Solar Activity and Ham Radio

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This paper and presentation is written to increase understanding and promote further study of solar activity for the Thibodaux Amateur Radio Club. I am in no way an expert or authority on this subject.

Electromagnetic waves, and in this case radio signals, interact with the media in which they travel. Radio signals can be reflected, refracted or diffracted in their media. These media interactions can cause radio signals to change direction or bend to reach areas which would not be otherwise possible if the radio signals travelled in a direct line.

The Sun has a major impact on ionospheric radio propagation, particularly in the HF spectrum. As the Sun provides radiation that influences the ionosphere and consequently HF radio propagation, any flares or other solar disturbances are of great importance to Amateur Radio. Under some circumstances these can enhance radio communications. Under other circumstances they can disrupt radio communications on the HF bands, while also sometimes affecting the VHF spectrum.

The following summarizes two major solar events and their effects on radio propagation:

SOLAR FLARES

A solar flare is a sudden flash of brightness observed over the Sun's surface which is interpreted as a large energy release of up to 6×10^{25} joules of energy (or about a sixth of the total energy output of the Sun each second, or 160,000,000,000 megatons of TNT). The flare ejects clouds of electrons, ions, and atoms through the corona of the sun into space. These clouds typically reach Earth a day or two after the event. The occurrence of solar flares correlate with the sunspot cycle, increasing in number towards the peak of the sunspot cycle.

It is believed that magnetic fields between sunspots are responsible for solar flares. When a magnetic field between the sunspots becomes twisted and sheared, the magnetic field lines may cross and reconnect with enormous explosive energy. When this occurs, an eruption of gases takes place through the solar surface which can extend tens of thousands of miles out from the surface of the Sun. Gases from within the sun start to rise, the area becomes heated even more, and this causes the level of visible radiation and other forms of radiation to increase.

Solar flares usually last for about an hour, after which the surface of the Sun usually returns to normal. The flares that affect radio propagation and radio communications on Earth may be noticed for some time afterwards.

Flares provide increase levels of ionization in the ionosphere. This increase in ionization of the ionosphere is what provides an effect on radio communications.

If the increased ionization occurs in the upper layers of the ionosphere, HF propagation is enhanced. If the lower layers of the ionosphere are affected, higher levels of attenuation of HF communications signals occurs and poor conditions may be experienced. In this case, an increase in the level of background noise in the VHF spectrum can also be detected easily.

Solar flares are classified by their intensity at X-ray wavelengths, i.e. wavelengths between 1 - 8 Angstroms. X-Ray intensity from the Sun is continually monitored by the National Oceanic and Atmospheric Administration (NOAA) via satellite detectors. The largest flares are called X-Class flares. M-Class flares are smaller, having one tenth the intensity of an X-Class flare. C-Class flares are one tenth the intensity of an M-Class flare.

CMEs

Coronal Mass Ejections, CMEs are huge bubbles of gas that are threaded with magnetic field lines,. The bubbles are ejected during a period of several hours. Material is thrown out from the Sun in one general direction and only if this is on an intersecting trajectory will it affect the Earth.

Although much greater than flares in many respects, CMEs were not discovered until spacecraft could observe the Sun from space. Prior to space travel, we could only view a CME during an eclipse at which time the corona of the Sun could be observed.

Although earth based coronagraphs are available, they are only able to view the very bright innermost area of the corona. Space based coronagraphs are able to gain a very much better view of the corona extending out to very large distances from the Sun, and consequently effectively view CMEs.

Like solar flares the frequency of CMEs vary according to the sunspot cycle, peaking around the sunspot maximum, and falling around the minimum.

CMEs can give rise to ionospheric storms. CMEs can provide a short lived enhancement to radio propagation conditions, but before long, it can result in a complete black out of radio communications .

SUMMARY

Solar disturbances are responsible for many of the major changes in the ionosphere. The effects of both CMEs and solar flares can cause major changes to ionospheric radio propagation, often disrupting them for hours or sometimes days. As a result, the ability to observe and classify them can help to forecast ionospheric radio propagation conditions.

References:

1. Poole, Ian : “Solar Flares and Disturbances for Radio Propagation”, Radio-Electronics.com
2. Phillips, Tony (27 May 2008). "Cartwheel Coronal Mass Ejection". *Science@NASA*. NASA.gov