Real-Time Ionospheric Corrections

A Real-World Example

For optimal performance, our Time and Frequency Standards can be configured with the Real-Time Ionospheric Corrections (RTIC) Option. This option improves the frequency stability of these products so they will exceed the stability of a 5071 cesium atomic standard. It does this by calculating the actual delay of the GPS signals as they propagate through the ionosphere. This delay can vary significantly from that calculated using the GPS broadcast model, which is a rough approximation of the night to day delay variation. This paper shows a real-world example that occurred on April 14, 2022.

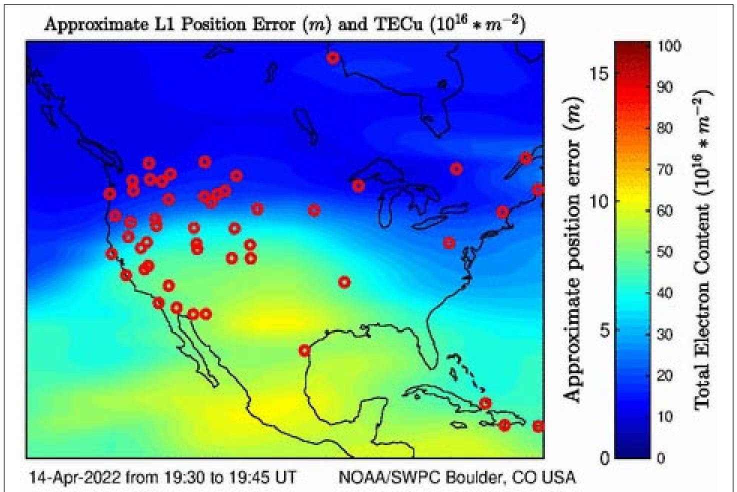

Figure 1. Total Electron Content

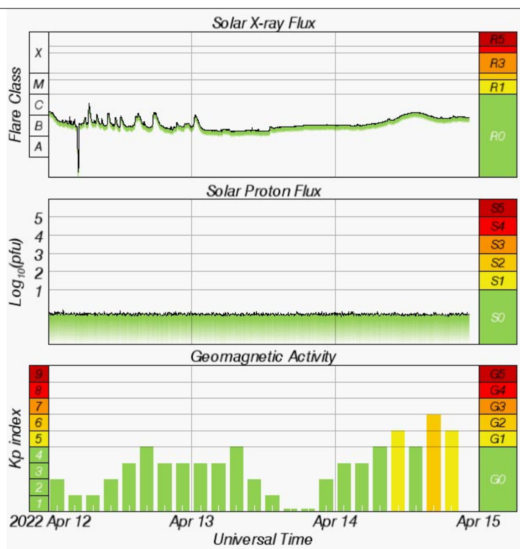

Figure 2. Solar Radiation Measures

Figure 1 is a snapshot from the NOAA Space Weather Prediction Center GPS Dashboard. It shows what the ionospheric Total Electron Content (TEC) was like on April 14, 2022 at 19:30 UTC over North America. It also shows that southwestern Colorado and the San Francisco Bay area in California, both at a latitude of about 38 degrees, had similar ionospheric conditions. This ionization is caused by solar radiation phenomena, and is generally maximum around local solar noon. On this particular day, the ionization levels were above normal.

Figure 2, also from the NOAA Space Weather Prediction Center GPS Dashboard, shows three different measures of the solar radiation. The bottom chart showing the Geomagnetic Activity is the best indicator of the ionization levels that were present at a particular time. What is interesting to note and remember when looking at the following Figure 3 and Figure 4, is that the Kp Index shown in Figure 2 reaches a high level of 6 at about the same time as the Figure 1 ionospheric TEC snapshot was taken. It is also important to notice that 24 hours earlier, on April 13, the Kp index was very low, essentially at baseline.

On the next page, Figure 3 shows the ionospheric delays from both the RTIC and GPS broadcast model calculations from a Meridian II unit operating at a facility in Ouray, CO, and Figure 4 shows the ionospheric delays from both the RTIC and GPS broadcast model calculations from a Meridian II unit operating at the EndRun Technologies facility in Santa Rosa, CA. Though operating at widely separated locations, the RTIC calculations are in excellent agreement.

These two charts display the correlation of the Figure 2 TEC levels with the RTIC-calculated ionospheric delays at about 19:30 UTC on April 13 and April 14. On April 13, the RTIC-calculated ionospheric delays are about 10 ns less than those via the GPS broadcast model, and on April 14 the RTIC-calculated delays are about 12 ns greater than those via the GPS broadcast model. In this example, use of the GPS broadcase model would have resulted in about 22 ns of peak-to-peak timing error. The results are remarkably consistent between the two widely separated Meridian II units. This illustrates the deterministic performance of this novel RTIC algorithm, performance that had been thought impossible to achieve with a single frequency GPS receiver.

KEY BENEFITS

- Real-time measurement and removal of ionospheric delays.
- Improves frequency stability: <4 x 10^{-14}
- Improves time domain stability by 50% (<2.5 nanoseconds STD).
- Compensates for disruptive ionospheric events (solar storms).
- Tighter absolute calibration.
- Exceeds stability of the standard 5071 cesium.
- Costs much less than dual frequency L1/L2 alternatives.

PRODUCT MODELS

Following are the models capable of being configured with the RTIC Option:

- Meridian II Precision TimeBase
- Tycho II Precision TimeBase
- RTM3205 Precision Timing Module
- Ninja Precision Timing Module

MORE INFORMATION

For details on the how and why of the Real Time Ionospheric Corrections option read this:

- RTIC Datasheet

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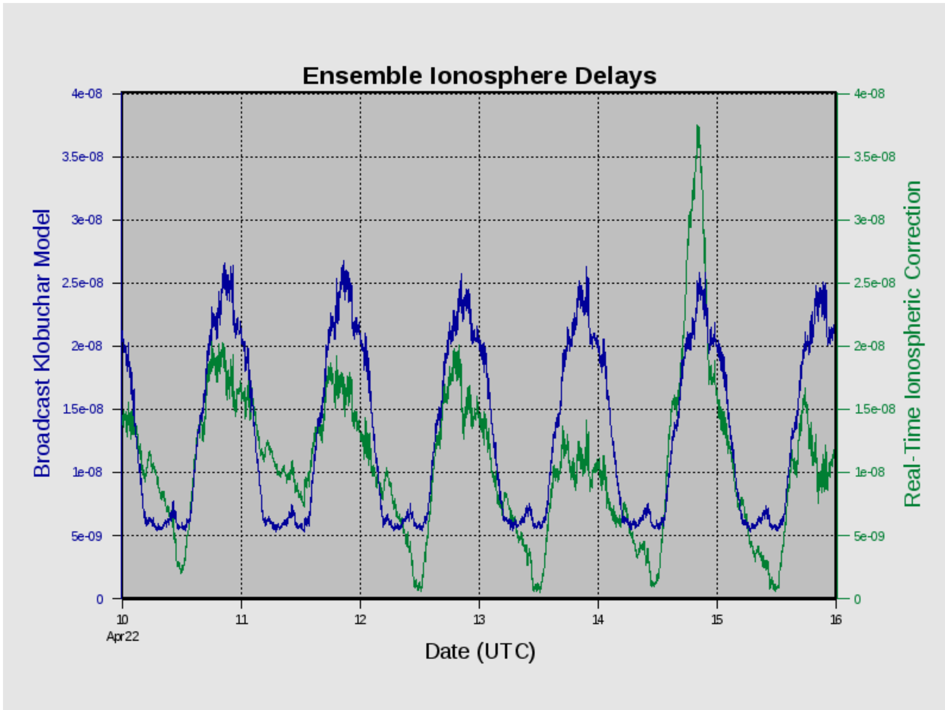

Figure 3. Ionospheric Event April 14, 2022 in Ouray, Colorado, USA

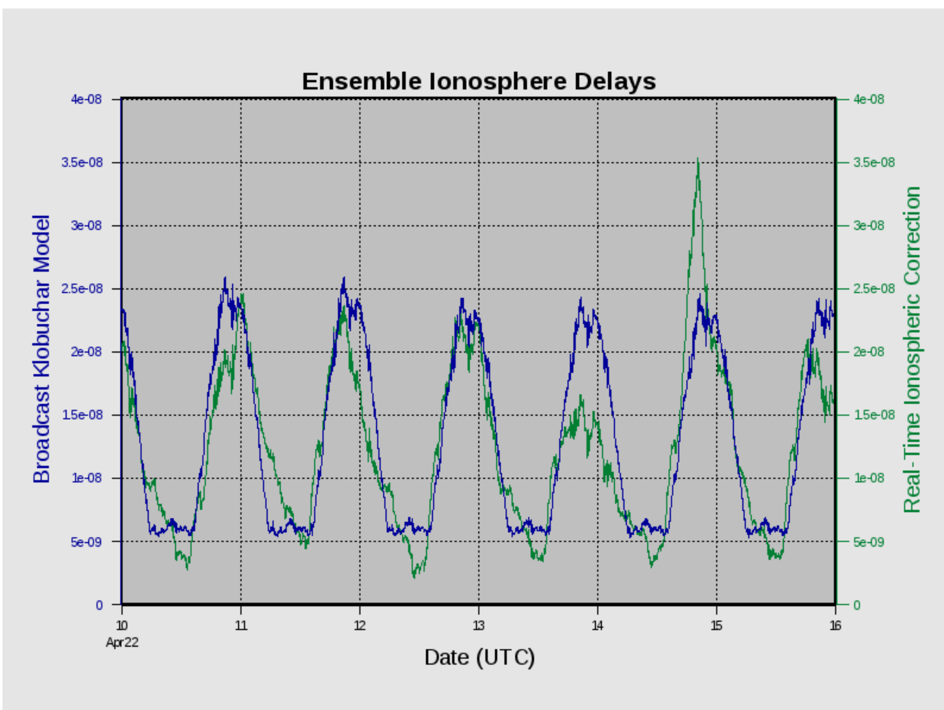

Figure 4. Ionospheric Event April 14, 2022 in Santa Rosa, California, USA

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