The Magnetic Heartbeat of the Sun
Diagnosing Pulses in the Solar MgII Index Using Wavelet Analysis
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Background

The solar Magnesium (Mg II) index, derived from the ratio of measurements across a solar absorption feature (280nm) in nearby spectral bands, serves as a proxy for solar chromospheric variability. Scientists use the MgII index to create models and predictions for complex dynamics such as climate variability, space weather and other atmospheric phenomena.

Problem:

There are currently various space-based instruments that acquire data for the MgII index and, depending on the instrument used, the data follows different temporal trends. These variations create issues in model outputs, depending on the instrument/data set used.

Objective:

We investigate the MgII index data in an effort to reconcile the differences and create one, composite record with elements common to all data sets. For our investigation we focus on the overlapping time segment of the SOCR Solstice, Bremen composite, and NOAA 16 data sets. We use wavelet analysis to analyze the time scales present in the data. We then apply a Bayesian approach to quantify the uncertainties of a record reconstructed with identified solar signals.

Method of Investigation

To investigate our data we apply a wavelet analysis to determine periods of significance. We then specify source signals to extract. We begin by extracting four known solar time scales within an average range: the half rotational period of the sun (25-28 days), the lifetime for active regions on the sun (3-7 months), and the 11-year solar cycle (9.5-13 years).

Extracting an average 11 year solar cycle from the data records of similar length is considered dubious due to the constraint in sample size. To overcome this challenge, we extrapolate the cycle signal from the full Bremen record (spanning over 35 years) onto the SOLSTICE and NOAA data sets.

After extraction of known solar trends we found an unexpected 1-2 year period common to all data sets that required further investigation.

Reconstruction Comparison

Comparison with Ground-based Data

Results and Conclusion

Through our investigation we show that wavelet analysis is a viable method of investigation across multiple data sets. Wavelet analysis allows for the specification of periods for defined trends and extraction of these signals and likewise allows for reconstruction of specific signals within the data.

With this process we were able to successfully extract signals we knew to be of solar origin (half rotational, full rotational, active region, and solar cycle periods), in order to investigate the remaining signals in the data. In these remaining signals we found a significant 1-2 year cycle, common to all three sets. Subsequent study of this signal proves that it is common to both ground-based and space-based data collection. This suggests the hemispheric difference in solar activity as a possible source of the signal (see below).

Further Work

Comparison of signals and reconstructions between all three data sets provides information on the discrepancies and their sources between the data sets. Further application of the Bayesian method could lead to a composite MgII index with signal elements common to all records and a quantified uncertainty the resulting record.

References

Mark Weber et.al. The MgII Index: A Proxy for Solar EUV.  