Natural Radio

News, Comments and Letters About Natural Radio

August 2003

May 29th Geomagnetic Storm As sometimes happens on the waning side of the sunspot cycle, geomagnetic storm producing solar activity has been frequent this past month. On May 26, 27 and 28 , the sun became very active and erupted with M and X-class flares that fired 3 CMEs directly at earth. On the morning of May 29 I checked for activity and since the K_p index was rising, I went out and monitored at about 1320 UTC (8:20 AM Local) and recorded weak chorus. Later that afternoon the Planetary K passed 8 after the impact of the combined CME and a severe geomagnetic storm was in process. I headed out to my favorite listening site, fortunately only about 10 minutes away, and recorded between 2000 and 2030 UTC (3:00 – 3:30 pm local). I was rewarded with some of the strangest sounds I had ever heard. Amazingly they were occurring in mid-afternoon with conditions varying wildly over the half hour that I was listening. I have uploaded some sample sounds in the .MP3 format have to the VLF_Group site on Yahoo at http://groups.yahoo.com/group/VLF_Group/.

My good fortune to catch this event was partly due to the fact that I regularly monitor Space Weather and the K_p index.

Monitoring The Magnetosphere In the November 2002 column, I listed some of the web resources for monitoring geomagnetic conditions and predicting potentially good listening times for Natural Radio. This month I thought we'd look a little closer the measurements of activity in the earth's geomagnetic field. There are a variety of readily available measurements of the earth's magnetic field and the interplanetary magnetic field.

Earth based Geomagnetic Measurements The popular A and K indices are derived from measurements of the earth's magnetic field at ground based observatories.

K-Index. The K-index is a code that is related to the maximum fluctuations of the horizontal components of the magnetic field measured on a given magnetometer, and relative to a geomagnetically quiet day. The conversion from maximum fluctuation measured in nano-teslas (nT) to K index varies between the different observatories in a manner that the historical rate of occurrence of certain levels of K are about the same for all monitoring observatories. In short, this means that observatories at higher geomagnetic latitudes require higher levels of fluctuation for a given K-index. The conversion table for the Boulder, CO magnetometer is shown on the left. Each observatory has its own conversion table.

K	nT
0	0-5
1	5-10
2	10-20
3	20-40
4	40-70
5	70-120
6	120-200
7	200-330
8	330-500
9	>500

The Boulder K index is reported at 18 minutes past the hour via WWV and WWVH.

The official Planetary K index (K_p) is calculate from a weighed average of K-indices from a network of geomagnetic observatories. Since these observatories don't report in real time, the official Planetary K is calculated after the fact and is an indicator of what conditions were during a previous time period.

At SEC (Space Environment Center, NOAA), the final real-time K-index which is referred to as the "Estimated K_p", (as opposed to the official K_p) appears on the website http://www.sec.noaa.gov/today.html, and is determined after the end of the prescribed three hour intervals (0000-0300, 0300-0600, …, 2100-2400). The maximum negative and positive deviations in the horizontal components during a given 3 hour period are added together to get the total maximum fluctuation. Of course, these deviations may occur anytime during the three hour measurement period. SEC uses real time estimates of the Kp index which are derived by the U.S. Air Force 55th Space weather Squadron.

A-Index Because of the non-linear relationship between the K-Index and the magnetic field measurements, taking the average of a set of K-indices is not meaningful. The A-index was invented to calculate some type of daily average for geomagnetic activity. Each K-index is converted back to a linear scale called the "equivalent three hourly range" a-index (note the lower case "a"). The daily A index is the average of eight "a" indices. The table at the left indicates the conversion.

K	a
0	0
1	3
2	7
3	15
4	27
5	48
6	80
7	140
8	240
9	400

Kp and the NOAA G-scale. The NOAA G-scale was designed to correspond in an easily understandable way to the significance of effects of geomagnetic storms. This corresponds directly to the estimated Planetary K index as shown below. For more information on the different NOAA Space Weather Scales, go to http://www.sec.noaa.gov/NOAAscales/index.html

K_p -index	NOAA Space Weather Scale Geomagnetic Storm Level
K_p<5	G0 – Below Storm
K_p =5	G1 – Minor Storm
K_p =6	G2 – Moderate Storm
K_p =7	G3 – Strong Storm
K_p =8	G4 – Severe Storm
K_p =9	G5 – Extreme Storm

Satellite based geomagnetic measurements.

GOES The GOES satellites are in a geostationary orbit above the equator. Their primary mission is weather photos, but they also contain sensors to monitor the Space Environment above the earth. The GOES Hp plot at the SEC Space Weather site http://www.sec.noaa.gov/today.html contains the 1-minute averaged parallel component of the magnetic field in nano-Teslas (nT), as measured at GOES-12 and GOES-10. The Hp component is perpendicular to the satellite orbit plane and thus essentially parallel to Earth's rotation axis. This is near real-time data and is a good way to watch for a suspected CME impact with the magnetosphere.

ACE ACE is positioned almost a million miles (1.5 million kilometers) from the Earth, situated in the Earth-Sun libration point called L1. By orbiting the L1 point, ACE stays in a relatively constant position with respect to the Earth as the Earth revolves around the Sun. (For more information on the libration or Lagrangian points, see http://www-istp.gsfc.nasa.gov/Education/wlagran.html) The location of ACE at the L1 libration point between the earth and the sun will enable ACE to give about a one hour advance warning of impending geomagnetic activity. With the approximate one hour lead time, this is a good way to get a "heads-up" on expected (as well as unexpected) geomagnetic disturbances.

The NOAA webpage http://www.sec.noaa.gov/NOAAscales/index.html has real-time data from the ACE satellite. The dial indicates the strength of the B_z component of the interplanetary magnetic field. This component is parallel to the magnetic axis of the earth and indicates how this incoming magnetic field carried on a CME or the solar wind, will couple with the earth's field. When the interplanetary magnetic field turns south compared to the Earth's magnetic field, geomagnetic activity will increase. As the B_z (Southward pointed) value becomes more negative, the associated geomagnetic activity increases.

The dial ranges from -50 to +50 nT. The dial is a linear scale from -10 to +10 nT and a different linear scale from -10 to -50 nT and +10 to +50 nT. For values beyond the maximum and minimum, the arrow will stay pegged at the maximum or minimum. If the magnetic field data is absent, the arrow will not appear. The arrow indicates the actual value of the latest 15 minute average of the B_z component of the magnetic field vector. The letters N and S refer to North and South of the magnetic equator. The color bar indicates green for positive values, yellow for small negative values, and red for large negative values of B_z.

So, that's a brief description of the various magnetic measurements that are available on the web. Use this data to help predict good listening conditions. As I learned in May, a geomagnetic storm can produce interesting listening conditions even during the day and even with heavy sferics.