A Dash Toward Sunspot Analysis: A Report on How a Plotly Dashboard Reveals the Nature of a Solar Cycle

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*Extra Credit Features Are Highlighted

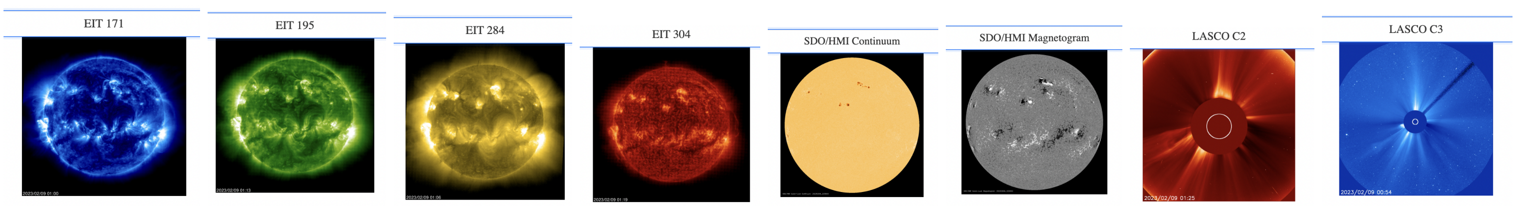
* **NOTE:** To properly run my dashboard, use the sunspot count month AND day files

Introduction/Background

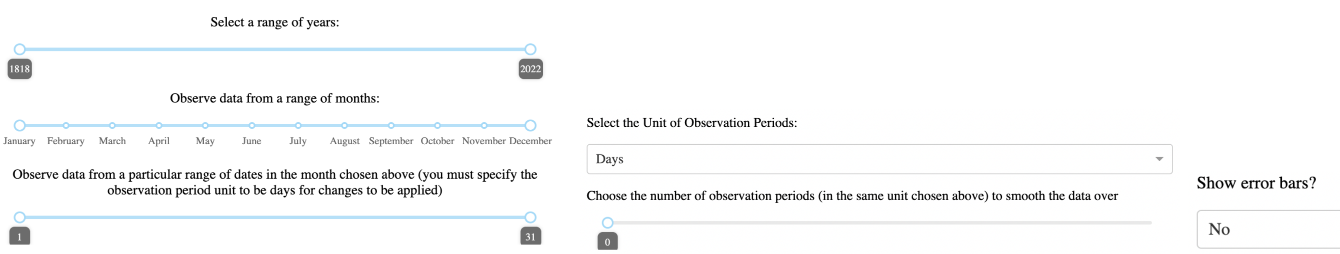
The information on sunspots in this dashboard derives from the Solar Influences Data Analysis Center, a department of the Royal Observatory of Belgium. Sunspots appear on the sun as dark marks since they have lower temperatures than other parts of the sun's surface. Magnetic fields prevent heat from the sun from reaching the surface at sunspot locations. This dashboard features real-time images of the sun taken with distinct filters. It also monitors the sunspot counts over time since more than 270 years ago. These counts are presented on a line chart with one line presenting the raw sunspot counts and one representing the average sunspot values over a user-defined number of observation periods. There is also a panel projecting the average sunspot counts per year. A scatterplot also exists to accentuate the variability of the sunspot cycle.

Data Sources, Methods, and Analysis

The dropdown at the top used to display a sun photo depends on a function that retrieves the filter a user selects from the menu as a string. The function outputs the corresponding link to a sun image as a result. The image contains a current real-time image of the sun from the Solar and Heliospheric Observatory of the National Air and Space Association (NASA). The user can see the sun through these filters: EIT 171, EIT 195, EIT 284, EIT 304, SDO/HMI continuum, SDO/HMI magnetogram, LASCO C2, and LASCO C3.

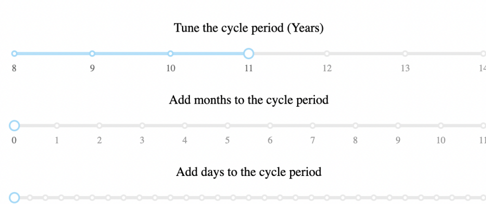


The functions that create the bar and line charts retrieve the user-defined unit for the observation periods (they can choose months OR days), smoothing degree (for the line charts), year range, month range, day range, and desire or lack thereof for error bars. The user controls those inputs with sliders and dropdown menus. For instance, the range slider under where it says "Select a range of years" enables a user to adjust the years presented on the charts' x-axes.



The topmost chart on the left displays one line showing the sunspot counts over the user-specified range stacked by another line with smoothed data. For the smoothed line, the user toggles a slider to control the number of observation periods used to calculate the moving averages for the smoothed sunspot count data. Moving averages eliminate "noise" data. Hence, as the smoothing window specified by the user increases, the smoothed line plot shrinks more vertically. The bar chart on the bottom left shows the average sunspot count per year. The user can also choose whether error bars are shown on these plots. Error bars indicate the data's standard deviation, or how far it is dispersed around the mean value.

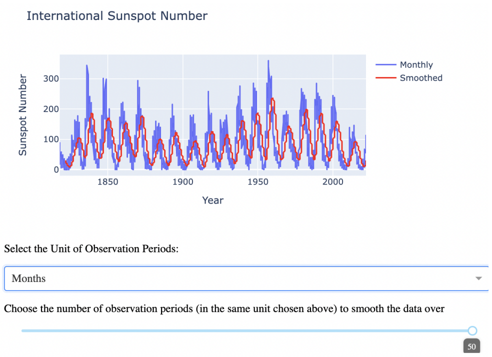
The scatter plot panel on the bottom right of the dashboard shows the variability of the sunspot cycle. It is built through a function that takes in the user-defined observation periods, year range, month range, day range, cycle period defined in years, additional months added to the cycle period, and additional days added to the cycle periods. The last three inputs are adjusted via the sliders beneath the plot, while the first four are retrieved via the same sliders and dropdown menus used by the line and bar chart functions.

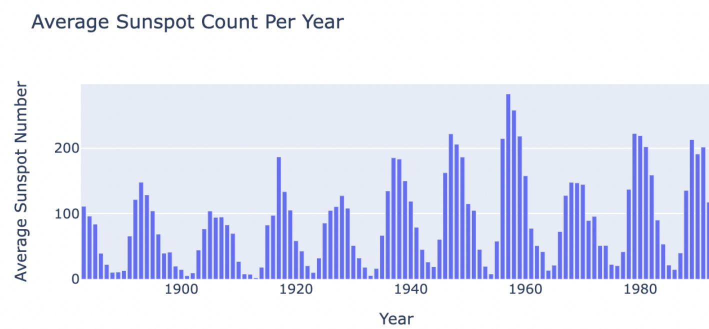


To create the scatterplot, the back-end program takes the modulus of the user-defined cycle length from the fraction dates within the original sunspot count file. For instance, if the user specified 11.271902806297 years as the tuning cycle period, then the program would transform the fraction date 2020.002739726027 into 2020.002739726027 % 11.27190280629 = 2.3321374. This calculation overlays each cycle upon itself, so as a user inputs a cycle length period closer to the actual period, the scatter plot would display lesser variability.

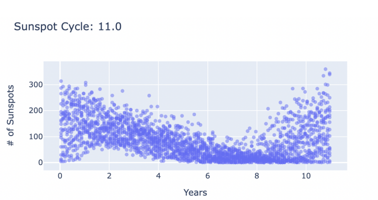
Conclusions

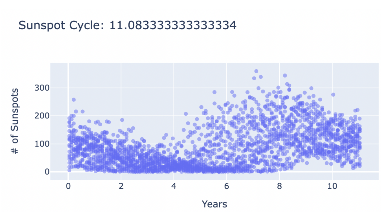
The international sunspot number chart (left) indicates that sunspot counts, and therefore solar activity, have varied over time cyclically. A greater number of sunspots suggests a greater amount of solar activity, while a lesser number conveys the opposite. Smoothing the data limits the number of years associated with peak values, making it easier to determine the cyclical nature of the sun's solar activity. Based on the plot created when smoothing the data over 50 days or months, solar activity has peaked about every 11 years (e.g., in 1849, 1860, and 1871). The bar chart display (right) agrees with the conclusions drawn from the line plots. The peaks in the bar chart, which represent years with the highest sunspot counts, correspond with about every 11 years on the x-axis.

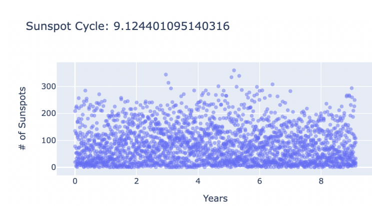




Accordingly, the scatter plot displays the least variation if the tuning cycle is defined by the user to be around 11 years (left). When the tuning cycle is tuned to other years (right), the scatter plot points form a rectangle indicating the sunspot counts are highly varied. Interestingly, toggling the cycle period by just one month (center) or even 5 days vastly affects the variability of the data points. The findings intriguingly remain consistent within various user-specified ranges of years, months, and days.







These findings align with how about every 11 years, the sun's north and south poles switch positions and revert to their original positions 11 years later. At the start of this solar cycle, the sun has the least sunspots. The sun yields the most number of sunspots during the middle of its solar cycle, and then the number plateaus again as the end of the cycle approaches. Therefore, based on the sun images at the time this abstract is being written, we are still experiencing the early-mid stages of a solar cycle since the sun does not have overtly many sunspots on its surface yet. As we reach the middle of the solar cycle, the number of sunspots should be much more abundant.

References

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