Ionospheric Hole made by the Kwangmyongsong-4 Rocket Launched from Norh Korea on Feb. 7, 2016, and Increase of Thrust of its Second Stage Engine

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Exhaust gas from ascending rockets and ballistic missiles bring large amount of water molecule to the ionosphere. Such water molecules receive positive electric charges from atmospheric ions, and their dissociative recombination with ionospheric electrons causes the formation of ionospheric holes (region of low electron density). Ionospheric total electron content (TEC) can be measured by comparing the carrier phases of the two L-band signals from Global Navigation Satellite System (GNSS) satellites, and such GNSS-TEC technique is useful in studying such ionospheric holes (Furuya & Heki, 2008). By analyzing the GNSS data from the dense network of GNSS receivers in Japan (GEONET), Ozeki & Heki (2010) compared ionospheric signatures by the two ballistic missiles launched from eastern North Korea, i.e. the 1998 Taepodong-1 and the 2009 Taepodong-2, and inferred their difference in thrusts. In 2012 December, a rocket, Unha-3, was launched southward from a launch pad in northwestern part of North Korea, and Nakashima & Heki (2014) studied the ionospheric hole made above the Yellow Sea/the South China Sea by the second/third stage engine of the rocket using a GLONASS (the Russian GNSS) satellite.

On February 7th, 2016, a new rocket Kwangmyongsong-4, was launched southward from the same launch pad at 9:31 JST (0:31 UT), and succeeded in putting an earth-observing satellite (KMS-4) into orbit. Here we studied the ionospheric hole made by this launch. Unlike the previous case, we could detect clear hole signatures with multiple satellites of both GPS and GLONASS. The hole emerged at 6-7 minutes after the launch, and its position and emergence time were similar to the previous 2012 case. However, the areal extent and the amount of TEC decrease were much more in the 2016 case. In the attached figure, we compare the TEC time series observed with GPS Satellite 29 from GEONET stations in western Kyushu, together with the past three cases. Clearly, the TEC decreases in the 2016 case are much larger than the past cases.

In all the rocket (missile) launches from North Korea, the first stage engine did not reach the ionospheric height, and it was the second stage engine that made the ionospheric holes (Ozeki & Heki, 2010). The overall figure of the present Kwangmyongsong-4 rocket looks quite similar to the previous Unha-3, but its payload (satellite) is suggested to be larger in size than the 2012 case. The thrust of the second stage engine may have been made more powerful to put this relatively large satellite into orbit. However, the vertical TEC above the Yellow Sea in the present case was ~30 TECU, which is twice as large as in the 2012 launch, and the comparison of the thrust in the two cases may need a more quantitative discussion.

References

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Figure caption: TEC time series in the 2016 February launch of Kwangmyongsong-4 from North Korea are compared with the past three cases, i.e. the 1998 Taepodong-1, the 2009 Taepodong-2, and the 2012 Unha-3 launches. The 2016 case shows much larger TEC decreases than these past launches.

Keywords: GNSS-TEC, North Korean rocket, ionospheric hole