Diagnosing and calibrating the multi-century sunspot number series

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Description:

Visual sunspot observations are at the base of the single longest scientific record of solar activity, spanning four centuries. The primary reference index, called sunspot number, was recently submitted to a full revision and re-calibration. A new improved series was released in July 2015, shedding new light on our understanding of the long-term variations and instabilities of the 11-year solar cycle. However, uncertainties remain and errors in past historical data need to be further determined using the most advanced data analysis techniques currently at our disposal. A good overview of this ongoing effort was the theme of a recent special issue of the Solar Physics journal (Vol 291, N° 9-10: http://link.springer.com/journal/11207/291/9/page/1). The current revival of long-term solar studies aims at improving our ability to predict the future evolution of the solar cycle, a primary quest in solar physics, at constraining the latest physical models of the solar dynamo, and at improving our understanding of the solar influence on Earth climate change.

The purpose of this thesis will be to exploit the full database of raw sunspot counts maintained by the World Data Center SILSO (sidc.be/silso), which contains more than 500.000 observations spanning several centuries, in order to derive a better understanding of the scale differences between past observers, starting from modern data produced by our worldwide SILSO observing network. Indeed, a key issue when building such a long-term record is to bring all observations to the same normalization scale, by diagnosing and compensating various inhomogeneity factors (instrumentation, observing practices, etc.). The level of solar activity can then be compared on a constant scale across multiple centuries back to 1610 (invention of the telescope).

The in-depth statistical study of the most recent part of the data (35 years, 280 stations since 1981) is currently at the core of the ongoing VAL-U-SUN project started in 2017 (Brain.be federal funding ; http://www.sidc.be/valusun/). The thesis proposed here would extend this investigation to earlier data over a much longer time interval and could exploit some of the statistical models and tools derived from the VAL-U-SUN project.

State-of-the-art statistical techniques will be implemented to derive the noise properties of past data (often loosely documented), through the use of other modern solar data and of advanced data mining techniques (multivariate analysis) to address e.g. data gaps in sparse series or to identify "families" of observers sharing common characteristics. This investigation will help to shed light on remaining discrepancies in past sunspot observations, and also between sunspot data and parallel solar and geomagnetic records.

This research will be developed in the context of the Royal Observatory of Belgium, one of the Belgian federal institutes (Uccle, Brussels) and specifically in the "Solar Physics and Space Weather" department (also known as SIDC: www.sidc.be). The SIDC aims at advancing knowledge on the Sun and its influence on the solar system, through research, in-house optical, radio and space observations, and through operational monitoring services. It hosts the World Data Center SILSO (Sunspot Index and Long-term Solar Observations), which is responsible for the production of the international sunspot number and for the long-term monitoring of the solar activity cycle (http://www.sidc.be/silso).

This research will benefit from the internationally recognized expertise of the WDC-SILSO team, which is at the core of the current ongoing research in this field. The team will provide its guidance and its international network of scientific collaborators in Europe, USA and Japan. Although our team is based in Brussels, part of the work can be carried out remotely, as the base data are accessible or storable off-site. The main pre-requisites are a good base knowledge of time series and statistical error analysis, and an interest in astronomical data processing and data mining techniques, and in long-term solar activity and Sun-Earth relations.

The interested candidate could benefit from one of the federal PhD grants provided annually by the Royal Observatory of Belgium. An application for this PhD topic will be submitted with support from the WDC-SILSO to the next call (June 2018), with rather good chances of selection.