Unveiling stellar magnetic activity using CoRoT seismic observations

Savita Mathur

High Altitude Observatory/National Center for Atmospheric research, Boulder, USA

R.A. García, D. Salabert, J. Ballot, C. Régulo, T.S. Metcalfe, A. Baglin

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Motivation

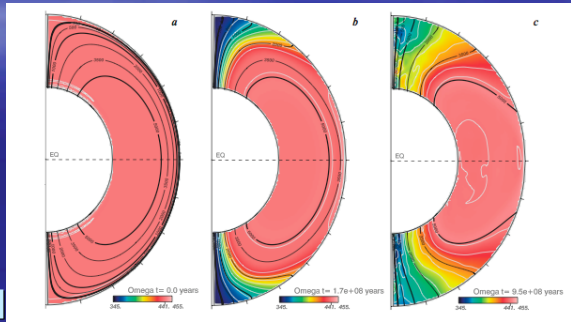
- Modeling of stellar dynamos: dependence on evolutionnary timescale [e.g. Baliunas et al. 1995; Jouve & Brun 2007]
- Cool star, like the Sun, with an $\alpha\Omega$ dynamo: longer period rotation ➔ longer cycle period [e.g. Thomas & Weiss 2008]

$$P_{cyc}/P_{rot} = \Omega/\Omega_{cyc} = CR_0^q$$

with $R_o=P_{rot}/\tau_c$, the Rosby number, τ_c the convective turnover time and q changing from 0.25 to 1

[Ossendrijver 1997; Saar 2002; Jouve et al. 2010]

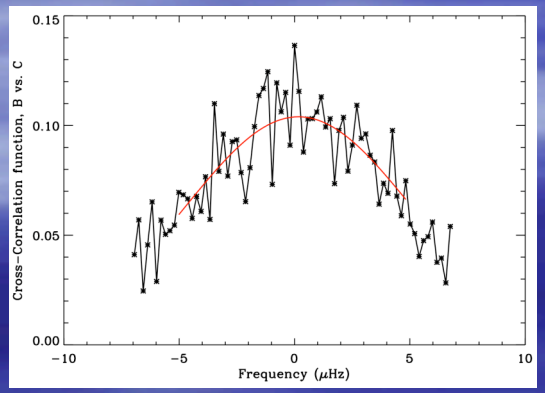
- Better constraints for simulations
- Better understanding of magnetic cycles

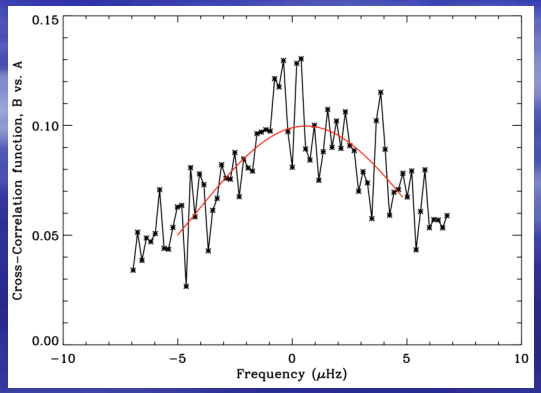


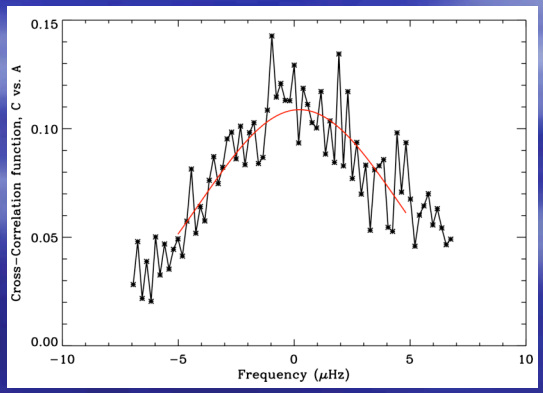
[Brun et al. 2006]

Methodology

- Frequency shifts
  - Globally:
    - Cross-correlation: [Pallé, Régulo & Roca-Cortés 1989]
      - PSD of small subseries
      - Subtract the background (Harvey-law model)
      - Cross-correlation function in the region of the p modes:
        - Gaussian function
      - Frequency range of ±7 μHz to estimate the third order moment of this function (skewness): asymmetry of the profile
      - Fit a Gaussian function using ±7 μHz. Maximum position of the cross-correlation peak







Methodology

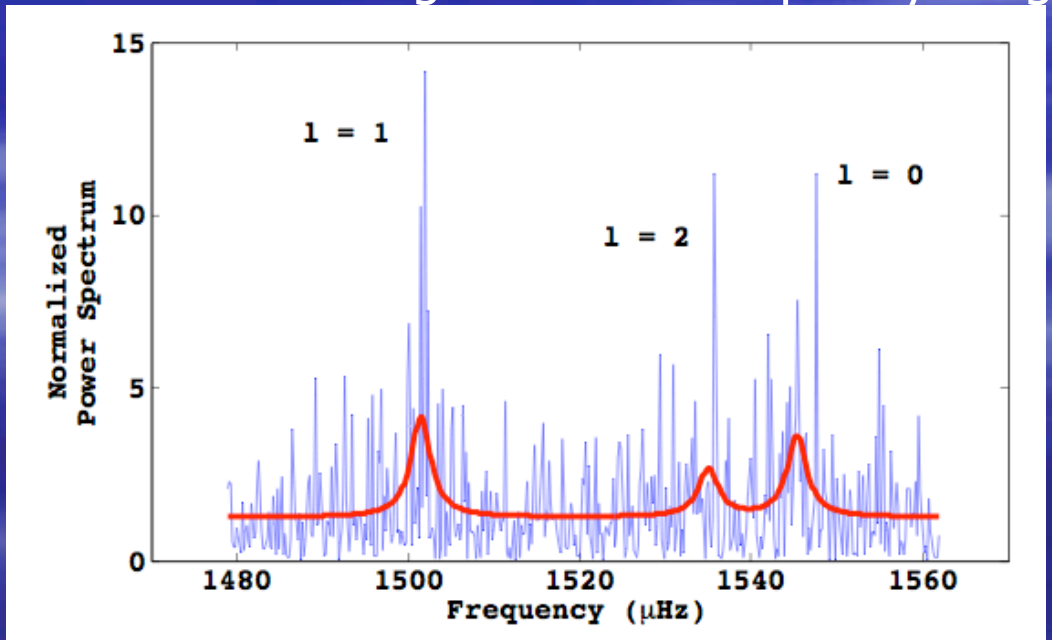
- Frequency shifts
  - Individual modes fitting:

For each subseries:

- standard likelihood maximization function

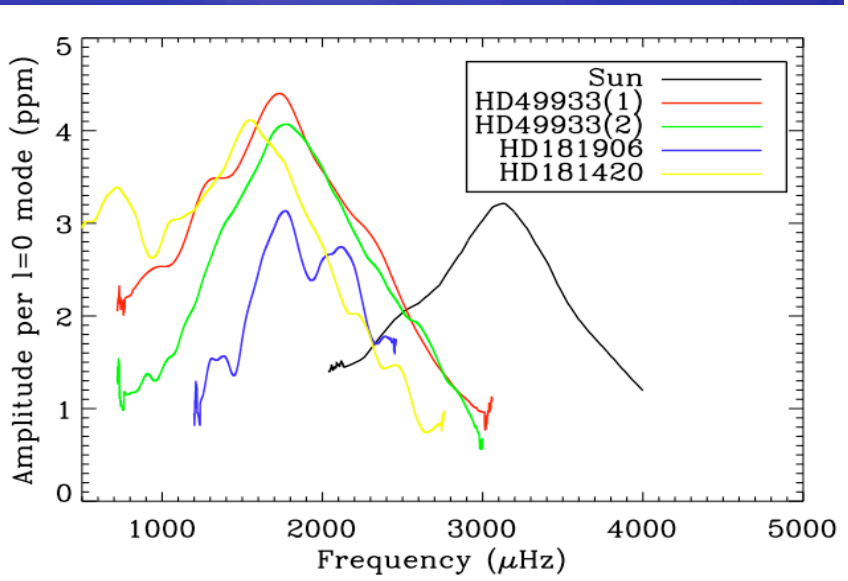
[Appourchaux, Gizon & Rabello Soares 1998]

- Lorentzian profile over frequency windows containing:
  - l=0, 1, and 2 modes
- Measure the difference of frequency compared to a reference
- Calculate the average over the frequency range studied



Methodology

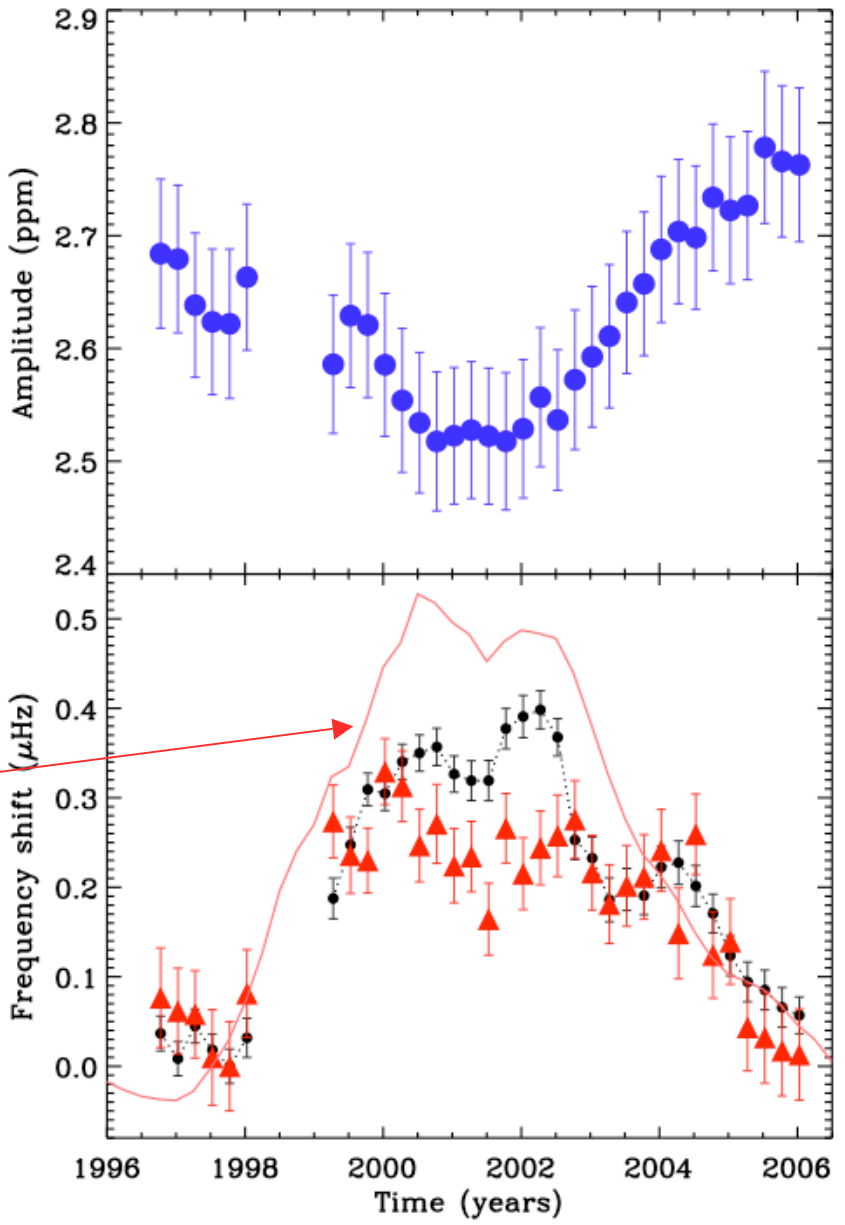
- Maximum bolometric amplitude per radial mode with the A2Z pipeline [Mathur et al. 2010]
  - Subtract background [Harvey 1985]
  - Smooth the PSD over $2\Delta\nu$
  - Fit the envelop with a Gaussian
  - Conversion to bolometric amplitude per radial mode [Michel et al. 2008]



Application to the Sun

- VIRGO data: 10 yrs
- Subseries of 1 yr
  - shifted by 1/4 yr
- Frequency shifts in the range:
  - 2400-3400 μHz
- Amplitude per radial mode:
  - 1900-5000 μHz

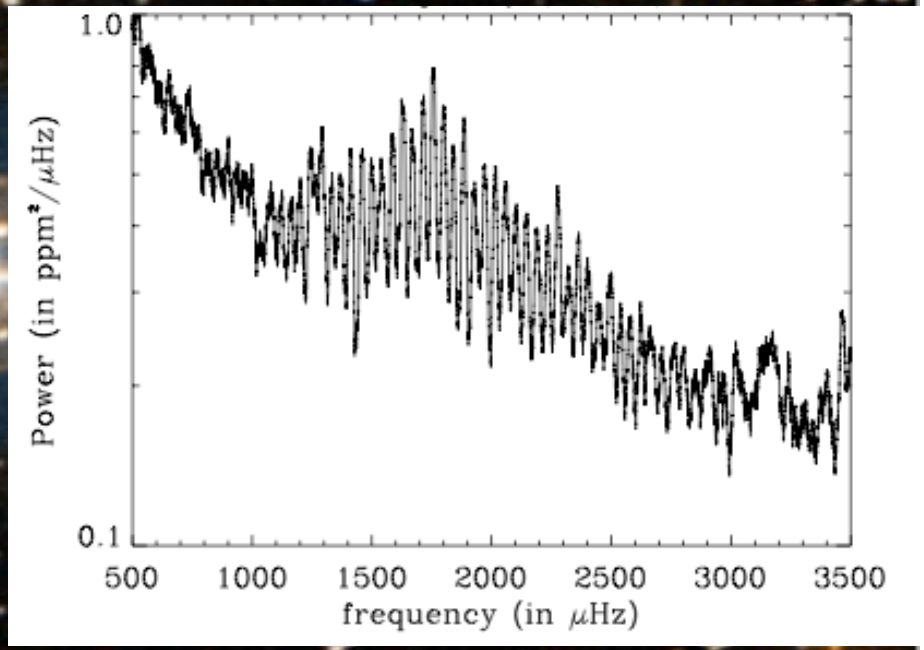
Sunspot number



[García et al. 2010, submitted to Science]

The CoRoT target: HD49933

- Stellar parameters:
  - F5V dwarf
    - 1.2 $M_\odot$; 1.3 $R_\odot$
  - P_{rot} = 3.4 days
  - Observed by CoRoT during 60 + 137 days
    - 50 oscillation modes measured



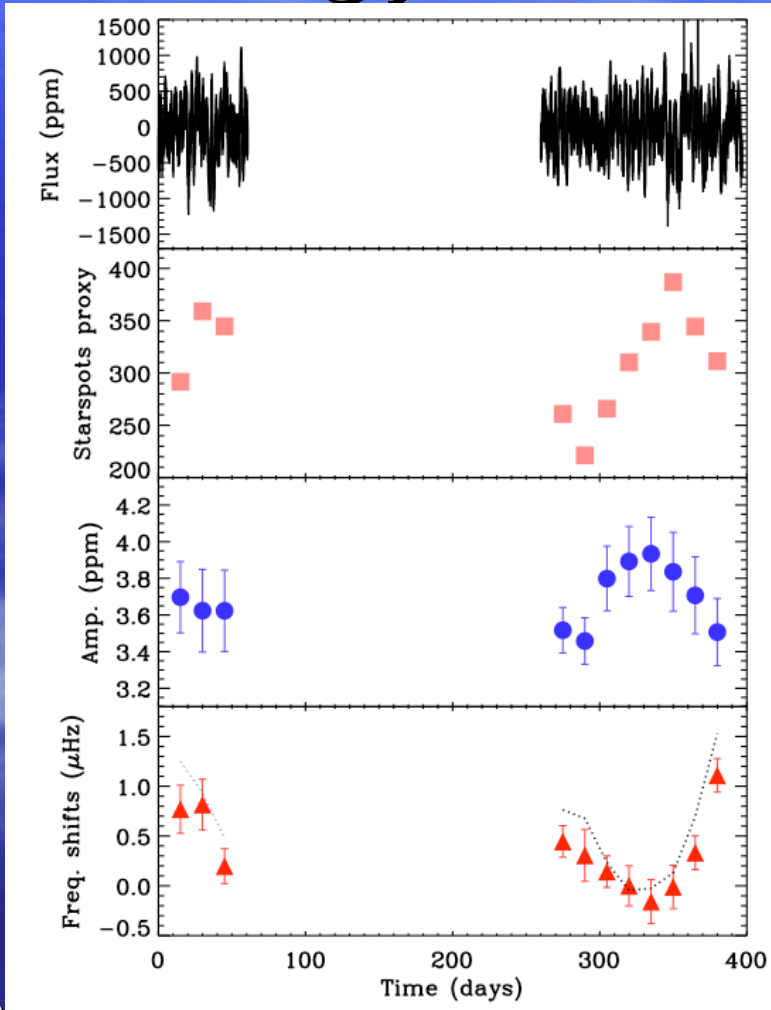
[Appourchaux et al. 2008; Benomar et al. 2009]

Hints of a magnetic-activity cycle with asteroseismology

- Subseries of 30 days shifted by 15 days
- Frequency shifts in the range 1460-2100 μHz
- Amplitude per radial mode in the range 1400-2500 μHz
- Standard deviation of time series

→ Anticorrelation between amplitude variation and frequency shifts evolution

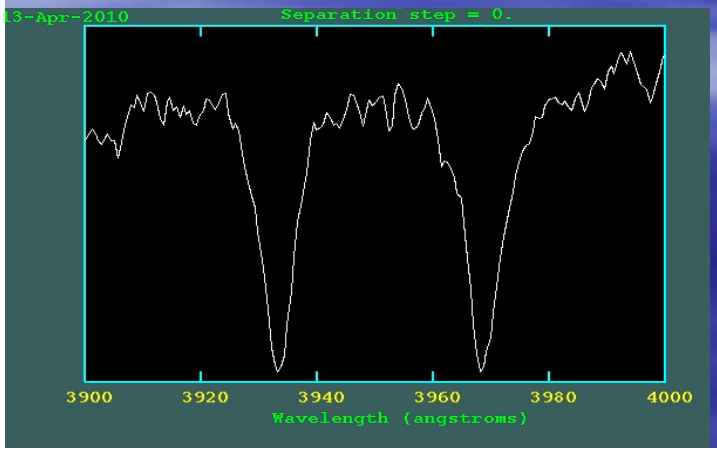
P_{cyc}>120days



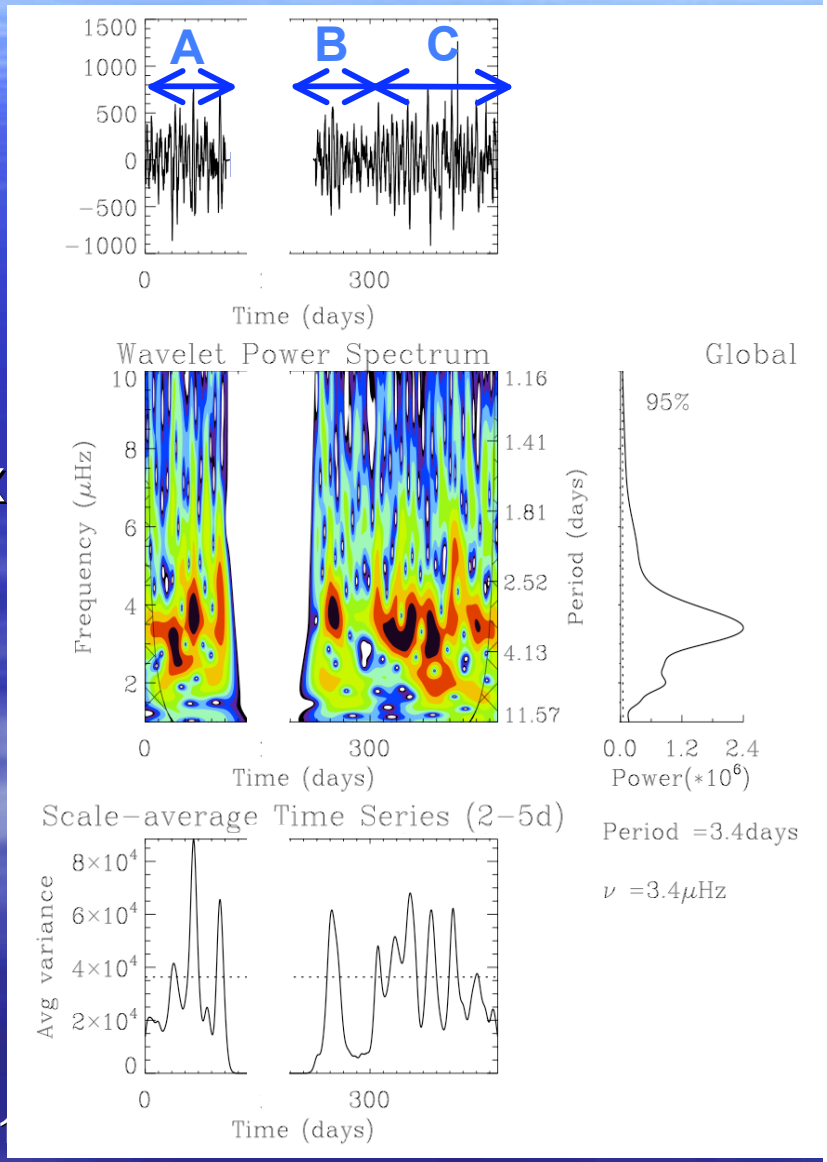
[García et al. 2010, submitted to Science]

HD49933

- Wavelet analysis:
  - Time-frequency evolution of power
    - More power in C➔higher activity
- Complementary observations
  - Ca H and K: Mount Wilson index of 0.3
    - Active star



[Poster Low-13]

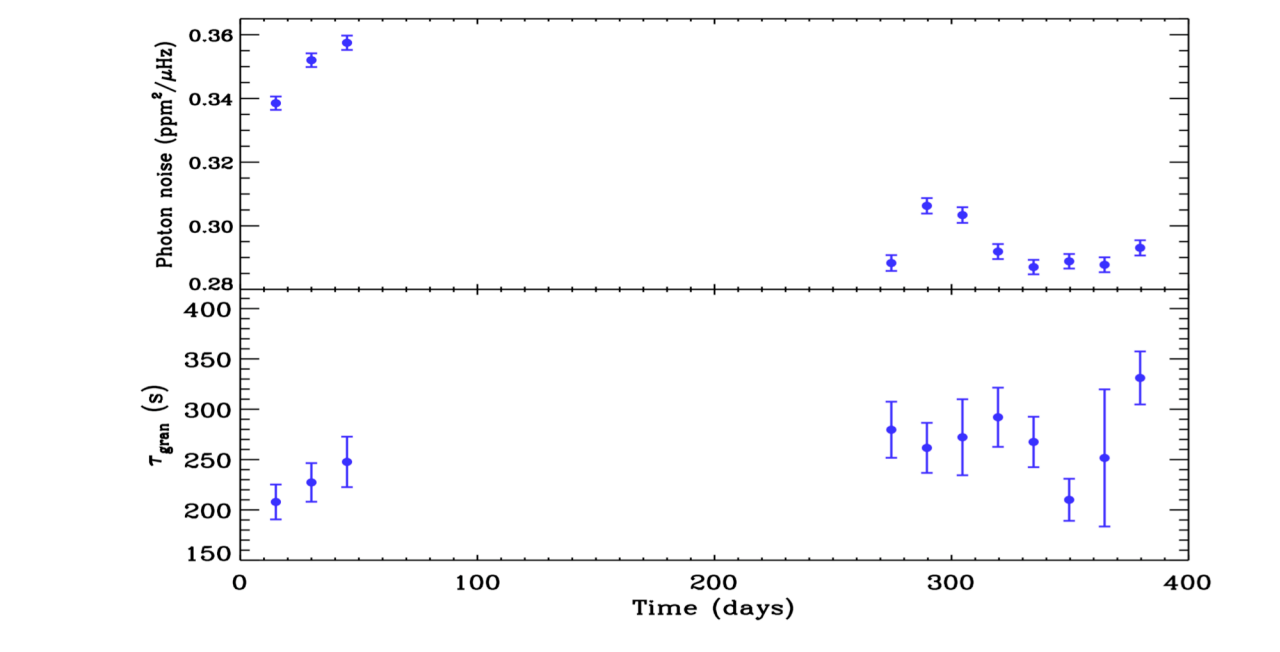


Conclusions

- Detection of a magnetic activity cycle with asteroseismic methods also tested on the Sun
  - Anticorrelation between amplitude and frequency shifts temporal variations
- Study of 2 other CoRoT targets (HD18420, HD49385)
  - work in pogress but lower SNR
- New observations on CaH and K scheduled for fall.

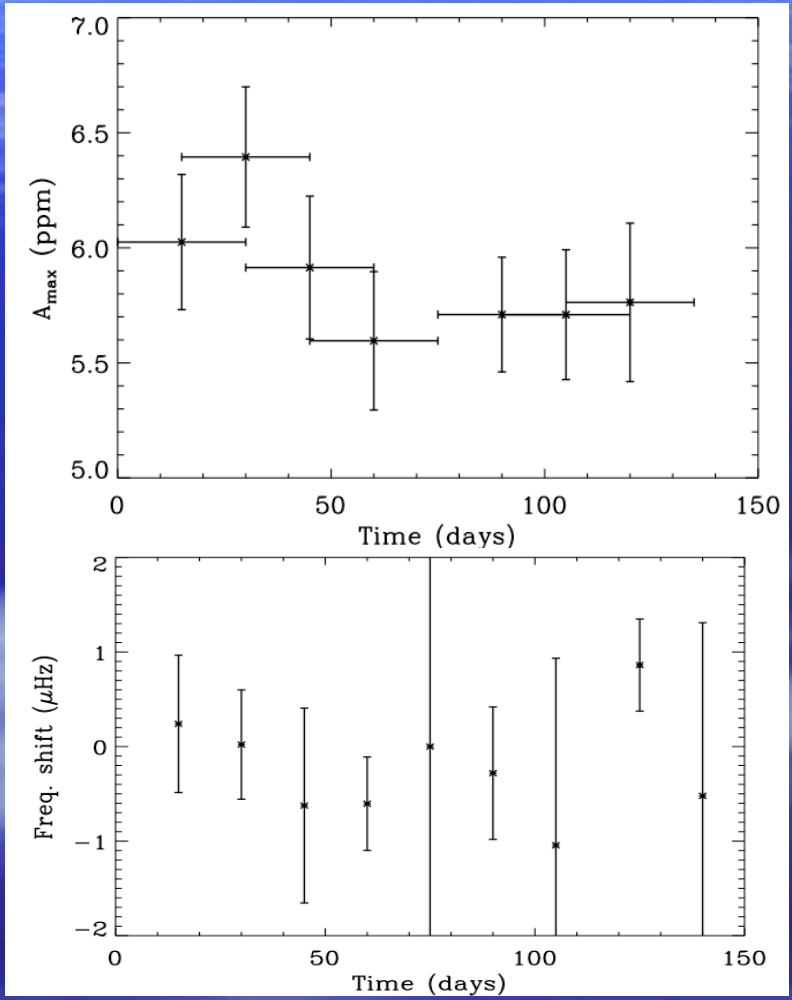
Thank you

Background evolution



Other CoRoT targets

HD181420



HD49385