Propagation
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CMEs and Their Impact to Contesting

The September/October column showed the impact of X-ray flares to propagation during a contest effort. This column is about the cousin of the flare – a coronal mass ejection (CME), and its impact to propagation during a contest.

Back in the pre-satellite days, it was believed that flares and CMEs went hand-in-hand. In other words, if one occurred then the other one did, too. But as we entered the space age, that picture changed. Data from satellites specifically launched to study the Sun now give a better picture of what's going on.

Flares and CMEs can occur together, or they can occur separately. The number of flares during a solar cycle tracks the smoothed sunspot number very well. The number of CMEs during a solar cycle tends to maximize a couple years after solar cycle maximum.

CMEs eject large amounts of solar matter. Normally the solar wind speed is about 400km/sec. But a CME can increase this dramatically, which essentially creates a shock wave. When the shock wave arrives in the vicinity of Earth, it can cause variations to and distortions in the Earth's magnetic field.

The result of this can be elevated A and k indices, auroral absorption, intense auroral ionization, and generally reduced MUFs (MUFs at low latitudes can sometimes be enhanced). Since the shock wave is traveling at a relatively slow speed (relative to the speed of light at 300,000km/sec), we have a day or two warning of an impending geomagnetic storm after seeing the explosion on the Sun.

The NASA ACE (Advanced Composition Explorer) spacecraft sits about 1 million miles from Earth on a direct line to the Sun. It measures the solar wind speed and orientation of the interplanetary magnetic field. This satellite gives us a 30 to 45 minute warning after it detects the shock wave.

Whether a CME causes a geomagnetic storm depends on how the CME will hit Earth (a direct blow or a glancing blow) and the orientation of the interplanetary magnetic field (abbreviated IMF, and another name for the Sun's magnetic field). A CME heading directly at us with the Bz component of the IMF turning south (negative) gives the best chance for a CME to impact the ionosphere.

Let's take a look at Bill W4ZV's log from the CQ WW CW 2001 contest (November 24 and 25), as it is a good example of what a CME can do to our contesting efforts. W4ZV did a single band effort on 10m. Figure 1 shows how many QSOs he made in the time periods indicated on both days.

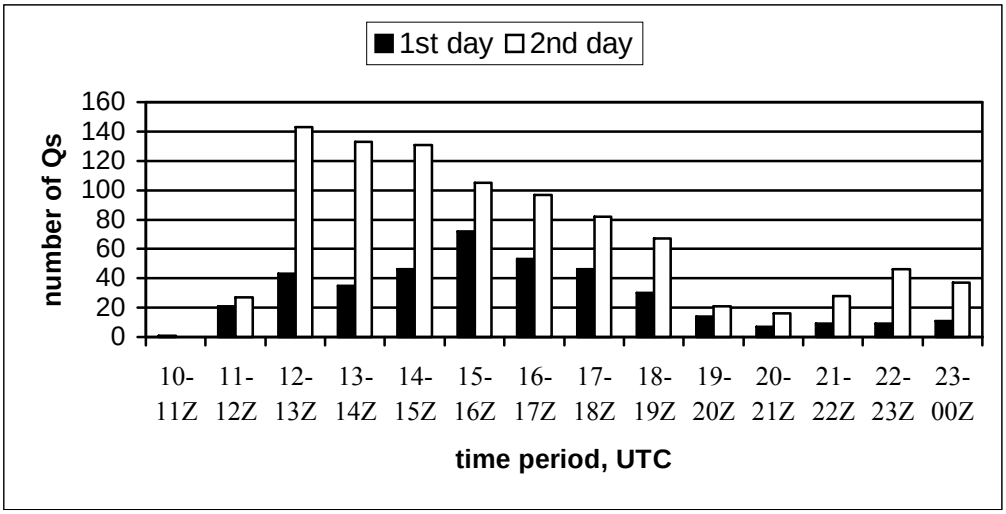

Figure 1 Number of Qs

It's quite obvious from the data that the first day was not too good. The second day was much better, and was essentially back to normal.

The cause of this was a CME that occurred concurrently with an X-ray flare of magnitude M9.9 at 2330 UTC on November 22. The CME passed the ACE spacecraft around 0539 UTC on November 24 (the first day of the contest), and the Bz component of the IMF turned strongly southward following the passage. The shock wave had peak velocities of 1000km/sec, and arrived near Earth about 30 minutes later. Thus we would expect the planetary Kp index to show a dramatic increase in the 06-09Z time period on the 24th. Figure 2 indeed shows this.

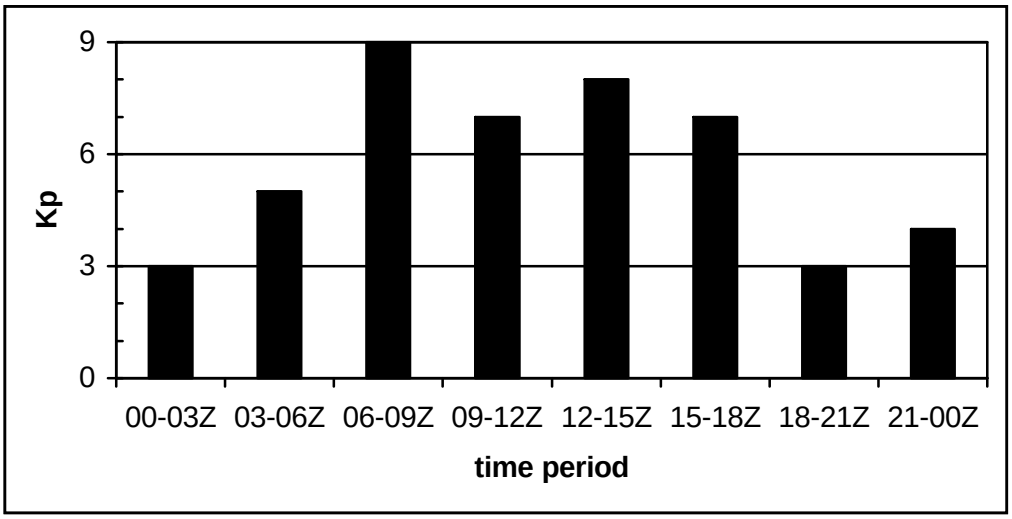

Figure 2 Kp index on November 24

These elevated k indices on the first day resulted in depressed MUFs and decreased run rates. On the second day, the Kp index was 3 and below for the entire period. With the

geomagnetic field settled down on the second day, the second day run rates in Figure 1 show that the ionosphere recovered to near normal.

Thus a CME and its resultant geomagnetic storm generally can cause long duration disruptions to propagation through the loss of electrons to the magnetotail. The band recovers when the geomagnetic field returns to normal and the lost electrons are replenished via the ionization process.

For more information about an impending CME, check out **solar.spacew.com/cme/**. This Solar Terrestrial Dispatch web site estimates the arrival time of the shock wave from a CME and estimates the relative shock strength. It should give you a general idea of how bad the bands will be affected (if at all) from an impending CME.