Exploring Solar Signals: A Bayesian Approach to Developing a Composite Mg II Index Record

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Solar activity poses possible risks to global systems such as power grids, communications, and GPS, so it is crucial to measure and predict this activity. One proxy used to infer the degree of solar variability is the Magnesium (Mg) II Index. The Mg II Index is the ratio between adjacent magnesium emission lines in the solar ultraviolet irradiance spectrum. The wings of the emission lines originate from the Sun's upper photosphere and the cores of the emission lines from the more variable upper chromosphere. The core-to-wing ratio of the Mg II emission lines, known as the Mg II index, therefore provides a measurement of chromospheric variability that is relatively free of instrumental error. While various Mg II indices have been measured from satellite measurements of ultraviolet irradiance, they span different time periods, platforms, and spectral resolutions. For these reasons, as well as differences in measurement uncertainty, the individual time series records do not agree. The objective of this study is to build a composite Mg II Index record from individual time series records of the SOlar Radiation and Climate Experiment (SORCE) SOLar STellar InterComparison Experiment (SOLSTICE), the University of Bremen Composite, and the NOAA 16 data sets. An objective framework known as the Bayesian Positive Source Separation (BPSS) will be used to determine the most-likely probability distribution of the composite record.

A prerequisite first step in the Bayesian analysis is the definition of statistically independent signals, or "sources". We apply the continuous wavelet transform to separate out the signals in each data set that correspond to known physical solar periods: the 24.7 day sidereal –the time it takes for the Sun's equator to complete one full rotation- period, 26.24 synodic –the time for a fixed feature on the Sun to complete on full rotation- period, the lifetime –approximately 3 months- of an active region, the 11 year Solar cycle denoted by a change between minimum and maximum periods of solar activity and appearances of magnetic features, and the 22 year Solar magnetic field reversal period. Other periodicities in the Mg II indices, not evaluated in this study, can be of solar origin or from uncorrected instrumental artifacts, including time or temperature dependencies in calibration corrections. We show results of the sum of these statistically independent components averaged over the individual records, producing a composite Mg II index that is contained within an uncertainty envelope and representative of the distribution of the signals over the three data sets. In ongoing work, the BPSS technique will be used to determine the maximally likely composite Mg II record, and future results will be compared to the derived uncertainty analysis of this work