

WAAS Technical Report
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DR#122: Ionospheric Equatorial Anomaly cause GPS Satellite PRN 4 and 20 to be set to Do Not Use (DNU) when GPS satellites are healthy
GPS Week/Day: Week 1783 Day 1 (3/10/2014)

Discussion:

WAAS broadcast two satellite alerts for PRN 20 on all three GEO data streams on 3/10/2014 at 2:21 GMT or 94888 seconds GPS time of week (TOW), the second alert occurred 847 seconds later. The alerts changed the UDREI from 14 (Not Monitored) to 15 (DNU) and the UDREI for PRN 20 was set at 15 for 6216 seconds before the UDREI was changed to monitored state (UDREI < 14). Figure 1 shows the expected UDREI (green trace) and the broadcast UDREI (red trace) for PRN 20 from GEO PRN 138.

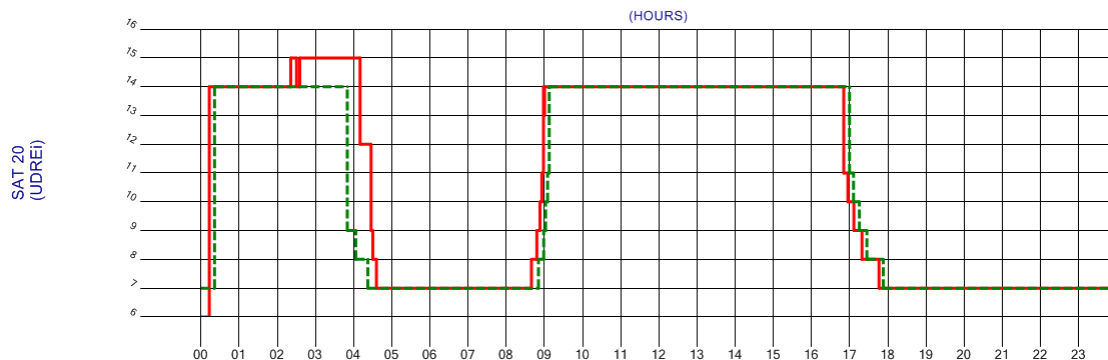


Figure 1 PRN 20 UDREI from GEO 138

. The WAAS satellite alert on PRN 4 occurred at 3:17 GMT or 98252 GPS TOW. The alert changed the UDREI from 14 (Not Monitored) to 15 (DNU) and the UDREI for PRN 4 remained at 15 for 471 seconds before the UDREI was changed to Not Monitored. Figure 2 shows the expected UDREI (green trace) and the broadcast UDREI (red trace) for PRN 4 from GEO PRN 138.

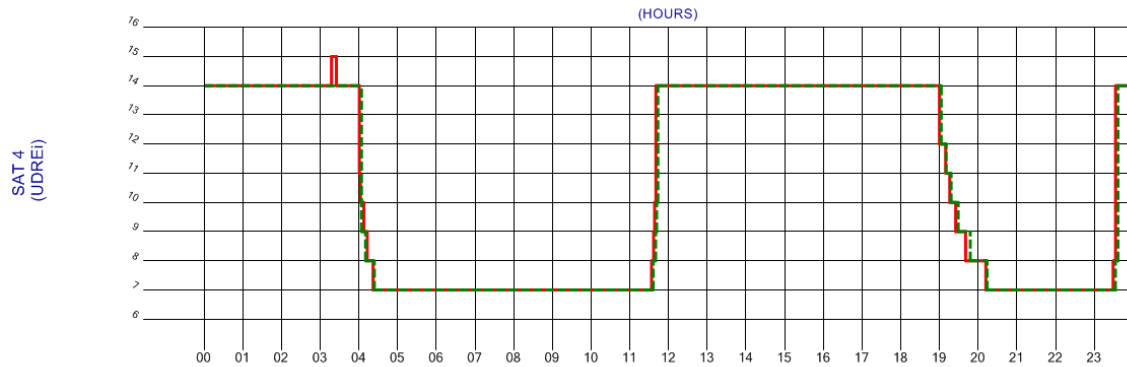


Figure 2 PRN 4 UDREI from GEO 138

During the times of the alert, both satellites PRN 20 and PRN 4 were GPS healthy and only visible at two southern WAAS reference stations (WRS), since the satellites were located far south of the WAAS service area as seen in Figure 3.

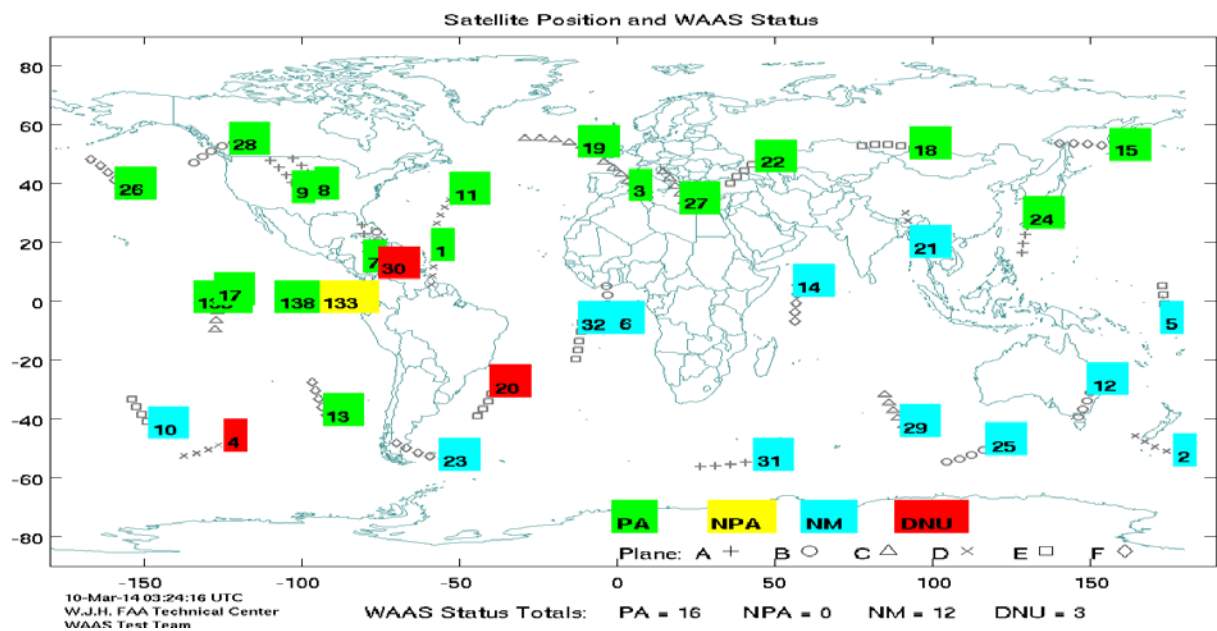


Figure 3 Satellite Position and WAAS UDREI Status

Daily SV alerts to DNU on the subject satellites started occurring on 2/27/2014 (Week 1781 Day 4) and WAAS continued to produce SV alert through 3/11/2014 (Week 1783 Day 2) due to an increase in the magnitude and disturbance of the ionosphere located at the equatorial region which is shown in Figure 4. The tails of the ionospheric equatorial anomaly are located over South America at the time of the SV alerts and cover the location of the expected satellite ionospheric pierce points from the WRS receivers.

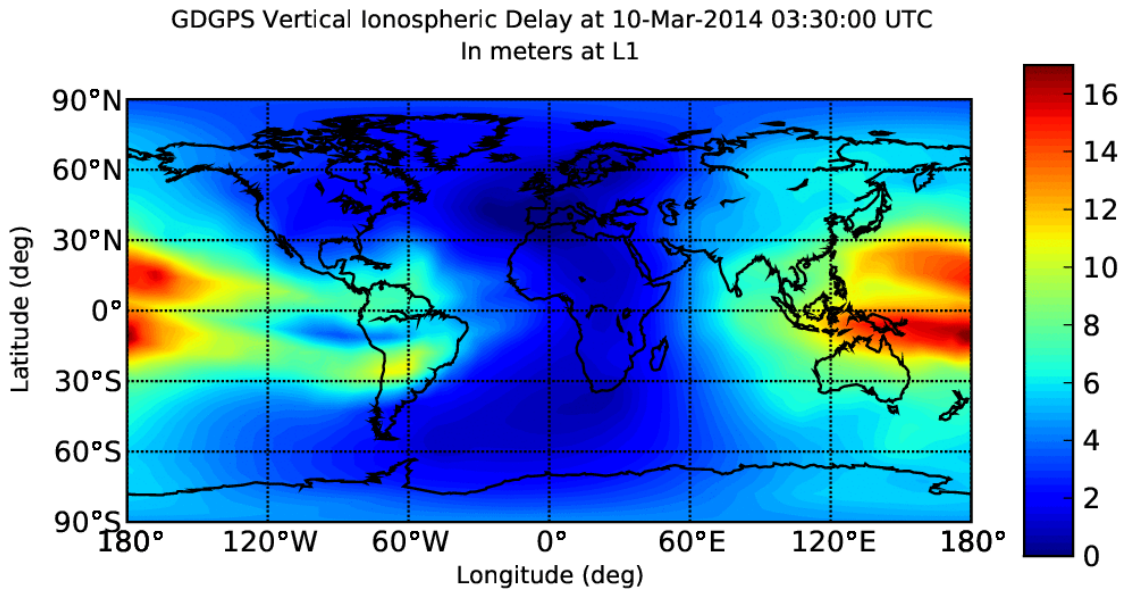


Figure 4 Vertical Ionospheric Delays at L1 Frequency

GPS Satellite PRN 20 was visible at Tapachula and San Juan reference stations and PRN 4 was visible at Tapachula and Puerto Vallarta at the time of the respective SV alerts. The GPS signals received at the three receiver threads at each reference station were severely affected by ionospheric scintillation which caused numerous interruptions in tracking of L1 and L2 frequencies. PRN 20 received signal strength on L1 and L2 at the Tapachula WRS is shown in Figure 5 on 3/10/2014 and compared to a nominal day (2/24/2014) during the same time period of the SV alert is shown in Figure 6. The blue trace is L1 C/No, the magenta trace is L2 C/no and the green trace is the period that WAAS set PRN 20 to Do Not Use state.

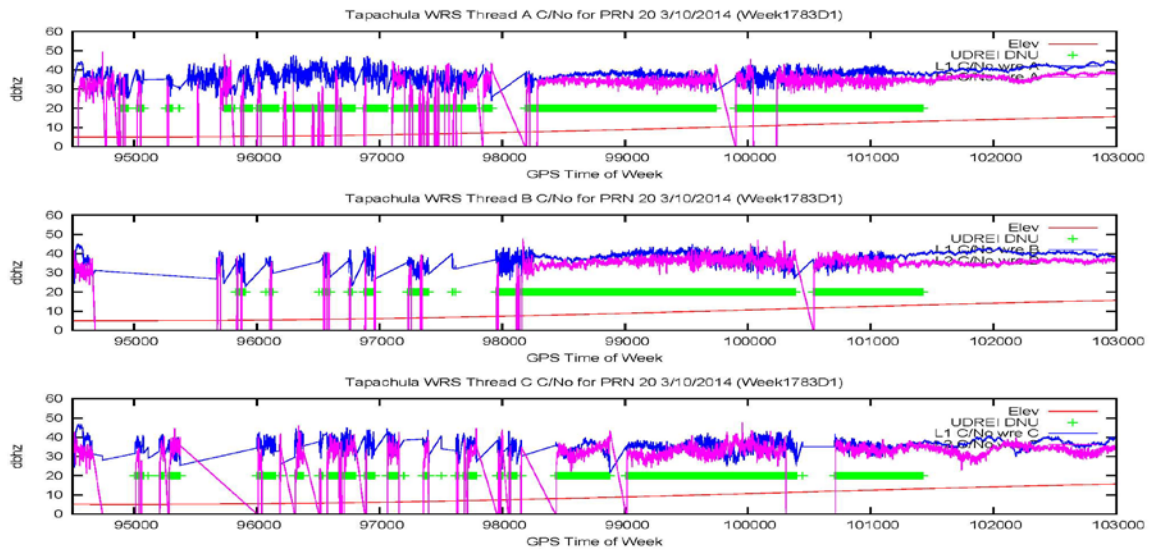


Figure 5 Tapachula WRS Signal Strength PRN 20 SV Alert 3/10/2014

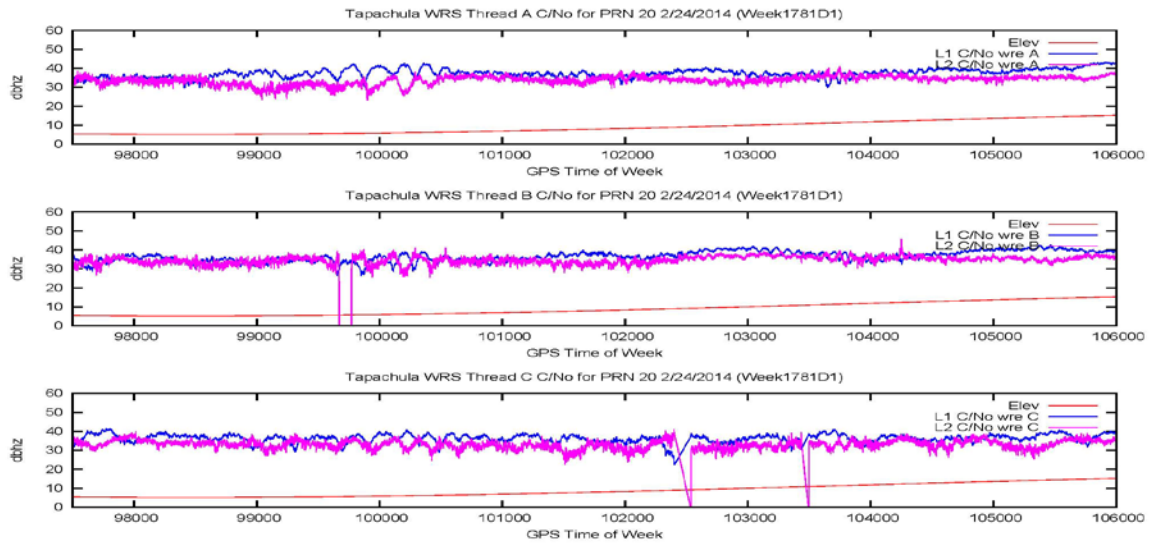


Figure 6 Tapachula WRS Signal Strength PRN 20 nominal day 2/24/2014

The apparent degradation in PRN 20 signal quality also affected the receiver observations of L1/ L2 code and carrier as seen in the dual frequency slant delay from Tapachula and San Juan, shown in Figure 7 and compared to the dual frequency slant delay of the nominal day (2/24/2014) shown in Figure 8.

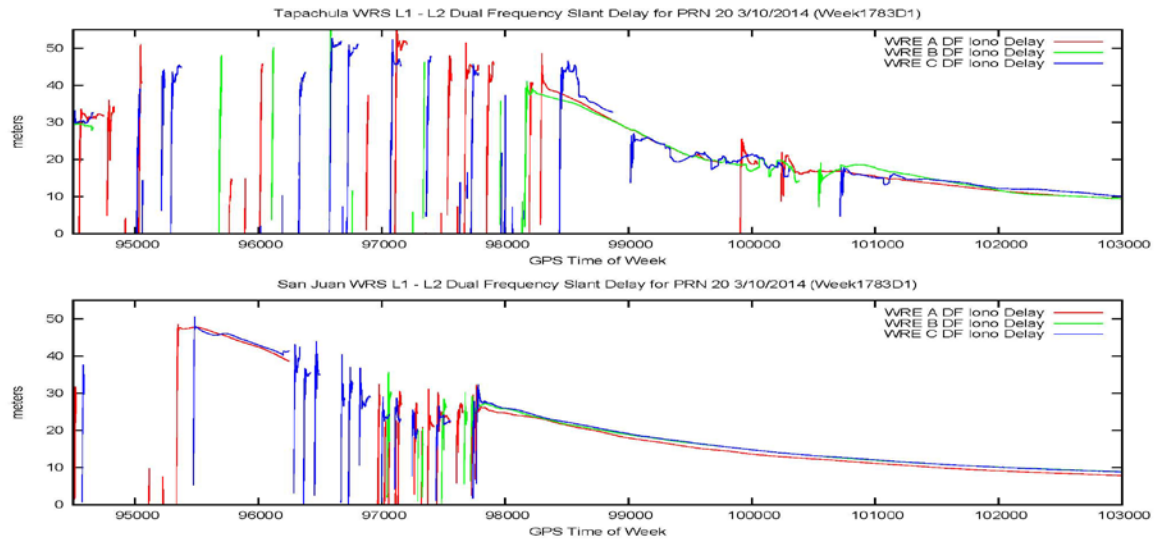


Figure 7 Tapachula & San Juan WRS L1 – L2 Slant Delay PRN 20 SV Alert 3/10/2014

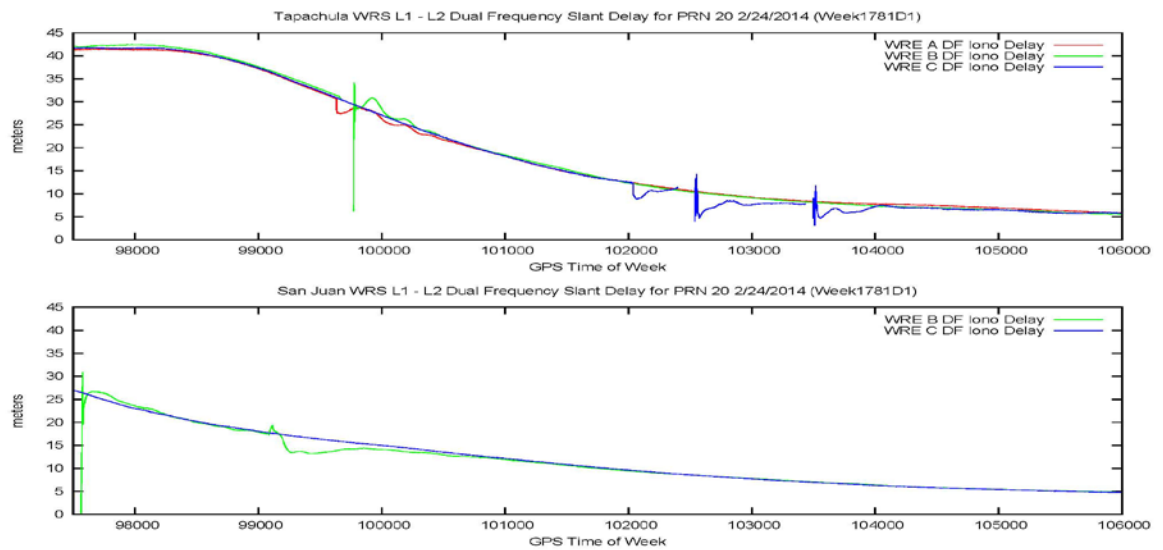


Figure 8 Tapachula & San Juan WRS L1 – L2 Slant Delay PRN 20 nominal 2/24/2014

Similarly, PRN 4 poor signal quality also affected the receiver observations of L1/ L2 code and carrier as seen in the dual frequency slant delay from Tapachula and Puerto Vallarta, shown in Figure 9 and compared to the dual frequency slant delay of the nominal day (2/24/2014) shown in Figure 10.

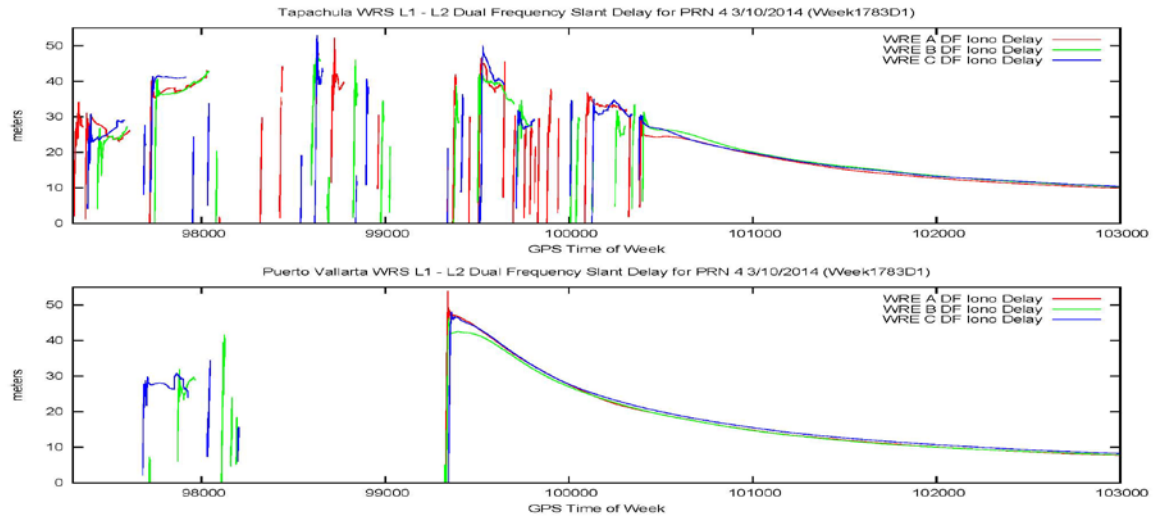


Figure 9 Tapachula & Puerto Vallarta WRS L1 – L2 Slant Delay PRN 4 SV Alert 3/10/2014

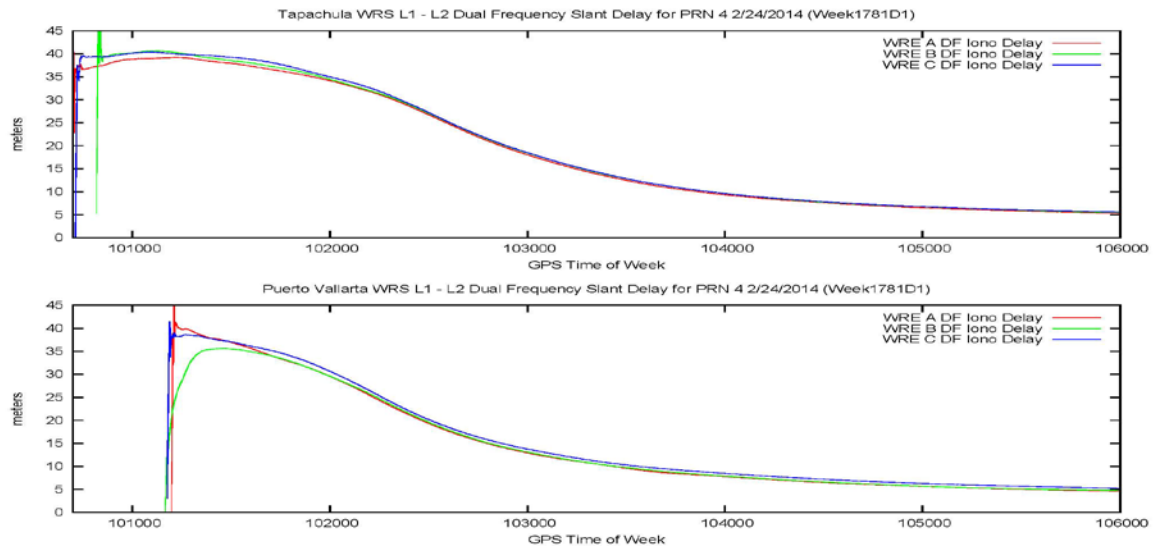


Figure 10 Tapachula & Puerto Vallarta WRS L1 – L2 Slant Delay PRN 4 nominal 2/24/2014

Conclusion:

The WAAS SV alerts on PRN 4 and PRN 20 are related to the increased ionospheric activity located in the equatorial region. The SV alerts started when the satellites were in view of only two WRS's in the south of the service volume. PRN 20 Do Not Use state persisted, when the satellite was GPS healthy, for over 6000 seconds reducing the time it was available to WAAS users to support navigation.