Does solar activity affect human happiness?
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Abstract
We investigate the direct influence of solar activity (represented by sunspot numbers) on human happiness (represented by the Twitter-based Happiness Index). We construct four models controlling for various statistical and dynamic effects of the analyzed series. The final model gives promising results. First, there is a statistically significant negative influence of solar activity on happiness which holds even after controlling for the other factors. Second, the final model, which is still rather simple, explains around 75% of variance of the Happiness Index. Third, our control variables contribute significantly as well: happiness is higher in no sunspots days, happiness is strongly persistent, there are strong intra-week cycles and happiness peaks during holidays. Our results strongly contribute to the topical literature and they provide evidence of unique utility of the online data.

1. Introduction

The influence of solar activity on human behavior and health has not only been a basis of various national sayings and folklore, it has also been an active and controversial scientific topic for decades [1–4]. As reviewed by Lipa et al. [4], the solar activity influences magnetosphere and ionosphere of the Earth both with short-lived disturbances such as solar flares and with long-lived structural changes in the magnetic field. However, other effects of the solar activity on the Earth, its climate, wildlife and human health and behavior have remained controversial until present days.

Mendoza & Díaz-Sandoval [5] study the relationship between solar activity and occurrence of myocardial infarctions in Mexico City and find a weak positive relationship. In their following study, Mendoza & Díaz-Sandoval [6] enlarge the dataset and they find that solar activity maxima are the most hazardous for myocardial infarctions deaths, mainly for age groups above 65 years. Broadening the study outside of Mexico as well, Mendoza & de la Peña [7] focus on lower latitudes, specifically Cuba and low latitudes of Mexico, and confirm the findings even for these conditions.

Cherry [8] argues and empirically shows (on the dataset from southeast Asia) that solar activity is correlated with the Schumann resonances, deviations of which are detected by human brain and lead to health problems and possible excessive death rates through the melatonin mechanism. Palmer et al. [9] review the topical literature focusing on the field of heliobiology. They specifically discuss the Schumann resonances potential to explain the effect of solar activity on human health and, in a light of the reviewed literature, find it a promising link. Babayev & Allahverdiyeva [10] study the effect of geomagnetic variability on brain functioning using EEG and find that abrupt changes in geomagnetic variability have strong negative effect mainly on emotional and vegetative parts of brain while personality characteristics are not affected significantly. Some studies take the effect of solar activity even further and e.g. Mikulecky [11] finds that historical revolutions culminated close to solar activity maxima while flourishing periods were near solar minima.

The recent studies thus suggest that increased solar activity has negative effect on humans, both from physical and mental health perspective. However, most of these studies are fixed in time, either by being connected to a specific event

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Evolution of daily sunspot numbers. Daily time series are available down to year 1818. The series follows a strongly cyclical path with a dominant scale of around 11 years.

of an increased solar activity or by being laboratory/experimental. This is mainly due to a problematic availability of data, specifically time series, of evolution of human health, be it physical or mental, that could filter out a possibility that the reported results are due to some other factors which are characteristic for the given event.

Here we focus on the effect of solar activity on human happiness. As the human happiness is generally not easily observable, we make use of the Happiness Index based on sentiment of Tweets (posts on Twitter) for a given day (more details are given in the Data section). Utilizing online data, and specifically the Twitter activity, has already proven useful in various disciplines [12–20]. In our specific case, it allows us to quantify the relation between solar activity, represented by sunspot numbers, and happiness. As both these series are available at daily frequency, it allows us to study the relationship as a standard multivariate time series relationship. In the following section, we provide a detailed description of statistical and dynamic properties of the analyzed series. The next section introduces a set of four models we use. And the last section presents the results with some additional discussion.

2. Data

We work with two base time series—sunspot numbers and the Happiness Index. Sunspot numbers serve as a proxy series for solar activity and it represents daily number of sunspots

\[ N_s + 10 \times N_g \]

where \( N_s \) is the number of sunspots observed and \( N_g \) is the number of groups counted over the entire solar disk. More details and history of the measures can be found on the provided webpage.

As a representative, we pick the day of Osama bin Laden’s death (2 May 2011). This day is a very sad day based on the index because the Tweets contain words “dead”, “death”, and “killed” which are considered to be negative. However, we can speculate that this was rather a happy day for the English speaking countries which are represented by English Tweets. Nevertheless, this is one of only few exceptions when the index gives opposite than expected happiness scores.

In an ideal situation, we would be able to obtain the list and content of the Tweets used for the index construction. The index could then be recreated using a more rigorous natural language processing which would have better handled the outlying sentiment values as the ones mentioned in the previous footnote. Unfortunately, these are not available.

Footnotes:
1 According to the Solar Influence Data Analysis Centre (SIDC) information, the daily total sunspot number is derived as \( N_s + 10 \times N_g \) where \( N_s \) is the number of sunspots observed and \( N_g \) is the number of groups counted over the entire solar disk. More details and history of the measures can be found on the provided webpage.

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