When the K Index Goes Up, Do the Higher Bands Always Get Worse?
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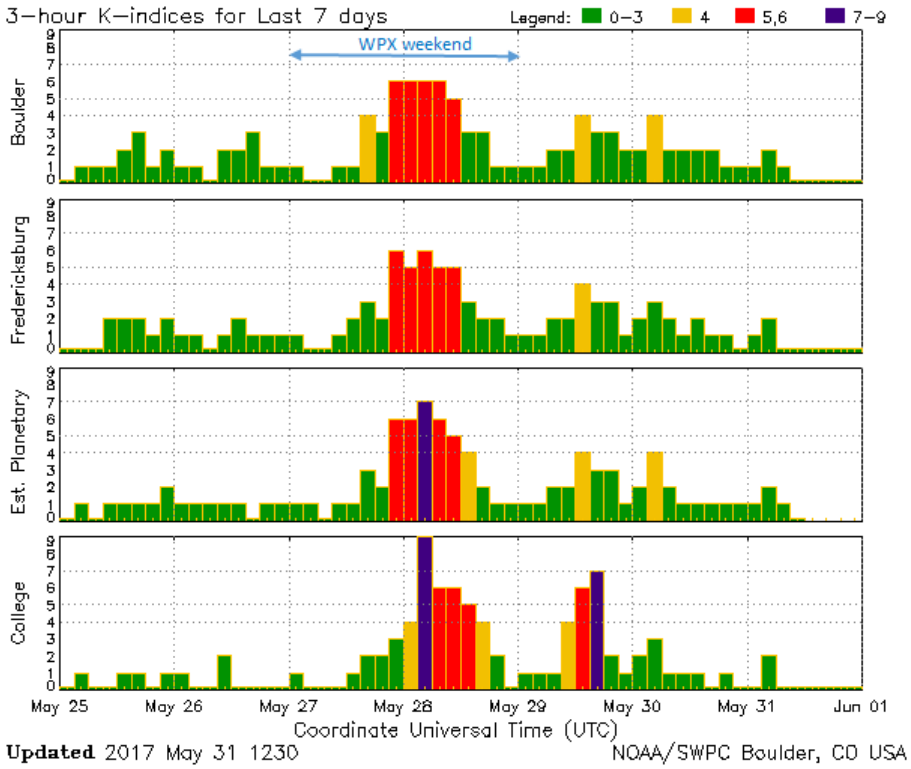
The ARRL Propagation Bulletin (edited by Tad K7RA) for June 2, 2017 had comments from two West Coast ops – K6CTW (east of Los Angeles) and N6GP (southeast of Los Angeles). Both ops were participating in the CQ WPX CW contest on the weekend of May 27-28. K6CTW made QSOs with YB, ZL, JA and KHØ on 15-Meters and on 20-Meters from 0440 UTC to 0540 UTC on Sunday May 28. N6GP made QSOs with JA and KH2 on 10-Meters around 0400 UTC, also on May 28.

K6CTW commented that it was usually not worth it to even check out band conditions for stations such as his running low power and simple antennas during a geomagnetic storm – especially a major geomagnetic storm such as the one during the WPX weekend. He finished by saying "*Be great to find out how this happened because isn't it a given that major geomagnetic storms totally disrupt the higher bands?*"

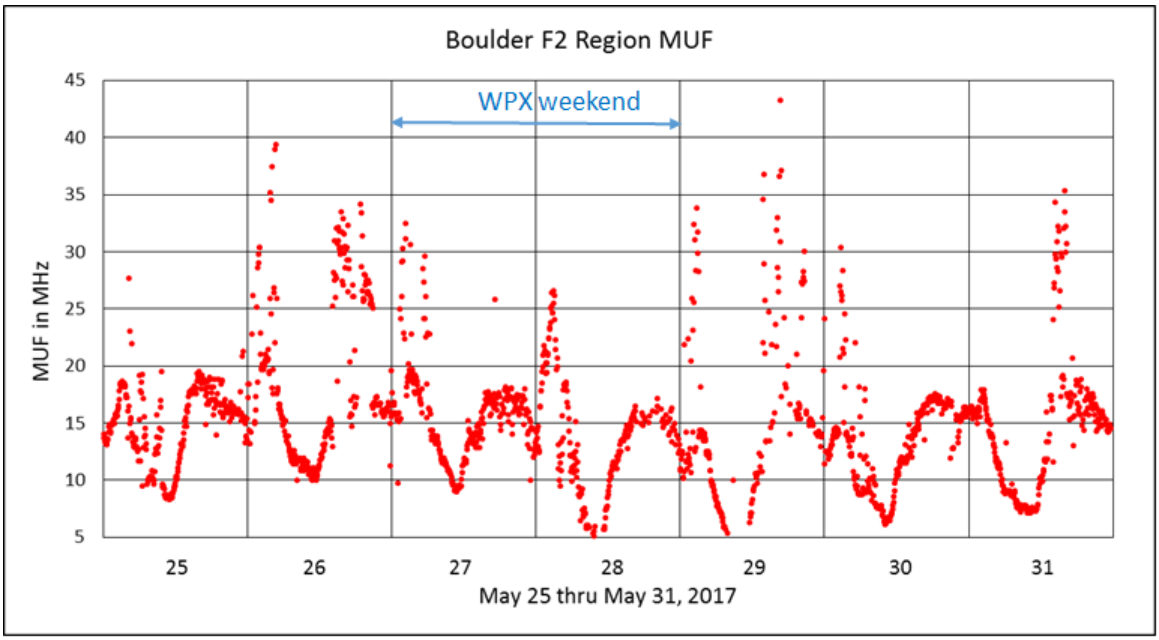
K7RA asked for my input on these observations, and I responded by saying that this was an excellent example of how we take a very complicated and dynamic process (the effect of a geomagnetic storm on the ionosphere) and try to simplify it with one general statement. I pointed out that these observations simply tell us that the question "isn't it a given that major geomagnetic storms totally disrupt the higher bands?" isn't 100% true. Let's dig deeper to try to understand what happened.

The following plot shows the K indices from May 25 through May 31.



A CME (coronal mass ejection) several days prior to the WPX weekend arrived in the vicinity of Earth around midday UTC on Saturday May 27 (the first day of the WPX contest). After this the K index began increasing. K indices greater than or equal to 5 occurred during the first half of Sunday (with a maximum of K = 9 during the 0300-0600 UTC period), and diminished throughout the rest of the day.

The important questions is "what did the ionosphere do during this geomagnetic storm period?" It would be nice to have an ionosonde along one of the paths cited in first paragraph, but we're out of luck there. So I looked at the Boulder (Colorado) ionosonde. It should be somewhat representative of what other ionosondes saw during this geomagnetic storm. Additionally, it took data every 5 minutes, so the time resolution is very good for most applications (during an eclipse, though, it would be nice to take data every 15 seconds or so). The Boulder F2 region data for May 25 through May 31 follows.



The first observation is the sinusoidal-like diurnal variation of the F2 region. During the day the noontime (1800 UTC) MUF (maximum useable frequency) for a 3000 km path with the midpoint over the Boulder ionosonde is around 20 MHz until the K index started increasing due to the geomagnetic storm. Then the noontime MUF decreased to 18 MHz on the 27th, to 16 MHz on the 28th and 29th, and started returning to normal on the 30th.

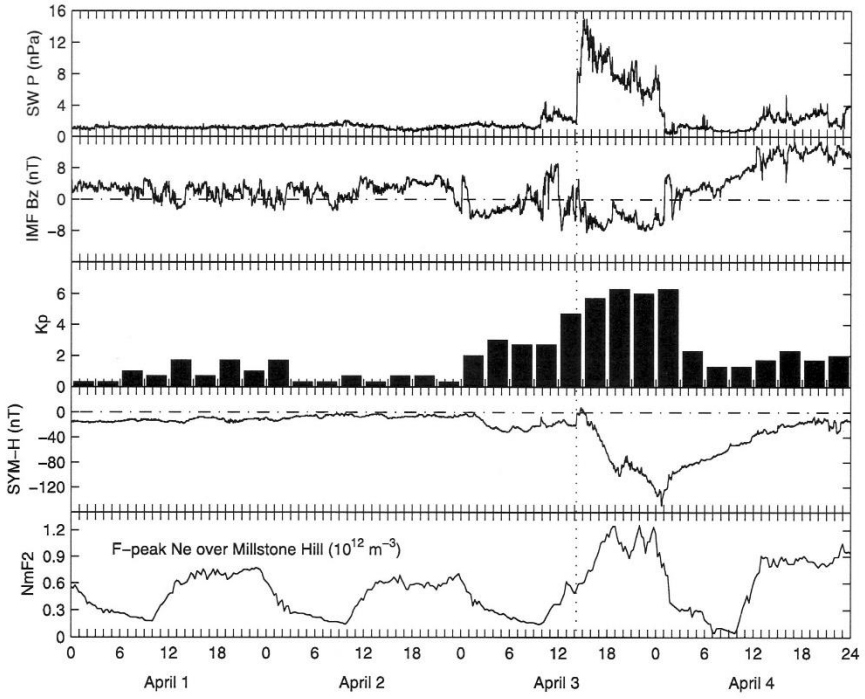
During the night, the midnight (0600 UTC) MUF was around 10 MHz until the 28th, when it dropped to 5 MHz due to the geomagnetic storm. The midnight MUF remained around 5 MHz on the 29th, again due to the geomagnetic storm, and began returning to normal on the 30th.

The second observation is the many random and short periods of significantly increased MUFs. What we're seeing here is the short-term day-to-day variation of the F2 region due to minor perturbations from geomagnetic field activity and events in the lower atmosphere coupling up to

the ionosphere. I believe the much-more-organized MUF increase early on during the 28th (generally corresponding to the periods cited by K6CTW and N6GP) was an enhancement due to this specific major geomagnetic storm. As mentioned earlier, it would be nice to have an ionosonde along one of the N6GP paths to confirm that 10-Meters could have been supported.

Now we can answer the question in the title of this paper. The answer is "no, the higher bands do not necessarily always get worse when the K index goes up." Although it might be tempting to say that the higher bands always get worse at the high latitudes, interesting things can still happen that suggest we should exercise caution in saying 'always.' On the other hand, I think it's safe to say that there can be periods of F2 region enhancements at the mid latitudes and low latitudes when the K index goes up.

As for what happens in the ionosphere to cause an electron density enhancement during a geomagnetic storm, let's quickly review a technical paper that analyzed this specific scenario. The authors looked at the geomagnetic storm of 3 April 2004. Their measurements showed the following.



The top plot is the solar wind pressure, the second plot is the Bz component of the interplanetary magnetic field, the third plot is the Kp index, the fourth plot is the Dst index and the bottom plot is the F2 region electron density. This geomagnetic storm began around 1400 UTC on April 3 (indicated by the vertical dotted line), with an enhancement in electron density of approximately 2 to 4 times the normal daytime diurnal peak in the 1400-2400 UTC time period on April 3.

From the above measurements and incoherent scatter radar measurements, the authors found that during the enhanced electron density period the F region electron temperature decreased by

about 1000 degrees K (a 40% decrease), the eastward electric field increased and the poleward meridional wind decreased.

The authors suggested that the major factor in the enhanced electron density for this geomagnetic storm (other may be different) was the enhanced eastward electric field, which caused an upwelling of the ionospheric plasma particles to altitudes with lower recombination. They also hypothesized that the reduction in the poleward wind may have helped by changing the composition of the mid latitude atmosphere to less molecular species, resulting in reduced electron loss.

Subsequent to the June 2 Propagation Bulletin, Chip K7JA (southeast of Los Angeles) added his comments. His experience started at 0401 UTC on the 28th with a QSO with VK5PAS on 10-Meter SSB. He noted this was an entirely surprising contact since it was in May with low sunspots. Starting at 0418 UTC he also worked about two dozen JAs, along with KHØ, KH2, ZL and more VK stations. This opening petered out around 0500 UTC. The VK, ZL and Pacific QSOs were likely via the storm-enhanced F2 region, but the JA QSOs are less certain. They could have also been via the F2 region, but we can't rule out sporadic E. As stated earlier, we have no ionosphere data to resolve this.

In summary, keep your ears open during geomagnetic storms – and at all other times, too – you may be pleasantly surprised with an unexpected QSO. The F2 region is very dynamic, and we do not yet fully understand nor have the ability to predict short-term events in the F2 region. When we are able to predict short-term events, we'll be closer to having daily propagation predictions – not monthly median propagation predictions as we do now.

Note 1 Huang, Foster, Goncharenko, Erickson, Rideout and Coster; *A strong positive phase of ionospheric storms observed by the Millstone Hill incoherent scatter radar and global GPS network*; **Journal of Geophysical Research**, Vol 110, A06303, doi:10.1029/2004JA010865, 2005