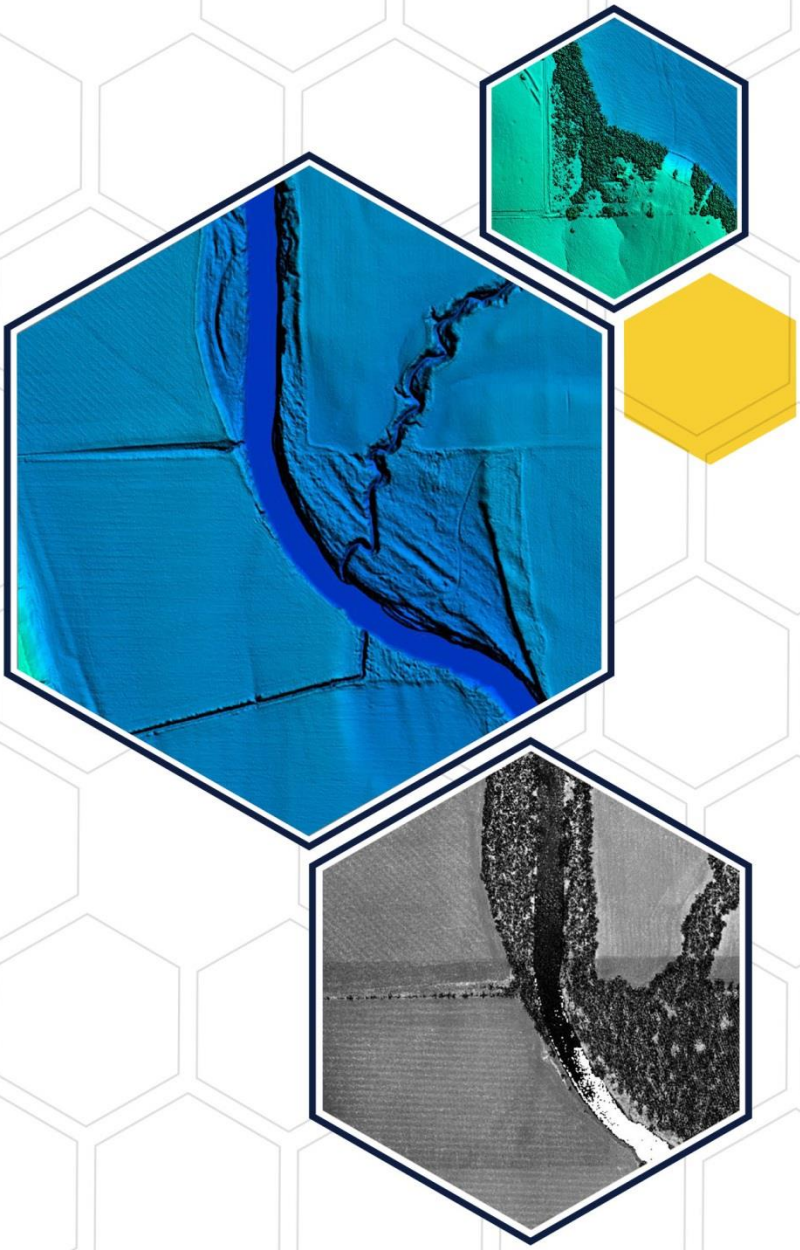

Aerial Lidar Report

16113
United States Geological Survey, 2017 Alabama 25 Counties Lidar (Block 4)
April 2018

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Section 1: Lidar Acquisition

1.1 Acquisition

The Atlantic Group, LLC (Atlantic) has successfully completed lidar acquisition for the 2017 Alabama 25 County Lidar (Block 4) Area of Interest (AOI). Lidar for this AOI was acquired in nineteen (19) flight mission completed on April 2nd, 2017 The project area encompasses 2,095,515 acres, 8480 square kilometers or 3274 square miles.

1.2 Acquisition Status Report

Upon notification to proceed, the flight crew loaded the flight plans and validated the flight parameters. Atlantic's Director of Flight Operations contacted air traffic control and coordinated flight pattern requirements. Lidar acquisition began immediately upon notification that control base stations were in place. During flight operations, the flight crew monitored weather and atmospheric conditions. Lidar missions were flown only when no condition existed below the sensor that would affect the collection of data. The pilot constantly monitored the aircraft course, position, pitch, roll, and yaw of the aircraft. The sensor operator monitored the sensor, the status of the GNSS constellations, and performed the first QC review during acquisition. The flight crew constantly reviewed weather and cloud locations. Any flight lines impacted by unfavorable conditions were marked as invalid and re-flown at an optimal time.

1.3 Acquisition Details

Atlantic acquired one-hundred and sixty-one (161) passes of the AOI as a series of perpendicular and/or adjacent flight-lines. Differential GNSS unit in aircraft recorded sample positions at 2 Hz or more frequency. Lidar data was only acquired when a minimum of 6 satellites were in view.

Atlantic lidar sensors are calibrated at a designated site located at the Fayetteville Municipal Airport (FYM) in Fayetteville, TN and are periodically checked and adjusted to minimize corrections at project sites.

1.4 Project Purpose

The primary purpose of the lidar survey was to establish measurements of the bare earth surface, as well as top surface feature data for providing geometric inputs for modeling, other numerical modeling and economic related assessments.

1.5 Lidar Flight-line Orientation

The following graphic represents the alignment of the project area of interest (AOI) and the flight-lines executed to provide AOI coverage.

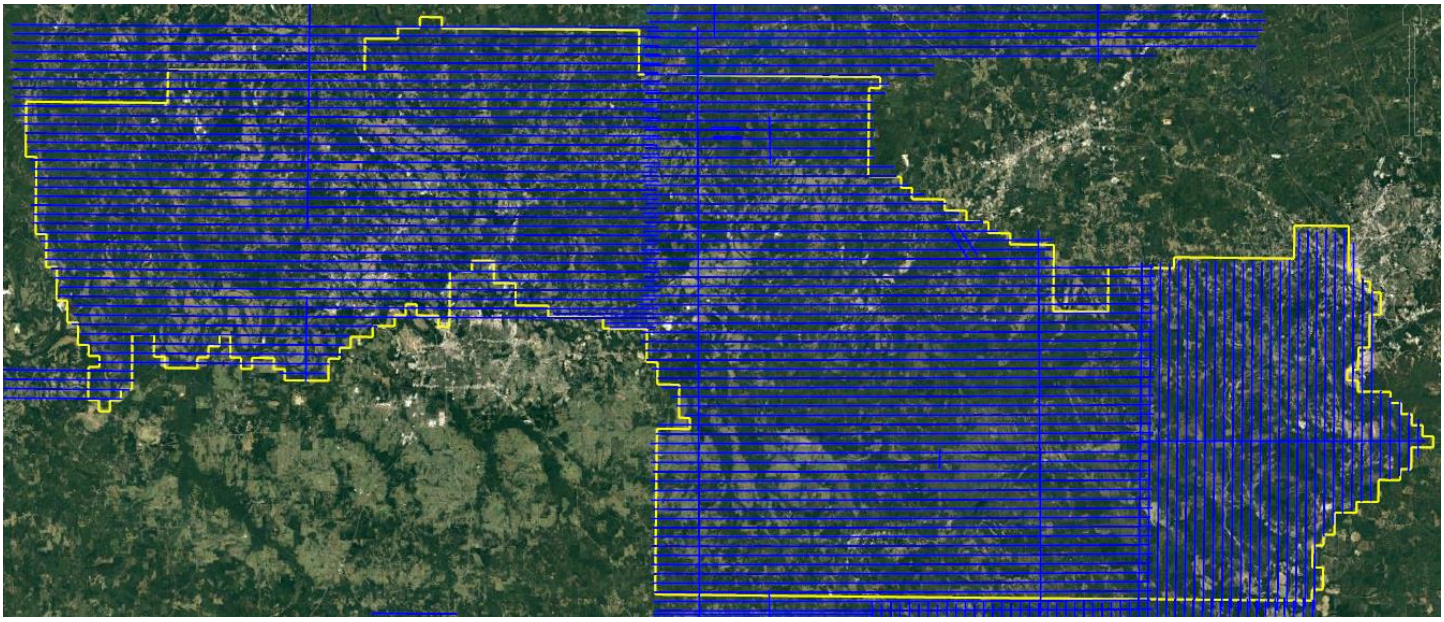


Figure 1: Trajectories as flown by Atlantic

1.6 Acquisition Equipment

Atlantic operated a Partenavia S.P.A P 68 C/TC (N775MW) outfitted with a Leica ALS70-HP lidar system during the collection of the project area. Table 1 represents a list of the features and characteristics for the Leica ALS70-HP lidar system:

Atlantic's Sensor Characteristics		
Leica ALS70-HP		
Manufacturer	Leica	
Model	ALS70 - HP	
Platform	Fixed-Wing	
Scan Pattern	Sine, Triangle, Raster	
Maximum Scan Rate (Hz)	Sine	200
	Triangle	158
	Raster	120
Field of View (°)	0 - 75 (Full Angle, User Adjustable)	
Maximum Pulse rate (kHz)	500	
Maximum Flying height (m AGL)	3500	
Number of returns	Unlimited	
Number of Intensity Measurements	3 (First, Second, Third)	
Roll Stabilization (Automatic Adaptive, °)	75 - Active FOV	
Storage Media	Removable 500 GB SSD	
Storage Capacity (Hours @ Max Pulse Rate)	6	
Size (cm)	Scanner	37 W x 68 L x 26 H
	Control Electronics	45 W x 47 D x 36 H
Weight (kg)	Scanner	43
	Control Electronics	45
Operating Temperature	0 - 40 °C	
Flight Management	FCMS	
Power Consumption	927 @ 22.0 - 30.3 VDC	

Table 1: Atlantic Sensor Characteristics

1.7 Lidar System Acquisition Parameters

Table 2 illustrates Atlantic's system parameters for lidar acquisition on this project.

Lidar System Acquisition Parameters	
Item	**Parameter**
System	Leica ALS-70 HP
Nominal Pulse Spacing (m)	0.5115
Nominal Pulse Density (pls/m²)	3.82
Nominal Flight Height (AGL meters)	2162
Nominal Flight Speed (kts)	130
Pass Heading (degree)	Varies
Sensor Scan Angle (degree)	45
Scan Frequency (Hz)	35.1
Pulse Rate of Scanner (kHz)	264.8
Line Spacing (m)	1,141
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	0.48
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	Yes
Beam Divergence (mrad)	0.22
Nominal Swath Width (m)	1,663
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

Table 2: Atlantic Lidar System Acquisition Parameters

1.8 GNSS Reference Station(s)

Five (5) Continuously Operating Reference Stations (CORS) were used to control the lidar acquisition for the project area. The coordinates provided in Table 3 below are in NAD83 (2011), Geographic Coordinate System, Ellipsoid, Meters.

GPS Reference Station Coordinates					
Designation	**Type**	**PID**	**Latitude (N)**	**Longitude (W)**	**Elevation**
ALLA	CORS	DM5373	32 55 02.64002	085 24 01.77791	238.544
ALA1	CORS	DM2678	32 35 55.86421	085 30 14.10823	185.476
AL62	CORS	DM2676	32 08 53.34292	085 41 12.35093	142.213
ALTU	CORS	DP4178	31 48 00.71565	085 57 15.51042	142.530
AL76	CORS	DM7125	31 52 29.93782	085 13 32.45603	101.523

Table 3: GNSS Reference Station Coordinates

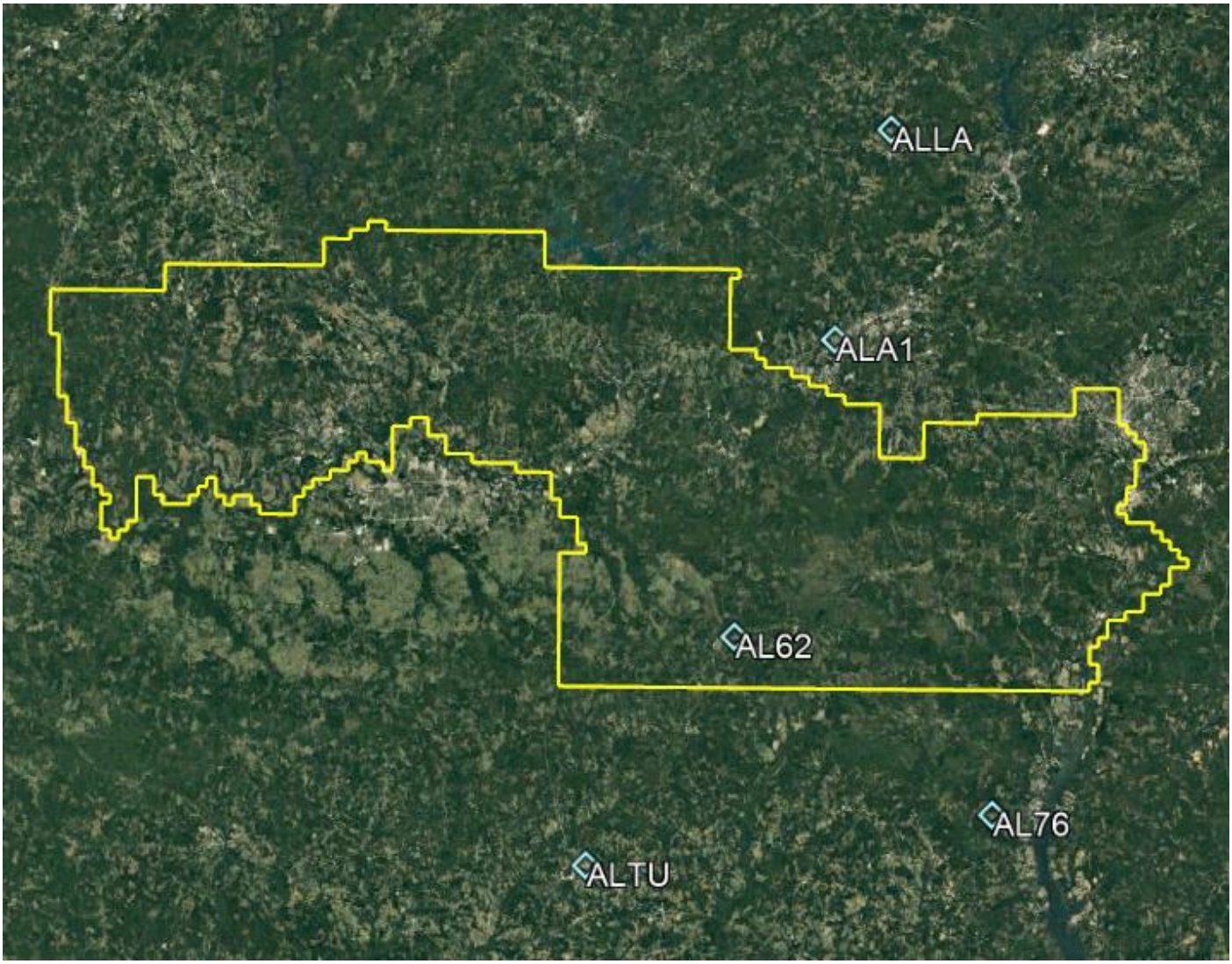


Figure 2: GNSS Reference Station(s)

1.9 Airborne GNSS Kinematic

Differential GNSS unit in aircraft collected positions at 2 Hz. Airborne GNSS data was processed using the Inertial Explorer (version 8.60.6717) software. Flights were flown with a minimum of 6 satellites in view (10° above the horizon).

For all flights, the GNSS data can be classified as good, with residuals of 3cm average or better but none larger than 10cm being recorded.

Data collected by the lidar unit is reviewed for completeness, acceptable density and to make sure all data is captured without errors or corrupted values. In addition, all GNSS, aircraft trajectory, mission information, and ground control files are reviewed and logged into a database.

GNSS processing results for each lift are included in **Section 5: GNSS Processing**.

Section 2: Lidar Processing

2.1 Lidar Point Cloud Generation

Atlantic used Leica software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Waypoint Inertial Explorer is used to extract the raw IPAS ABGNSS/IMU data, which is further processed in combination with controlled base stations to provide the final Smoothed Best Estimate Trajectory (SBET) for each mission. The SBET's are combined with the raw laser scan files to export the Lidar ASCII Standard (*.las) formatted swath point clouds.

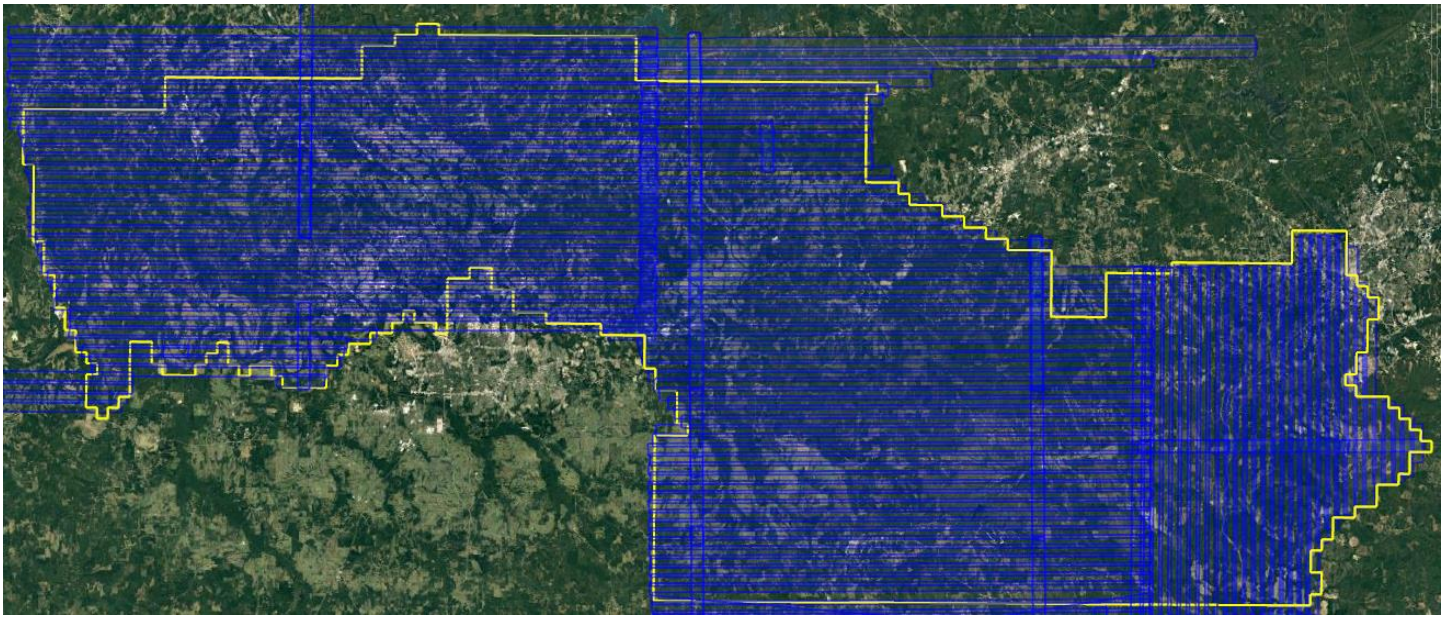


Figure 3: Lidar swath data showing complete coverage

2.2 Coordinate Reference System

Horizontal Datum:	North American Datum of 1983 (2011)
Coordinate System:	Universal Transverse Mercator Zone 16 North
Vertical Datum:	North American Vertical Datum of 1988
Geoid Model:	Geoid12B
Units of Reference:	Meters

2.3 Lidar Point Cloud Statistics

Table 4 illustrates the overall lidar point cloud statistics for this project.

Point Cloud Statistics	
Category	**Value**
Total Points	52,632,276,265
Nominal Pulse Spacing (m)	0.5115
Nominal Pulse Density (pls/m²)	3.82
Nominal Pulse Spacing (ft)	1.6781
Nominal Pulse Density (pls/ft²)	0.36
Aggregate Total Points	42,351,820,412
Aggregate Nominal Pulse Spacing (m)	0.4482
Aggregate Nominal Pulse Density (pls/m²)	4.98
Aggregate Nominal Pulse Spacing (ft)	1.4705
Aggregate Nominal Pulse Density (pls/ft²)	0.46

Table 4: Lidar Point Cloud Statistics

2.4 Expected Horizontal Positional Error

As described in Section 7.5 of the ASPRS Positional Accuracy Standards for Digital Geospatial Data the horizontal errors in lidar data are largely a function of GNSS positional error, INS angular error, and flying altitude. Therefore, lidar data collected with GNSS error of 8cm and the IMU error of 0.00427 degrees at an altitude of 2162m; the expected radial horizontal positional error will be RMSEz = 31.0cm.

2.5 Smooth Surface Repeatability (Intraswath)

Departures from planarity of first returns within single swaths in non-vegetated areas were assessed at multiple locations with hard surface areas (parking lots or large rooftops) inside the project area. Each area was evaluated using signed difference rasters (maximum elevation – minimum elevation) at a cell size equal to 2 x ANPS, rounded to the next integer. The following graphic depicts a sample of the assessment.

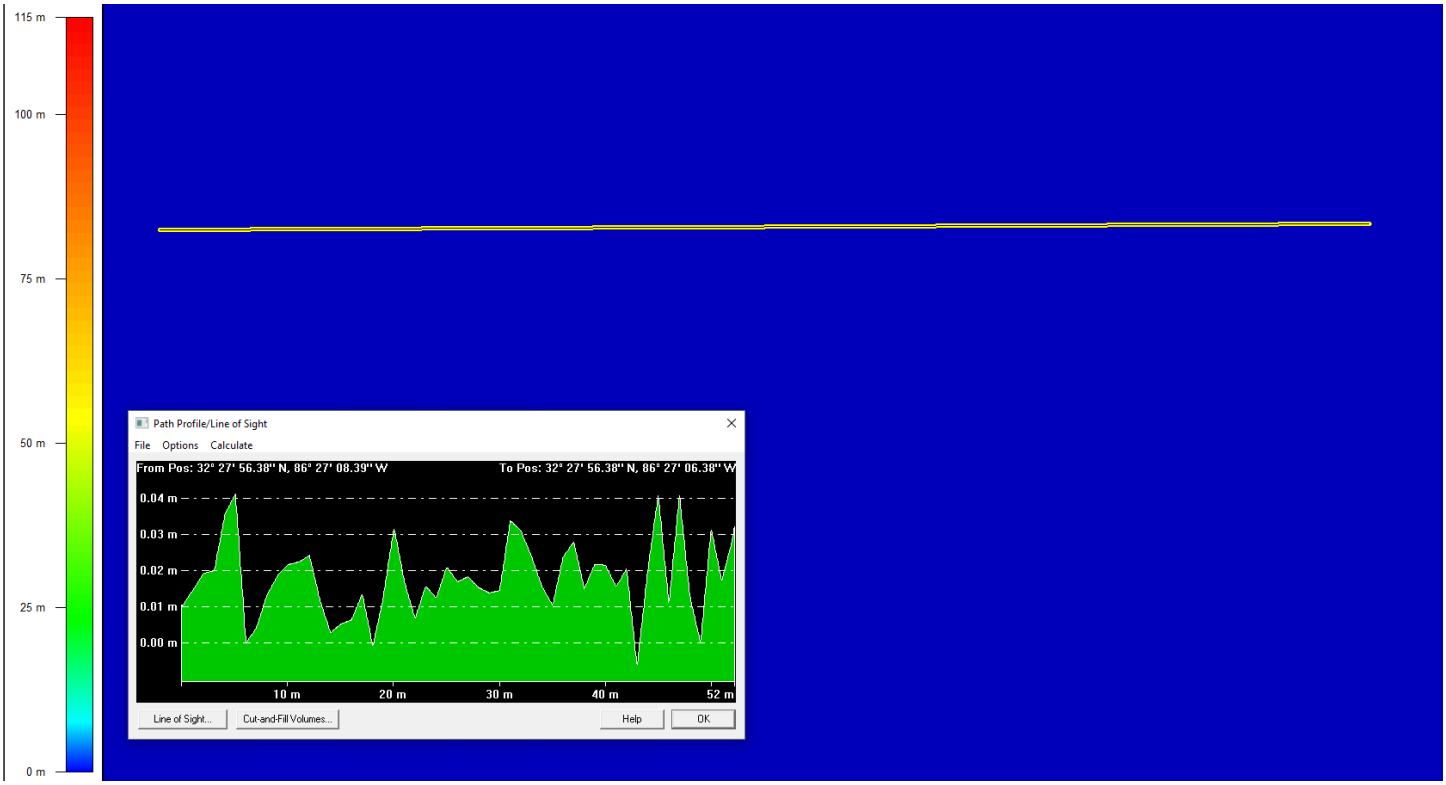


Figure 4: Smooth Surface Repeatability of ≤6cm

2.6 Lidar Calibration

Lidar ranging data were initially calibrated using previous best parameters for this instrument and aircraft. Using a combination of GeoCue, TerraScan and TerraMatch; the overlapping swath point clouds are corrected for any orientation or linear deviations to obtain the best fit swath-to-swath calibration. Relative calibration was evaluated using advanced plane-matching analysis and parameter corrections derived. This process was repeated interactively until residual errors between overlapping swaths, across all project missions, was reduced to ≤2cm. A final analysis of the calibrated lidar is preformed using a TerraMatch Tie Line report for an overall statistical model of the project area.

Upon completion of the data calibration, Atlantic runs a complete set of elevation difference intensity rasters (dZ Orthos). A user-defined color ramp is applied depicting the offsets between overlapping swaths based on project specifications. The dZ orthos provide an opportunity to review the data calibration in a qualitative manner. Atlantic assigns green to all offset values that fall below the required RMSDz requirement of the project. A yellow color is assigned for offsets that fall between the RMSDz value and 1.5x of that value. Finally, red values are assigned to all values that fall beyond 1.5x of the RMSDz requirements of the project.

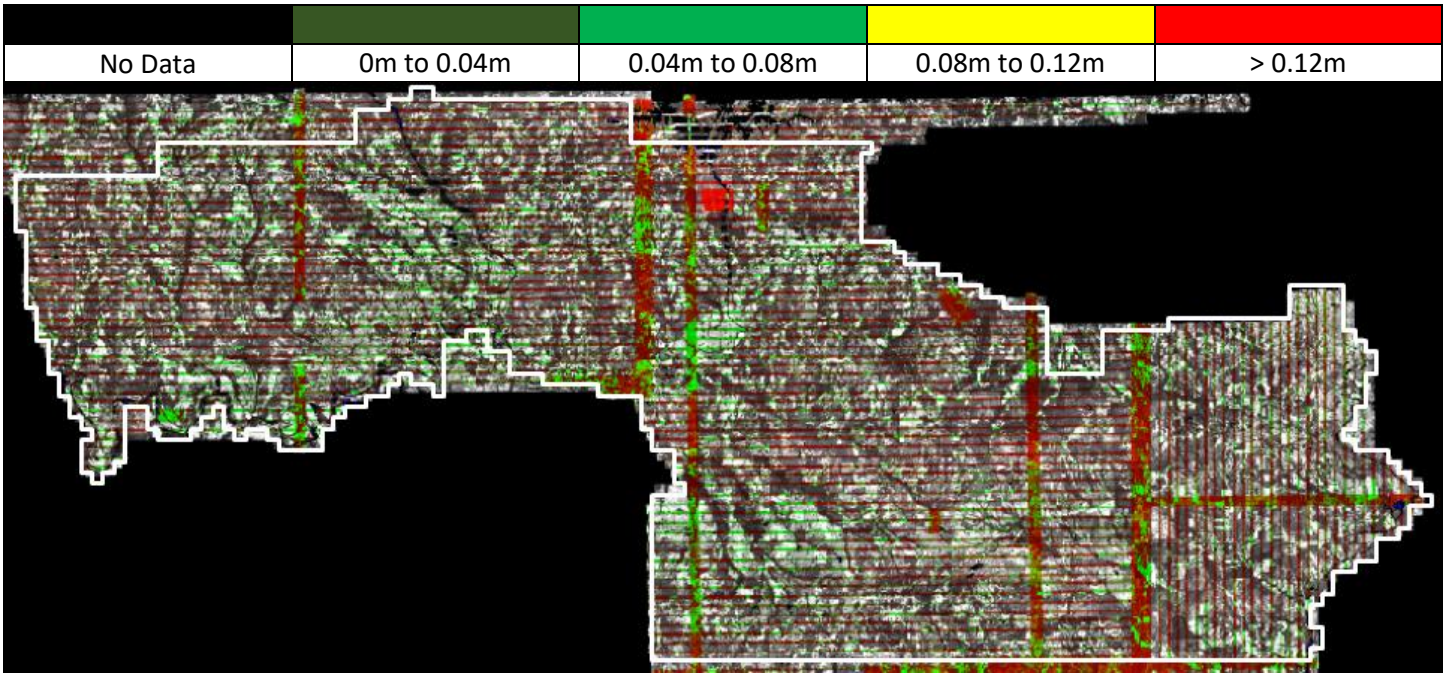


Figure 5: Swath Overlap Difference of ≤8cm, Maximum of ±16cm

2.7 Overlap Consistency (Interswath)

An overall statistical assessment of the relative accuracy using TerraMatch Tie Line Report between lidar swaths can be found in Tables 5, 6, 7, and 8 below. The values provided are in meters.

Average Magnitudes Per Line							
Line	**X**	**Y**	**Z**	**Line**	**X**	**Y**	**Z**
2007	0.036	0.031	0.016	**2209**	0.022	0.026	0.016
2008	0.029	0.026	0.014	**2210**	0.023	0.025	0.015
2014	0.148	0	0.014	**2211**	0.022	0.027	0.016
2015	0.017	0.013	0.014	**2212**	0.019	0.021	0.015
2016	0.014	0.015	0.017	**2213**	0.015	0.015	0.015
2017	0.022	0.024	0.015	**2214**	0.041	0.026	0.024
2018	0.022	0.014	0.014	**2216**	0.017	0.018	0.017
2019	0.015	0.007	0.013	**2217**	0.014	0.014	0.016
2020	0.021	0.005	0.015	**2218**	0.02	0.021	0.016
2021	0.013	0.012	0.014	**2219**	0.016	0.021	0.017
2022	0.022	0.016	0.021	**2220**	0.021	0.015	0.021
2023	0.026	0.02	0.013	**2221**	0.033	0.024	0.023
2024	-	-	0.014	**2222**	0.021	0.021	0.016
2031	0.012	0.015	0.016	**2223**	0.016	0.016	0.015

2032	0.013	0.019	0.015	**2224**	0.02	0.015	0.017
2033	0.015	0.021	0.014	**2225**	0.019	0.018	0.016
2034	0.015	0.017	0.013	**2226**	0.022	0.016	0.016
2035	0.013	0.014	0.013	**2227**	0.024	0.016	0.016
2036	0.013	0.017	0.014	**2228**	0.022	0.012	0.016
2037	0.018	0.023	0.015	**2229**	0.027	0.016	0.019
2038	0.014	0.021	0.016	**2230**	0.023	0.02	0.018
2039	0.014	0.021	0.015	**2231**	0.026	0.023	0.021
2040	0.013	0.017	0.016	**2232**	0.018	0.018	0.016
2048	0.015	0.019	0.015	**2233**	0.027	0.02	0.023
2049	0.016	0.017	0.016	**2234**	0.019	0.022	0.017
2050	0.018	0.017	0.016	**2235**	0.02	0.023	0.017
2051	0.017	0.016	0.015	**2236**	0.02	0.019	0.018
2053	0.025	0.019	0.022	**2237**	0.018	0.023	0.018
2054	0.018	0.018	0.016	**2238**	0.017	0.018	0.017
2055	0.019	0.02	0.016	**2239**	0.015	0.016	0.016
2056	0.019	0.02	0.015	**2240**	0.016	0.017	0.015
2057	0.02	0.017	0.015	**2241**	0.017	0.018	0.016
2058	0.019	0.017	0.016	**2242**	0.016	0.017	0.015
2059	0.022	0.019	0.016	**2243**	0.016	0.017	0.016
2060	0.024	0.021	0.016	**2244**	0.015	0.017	0.015
2061	0.016	0.015	0.021	**2245**	0.019	0.015	0.022
2062	0.016	0.015	0.017	**2246**	0.014	0.015	0.015
2063	0.02	0.017	0.016	**2247**	0.015	0.016	0.017
2064	0.024	0.021	0.016	**2248**	0.03	0.023	0.017
2065	0.018	0.018	0.016	**2249**	0.02	0.017	0.016
2066	0.018	0.016	0.022	**2250**	0.016	0.015	0.016
2067	0.017	0.027	0.017	**2251**	0.015	0.018	0.015
2068	0.015	0.017	0.015	**2252**	0.017	0.018	0.015
2069	0.018	0.019	0.017	**2253**	0.016	0.013	0.02
2070	0.022	0.02	0.017	**2254**	0.021	0.022	0.021
2071	0.019	0.018	0.017	**2255**	0.028	0.019	0.021
2072	0.015	0.015	0.016	**2256**	0.019	0.015	0.014
2073	0.017	0.017	0.017	**2257**	0.018	0.014	0.015
2074	0.016	0.017	0.019	**2258**	0.018	0.014	0.014
2114	0.028	0.023	0.015	**2259**	0.018	0.019	0.016
2122	0.016	0.018	0.016	**2260**	0.019	0.024	0.015
2154	0.016	0.067	0.016	**2261**	0.028	0.018	0.015
2155	0.024	0.028	0.016	**2262**	0.027	0.022	0.015
2156	0.024	0.02	0.018	**2263**	0.025	0.034	0.019

2161	0.016	0.02	0.017	**2264**	-	-	0.017
2162	0.026	0.032	0.017	**2265**	-	-	0.016
2163	0.033	0.029	0.016	**2266**	-	-	0.014
2164	0.031	0.032	0.017	**2267**	0.081	0.083	0.014
2165	0.039	0.026	0.017	**2268**	0.082	0.073	0.015
2166	0.028	0.03	0.016	**2269**	0.015	0.013	0.013
2167	0.026	0.028	0.016	**2270**	0.012	0.01	0.015
2168	0.03	0.023	0.021	**2271**	0.011	0.011	0.02
2169	0.019	0.021	0.017	**2272**	0.011	0.016	0.017
2170	0.06	0.044	0.02	**2273**	0.012	0.018	0.023
2171	0.023	0.024	0.019	**2274**	0.013	0.014	0.018
2172	0.017	0.019	0.016	**2275**	0.012	0.011	0.012
2173	0.015	0.014	0.02	**2276**	0.013	0.01	0.014
2174	0.021	0.022	0.014	**2277**	0.015	0.013	0.016
2175	0.026	0.028	0.015	**2278**	0.016	0.015	0.016
2176	0.024	0.026	0.015	**2279**	0.016	0.016	0.015
2177	0.022	0.019	0.015	**2280**	0.016	0.023	0.016
2178	0.019	0.019	0.015	**2281**	0.018	0.026	0.015
2179	0.023	0.019	0.016	**2282**	0.019	0.018	0.016
2180	0.033	0.028	0.017	**2283**	0.016	0.019	0.016
2181	0.026	0.023	0.015	**2284**	0.022	0.022	0.015
2187	0.022	0.021	0.015	**2285**	0.026	0.024	0.015
2190	0.016	0.015	0.016	**2286**	0.025	0.026	0.016
2192	0.016	0.015	0.017	**2287**	0.02	0.031	0.022
2194	0.018	0.021	0.015	**2288**	0.016	0.017	0.015
2196	0.023	0.024	0.016	**2293**	0.011	0.01	0.016
2198	0.022	0.02	0.015	**2294**	-	-	0.025
2203	0.031	0.018	0.02	**2295**	-	-	0.024
2205	0.023	0.023	0.021	**2296**	0.027	0.024	0.022
2207	0.024	0.023	0.017	**2297**	0.023	0.026	0.021
2208	0.02	0.024	0.016	**2298**	0.019	0.022	0.02
				2299	0.015	0.007	0.019

Table 5: Average Tie Line Magnitudes per Line

Internal Observation Statistics			
Category	**X**	**Y**	**Z**
Average Magnitude	0.016	0.017	0.016
RMS Values	0.026	0.027	0.022
Maximum Values	0.156	0.158	0.159
Observation Weight	130470.0	130470.0	927406.0

Table 6: Tie Line Observation Statistics

Overall Relative Accuracy	
Category	**Mismatch**
Average 3D Mismatch	0.01933
Average XY Mismatch	0.02846
Average Z Mismatch	0.01640

Table 7: Relative Accuracy Results

TerraMatch Tie Lines	
Category	**Observations**
Section Lines	336,503
Roof Lines	61,450

Table 8: Total Tie Lines

2.8 Lidar Classification

Atlantic uses multiple automated filtering routines on the calibrated lidar point cloud identifying and extracting bare-earth and above ground features. GeoCue, TerraScan, and TerraModeler software was used for the initial batch processing and manual editing of the lidar point clouds. Atlantic utilized collected breakline data to preform classification for classes' 9-Water and 10-Ignored Ground in LP360. Outlined in Table 9 are the classification codes utilized for this project.

ASPRS Standard Lidar Point Classes	
Code	**Description**
1	Unclassified
2	Ground
7	Low Noise
9	Water
10	Ignored Ground
17	Bridges
18	High Noise
Flags	Overlap & Withheld

Table 9: Point Cloud Classification Scheme

Section 3: Lidar Accuracy

3.1 Ground Surveyed Check Points

Atlantic established a total of eighty-seven (87) check points for this Block 4 project (54 NVA + 33 VVA). Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from lidar points in clear and open areas. A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of 5 times the NPS exists with less than 1/3 of the $RMSE_Z$ deviation from a low-slope plane. Slopes that exceed 10 percent were avoided. Each land cover type representing 10 percent or more of the total project area were tested and reported with a VVA. In land cover categories other than dense urban areas, the tested points did not have obstructions 45 degrees above the horizon to ensure a sufficient TIN surface. The VVA value is provided as a target. It is understood that in areas of dense vegetation, swamps, or extremely difficult terrain, this value may be exceeded. The NVA value is a requirement that must be met, regardless of any allowed "busts" in the VVA(s) for individual land cover types within the project. Checkpoints for each assessment (NVA & VVA) are required to be well-distributed throughout the land cover type, for the entire project area.

3.2 Vertical Accuracy Requirements

Below are the vertical accuracy reporting requirements for this project:

Vertical Accuracy Reporting Requirements in Meters:

$RMSE_Z \leq 10.0$cm (Non-Vegetated Swath, DEM)
NVA ≤ 19.6cm 95% Confidence Level (Swath, DEM)
VVA ≤ 29.4cm 95^{th} Percentile (DEM)

Vertical Accuracy Reporting Requirements in Feet:

$RMSE_Z \leq 0.328$ft (Non-Vegetated Swath, DEM)
NVA ≤ 0.643ft 95% Confidence Level (Swath, DEM)
VVA ≤ 0.965ft 95^{th} Percentile (DEM)

*The terms FVA (Fundamental Vertical Accuracy), SVA (Supplemental Vertical Accuracy) and CVA (Consolidated Vertical Accuracy) are from the National Digital Elevation Program (NDEP) Guidelines for Digital Elevation Data (2004). The term FVA refers to open terrain, urban and levee classes; the term SVA refers to classes tested that are in addition or supplemental to the open terrain; the term CVA refers to the consolidated accuracy of the data from all classes (FVA + SVA).

*The terms NVA (Non-vegetated Vertical Accuracy) and VVA (Vegetated Vertical Accuracy) are from the ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014). The term NVA refers to assessments in clear, open areas (which typically produce only single lidar returns); the term VVA refers to assessments in vegetated areas (typically characterized by multiple return lidar).

3.3 Check Point Distribution

The following graphics depict the location and distribution of NVA and VVA check points established for this project.

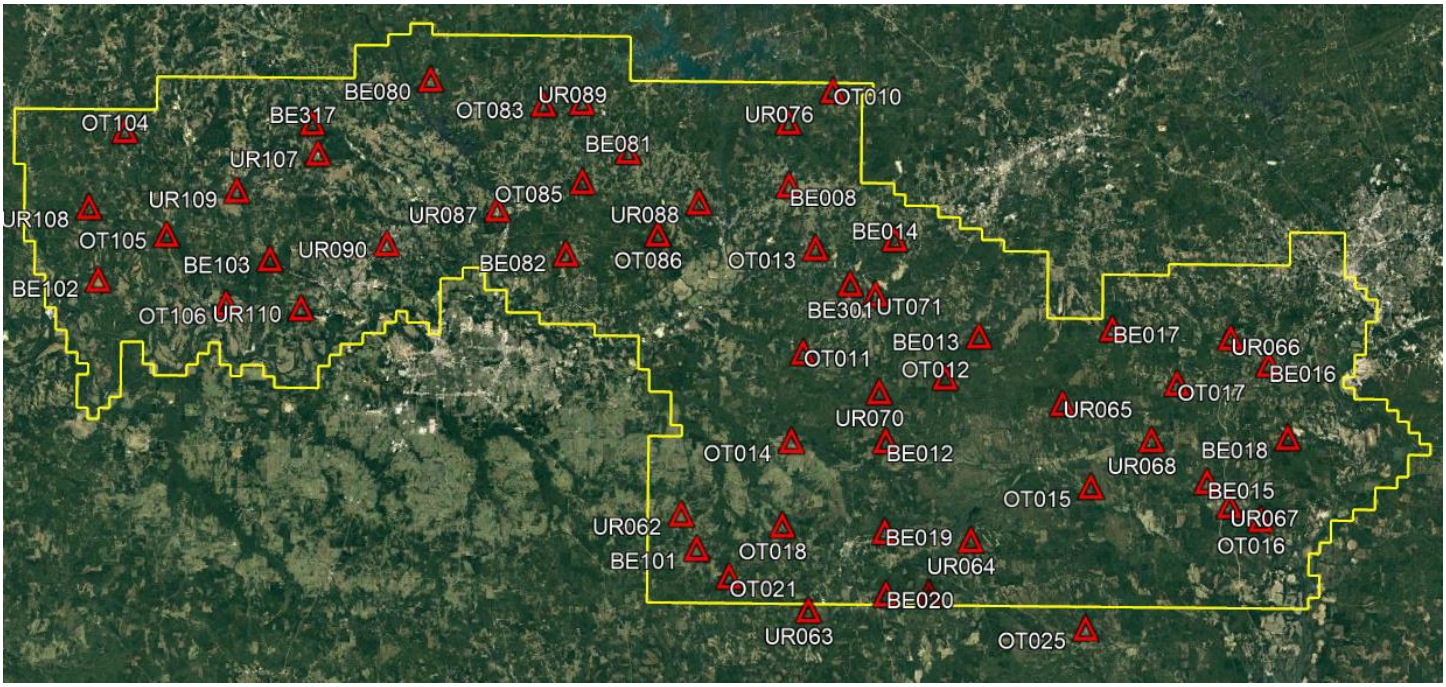


Figure 6: Non-vegetated Vertical Accuracy (NVA) Check Point Distribution

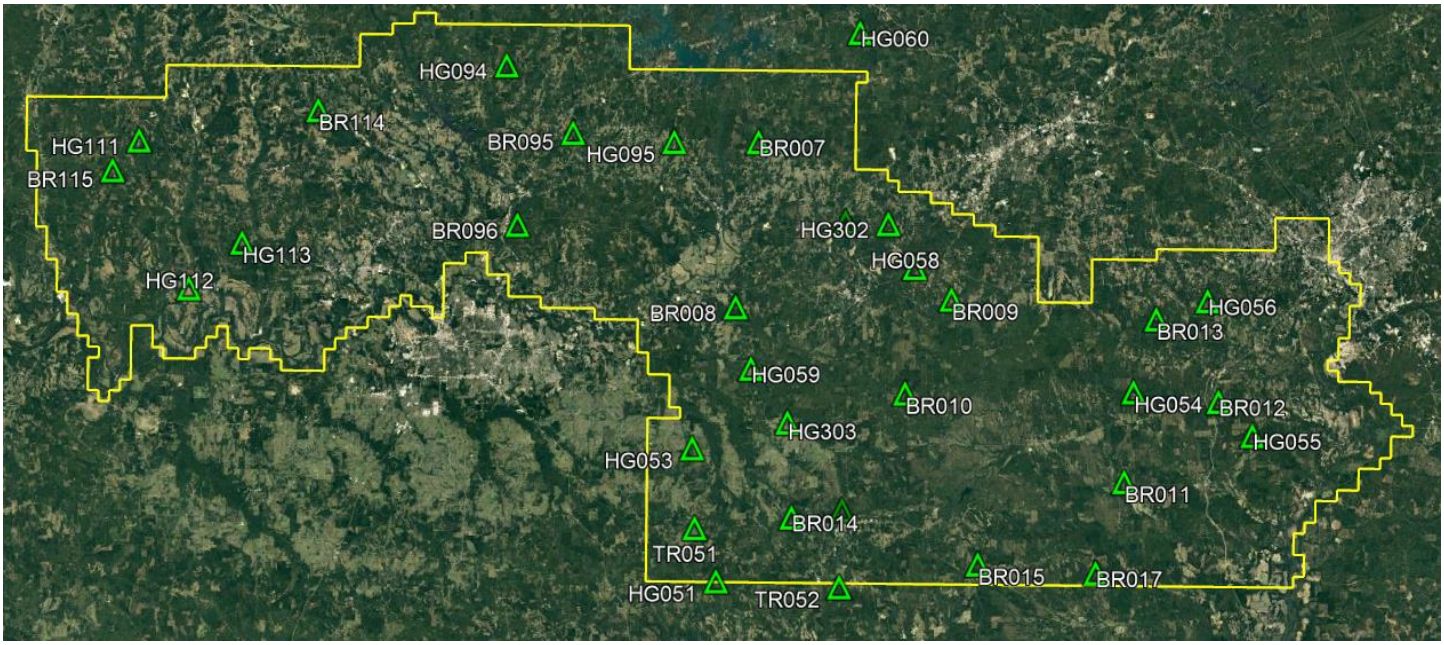


Figure 7: Vegetated Vertical Accuracy (VVA) Check Point Distribution

3.4 Vertical Accuracy Results

An overall statistical assessment of the check points can be found in Tables 10 and 11 below. The values provided are in meters.

Non-vegetated Vertical Accuracy (NVA) and Vegetated Vertical Accuracy (VVA)				
Broad Land Cover Type	**# of Points**	**RMSEz**	**95% Confidence Level**	**95th Percentile**
NVA of Point Cloud	53	0.055	0.108	
NVA of Bare Earth	54	0.056	0.111	
NVA of DEM	52	0.052	0.102	
VVA of Bare Earth	31	0.109		0.176

Table 10: Non-vegetated Vertical Accuracy (NVA) and Vegetated Vertical Accuracy (VVA)

Vegetated Vertical Accuracy (VVA) 5% Outliers > 95th Percentile (0.250m)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
BR008	606111.926	3586859.602	76.322	76.701	Brush	0.379
BR009	636042.145	3588241.129	114.142	114.491	Brush	0.349

Table 11: 5% Outlier Check Points

3.5 Check Point Assessment

A vertical accuracy assessment of the NVA & VVA check points against the lidar point cloud and bare-earth lidar can be found in Tables 12, 13, 14, and 15 below. The coordinates provided are in NAD83 (2011), UTM Zone 16 North, NAVD88 (Geoid12B), Meters.

Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (Point Cloud)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
BE008	612745.944	3605609.533	160.375	160.297	Bare Earth/Open Terrain	-0.078
BE012	626244.360	3571203.199	102.927	102.916	Bare Earth/Open Terrain	-0.011
BE013	638767.037	3585503.812	117.999	118.006	Bare Earth/Open Terrain	0.007
BE014	627173.069	3598518.884	121.441	121.502	Bare Earth/Open Terrain	0.061
BE015	670032.670	3566136.929	98.943	98.999	Bare Earth/Open Terrain	0.056
BE016	678268.153	3582074.050	87.422	87.487	Bare Earth/Open Terrain	0.065
BE017	656907.758	3586678.231	114.516	114.560	Bare Earth/Open Terrain	0.044
BE018	680994.259	3572186.332	113.501	113.565	Bare Earth/Open Terrain	0.064
BE019	626250.183	3558932.191	167.984	167.916	Bare Earth/Open Terrain	-0.068
BE020	626503.165	3550471.020	160.114	160.115	Bare Earth/Open Terrain	0.001
BE080	563875.982	3619481.494	138.743	138.817	Bare Earth/Open Terrain	0.074
BE081	590836.438	3609953.631	163.652	163.631	Bare Earth/Open Terrain	-0.021
BE082	582545.268	3596005.822	151.855	151.800	Bare Earth/Open Terrain	-0.055
BE101	600736.036	3556391.879	100.637	100.632	Bare Earth/Open Terrain	-0.005
BE102	518799.211	3591920.454	105.542	105.584	Bare Earth/Open Terrain	0.042
BE103	542252.371	3594916.798	75.183	75.211	Bare Earth/Open Terrain	0.028
BE301	621198.096	3592352.271	95.842	95.840	Bare Earth/Open Terrain	-0.002
BE317	547832.426	3613445.052	121.243	121.350	Bare Earth/Open Terrain	0.107

OT010	618580.206	3618467.124	215.713	215.811	Bare Earth/Open Terrain	0.098
OT011	614905.593	3583034.734	88.818	88.856	Bare Earth/Open Terrain	0.038
OT012	634223.193	3579876.354	123.855	123.918	Bare Earth/Open Terrain	0.063
OT013	616451.244	3597185.173	90.951	91.030	Bare Earth/Open Terrain	0.079
OT014	613438.185	3571084.078	88.443	88.557	Bare Earth/Open Terrain	0.114
OT015	654209.064	3565313.470	100.302	100.411	Bare Earth/Open Terrain	0.109
OT016	677426.215	3561053.049	72.281	72.308	Bare Earth/Open Terrain	0.027
OT017	665790.054	3579374.012	150.436	150.480	Bare Earth/Open Terrain	0.044
OT018	612326.543	3559648.749	90.617	90.613	Bare Earth/Open Terrain	-0.004
OT019	632339.634	3550659.735	159.182	159.164	Bare Earth/Open Terrain	-0.018
OT021	605161.501	3552658.055	110.014	109.986	Bare Earth/Open Terrain	-0.028
OT025	653709.699	3546127.123	96.300	96.314	Bare Earth/Open Terrain	0.014
OT083	579286.355	3616235.463	161.529	161.544	Bare Earth/Open Terrain	0.015
OT085	584677.505	3605796.010	109.655	109.674	Bare Earth/Open Terrain	0.019
OT086	595000.079	3598802.754	144.390	144.498	Bare Earth/Open Terrain	0.108
OT104	522199.572	3612160.552	148.676	148.678	Bare Earth/Open Terrain	0.002
OT105	528095.537	3598089.986	76.342	76.419	Bare Earth/Open Terrain	0.077
OT106	536343.744	3588831.037	47.849	47.935	Bare Earth/Open Terrain	0.086
UR062	598584.434	3561022.116	102.568	102.516	Urban	-0.052
UR063	615997.493	3548194.429	169.516	169.513	Urban	-0.003
UR064	637963.697	3557906.946	177.549	177.488	Urban	-0.061
UR065	650236.963	3576493.035	155.641	155.630	Urban	-0.011
UR066	673039.438	3585647.479	100.728	100.747	Urban	0.019
UR067	673132.522	3562890.367	74.787	74.769	Urban	-0.018
UR068	662397.648	3571714.662	97.524	97.451	Urban	-0.073
UR070	625276.318	3577798.419	91.569	91.602	Urban	0.033
UR076	612597.307	3614164.887	194.727	194.745	Urban	0.018
UR088	600542.729	3603180.857	145.554	145.617	Urban	0.063
UR089	584498.525	3616532.838	192.374	192.355	Urban	-0.019
UR090	558166.797	3597134.365	96.939	96.979	Urban	0.040
UR107	548643.295	3609292.323	185.119	185.183	Urban	0.064
UR108	517395.619	3601749.452	77.280	77.326	Urban	0.046
UR109	537643.356	3604165.415	120.363	120.445	Urban	0.082
UR110	546596.777	3588315.640	57.815	57.833	Urban	0.018
UT071	624639.084	3591005.187	97.281	97.265	Urban	-0.016

Table 12: Lidar Point Cloud NVA Assessment

Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (Bare-Earth)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
BE008	612745.944	3605609.533	160.375	160.297	Bare Earth/Open Terrain	-0.078
BE012	626244.360	3571203.199	102.927	102.916	Bare Earth/Open Terrain	-0.011
BE013	638767.037	3585503.812	117.999	118.006	Bare Earth/Open Terrain	0.007
BE014	627173.069	3598518.884	121.441	121.502	Bare Earth/Open Terrain	0.061

BE015	670032.670	3566136.929	98.943	98.999	Bare Earth/Open Terrain	0.056
BE016	678268.153	3582074.050	87.422	87.487	Bare Earth/Open Terrain	0.065
BE017	656907.758	3586678.231	114.516	114.560	Bare Earth/Open Terrain	0.044
BE018	680994.259	3572186.332	113.501	113.565	Bare Earth/Open Terrain	0.064
BE019	626250.183	3558932.191	167.984	167.916	Bare Earth/Open Terrain	-0.068
BE020	626503.165	3550471.020	160.114	160.115	Bare Earth/Open Terrain	0.001
BE080	563875.982	3619481.494	138.743	138.817	Bare Earth/Open Terrain	0.074
BE081	590836.438	3609953.631	163.652	163.599	Bare Earth/Open Terrain	-0.053
BE082	582545.268	3596005.822	151.855	151.800	Bare Earth/Open Terrain	-0.055
BE101	600736.036	3556391.879	100.637	100.632	Bare Earth/Open Terrain	-0.005
BE102	518799.211	3591920.454	105.542	105.584	Bare Earth/Open Terrain	0.042
BE103	542252.371	3594916.798	75.183	75.211	Bare Earth/Open Terrain	0.028
BE301	621198.096	3592352.271	95.842	95.840	Bare Earth/Open Terrain	-0.002
BE317	547832.426	3613445.052	121.243	121.350	Bare Earth/Open Terrain	0.107
OT010	618580.206	3618467.124	215.713	215.811	Bare Earth/Open Terrain	0.098
OT011	614905.593	3583034.734	88.818	88.856	Bare Earth/Open Terrain	0.038
OT012	634223.193	3579876.354	123.855	123.900	Bare Earth/Open Terrain	0.045
OT013	616451.244	3597185.173	90.951	91.030	Bare Earth/Open Terrain	0.079
OT014	613438.185	3571084.078	88.443	88.557	Bare Earth/Open Terrain	0.114
OT015	654209.064	3565313.470	100.302	100.411	Bare Earth/Open Terrain	0.109
OT016	677426.215	3561053.049	72.281	72.308	Bare Earth/Open Terrain	0.027
OT017	665790.054	3579374.012	150.436	150.480	Bare Earth/Open Terrain	0.044
OT018	612326.543	3559648.749	90.617	90.608	Bare Earth/Open Terrain	-0.009
OT019	632339.634	3550659.735	159.182	159.164	Bare Earth/Open Terrain	-0.018
OT021	605161.501	3552658.055	110.014	109.986	Bare Earth/Open Terrain	-0.028
OT025	653709.699	3546127.123	96.300	96.314	Bare Earth/Open Terrain	0.014
OT083	579286.355	3616235.463	161.529	161.544	Bare Earth/Open Terrain	0.015
OT085	584677.505	3605796.010	109.655	109.674	Bare Earth/Open Terrain	0.019
OT086	595000.079	3598802.754	144.390	144.498	Bare Earth/Open Terrain	0.108
OT104	522199.572	3612160.552	148.676	148.678	Bare Earth/Open Terrain	0.002
OT105	528095.537	3598089.986	76.342	76.425	Bare Earth/Open Terrain	0.083
OT106	536343.744	3588831.037	47.849	47.931	Bare Earth/Open Terrain	0.082
UR062	598584.434	3561022.116	102.568	102.516	Urban	-0.052
UR063	615997.493	3548194.429	169.516	169.513	Urban	-0.003
UR064	637963.697	3557906.946	177.549	177.488	Urban	-0.061
UR065	650236.963	3576493.035	155.641	155.630	Urban	-0.011
UR066	673039.438	3585647.479	100.728	100.747	Urban	0.019
UR067	673132.522	3562890.367	74.787	74.759	Urban	-0.028
UR068	662397.648	3571714.662	97.524	97.451	Urban	-0.073
UR070	625276.318	3577798.419	91.569	91.602	Urban	0.033
UR076	612597.307	3614164.887	194.727	194.745	Urban	0.018
UR087	573149.582	3601971.279	56.617	56.735	Urban	0.118
UR088	600542.729	3603180.857	145.554	145.617	Urban	0.063

UR089	584498.525	3616532.838	192.374	192.355	Urban	-0.019
UR090	558166.797	3597134.365	96.939	96.979	Urban	0.040
UR107	548643.295	3609292.323	185.119	185.153	Urban	0.034
UR108	517395.619	3601749.452	77.280	77.328	Urban	0.048
UR109	537643.356	3604165.415	120.363	120.445	Urban	0.082
UR110	546596.777	3588315.640	57.815	57.807	Urban	-0.008
UT071	624639.084	3591005.187	97.281	97.265	Urban	-0.016

Table 13: Bare-Earth Lidar NVA Assessment

Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (DEM)						
PointID	**Easting**	**Northing**	**KnownZ**	**DEMZ**	**Description**	**DeltaZ**
BE008	612745.944	3605609.533	160.375	160.303	Bare Earth/Open Terrain	0.072
BE012	626244.360	3571203.199	102.927	102.922	Bare Earth/Open Terrain	0.005
BE013	638767.037	3585503.812	117.999	118.032	Bare Earth/Open Terrain	-0.033
BE014	627173.069	3598518.884	121.441	121.506	Bare Earth/Open Terrain	-0.065
BE015	670032.670	3566136.929	98.943	98.963	Bare Earth/Open Terrain	-0.020
BE016	678268.153	3582074.050	87.422	87.479	Bare Earth/Open Terrain	-0.057
BE017	656907.758	3586678.231	114.516	114.557	Bare Earth/Open Terrain	-0.041
BE018	680994.259	3572186.332	113.501	113.530	Bare Earth/Open Terrain	-0.029
BE019	626250.183	3558932.191	167.984	167.889	Bare Earth/Open Terrain	0.095
BE020	626503.165	3550471.020	160.114	160.114	Bare Earth/Open Terrain	0.000
BE080	563875.982	3619481.494	138.743	138.813	Bare Earth/Open Terrain	-0.070
BE081	590836.438	3609953.631	163.652	163.607	Bare Earth/Open Terrain	0.045
BE082	582545.268	3596005.822	151.855	151.811	Bare Earth/Open Terrain	0.044
BE101	600736.036	3556391.879	100.637	100.633	Bare Earth/Open Terrain	0.004
BE102	518799.211	3591920.454	105.542	105.583	Bare Earth/Open Terrain	-0.041
BE103	542252.371	3594916.798	75.183	75.193	Bare Earth/Open Terrain	-0.010
BE301	621198.096	3592352.271	95.842	95.833	Bare Earth/Open Terrain	0.009
BE317	547832.426	3613445.052	121.243	121.340	Bare Earth/Open Terrain	-0.097
OT010	618580.206	3618467.124	215.713	215.809	Bare Earth/Open Terrain	-0.096
OT011	614905.593	3583034.734	88.818	88.840	Bare Earth/Open Terrain	-0.022
OT012	634223.193	3579876.354	123.855	123.910	Bare Earth/Open Terrain	-0.055
OT013	616451.244	3597185.173	90.951	91.012	Bare Earth/Open Terrain	-0.061
OT014	613438.185	3571084.078	88.443	88.557	Bare Earth/Open Terrain	-0.114
OT015	654209.064	3565313.470	100.302	100.377	Bare Earth/Open Terrain	-0.075
OT016	677426.215	3561053.049	72.281	72.288	Bare Earth/Open Terrain	-0.007
OT017	665790.054	3579374.012	150.436	150.481	Bare Earth/Open Terrain	-0.045
OT018	612326.543	3559648.749	90.617	90.619	Bare Earth/Open Terrain	-0.002
OT019	632339.634	3550659.735	159.182	159.162	Bare Earth/Open Terrain	0.020
OT021	605161.501	3552658.055	110.014	109.984	Bare Earth/Open Terrain	0.030
OT083	579286.355	3616235.463	161.529	161.534	Bare Earth/Open Terrain	-0.005
OT085	584677.505	3605796.010	109.655	109.658	Bare Earth/Open Terrain	-0.003
OT086	595000.079	3598802.754	144.390	144.473	Bare Earth/Open Terrain	-0.083

OT104	522199.572	3612160.552	148.676	148.677	Bare Earth/Open Terrain	-0.001
OT105	528095.537	3598089.986	76.342	76.354	Bare Earth/Open Terrain	-0.012
OT106	536343.744	3588831.037	47.849	47.925	Bare Earth/Open Terrain	-0.076
UR062	598584.434	3561022.116	102.568	102.489	Urban	0.079
UR064	637963.697	3557906.946	177.549	177.477	Urban	0.072
UR065	650236.963	3576493.035	155.641	155.627	Urban	0.014
UR066	673039.438	3585647.479	100.728	100.745	Urban	-0.017
UR067	673132.522	3562890.367	74.787	74.774	Urban	0.013
UR068	662397.648	3571714.662	97.524	97.458	Urban	0.066
UR070	625276.318	3577798.419	91.569	91.590	Urban	-0.021
UR076	612597.307	3614164.887	194.727	194.739	Urban	-0.012
UR087	573149.582	3601971.279	56.617	56.724	Urban	-0.107
UR088	600542.729	3603180.857	145.554	145.593	Urban	-0.039
UR089	584498.525	3616532.838	192.374	192.337	Urban	0.037
UR090	558166.797	3597134.365	96.939	96.938	Urban	0.001
UR107	548643.295	3609292.323	185.119	185.158	Urban	-0.039
UR108	517395.619	3601749.452	77.280	77.326	Urban	-0.046
UR109	537643.356	3604165.415	120.363	120.451	Urban	-0.088
UR110	546596.777	3588315.640	57.815	57.804	Urban	0.011
UT071	624639.084	3591005.187	97.281	97.283	Urban	-0.002

Table 14: Bare=Earth DEM NVA Assessment

Vegetated Vertical Accuracy (VVA) Check Point Assessment (Bare Earth)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
BR007	609045.422	3609639.460	174.452	174.600	Brush	0.148
BR010	629745.195	3575243.376	104.787	104.929	Brush	0.142
BR011	660324.343	3563361.081	87.837	87.995	Brush	0.158
BR012	673347.946	3574532.410	99.947	100.131	Brush	0.184
BR013	664559.146	3585822.271	108.852	108.905	Brush	0.053
BR014	614161.070	3558008.376	102.530	102.651	Brush	0.121
BR015	640086.437	3551805.851	150.318	150.391	Brush	0.073
BR017	656485.635	3550727.760	116.251	116.345	Brush	0.094
BR095	583300.316	3610635.010	138.167	138.213	Brush	0.046
BR096	575705.381	3597898.318	92.305	92.410	Brush	0.105
BR114	547816.974	3613446.714	120.898	120.871	Brush	-0.027
BR115	519188.946	3604896.554	93.142	93.274	Brush	0.132
HG051	603776.488	3549112.877	183.121	183.194	High Grass	0.073
HG052	621163.428	3559092.666	116.599	116.646	High Grass	0.047
HG053	600293.819	3567396.171	76.980	77.126	High Grass	0.146
HG054	661496.218	3575747.954	131.796	131.864	High Grass	0.068
HG055	678129.195	3569896.972	99.410	99.496	High Grass	0.086
HG056	671680.812	3588407.778	123.642	123.692	High Grass	0.050
HG057	621241.432	3598763.143	120.621	120.758	High Grass	0.137

HG058	630915.687	3592553.025	150.040	150.059	High Grass	0.019
HG059	608318.027	3578425.292	73.732	73.903	High Grass	0.171
HG060	622999.738	3624848.784	220.069	220.058	High Grass	-0.011
HG094	573973.253	3619858.404	168.498	168.525	High Grass	0.027
HG095	597355.904	3609533.483	173.129	173.215	High Grass	0.086
HG111	522840.694	3609049.022	120.739	120.911	High Grass	0.172
HG112	530058.826	3588703.819	95.175	95.264	High Grass	0.089
HG113	537412.245	3595066.736	147.810	147.959	High Grass	0.149
HG302	627173.224	3598546.543	121.917	122.008	High Grass	0.091
HG303	613462.945	3571075.626	89.399	89.579	High Grass	0.180
TR051	600735.111	3556409.169	100.994	101.011	Trees	0.017
TR052	620874.089	3548481.543	158.887	158.967	Trees	0.080

Table 15: Bare-Earth Lidar VVA Assessment

Section 4: Certification

4.1 Limitations of Use

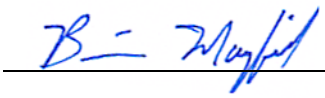
The accuracy assessment confirms that the data may be used for the intended applications stated in the **Project Purpose** section of this document. The dataset may also be used as a topographic input for other applications but the user should be aware that this lidar dataset was designed with a specific purpose and was not intended to meet specifications and/or requirements of users outside of the U.S. Geological Survey.

It should also be noted that lidar points do not represent a continuous surface model. Lidar points are discrete measurements of the surface and any values derived within a triangle of three lidar points are interpolated. As such, the user should not use the resultant lidar dataset for vertical placement of a planimetric feature such as a headwall, building footprint or any other planimetric feature unless there is an associated lidar point that can be reasonably located on this structure.

Consideration should be given by the end user of this dataset to the fact that this lidar dataset was developed differently and that previous lidar datasets that may be available for this geographic location. It is likely that the data in this project was created using different geodetic control, a different Geoid, newer lidar technology and more up-to-date processing techniques. As such, any direct comparative analysis performed between this dataset and previous datasets could result in misleading or inaccurate results. Users are encouraged to proceed with caution while performing this type of comparative analysis and to completely understand the variables that make each of these datasets unique and not corollary.

It is encouraged that the user refers to the full FGDC Metadata and project reports for a complete understanding on the content of this dataset.

I, hereby, certify to the extent of my knowledge that the statements and statistics represented in this document are true and factual.



Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276

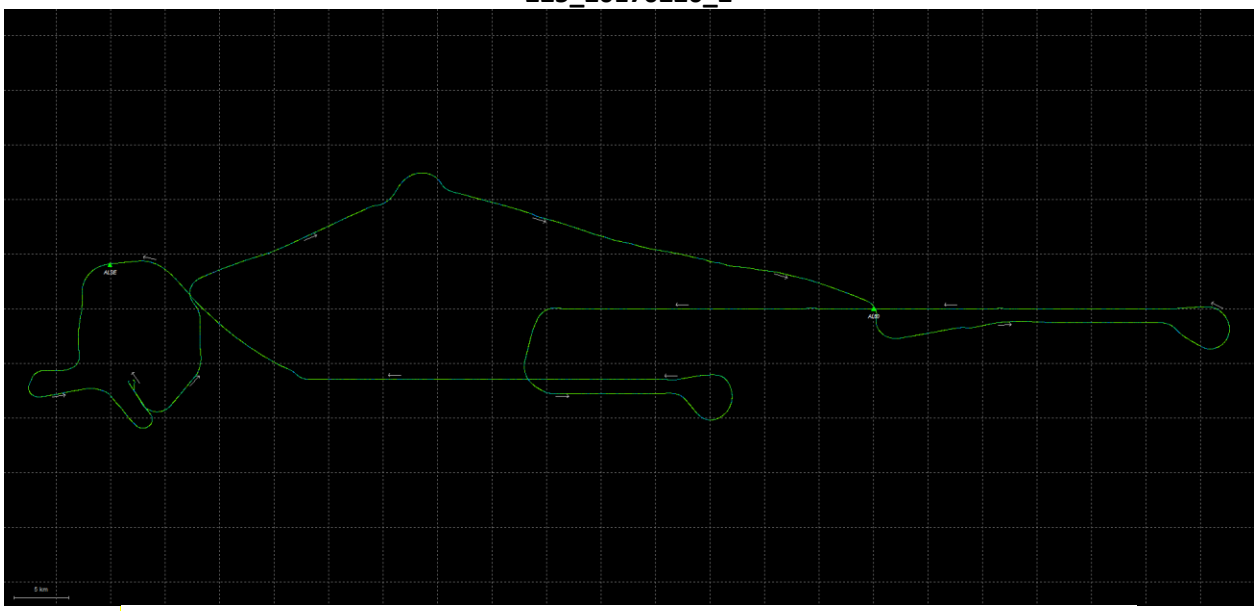
Section 5: **GNSS Processing**

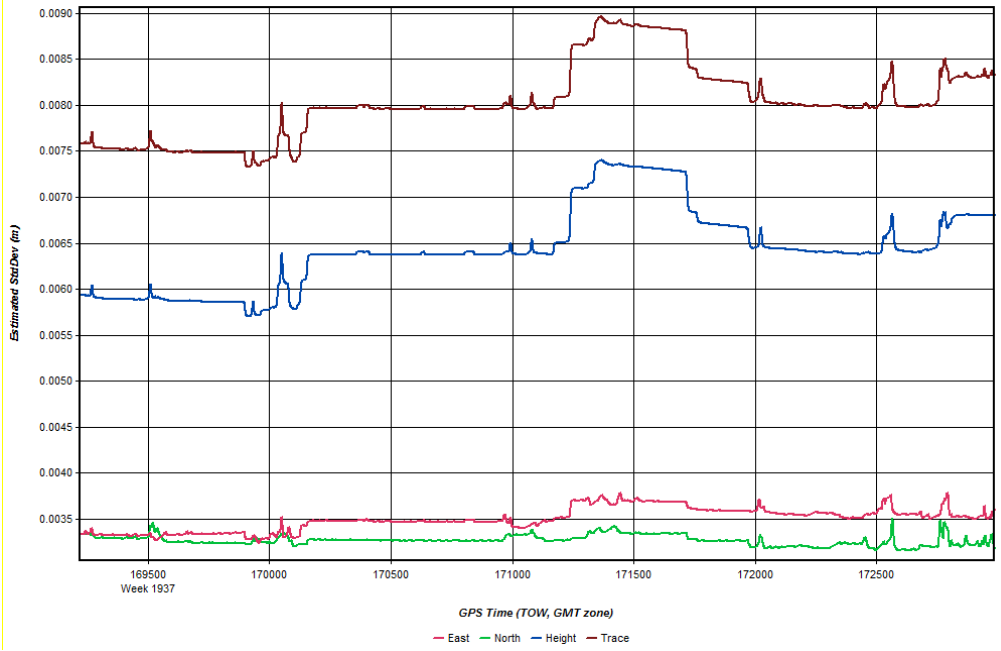
Inertial Explorer version 8.60.6717

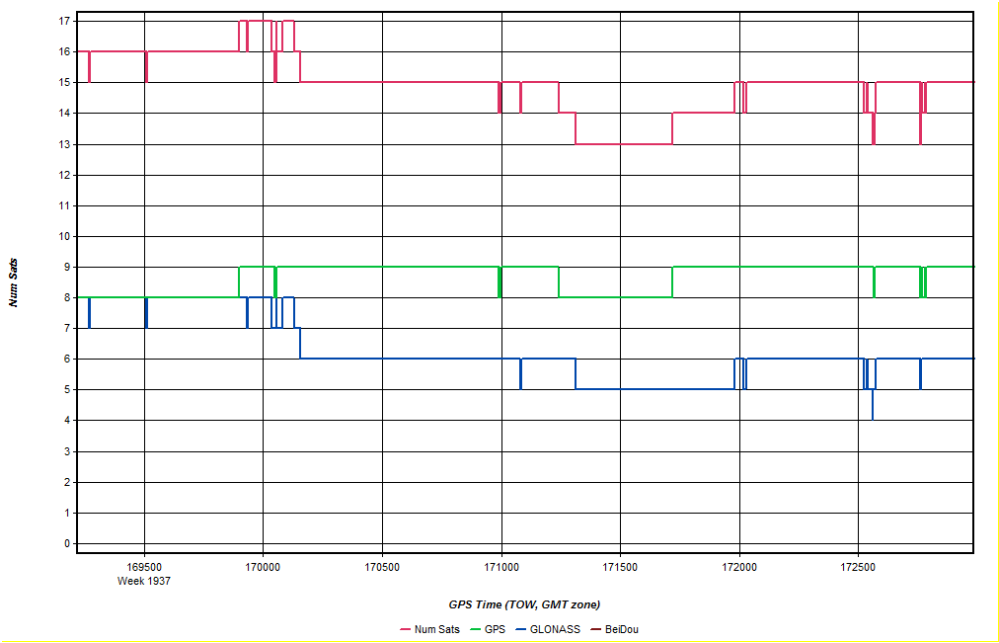
Plots by Mission: Coverage Map, Estimated Position Accuracy, Number of Satellites, Combined Separation, and PDOP.

Coverage Map	The Coverage Map plot shows the Aircraft GNSS-IMU Trajectory in reference to localized GNSS Reference Stations.
Estimated Position Accuracy	The Estimated Position Accuracy plot shows the standard deviations of the east, north, and up directions versus time for the solution. The total standard deviation with a distance dependent component is also plotted.
Number of Satellites	Plots the number of satellites used in the solution as a function of time. The number of GPS satellites, GLONASS satellites, and the total number of satellites are distinguished with separate lines.
Combined Separation	Plots the north, east, and height position difference between any two solutions loaded into the project. This is most often the forward and reverse processing results, unless other solutions have been loaded from the Combine Solutions dialog. Plotting the difference between forward and reverse solutions can be very helpful in quality checking. When processing both directions, no information is shared between forward and reverse processing. Thus both directions are processed independently of each other. When forward and reverse solutions agree closely, it helps provide confidence in the solution. To a lesser extent, this plot can also help gauge solution accuracy.
PDOP	PDOP is a unit less number which indicates how favorable the satellite geometry is to 3D positioning accuracy. A strong satellite geometry, where the PDOP is low, occurs when satellites are well distributed in each direction (north, south, east and west) as well as directly overhead. Values in the range of 1-2 indicate very good satellite geometry, 2-3 are adequate in the sense that they do not generally, by themselves, limit positioning accuracy. Values between 3 and 4 are considered marginal, and values approaching or exceeding 5 can be considered poor. PDOP spikes can occur on aircraft turns were the antenna angle is unfavorable, these spikes while aesthetically unfavorable do not generally reduce the accuracy of the acquired data.

225_20170220_2



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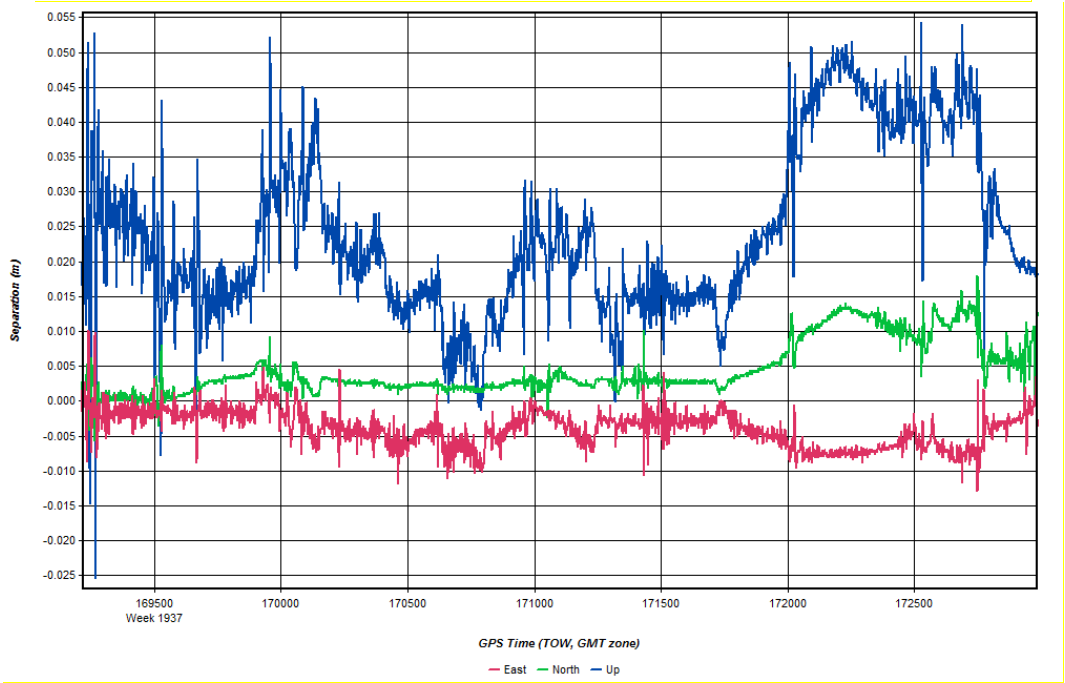
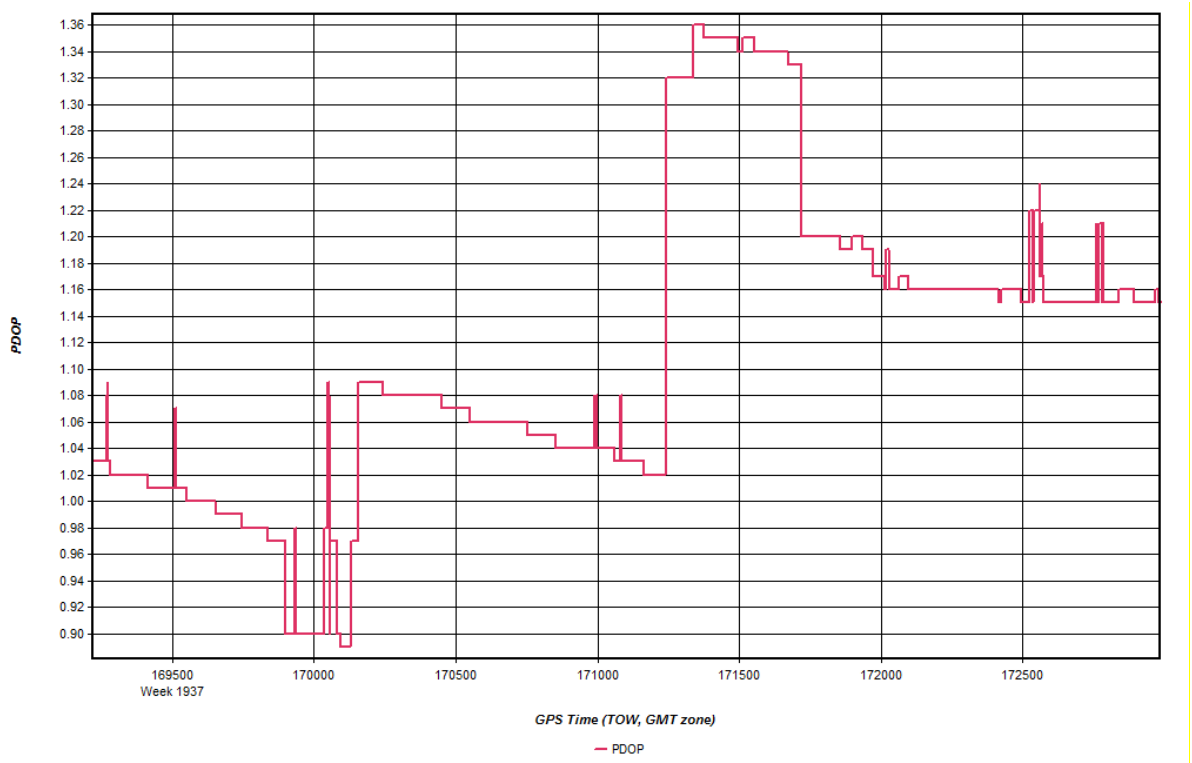
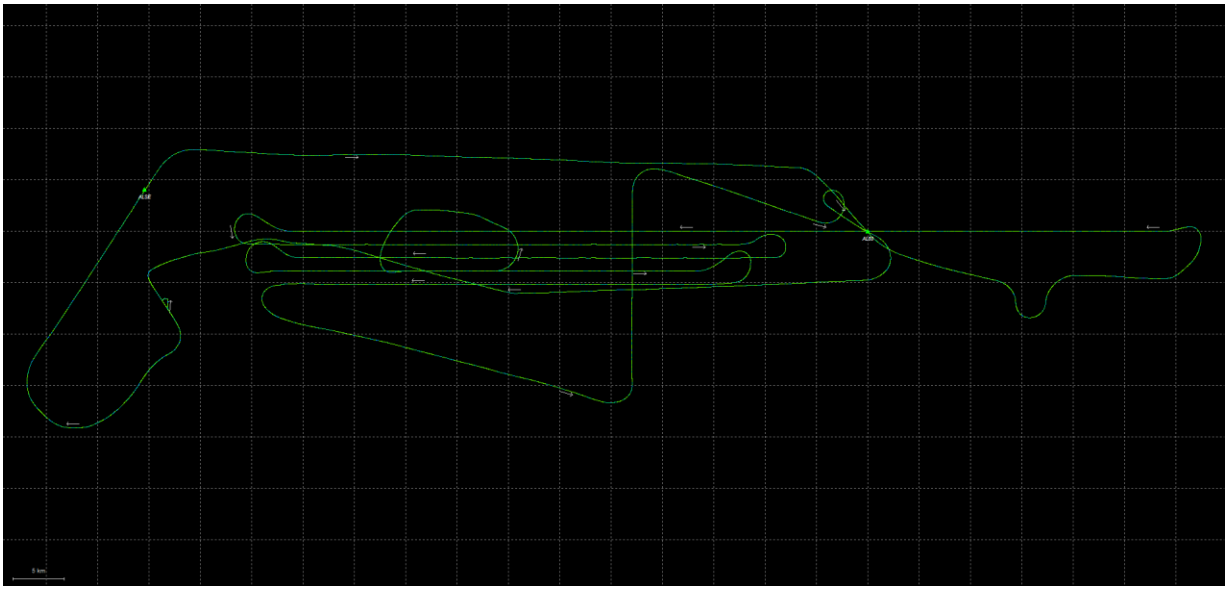
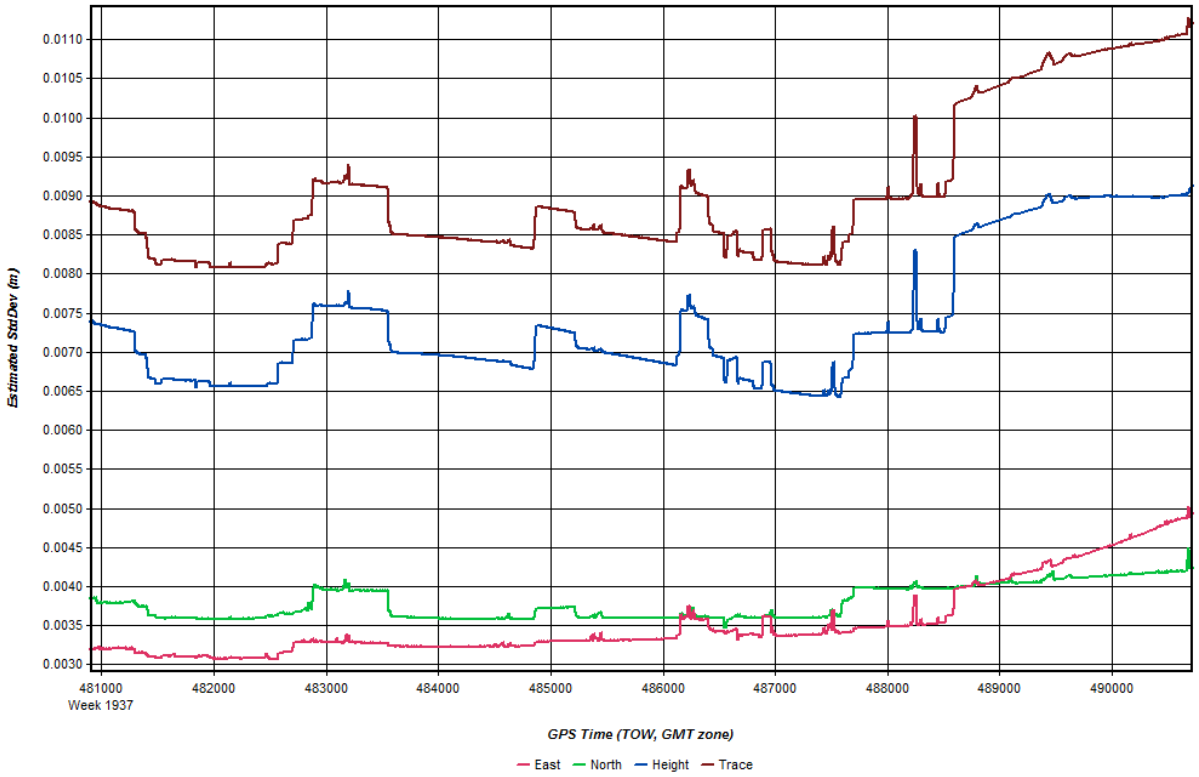
13
12
11
10
9
8
7
6
5
4
3
2
1
0
169500
Week 1937
170000
170500
171000
171500
172000
172500
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

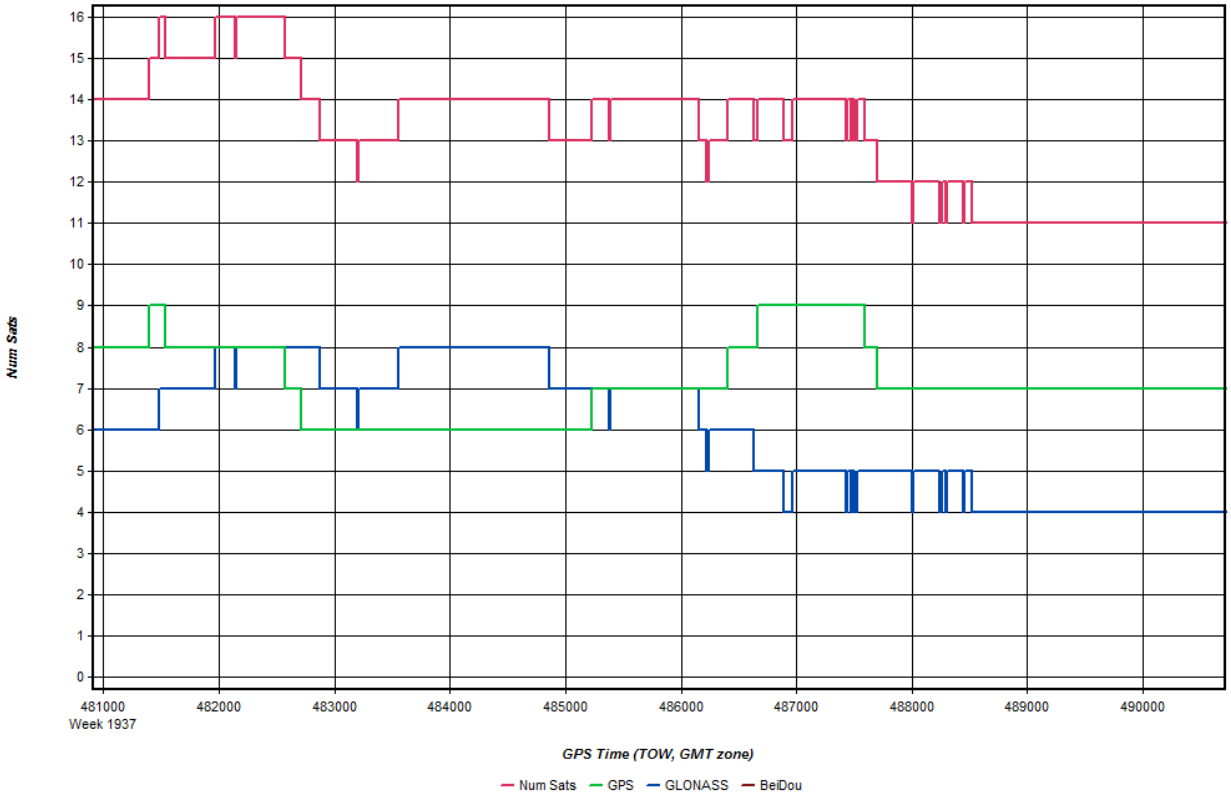

Separation (m)
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
169500
Week 1937
170000
170500
171000
171500
172000
172500
GPS Time (TOW, GMT zone)
East
North
Up

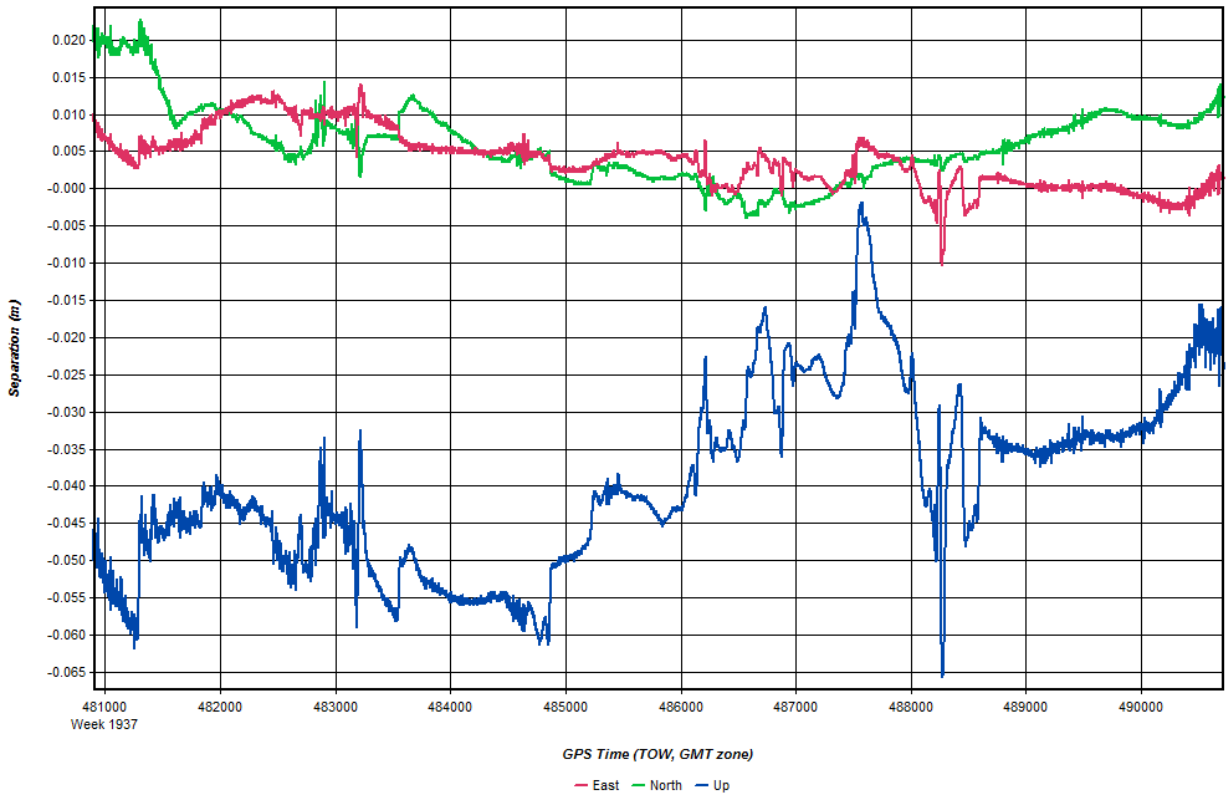


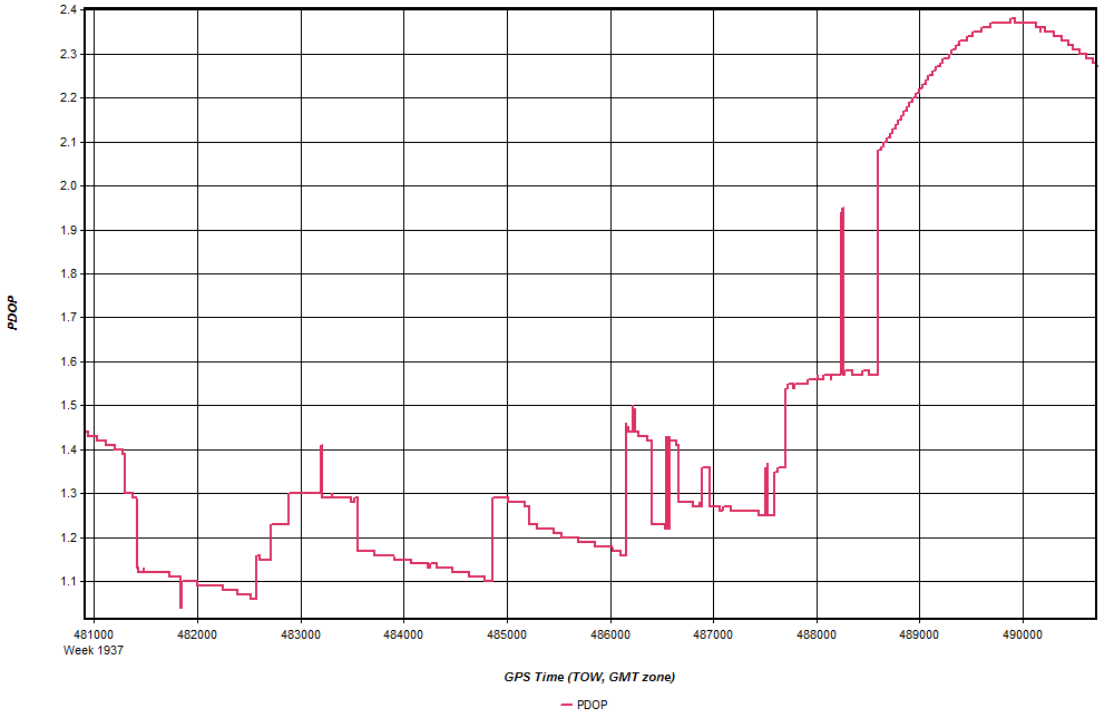
225_20170224_1



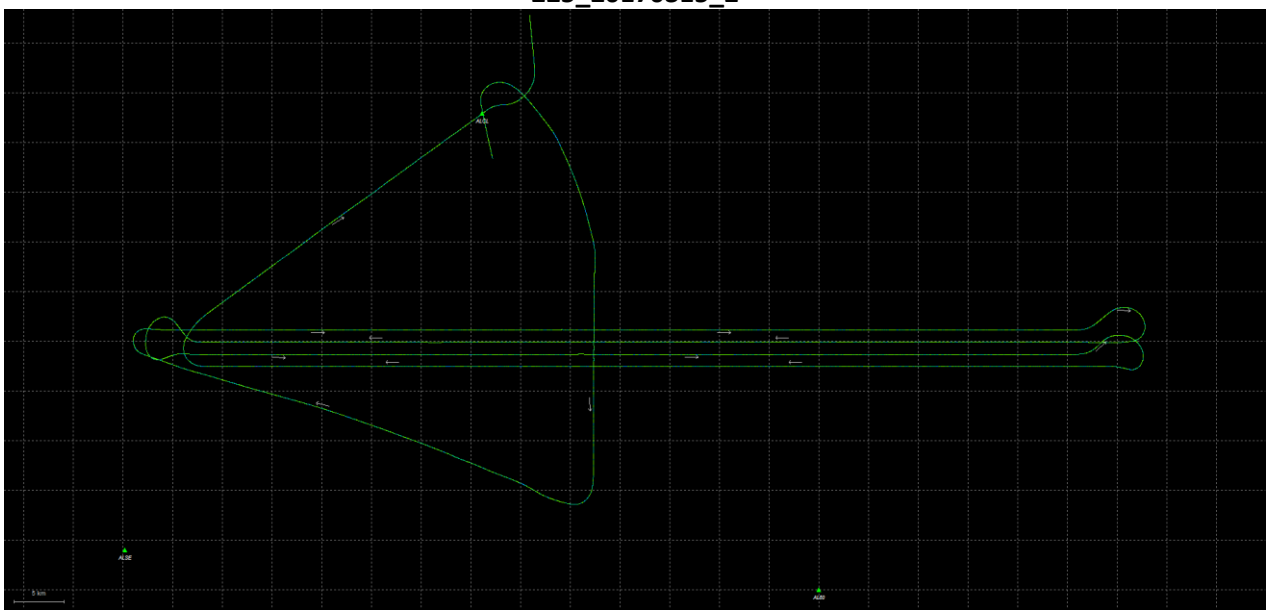

Estimated StdDev (m)
0.0110
0.0105
0.0100
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
0.0035
0.0030
481000
Week 1937
482000
483000
484000
485000
486000
487000
488000
489000
490000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

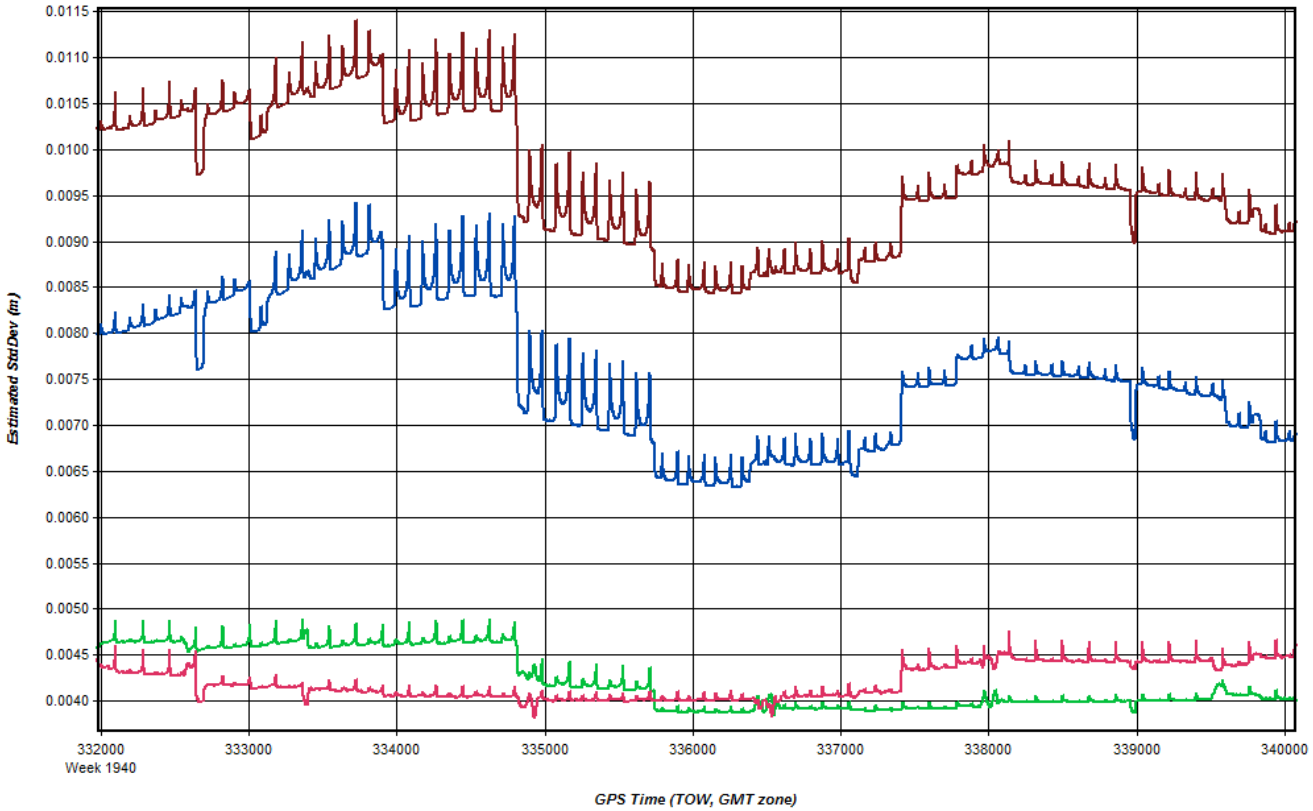

Num Sats
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
481000
Week 1937
482000
483000
484000
485000
486000
487000
488000
489000
490000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

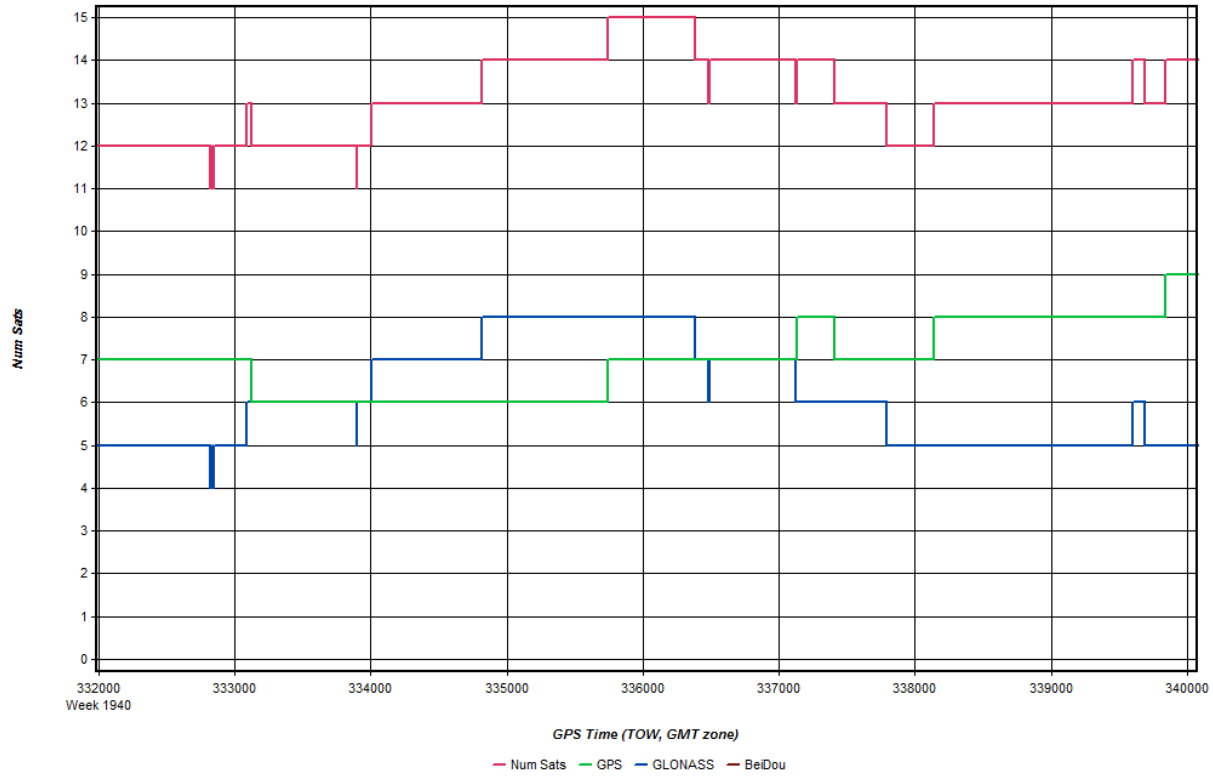

Separation (m)
0.020
0.015
0.010
0.005
-0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
-0.050
-0.055
-0.060
-0.065
481000
Week 1937
482000
483000
484000
485000
486000
487000
488000
489000
490000
GPS Time (TOW, GMT zone)
East
North
Up

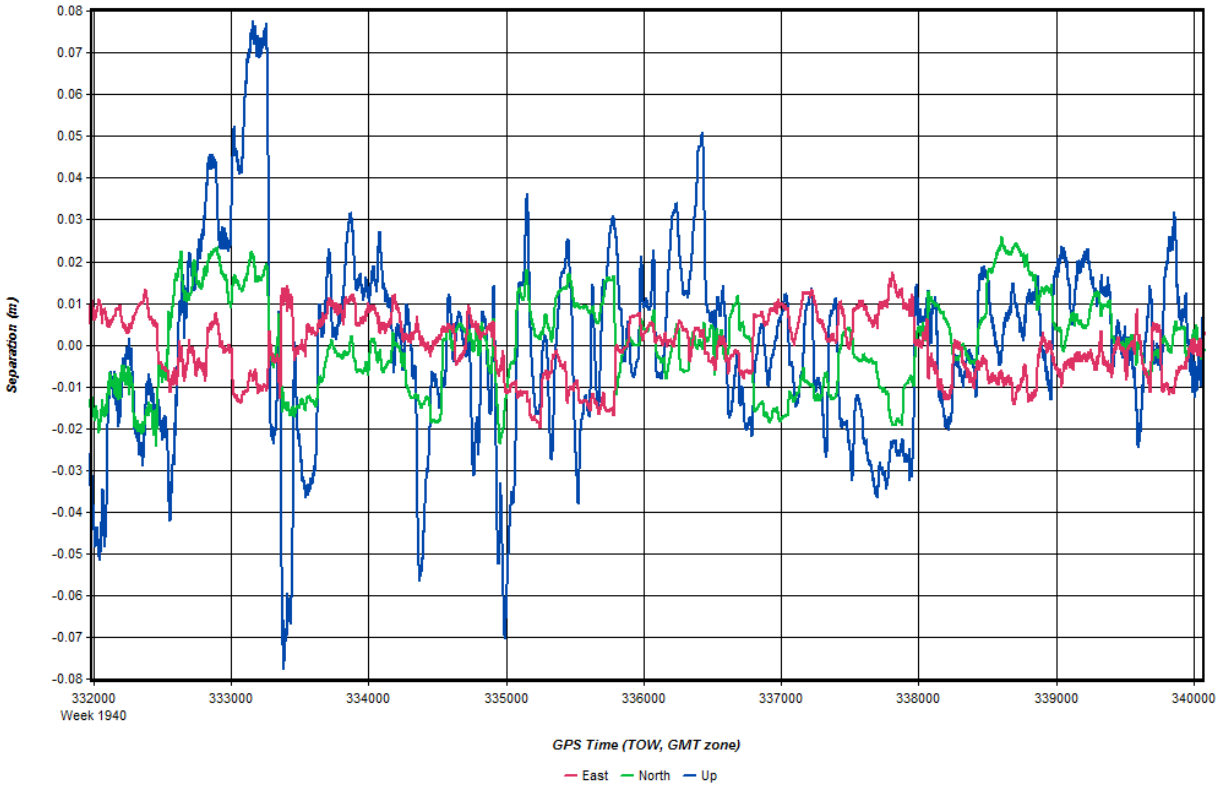


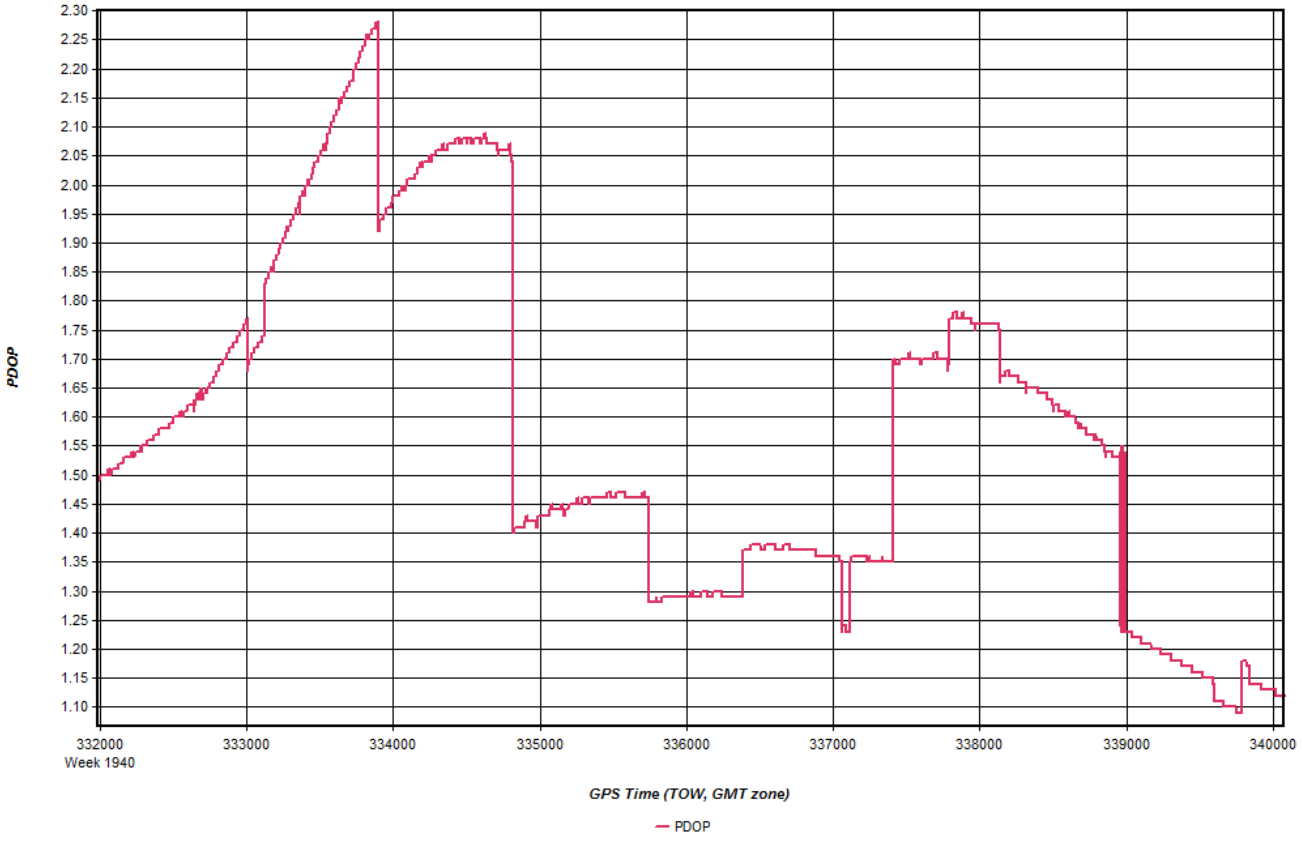
225_20170315_2



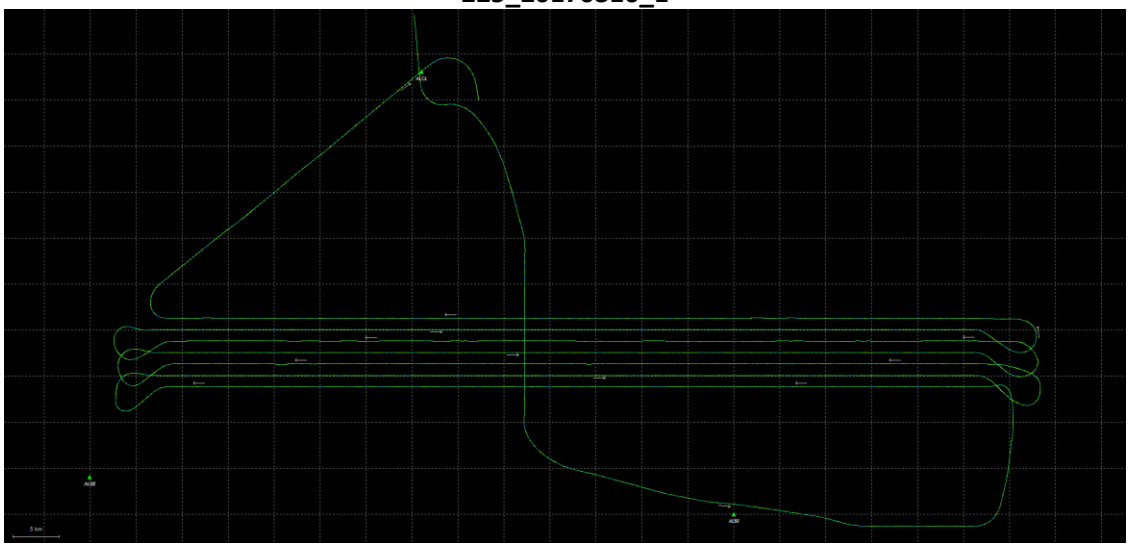

Estimated StdDev (m)
0.0115
0.0110
0.0105
0.0100
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
332000
Week 1940
333000
334000
335000
336000
337000
338000
339000
340000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

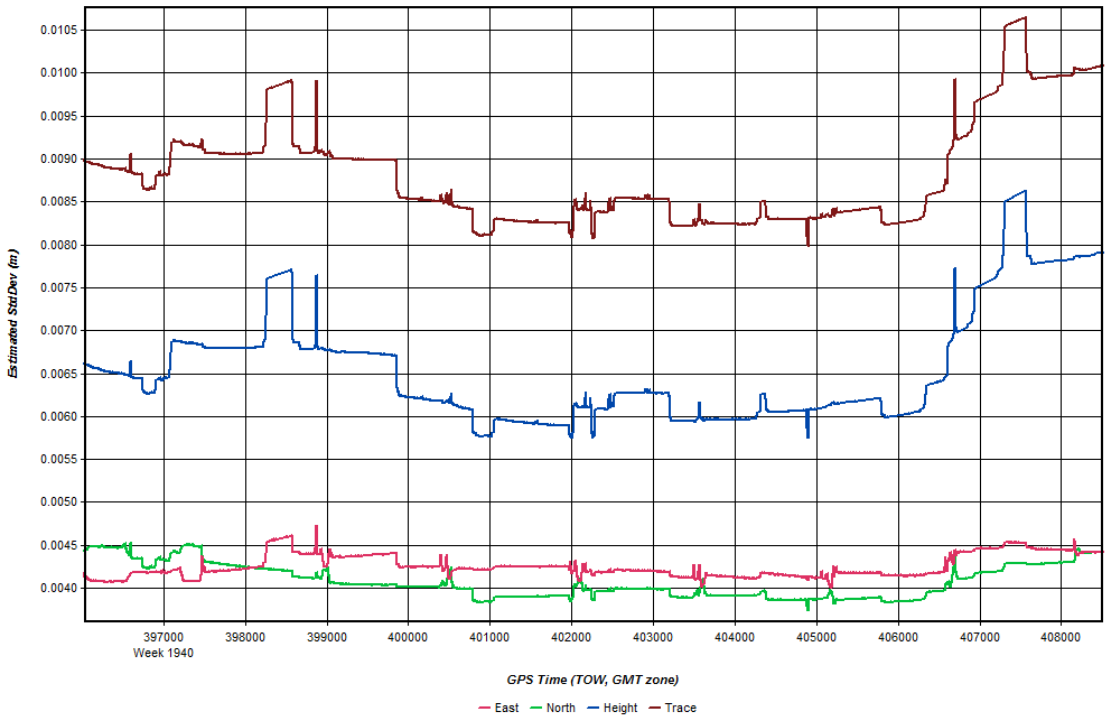

Num Sats
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
332000
Week 1940
333000
334000
335000
336000
337000
338000
339000
340000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

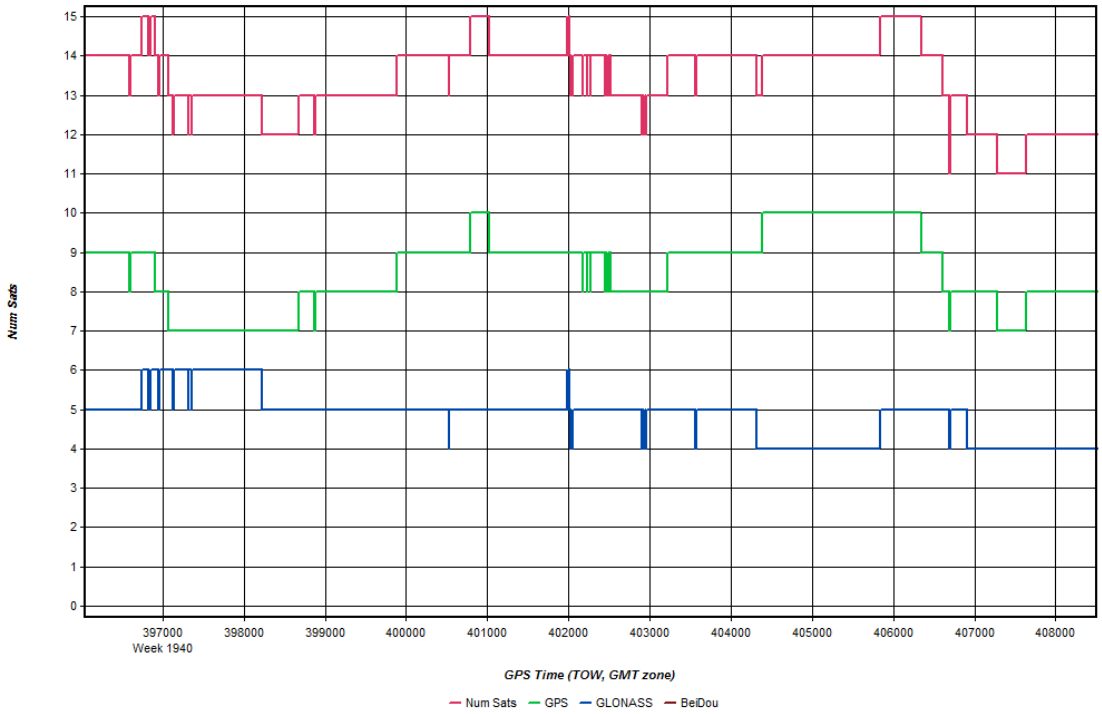

Separation (m)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
332000
Week 1940
333000
334000
335000
336000
337000
338000
339000
340000
GPS Time (TOW, GMT zone)
East
North
Up

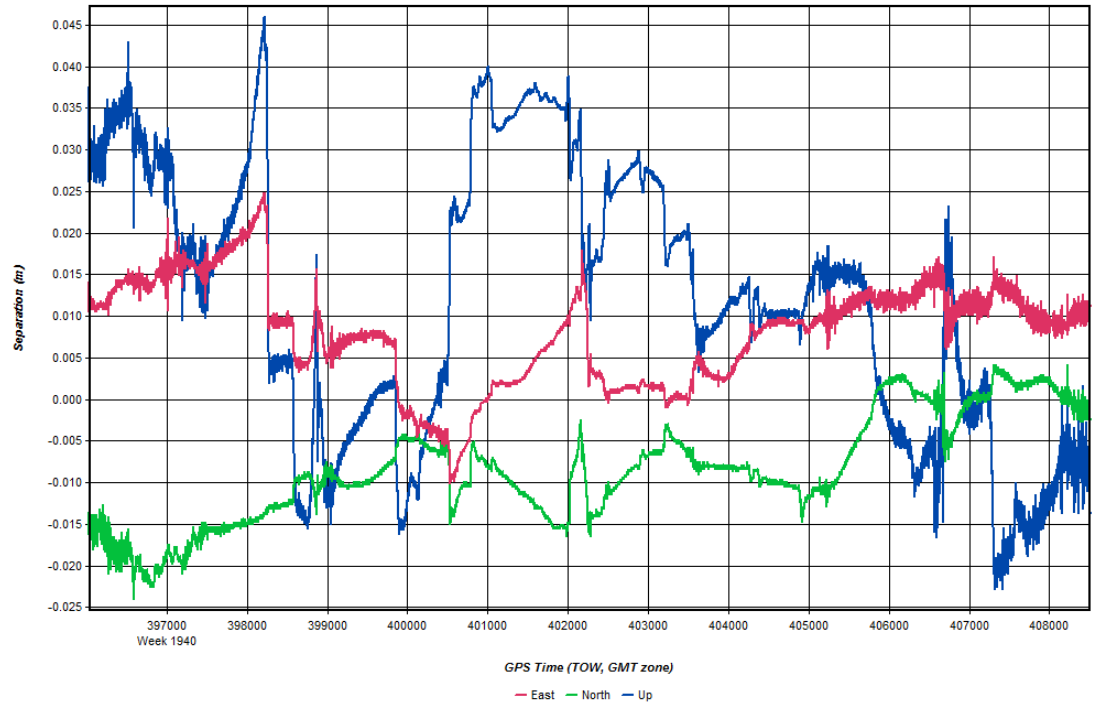

PDOP
2.30
2.25
2.20
2.15
2.10
2.05
2.00
1.95
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
332000
Week 1940
333000
334000
335000
336000
337000
338000
339000
340000
GPS Time (TOW, GMT zone)
PDOP

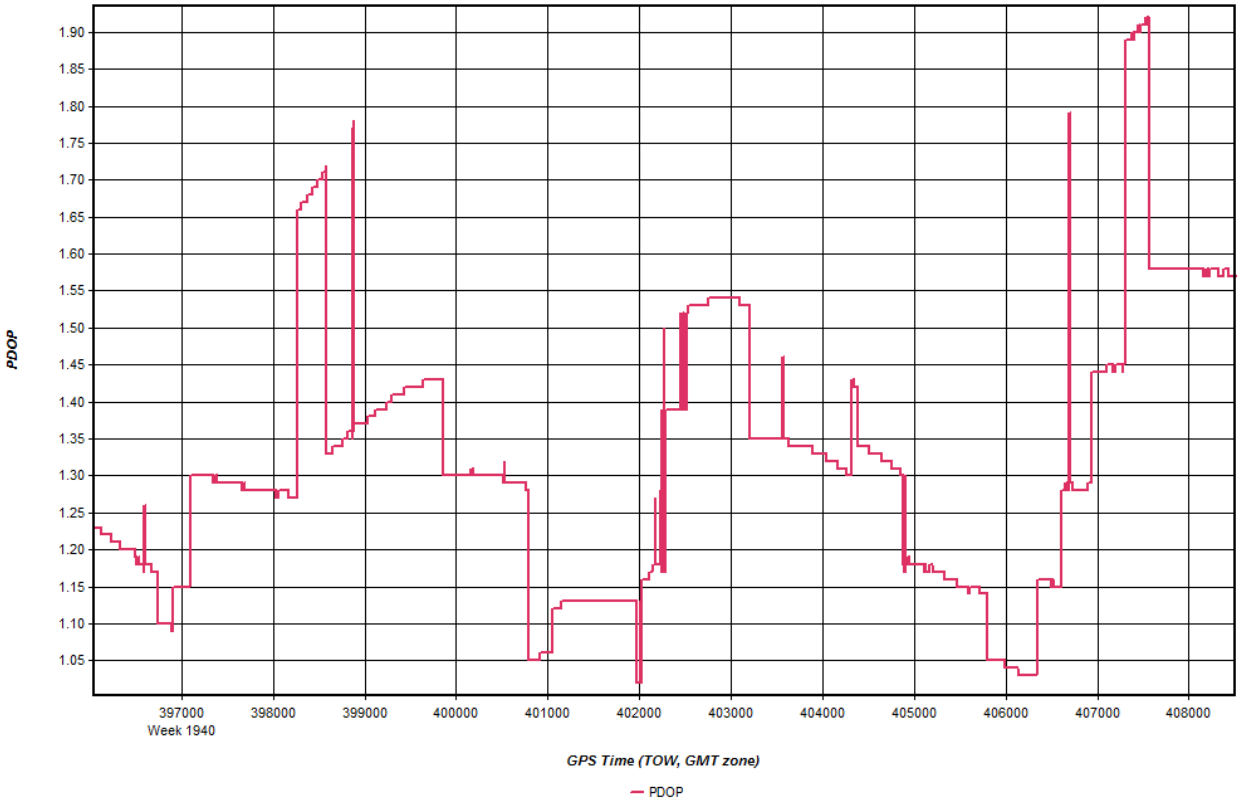
225_20170316_1



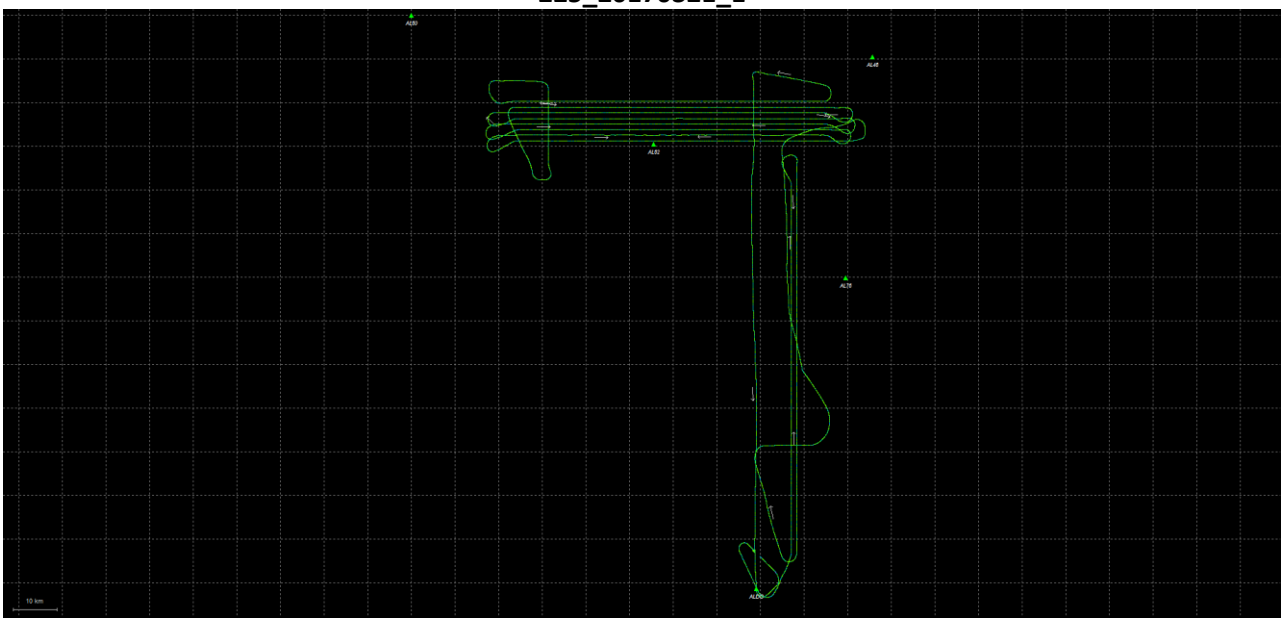


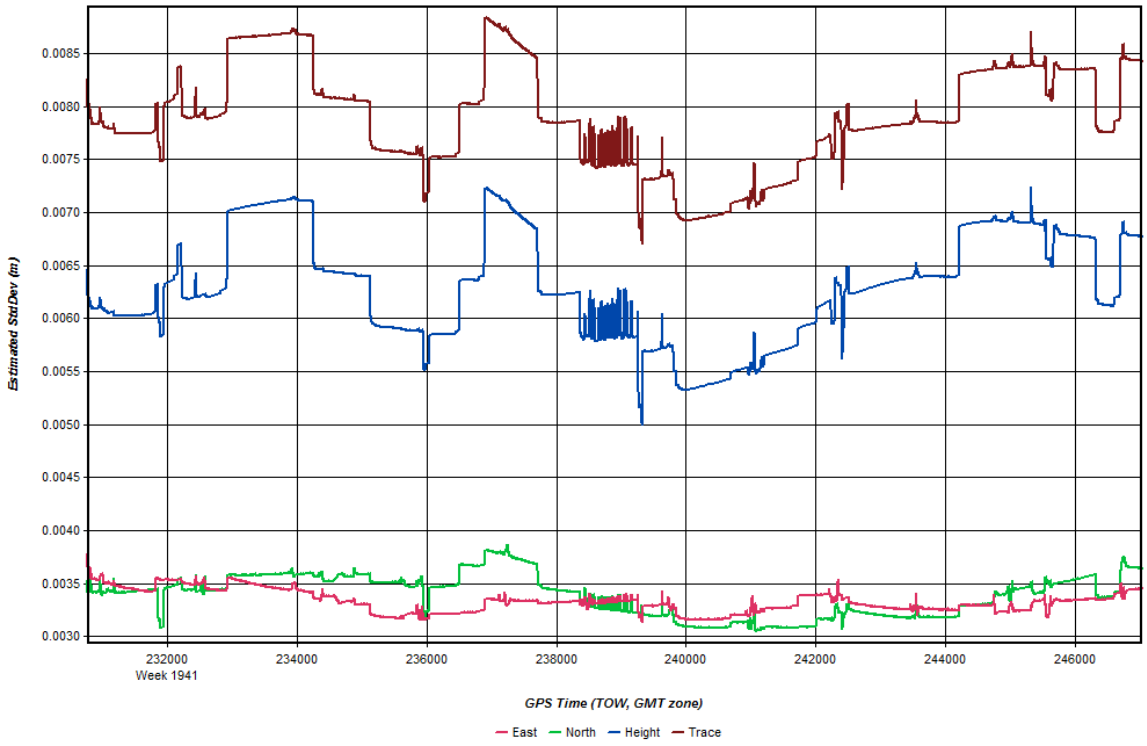

Num Sats
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
397000
Week 1940
398000
399000
400000
401000
402000
403000
404000
405000
406000
407000
408000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

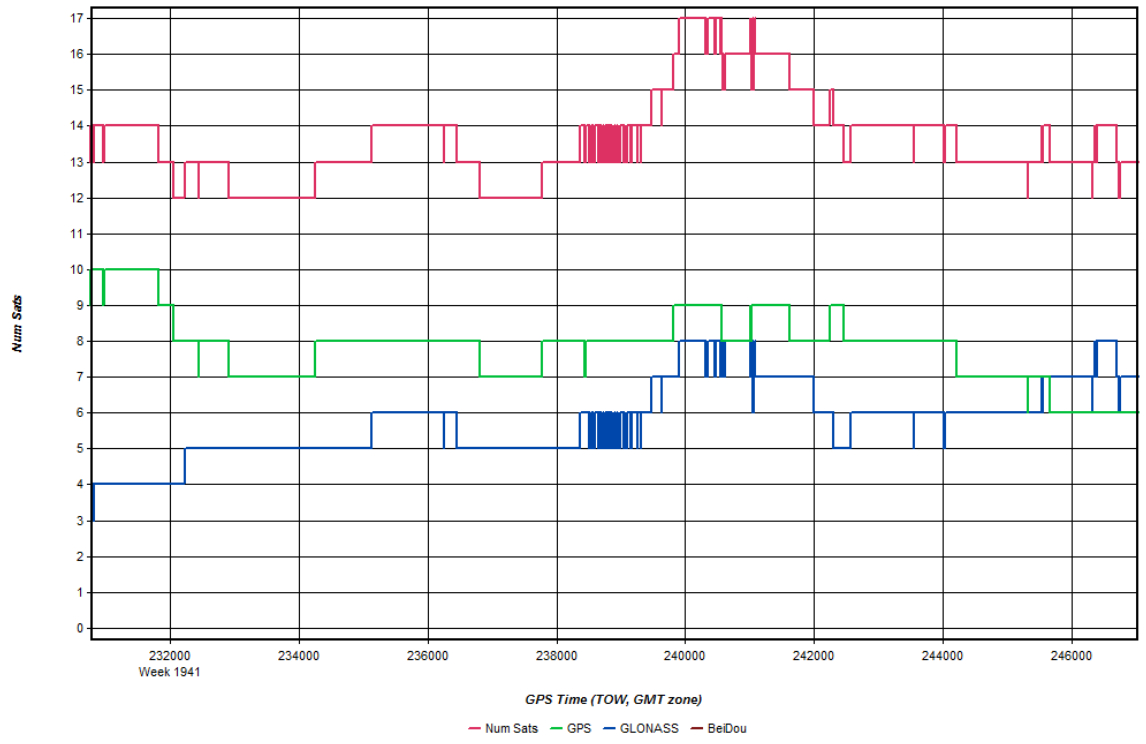

Separation (m)
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
397000
Week 1940
398000
399000
400000
401000
402000
403000
404000
405000
406000
407000
408000
GPS Time (TOW, GMT zone)
East
North
Up

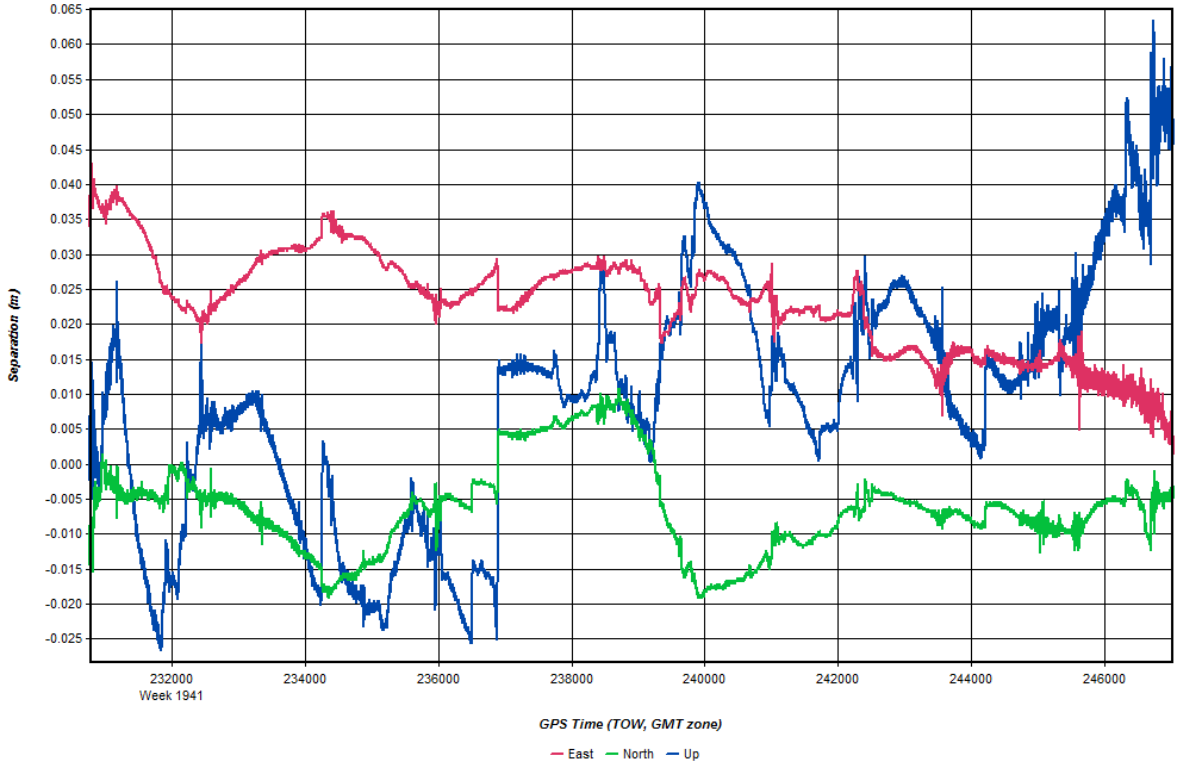


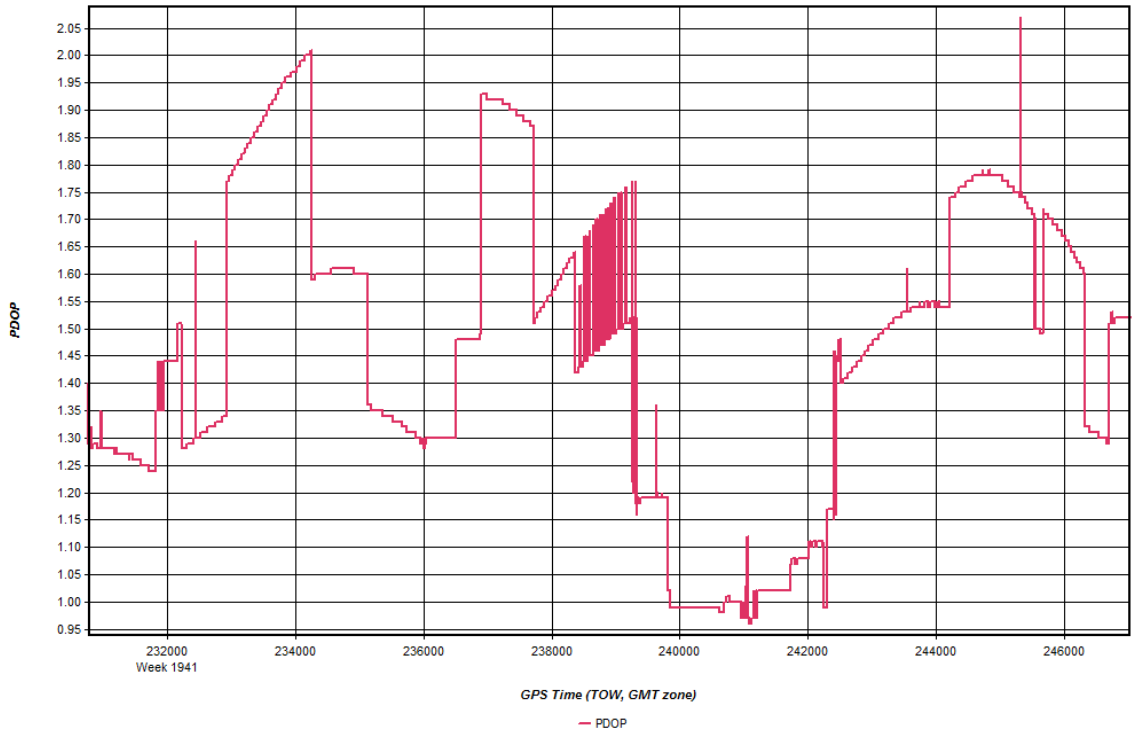
225_20170321_1



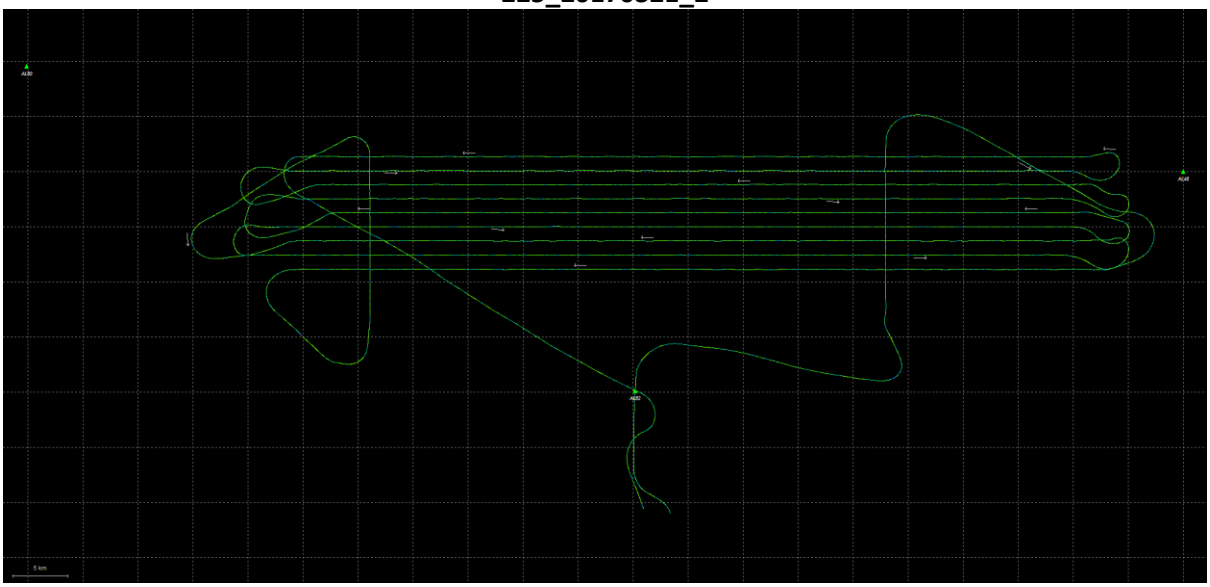

Estimated StdDev (m)
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
0.0035
0.0030
232000
Week 1941
234000
236000
238000
240000
242000
244000
246000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

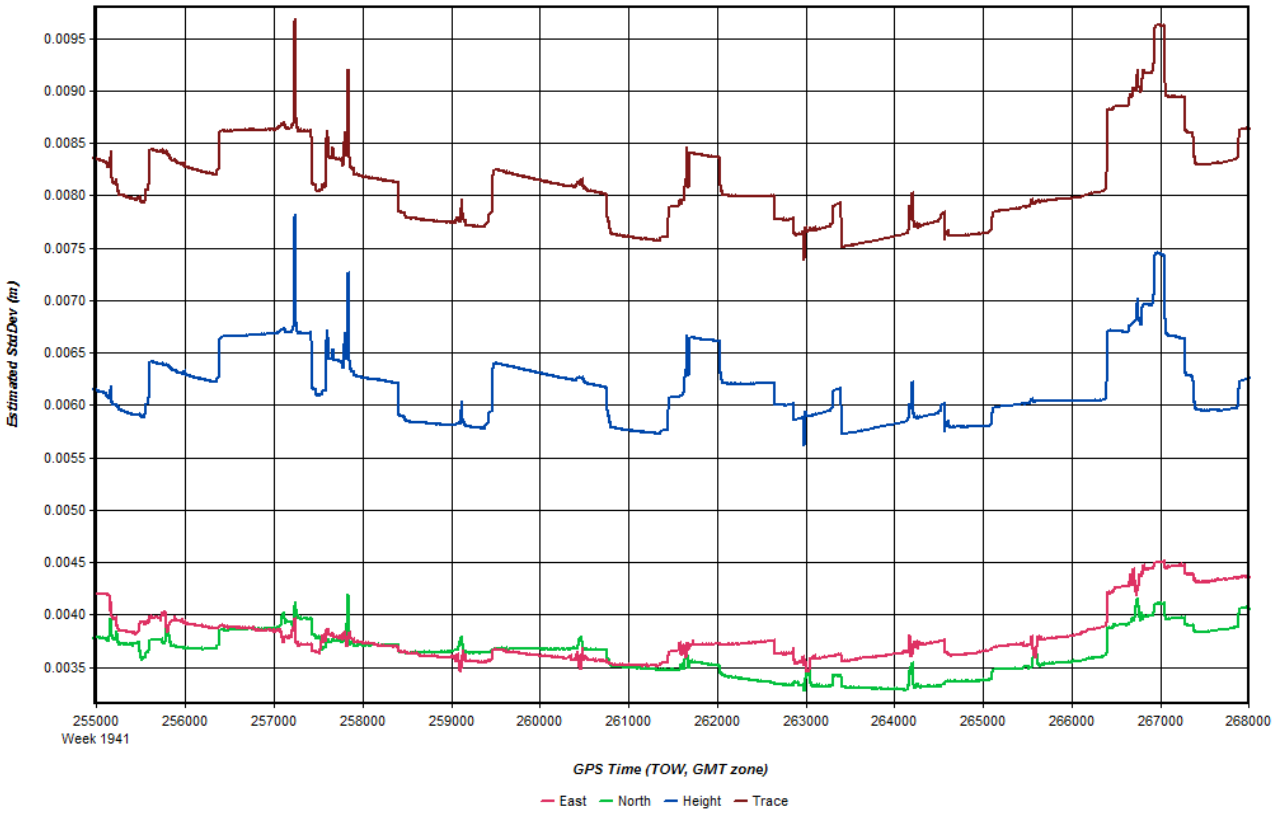

Num Sats
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
232000
Week 1941
234000
236000
238000
240000
242000
244000
246000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

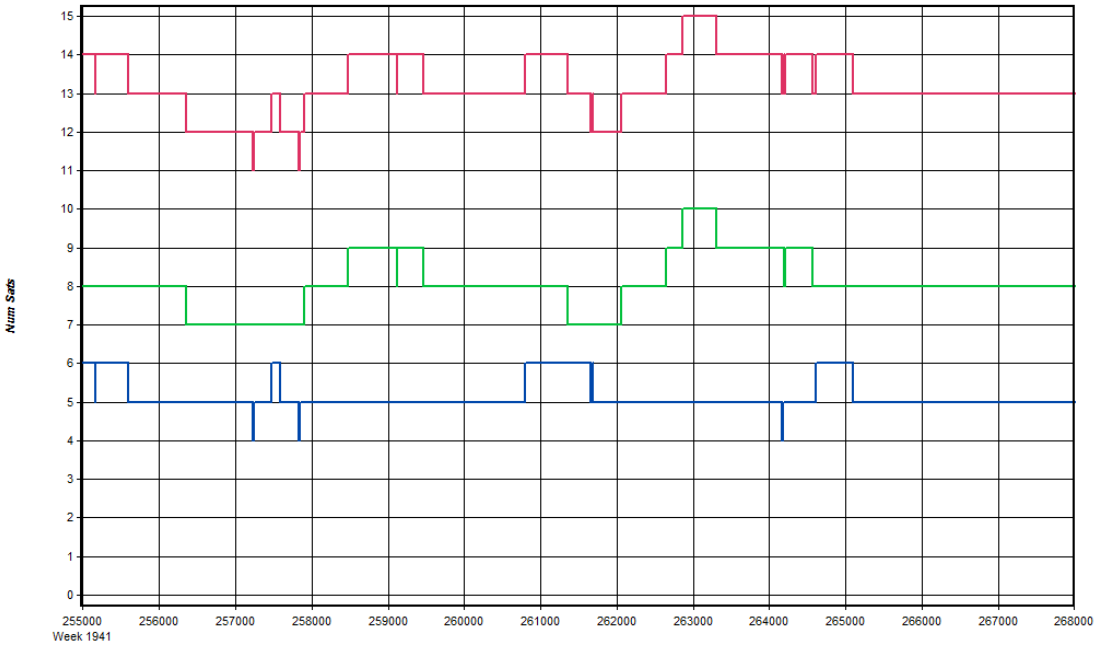

Separation (m)
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
232000
Week 1941
234000
236000
238000
240000
242000
244000
246000
GPS Time (TOW, GMT zone)
East
North
Up

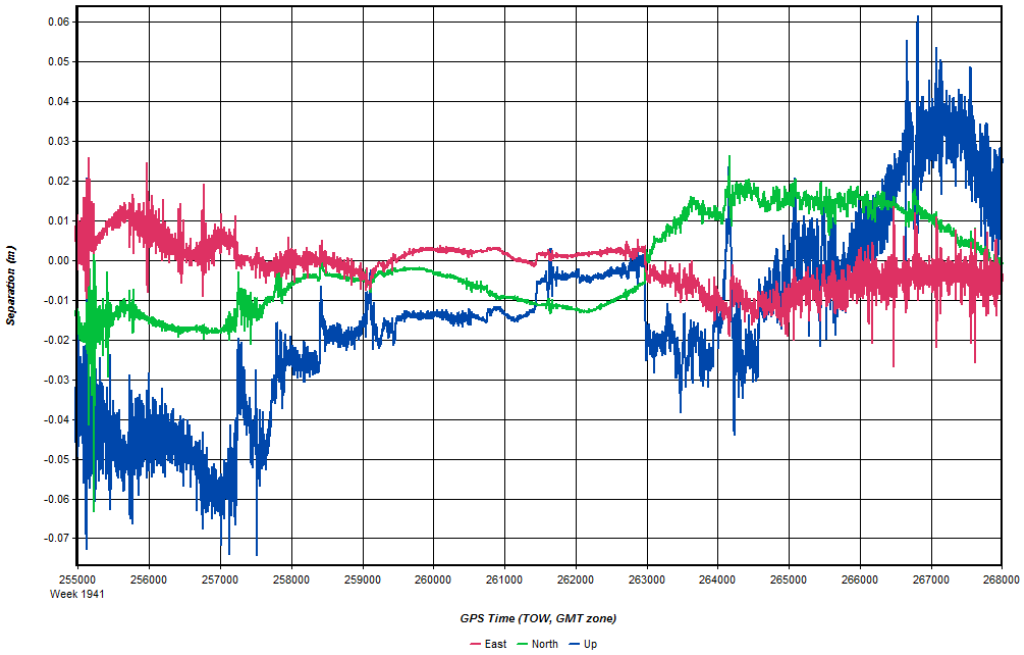

PDOP
2.05
2.00
1.95
1.90
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
232000
Week 1941
234000
236000
238000
240000
242000
244000
246000
GPS Time (TOW, GMT zone)
PDOP

225_20170321_2

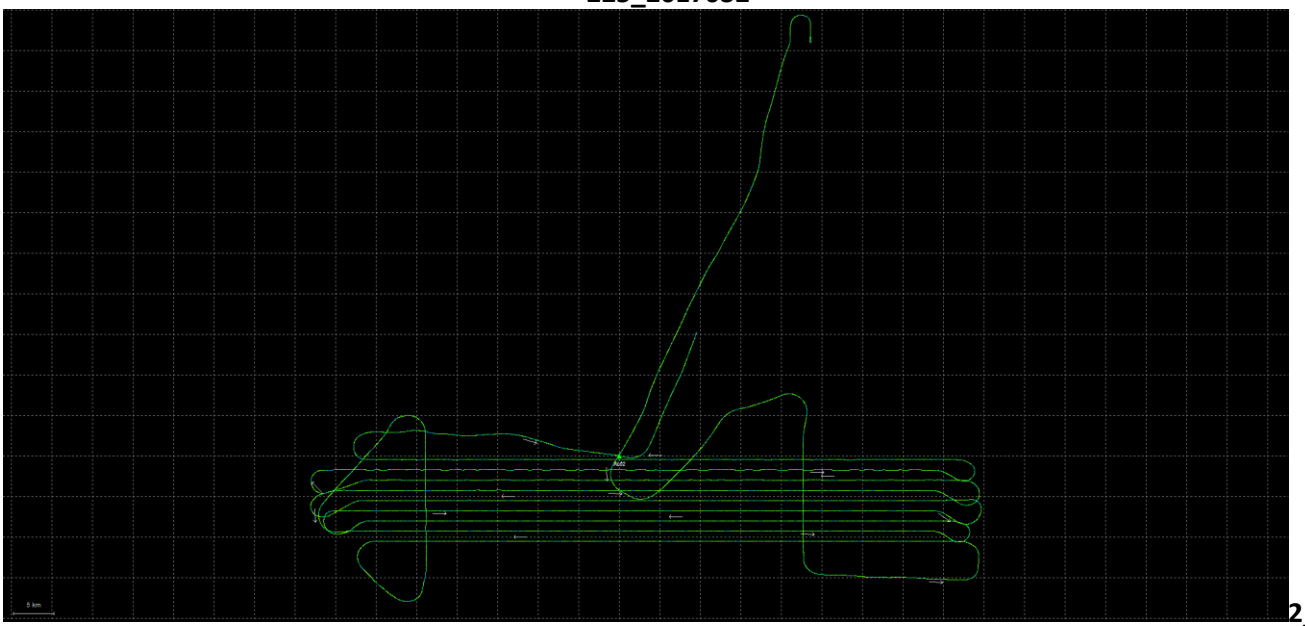




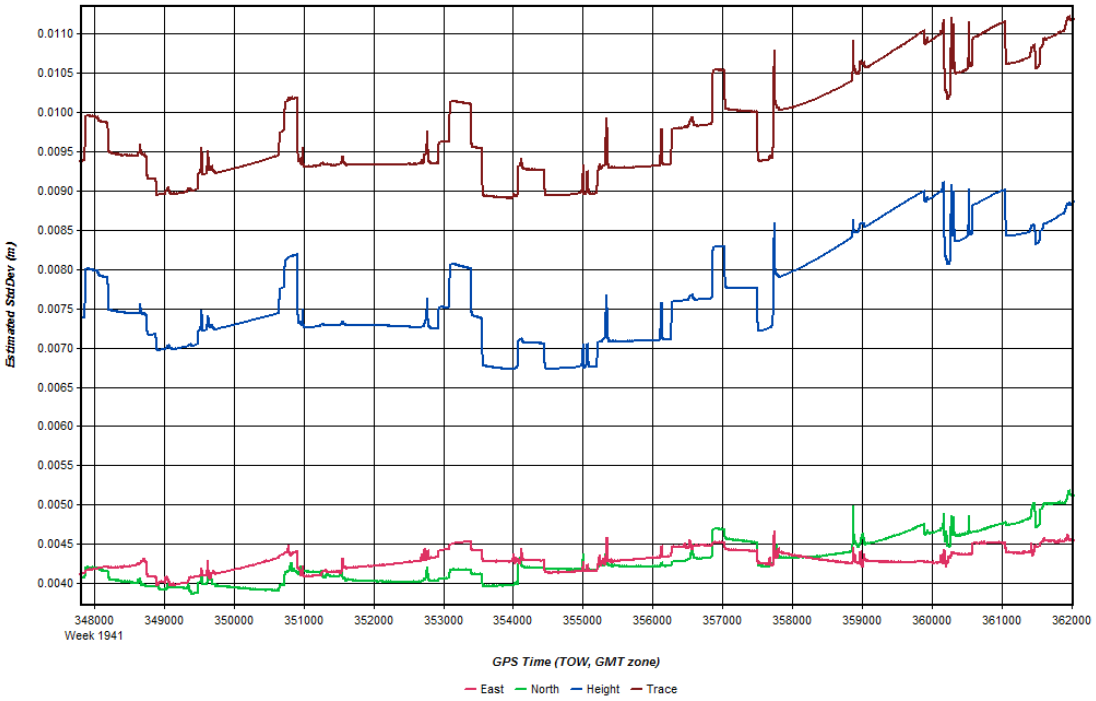

Num Sats
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
255000
Week 1941
256000
257000
258000
259000
260000
261000
262000
263000
264000
265000
266000
267000
268000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

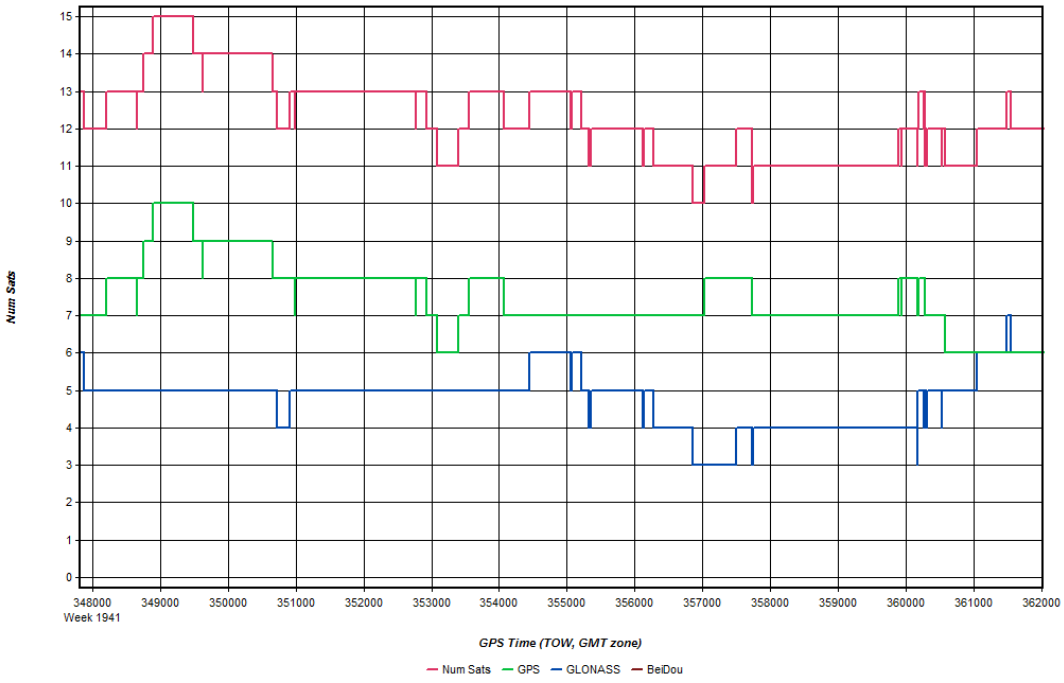

Separation (m)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
255000
Week 1941
256000
257000
258000
259000
260000
261000
262000
263000
264000
265000
266000
267000
268000
GPS Time (TOW, GMT zone)
East
North
Up

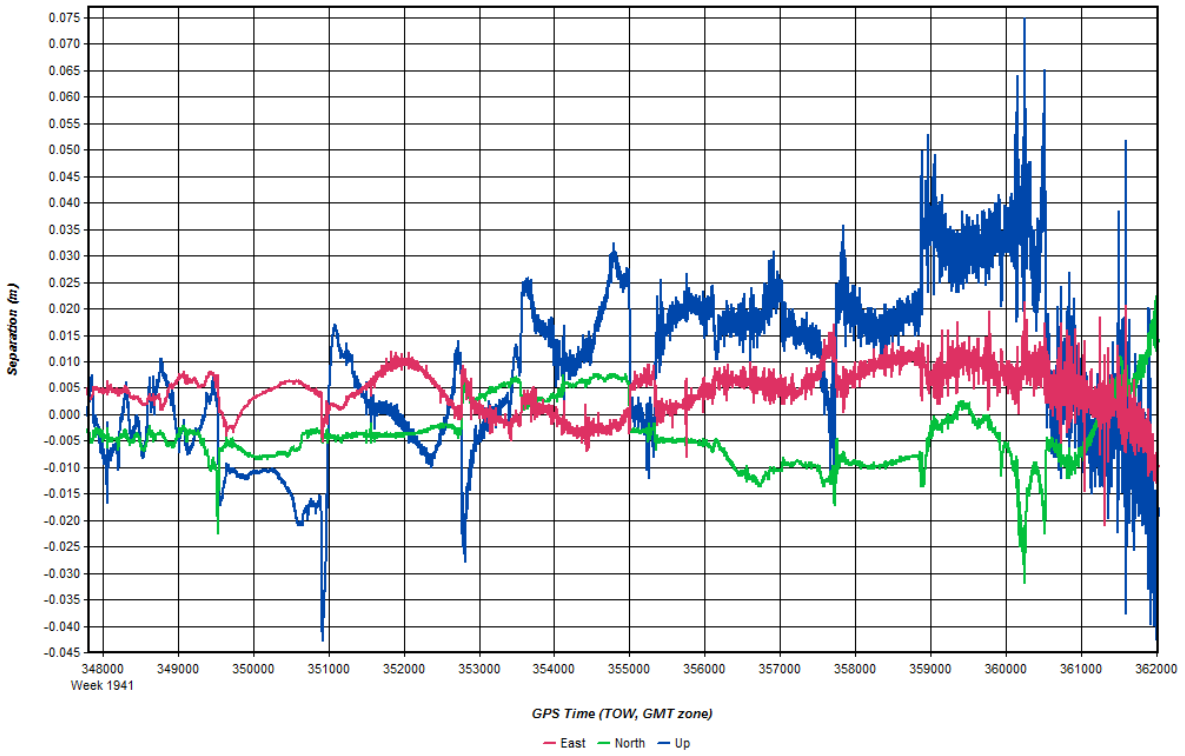
225_2017032

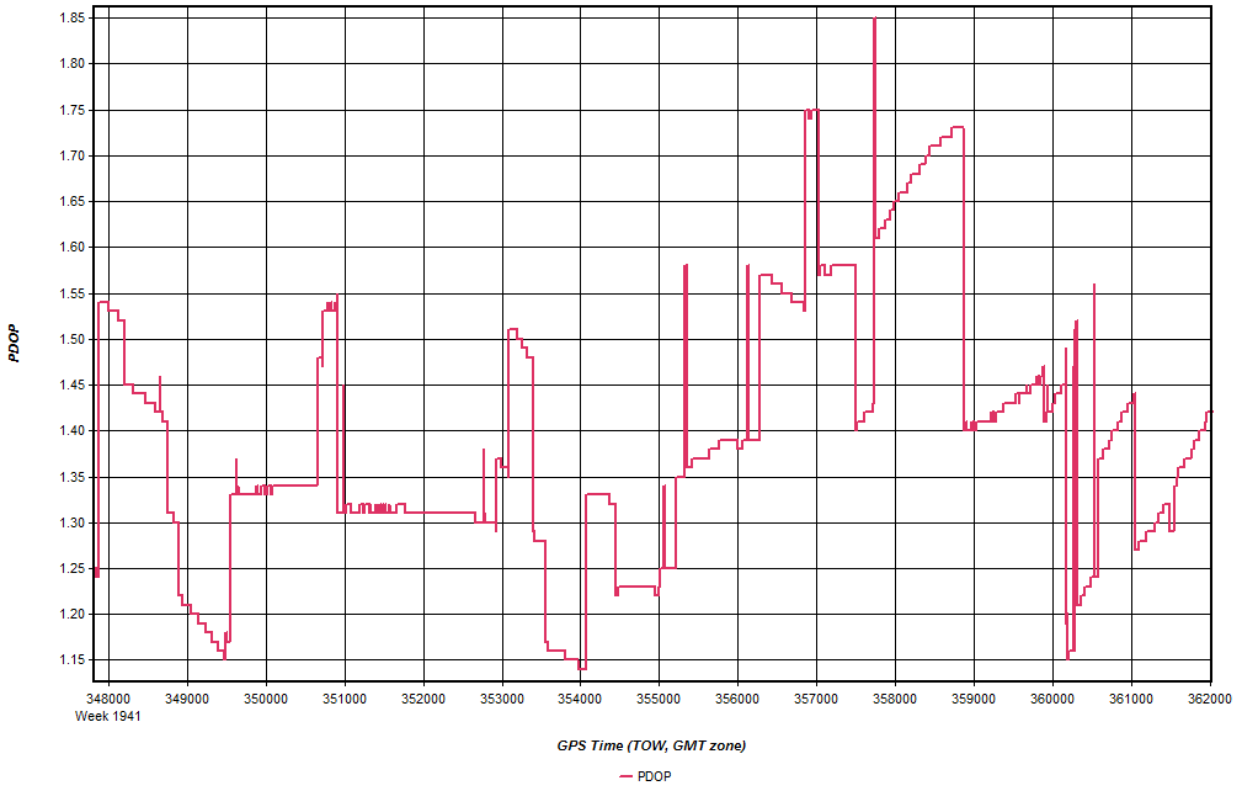


2_3

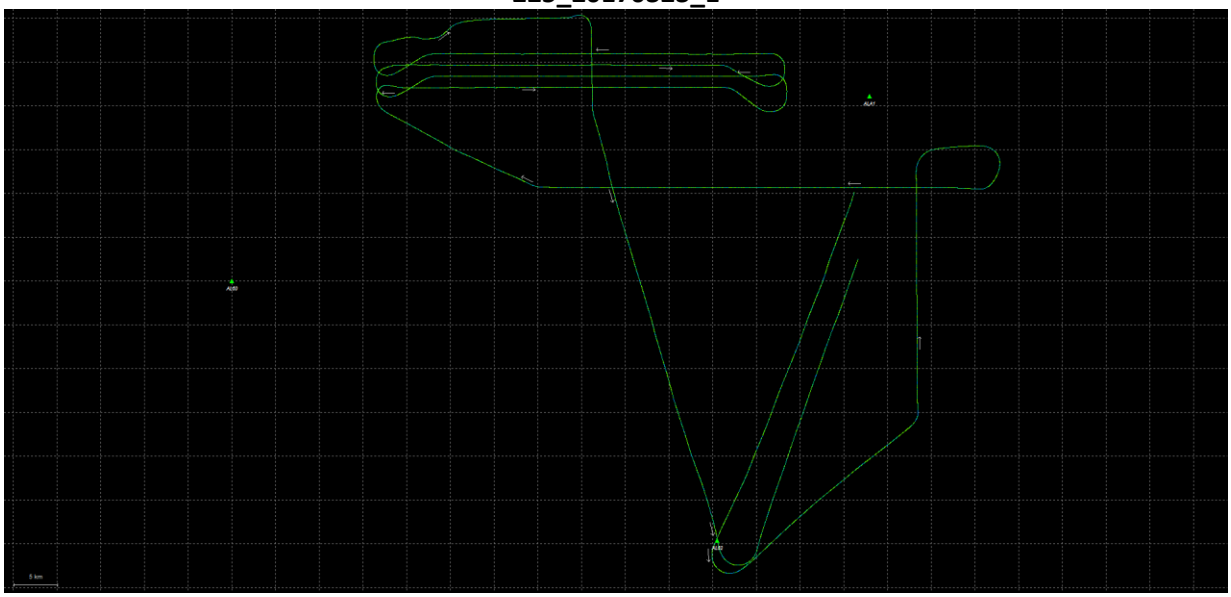

Estimated StdDev (m)
0.0110
0.0105
0.0100
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
348000
Week 1941
349000
350000
351000
352000
353000
354000
355000
356000
357000
358000
359000
360000
361000
362000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

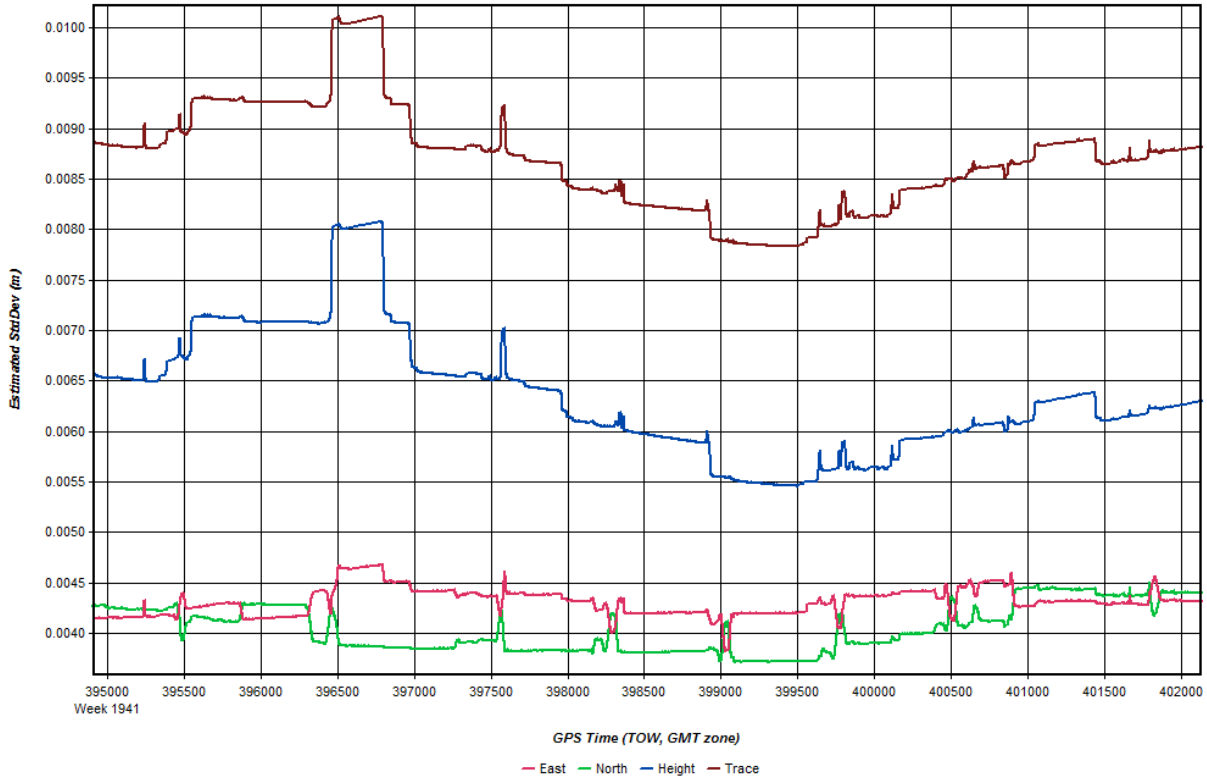

Num Sats
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
348000
Week 1941
349000
350000
351000
352000
353000
354000
355000
356000
357000
358000
359000
360000
361000
362000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

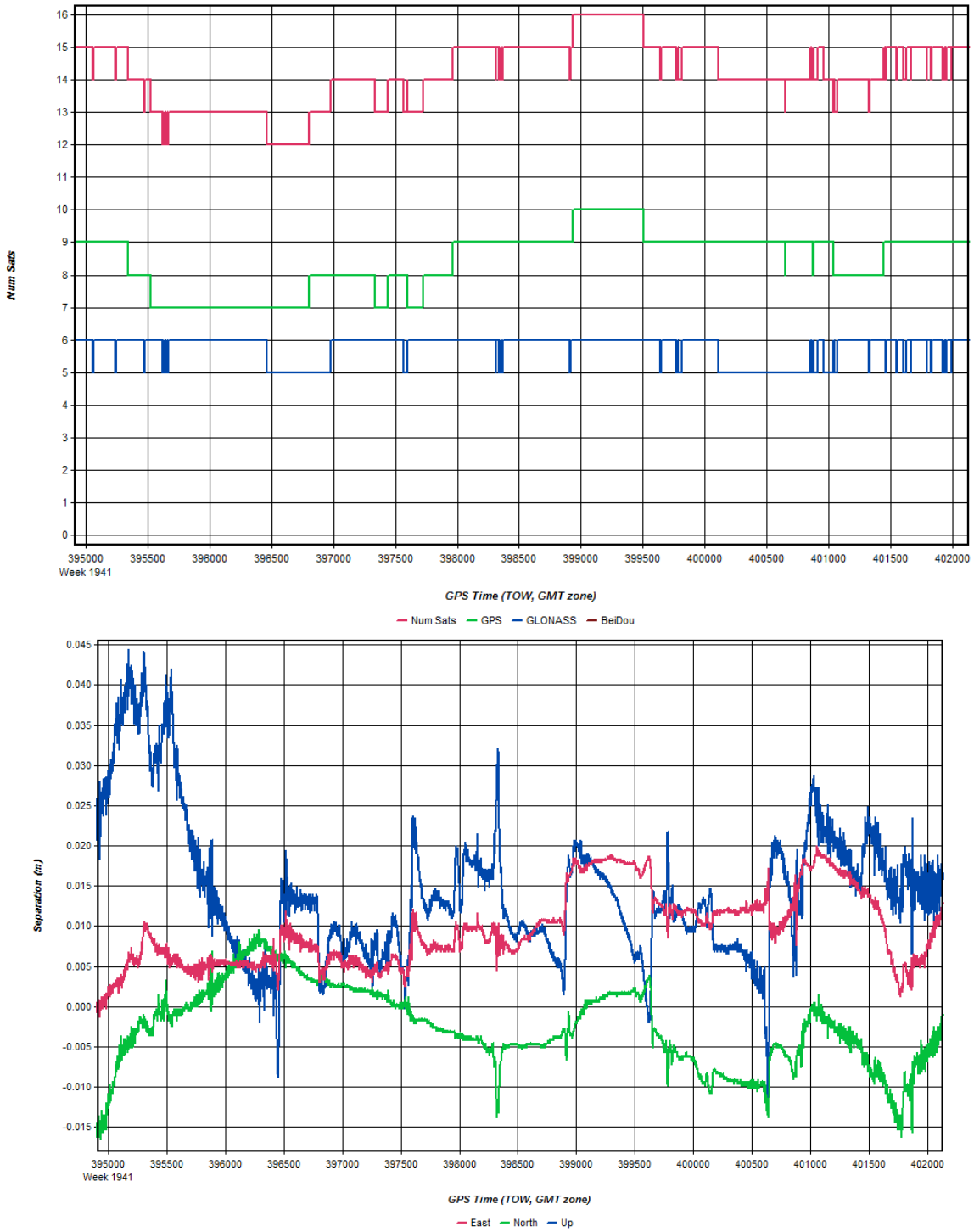

Separation (m)
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
348000
Week 1941
349000
350000
351000
352000
353000
354000
355000
356000
357000
358000
359000
360000
361000
362000
GPS Time (TOW, GMT zone)
East
North
Up

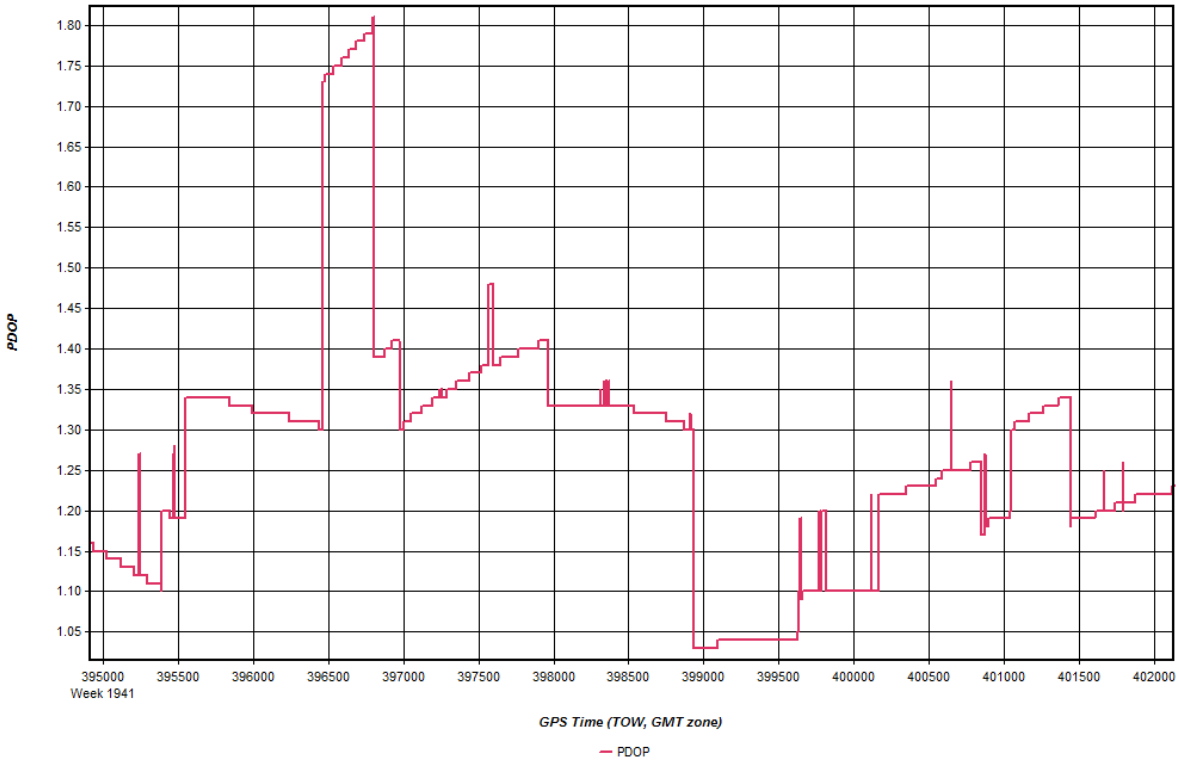

PDOP
1.85
1.80
1.75
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
348000
Week 1941
349000
350000
351000
352000
353000
354000
355000
356000
357000
358000
359000
360000
361000
362000
GPS Time (TOW, GMT zone)
PDOP

225_20170323_1

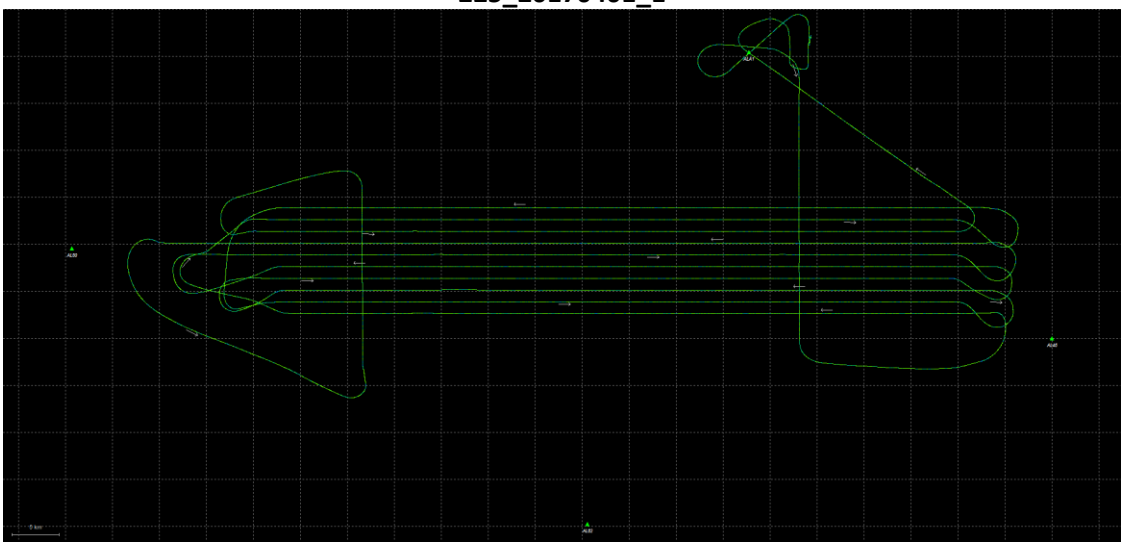


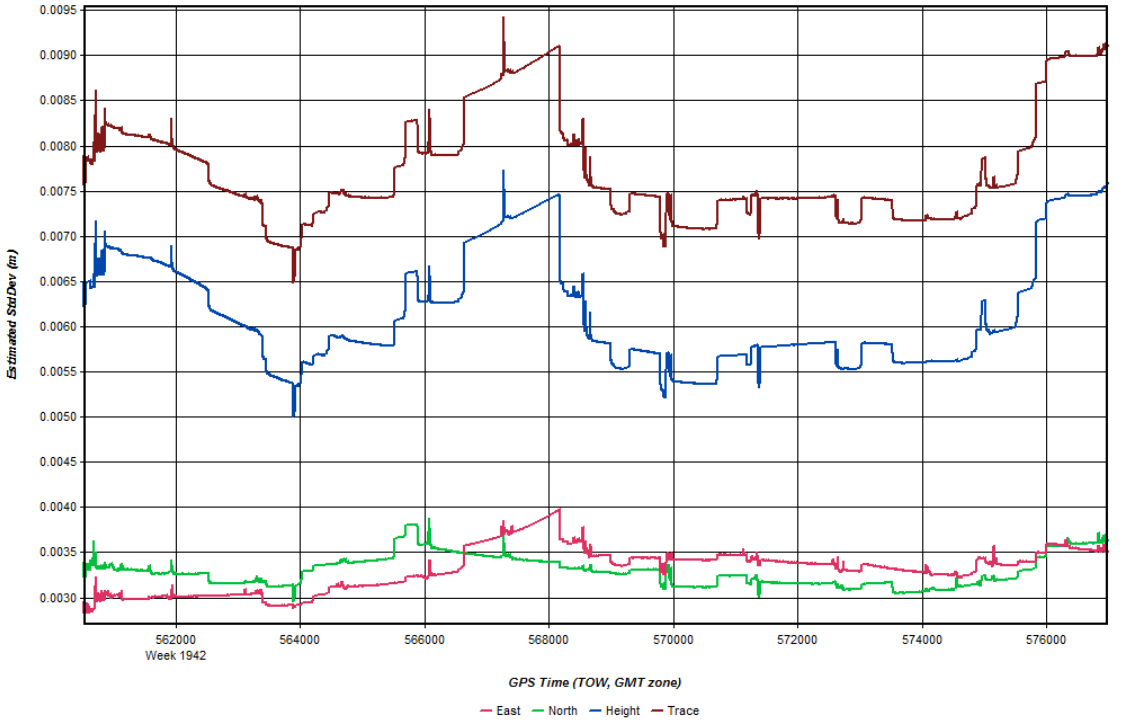


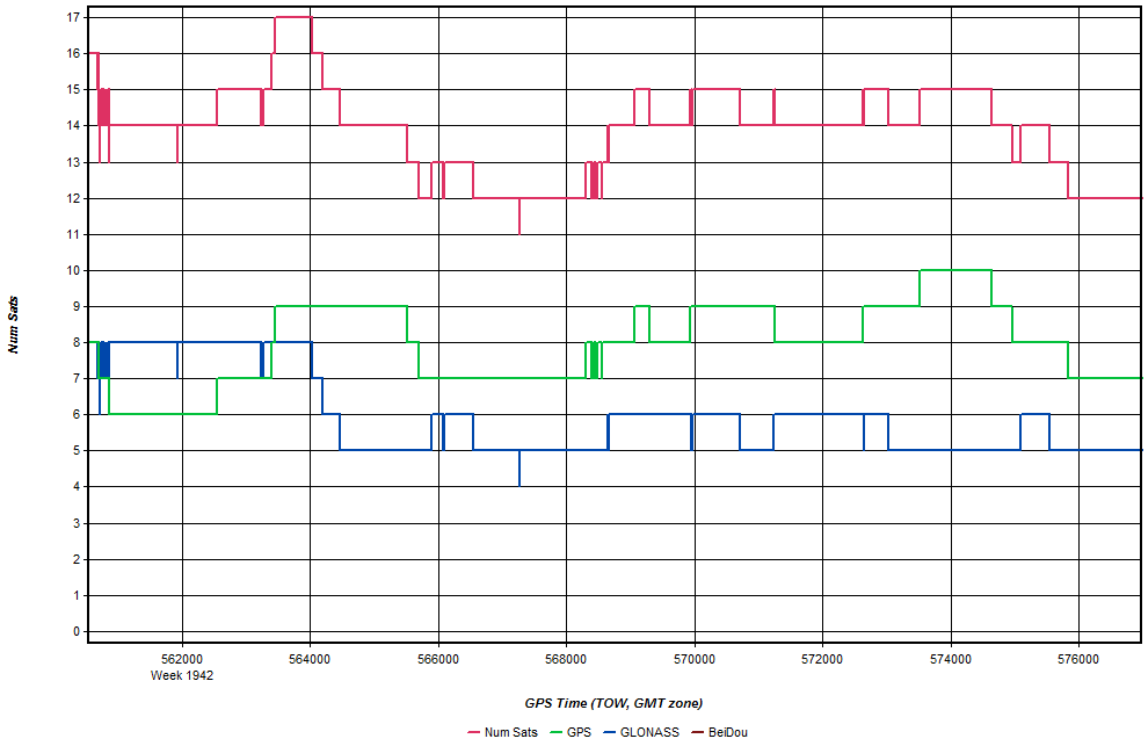

Num Sats
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
395000
Week 1941
395500
396000
396500
397000
397500
398000
398500
399000
399500
400000
400500
401000
401500
402000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Separation (m)
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
East
North
Up

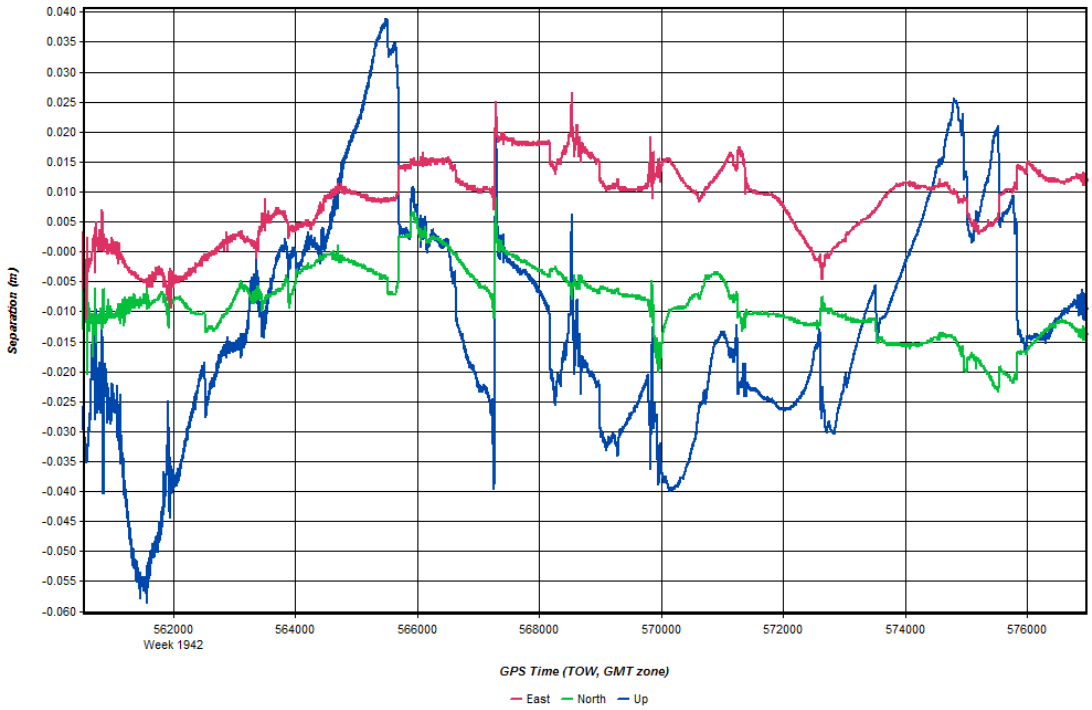


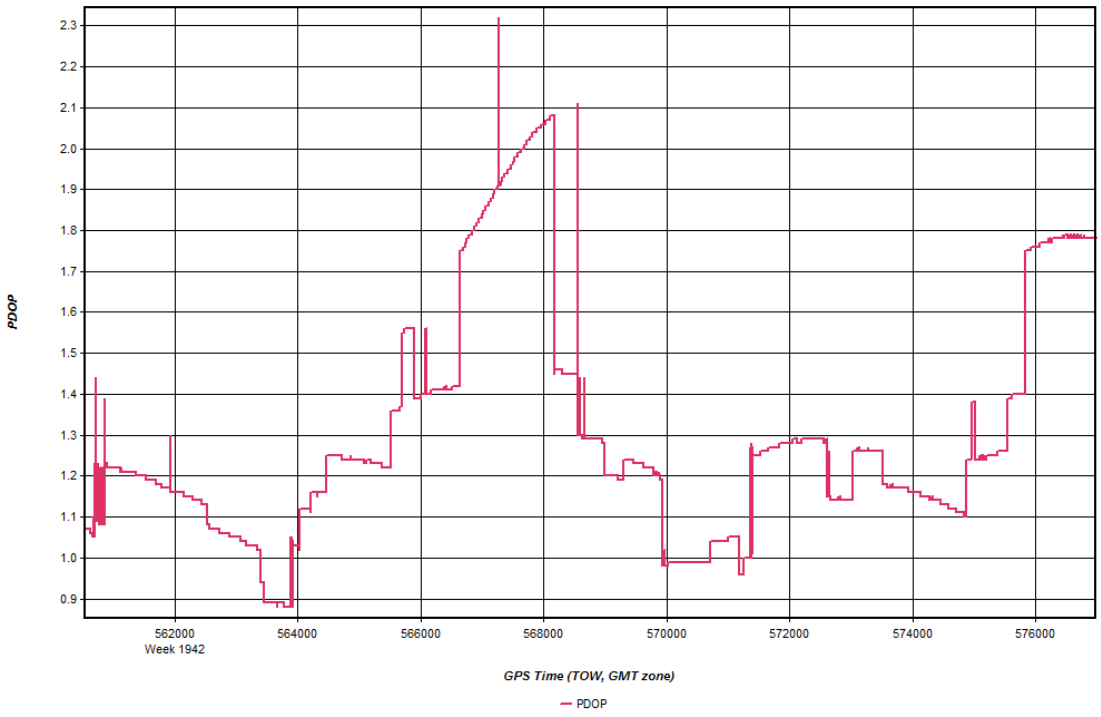
225_20170401_1



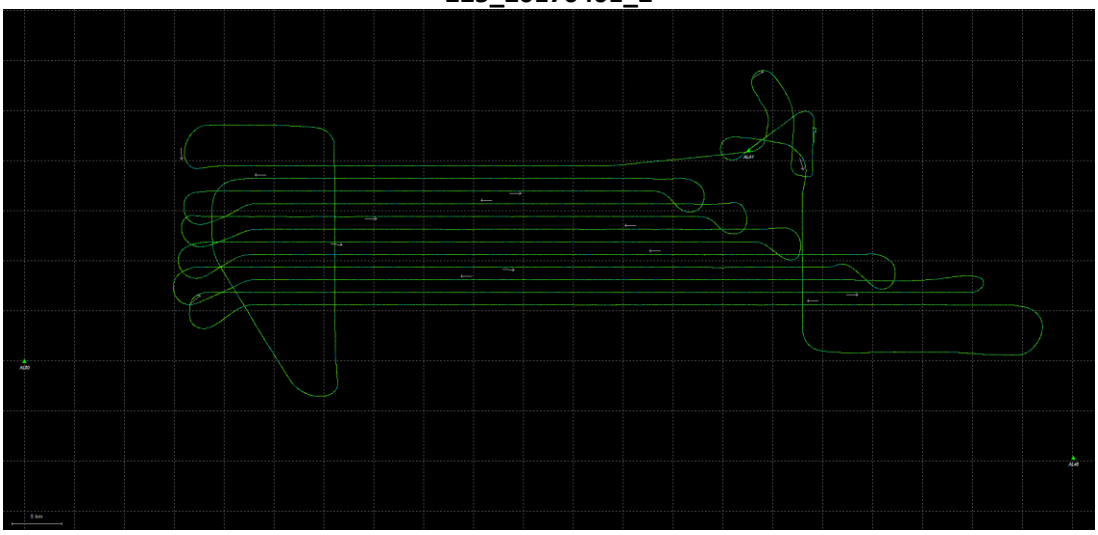

Estimated StdDev (m)
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
0.0035
0.0030
562000
Week 1942
564000
566000
568000
570000
572000
574000
576000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

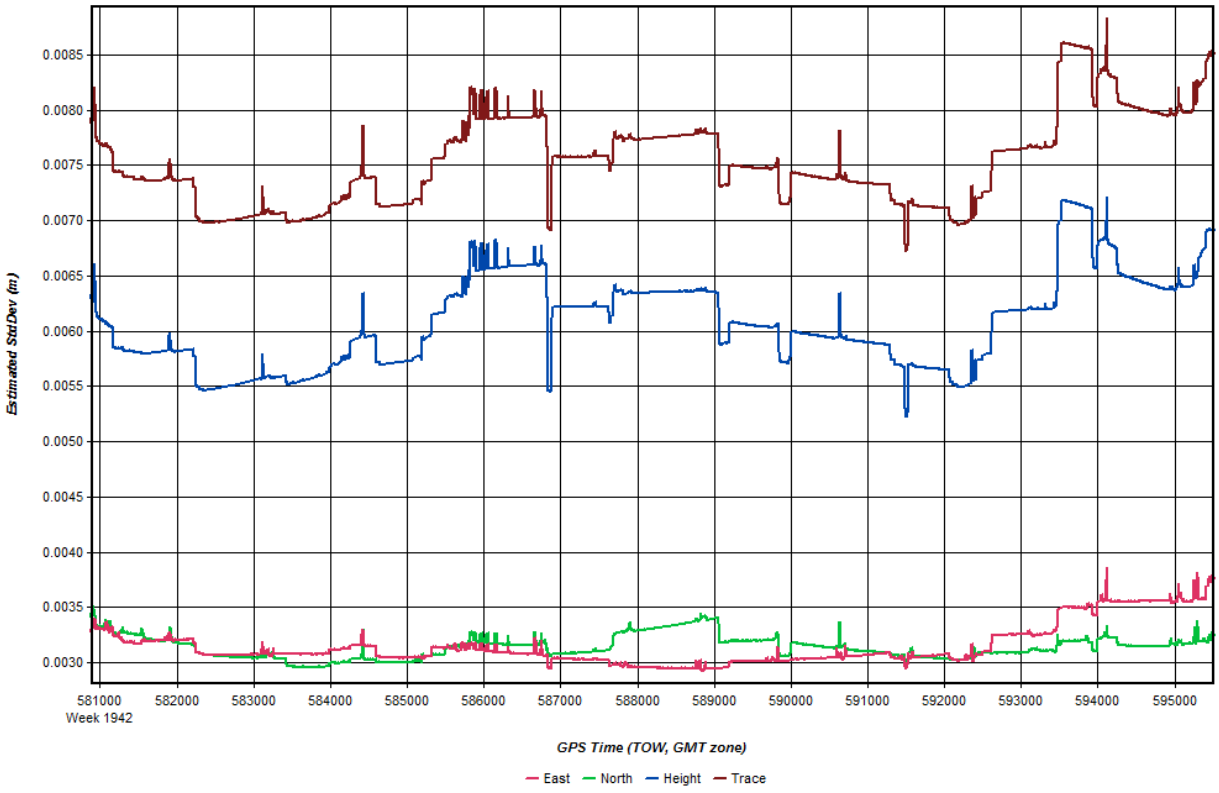

Num Sats
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
562000
Week 1942
564000
566000
568000
570000
572000
574000
576000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

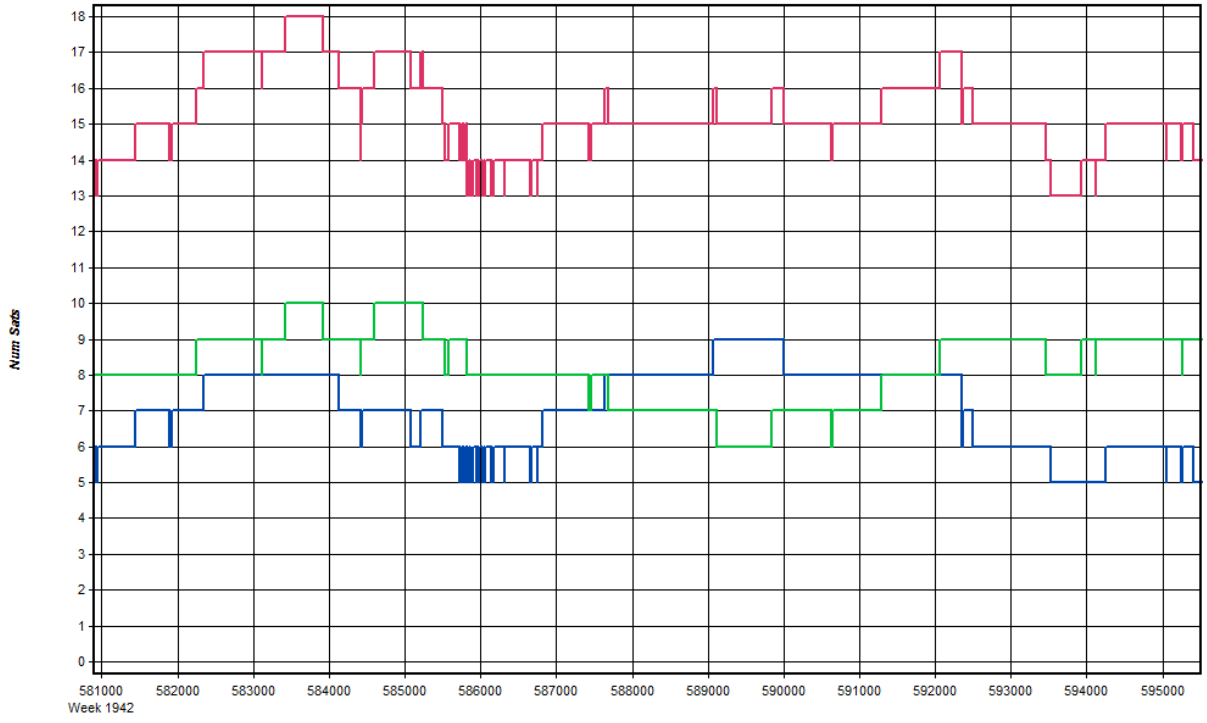

Separation (m)
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
-0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
-0.050
-0.055
-0.060
562000
Week 1942
564000
566000
568000
570000
572000
574000
576000
GPS Time (TOW, GMT zone)
East
North
Up

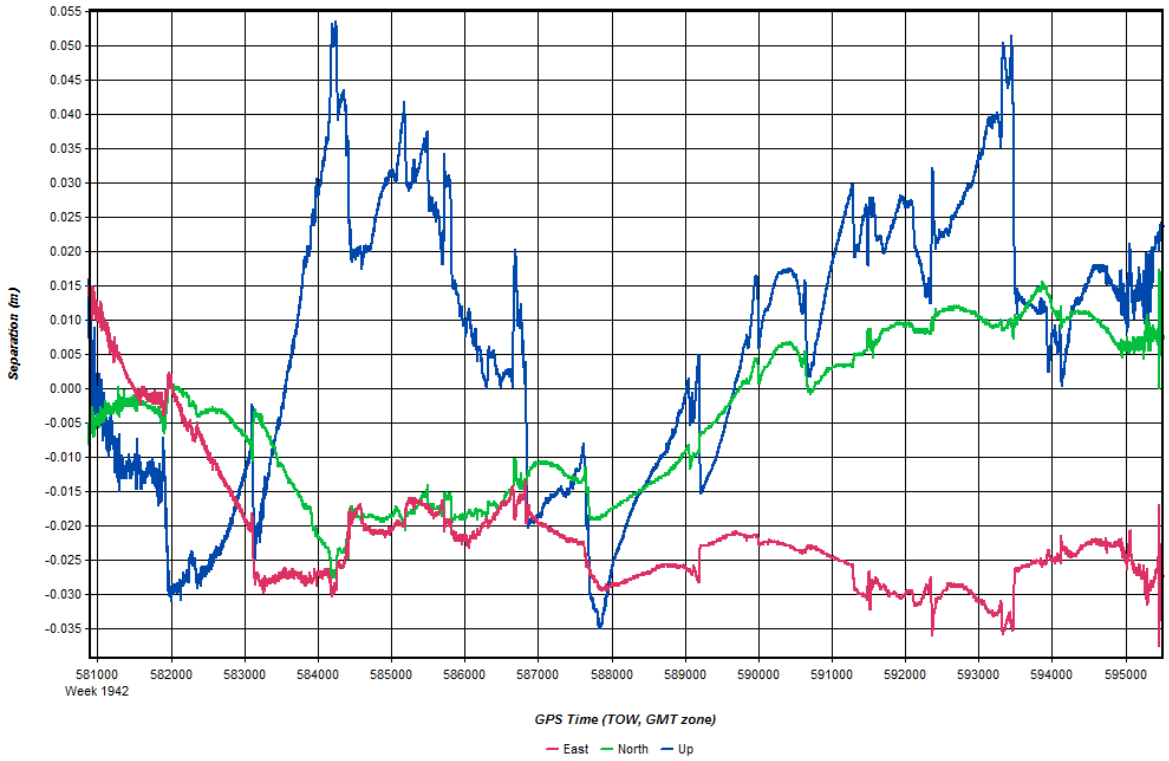

PDOP
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
562000
Week 1942
564000
566000
568000
570000
572000
574000
576000
GPS Time (TOW, GMT zone)
PDOP

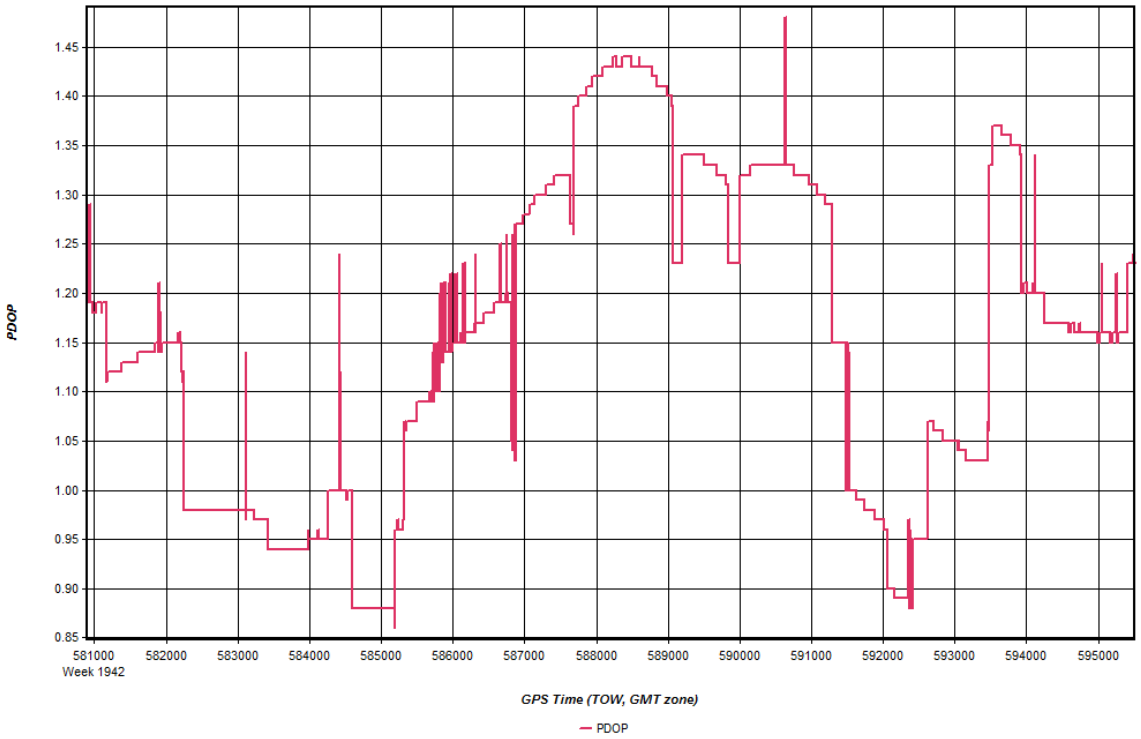
225_20170401_2



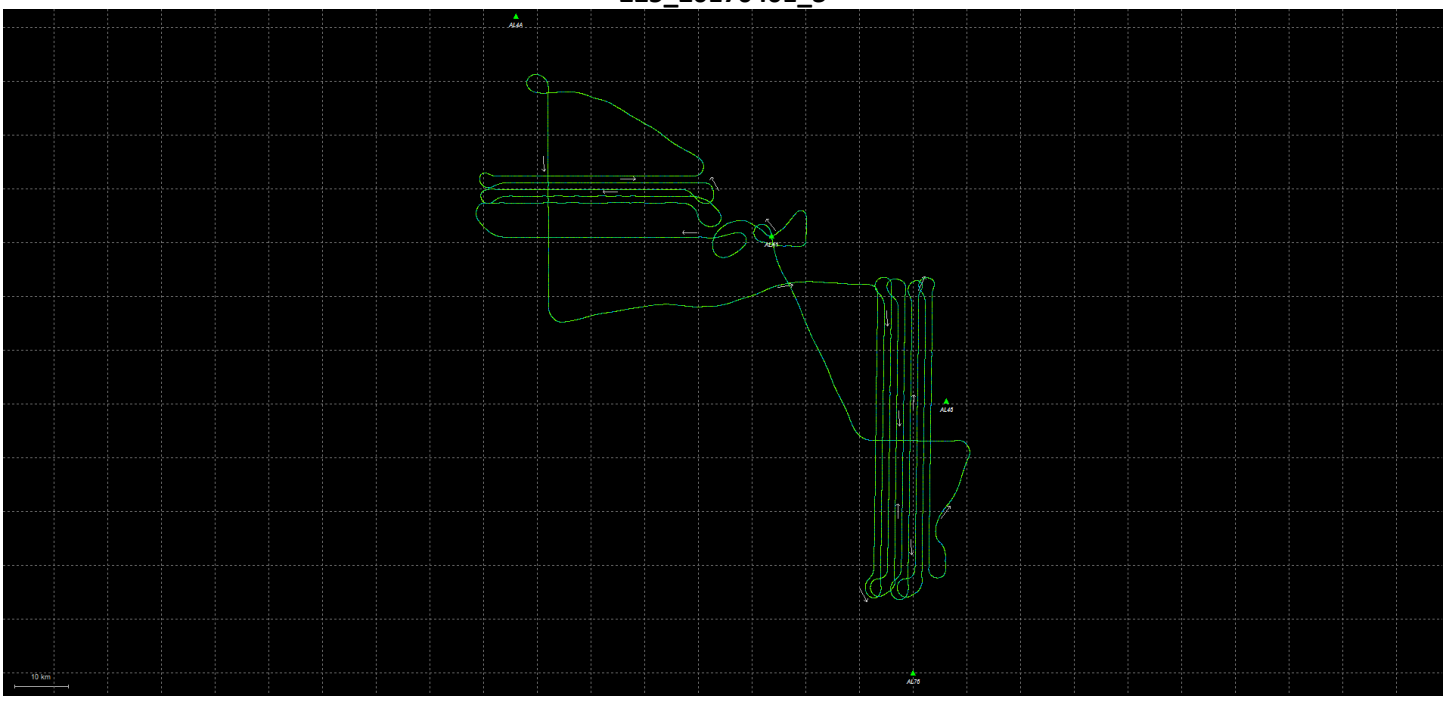


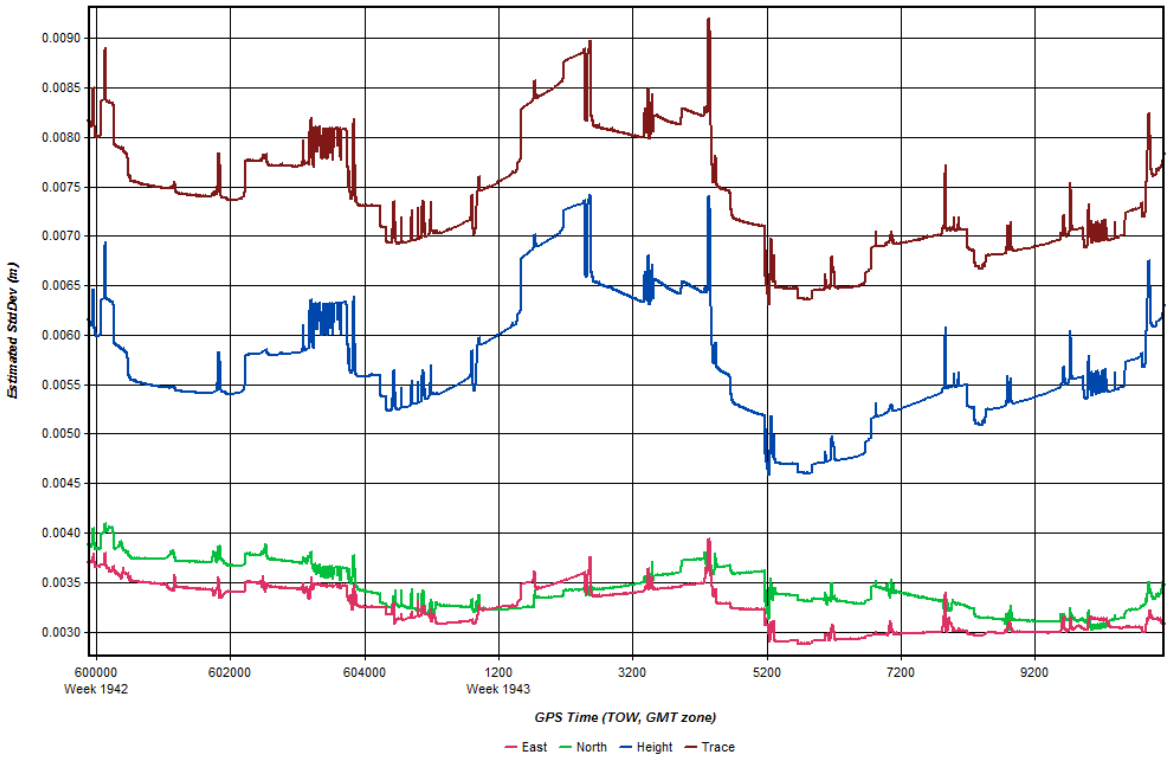

Num Sats
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
581000
Week 1942
582000
583000
584000
585000
586000
587000
588000
589000
590000
591000
592000
593000
594000
595000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

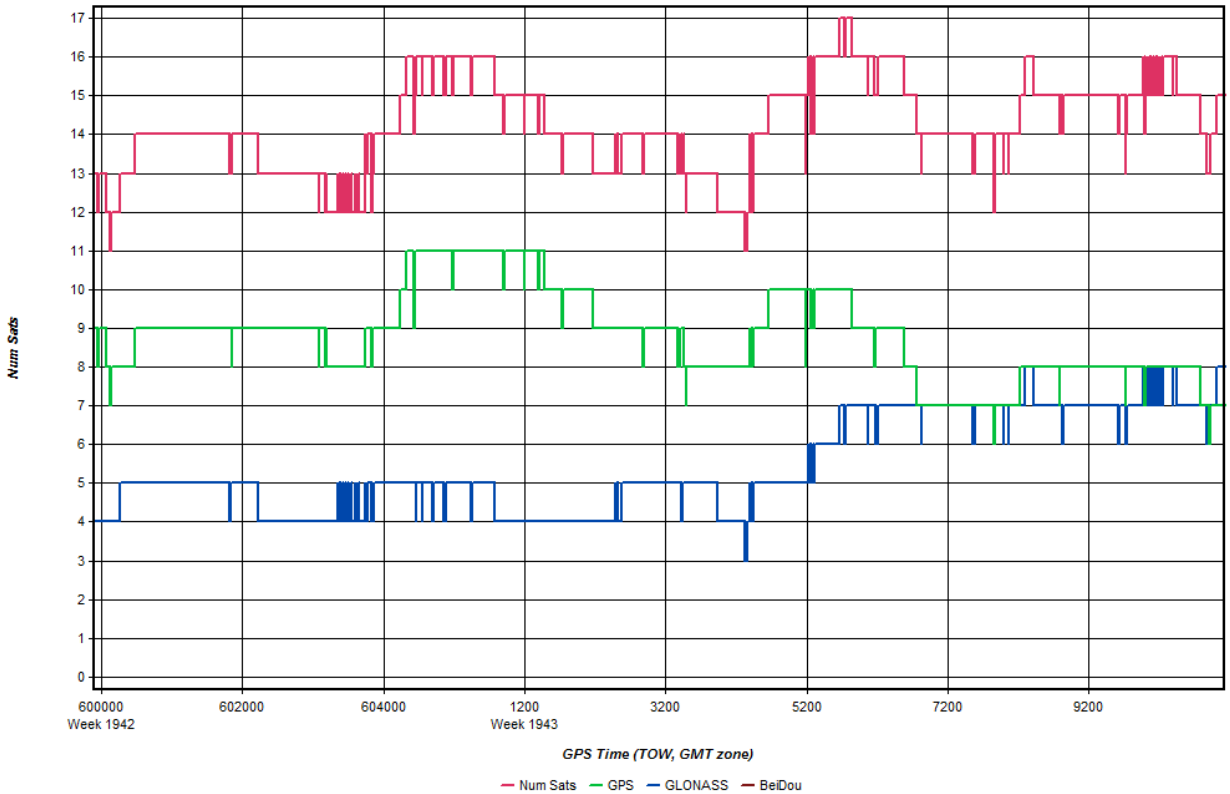

Separation (m)
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
581000
Week 1942
582000
583000
584000
585000
586000
587000
588000
589000
590000
591000
592000
593000
594000
595000
GPS Time (TOW, GMT zone)
East
North
Up

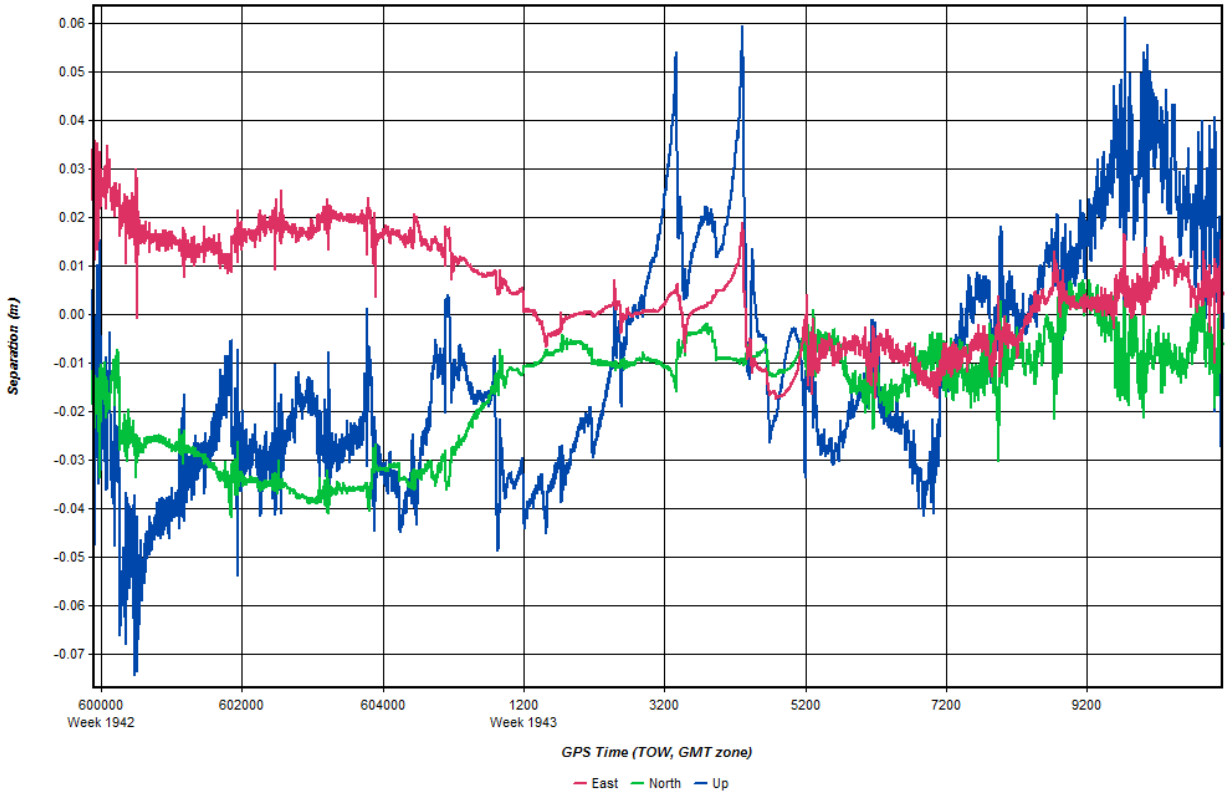


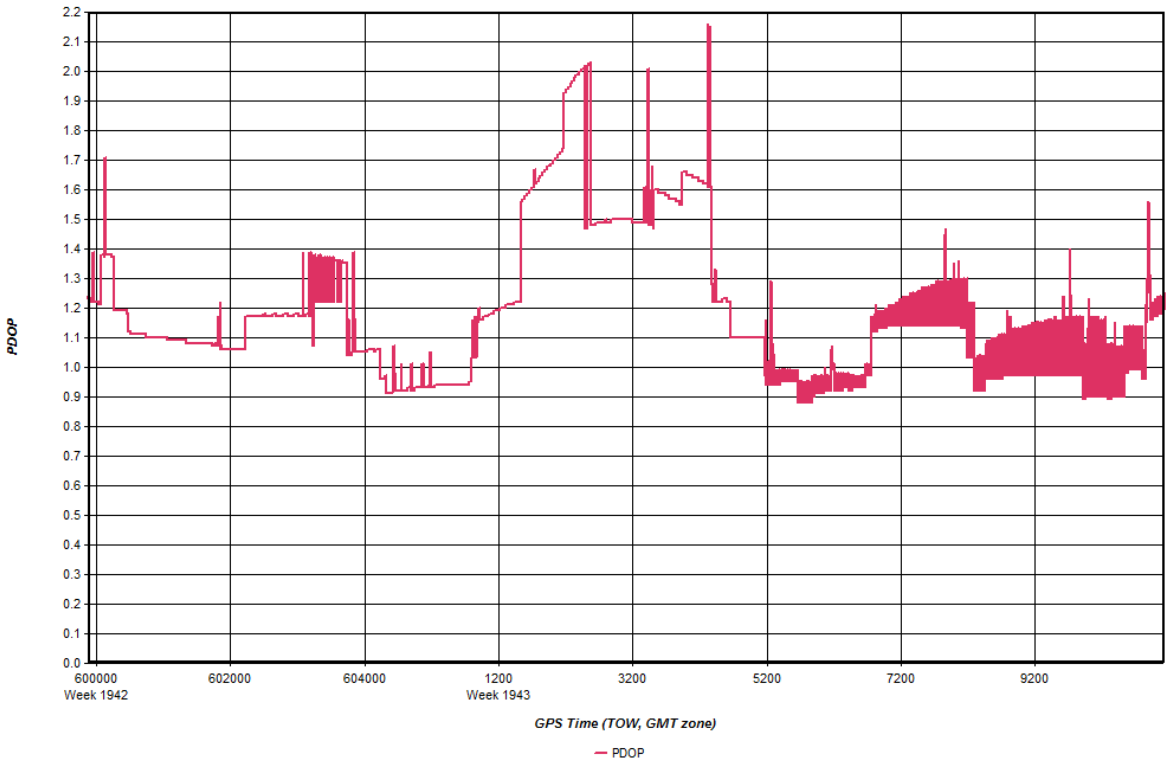
225_20170401_3



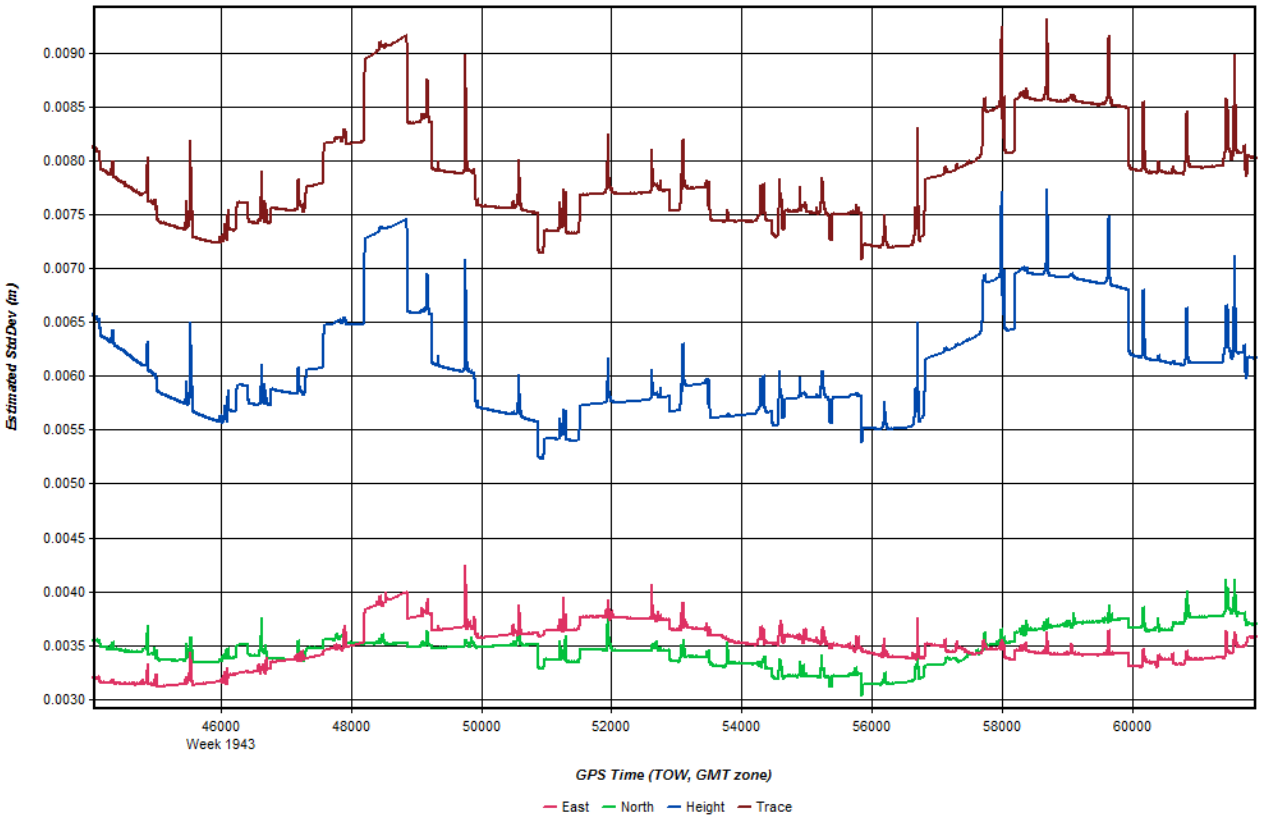

Estimated StdDev (m)
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
0.0035
0.0030
600000
Week 1942
602000
604000
1200
Week 1943
3200
5200
7200
9200
GPS Time (TOW, GMT zone)
East
North
Height
Trace

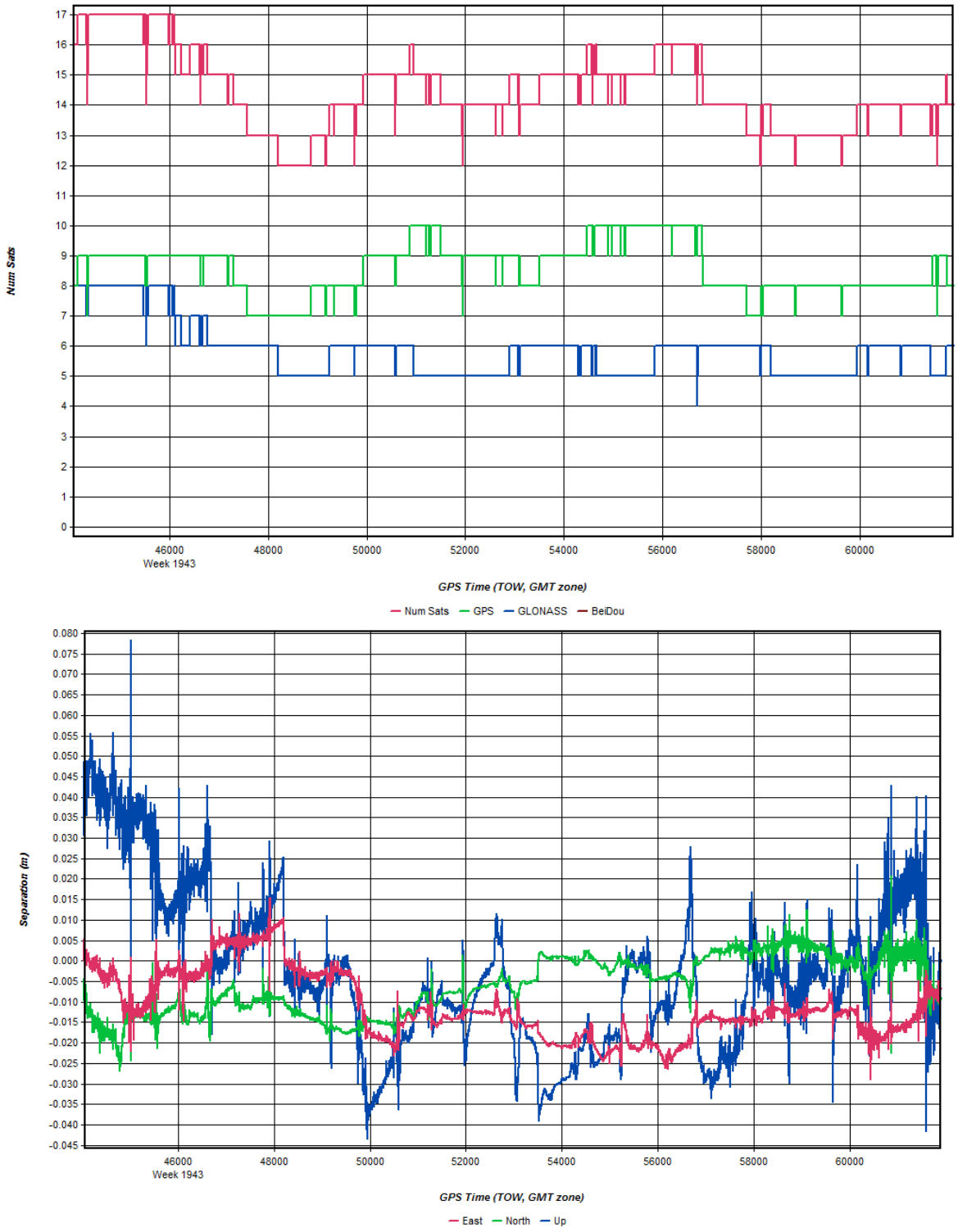

Num Sats
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
600000
Week 1942
602000
604000
1200
Week 1943
3200
5200
7200
9200
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

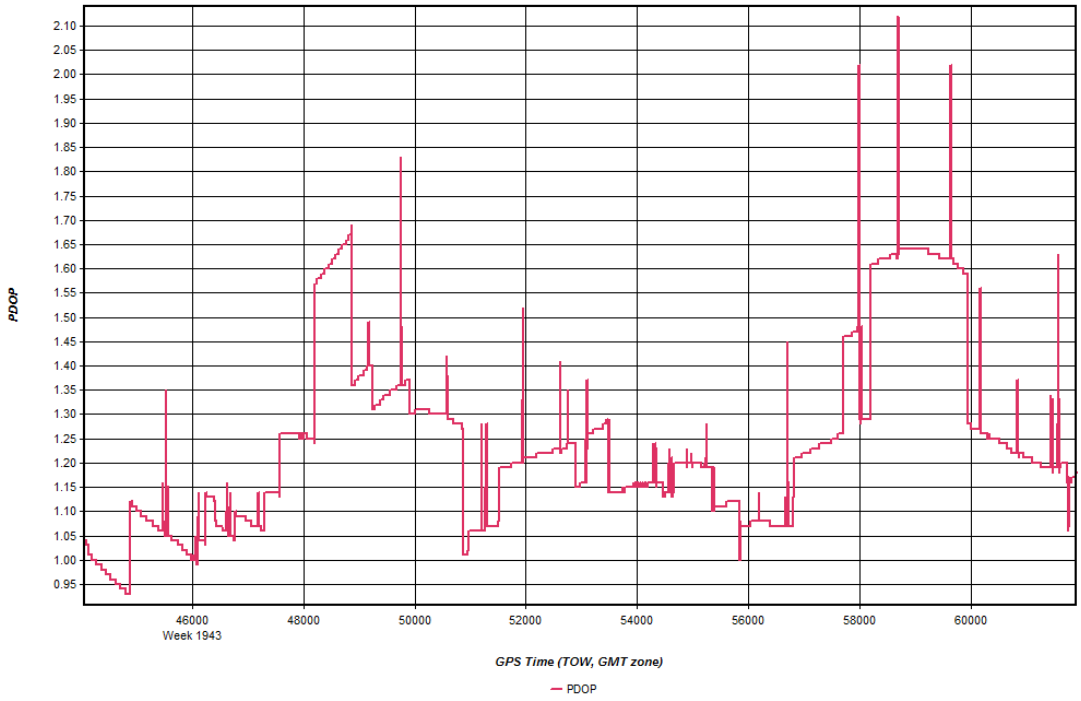

Separation (m)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
600000
Week 1942
602000
604000
1200
Week 1943
3200
5200
7200
9200
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
600000
Week 1942
602000
604000
1200
Week 1943
3200
5200
7200
9200
GPS Time (TOW, GMT zone)
PDOP

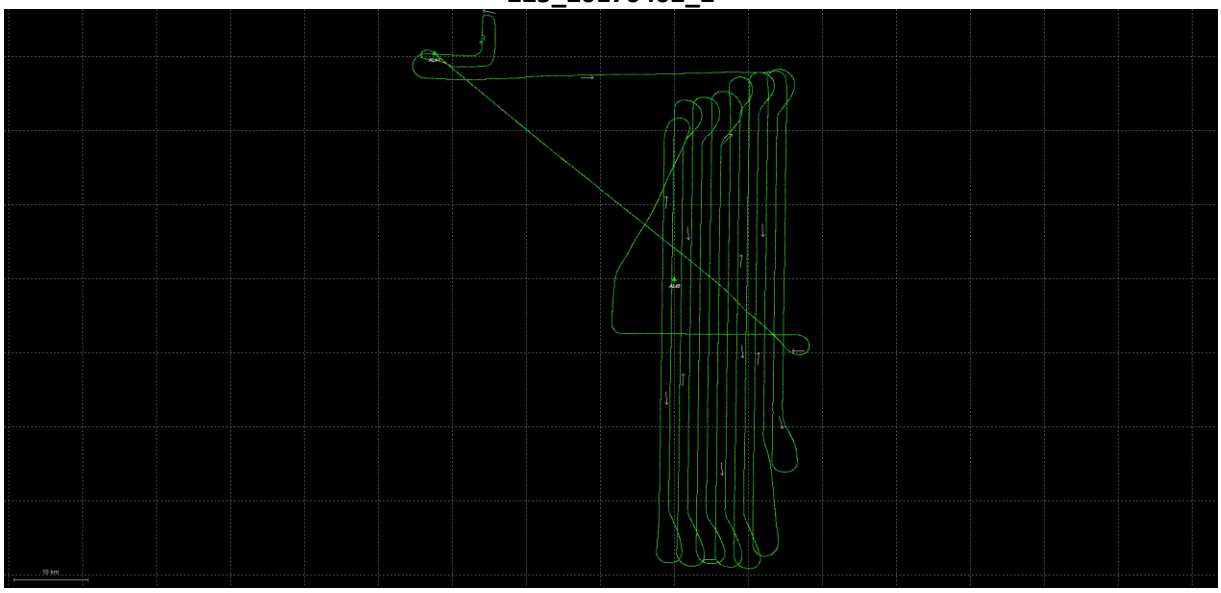
225_20170402_1

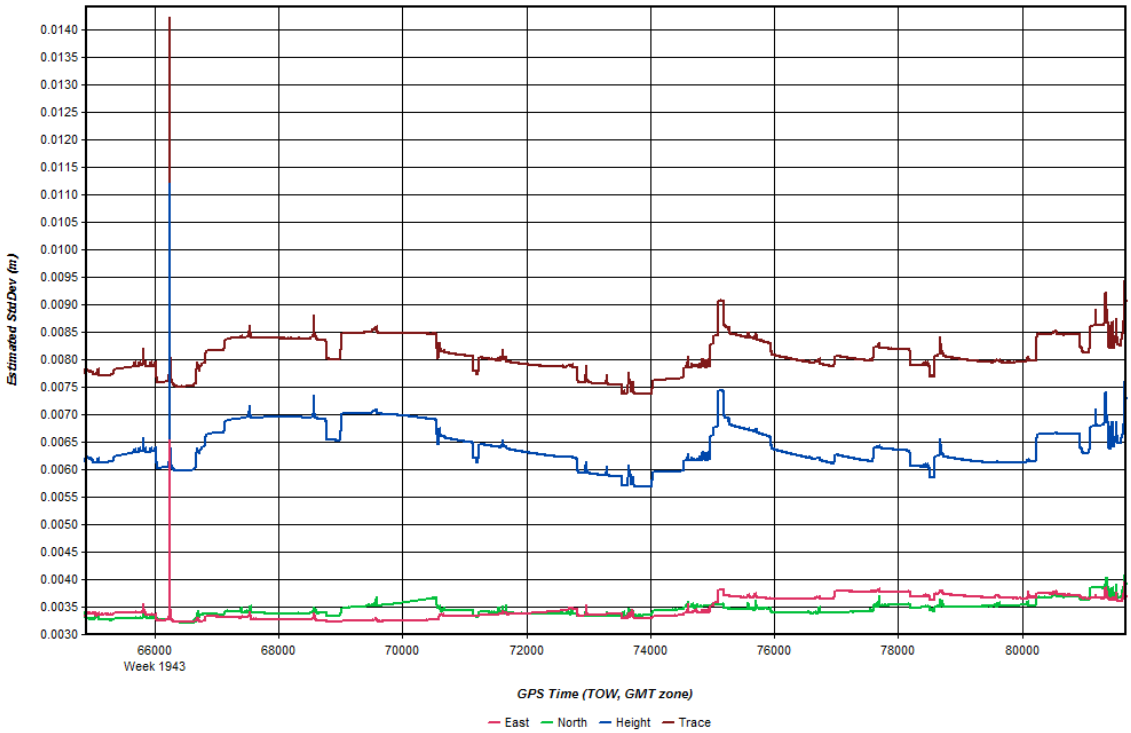


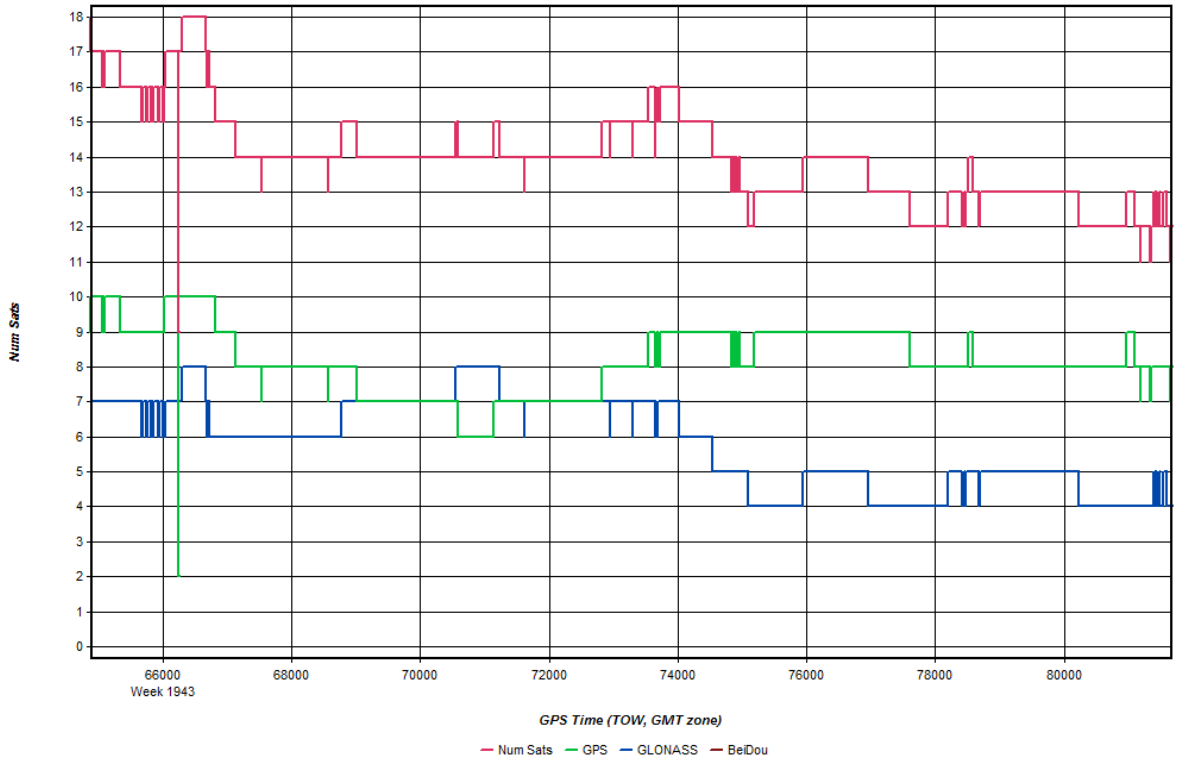

Num Sats
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
46000
Week 1943
48000
50000
52000
54000
56000
58000
60000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Separation (m)
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
46000
Week 1943
48000
50000
52000
54000
56000
58000
60000
GPS Time (TOW, GMT zone)
East
North
Up

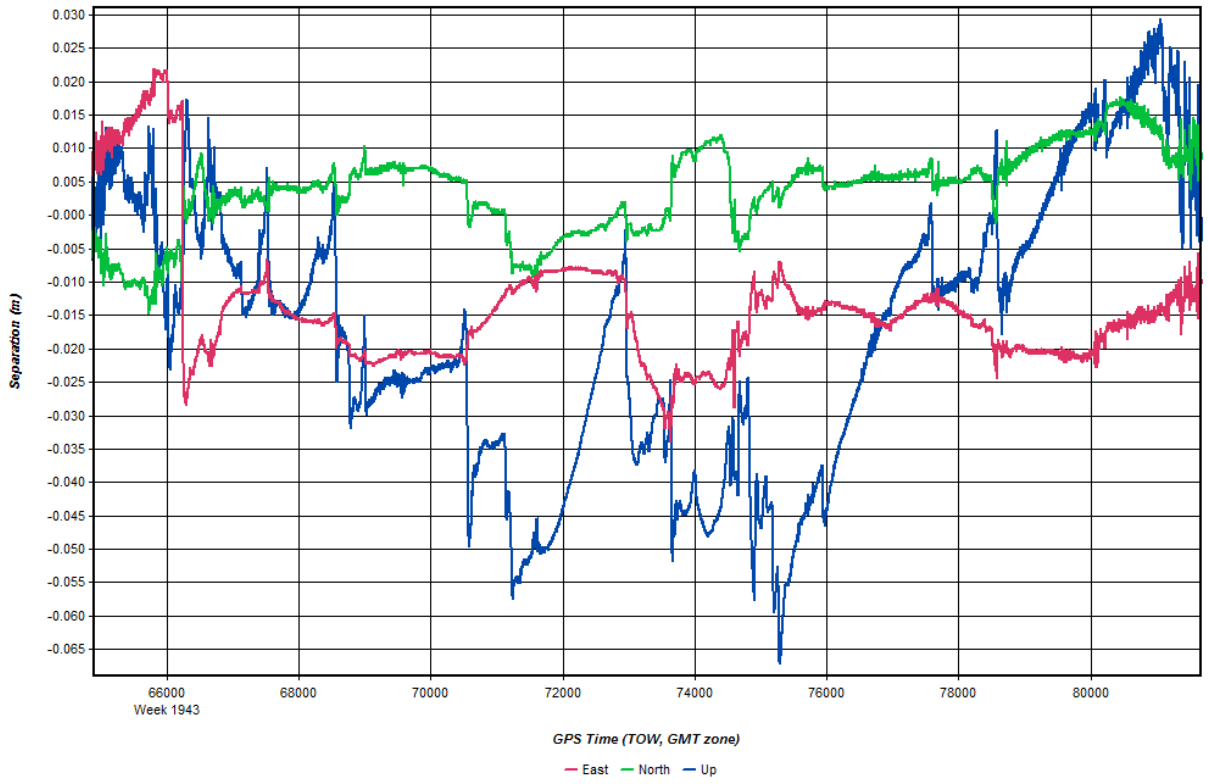


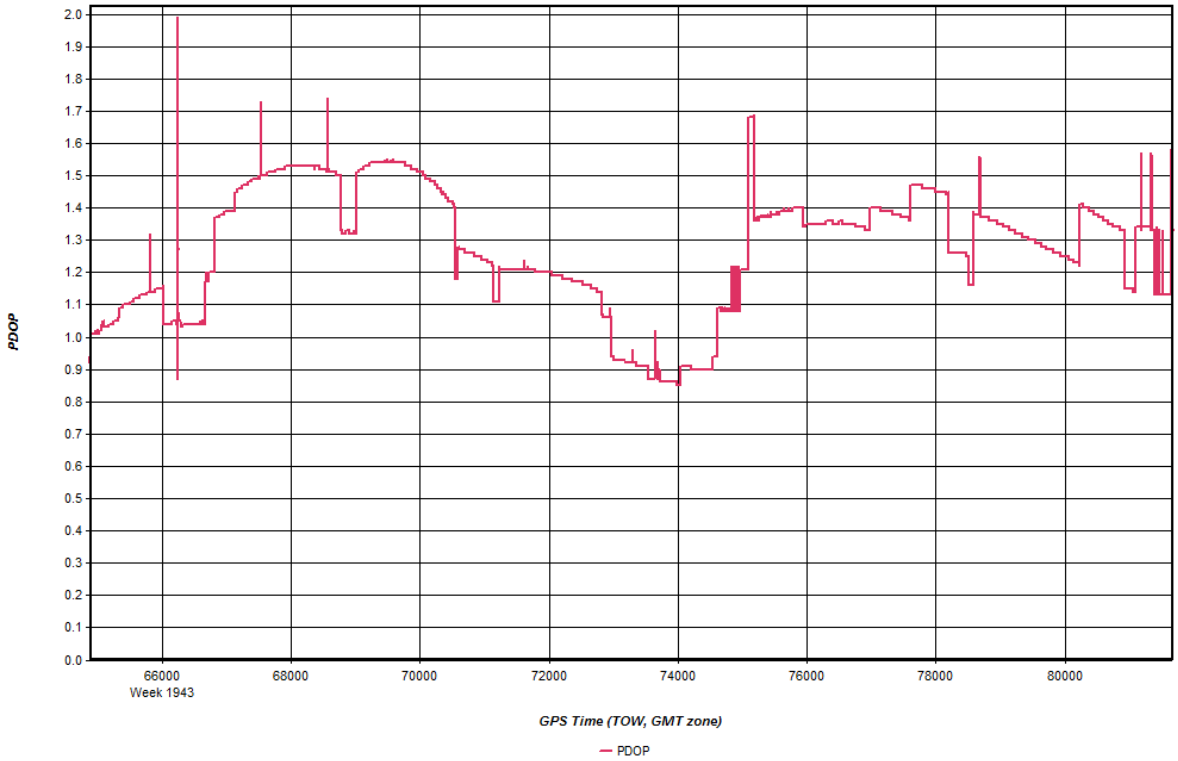
225_20170402_2



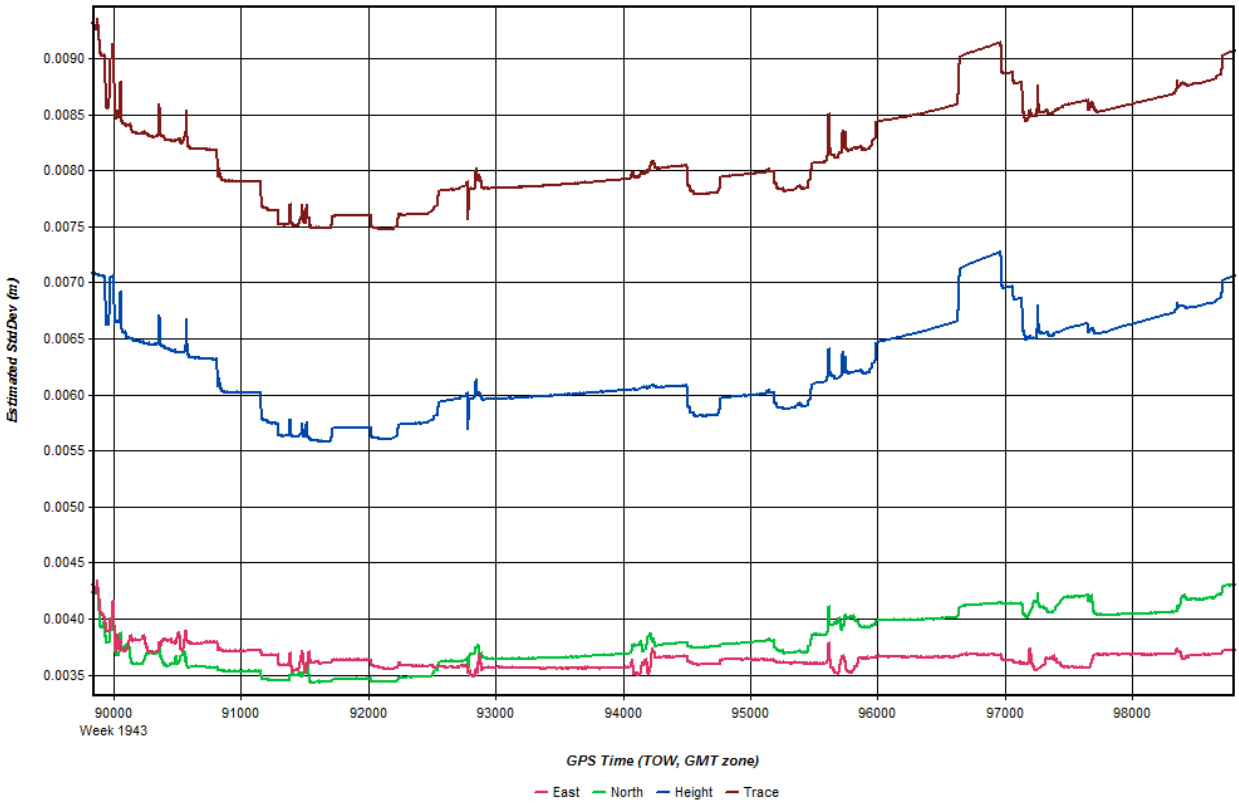

Estimated StdDev (m)
0.0140
0.0135
0.0130
0.0125
0.0120
0.0115
0.0110
0.0105
0.0100
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
0.0035
0.0030
66000
Week 1943
68000
70000
72000
74000
76000
78000
80000
GPS Time (TOW, GMT zone)
East
North
Height
Trace


Num Sats
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
66000
Week 1943
68000
70000
72000
74000
76000
78000
80000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

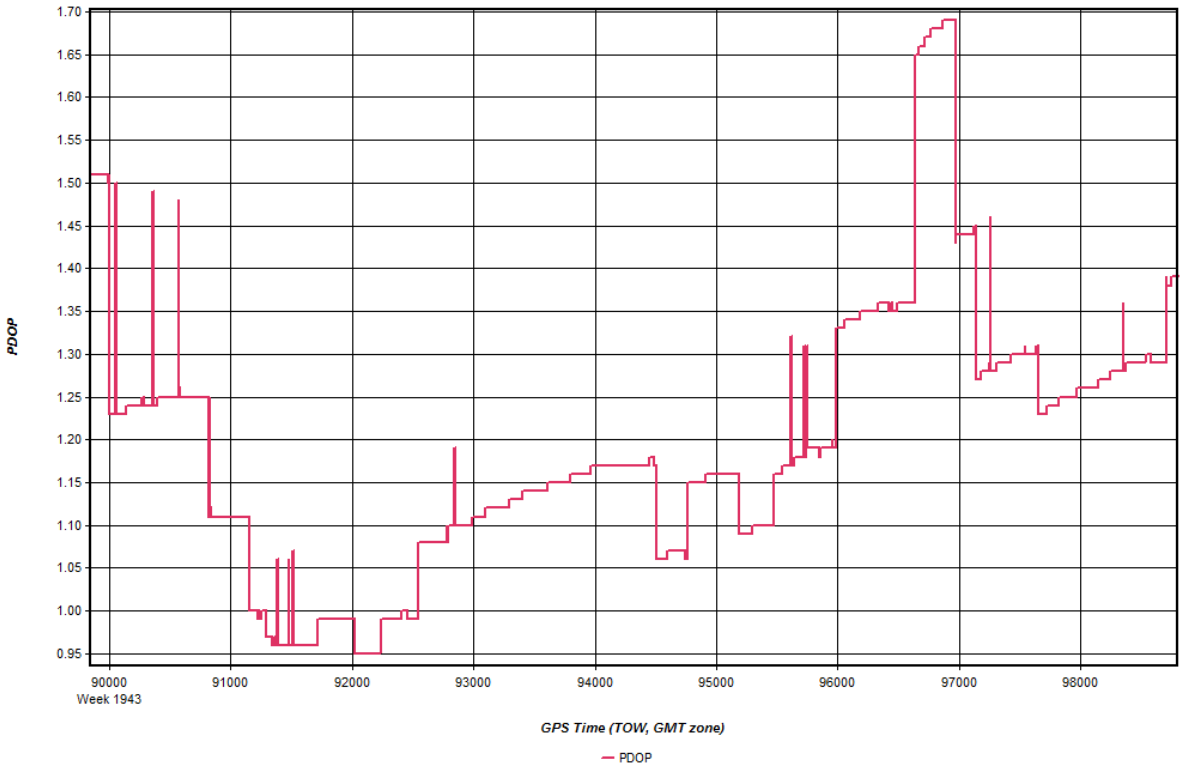

Separation (m)
0.030
0.025
0.020
0.015
0.010
0.005
-0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
-0.050
-0.055
-0.060
-0.065
66000
Week 1943
68000
70000
72000
74000
76000
78000
80000
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
66000
Week 1943
68000
70000
72000
74000
76000
78000
80000
GPS Time (TOW, GMT zone)
PDOP

225_20170402_3




Num Sats
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
90000
Week 1943
91000
92000
93000
94000
95000
96000
97000
98000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Separation (m)
0.030
0.025
0.020
0.015
0.010
0.005
-0.000
-0.005
-0.010
-0.015
-0.020
-0.025
-0.030
-0.035
-0.040
-0.045
-0.050
-0.055
-0.060
90000
Week 1943
91000
92000
93000
94000
95000
96000
97000
98000
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
1.70
1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
90000
Week 1943
91000
92000
93000
94000
95000
96000
97000
98000
GPS Time (TOW, GMT zone)
PDOP