A Spectral Analysis of Geomagnetic Field Dynamics Across Solar Cycles

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Background

The Earth's geomagnetic activity is intricately linked to solar phenomena, particularly the 11-year solar cycle, as highlighted in Kotze (2016). While this relationship is acknowledged, understanding the nuanced variations in geomagnetic activity during different solar cycles remains a complex challenge.

Goal

This project aims to investigate the behaviour and variation of periodicities in geomagnetic observatory data during various solar cycles, with a specific focus on the characteristics of the synodic 27-day period and its different harmonics.

Methodology

1. Data Acquisition: Extract the H component data from the archival records of the Hermanus magnetic observatory, ensuring a comprehensive dataset spanning from 1940 to the present day.

2. Data Preprocessing: Compute daily averages and segment the dataset into year-intervals to facilitate detailed analysis across multiple solar cycles.

3. Spectral Analysis: Employ spectral analysis techniques to the geomagnetic data within each year-interval. Specifically, focus on identifying and quantifying the strength of the 27-day periodicity and its harmonics. A 95% statistical significance level will be used to verify results.

4. Comparative Assessment: Conduct a comparative analysis between solar maximum and minimum intervals to discern any distinctive patterns or variations in the strength and characteristics of the identified periodicities.

Expected Outcomes

Identification of dominant periodicities within the geomagnetic field across various solar cycles, shedding light on the underlying mechanisms driving geomagnetic activity.

Quantification of the variability in the strength and characteristics of the synodic 27-day period and its harmonics over different phases of the solar cycle.

Insights into the complex interplay between solar activity and geomagnetic dynamics, contributing to advancements in space weather research and prediction capabilities.

Significance: Understanding the relationship between solar cycles and geomagnetic activity is essential to better our understanding of space weather phenomena. By systematically analyzing geomagnetic data across multiple solar cycles, this study will offer valuable insights into the underlying processes governing geomagnetic dynamics, with implications for space weather forecasting and mitigation strategies.

Kotzé, P.B., Spectrum analysis of short-period K-index behaviour at high and mid-latitudes, Annales Geophysicae, 33, 31-37, doi:10.5194/angeo-33-31-2015, 2015

Kotzé, P.B., Spectral analysis of auroral geomagnetic activity during various solar cycles between 1960 and 2014, *Annales Geophysicae*, 34, 1159-1164, 2016, doi:10.5194/angeo-34-1159-2016.