WAAS Technical Report
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Pomona, New Jersey
2/7/07

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DR# 47: Ionospheric Scintillation Caused Loss of Satellite Tracking at Fairbanks
GPS Week/Day: Week 1399 Day 0 (10/29/06)

Discussion:

On GPS Week 1399 Day 0, unusually high maximum errors and maximum ratios (position error to protection level) at the Fairbanks WRE-B prompted investigation into its cause. With the receiver in PA mode, the maximum vertical error was 7.210 meters, and the maximum horizontal error was 4.489 meters. The maximum ratios of the position error divided by the protection level at a given time were also unusually high: 0.245 vertically, and 0.290 horizontally. Both of these are above the one-sigma value: 1/5.33 = 0.188.

Figure 1 shows the vertical position errors and one-sigma VPL vertical error bounding (VPL/5.33). When the one-sigma VPL exceeds the one-sigma VAL (50/5.33=9.38), LPV service is not available. Notice the sharp, sudden, brief increase in VPL and VPE.

Also included in Figure 1 is the number of satellites not used in the solution (when non-zero). This indicates that there was a problem with satellite tracking at the time.

As with Thread B, Threads A and C lost track of several satellites, though their VPL's crossed the VAL threshold before their VPE's could climb as high as Thread B's, so their VPE's were not as high while PA service was available. This common effect suggests that something other than receiver error occurred.

All other Alaska sites stopped using no more than one satellite during the time in question, suggesting that the event observed at Fairbanks was relatively localized.

Figures 2 through 4 show the smoothed errors due to the Ionosphere for each satellite used during the time in question. The Ionospheric errors are computed by subtracting the truth from the estimated Ionospheric error. The gaps in the lines for several satellites indicate that there was no valid L2 measurement at that time.

The sudden changes in Ionospheric error for multiple satellites, as shown in Figures 2 through 4, is consistent with the explanation that brief, relatively localized scintillation in the Ionosphere caused the loss of satellite tracking at Fairbanks. Loss of satellite tracking is a known effect of such scintillation, so the correlated timing is highly suggestive. Furthermore, comparing plots of the dual frequency measurement to the Ionospheric error showed striking similarities, indicating that the errors were caused wholly by Ionospheric scintillation. (The dual frequency

measurement is L2 pseudorange – L1 pseudorange. It is used as "truth" in calculating the Ionospheric error.)

Conclusions:

On GPS Week 1399 Day 0, relatively localized Ionospheric scintillation caused a loss of GPS satellite tracking at the Fairbanks WRS. As satellites were dropped from the navigation solution, the WAAS protection levels rose accordingly, resulting in a loss of PA service at Fairbanks. Though the errors did briefly exceed the one-sigma protection levels, at no point did they exceed the actual protection levels—i.e. all position errors were bounded, and WAAS performed as expected.

Figure 1. Fairbanks VPE & One-Sigma VPL.

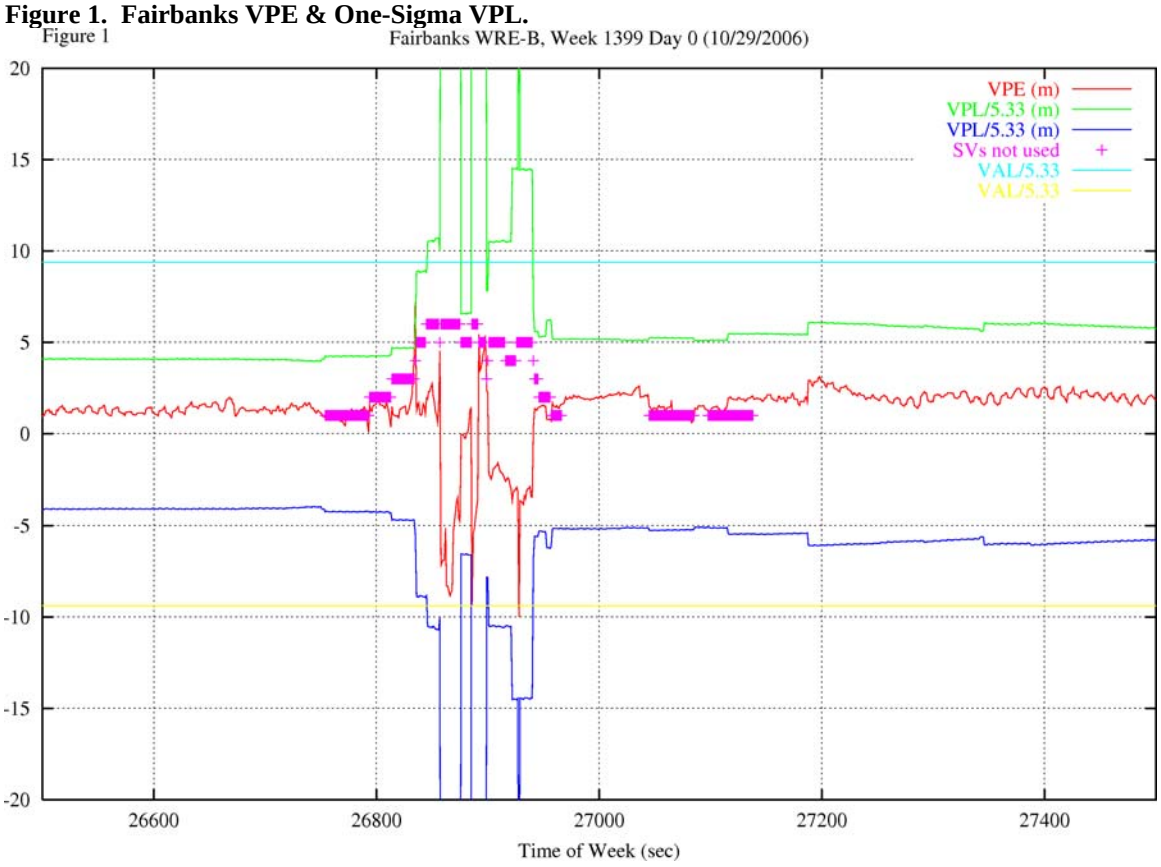


Figure 2.

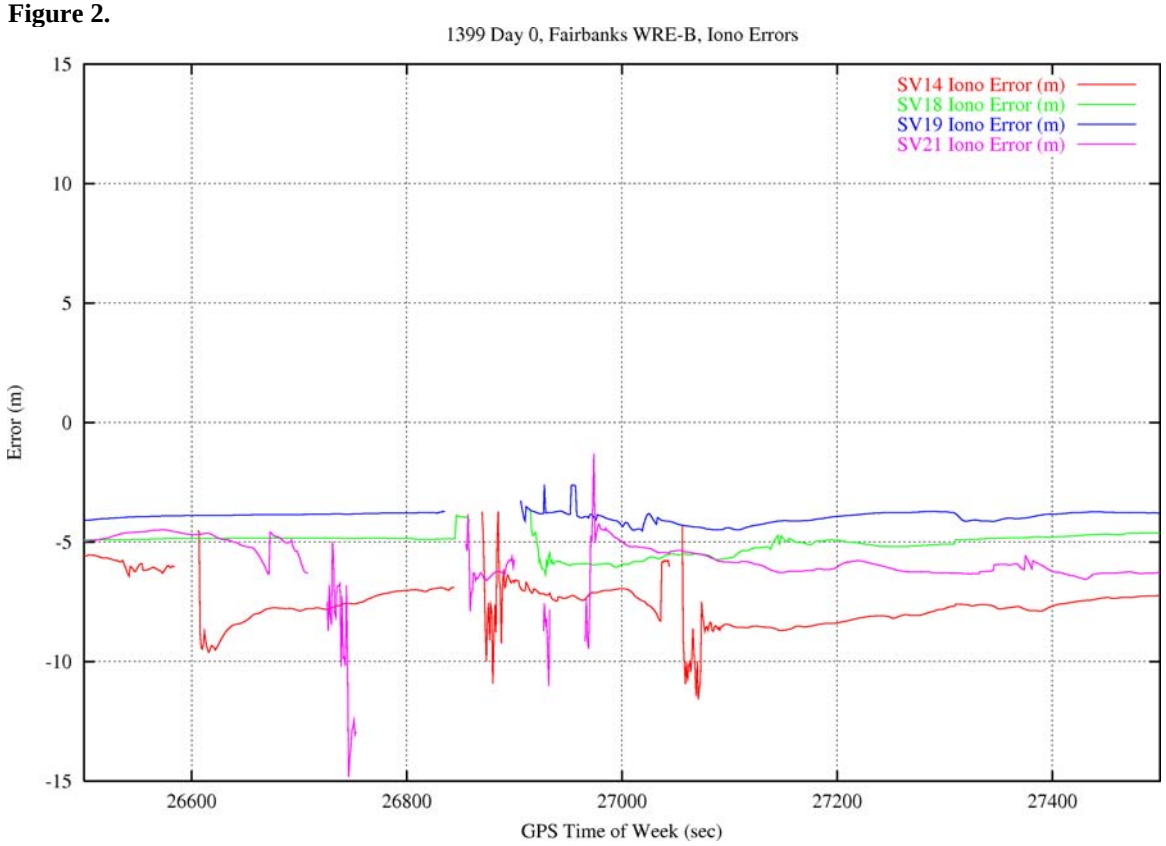


Figure 3.

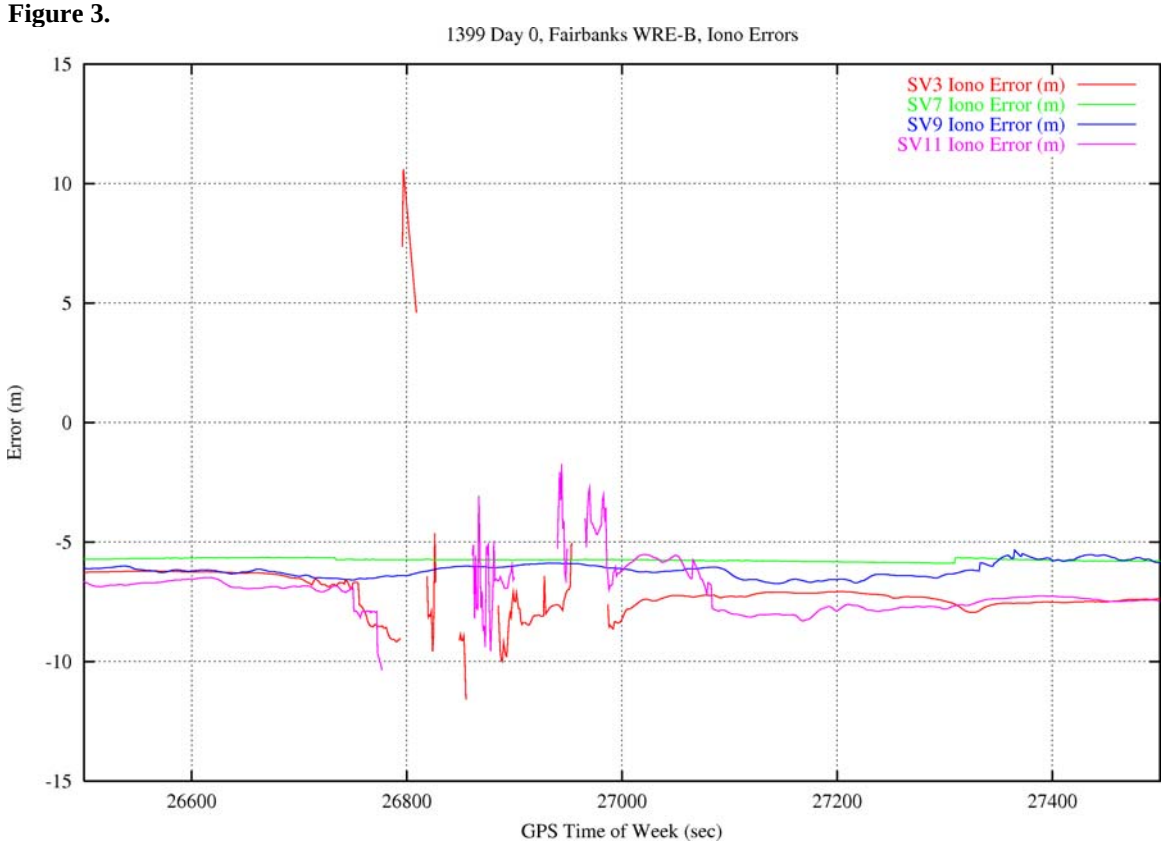
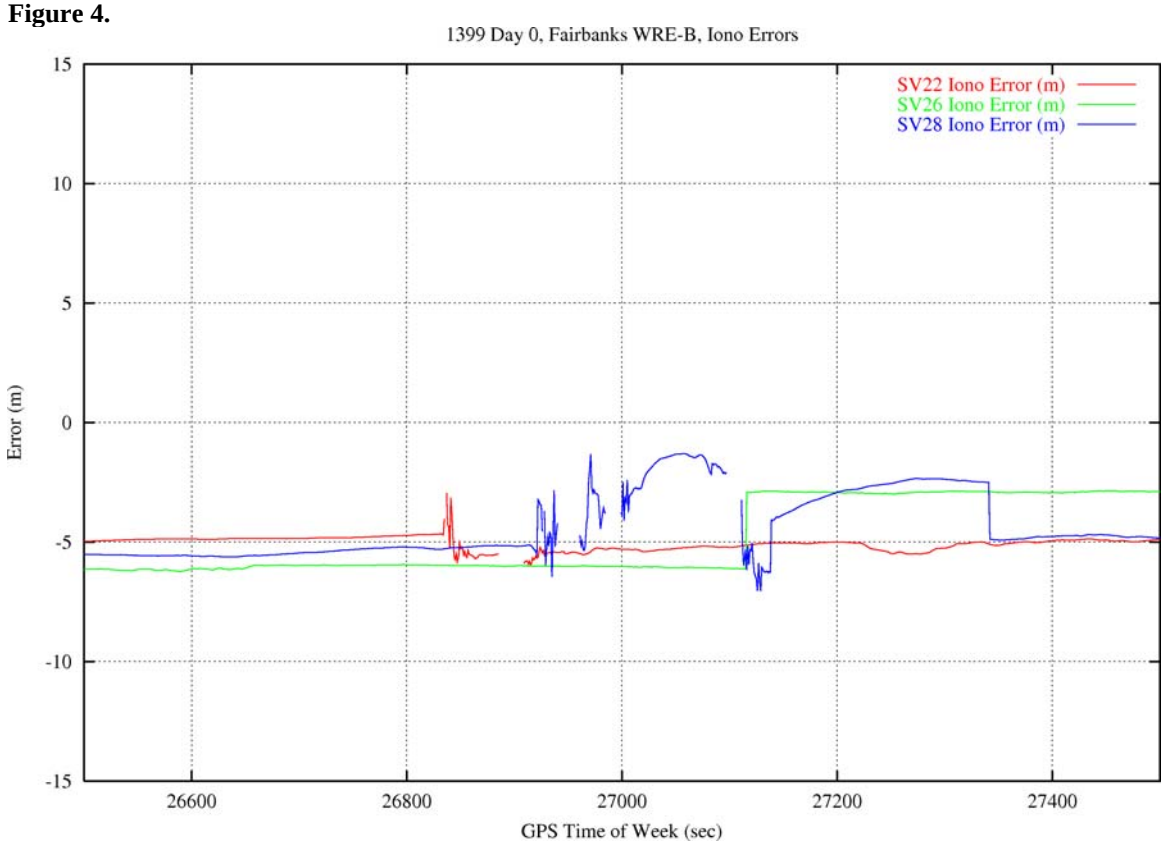


Figure 4.


1399 Day 0, Fairbanks WRE-B, Iono Errors
SV22 Iono Error (m)
SV26 Iono Error (m)
SV28 Iono Error (m)
Error (m)
15
10
5
0
-5
-10
-15
26600
26800
27000
27200
27400
GPS Time of Week (sec)