Overview
The use of multi-constellation GNSS receivers has been assumed as a way to increase system integrity both by increased coverage during normal operations and by redundancy in the event of a constellation failure. As of April 1, 2014, the entire GLONASS constellation was disrupted as illegal GLONASS ephemeris was loaded to each satellite, thus effectively degrading all GLONASS signals. The outage started at 02:00 UTC and continued for more than 10 hours as affected satellites broadcast navigation messages with incorrect application times.

Although the ephemeris were incorrect, pseudoranges were correctly broadcast on both L1 and L2 frequencies, and the carrier phases themselves were not affected. In the best case, GNSS receivers could be expected to continue to track all signals, including GLONASS (as many did) and in the worst case to continue to at least track GPS and other constellations. However, in many cases, receivers autonomous integrity monitoring (RAIM) failed to exclude the illegal GLONASS ephemeris while computing positions.

GeoNet - Track Results

These figures show processing results from the stations TNP in New Zealand. The upper two figures show processing results from the raw T02 files. The lower two figures show the processing results from data collected via RTCM streams. The outage affected the RTCM processing up to the time when GLONASS tracking was disabled.

GeoNet - Daily Time Series

Observations from the GeoNet network in New Zealand indicate that a significant percentage of the 76 GLONASS-enabled receivers experienced total tracking failures during the outage period, which caused real-time stream ing outage and data loss. Network operators disabled GLONASS tracking on a subset of receivers as they were streaming RTCM messages. The receivers immediately returned to normal tracking behavior after GLONASS was disabled.

GeoNet - Visible Satellites

Some sites exhibited tracking problems only with GLONASS: Sites were flagged as missing epochs if the predicted number of satellites was less than 4. Some sites continued tracking throughout the outage: Sites were flagged as no missing epochs if the predicted number of satellites was greater than or equal to 4. Sites were flagged as partial missing epochs if the predicted number of satellites was between 3 and 4.

Receiver Clock

Clock bias estimates as computed by GPS/GNSS for the station BDDY on day 91 of 2014. Clock steering on this L1a Delta receiver stopped functioning correctly following the beginning of the outage. The clock steering did not recover until the receiver was restarted on day 92.

Visible Satellites

Some sites exhibited tracking problems only with GLONASS:

Receivers

Sites were flagged as missing epochs if the predicted number of epochs did not match the number recorded in the UNAVCO archive. The results have been organized by receiver type.

Summary

By analyzing data collected from 316 GLONASS-enabled sites in the UNAVCO archive and 79 sites in GeoNet we have observed that GLONASS & GPS tracking at a significant number of sites was impacted by the outage. Receiver type did seem to play a role in determining the probability of tracking failures. It is likely that failure of Receiver Autonomous Integrity Monitoring (RAIM) was the primary cause for tracking interruptions at affected sites. Manufacturers are working on improving RAIM and updates should be available in future firmware releases. Despite the effects from the outage, the heterogeneous nature of the IGS network helped to ensure stable orbit and clock products throughout the GLONASS outage.

AGU FALL MEETING 2014