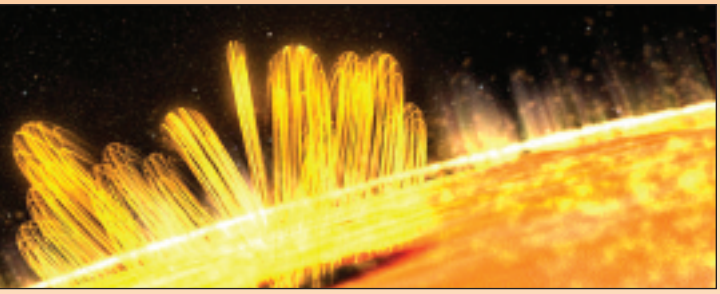
Are We Ready for the Next Solar Storm?

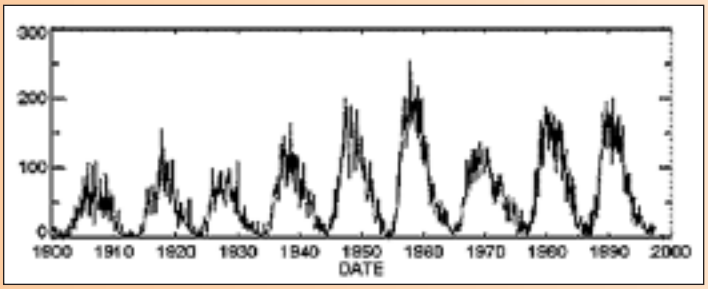


By Peter Afshar

On January 4, 2008 a new sunspot appeared on the surface of the sun signaling the start of a new Solar Cycle, according to David Hathaway of the Marshall Space Flight Center. A sunspot is an area of magnetic activity on the surface of the sun that appears as a dark spot on its surface. It is generally believed that the number of sunspots correlates with the intensity of solar radiation.

Over the past few years of marginal solar activity, several organizations from the scientific community have been paying close attention to the problems that this new cycle of solar activity may bring. Solar activity or solar variations are changes in the amount of radiant energy emitted by the sun commonly known as a Sun Storm. These storms are often accompanied by colorful auroras in lower latitudes as well as communication disruptions.

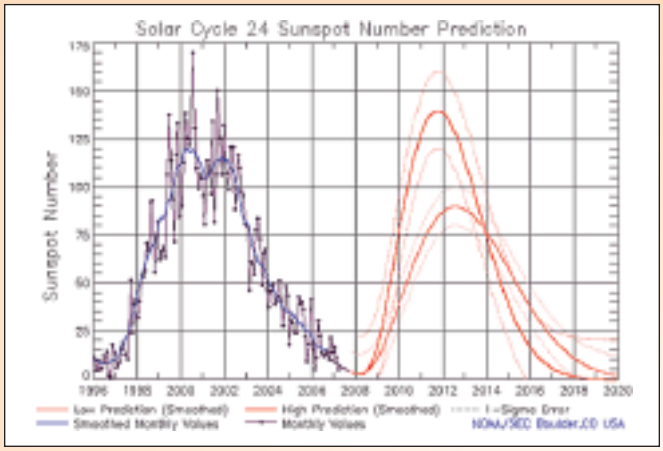
Solar cycles follow different periodical patterns, among which the 11-year cycle is the most studied. Other periodical patterns such as 22, 100, 200 and 2300 year cycles have been proposed. Graph (a) shows the 11-year cycle of solar activity during the last millennium. As can be seen, each cycle usually reaches its peak every 11 years. Each cycle normally lasts for 3-4 years, with approximately 4-6 months of maximum activity.



Graph (a) solar cycles during the last millennium. Source: David Hathaway, NASA MSFC.

According to NASA the next cycle, named Cycle 24, started in early 2008. Graph (b) shows the predictions on the number of sun spots that indirectly contribute to the intensity of the solar activity. Based on these predictions, cycle 24 will build up during 2008 and will continue through 2015, peaking between early to mid 2011.

It is generally understood that navigation, power and communications systems that rely on GPS satellite navigation will be disrupted by violent solar activity in 2011. The extent of this



Graph (b) prediction of sunspot number

is rather difficult to predict due to the random nature of radio bursts caused by the solar activity.

"Intense solar activity won't begin immediately," notes NASA solar specialist David Hathaway. "Solar cycles usually take a few years to build from solar minimum (where we are now) to Solar Max, expected in 2011 or 2012."

Based on past experience, we can surmise that the anticipated solar activity could affect GPS activity in two ways:

a) Directly affecting the GPS signals
b) Directly affecting RTK performance

The most direct affect of the solar cycle comes from charged particles from solar flares. These particles produce radio noise, which peak in the 1.2 and 1.6 gigahertz bands used by GPS. Normally, radio noise in these bands is very low so receivers can easily pick up weak signals from orbiting satellites. Reports from the last solar cycle peak in 2000-2001 offer the possibility that solar flares could knock off the signals completely for certain days and hours during the maximum period of activity. It should be noted that for most of the period of activity that won't be the case.

As surveyors, it is important for us to know how the solar flares will affect surveys based on Real Time Kinematic (RTK) surveying. The classical RTK technique requires that GPS data be transmitted from a reference receiver (known as the "Base") to one or more receiver units (known as "rovers").

Charged particles from solar flares may have a two-fold impact on RTK. Firstly, they can interrupt the radio data link between the base and rover. This data link that supplies the

"rover" with "corrections" usually comes through UHF radio or a cell phone network. Similar to the black out of GPS signals, outage of radio/cell phone link has happened before and probably will occur in this cycle but it is expected to occur only on the worst days of solar activity.

RTK performance will also be compromised as a result of the impact of solar flares on the earth's atmosphere, specifically the ionosphere. It is well known that the accuracy and reliability of the standard RTK solution decreases with increasing distance from the reference station or Base. This limitation on the distance between the roving receiver and the Base station is due in part to the systematic effects of ephemeris, tropospheric and ionospheric errors.

These systematic errors result in reduced accuracy and increasing initialization time (first fix) as the distance between the Base and rover increases. This phenomenon will become increasingly evident as we approach a peak in the cycle of solar activity. In other words, the rover may not perform adequately farther than a few kilometers from the Base in peak times compared to days of low solar activity when the rover may go as far as 30 kilometers. A simple reason behind this failure is that the ionospheric conditions above the Base receiver can vary greatly compared to the ionospheric conditions above the rover. Hence, the signal waves travel through different mediums, making ambiguity resolution impossible or at least difficult. In short, classic Base-rover systems used for RTK will be affected the most due to this phenomenon.

In order to avoid the distance-based errors of a conventional Base-rover combination, several manufacturers have proposed the concept of GPS Reference Station Networks. These networks allow us to model systematic errors over the coverage area. In some of the networks, base stations can be created mathematically by the system close enough to the rover to reduce or eliminate systematic errors.

First auroras of the new solar cycle
- credit Calvin-Hall

The GPS Reference Station Networks require a continuous data connection between the control center (main server) and all reference stations, which is usually provided by an internet link. Raw GPS data can then be transmitted continuously to the server. The server will model all the systematic error sources and adjust the network constantly. Whenever a rover connects to the server and provides its position, appropriate corrections are sent to the rover via a GSM cellular link.

In conclusion, it is predicted that users performing their RTK surveys based on a network solution will be the least affected during the solar activity cycles.

Updates on Solar Activity can be tracked at the following web sites:

- http://solarscience.msfc.nasa.gov/SunspotCycle.shtml
- http://sohowww.nascom.nasa.gov/
- http://www.spaceweather.com/

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Date to Remember

Geomatics Picnic

Friday, October 3, 2008

York University, Keele Campus

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