

Are Magnetic Storms Getting Stronger?

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Aim

The aim of this project is to describe:

- the causes of magnetic storms,
- the subsequent effects of magnetic storms and space weather, and
- whether or not magnetic storms are actually getting stronger.

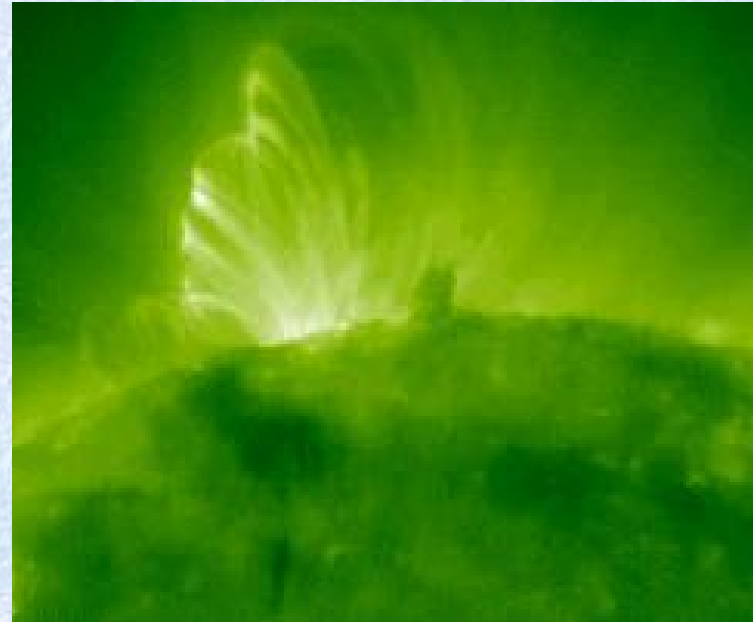
Introduction

'Magnetic storms' are caused by the interaction of the solar wind with the Earth's magnetosphere.

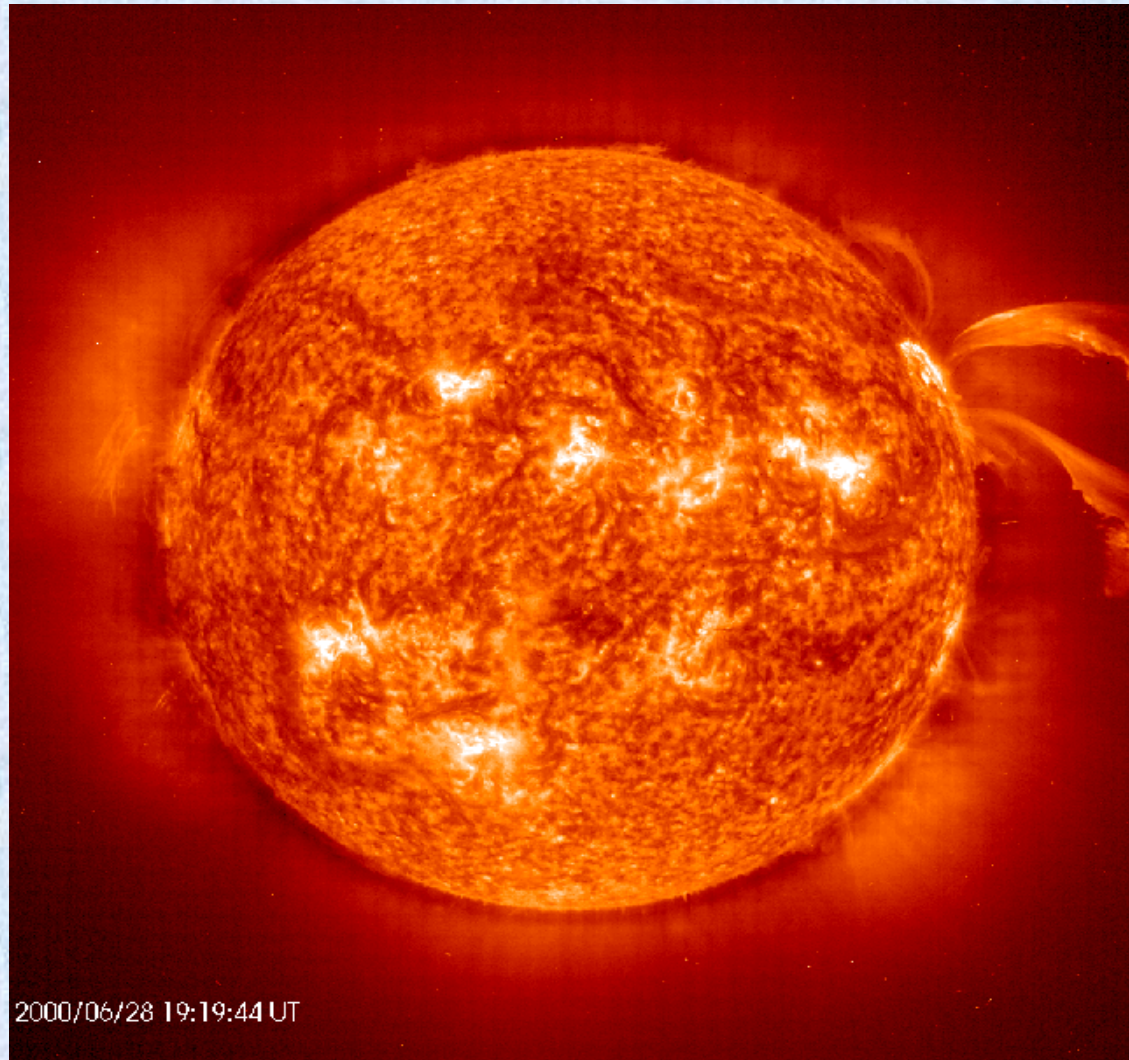
The solar wind is a plasma stream that moves outward from the Sun. It is made up of particles and photons that have been ejected from the Sun.

The solar wind also carries the frozen-in interplanetary magnetic field (IMF).

The primary source of the solar wind and high energy particles are sunspots, solar flares, coronal holes and coronal mass ejections (CMEs).

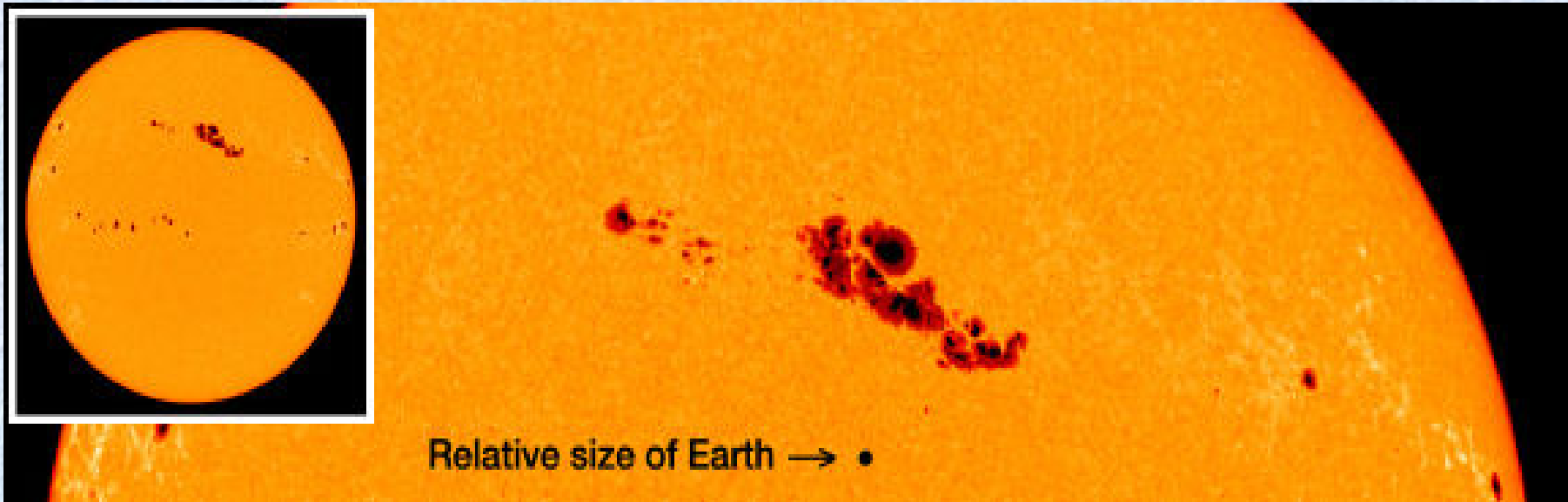


(Photos Courtesy of NASA)

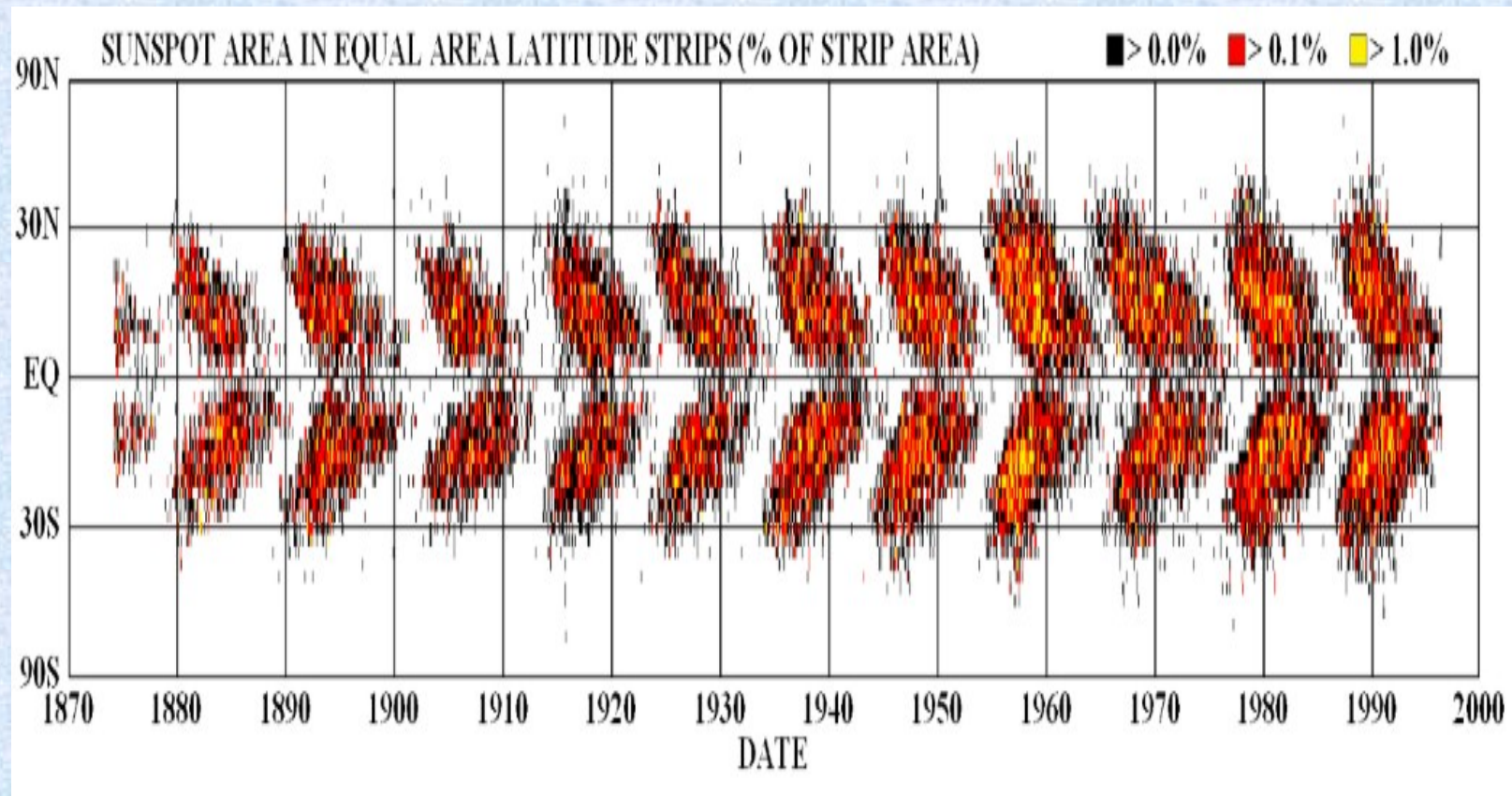


SOHO EIT Image of Sun and Prominence. (Photo Courtesy of NASA)

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Active region 9393 as seen by the MDI instrument on NASA's Solar and Heliospheric Observatory (SOHO) satellite. On 30 March 2001, the sunspot area within the group spanned an area more than 13 times the entire surface of the Earth. It was the source of numerous flares and coronal mass ejections, including one of the largest flares recorded in 25 years on 2 April 2001.

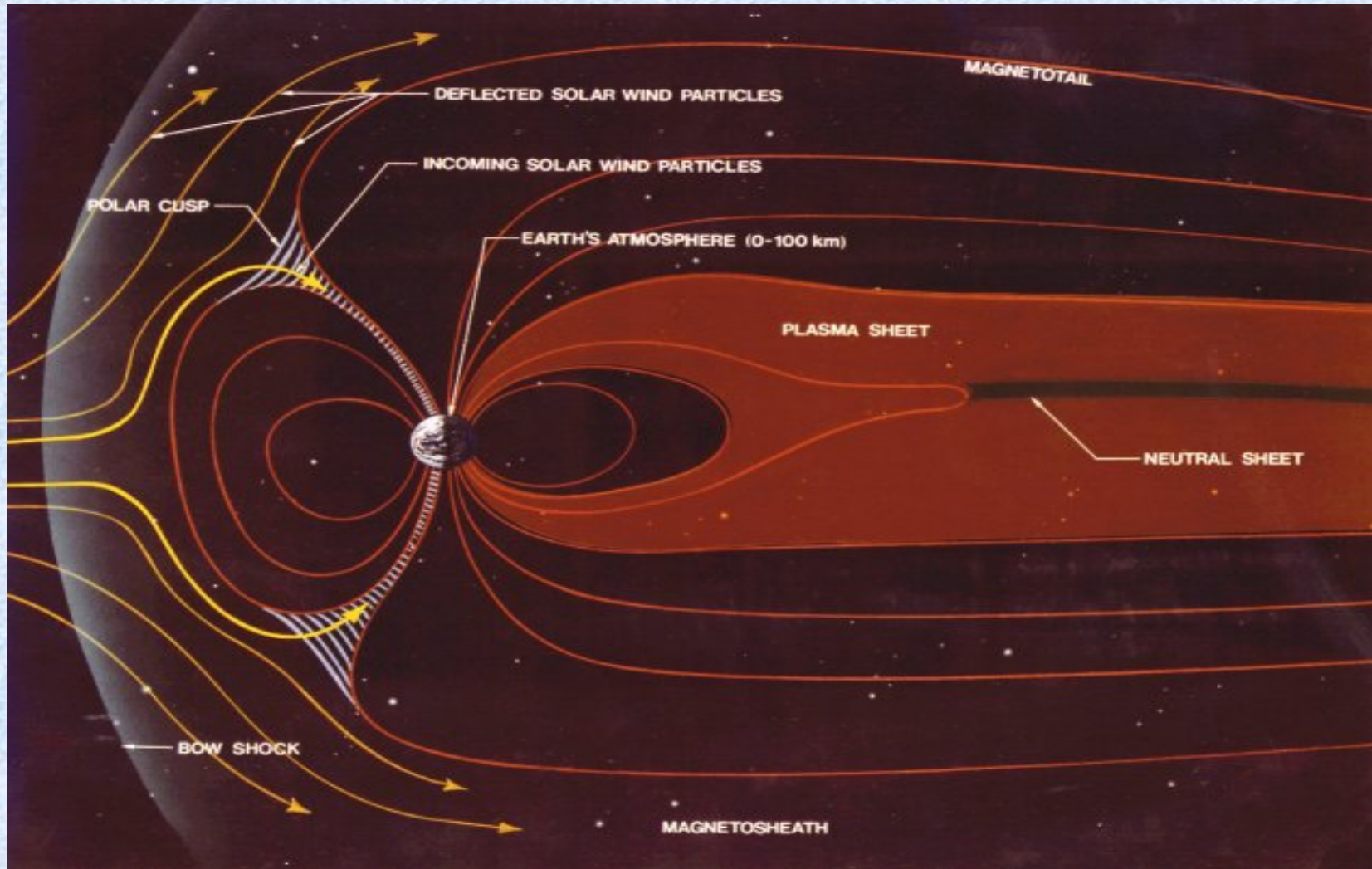


**Butterfly Diagram Showing Sunspot Migration Over Time.
This diagram shows sunspot location from solar minimum to solar
maximum.**

Magnetic Storms

Reconnection occurs between the IMF and the geomagnetic field.

This project has found that there is a strong correlation between storm incidence and the 11 year solar cycle.



Schematic Diagram of the Earth's Magnetosphere (Courtesy NASA)

Space Weather Effects

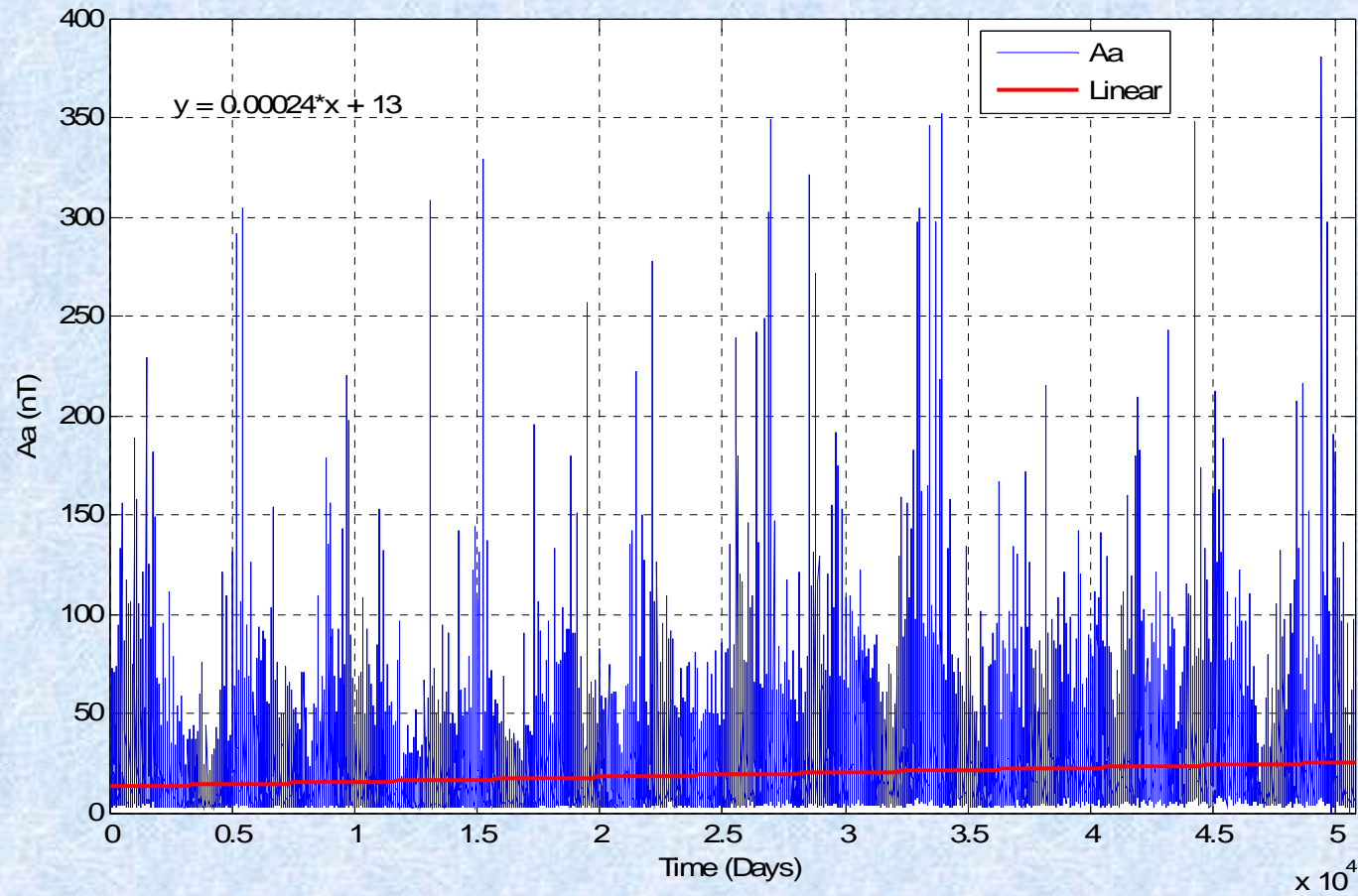
Effects can include:

- electronic failures in spacecraft and aircraft,
- immediate and long term effects on astronauts and aircraft crews,
- interruptions to telecommunication and navigation systems,
- electric power transmission failures, and
- effects to oil and gas pipelines.
- Some people even believe that space weather can affect the Earth's climate.

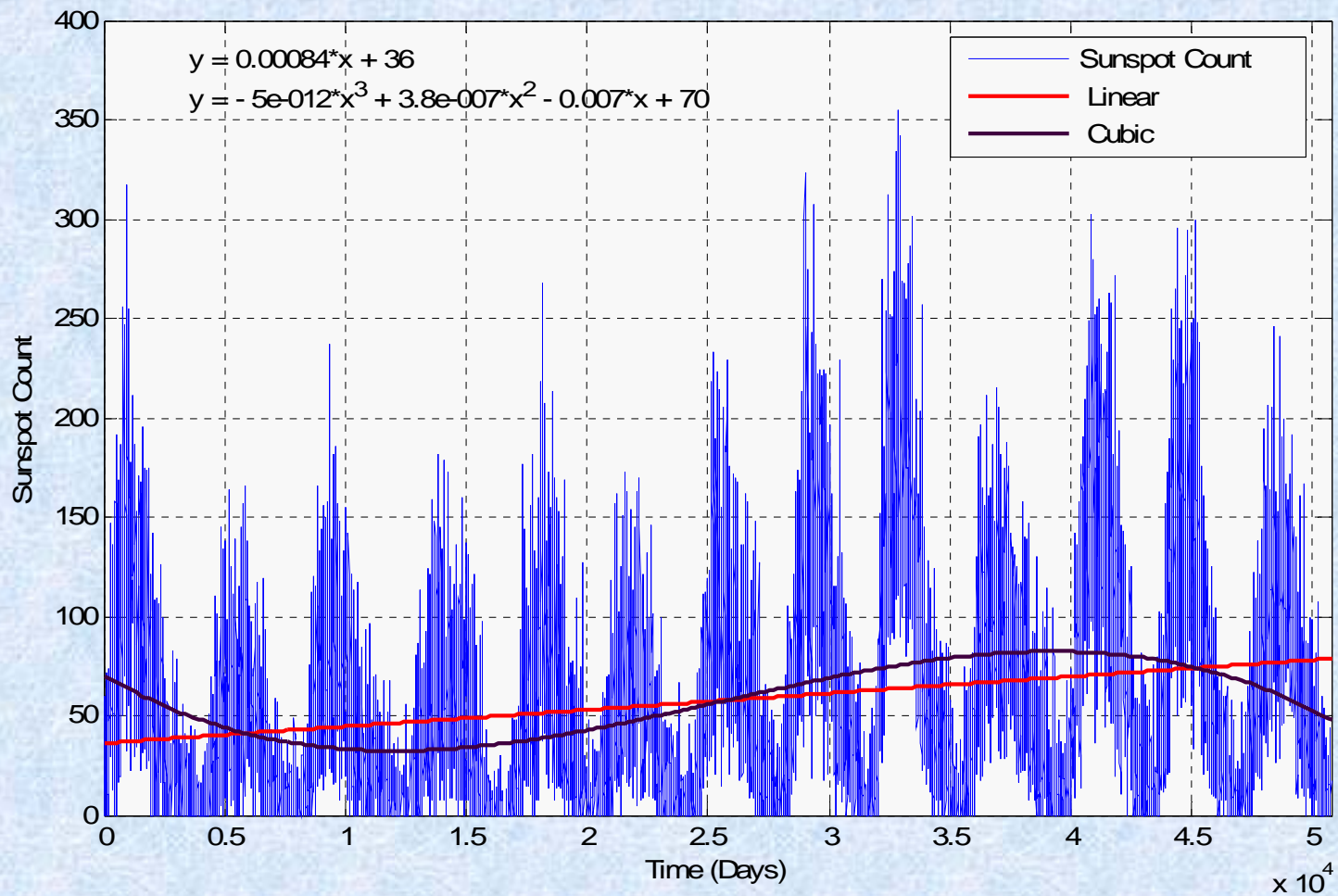
Method

- Daily and yearly Aa and sunspot count data were collected for a 139 year period.
- Sunspot data for a 300 year period was also collected (Proxy for aa?).
- Plots of the raw data, yearly averages and FFT were made.
- The plots were then analysed to determine trends or patterns.

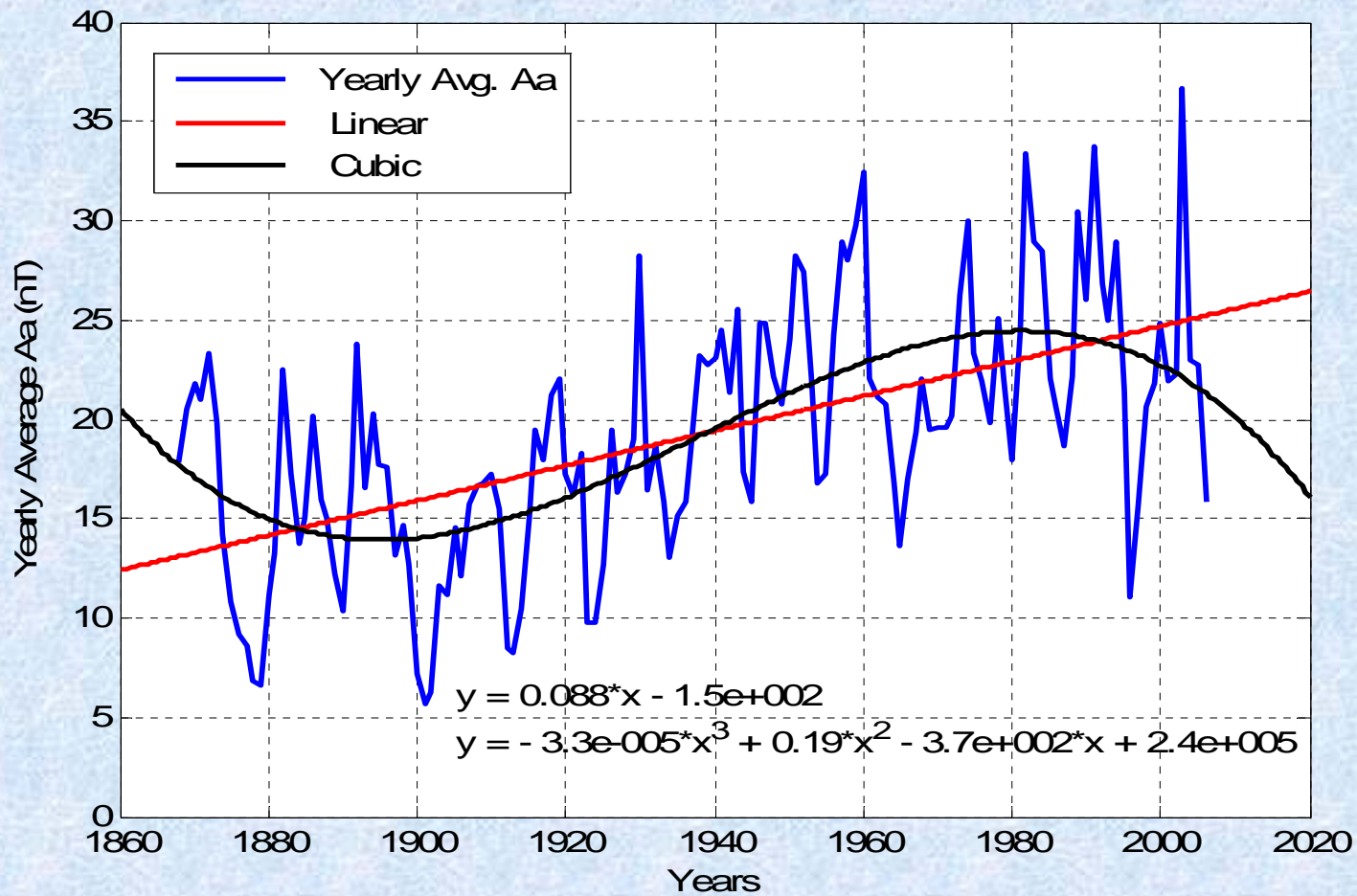
Results



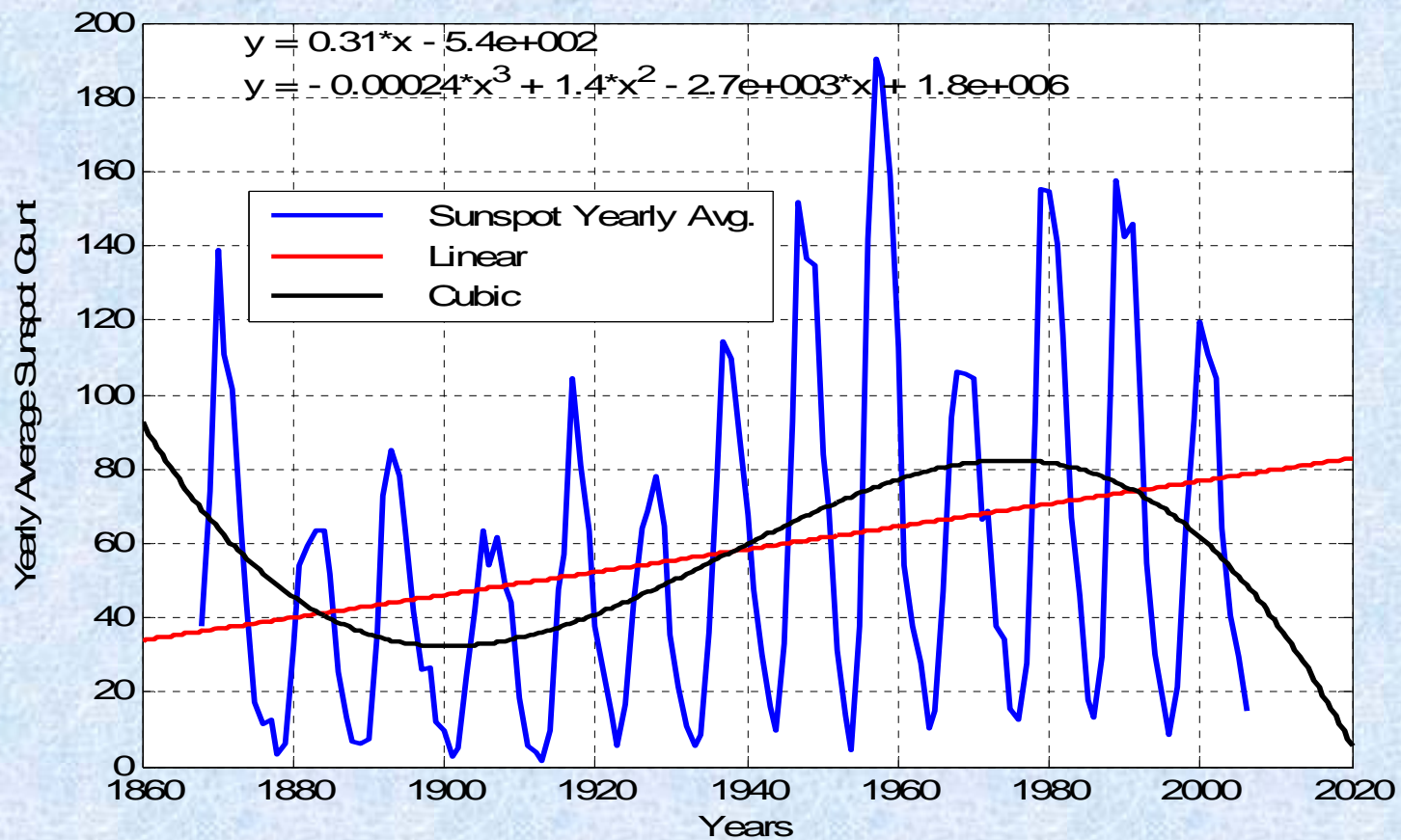
Plot of Aa (nT) and Time (Days) for Period 1.1.1868 to 31.12.2006



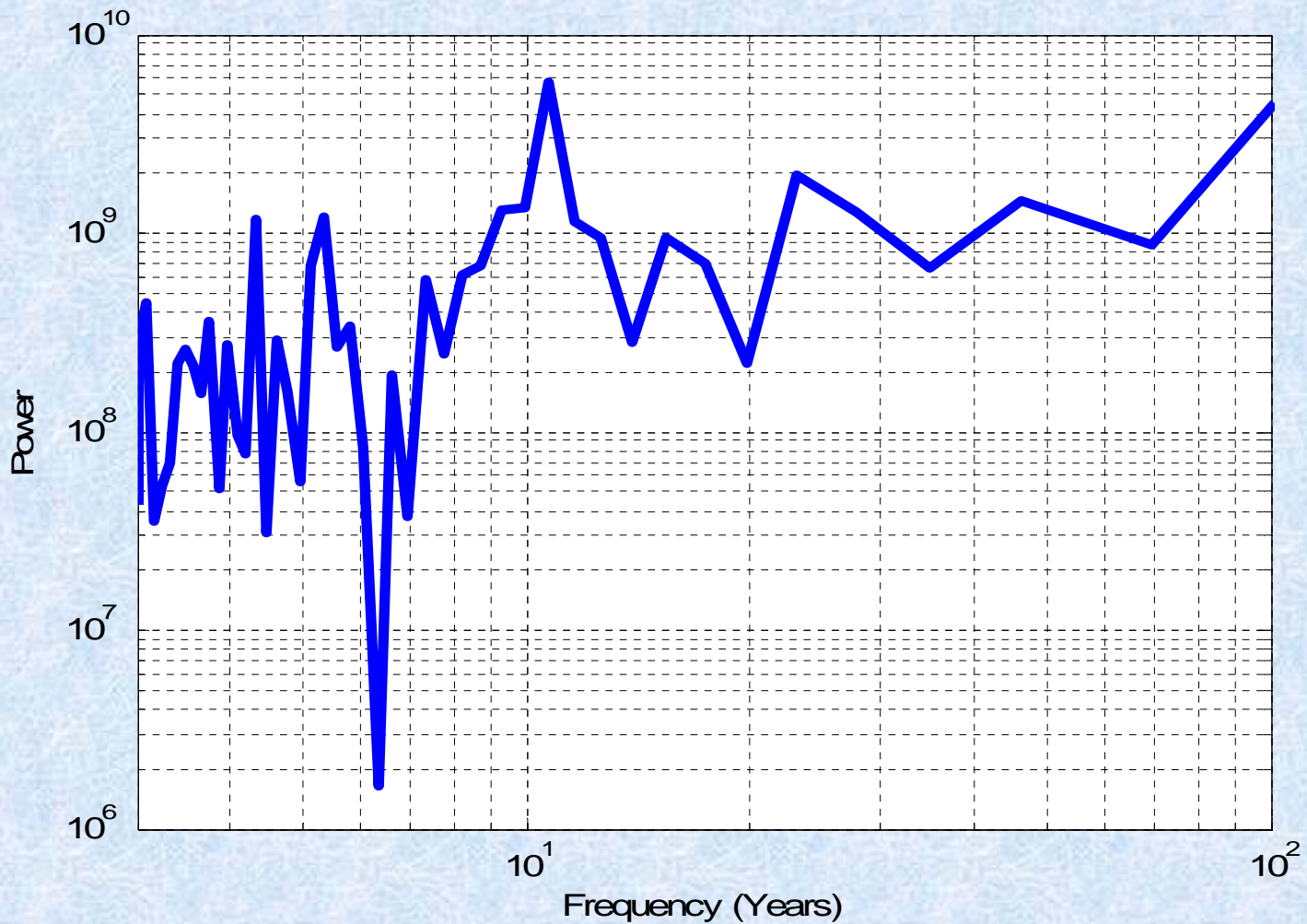
Plot of Sunspot Count and Time (Days) for period 1.1.1868 to 31.12.2006



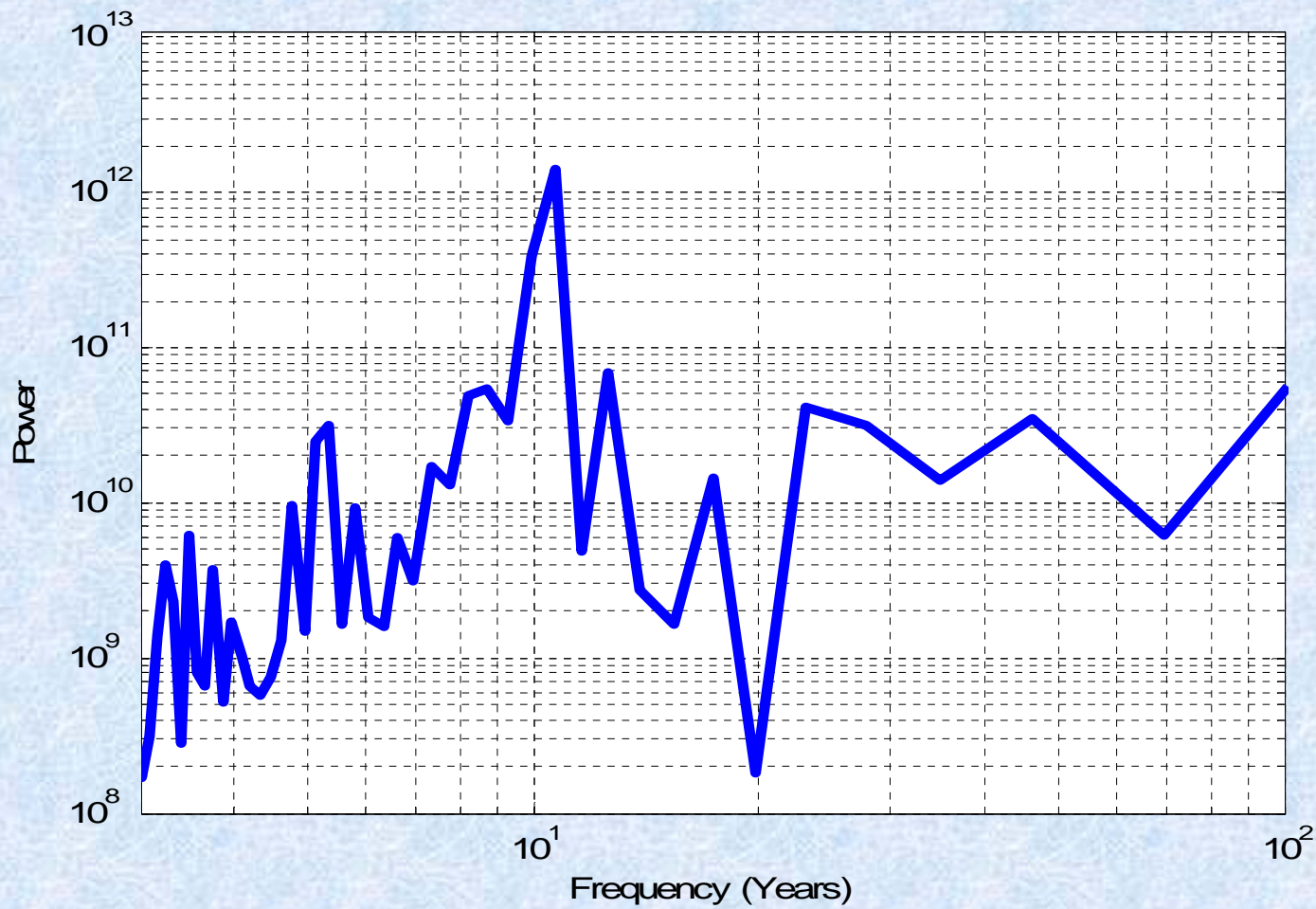
Plot of Yearly Average Aa (nT) and Years for Period 1868 to 2006



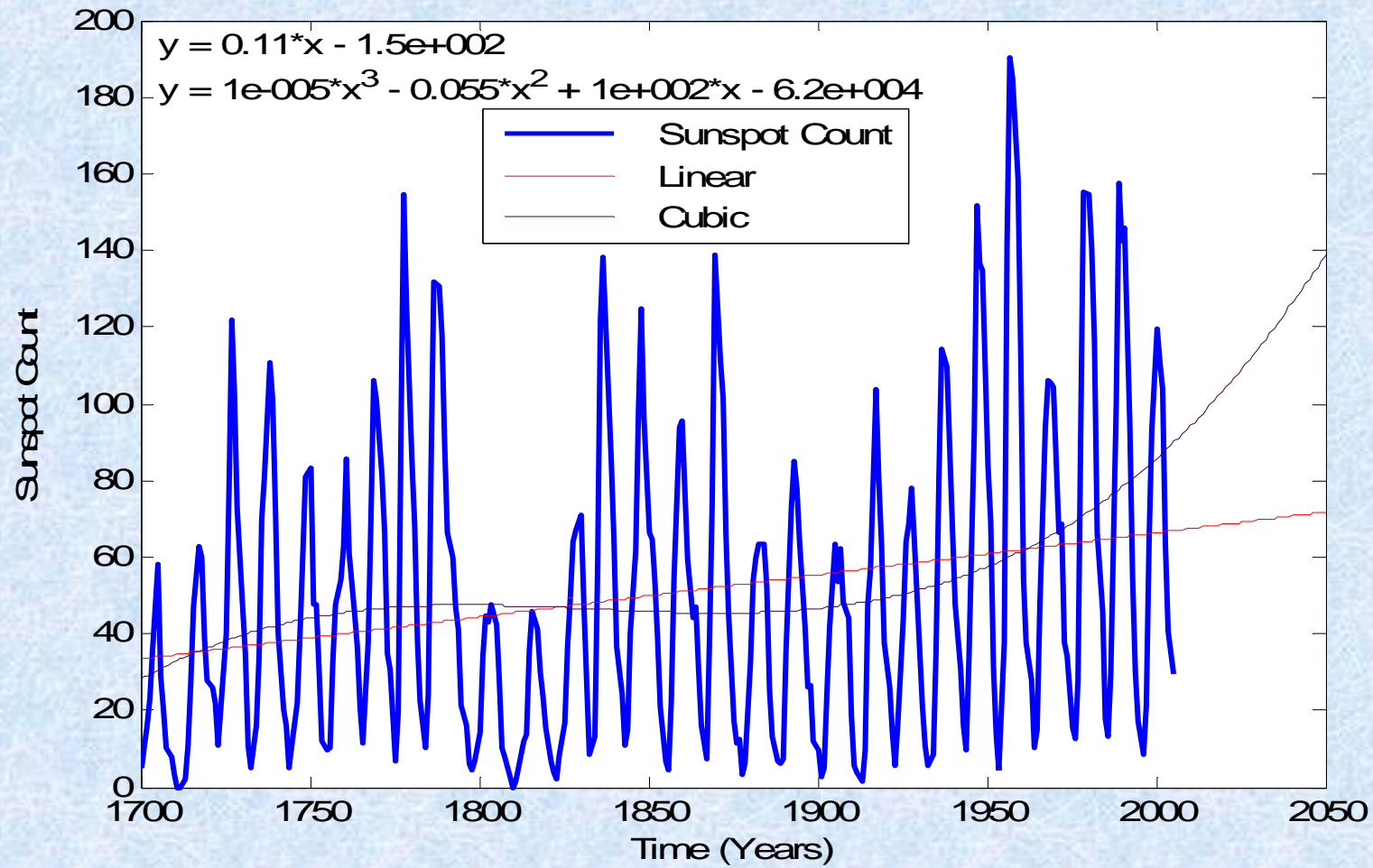
Plot of Yearly Average Sunspot Count and Years for Period 1868 to 2006



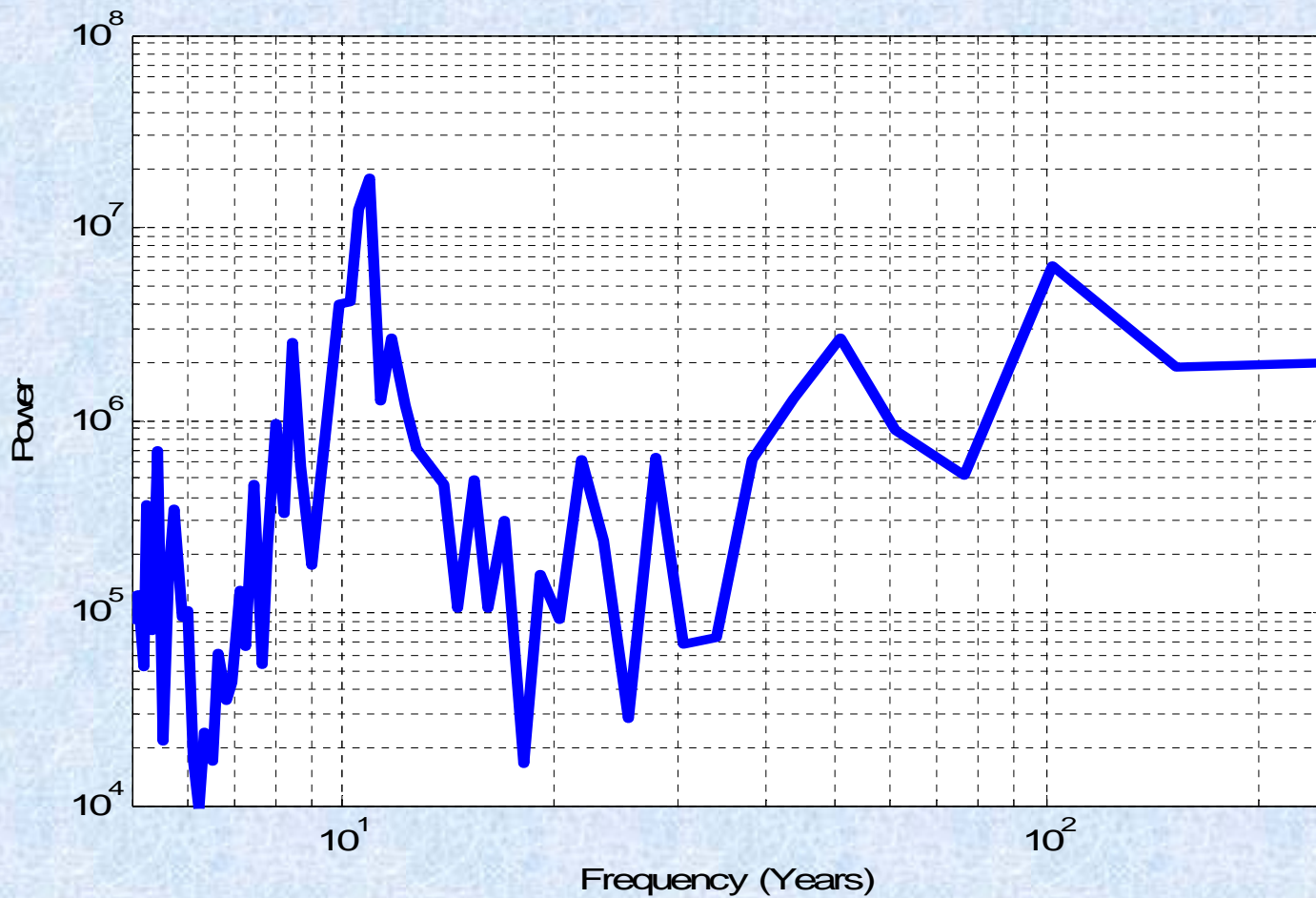
Log-Log Plot of FFT Power Spectrum and Frequency (Years) for Aa Data



Log-Log Plot of FFT Power Spectrum and Frequency (Years) for Sunspot Count Data



Plot of Yearly Average Sunspot Count and Years for Period 1700 to 2006



Log-Log Plot of FFT Power Spectrum and Frequency (Years) for Sunspot Count Data for Period 1700 to 2006

Conclusions

- Aa (aa) has increased linearly over past 139 years.
- There is a strong correlation between aa and sunspot count as aa closely follows the 11 year solar cycle. There is also a 100 year sunspot cycle.
- There appears to be an increase in the intensity of magnetic storms based on the increasing trend in Aa data. Individual storms, however, can occur at any time and are not getting larger.

Conclusions (cont'd)

- Increasing vulnerability of more sensitive electronic equipment to space weather effects.
- Increased risks to insurers of spacecraft and other large susceptible infrastructure items. Eg US\$200B worth of satellites (replacement cost) in Earth orbit at present.

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