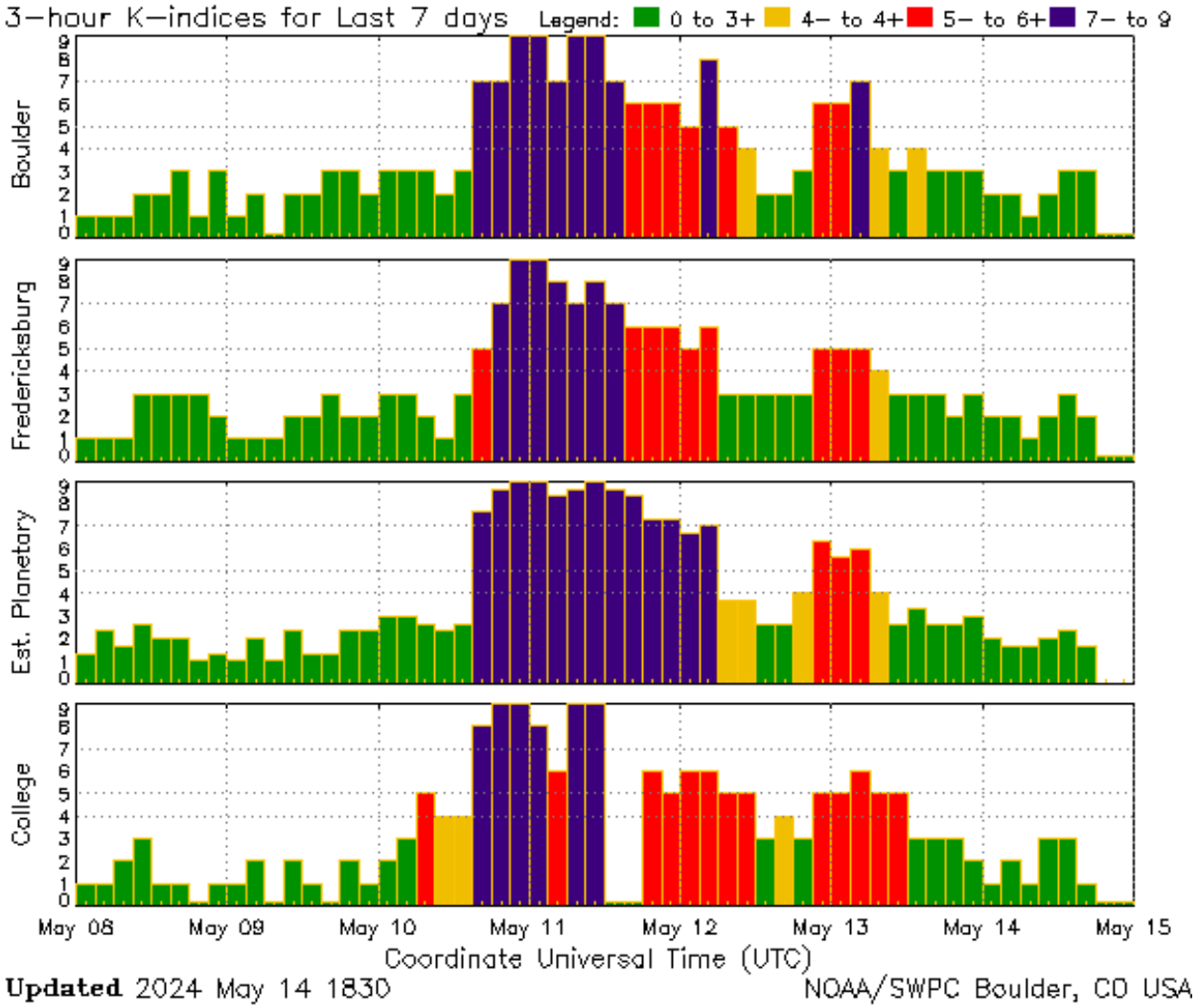
Geomagnetic Storm - May 10-12, 2024

Earth’s free light show causes chaos for some… but not so much for Trimble customers

As night fell on May 10, 2024, millions of curious people across the globe ventured outside in hopes of catching a glimpse of the northern lights in the darkness — and better yet, capturing a spectacular photo. Previously visible only in arctic regions, this phenomenon came into view as far south as Alabama and California as the night’s aurora borealis revealed itself, etching the moment into our memories. And it all became possible thanks to solar activity being at nearly a 20-year high.

But what was a sense of beauty and wonder for many also served as a time of concern and even angst for those who either provide or rely on accurate positioning from satellites. This unusual phenomenon was caused by a G5 level geomagnetic storm that lasted two days — making it the most significant geomagnetic storm descended on Earth since 2003. NOAA’s Space Weather Prediction Center measured its Estimated Planetary K-Index (Kp index) — a common metric-based gauge for geomagnetic storms — on a 9 point scale, on which it hit maximum values at various monitoring stations.



https://www.swpc.noaa.gov/products/station-k-and-indices

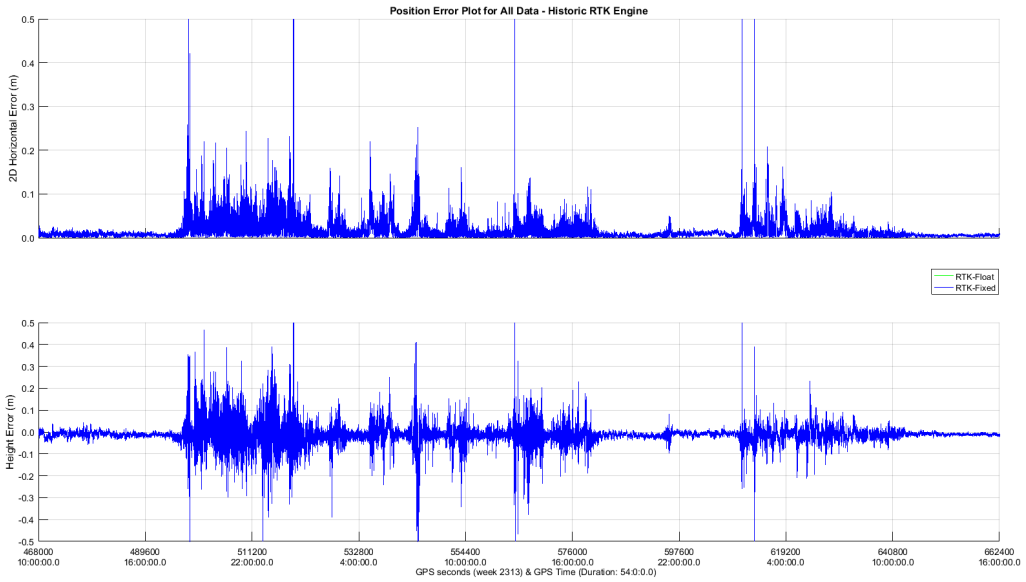
The aurora borealis sets the stage to gauge Trimble IonoGuard

This provided the ultimate opportunity to field test the performance of Trimble IonoGuard™, as Dr. Stuart Riley, Trimble VP of technology - GNSS, notes in this LinkedIn post. IonoGuard, unveiled in October, is the culmination of Trimble's decades of data collection and engineering development. Purposefully designed to help mitigate the impacts of ionospheric disturbances on GNSS performance with ample signal tracking change capabilities, this solution estimates various parameters on a per-satellite basis, adjusting the position engine to maintain accuracy.

Due to seasonal effects and the nature of this storm, it was expectedly less impactful in equatorial regions, while significant effects were seen in polar and mid-latitude areas. Riley's post focuses on the effects seen at a site in Northern Alberta, Canada (around 57 degrees north latitude).

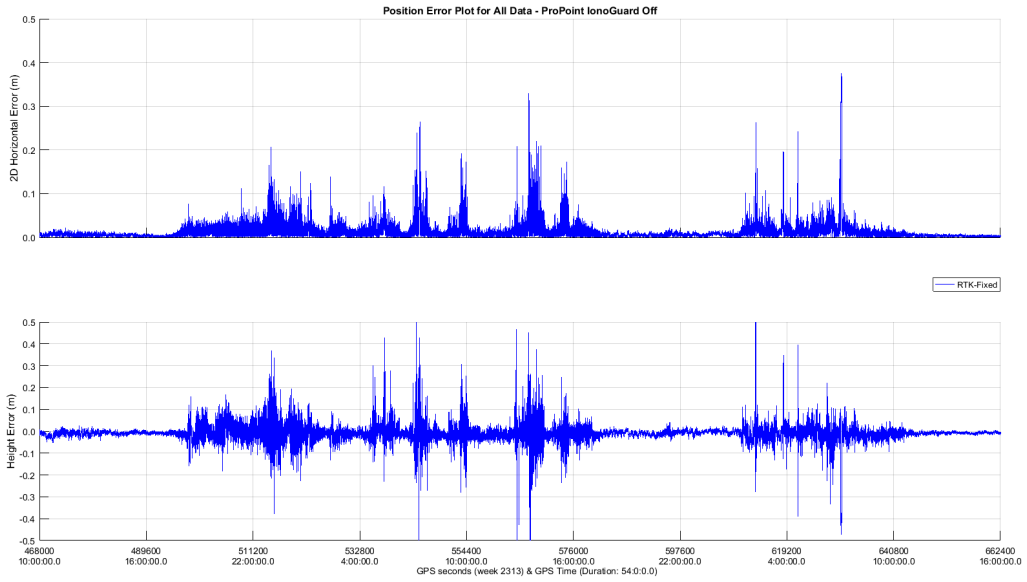
Northern Alberta

GNSS receivers in Northern Alberta saw the ionospheric disturbance begin around 18:00 hours UTC on May 10. Looking at Trimble's historic RTK engine on a 1.8 kilometer RTK baseline we see that the position solution was severely impacted throughout the storm. The system struggles to provide reliable positioning during the storm, with large outliers occurring frequently.

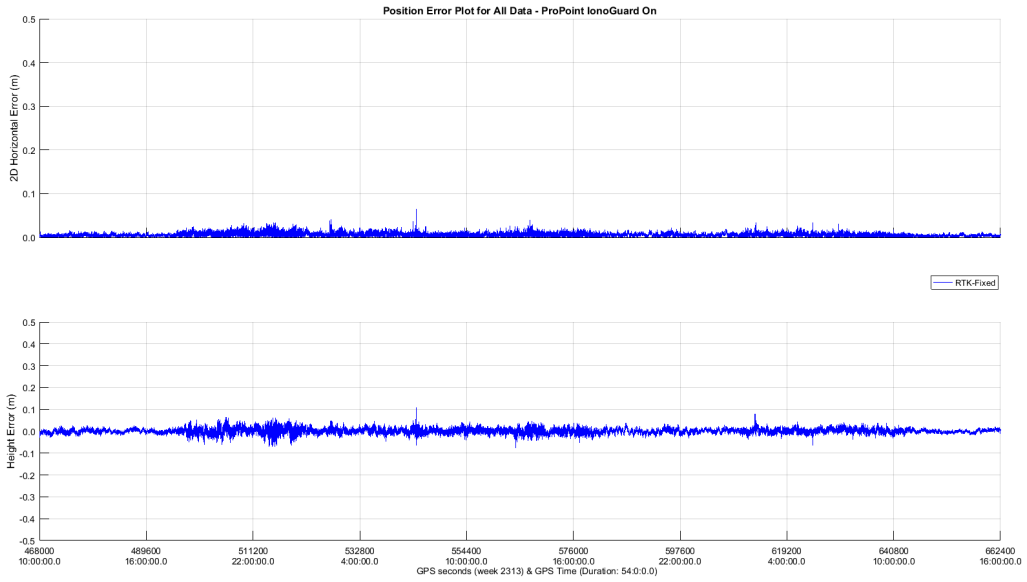


The Trimble ProPoint engine (without IonoGuard) performs better, although it struggles to provide reliable positioning with errors of tens of centimeters.[1]

[1] An earlier version of this paper had used the ProPoint RTK engine from the version 6.20 firmware in the analysis, rather than the version 6.26 ProPoint RTK engine used throughout this analysis. The earlier ProPoint RTK engine was more susceptible to drops out of RTK due to the ionospheric disturbances.



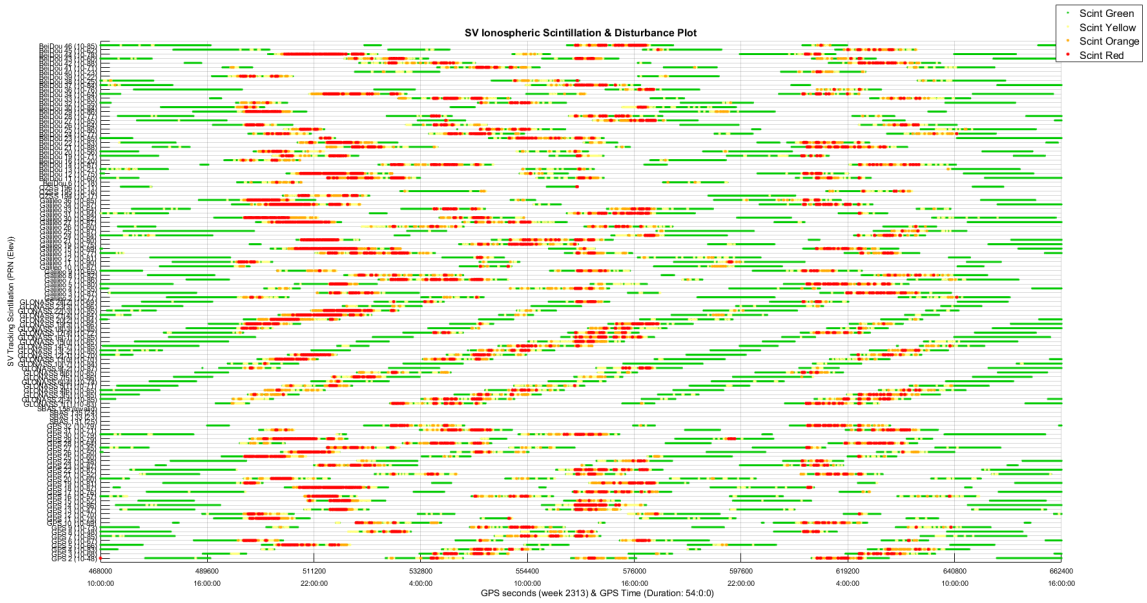
Conversely, a GNSS receiver on the same antenna running IonoGuard technology reflects a dramatic improvement in positioning performance.



Some limited impact is seen from the ionospheric disturbance; however, users in areas affected by scintillation and other disturbances reported being able to work through any issues using IonoGuard, while other machines were forced to stop due to positioning inaccuracies.

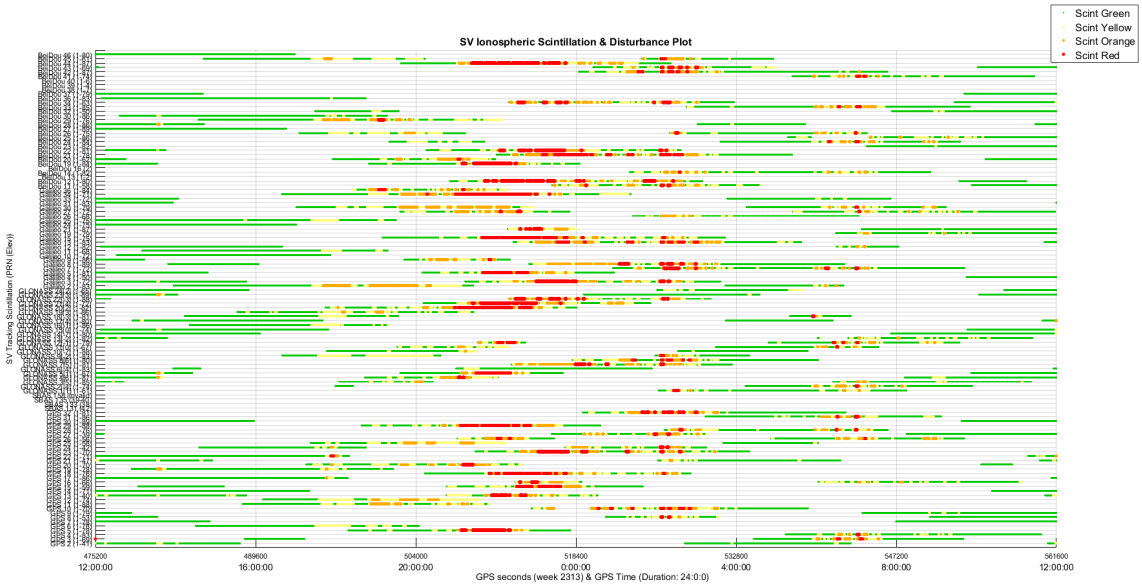
This dramatic improvement in performance is achieved by quantifying ionospheric disturbance on individual satellites, characterized using three different metrics formulated by decades of

Trimble research and development to indicate scintillation and other ionospheric disturbances. The plot below indicates how individual satellite signals are affected by ionospheric disturbance. Note: not all satellites are affected equally at the same time, allowing us to form a “best” solution by picking out the “good” satellites.

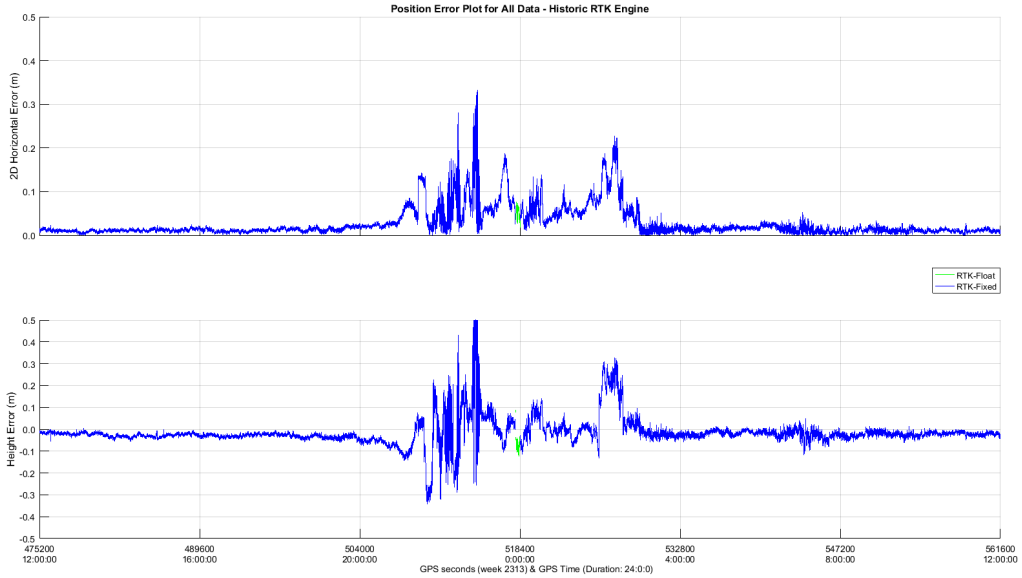


Denver

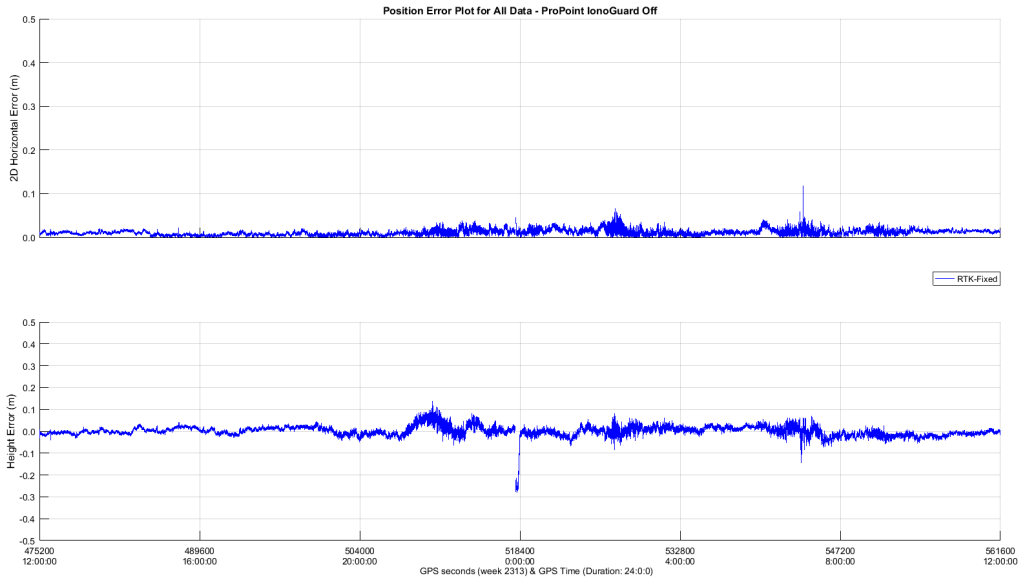
While Northern Alberta may seem like an extreme case, reports reveal that the storm shut down some operations relying on GPS/GNSS systems throughout the north-American midwest region during peak planting season. Looking at the IonoGuard metrics in the Denver, CO., area (about 40 degrees north latitude), less ionospheric disturbance was seen — yet there were enough operational GNSS shutdowns reported to warrant a mention on the news. Looking again at the plot of how individual satellite signals are affected by ionospheric disturbance we see periods where the ionosphere is disrupting many of the tracked satellites.



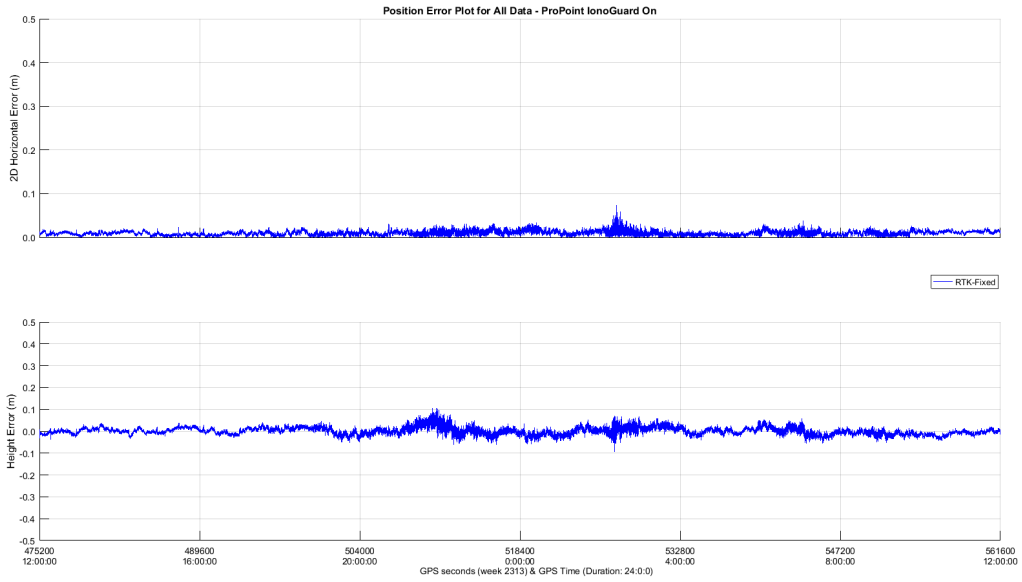
Looking at Trimble's historic RTK engine on a 5.7 kilometer RTK baseline we see that the position solution was severely impacted at the peak of the storm. Position errors of tens of centimeters are frequently observed. These types of position errors shut down many farming operations as reported by the news outlets.



The new Trimble ProPoint engine (without IonoGuard) performed considerably better; however, additional noise and an almost 30 centimeter outlier in the vertical was observed.

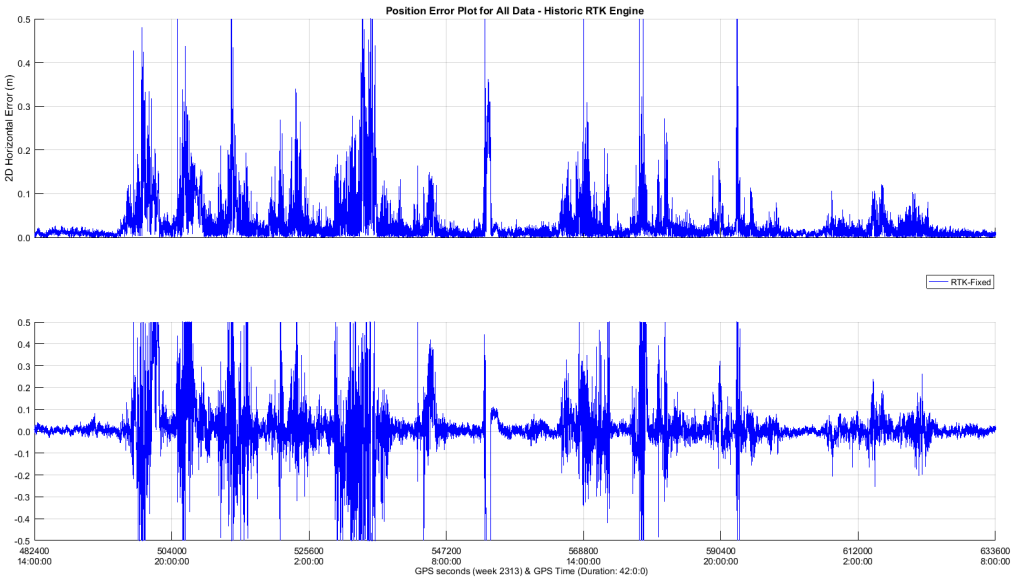


With IonoGuard enabled, the ProPoint RTK solution sees only a slight increase in noise during the peaks of the storm, but overall positioning is improved and outliers are removed.

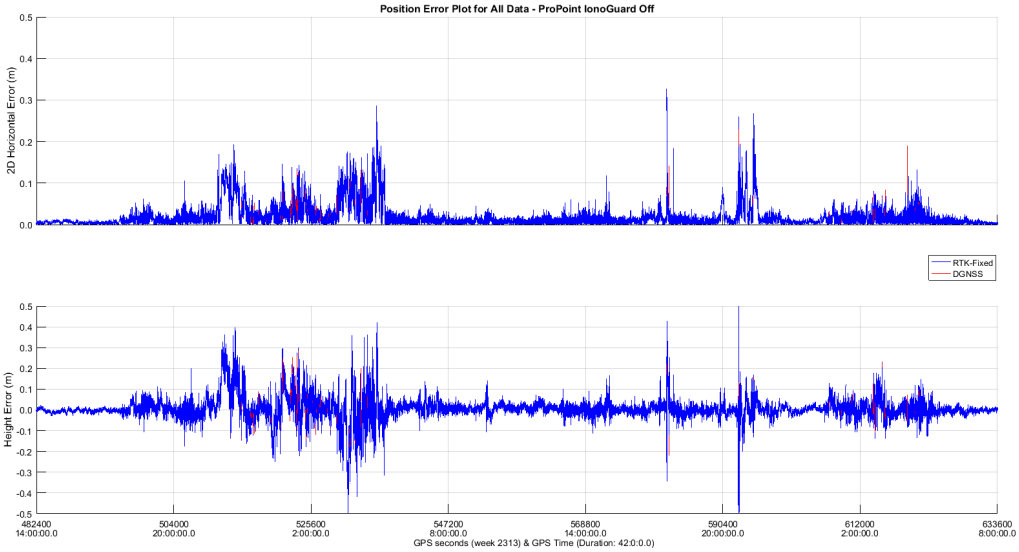


Sweden

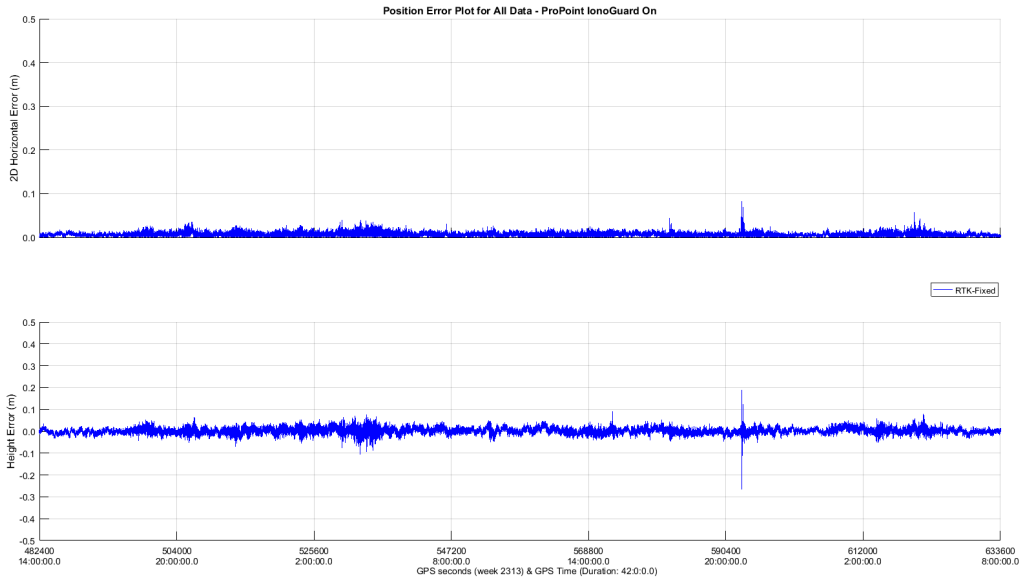
Next, moving to Umea, Sweden at almost 64° North Latitude and looking at a 10 kilometer RTK baseline we see Trimble's historic RTK engine struggles to provide reliable positioning during the storm. Position errors frequently exceed half meter.



The Trimble ProPoint engine (without IonoGuard) performs better, although it struggles to provide reliable positioning with errors of tens of centimeters and occasionally drops out of RTK-fixed state.

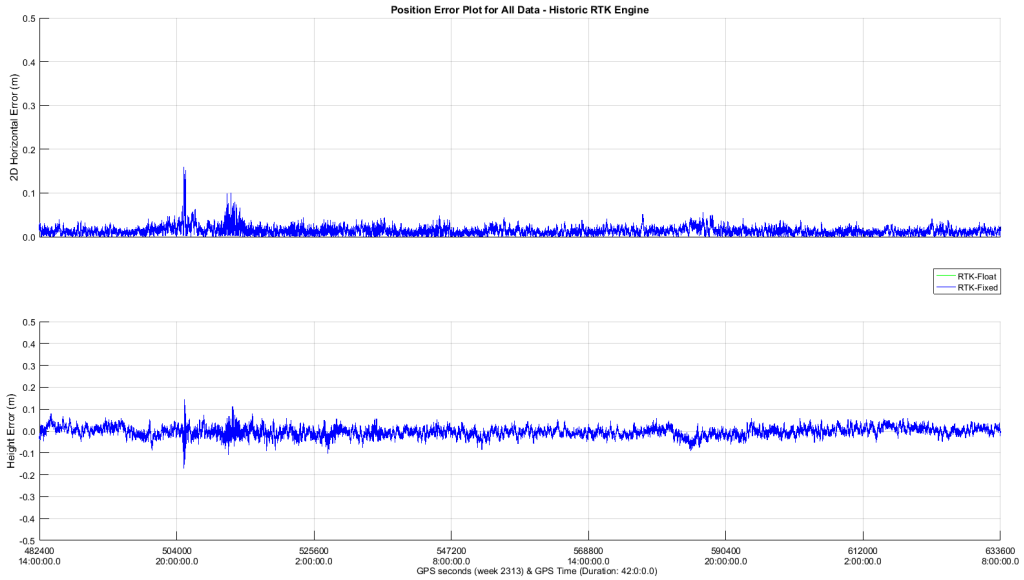


With IonoGuard enabled, the ProPoint RTK solution is dramatically improved. Some position noise is seen during the peaks of the storm, but the overall performance is good enough to keep typical users operating throughout the storm.

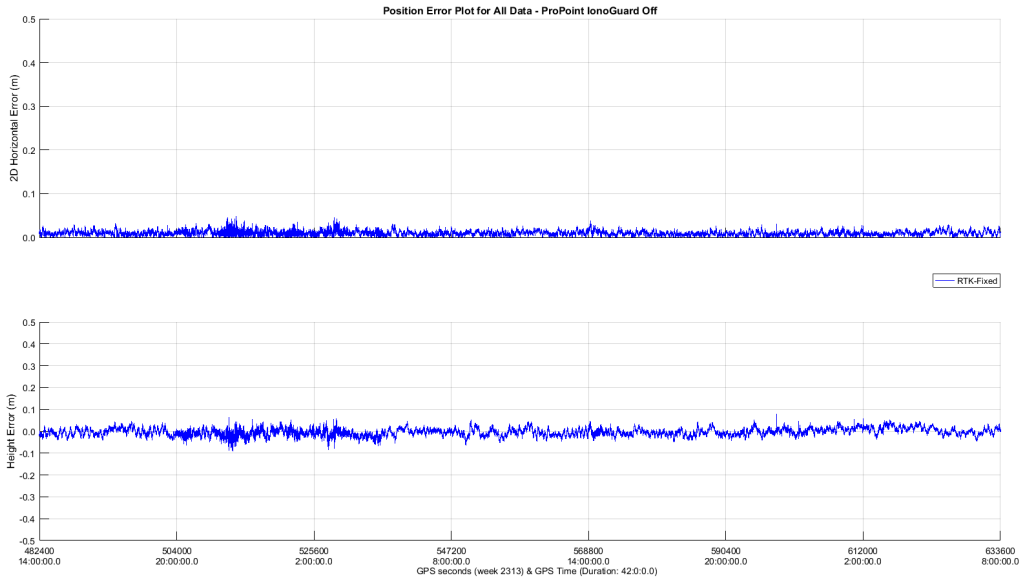


Belgium

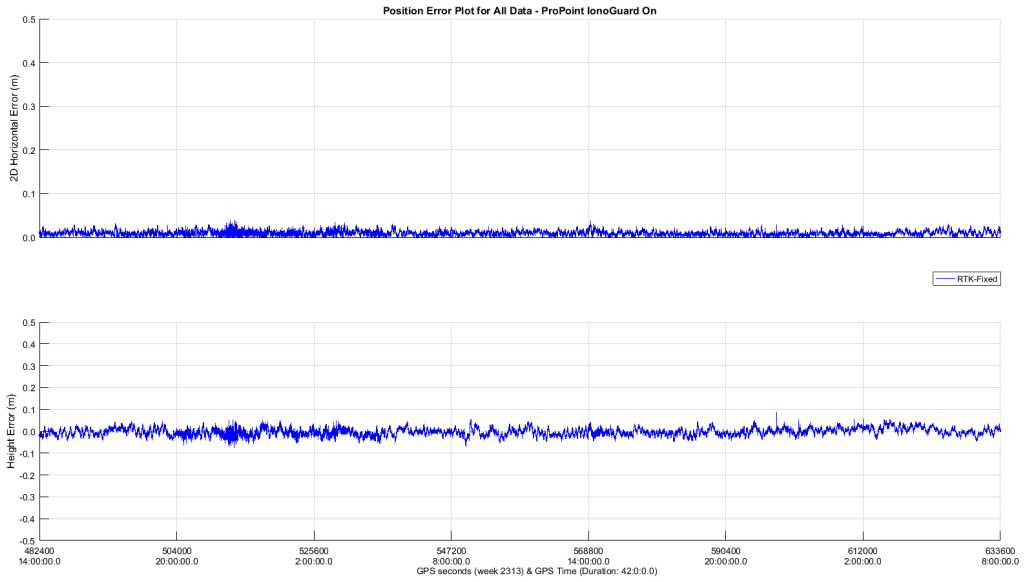
Finally, moving South to a 13.7 kilometer RTK baseline East of Brussels, Belgium (at 51° North Latitude) we see dramatically different effects from the storm; the historic RTK engine performs quite well through the storm, although slight increases in noise are seen at times.



The Trimble ProPoint engine (without IonoGuard) performs very well during the storm, showing a significant improvement over the historic RTK engine.



With IonoGuard enabled, the ProPoint RTK solution shows only slight improvements, indicating that the effects of the storm at mid-latitudes in Europe were minimal during this specific event.



Drawing its strength from decades of meticulous data collection and engineering expertise, IonoGuard demonstrates Trimble's commitment to staying a step ahead of problems — providing our customers with uninterrupted coverage they can depend on.

Learn more about Trimble IonoGuard by visiting our website and/or downloading the technical paper. And keep watching for additional blog posts related to the beneficial effects of IonoGuard in other parts of the world.