

Exploring Solar Signals:

A Bayesian Approach to Developing a Composite Mg II Index Record



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Outline

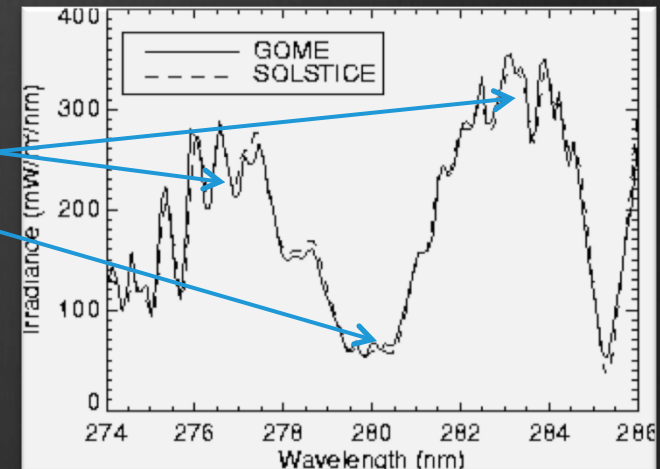
- ⦿ What is the Mg II Index?
- ⦿ Bayesian Theorem and Likelihood Theory
- ⦿ Wavelet Theory
 - ⦿ Wavelets as a method to separate out physical signals within larger data sets
- ⦿ Building a composite data set from the Bremen composite, SORCE SOLSTICE, and NOAA 16

What is the Magnesium (Mg) II Index?

(And why should we care?)

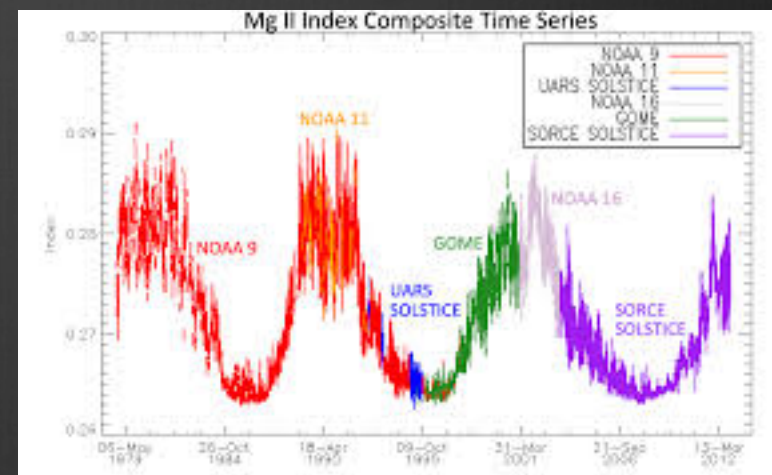
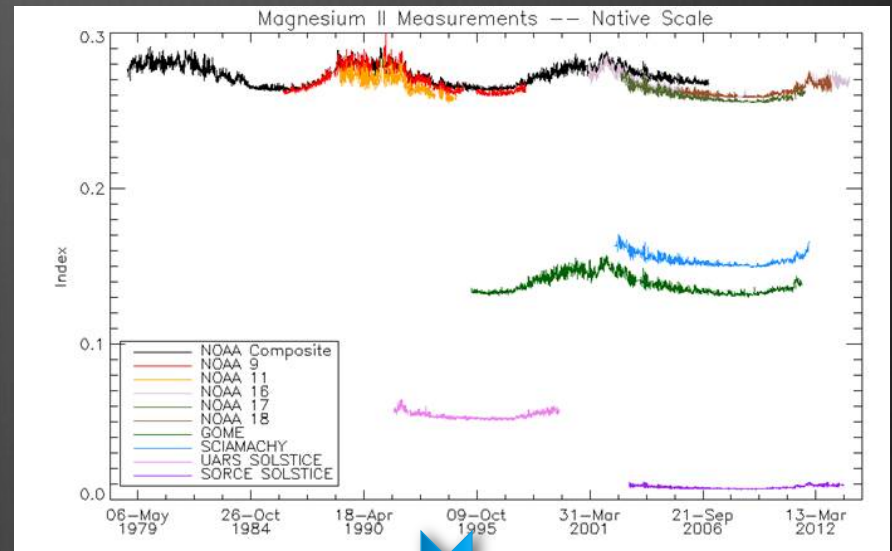
- Solar activity can pose risks to global systems
- Changes in the Chromosphere important in the long term behavior of Earth's atmospheric climate
- Mg II index proxy for measuring variability of the Sun's chromosphere
- Measures the core-to-wing ratio in the solar ultraviolet irradiance spectrum

- Absorption Wings – Upper Photosphere
- Emission Core – Upper Chromosphere



A Composite Mg II Index

- ❁ Various instruments have measured the Mg II Index
- ❁ However, different
 - ❁ Time periods
 - ❁ Platforms
 - ❁ Spectral Resolutions
 - ❁ Measurement Uncertainty
- ❁ Composite Index is necessary



Data Sets

- The Bremen Composite
 - GOME (Global Ozone Monitoring Experiment)
 - SCIABACY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY)
 - GOME 2
- SORCE SOLSTICE (SOlar Radiation and Climate Experiment, SOLar STellar Irradiance Comparison Experiment)
- NOAA 16

Bayes' Theorem and Likelihood Theory

- ⊗ If you don't have a model, can you make predictions about your data?
- ⊗ Likelihood a model/ hypothesis given your information(data) and any prior assumptions
- ⊗ Bayesian Probability:

$$p(\Theta | y) \propto p(\Theta)p(y | \Theta)$$

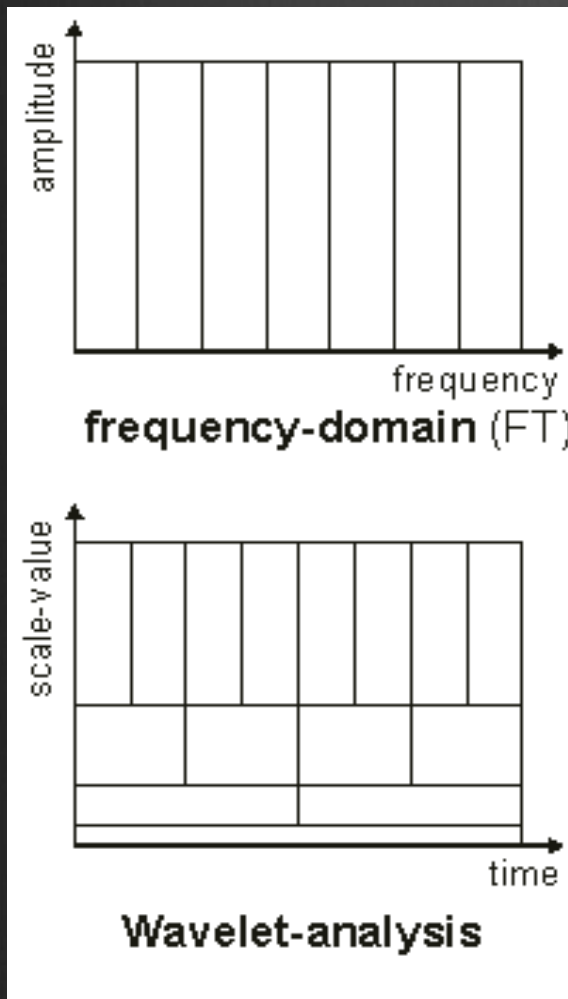
- ⊗ Likelihood:

$$p(y | \Theta) = L(\Theta | y)$$

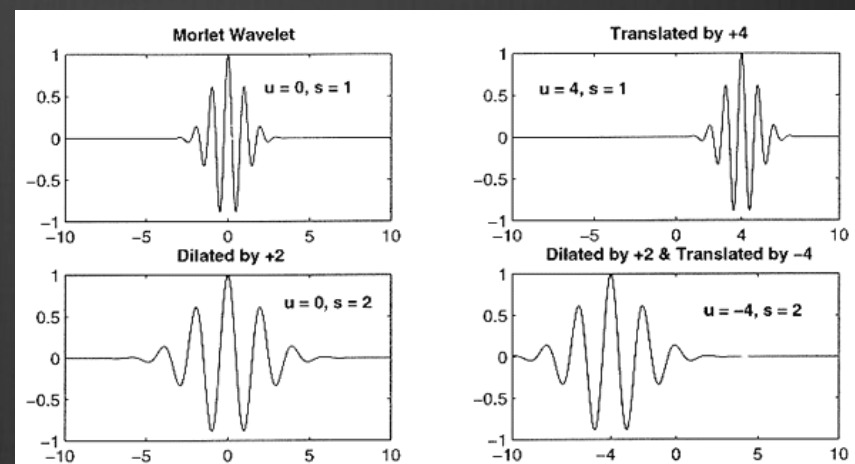
$$L(\Theta | y) = \prod f(y | \Theta)$$

Wavelet Theory:

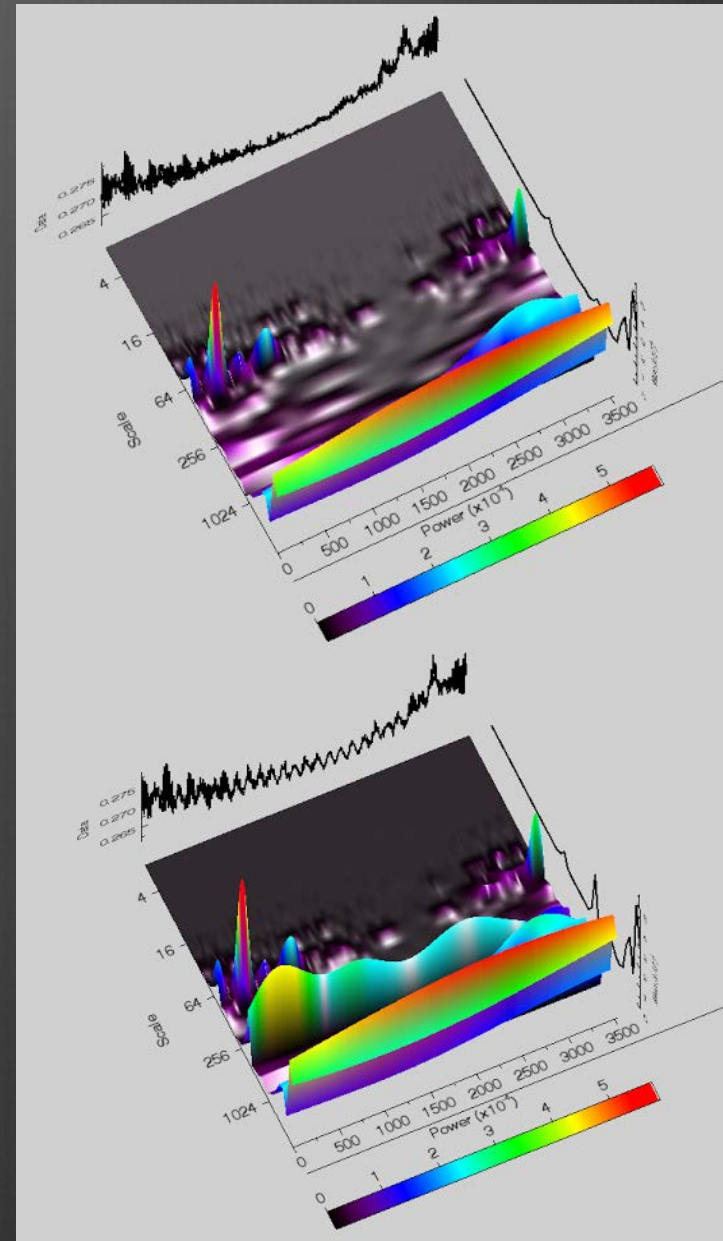
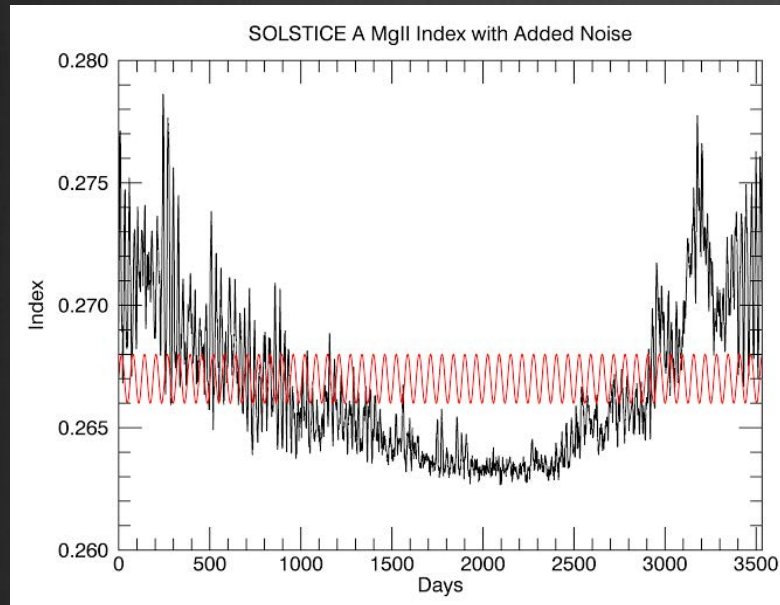
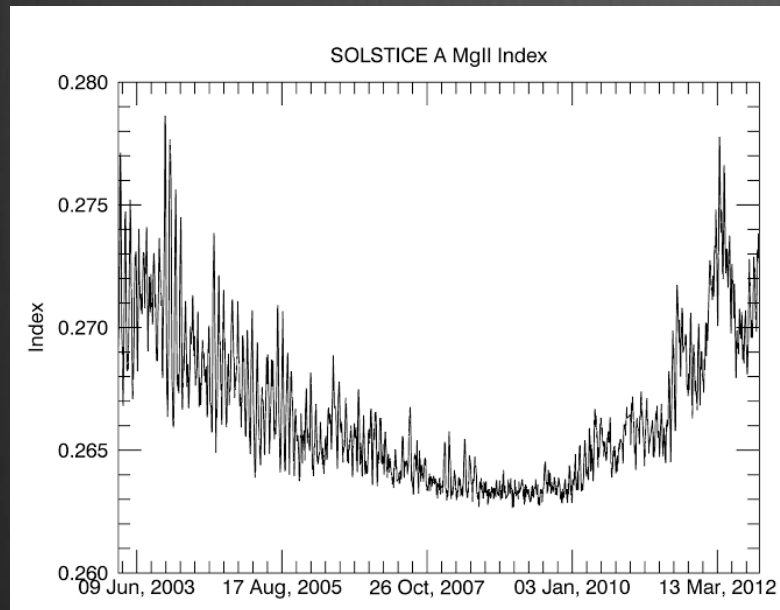
Establishing Statistical Independence



- Tool to examine individual signals within the data and determine statistical significance
- Composed of 'Mother' functions
- Similar to FFT (Fast Fourier Transform)
- Irregular waves of short, limited duration



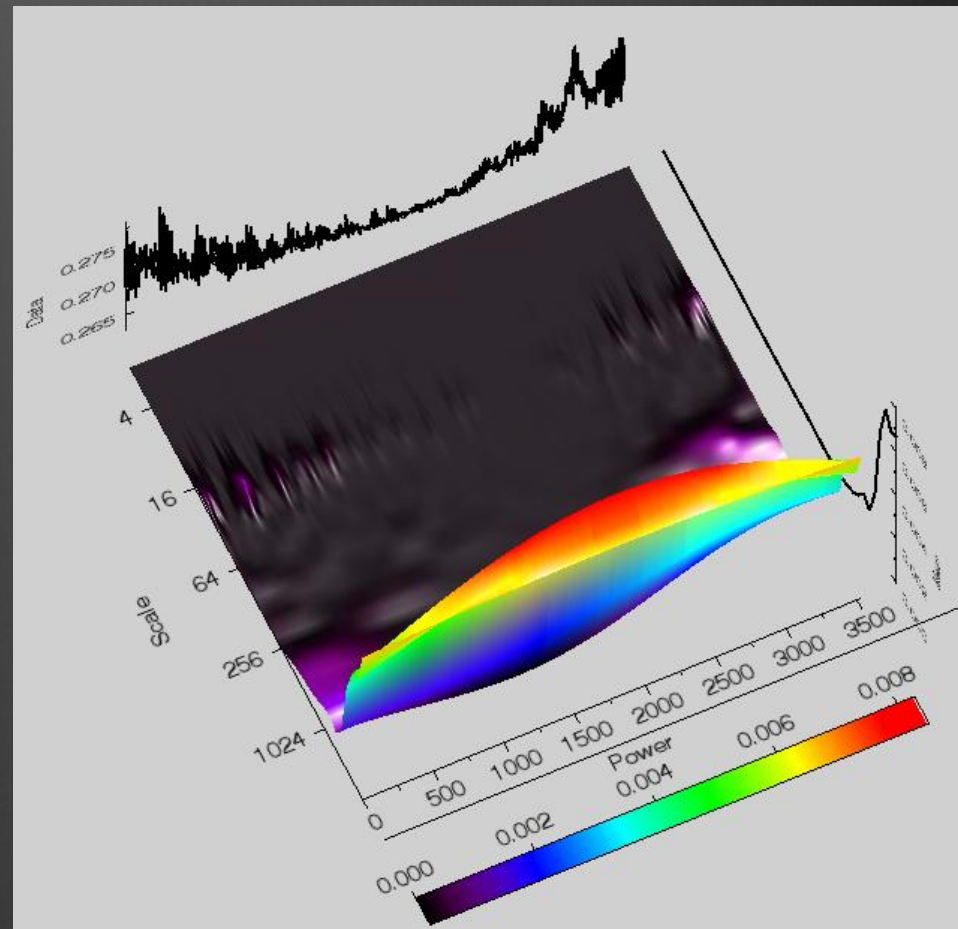
Wavelets cont.



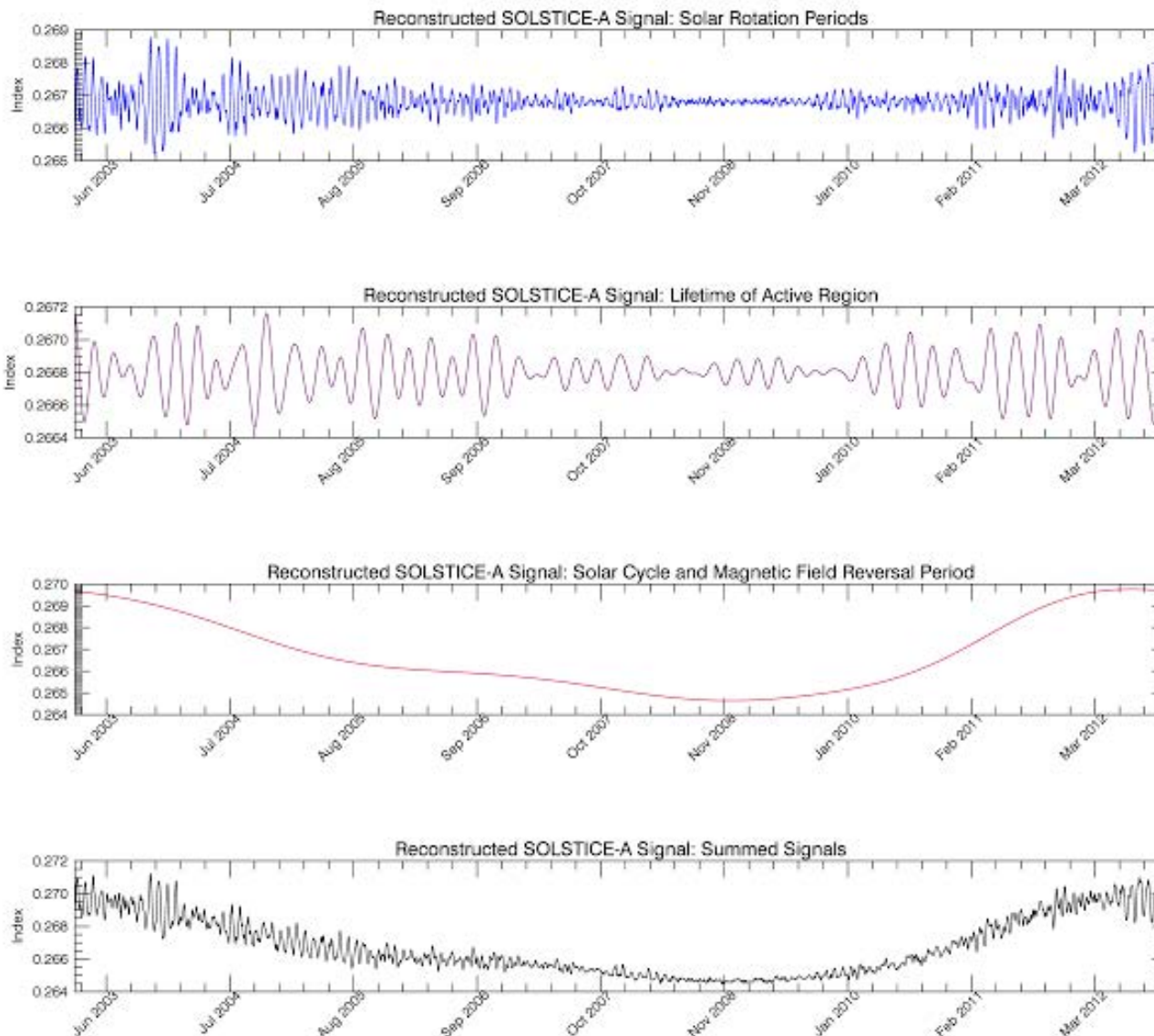
Physical Signals

- ⦿ 24.7-Day Sidereal Period
 - ⦿ Time for equator to complete one full rotation
- ⦿ 26.2-Day Synodic Period
 - ⦿ Time for fixed feature on the sun to complete one full rotation
- ⦿ Lifetime of active region on the Sun (~3 Months)
- ⦿ 11-Year Solar Cycle
- ⦿ 22-Year Magnetic Field Reversal Period

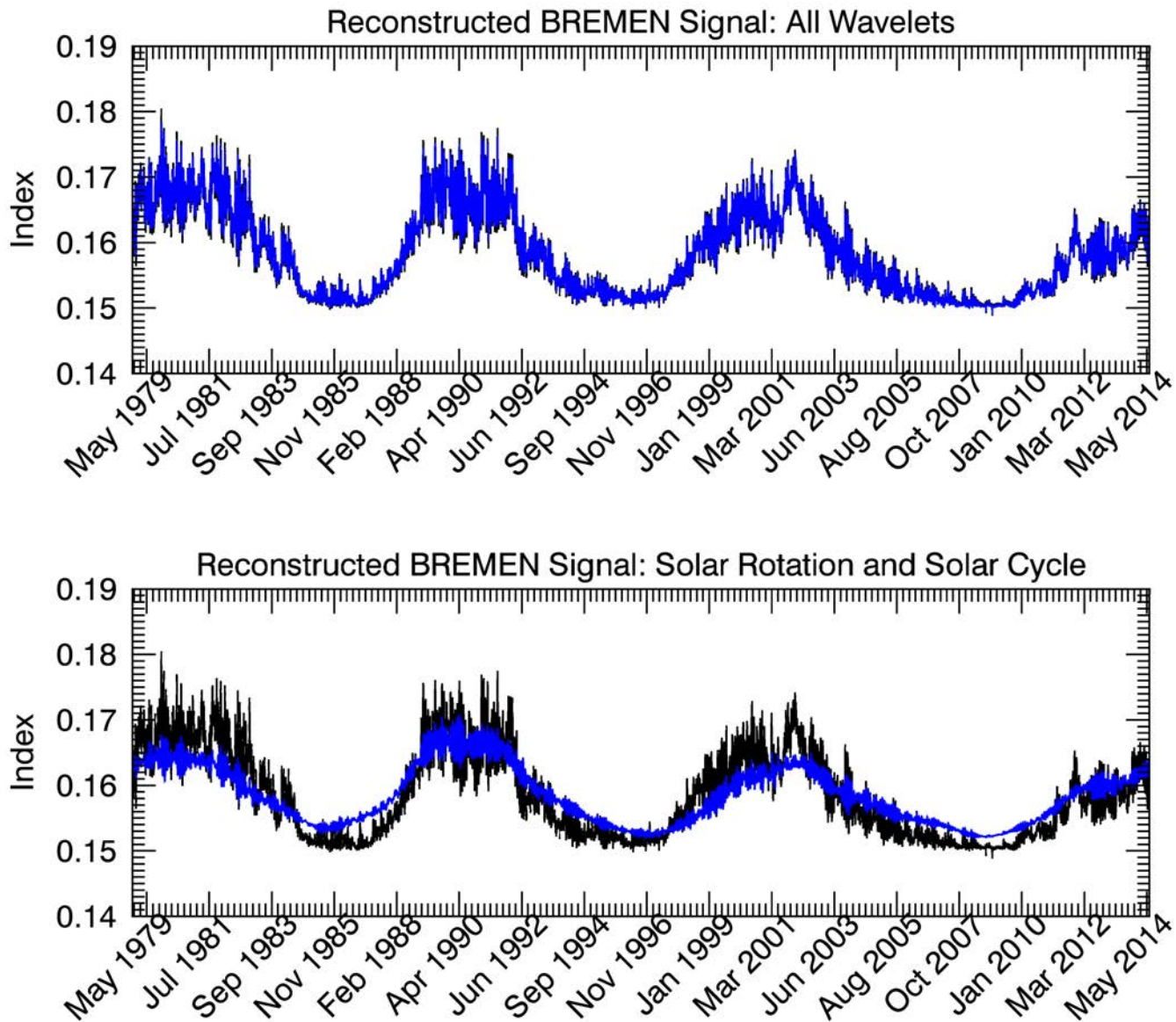
Signals within the Data



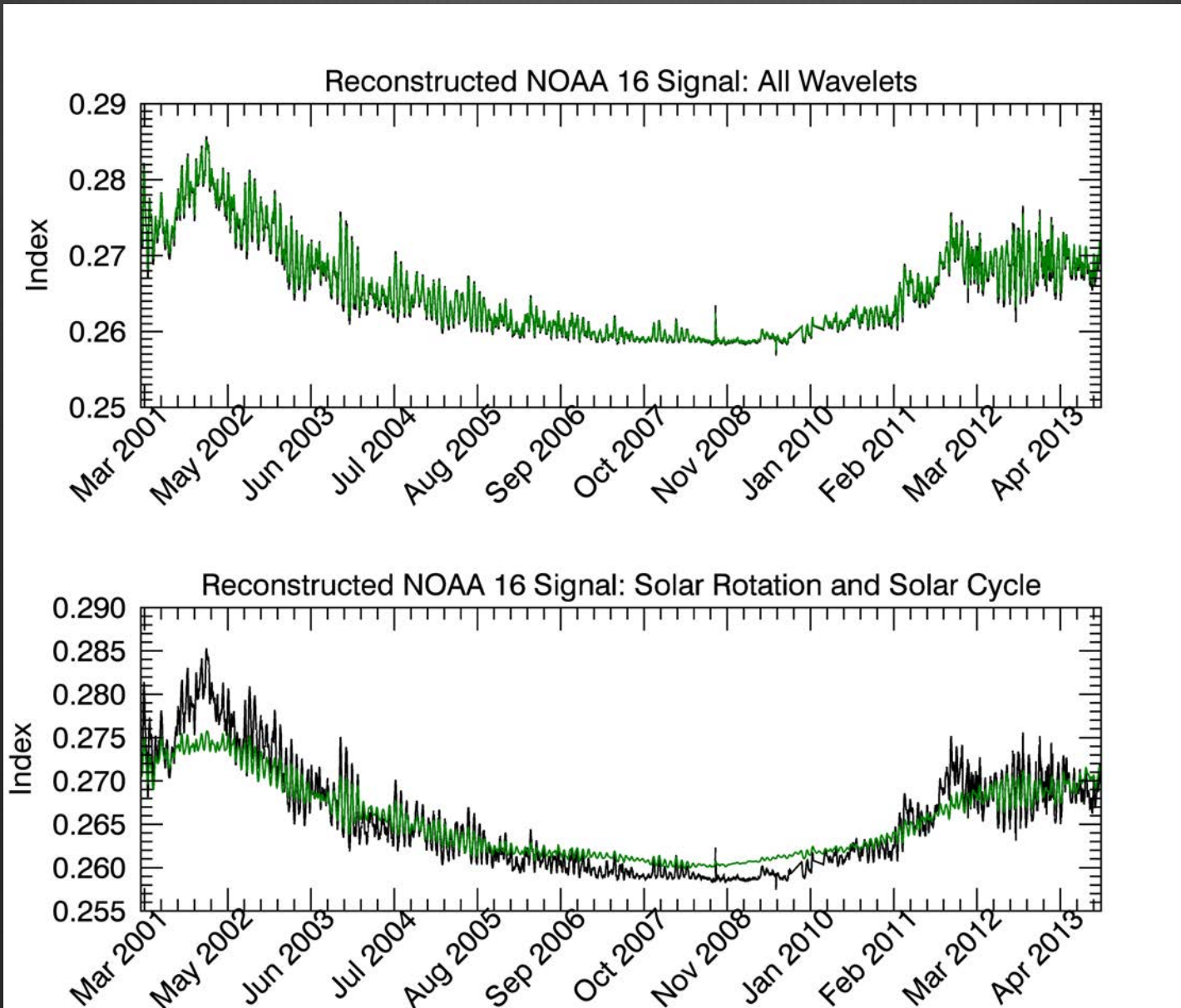
Signals within the Data



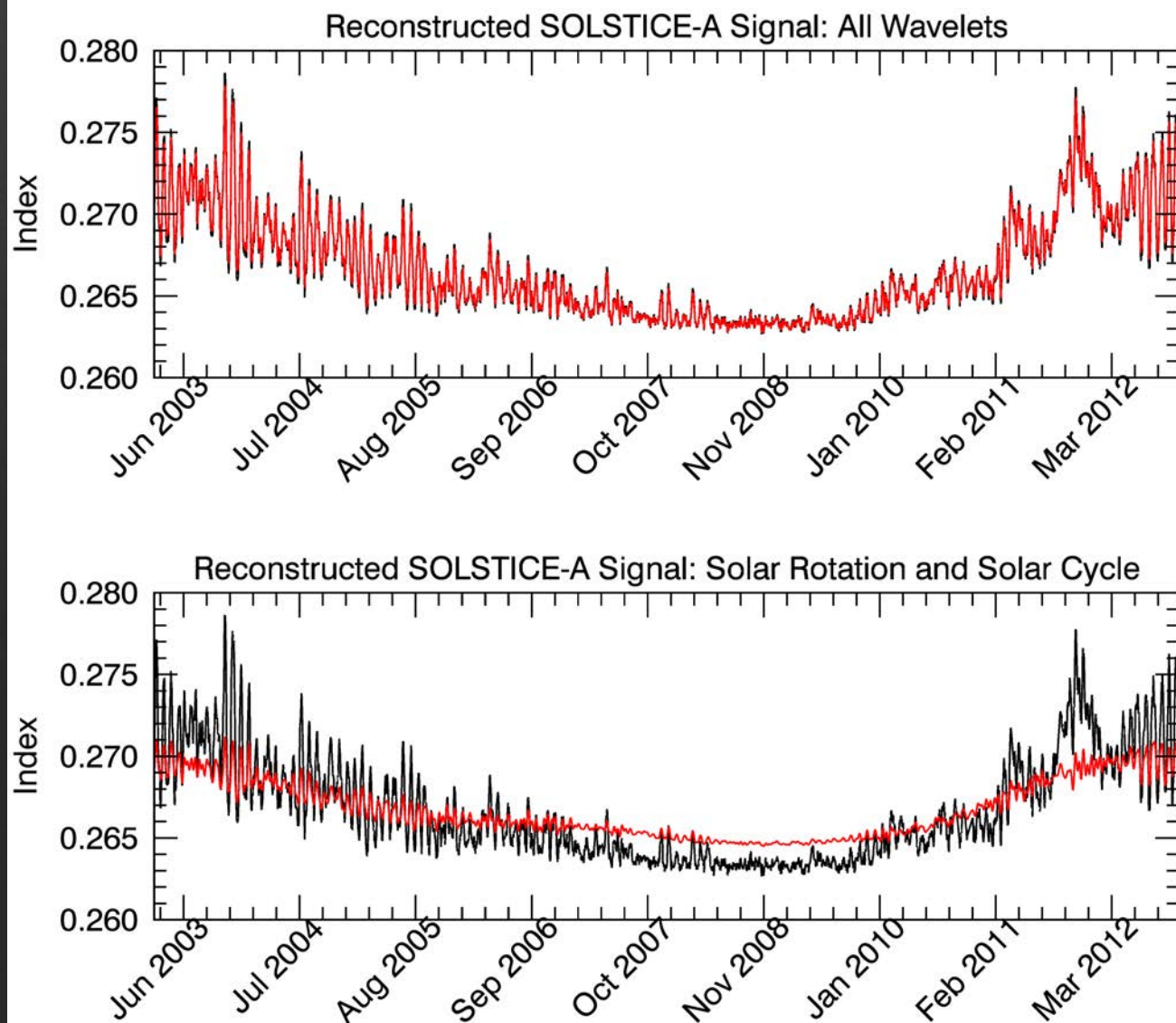
The Bremen Composite



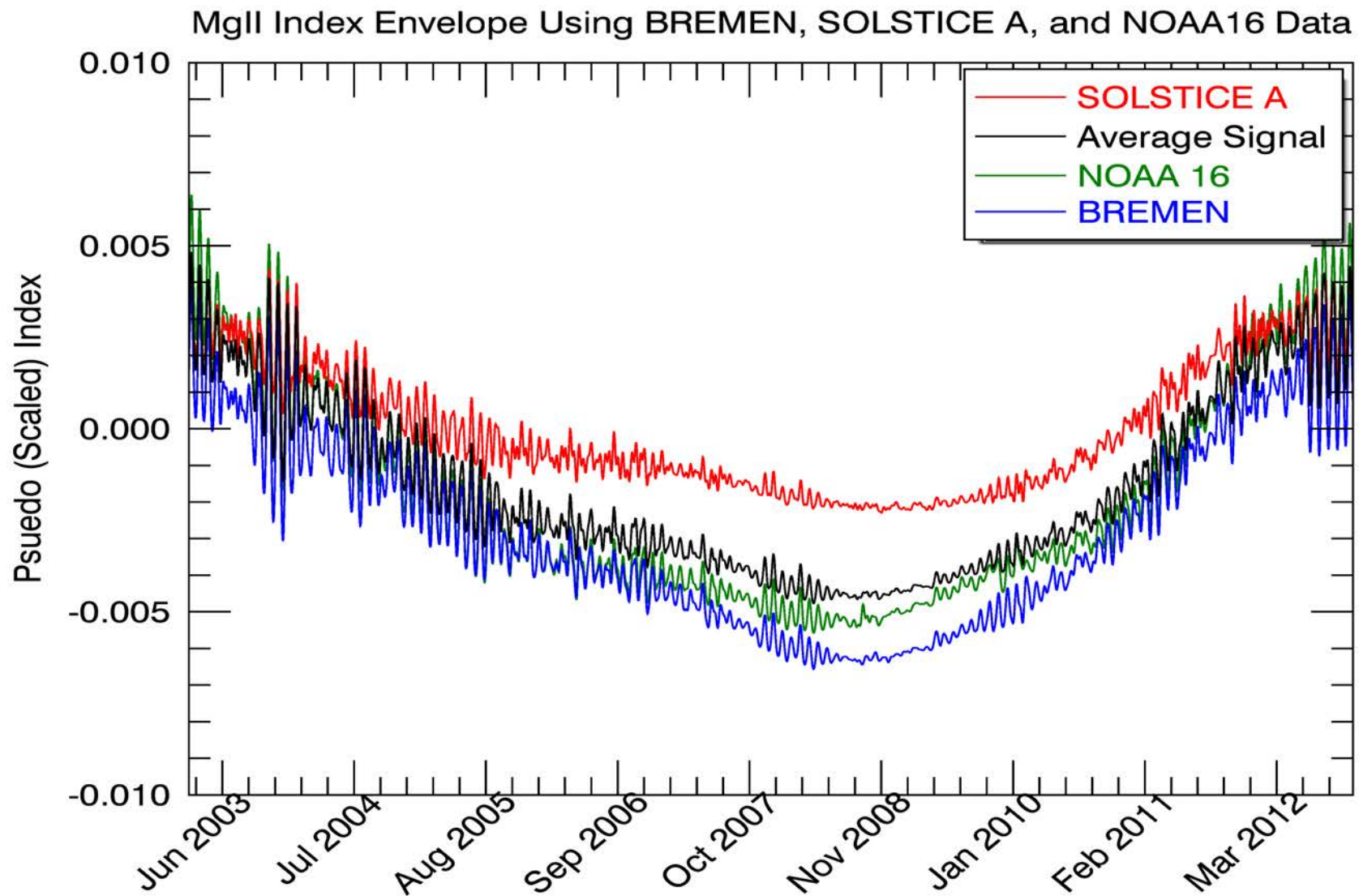
NOAA 16



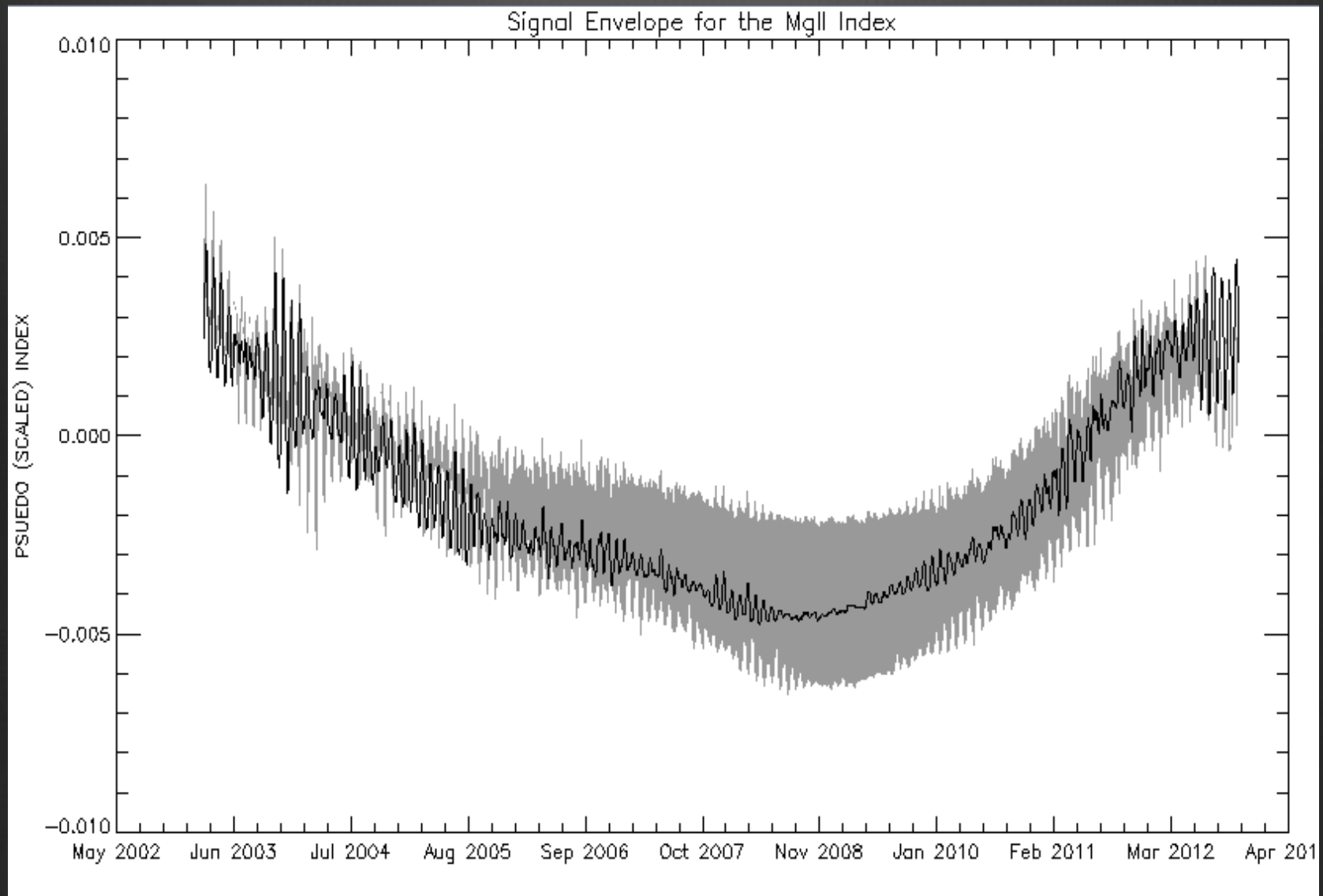
SORCE SOLSTICE

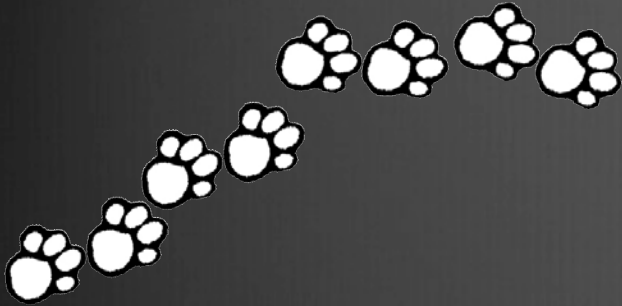


Averaged Signals → Composite Index



Mg II Composite





Next Steps

- ⊗ Apply the BPSS (Bayesian Positive Source Separation) technique to determine the maximally likely composite Mg II record
 - ⊗ Future results can be compared to derived uncertainty analysis
- ⊗ Using the BPSS technique will provide the 'best' Mg II index
- ⊗ Explore signals not analyzed in this research
 - ⊗ Solar Origin?
 - ⊗ Instrumental Error?
 - ⊗ Such as: time and temperature dependencies in calibration corrections

Conclusion

- ⊗ First Estimate of the Mg II Composite Index
 - ⊗ Composite Mg II Index contained within the range
- ⊗ Compare and Conceptualize and further research
 - ⊗ Uncertainty analysis of this research



Acknowledgements

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Questions?