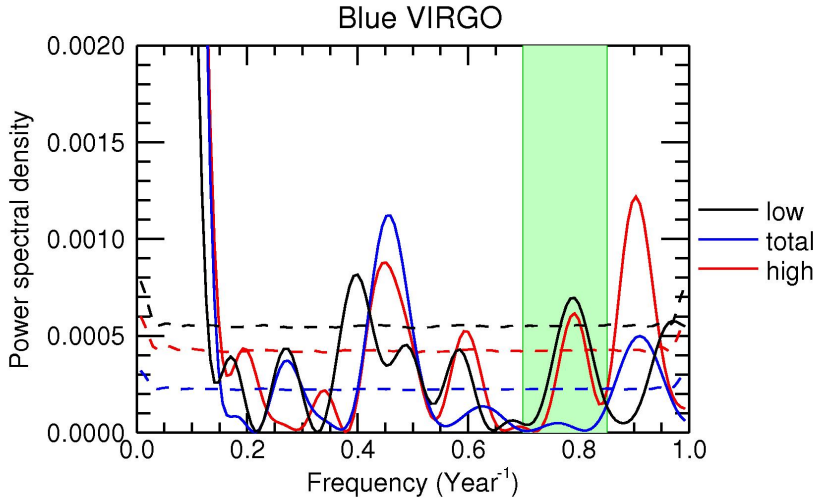

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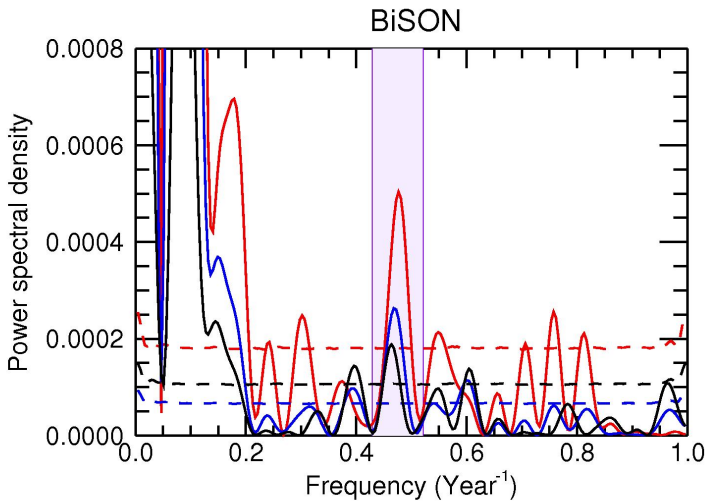

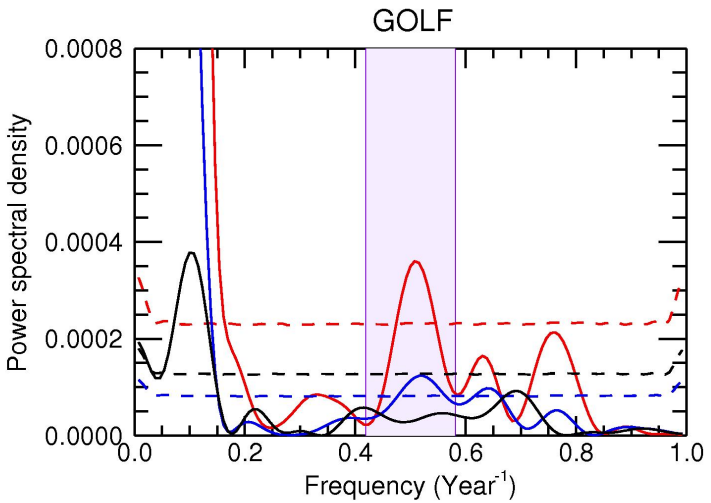

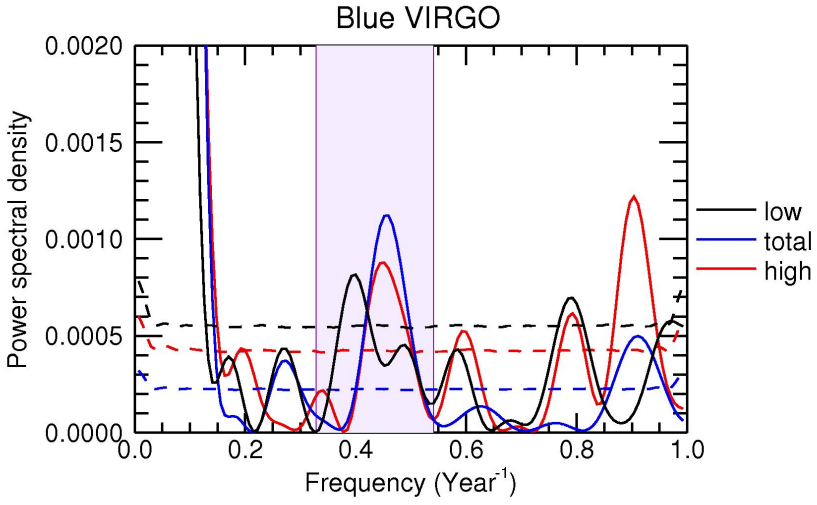

Is this evidence for a second dynamo?

- One possibility is a dynamo action seated near the bottom of the rotational shear layer extending 5% below the surface.
- When the 11-yr cycle is in a strong phase the buoyant magnetic flux rise from the base of the convection zone.
  - This could nudge the magnetic field processed by the second dynamo into shallow layers.
- When the 11-yr cycle is in a weak phase the second dynamo would not be buoyant enough to be detected in modes or other proxies.

Conclusions

- A quasi-biennial signal is visible in all three data sets.
- The signal appears to be
  - distinct and separate from
  - but nevertheless susceptible to

  the main 11-year solar cycle.
- One possible explanation is a second dynamo.

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- Thanks for listening!

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- One possibility is a dynamo action seated near the bottom of the layer extending 5% below the surface.
- This region shows strong rotational shear.

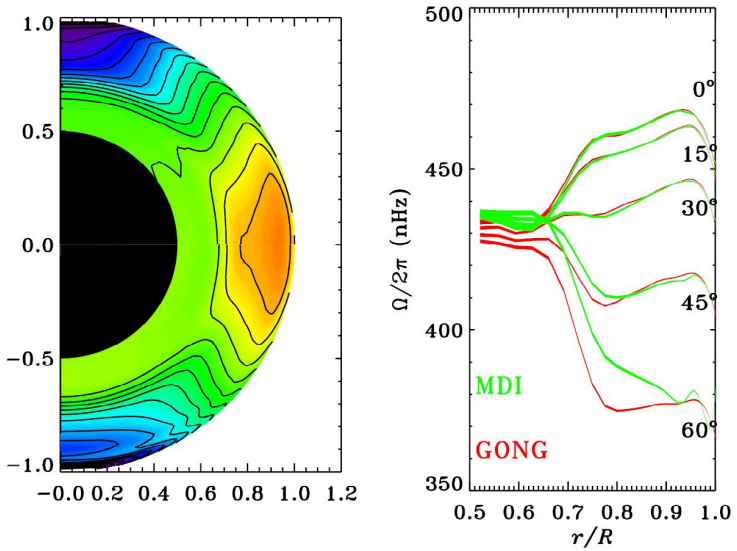

Figure: Courtesy of R. Howe and appearing in Chaplin & Basu, 2008, Sol. Phys, 251, 53.