EECE5554 Lab 2 Analysis

## Setup and Data Collection

Two C099-F9P application boards were set up to communicate via the built-in ODIN-W2 Wi-Fi module with each board connected to a ZED-FP9 GNSS receiver. One board was flashed as the Base and the other as the Rover for Real-Time Kinematic (RTK) GPS data acquisition.

Data was collected in two locations: the Columbus Parking Garage roof with a clear and unobstructed view of the sky, and on the ground outside of ISEC with an occluded view of the sky with potential reflections. At each location, 10 minutes of data was collected with the Rover in a stationary position, and another dataset was collected with the Rover moving; following a structured path and returning to the same starting point with the same heading. Similar to the Lab 1 setup, the Rover laptop subscribed to a custom GPS driver that received and stored parameters of interest into a rosbag for future playback and analysis.

In addition to the data collected from Lab 1, the RTK Fix Type was included in the GPS driver. There are two different fix types that are of note: RTK Fixed and RTK Float. In the RTK Fixed mode, the rover is constantly attempting to fix ambiguities whenever possible, compared to the RTK Float mode which estimates those ambiguities but does not attempt to fix them.

## Analysis

Using Matlab and the ROS Toolbox, the rosbags for all four datasets were extracted and parsed to isolate UTM Northing (m), UTM Easting (m), Altitude (m), time (s), and Fix Type. Easting vs. Northing, Time vs. Altitude, Time vs. Easting, and Time vs. Northing were plotted in quadrants for each individual dataset and are attached to the end of this document. Within the plots, data points were colored differently depending on the RTK fix type: the **red** data points represent RTK Float and the **blue** data points represent RTK Fixed.

It is clear from all data collected, even in the partially occluded cases, that the RTK method is more precise than the individual GPS recordings from Lab 1. In the stationary recording in a clear environment, the segmentation of data into what appears as discreet points in the Easting vs. Northing plot shows the predicted cm-level accuracy and mm-level precision in Easting, Northing, and Altitude promised with RTK-based GPS data collection.

The minimal error that exists in this stationary clear case can be seen by the bounds in Easting and Northing of only 14cm and with a nearly constant altitude. Furthermore, after removing outliers, much of the collected data lies within a 2-cm bound. The outliers, in this case, are due to a transition from RTK Fixed to RTK Float, as seen by the change in color from blue to red in the plot. Comparatively, the stationary occluded case data has a wider bound than in the clear case, as the easting and northing data is spread to over a meter of variability. This is due to a poorer satellite geometry related to restricted access to the sky, as the number of satellites visible from the ground is reduced. This is visualized in the variability of RTK fix types, where the clear environment was primarily in RTK Fixed mode, the occluded environment spent much of the time in the less-precise Float mode.

These transitions from Float mode to Fixed mode and vice versa are often correlated with a jump in data. This is best exemplified in the Altitude vs. Time and Easting vs. Time plots for the moving case in the occluded environment. The discontinuity appears in conjunction with a change in fix type. This is

likely a result of walking away from the ISEC building and towards the road with a clearer view of the sky, resulting in a better fix. This change in direction can be seen in the Easting vs. Northing plot. This can also be seen in the comparison of altitude data for both the stationary and moving recordings in the occluded environment. Both received a RTK Fixed mode towards the end of data collection that agreed well with each other and approached the expected altitude.

In the moving dataset in the clear environment, the RTK remained in Fixed mode throughout with very clean and predictable data. It was so precise that small oscillations can be seen in the Easting vs. Northing plot that correspond to individual steps taken by the operator holding the GPS receiver. Therefore, it is difficult to isolate errors in data, as any perturbations are likely human error. The only area of confusion arises when time is approximately 35-seconds into the recording where there is a clear jump in position in both Easting and Altitude, but not in Northing. No intuition behind this phenomenon has been found to this point.

In summary, using the base reference with the same satellites as a rover has helped reduce noise from ionospheric interference, multipath effects, and other sources of signal disturbance resulting in mm-level precision and cm-level accuracy.

Matthew Euliano 2/22/2022

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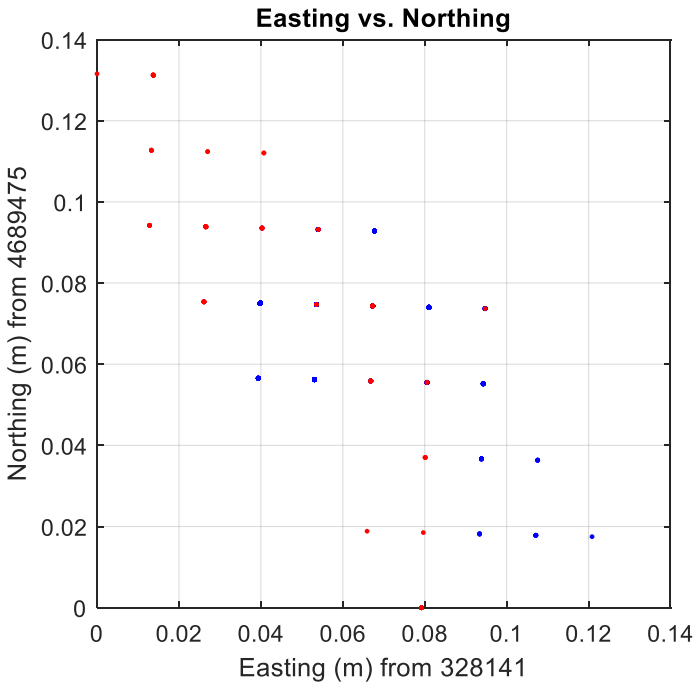
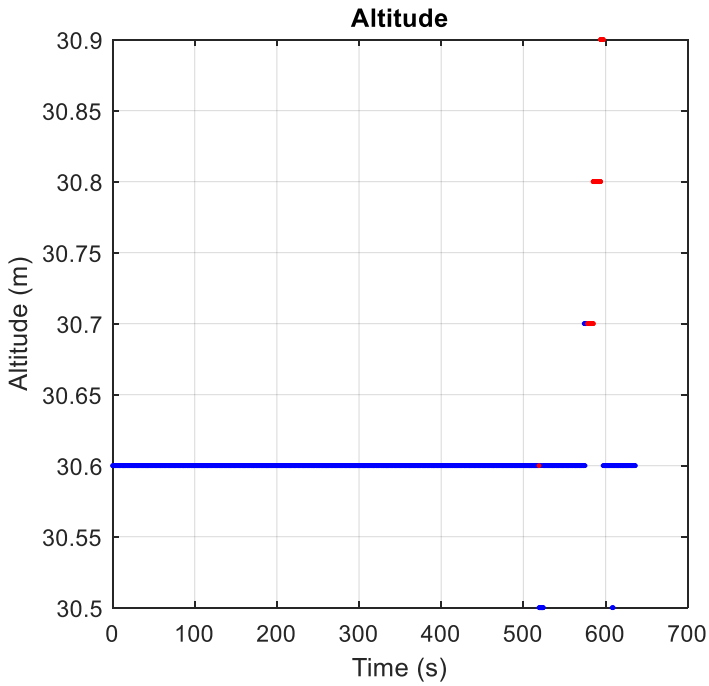
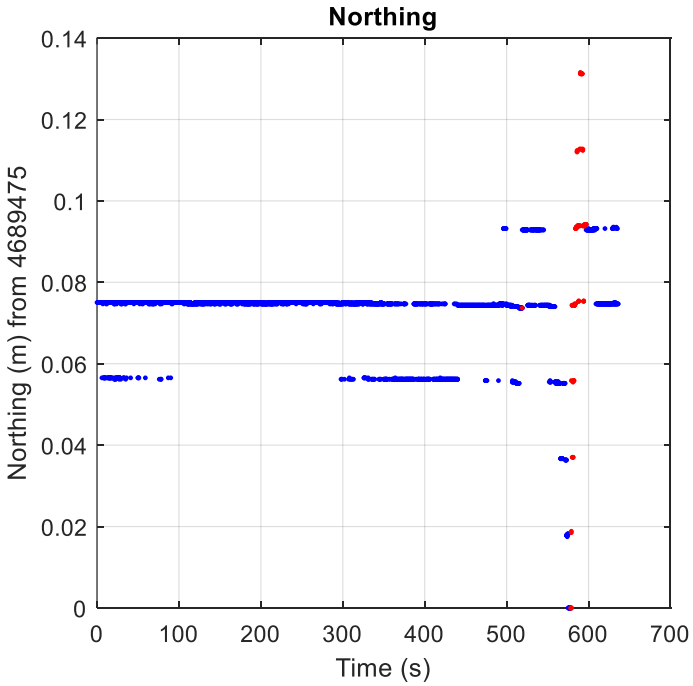
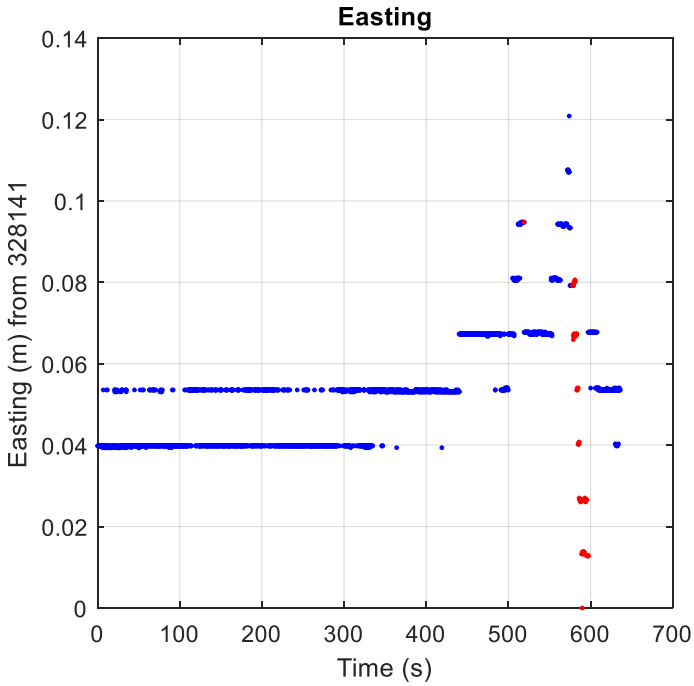
# Stationary Recording - Clear




**Note:** Red data points represent RTK Float, Blue data points represent RTK Fixed.

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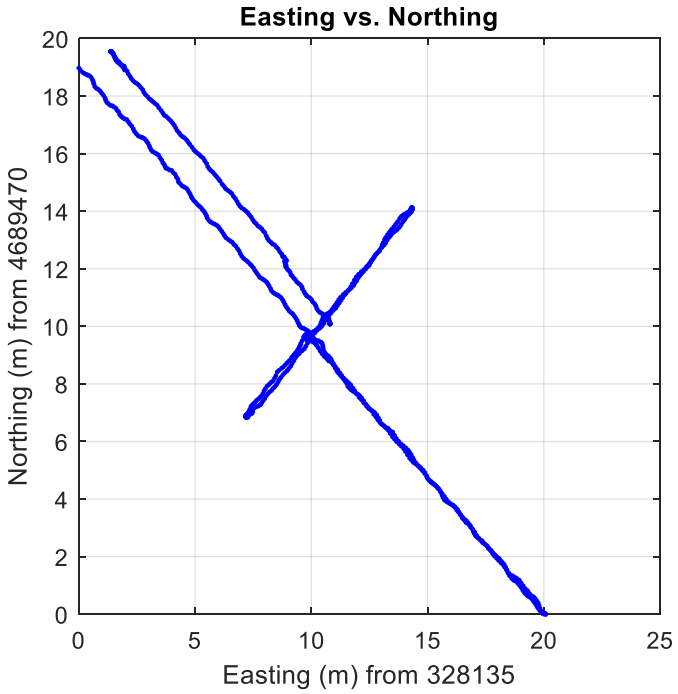
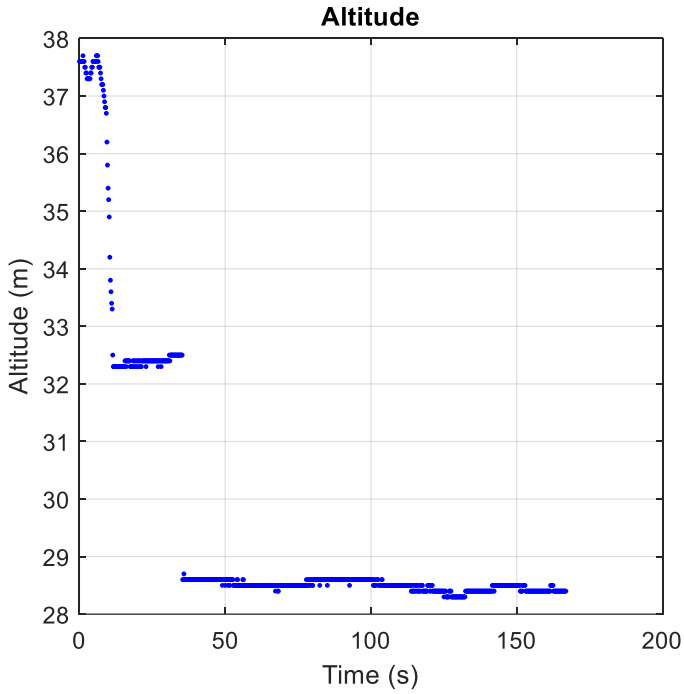
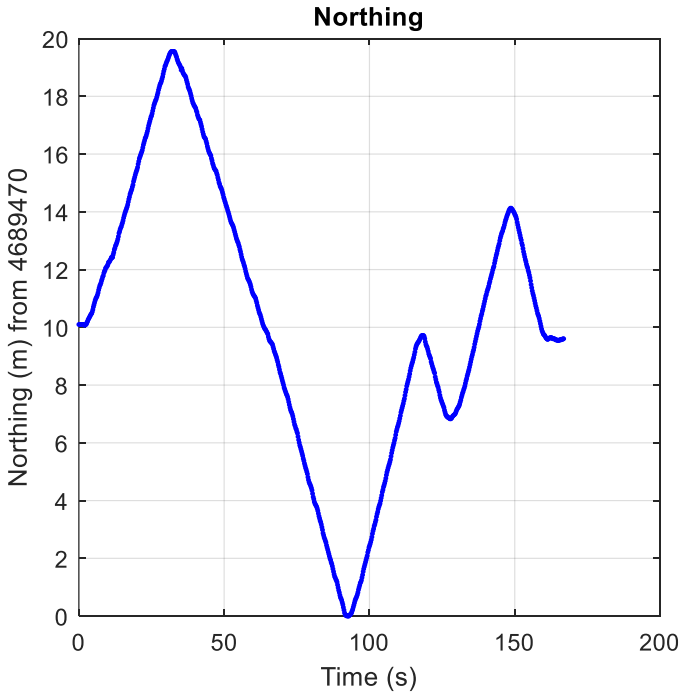
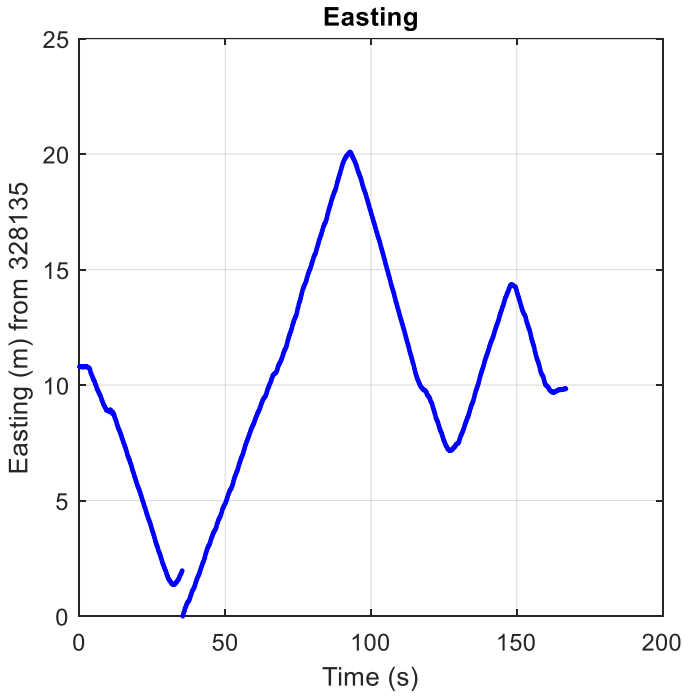
# Moving Recording - Clear

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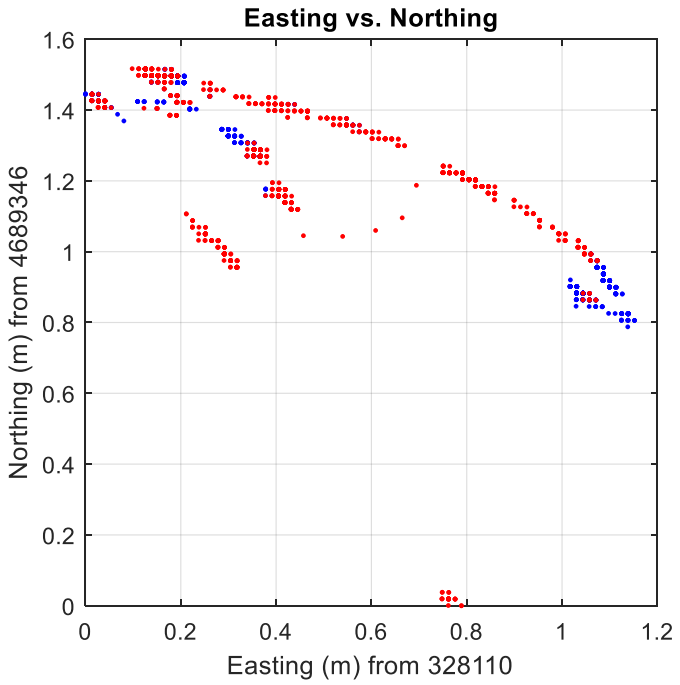
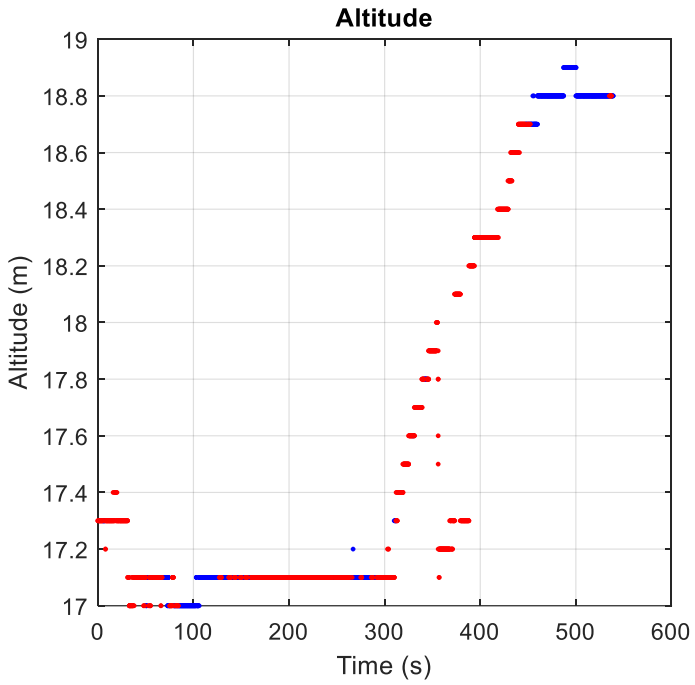
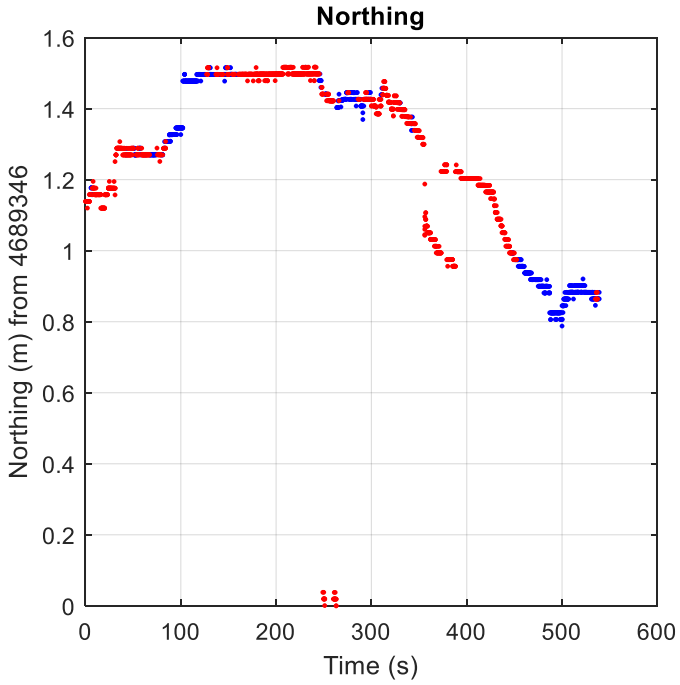
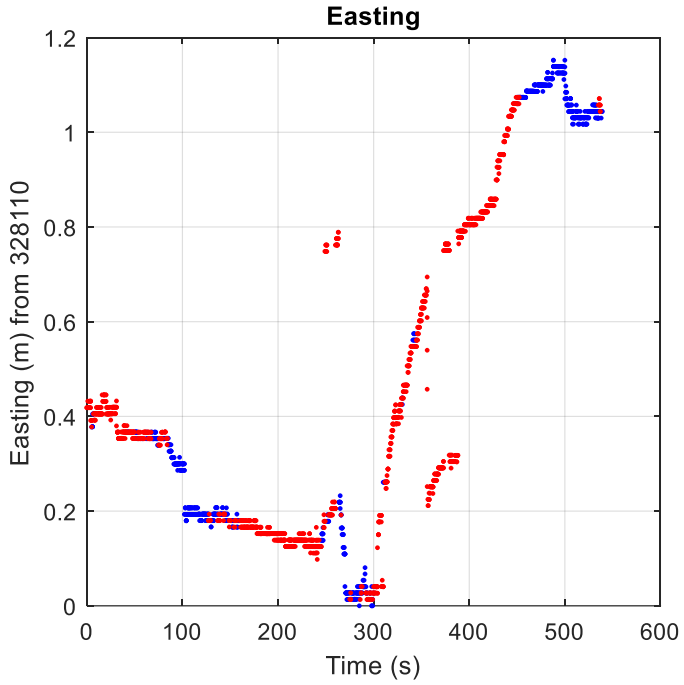
# Stationary Recording - Occluded




**Note:** Red data points represent RTK Float, Blue data points represent RTK Fixed.

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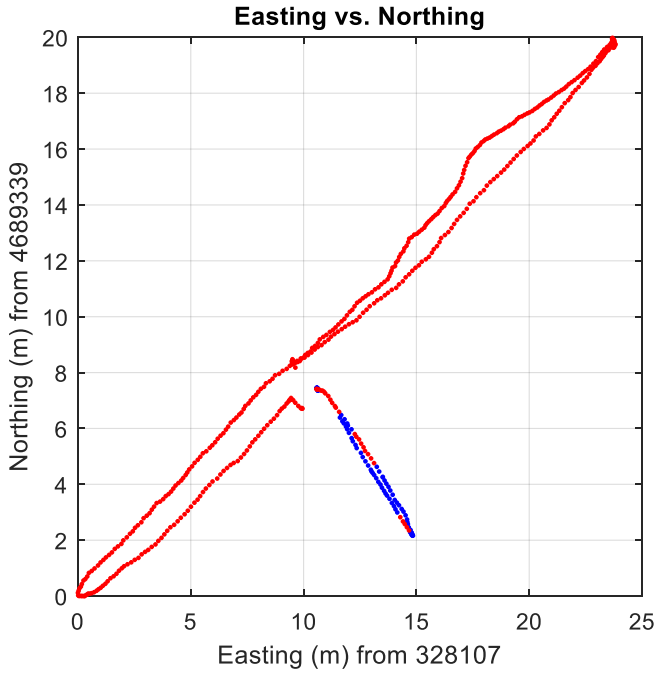
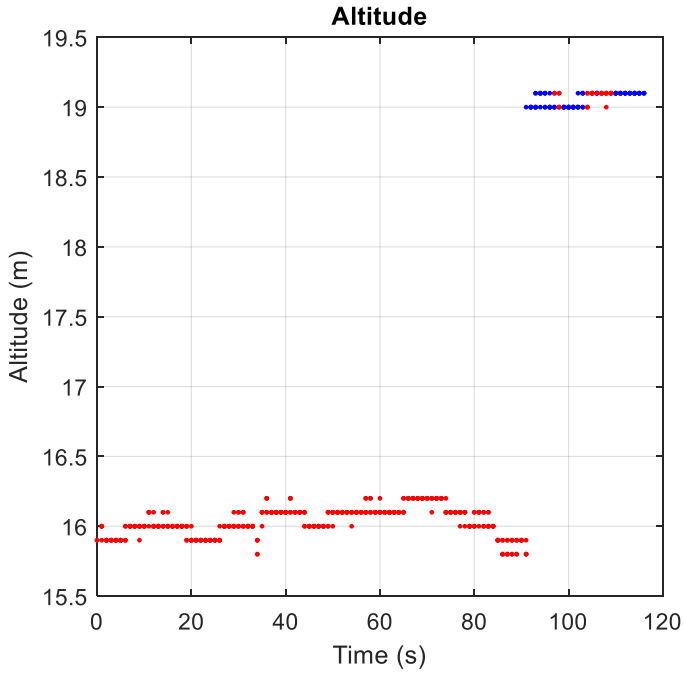
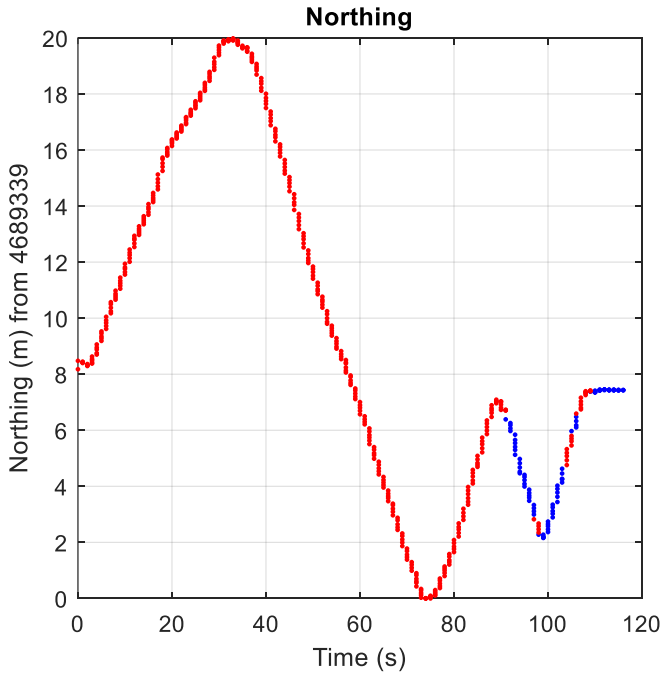
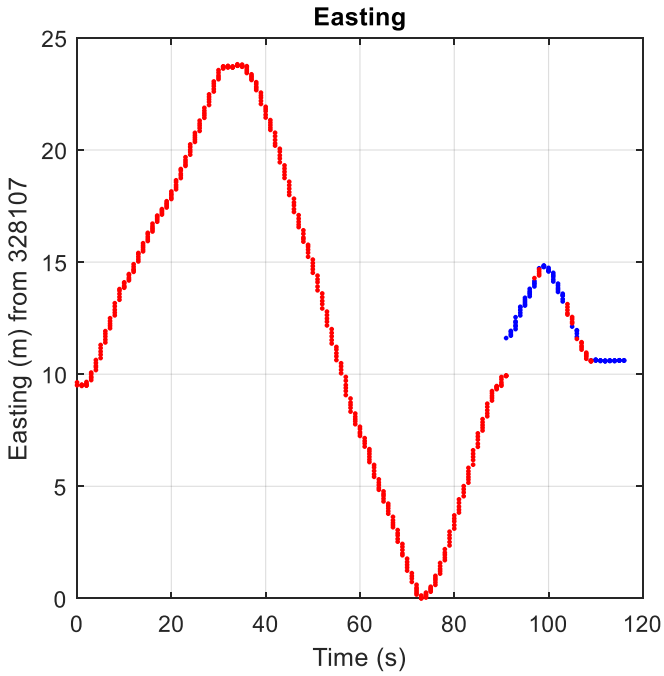
# Moving Recording - Occluded




**Note:** Red data points represent RTK Float, Blue data points represent RTK Fixed.