Sunspot number analysis

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1 Introduction

This first project is designed to acquaint you with the Matlab programming environment, as well as writing a professional-style report.

2 Project Requirements

Step 1 Download the **daily** sunspot number from `www.sidc.be/silso/datafiles`. (Note that all web sites listed here are also hyperlinks on the EP 410 course web page.)

Step 2 The text file contains the historical sunspot numbers from 1818 until the present. However, because much of the early data is missing (and to make sure we are all working on the same data set) truncate the file so that it contains only data from 1 Jan 1849 — 31 Dec 2015. This should give you a text file with 7 columns and 60,995 rows. (Make sure this is correct by counting the number of days - including leap days!) Plot this raw data in any manner you think will be enlightening for the reader. See below for more specific instructions.

Step 3 Because there is quite a bit of variation, smoothing the function is helpful for seeing trends. One simple method is to average n adjacent values, and to plot this average. This is what is done to create the "monthly average" sunspot number files, also available on the SILSO web page. A simple moving average (or running average) is included in the matlab file. Investigate how changing the value of n enhances or hides features in the data. Read §13.9 in Numerical Recipes (scan supplied) to decide how to approach smoothing.

(Note that the algorithm included in the matlab file is not strictly a moving average because the endpoints are wrapped. Option 1: Write a correct algorithm. Option 2: Write a weighted average algorithm. If you choose this option, you will need to explain, in detail, the mathematic of your weighting scheme.)

Step 4 Read Chapter 12 in "Numerical Recipes" (supplied on the course website). Write a detailed discussion of a discrete Fourier transform (DFT). Include a description of key concepts such as the Nyquist frequency.

Step 6 Perform a discrete Fourier transform on the data. Find all the strong peaks in the data, and estimate their strength and their width. (Look for 11 years, 22 years, 27 days.) Explain why some peaks are stronger than others, and why some are wider than others. The paper by Snodgrass and Ulrich (1990) might be helpful. Matlab has a built in "fast Fourier transform" (FFT) routine, which is nothing but a discrete Fourier transform where the length of the time series must be a power of 2 (i.e., 2^n, where n is an integer). If the time series has this length, then there is a way to perform the DFT with a small number of arithmetic operations. Include a *brief* description of the FFT algorithm in your report.

Step 7 Modify the plots given in "sunspots.m" to highlight the results you wish to present. Do not simply reproduce the plots that I have written. If you need help with Matlab, please come see me, or talk to your fellow students.

3 Report Requirements

As before, use this document as a template. You don't need to write an abstract, as this is not a journal article, but you do need to organize your report into logical sections, and include references to journal articles that you get information from. In addition, you must acknowledge where you got the data from — how to do this is given on the SILSO web page.

You must include a table for your report where you show a small portion of the raw dataset and explain what each column is. In addition, you should create several plots to highlight results. However, any plot must be explained thoroughly in the text and in the caption for the figure. Each figure must have a caption with complete sentences.

Again, your audience is your fellow classmates, who know everything that you do about space physics, but nothing about this particular project. The title should be something like "An analysis of the historical sunspot number." Some background of the solar physics should be included (how much is up to you), and then a mathematical analysis of the sunspot number time series. Make sure you clearly explain in the text all the mathematical operations that you perform

There is no length requirement for this report, as long as you include all the steps outlined above. Your file should be named exactly as this template file, with your last name replacing my last name. That is, turn in the resulting `pdf` file via email, and name the file `YourLastName_ep410_Report1_SSN.pdf`.

Some quotes to remember while you write.

> "... the scientist is under obligation to write not only so that he may be understood but so that he *cannot be misunderstood*."

> "It is not enough for you to have a good idea or to do good work; you must also be able to make other people understand what you are doing, why you are doing it, and with what result."

References

[1] Alfvén, H. (1976), On frozen-in field lines and field-line reconnection, *J. Geophys. Res.*, *81*, 4019-4021.