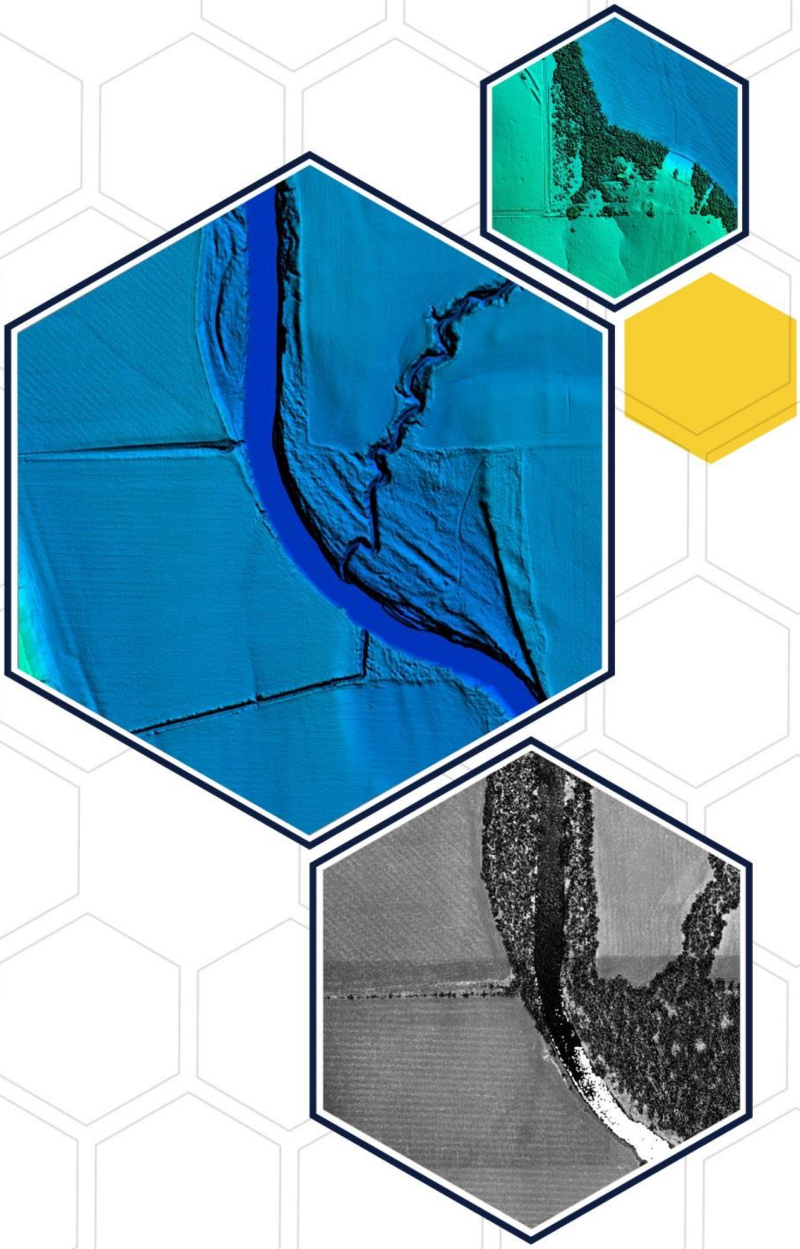

Aerial Lidar Report

17019
National Oceanic and Atmospheric Administration (NOAA)/ Georgia Department of Natural Resources (GDNR), Georgia 9 County Lidar
July 2019

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Section 1: Lidar Acquisition

1.1 Acquisition

The Atlantic Group, LLC (Atlantic) has successfully completed lidar acquisition for the Georgia 9 County Lidar area of interest (AOI). Lidar for this AOI was acquired in sixteen (16) flight missions completed between November 25th, 2017 and January 24th, 2018. The project area encompasses 1,550,933 acres, 6,276 square kilometers or 2,423 square miles.

1.2 Acquisition Status Report

Upon notification to proceed, the flight crew loaded the flight plans and validated the flight parameters. The Acquisition Manager 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 PDOPs, and performed the first Q/C 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 immediately or at an optimal time.

1.3 Acquisition Details

Atlantic acquired one hundred and eighty- nine (183) passes of the AOI as a series of perpendicular and/or adjacent flight lines. The flight plan included zigzag flight line collection as a result of the inherent IMU drift associated with all IMU systems. Differential GPS unit in aircraft recorded sample positions at 2 Hz or more frequency. Lidar data was only acquired when GPS PDOP was ≤ 4 and at least 6 satellites were in view.

Atlantic lidar sensors are calibrated at a designated site located in Huntsville, AL 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.

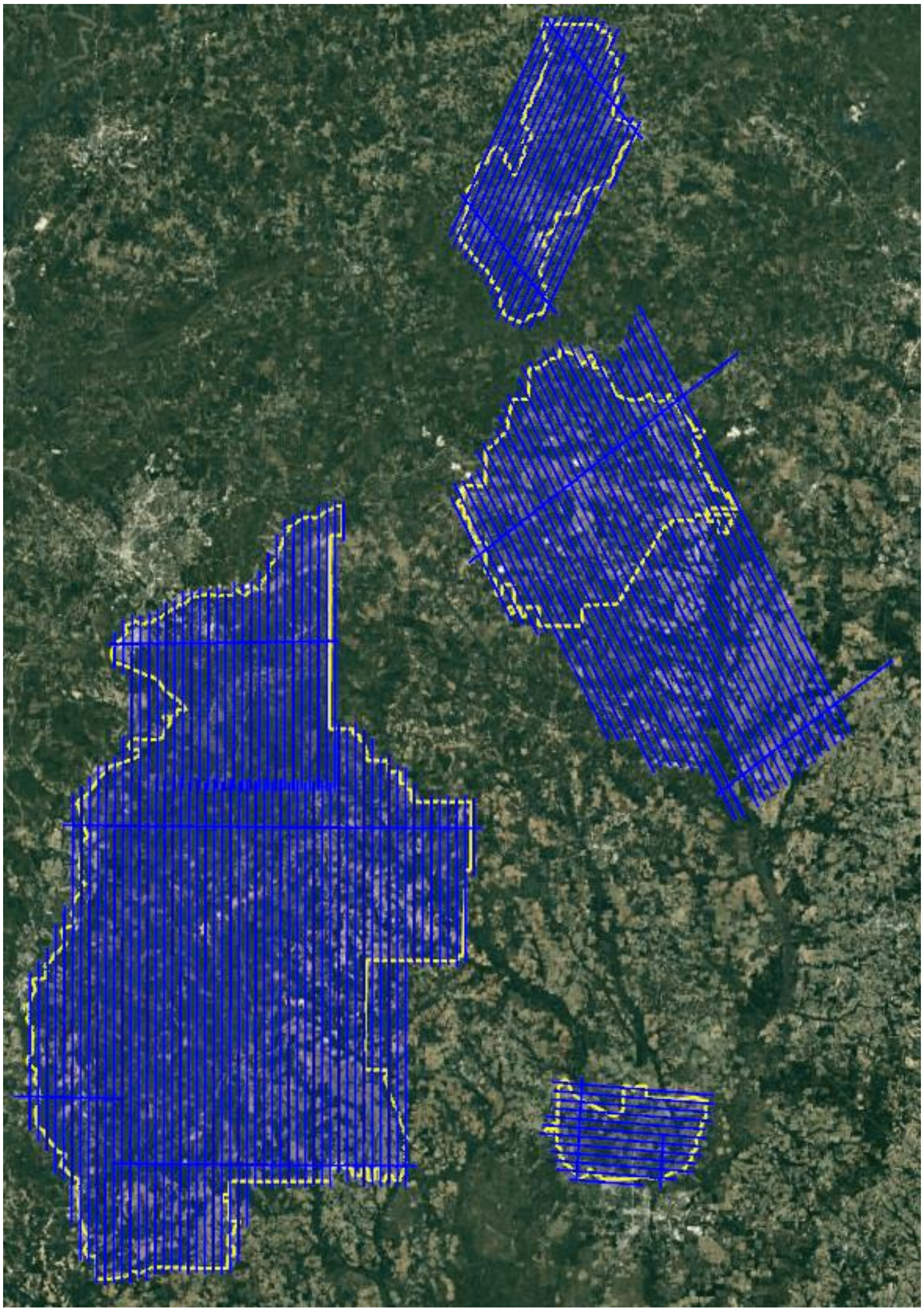

Figure 1: Trajectories as flown by Atlantic

1.6 Acquisition Equipment

Atlantic operated a Cessna T210L (N732JE) and a Pacific Aerospace PAC750XL (N750VX) 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)	0.5
Nominal Pulse Density (pls/m^2)	2.4
Nominal Flight Height (AGL meters)	1957
Nominal Flight Speed (kts)	120
Pass Heading (degree)	Varies
Sensor Scan Angle (degree)	45
Scan Frequency (Hz)	34.8
Pulse Rate of Scanner (kHz)	263
Line Spacing (m)	1,101
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	0.43
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	Yes
Beam Divergence (mrad)	0.22
Nominal Swath Width (m)	1,673
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

Table 2: Atlantic Lidar System Acquisition Parameters

1.8 GPS Reference Station(s)

Six (6) CORS stations and Two (2) Trimble 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**
GACR	CORS	DH4140	32 22 51.43557	083 20 46.40581	99.202
GANW	CORS	DH3600	33 18 20.80154	084 46 02.48264	261.519
GABY	CORS	DL2033	31 22 39.29719	084 56 06.66402	65.01
AEL	Trimble		32 13 39.93640	084 18 25.83767	149.491
GAED	Trimble		31 36 01.11951	084 51 42.37127	105.246
AL76	CORS	DM7125	31 52 29.93780	085 13 32.45608	101.53
ALLA	CORS	DM5373	32 55 02.64002	085 24 01.77794	238.55

Table 3: GPS Reference Station Coordinates

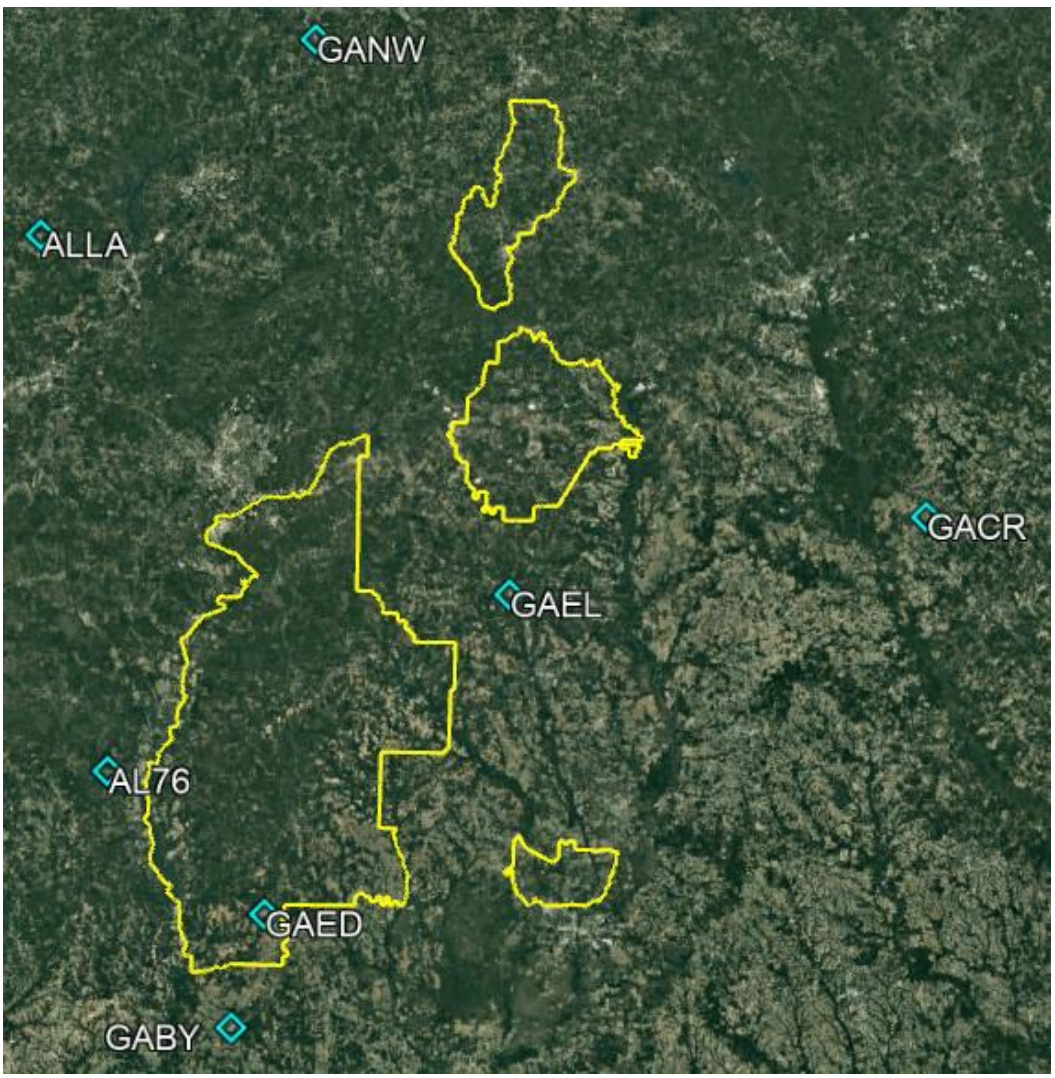

Figure 2: GPS Reference Station(s)

1.9 Airborne GPS Kinematic

Differential GPS unit in aircraft collected positions at 2 Hz. Airborne GPS data was processed using the Inertial Explorer (version 8.60.5025) software. Flights were flown with a minimum of 6 satellites in view (10° above the horizon) and with a PDOP of ≤4 when the laser was online.

For all flights, the GPS data can be classified as good, with GPS 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 GPS, aircraft trajectory, mission information, and ground control files are reviewed and logged into a database.

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

Section 2: Lidar Processing

2.1 Generation of Laser Points

Atlantic used a combination of Waypoint and Leica software products to extract the lidar swath data from the raw flight records. Waypoint Inertial Explorer is used to extract the raw IPAS ABGPS/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 (*.las) formatted swath point clouds.

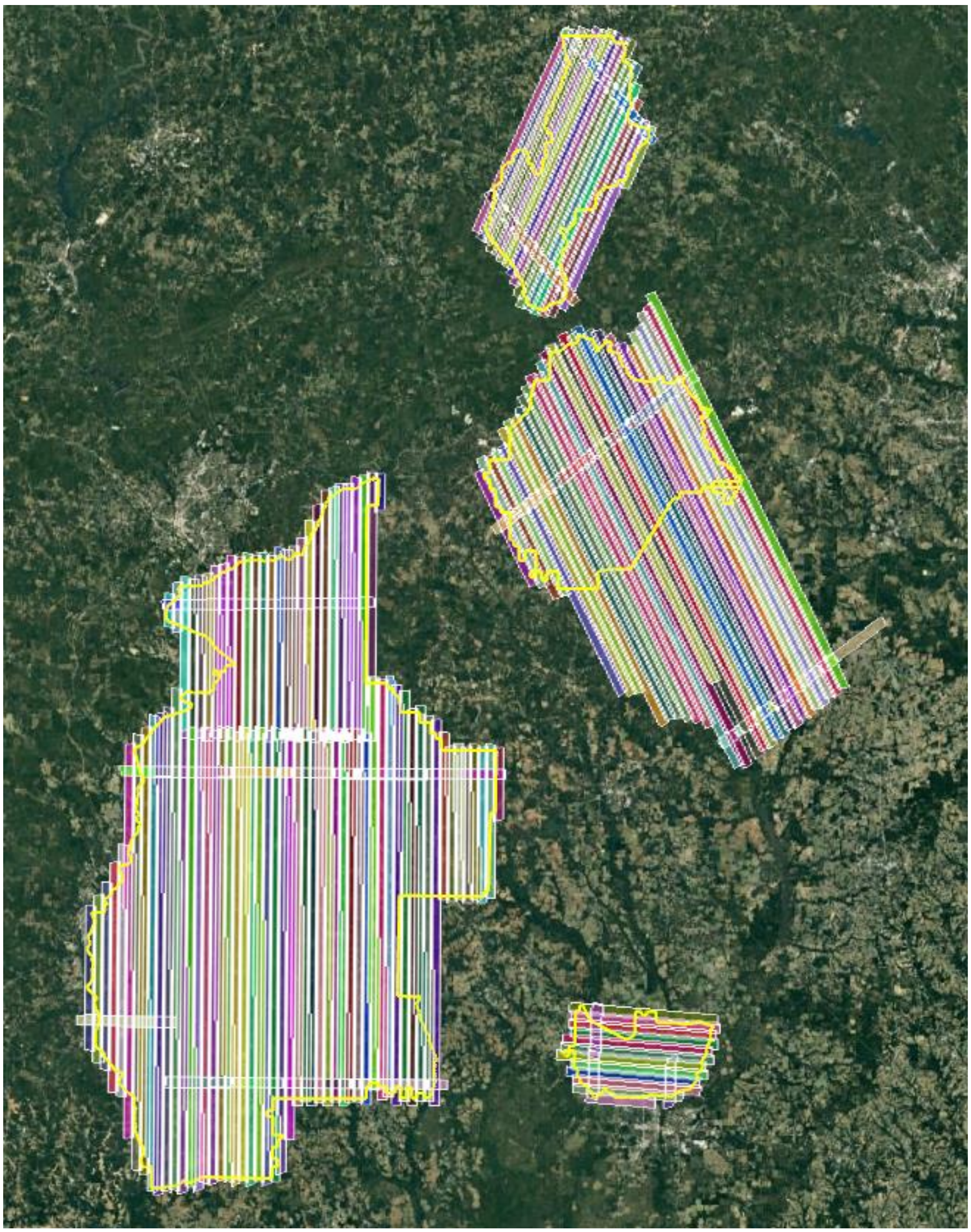

Figure 3: Lidar swath data showing complete coverage

Coordinate Reference System

Horizontal Datum:	North American Datum of 1983 (2011)
Coordinate System:	State Plane
Vertical Datum:	North American Vertical Datum of 1988
Geoid Model:	Geoid12B
Units of Reference:	Horizontal U.S. Survey Feet/Vertical Meters

2.2 Lidar Point Cloud Statistics

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

Point Cloud Statistics	
Category	**Value**
Total Points	51,786,222,802
Nominal Pulse Spacing (m)	0.5399
Nominal Pulse Density (pls/m²)	3.43
Nominal Pulse Spacing (ft)	1.7713
Nominal Pulse Density (pls/ft²)	0.32
Aggregate Total Points	31,057,155,172
Aggregate Nominal Pulse Spacing (m)	0.4116
Aggregate Nominal Pulse Density (pls/m²)	5.90
Aggregate Nominal Pulse Spacing (ft)	1.3504
Aggregate Nominal Pulse Density (pls/ft²)	0.55

Table 4: Lidar Point Cloud Statistics

2.3 Lidar Classification

The calibrated point cloud data from the laser sensor was merged to produce processed (*.las) file(s) including but not limited to 3D position, intensity, and time-stamp. A filtering methodology was utilized to produce a multi-return surface elevation model dataset with bare-earth conditions. GeoCue, TerraScan, and TerraModel software was used for the initial batch processing and manual editing of the (*.las) point clouds. Atlantic utilized collected breakline data to perform classification for classes' 9-Water and 10-Ignored Ground in LP360. Outlined in Table 5 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

Table 5: Point Cloud Classification Scheme

Section 3: Relative Accuracy Assessment

3.1 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 1,957m; the expected radial horizontal positional error will be $RMSE_r$ = 43cm.

3.2 Calibration of Lidar Point Cloud

LiDAR ranging data were initially calibrated using previous best parameters for this instrument and aircraft. Using a combination of GeoCue, and TerraSolid's 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 2 cm or less. A final analysis of the calibrated LiDAR is preformed using a TerraMatch Tie Line report for an overall statistical model of the project area.

3.3 Relative Vertical Accuracy

Upon completion of the data calibration, Atlantic runs a complete set of Delta-Z (dZ) ortho images. 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 interswath accuracy 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.

No Data	0ft to 0.131ft	0.131ft to 0.262ft	0.262ft to 0.393ft	> 0.393ft

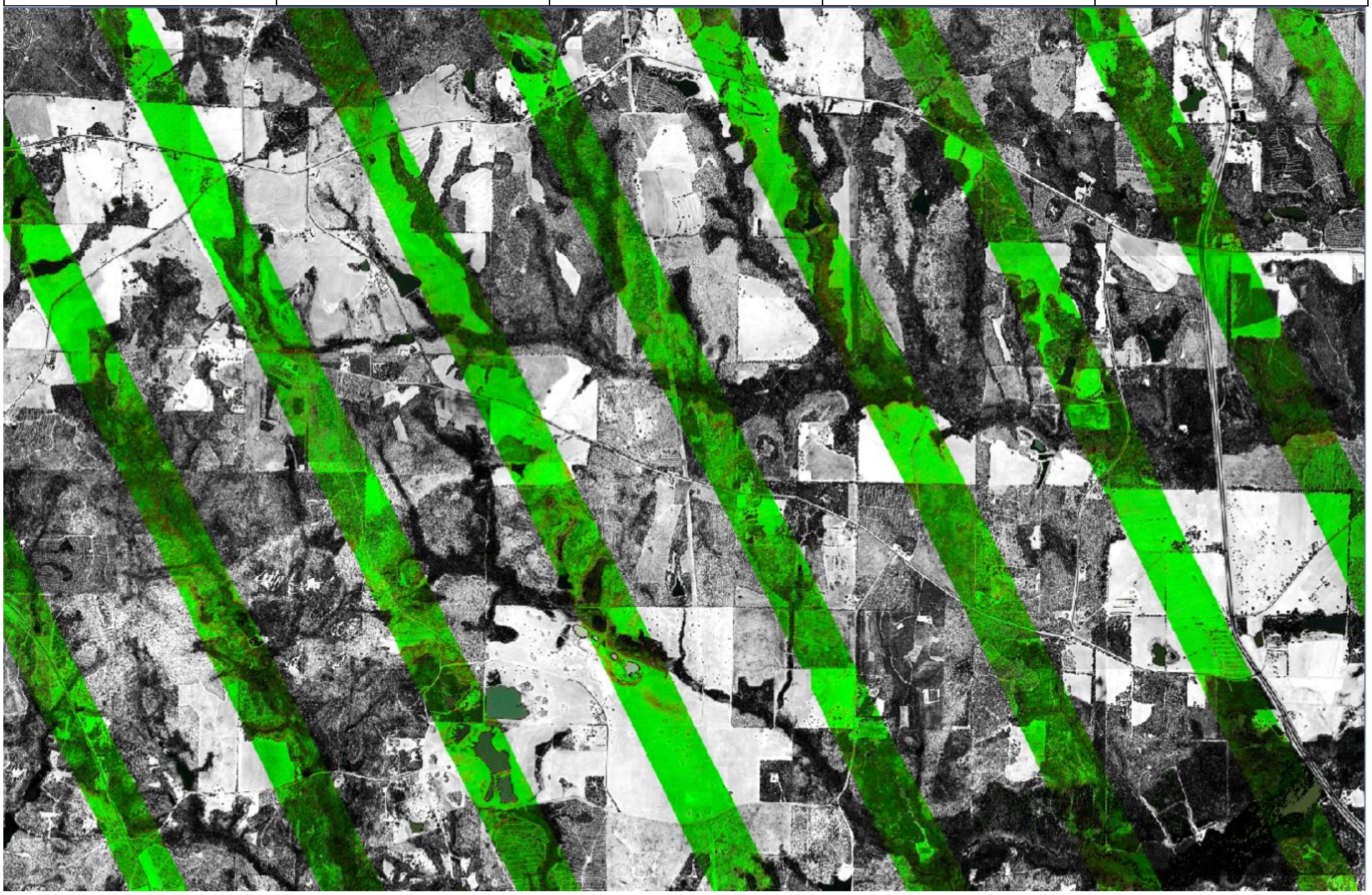

Figure 4: dZ ortho sample

3.4 Interswath Accuracy Results

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

Internal Observation Statistics			
Category	**X**	**Y**	**Z**
Average Magnitude	0.058	0.057	0.055
RMS Values	0.096	0.092	0.080
Maximum Values	0.519	0.517	0.524
Observation Weight	109041.0	109041.0	818925.0

Table 6: Tie Line Observation Statistics

Overall Relative Accuracy	
Category	**Mismatch**
Average 3D Mismatch	0.05523
Average XY Mismatch	0.09714
Average Z Mismatch	0.05492

Table 7: Relative Accuracy Results

TerraMatch Tie Lines	
Category	**Observations**
Section Lines	11,535,869
Roof Lines	48,949

Table 8: Total Tie Lines

Section 4: Vertical Accuracy Assessment

4.1 Ground Surveyed Check Points

Atlantic established a total of fifty -two (52) check points for this project (29 NVA + 23 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.

4.2 Vertical Accuracy

Below are the vertical accuracy reporting requirements for this project:

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 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).

4.3 Check Point Distribution

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

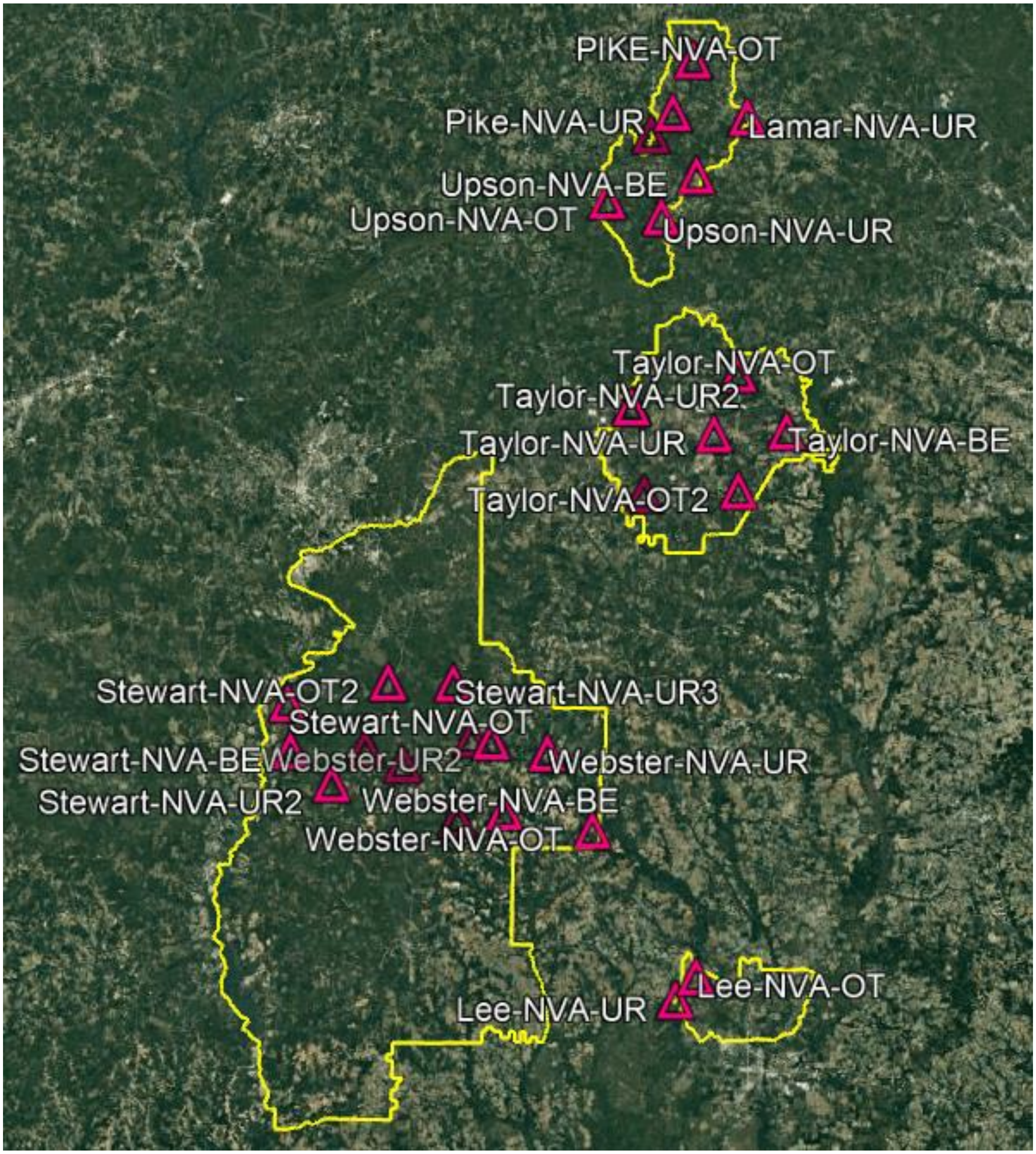

Figure 5: Non-vegetated Vertical Accuracy (NVA) Check Point Distribution

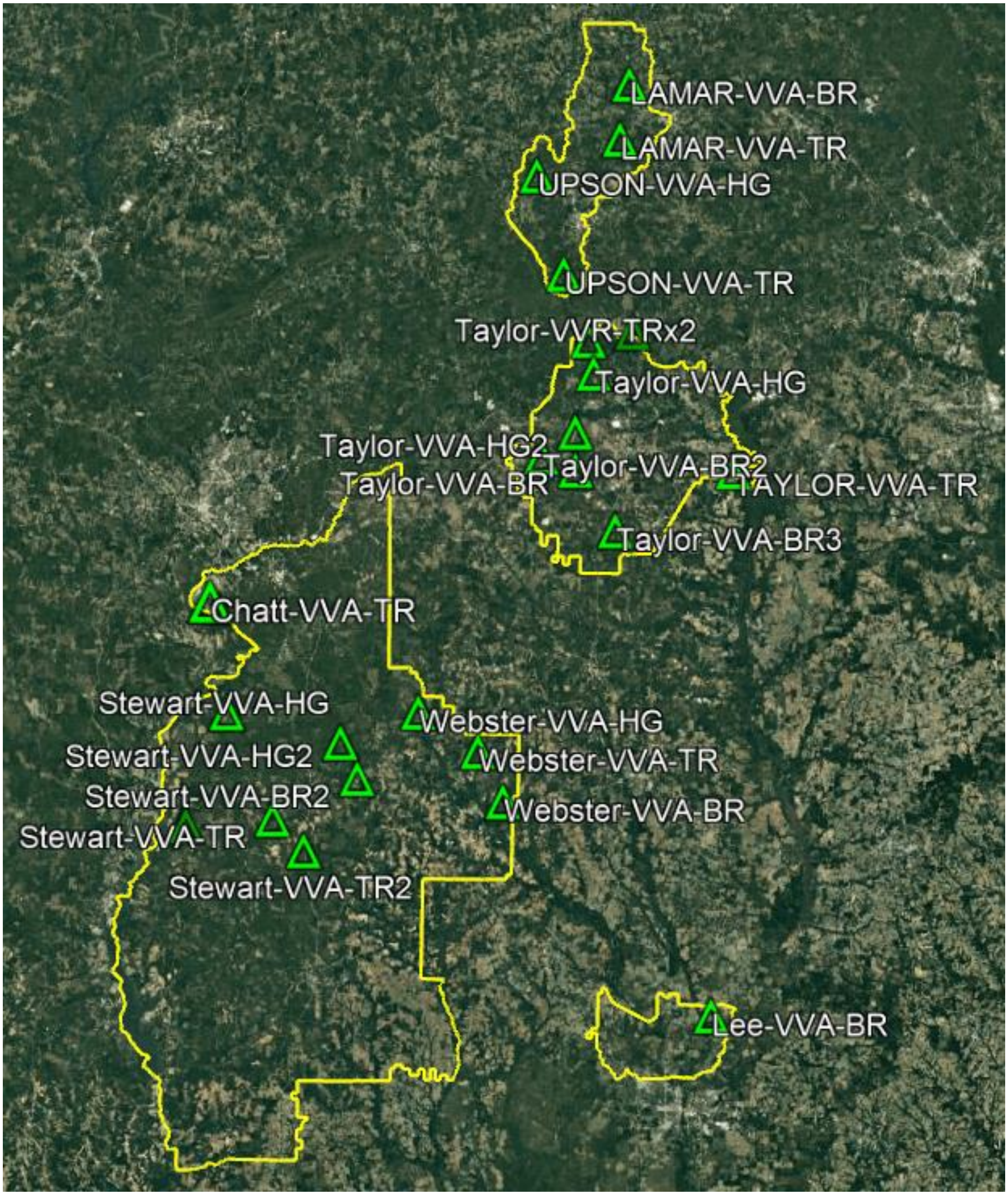

Figure 6: Vegetated Vertical Accuracy (VVA) Check Point Distribution

4.4 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 10, 11, 12, and 13 below. The coordinates provided are in NAD83 (2011), State Plante Georgia West (FIPS 1002) US Feet, NAVD88 (Geoid12B), Meters.

Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (Point Cloud)						
PointID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
Stewart-NVA-BE	2037643.620	753289.710	73.327	73.384	Bare Earth/Open Terrain	-0.057
Taylor-NVA-BE	2316691.322	930677.196	124.514	124.486	Bare Earth/Open Terrain	0.028
Taylor-NVA-BE3	2236599.128	895682.397	193.943	193.929	Bare Earth/Open Terrain	0.014
Webster-NVA-BE	2157563.933	718877.821	152.585	152.470	Bare Earth/Open Terrain	0.115
Pike-NVA-BE	2241386.913	1096836.293	274.326	274.360	Bare Earth/Open Terrain	-0.034
Upson-NVA-BE	2266758.124	1073949.683	240.741	240.819	Bare Earth/Open Terrain	-0.078
Stewart-NVA-OT	2036262.108	779808.319	94.574	94.622	Bare Earth/Open Terrain	-0.048
Stewart-NVA-OT2	2092710.443	791247.499	116.051	116.138	Bare Earth/Open Terrain	-0.087
Stewart-NVA-OT3	2079689.774	754515.303	192.570	192.667	Bare Earth/Open Terrain	-0.097
Stewart-NVA-OT4	2131010.876	715080.465	158.009	158.017	Bare Earth/Open Terrain	-0.009
Taylor-NVA-OT	2289680.196	962972.303	168.059	167.984	Bare Earth/Open Terrain	0.075
Taylor-NVA-OT2	2289531.899	897550.170	154.275	154.393	Bare Earth/Open Terrain	-0.118
Webster-NVA-OT	2206980.622	708203.401	122.543	122.514	Bare Earth/Open Terrain	0.028
Lee-NVA-OT	2264836.507	626085.778	85.548	85.567	Bare Earth/Open Terrain	-0.018
PIKE-NVA-OT	2265159.809	1138598.153	254.923	254.904	Bare Earth/Open Terrain	0.019
Upson-NVA-OT	2216547.159	1059939.143	243.268	243.361	Bare Earth/Open Terrain	-0.093
Stewart-NVA-UR	2100687.325	745627.865	175.218	175.202	Urban	0.016
Stewart-NVA-UR2	2060788.051	734944.182	175.866	175.958	Urban	-0.092
Stewart-NVA-UR3	2129202.885	790623.891	205.817	205.816	Urban	0.001
Stewart-NVA-UR4	2139439.223	759657.944	186.810	186.836	Urban	-0.026
Taylor-NVA-UR	2275948.849	929263.550	190.049	190.043	Urban	0.006
Taylor-NVA-UR2	2229766.507	944422.363	193.976	193.871	Urban	0.105
Taylor-NVA-UR3	2229766.504	944422.379	193.945	193.871	Urban	0.074
Upson-NVA-UR	2246957.361	1050708.137	227.487	227.475	Urban	0.012
Webster-NVA-UR	2181790.943	751503.675	138.850	138.867	Urban	-0.017
Webster-UR2	2150441.392	758115.148	174.327	174.260	Urban	0.067
Lee-NVA-UR	2253226.766	613051.583	84.719	84.728	Urban	-0.009
Lamar-NVA-UR	2295420.703	1106402.818	258.608	258.568	Urban	0.041
Pike-NVA-UR	2253703.023	1109129.163	240.907	240.902	Urban	0.005

Table 10: Lidar Point Cloud NVA Assessment

Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (Bare-Earth)						
PointID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
Stewart-NVA-BE	2037643.620	753289.710	73.327	73.391	Bare Earth/Open Terrain	-0.064
Taylor-NVA-BE	2316691.322	930677.196	124.514	124.499	Bare Earth/Open Terrain	0.016
Taylor-NVA-BE3	2236599.128	895682.397	193.943	193.948	Bare Earth/Open Terrain	-0.005

Webster-NVA-BE	2157563.933	718877.821	152.585	152.482	Bare Earth/Open Terrain	0.103
Pike-NVA-BE	2241386.913	1096836.293	274.326	274.405	Bare Earth/Open Terrain	-0.079
Upson-NVA-BE	2266758.124	1073949.683	240.741	240.843	Bare Earth/Open Terrain	-0.102
Stewart-NVA-OT	2036262.108	779808.319	94.574	94.631	Bare Earth/Open Terrain	-0.058
Stewart-NVA-OT2	2092710.443	791247.499	116.051	116.149	Bare Earth/Open Terrain	-0.098
Stewart-NVA-OT3	2079689.774	754515.303	192.570	192.686	Bare Earth/Open Terrain	-0.116
Stewart-NVA-OT4	2131010.876	715080.465	158.009	158.033	Bare Earth/Open Terrain	-0.024
Taylor-NVA-OT	2289680.196	962972.303	168.059	168.001	Bare Earth/Open Terrain	0.058
Taylor-NVA-OT2	2289531.899	897550.170	154.275	154.409	Bare Earth/Open Terrain	-0.133
Webster-NVA-OT	2206980.622	708203.401	122.543	122.526	Bare Earth/Open Terrain	0.016
Lee-NVA-OT	2264836.507	626085.778	85.548	85.566	Bare Earth/Open Terrain	-0.018
PIKE-NVA-OT	2265159.809	1138598.153	254.923	254.929	Bare Earth/Open Terrain	-0.006
Upson-NVA-OT	2216547.159	1059939.143	243.268	243.318	Bare Earth/Open Terrain	-0.050
Stewart-NVA-UR	2100687.325	745627.865	175.218	175.152	Urban	0.066
Stewart-NVA-UR2	2060788.051	734944.182	175.866	175.905	Urban	-0.039
Stewart-NVA-UR3	2129202.885	790623.891	205.817	205.836	Urban	-0.019
Stewart-NVA-UR4	2139439.223	759657.944	186.810	186.855	Urban	-0.045
Taylor-NVA-UR	2275948.849	929263.550	190.049	190.062	Urban	-0.013
Taylor-NVA-UR2	2229766.507	944422.363	193.976	193.890	Urban	0.085
Taylor-NVA-UR3	2229766.504	944422.379	193.945	193.890	Urban	0.055
Upson-NVA-UR	2246957.361	1050708.137	227.487	227.498	Urban	-0.011
Webster-NVA-UR	2181790.943	751503.675	138.850	138.807	Urban	0.043
Webster-UR2	2150441.392	758115.148	174.327	174.280	Urban	0.047
Lee-NVA-UR	2253226.766	613051.583	84.719	84.721	Urban	-0.002
Lamar-NVA-UR	2295420.703	1106402.818	258.608	258.593	Urban	0.015
Pike-NVA-UR	2253703.023	1109129.163	240.907	240.925	Urban	-0.018

Table 11: Bare-Earth Lidar NVA Assessment

Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (DEM)						
PointID	**Easting**	**Northing**	**KnownZ**	**DEMZ**	**Description**	**DeltaZ**
Stewart-NVA-BE	2037643.620	753289.710	73.327	73.372	Bare Earth/Open Terrain	-0.046
Taylor-NVA-BE	2316691.322	930677.196	124.514	124.504	Bare Earth/Open Terrain	0.010
Taylor-NVA-BE3	2236599.128	895682.397	193.943	193.921	Bare Earth/Open Terrain	0.022
Webster-NVA-BE	2157563.933	718877.821	152.585	152.481	Bare Earth/Open Terrain	0.104
Pike-NVA-BE	2241386.913	1096836.293	274.326	274.400	Bare Earth/Open Terrain	-0.074
Upson-NVA-BE	2266758.124	1073949.683	240.741	240.800	Bare Earth/Open Terrain	-0.059
Stewart-NVA-OT	2036262.108	779808.319	94.574	94.578	Bare Earth/Open Terrain	-0.004
Stewart-NVA-OT2	2092710.443	791247.499	116.051	116.109	Bare Earth/Open Terrain	-0.058
Stewart-NVA-OT3	2079689.774	754515.303	192.570	192.698	Bare Earth/Open Terrain	-0.128
Stewart-NVA-OT4	2131010.876	715080.465	158.009	158.011	Bare Earth/Open Terrain	-0.002
Taylor-NVA-OT	2289680.196	962972.303	168.059	167.991	Bare Earth/Open Terrain	0.068
Taylor-NVA-OT2	2289531.899	897550.170	154.275	154.406	Bare Earth/Open Terrain	-0.131
Webster-NVA-OT	2206980.622	708203.401	122.543	122.498	Bare Earth/Open Terrain	0.045

Lee-NVA-OT	2264836.507	626085.778	85.548	85.625	Bare Earth/Open Terrain	-0.077
PIKE-NVA-OT	2265159.809	1138598.153	254.923	254.933	Bare Earth/Open Terrain	-0.010
Upson-NVA-OT	2216547.159	1059939.143	243.268	243.288	Bare Earth/Open Terrain	-0.020
Stewart-NVA-UR	2100687.325	745627.865	175.218	175.181	Urban	0.037
Stewart-NVA-UR2	2060788.051	734944.182	175.866	175.900	Urban	-0.034
Stewart-NVA-UR3	2129202.885	790623.891	205.817	205.792	Urban	0.025
Stewart-NVA-UR4	2139439.223	759657.944	186.810	186.815	Urban	-0.005
Taylor-NVA-UR	2275948.849	929263.550	190.049	190.037	Urban	0.012
Taylor-NVA-UR2	2229766.507	944422.363	193.976	193.885	Urban	0.090
Taylor-NVA-UR3	2229766.504	944422.379	193.945	193.885	Urban	0.060
Upson-NVA-UR	2246957.361	1050708.137	227.487	227.476	Urban	0.011
Webster-NVA-UR	2181790.943	751503.675	138.850	138.796	Urban	0.054
Webster-UR2	2150441.392	758115.148	174.327	174.244	Urban	0.084
Lee-NVA-UR	2253226.766	613051.583	84.719	84.782	Urban	-0.062
Lamar-NVA-UR	2295420.703	1106402.818	258.608	258.578	Urban	0.031
Pike-NVA-UR	2253703.023	1109129.163	240.907	240.884	Urban	0.023

Table 12: Bare=Earth DEM NVA Assessment

Vegetated Vertical Accuracy (VVA) Check Point Assessment (Bare Earth)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
Stewart-VVA-BR2	2127118.173	752665.288	183.880	184.148	Brush	-0.267
Webster-VVA-BR	2206023.228	739911.014	120.839	120.987	Brush	-0.148
LAMAR-VVA-BR	2276042.849	1126809.593	230.746	230.857	Brush	-0.111
Lee-VVA-BR	2318560.236	623760.540	76.323	76.537	Brush	-0.213
Taylor-VVA-BR3	2267342.508	885696.078	131.093	131.205	Brush	-0.112
Stewart-VVA-HG	2056564.718	788202.226	121.696	121.895	High Grass	-0.199
Stewart-VVA-HG2	2118086.215	772034.526	177.398	177.466	High Grass	-0.068
Taylor-VVA-HG	2256002.711	970543.976	205.964	206.178	High Grass	-0.214
Taylor-VVA-HG2	2245959.136	938815.026	193.556	193.741	High Grass	-0.185
Webster-VVA-HG	2160347.742	788141.984	172.956	172.961	High Grass	-0.005
UPSON-VVA-HG	2225627.328	1077470.732	242.464	242.614	High Grass	-0.150
Stewart-VVA-TR	2081162.286	730849.328	127.844	127.962	Trees	-0.118
Stewart-VVA-TR2	2097936.855	713748.815	141.309	141.304	Trees	0.005
Upson-VVA-TR	2277230.259	992681.326	112.594	112.723	Trees	-0.129
Taylor-VVR-TRx2	2253287.990	988290.804	140.490	140.621	Trees	-0.131
Webster-VVA-TR	2192546.807	767001.637	124.898	124.901	Trees	-0.003
Chatt-VVA-TR	2047718.911	848308.073	75.806	75.942	Trees	-0.137
LAMAR-VVA-TR	2270822.461	1096990.001	221.248	221.276	Trees	-0.028
TAYLOR-VVA-TR	2331473.299	917332.391	96.532	96.665	Trees	-0.132
UPSON-VVA-TR	2239989.653	1024217.117	171.614	171.732	Trees	-0.118

Table 13: Bare-Earth Lidar VVA Assessment

4.5 Vertical Accuracy Results

An overall statistical assessment of the check points can be found in Tables 14 and 15 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	29	0.061	0.119	
NVA of Bare Earth	29	0.061	0.119	
NVA of DEM	29	0.060	0.117	
VVA of Bare Earth	20	0.143		0.216

Table 14: Non-vegetated Vertical Accuracy (NVA) and Vegetated Vertical Accuracy (VVA)

Vegetated Vertical Accuracy (VVA) 5% Outliers > 95th Percentile (0.287m)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
Stewart-VVA-BR	2034109.894	727348.022	123.933	124.224	Brush	-0.291
Taylor-VVA-BR	2245947.050	918301.261	165.885	165.983	Brush	-0.098
Taylor-VVA-BR2	2227443.245	925448.988	204.611	204.901	Brush	-0.290

Table 15: 5% Outlier Check Points

Section 5: Certification

5.1 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 National Oceanic and Atmospheric Administration (NOAA)/ Georgia Department of Natural Resources (GDNR).

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.

B. Mayfield

Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276

American Society for Photogrammetry and Remote Sensing
BRIAN MAYFIELD
CERTIFIED
PHOTOGRAMMETRIST
(ASPRS) NO. R1276
Exp. 11/2/2020

Section 6: GPS Processing

Inertial Explorer Version 8.60.5025

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

Coverage Map	The Coverage Map plot shows the Aircraft GPS-IMU Trajectory in reference to localized GPS 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.

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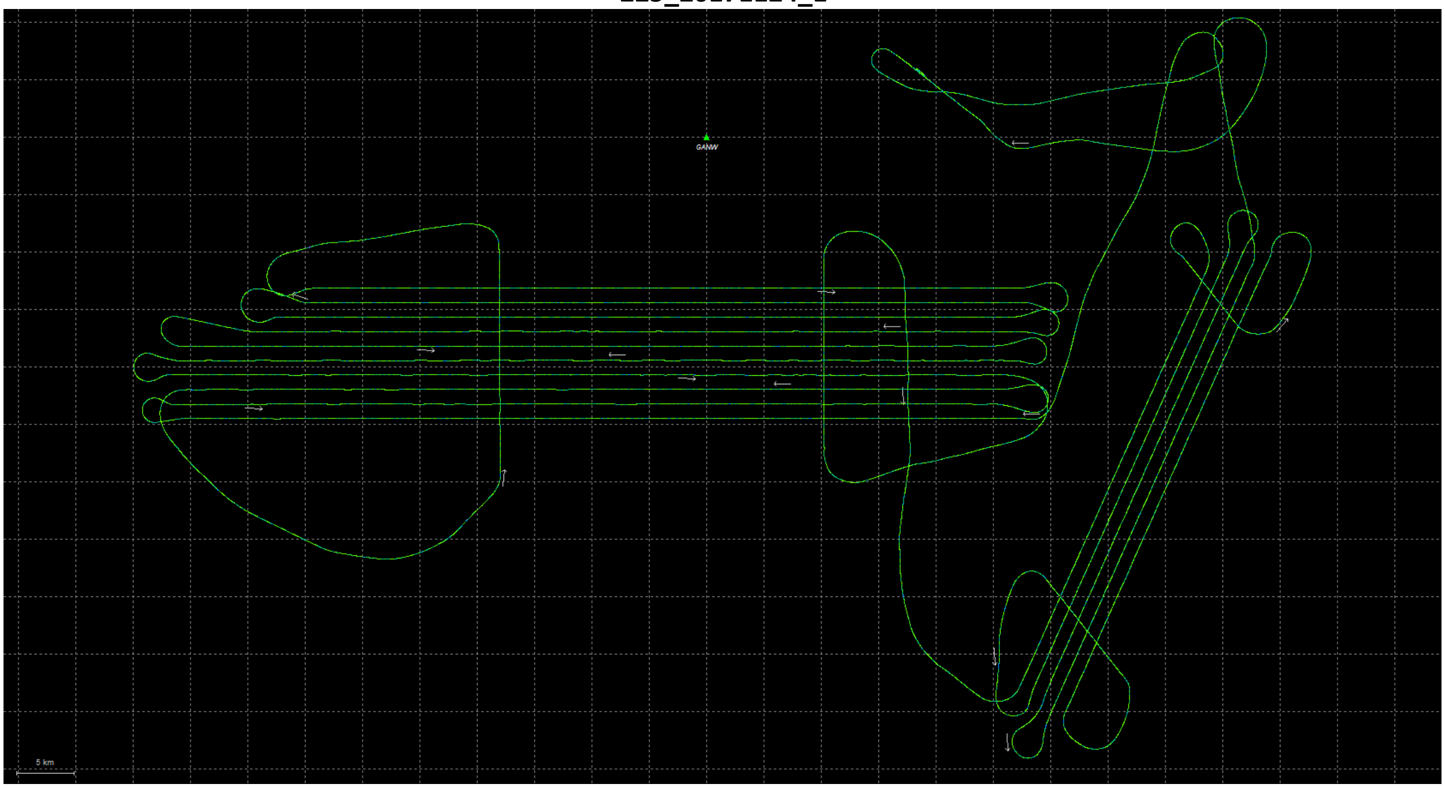

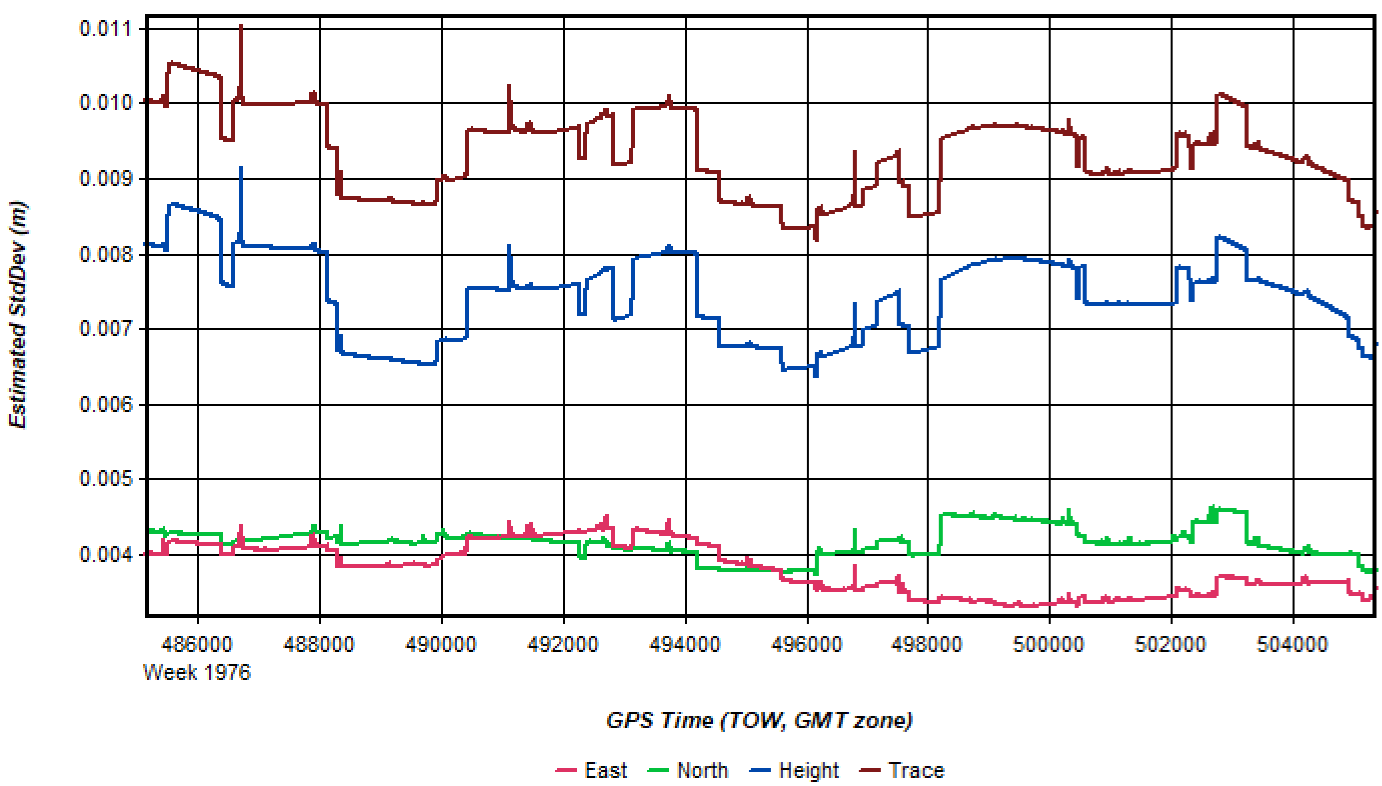

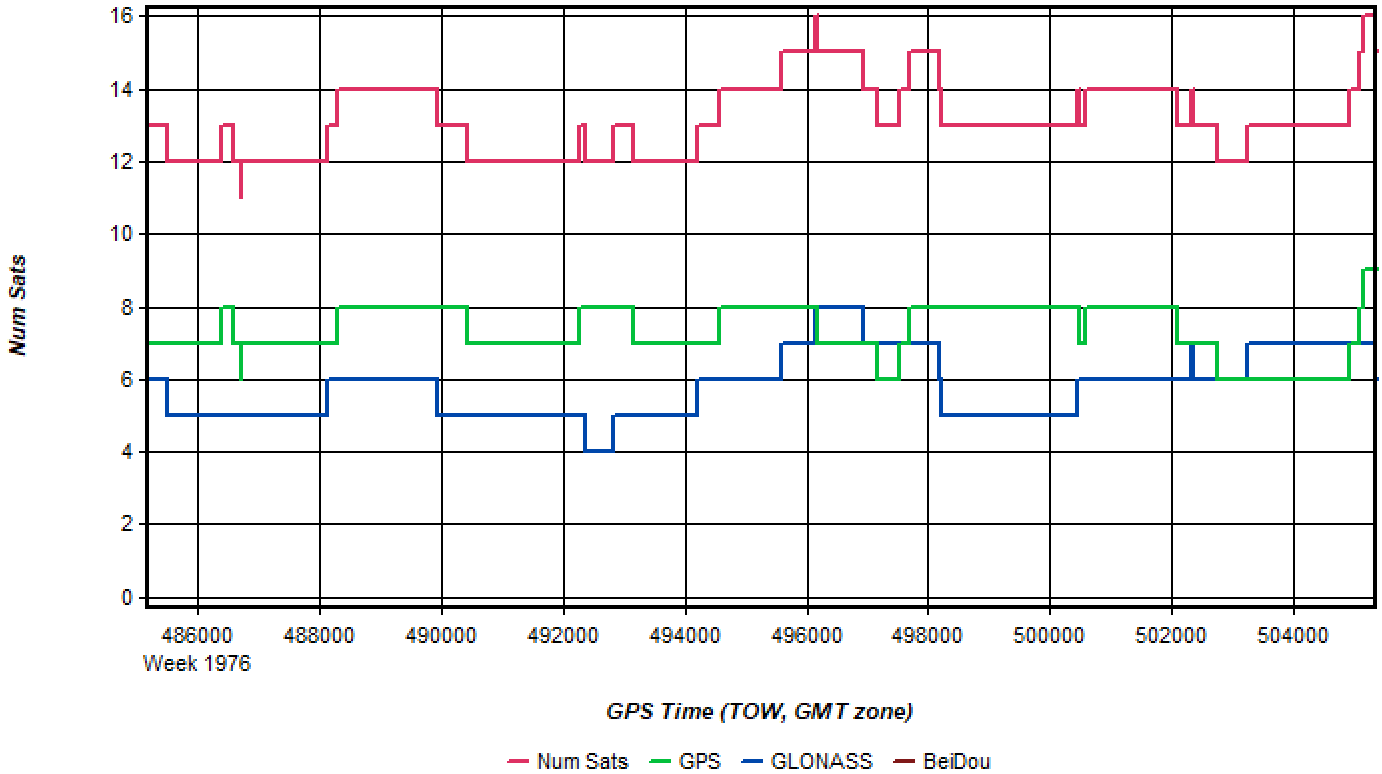
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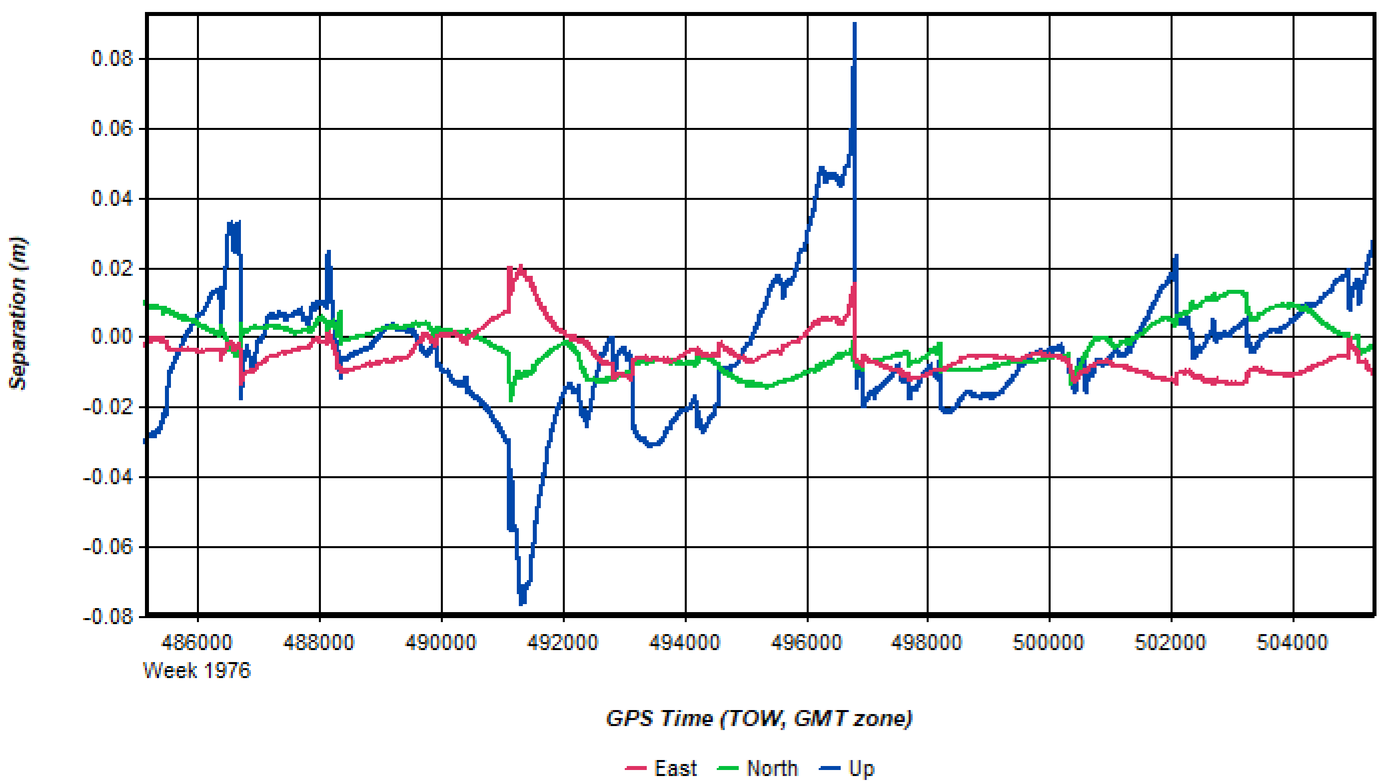
Num Sats
GPS
GLONASS
BeiDou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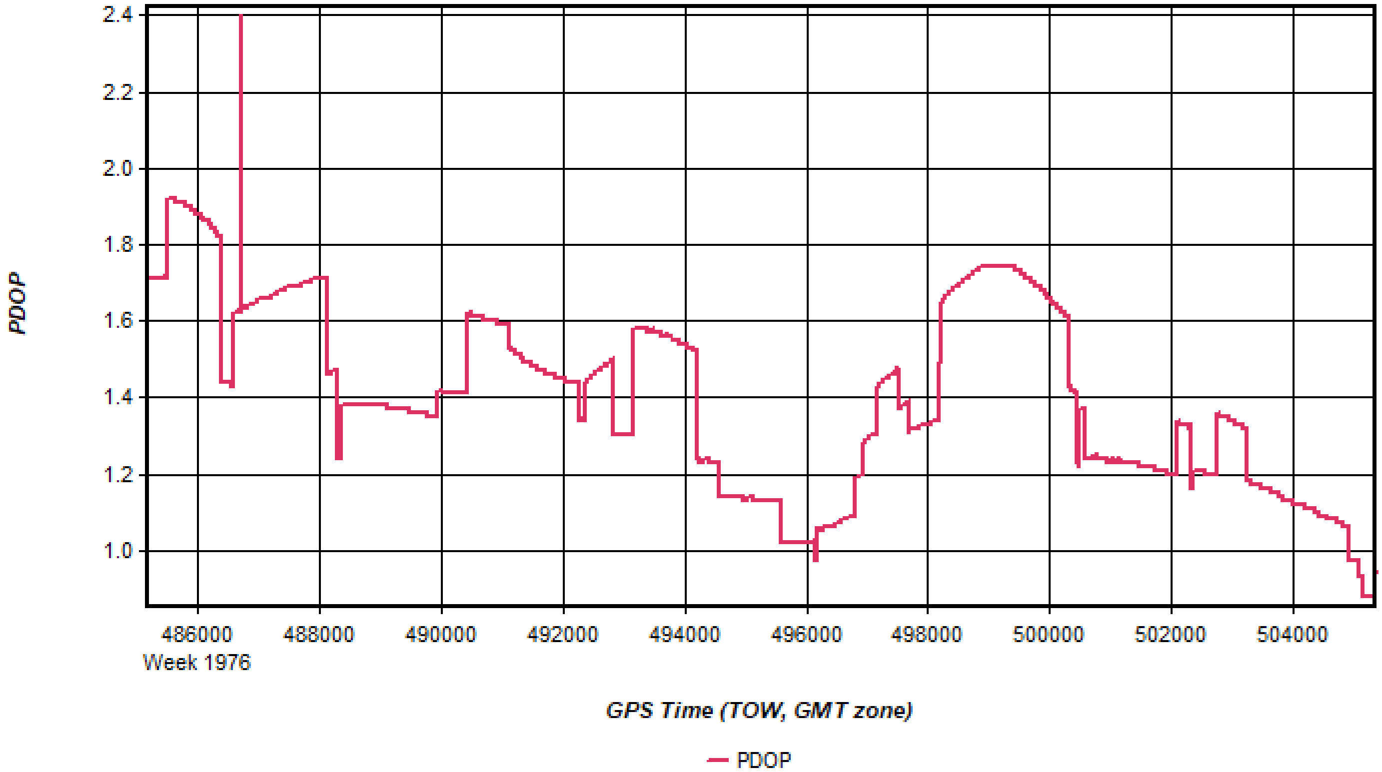
Week 1976
GPS Time (TOW, GMT zone)
East
North
Up



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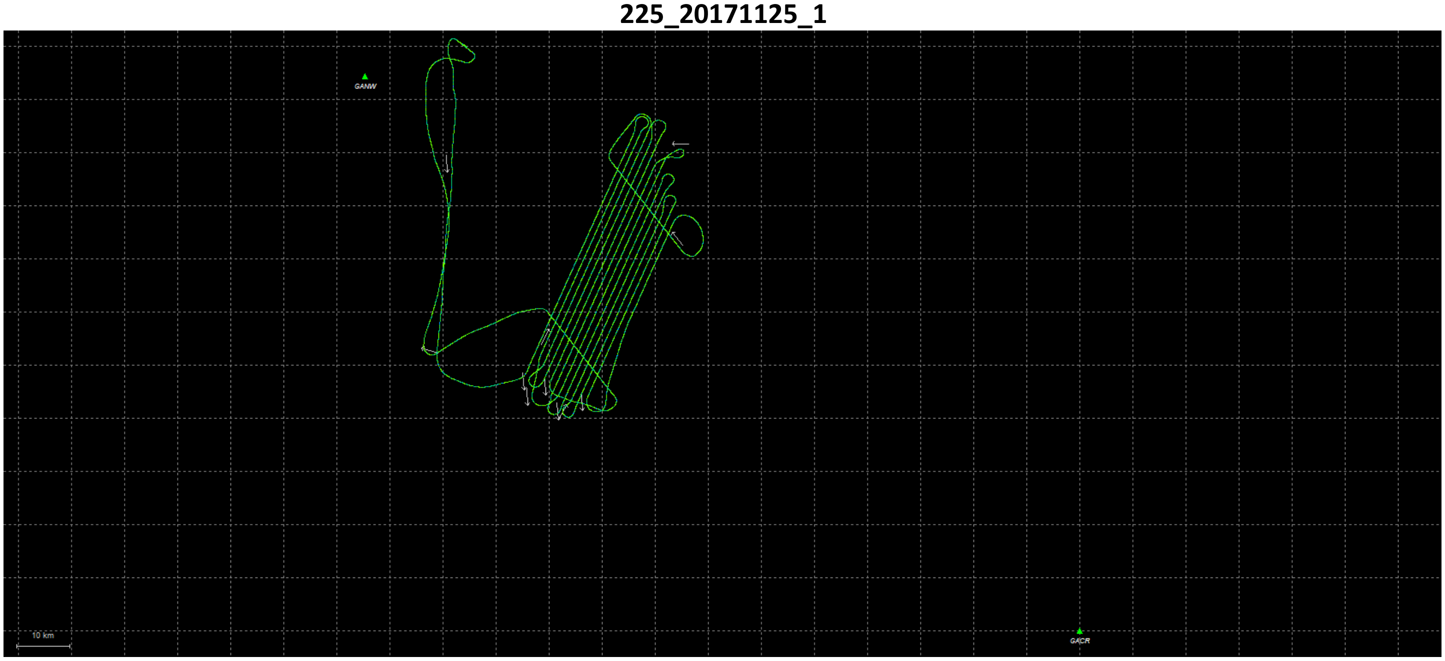

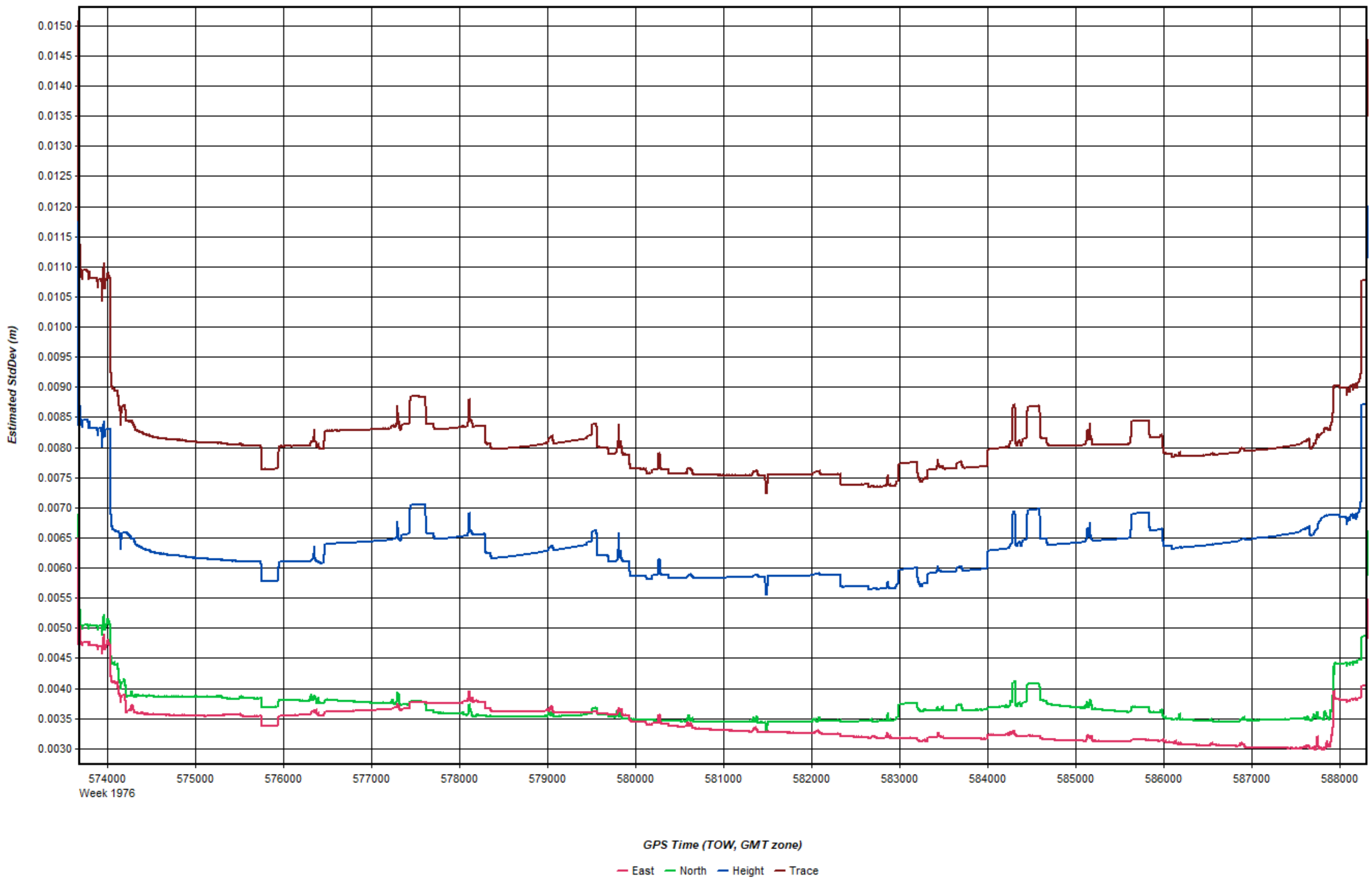
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0.0090
0.0085
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0.0075
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0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
0.0035
0.0030
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Week 1976
575000
576000
577000
578000
579000
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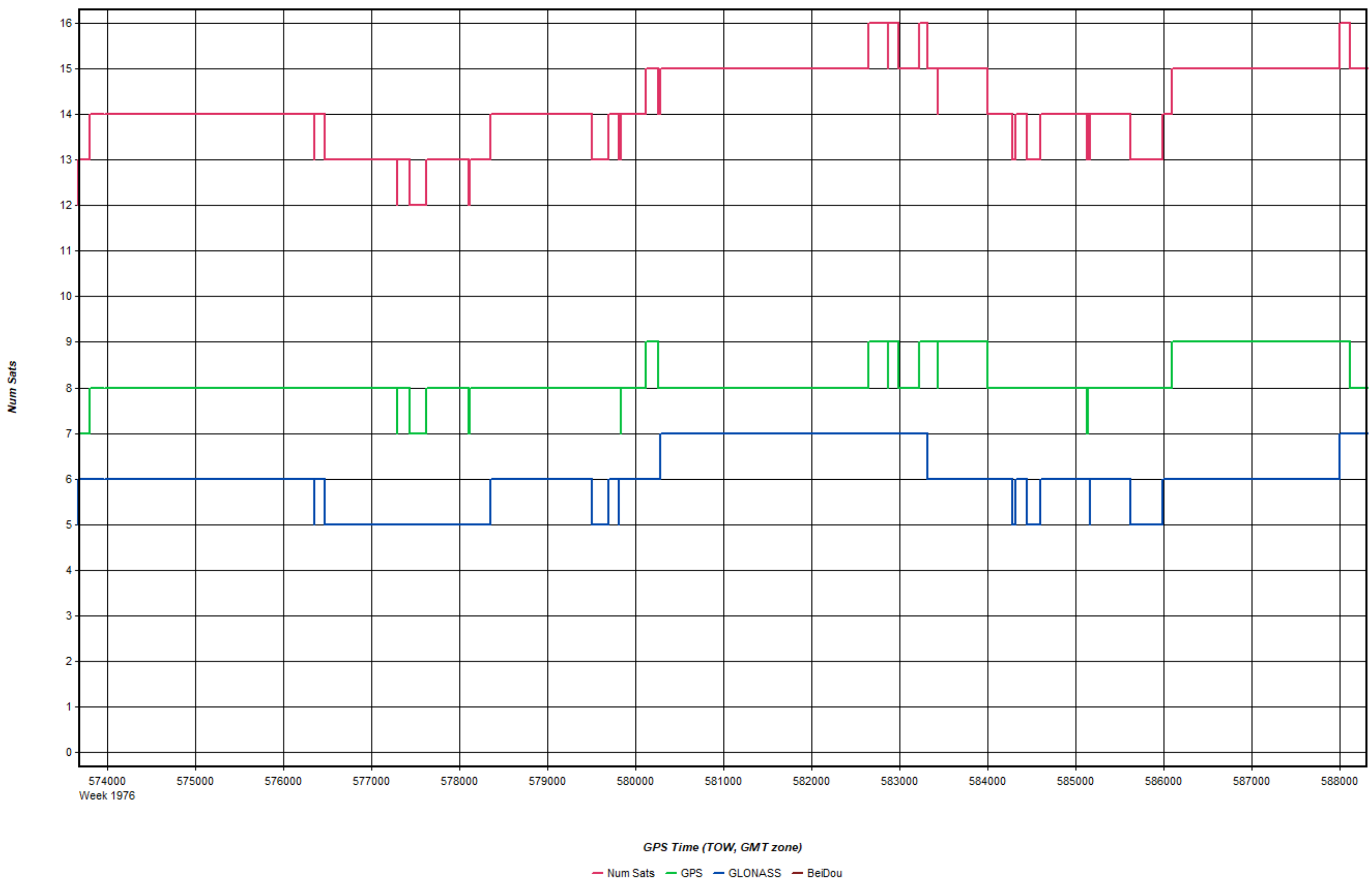
North
Height
Trace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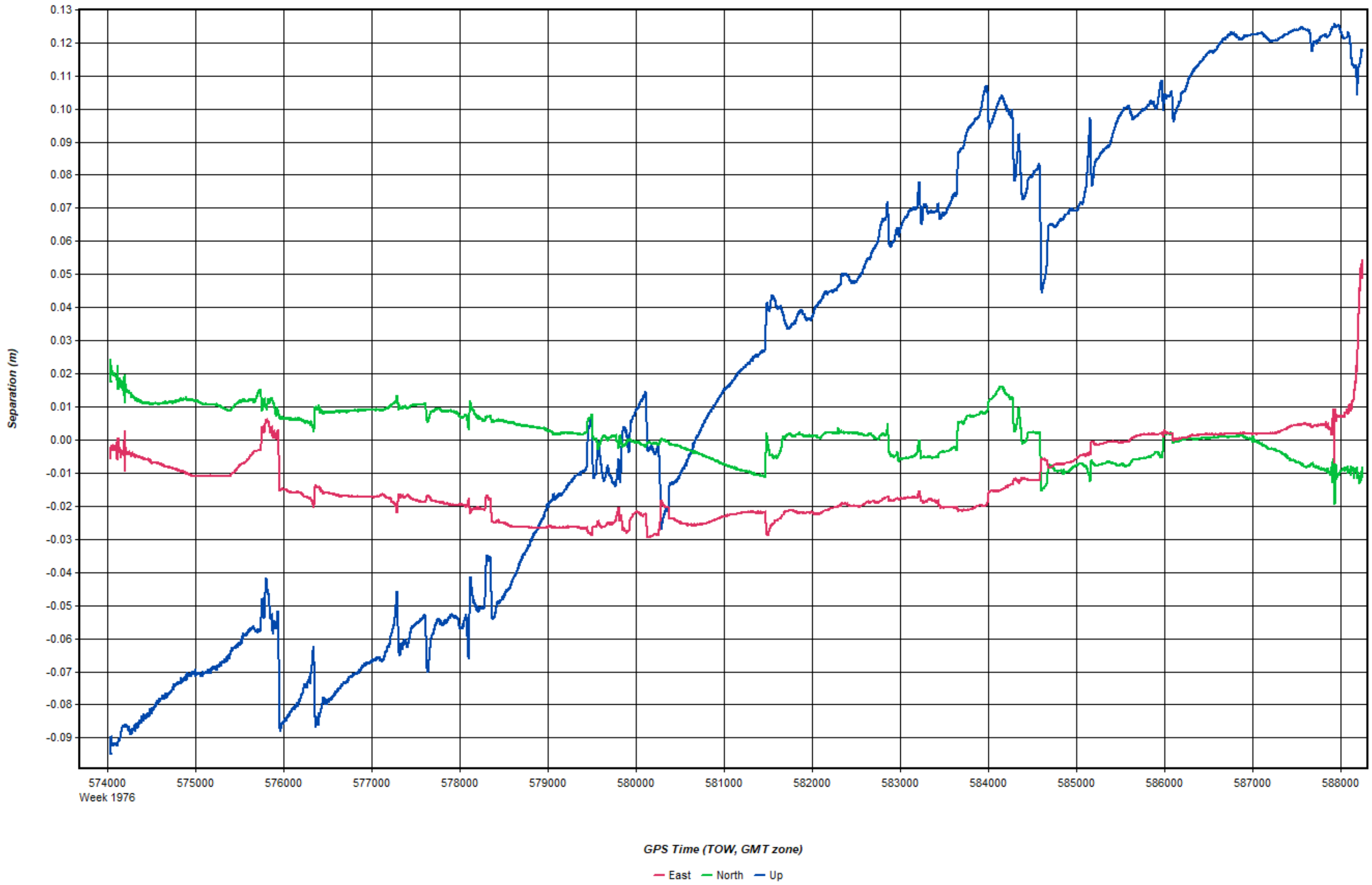
GPS
GLONASS
BeiDou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0.00
-0.01
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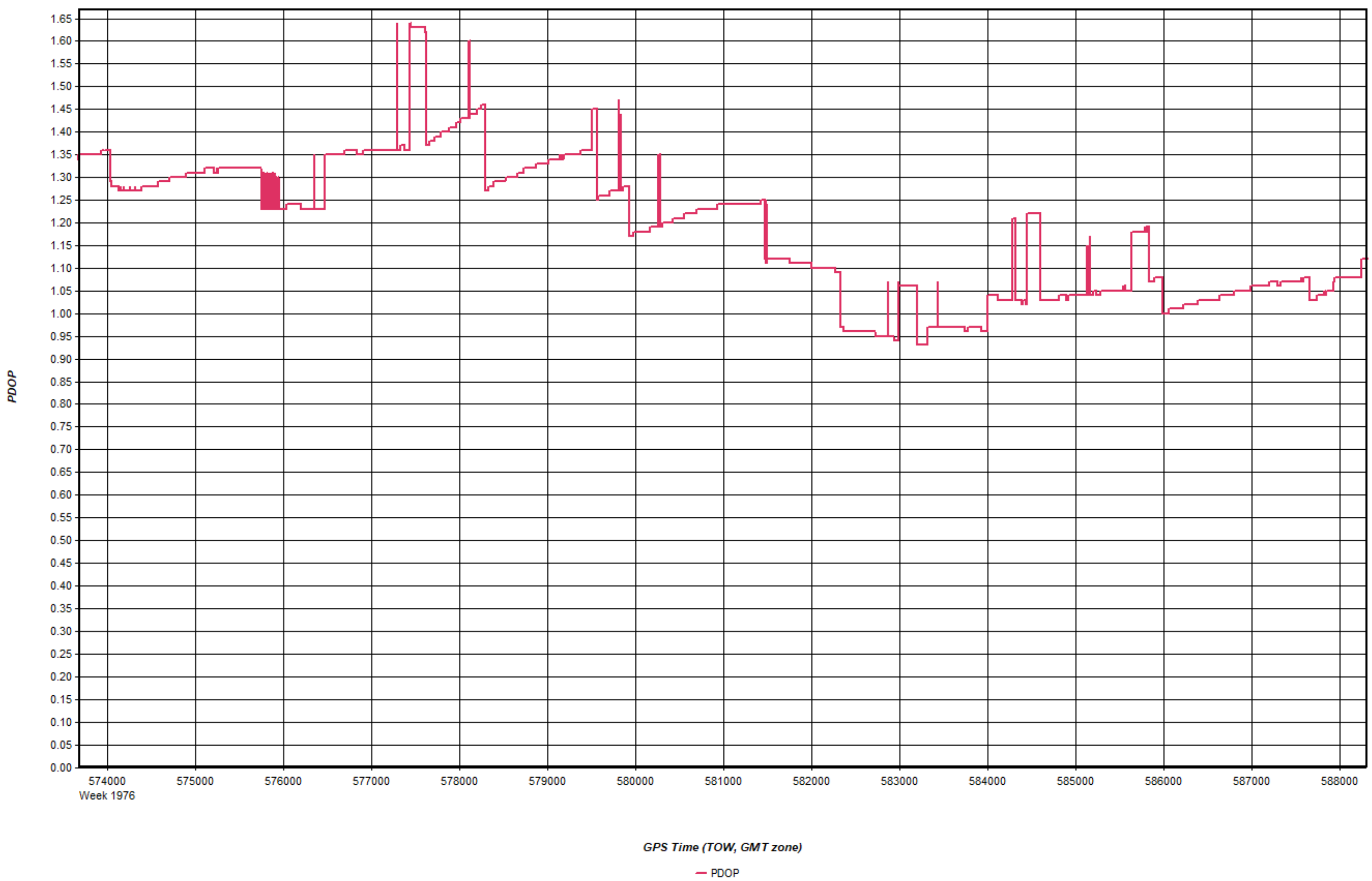
GPS Time (TOW, GMT zone)
East
North
Up



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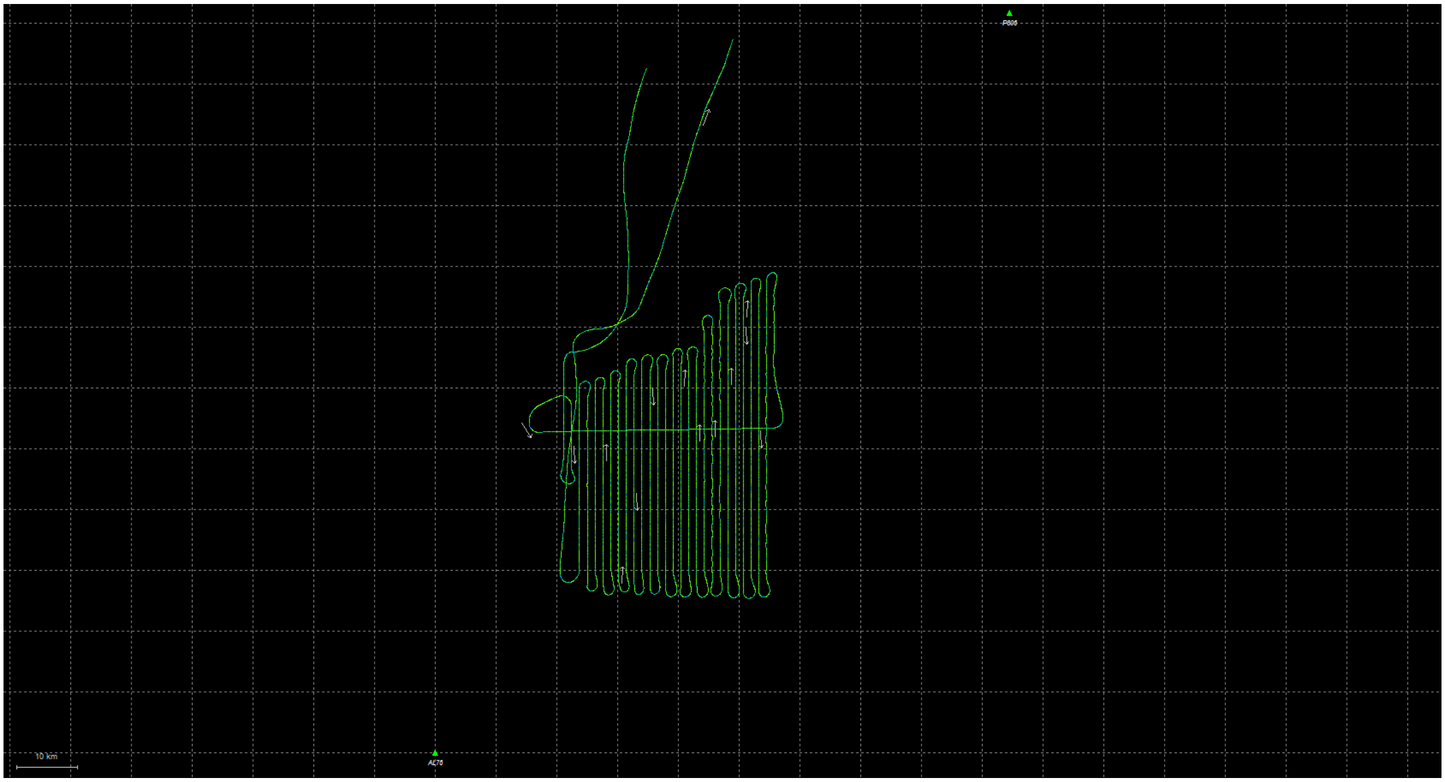

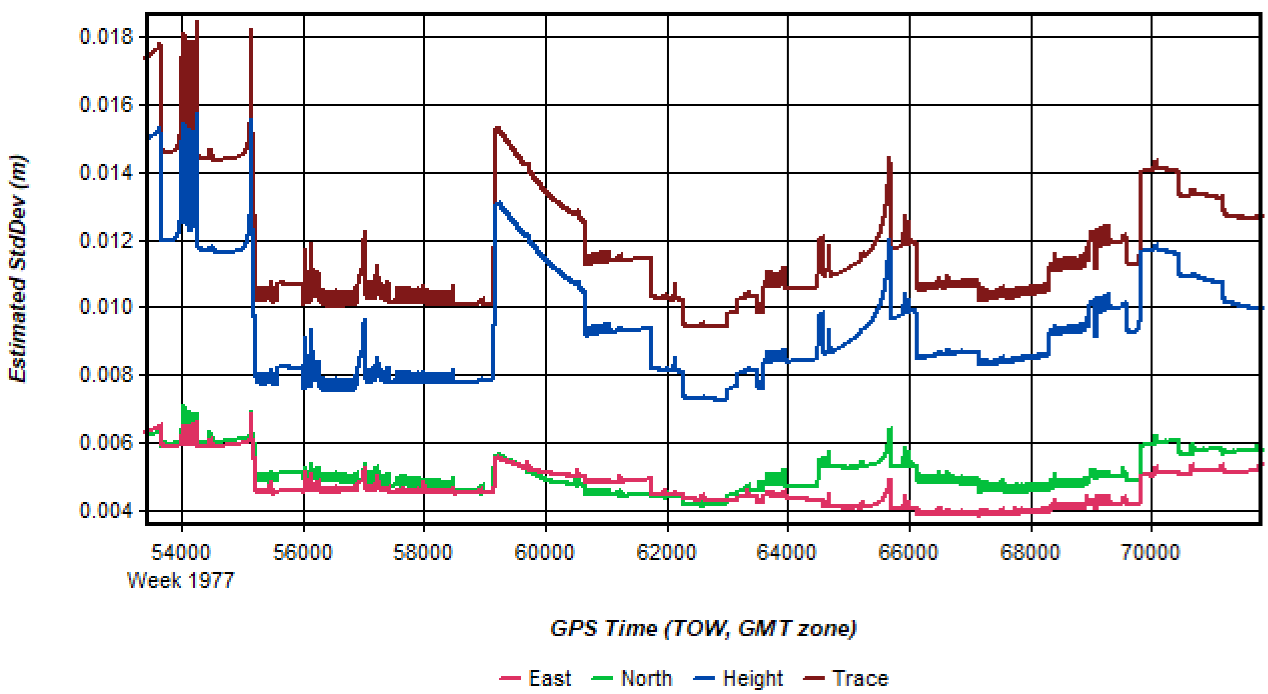
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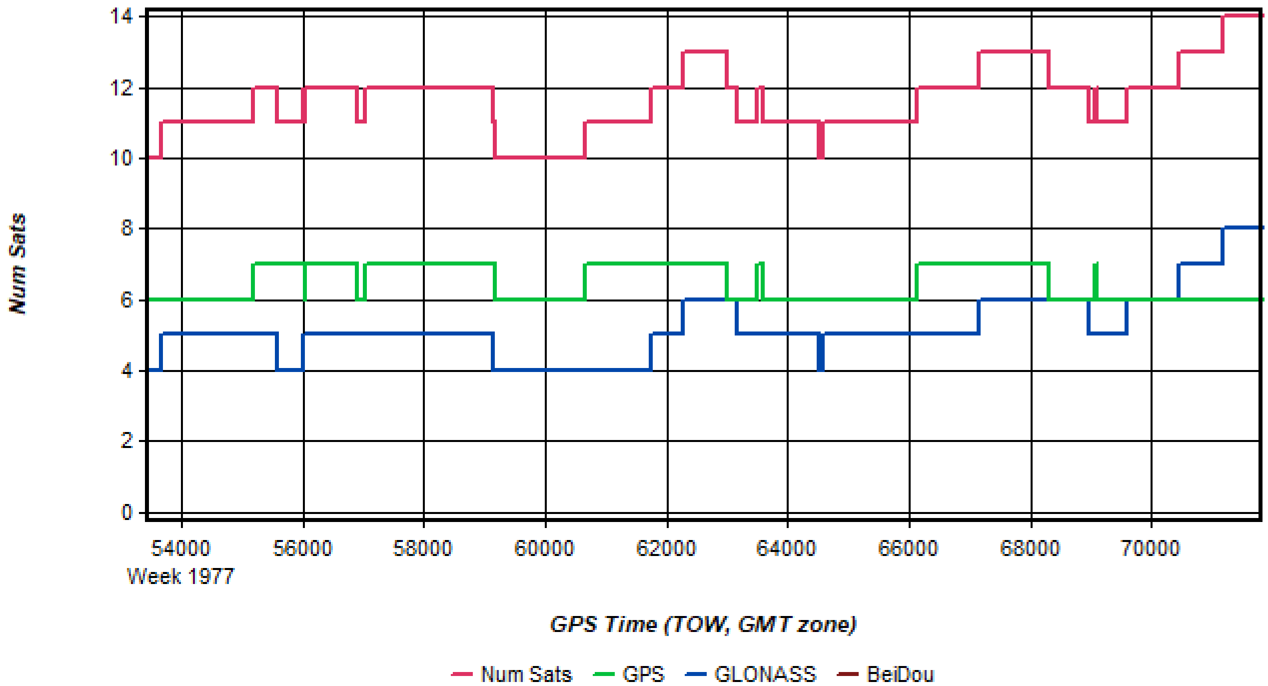
East
North
Height
Trace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GPS
GLONASS
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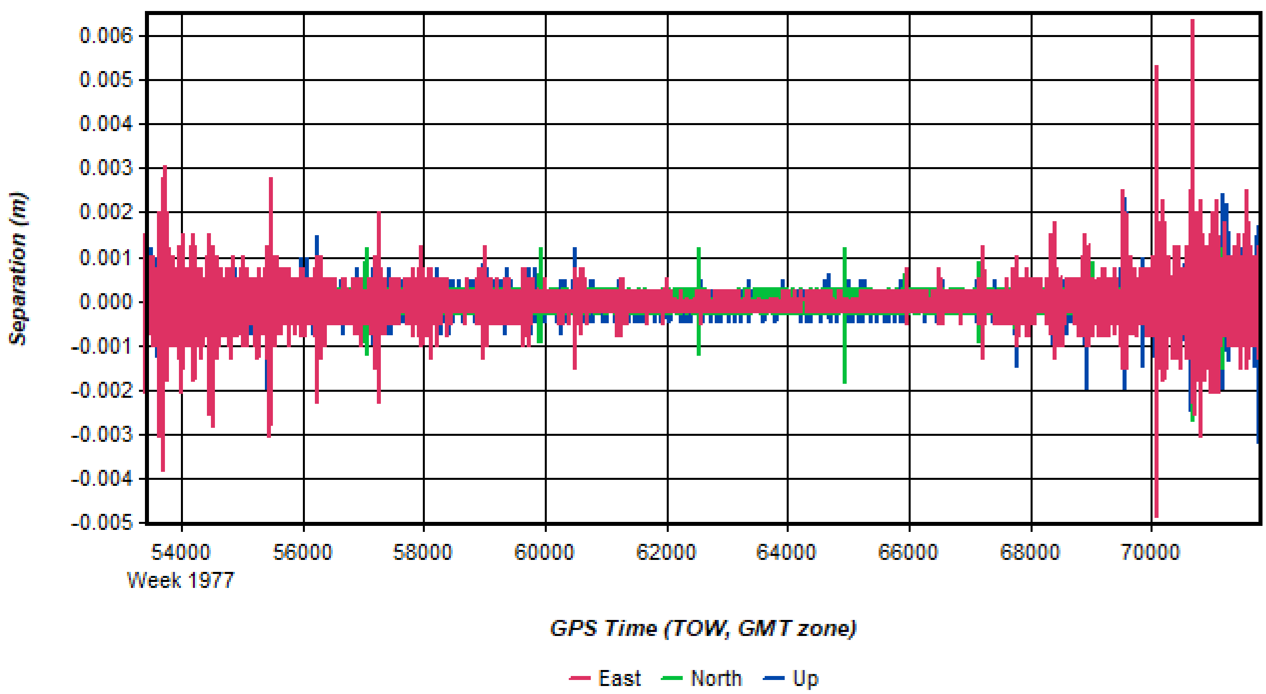
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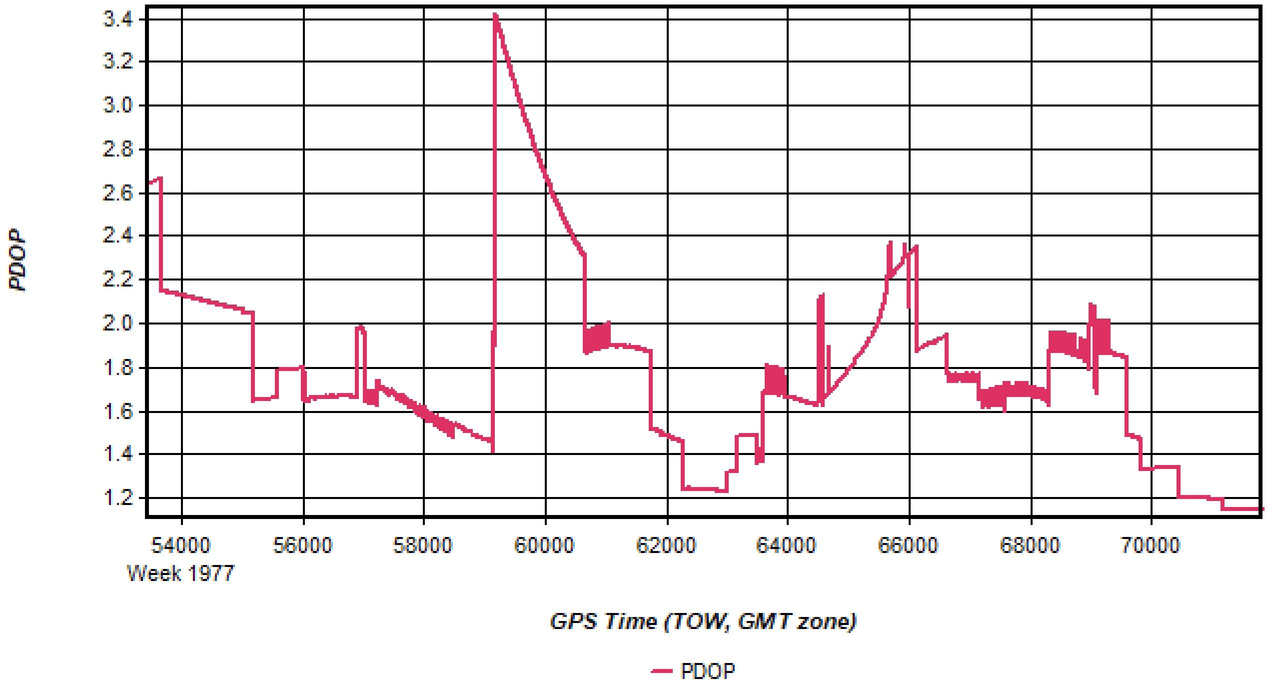
East
North
Up



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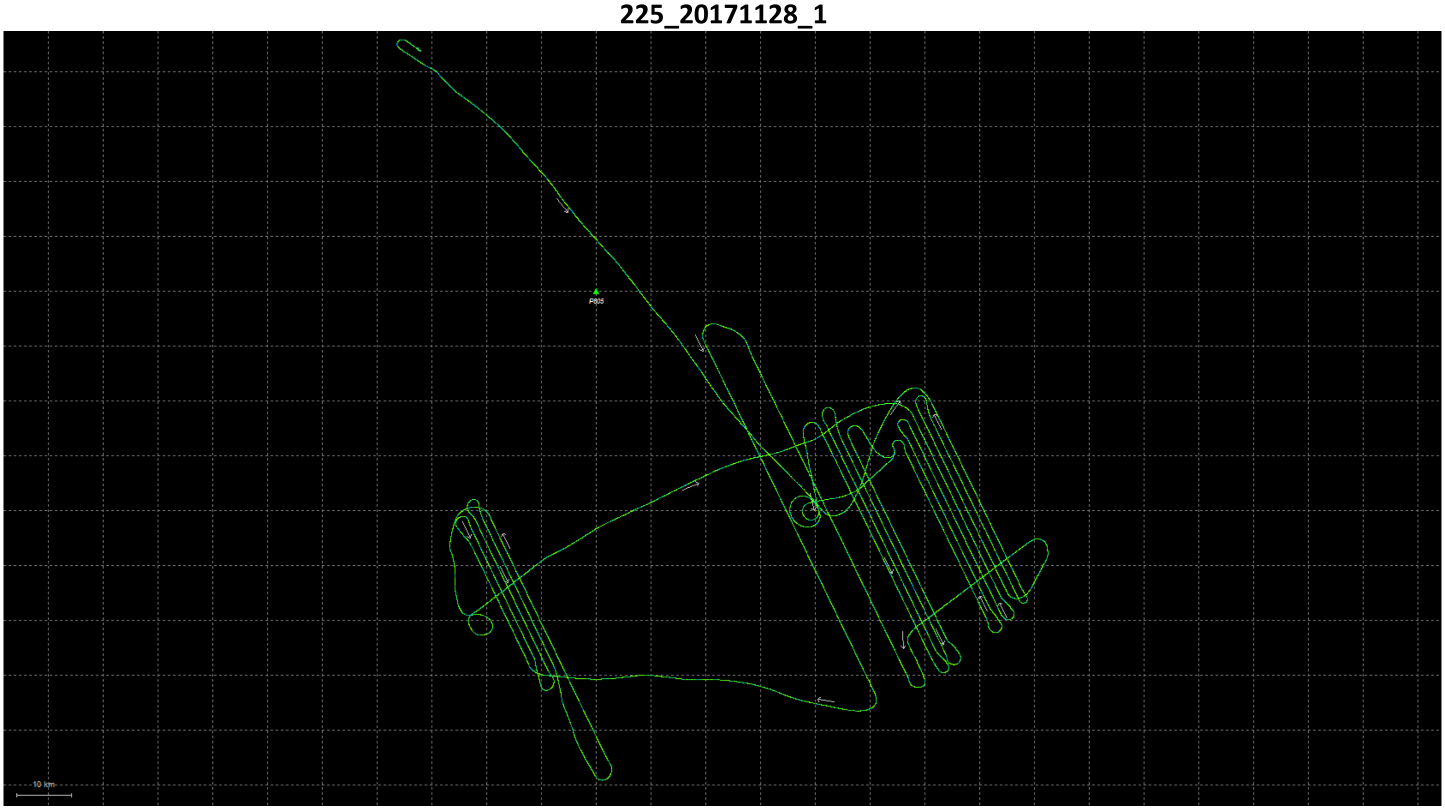

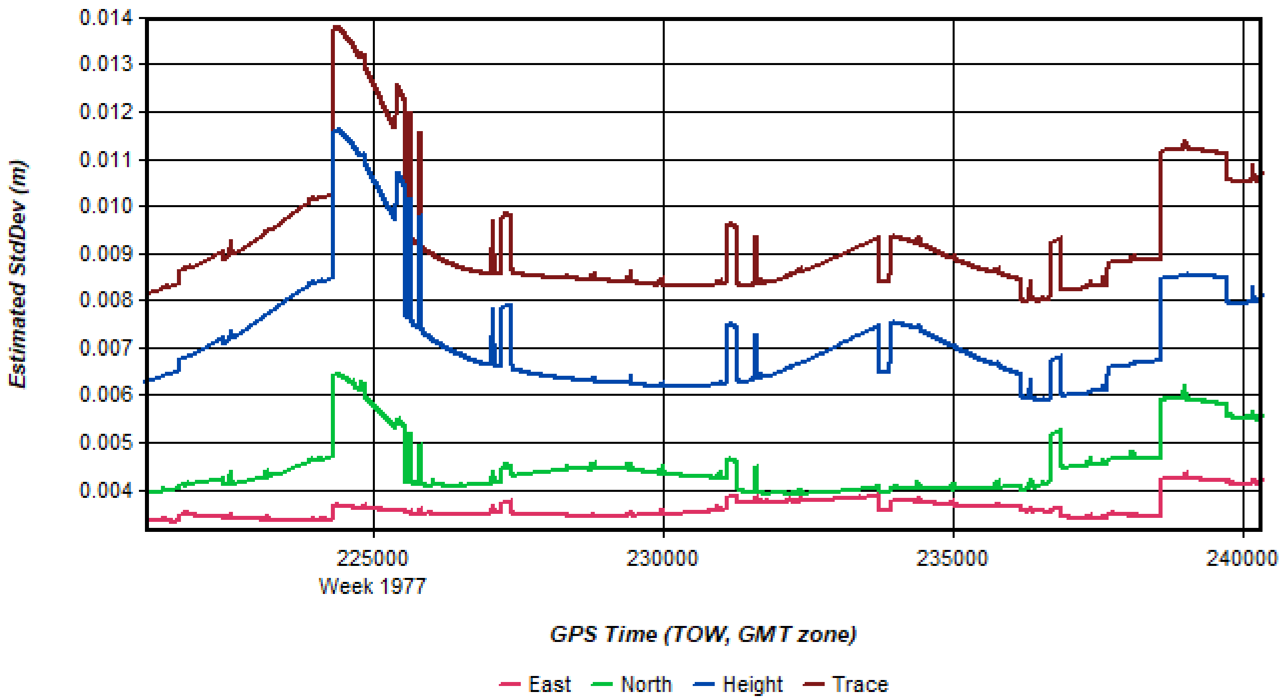
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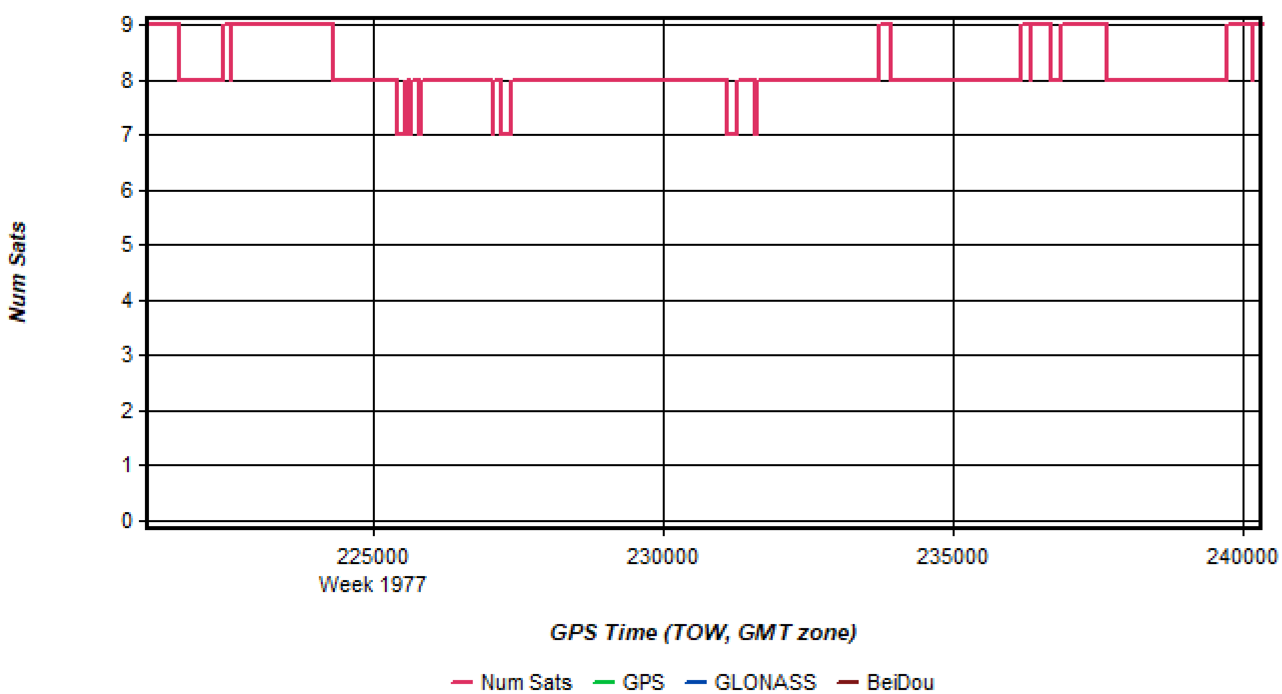
GPS Time (TOW, GMT zone)
East
North
Height
Trace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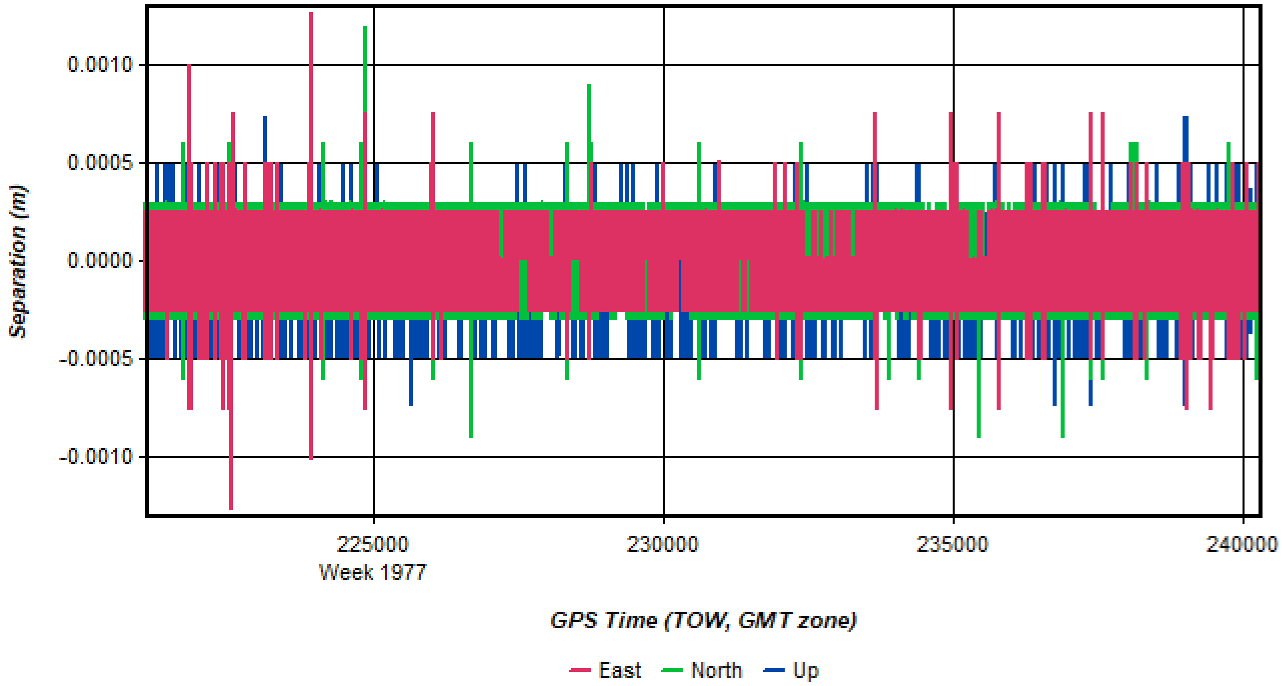
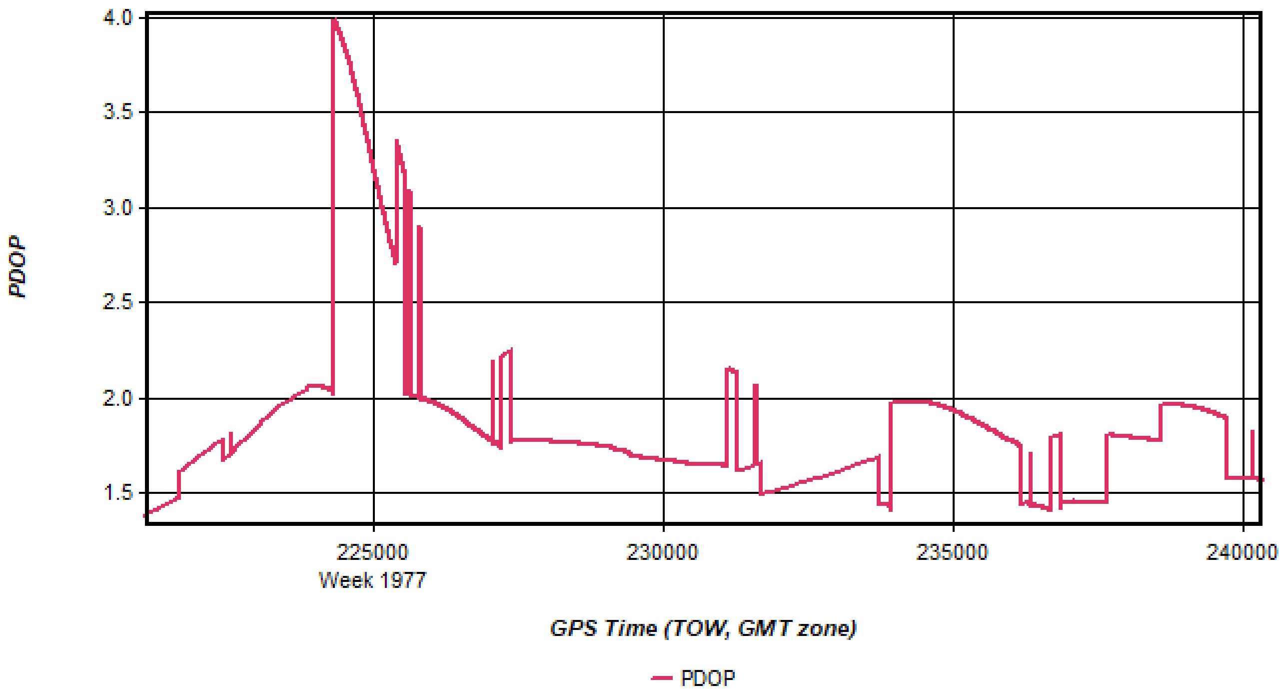
GPS
GLONASS
BeiDou





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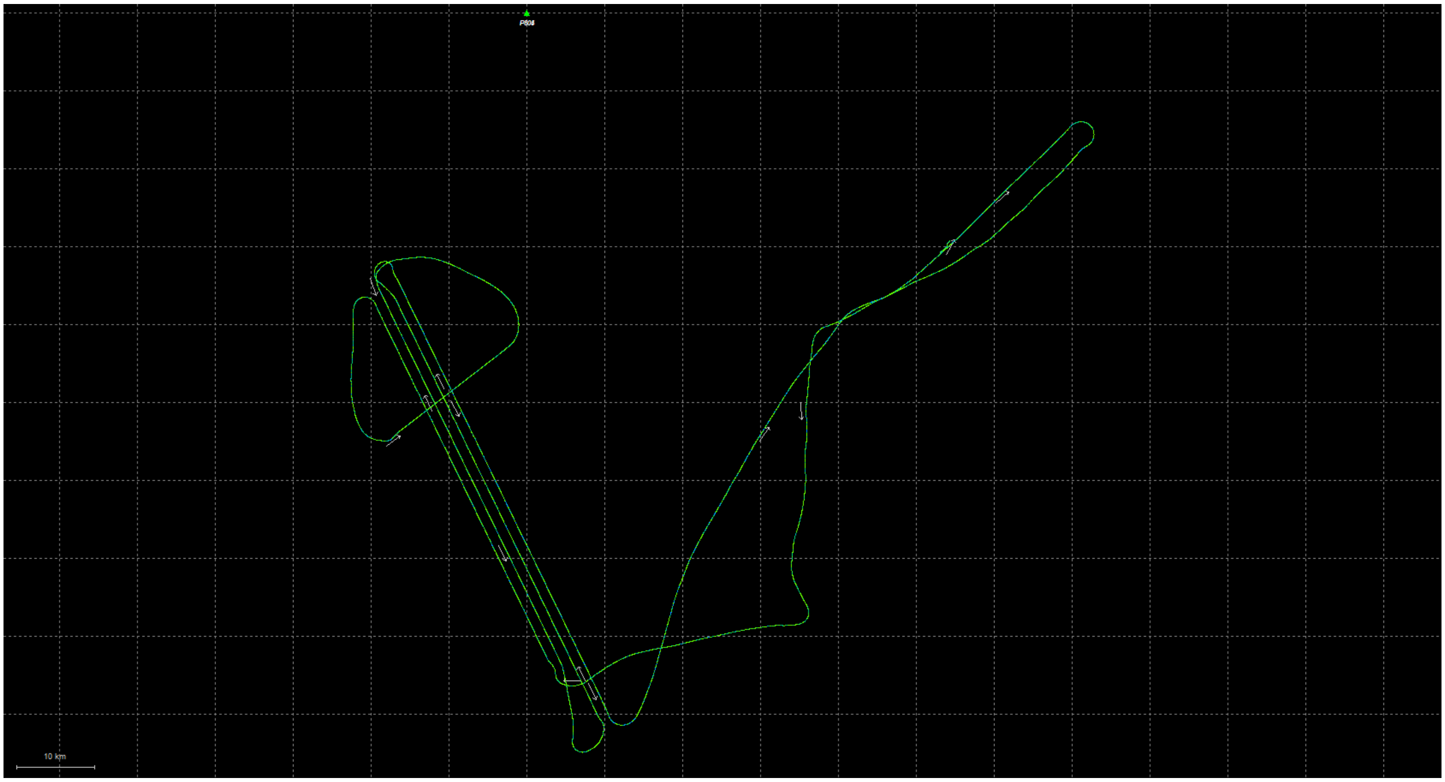

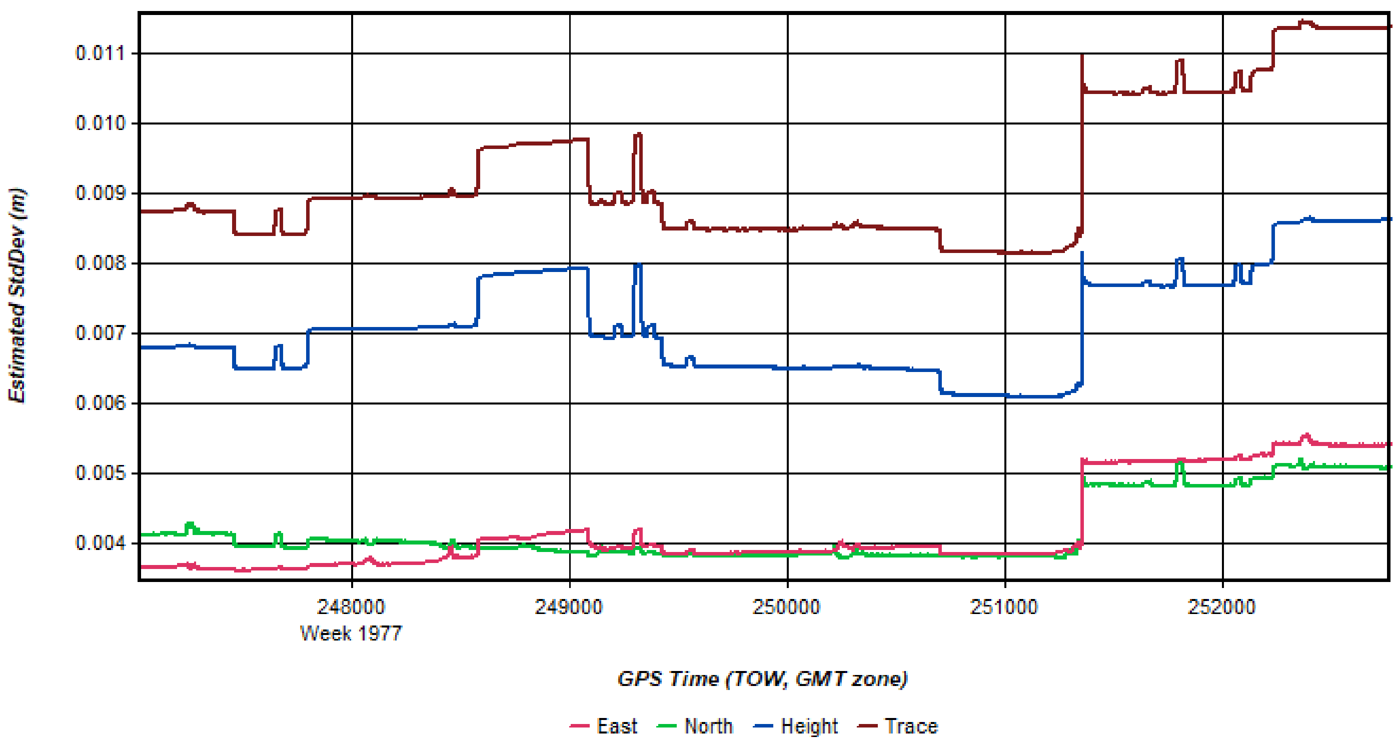
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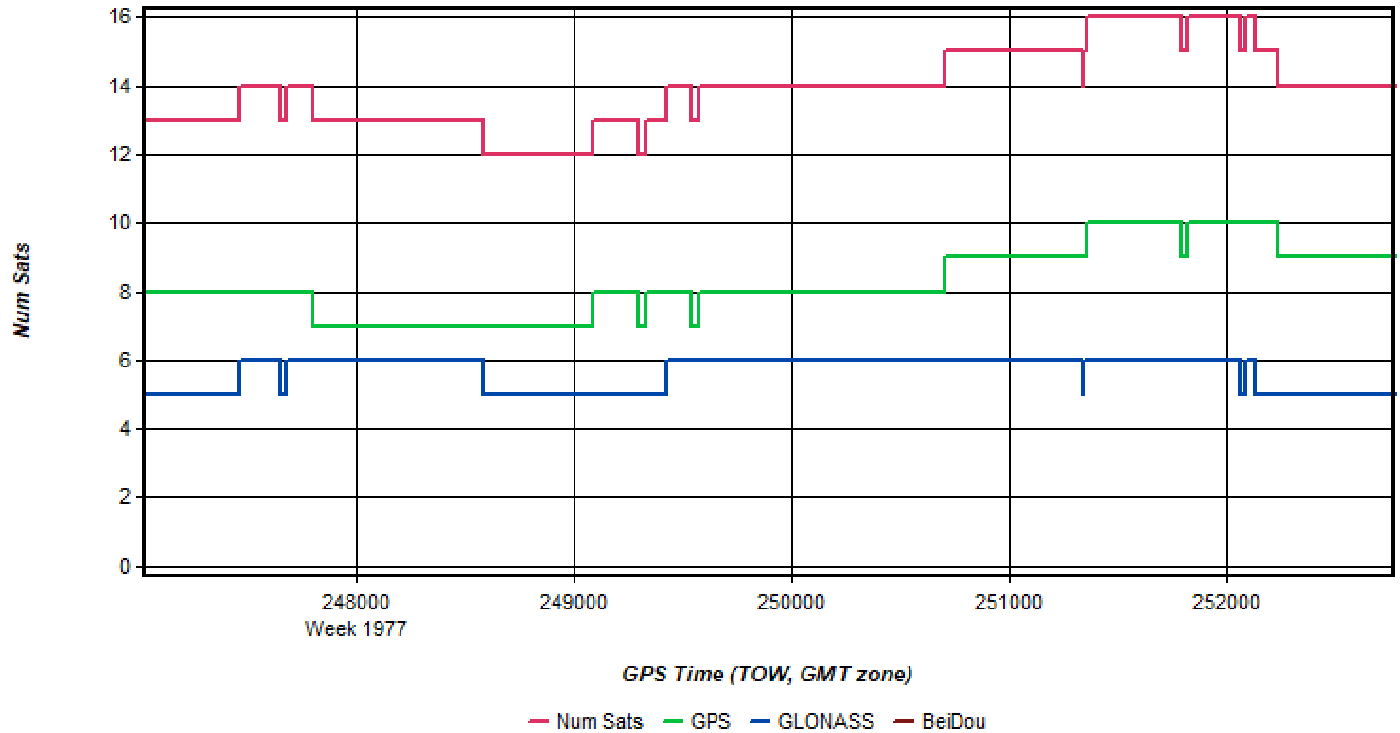
GPS Time (TOW, GMT zone)
East
North
Height
Trace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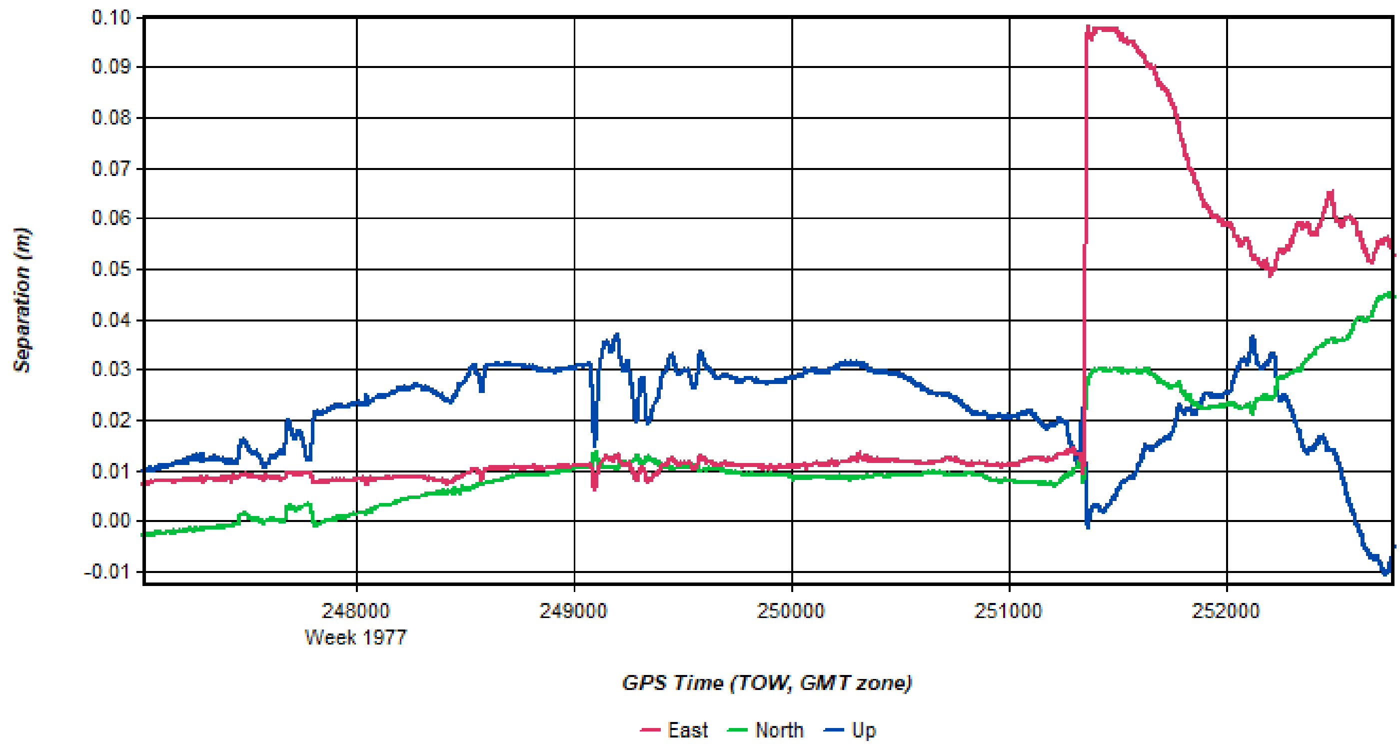
Num Sats
GPS
GLONASS
BeiDou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Week 1977
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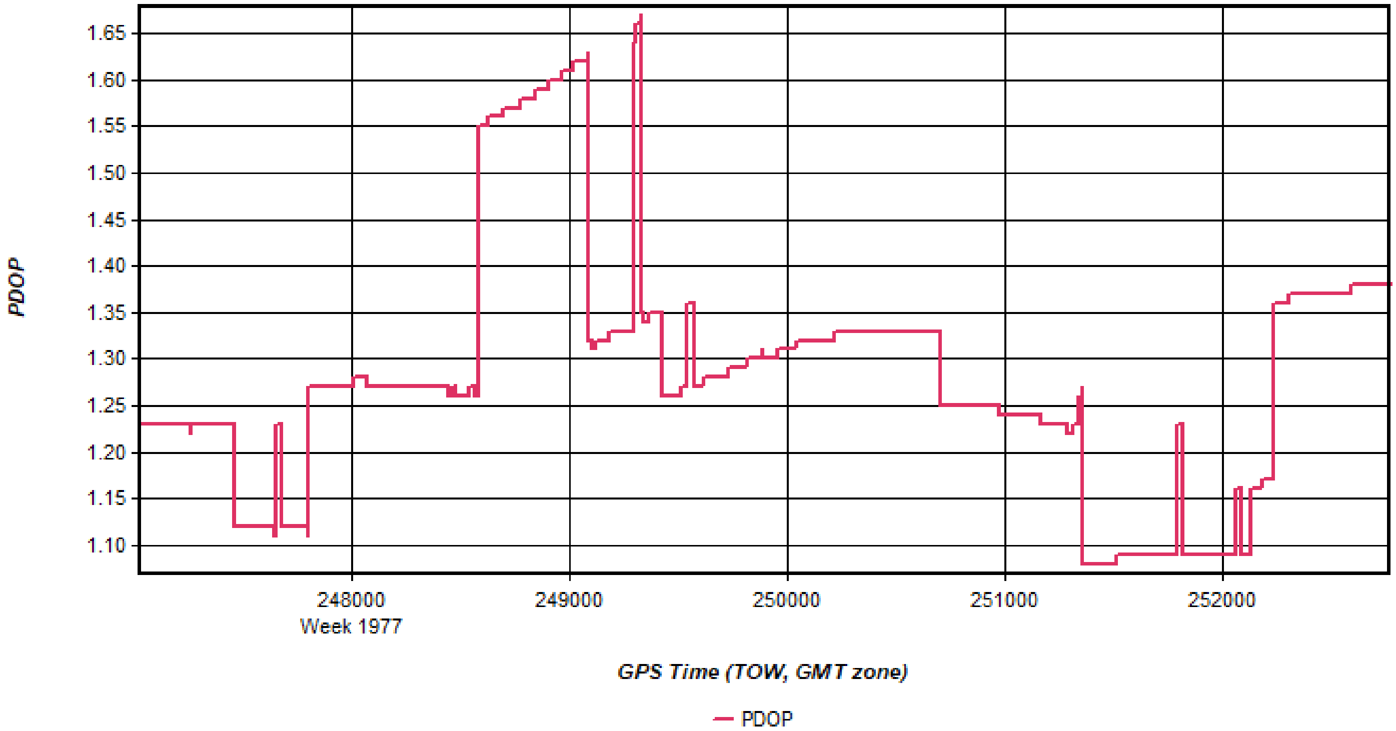
GPS Time (TOW, GMT zone)
East
North
Up



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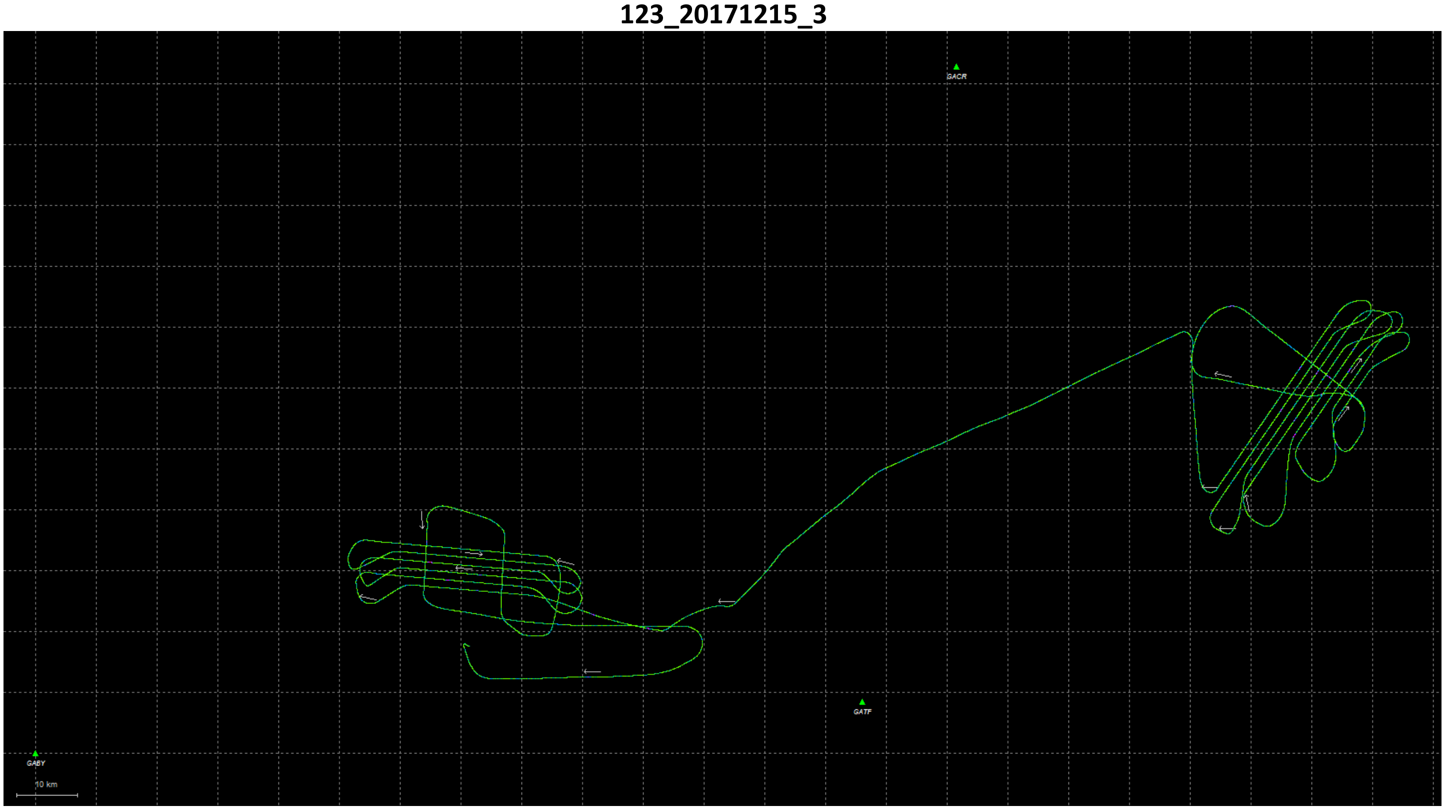

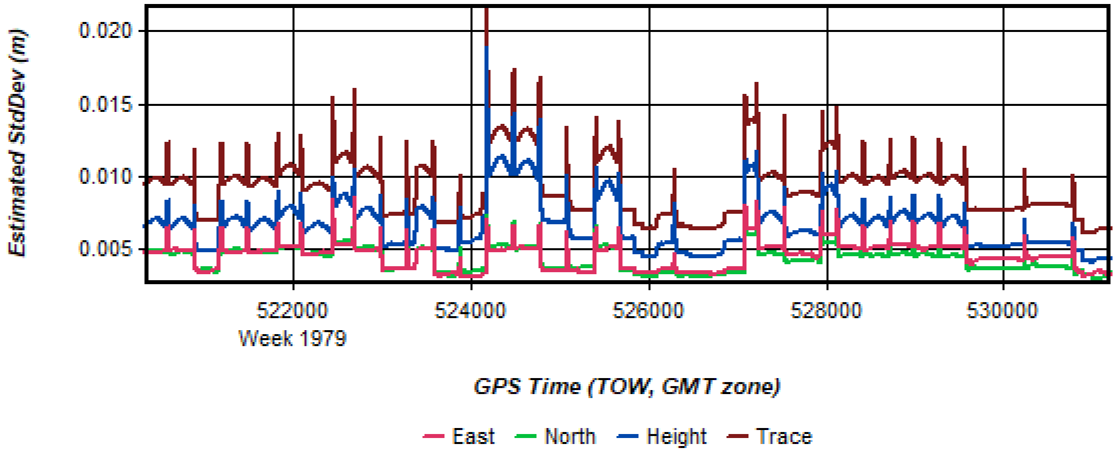

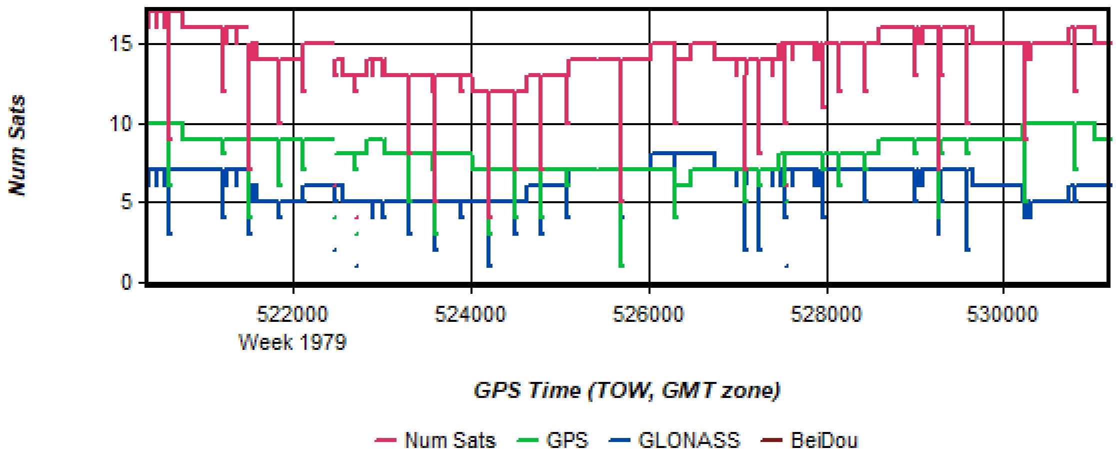

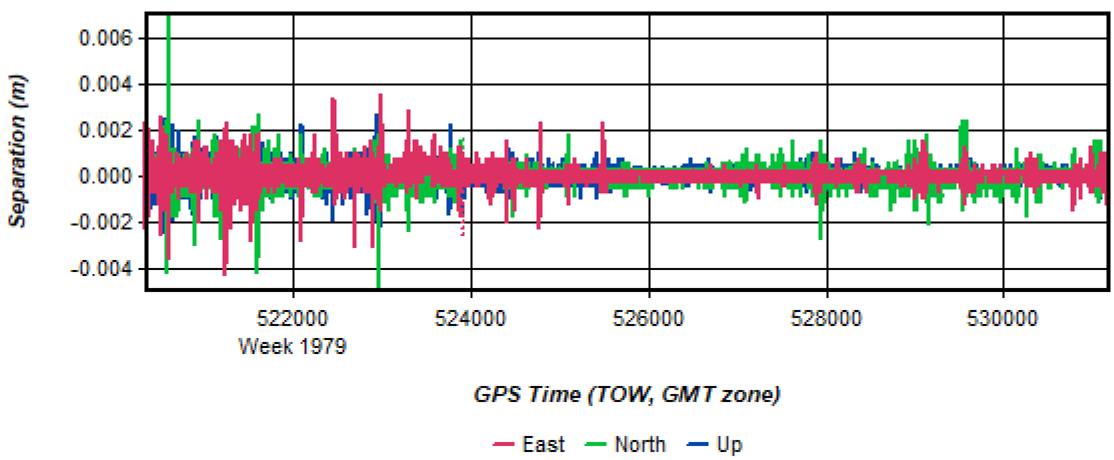

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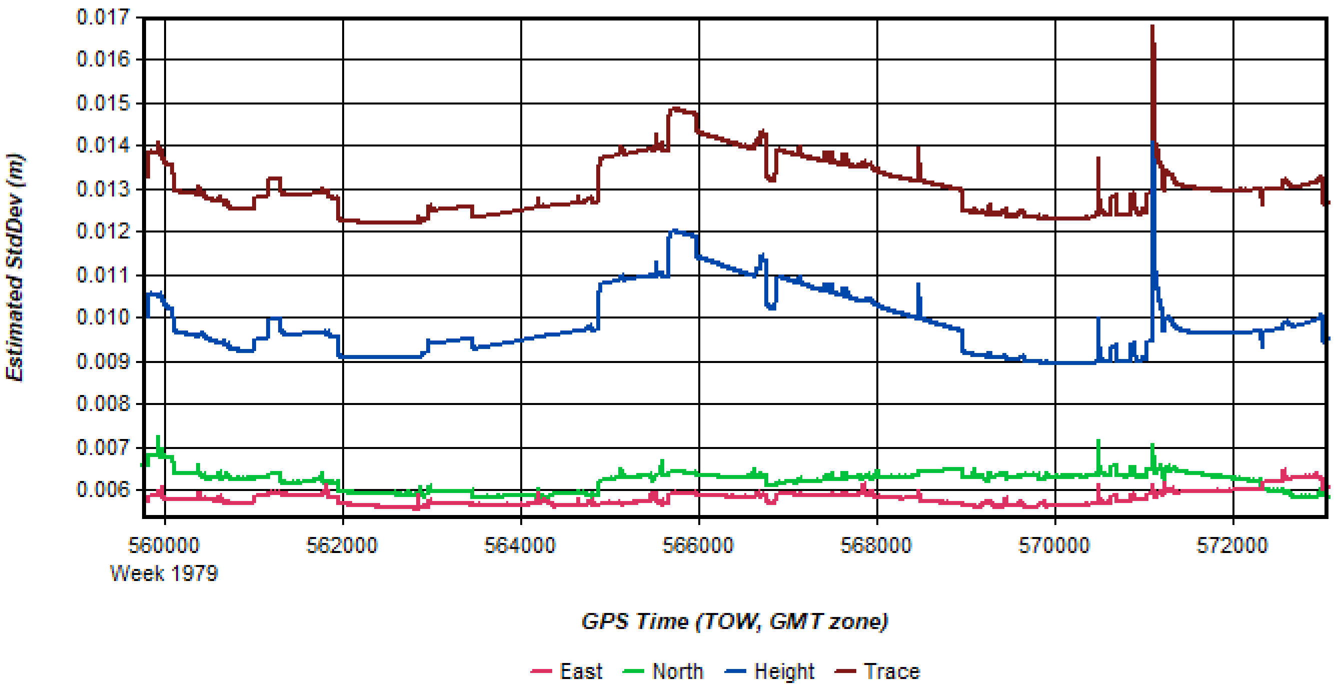
20 km
GATF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0.007
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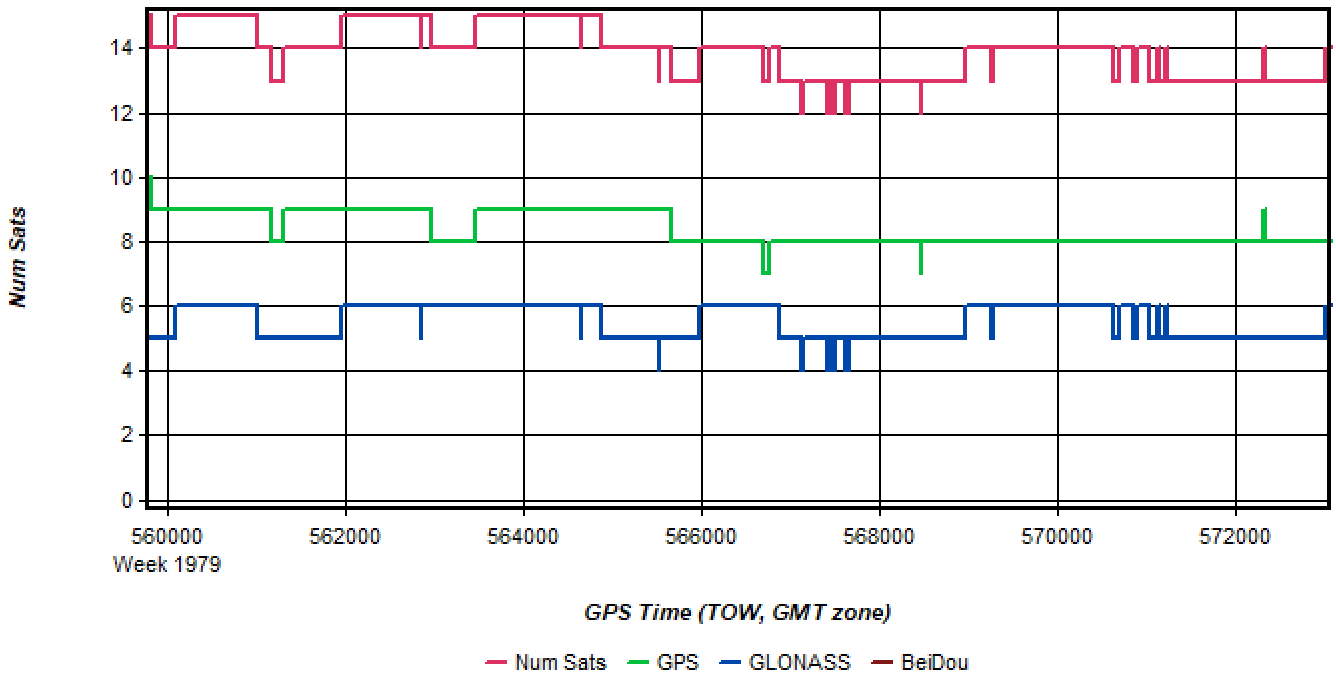
GPS Time (TOW, GMT zone)
East
North
Height
Trace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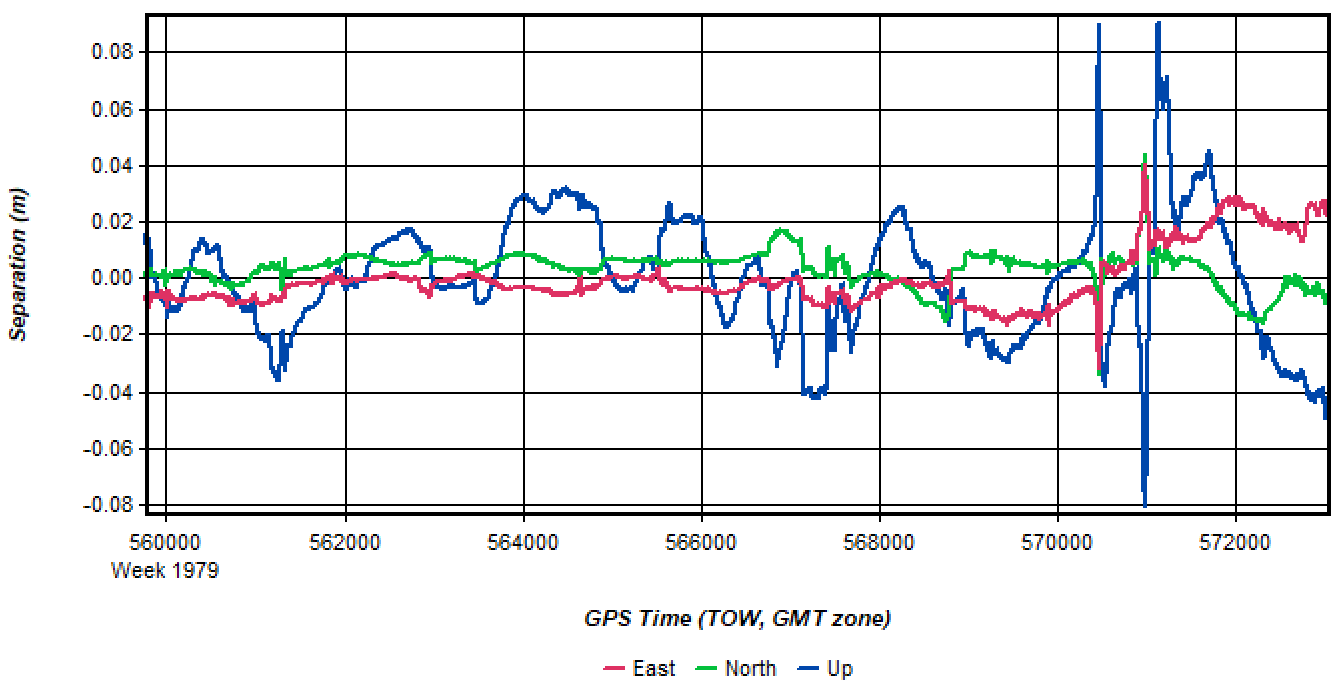
Num Sats
GPS
GLONASS
BeiDou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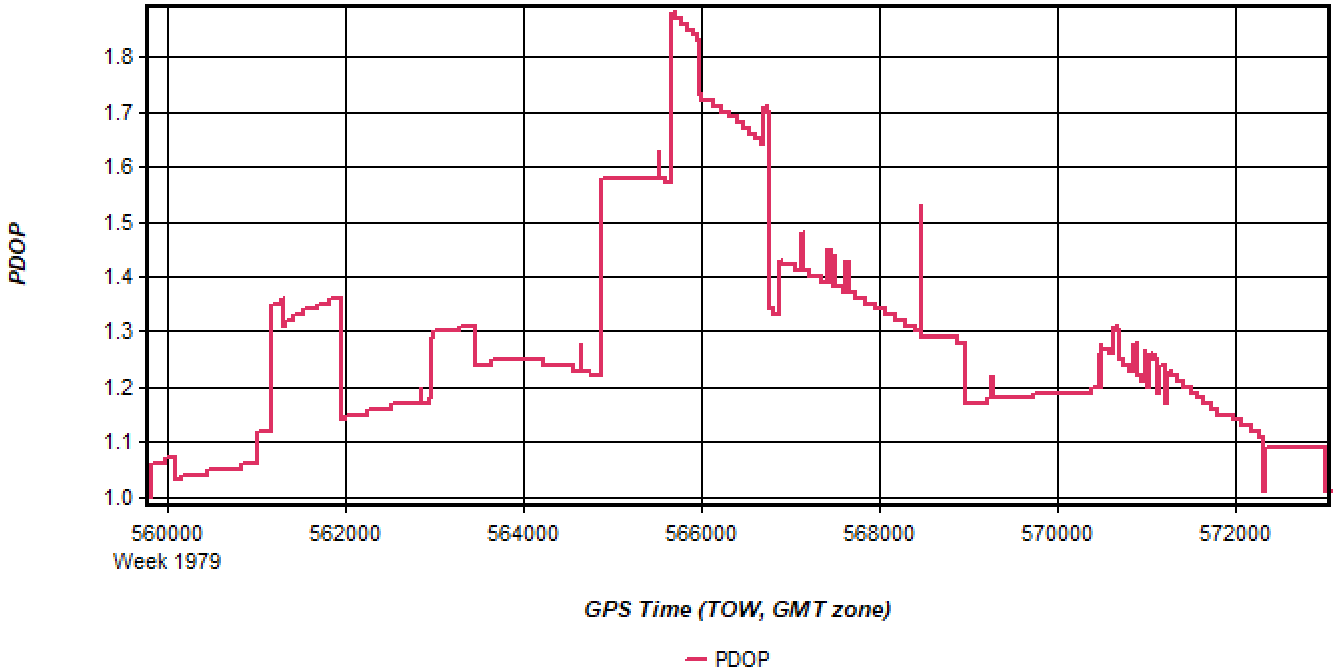
572000
GPS Time (TOW, GMT zone)
East
North
Up



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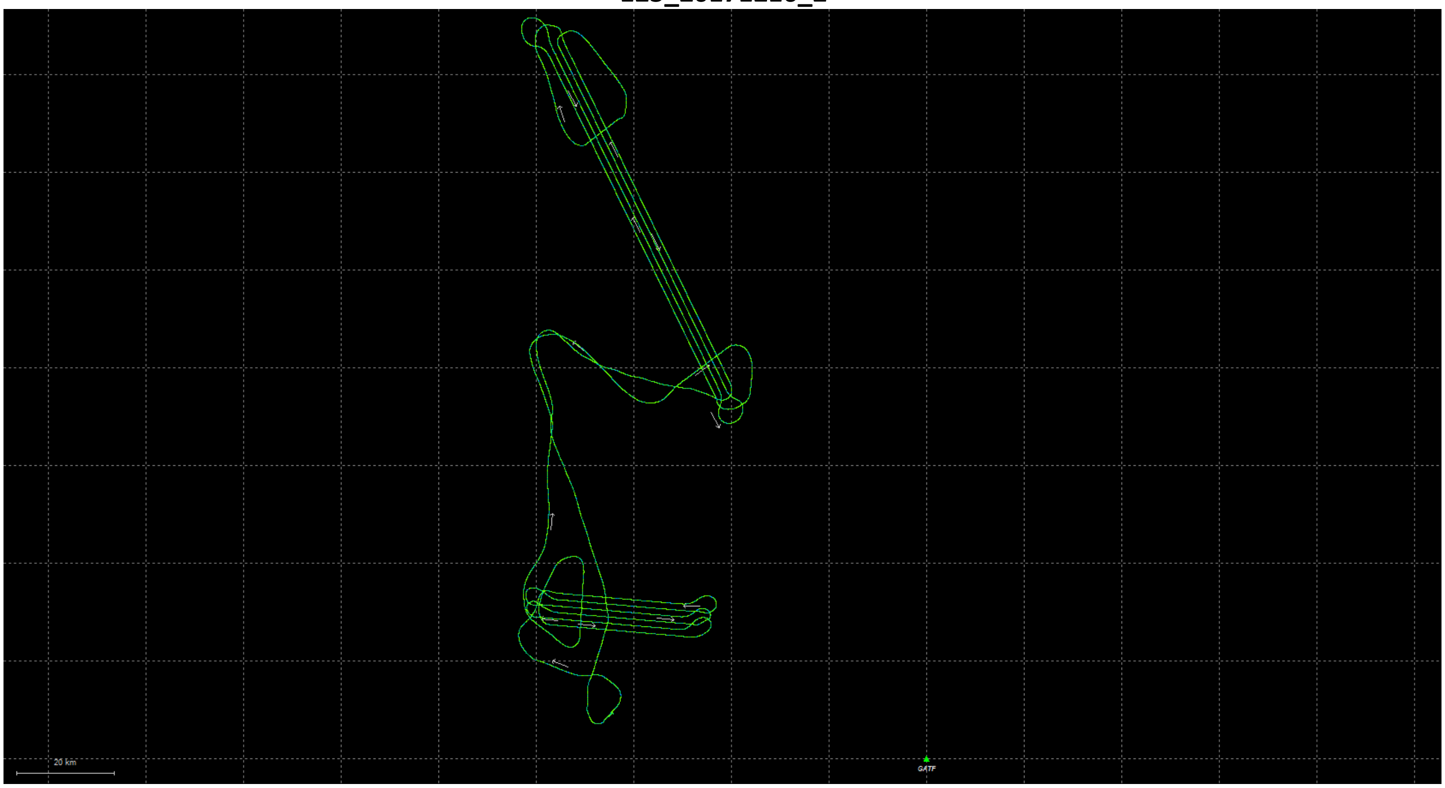

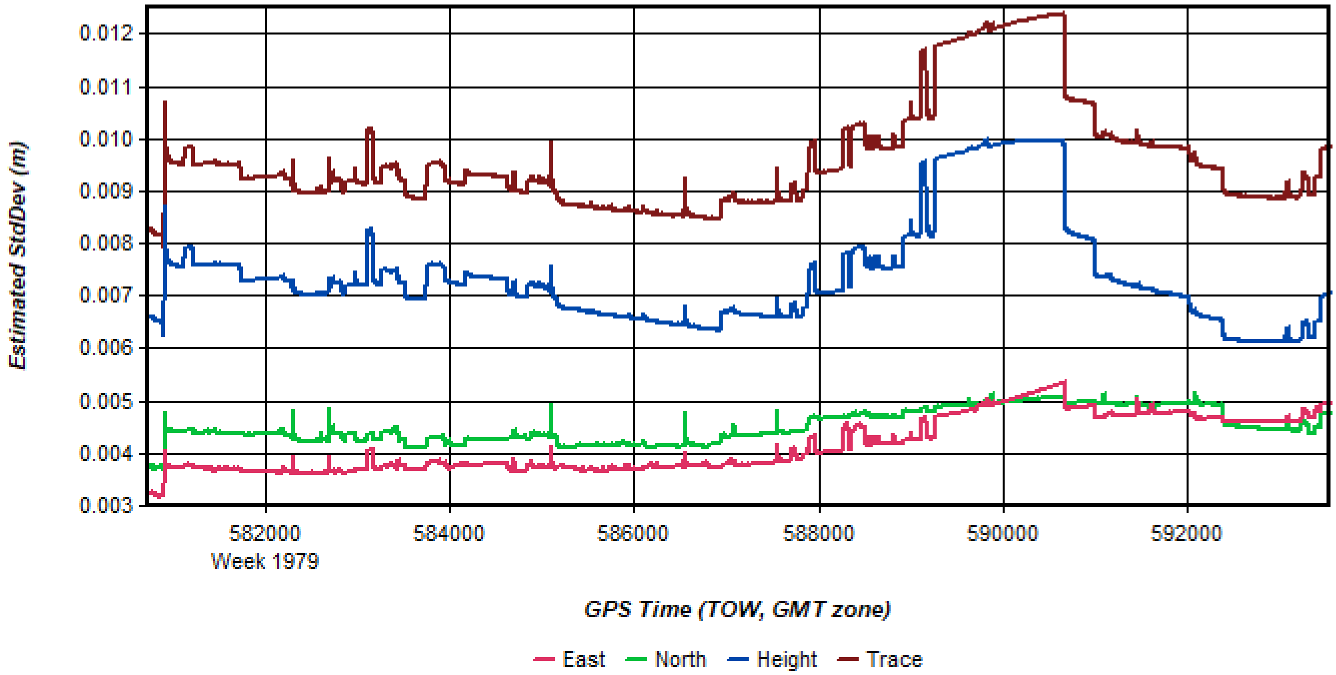
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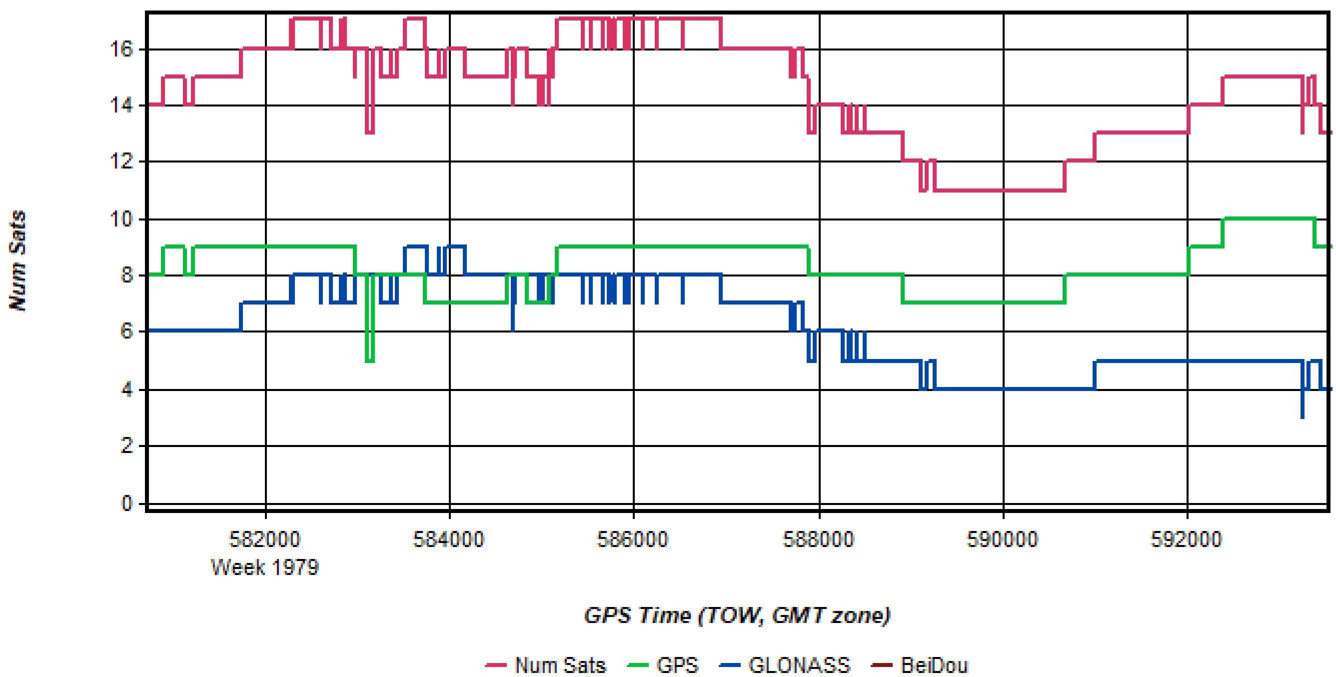
GPS Time (TOW, GMT zone)
East
North
Height
Trace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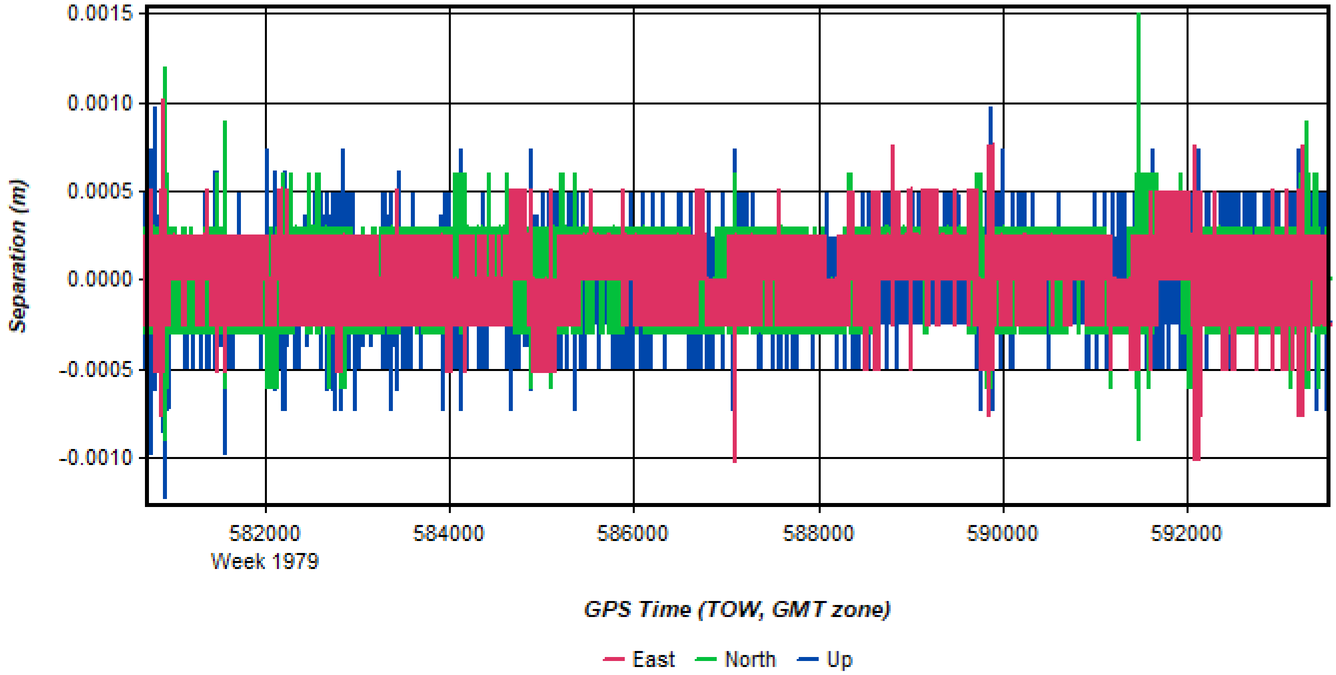
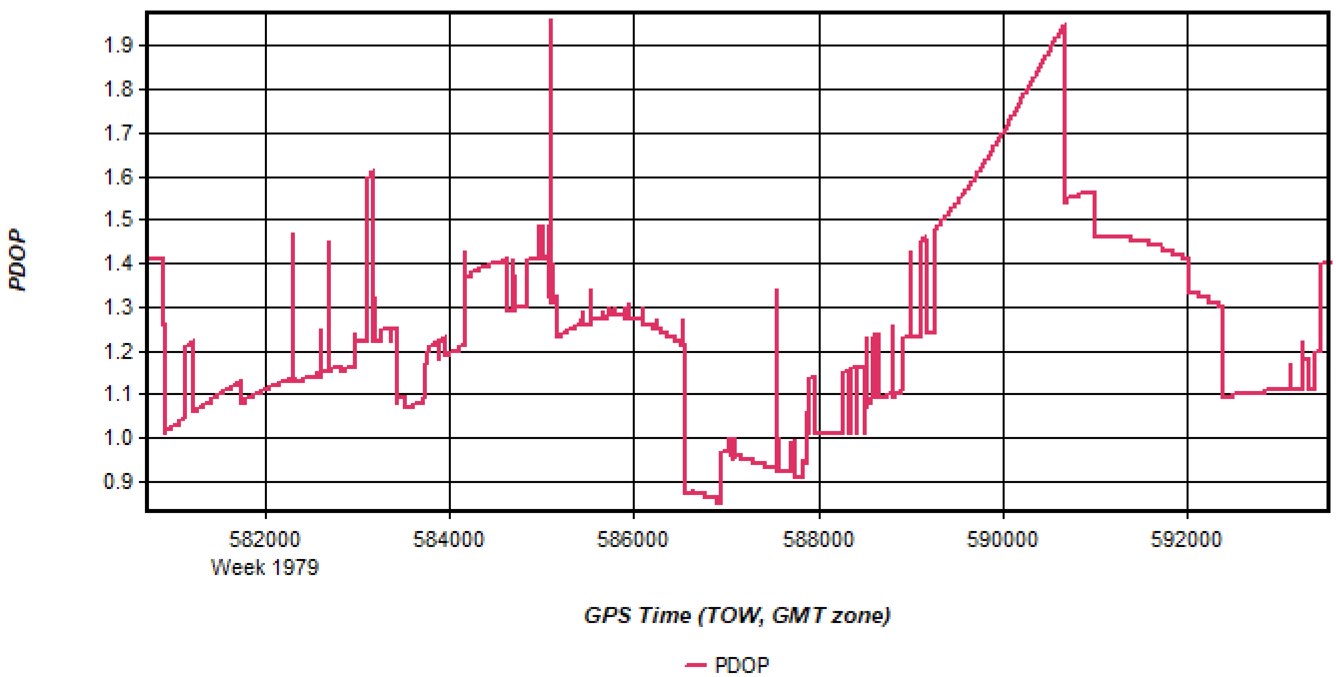
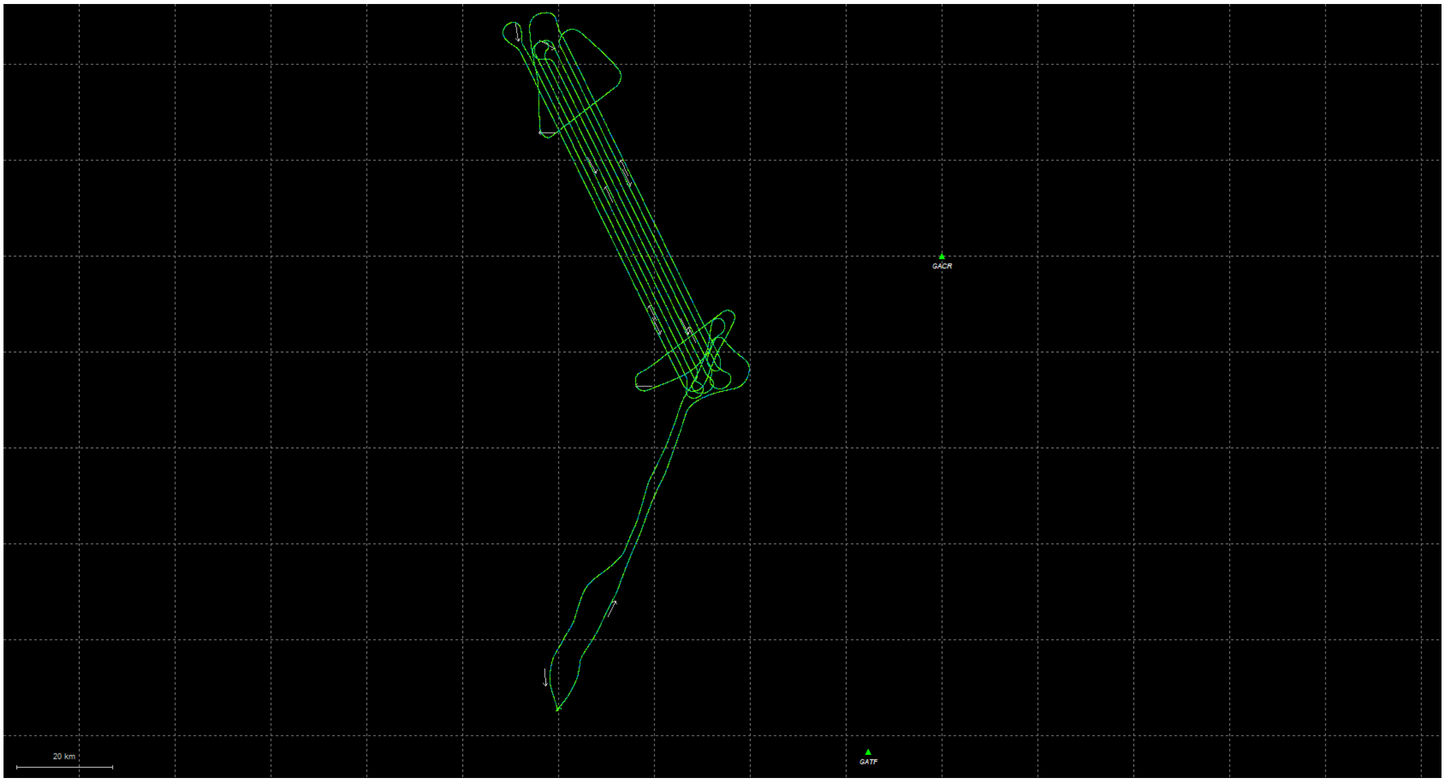
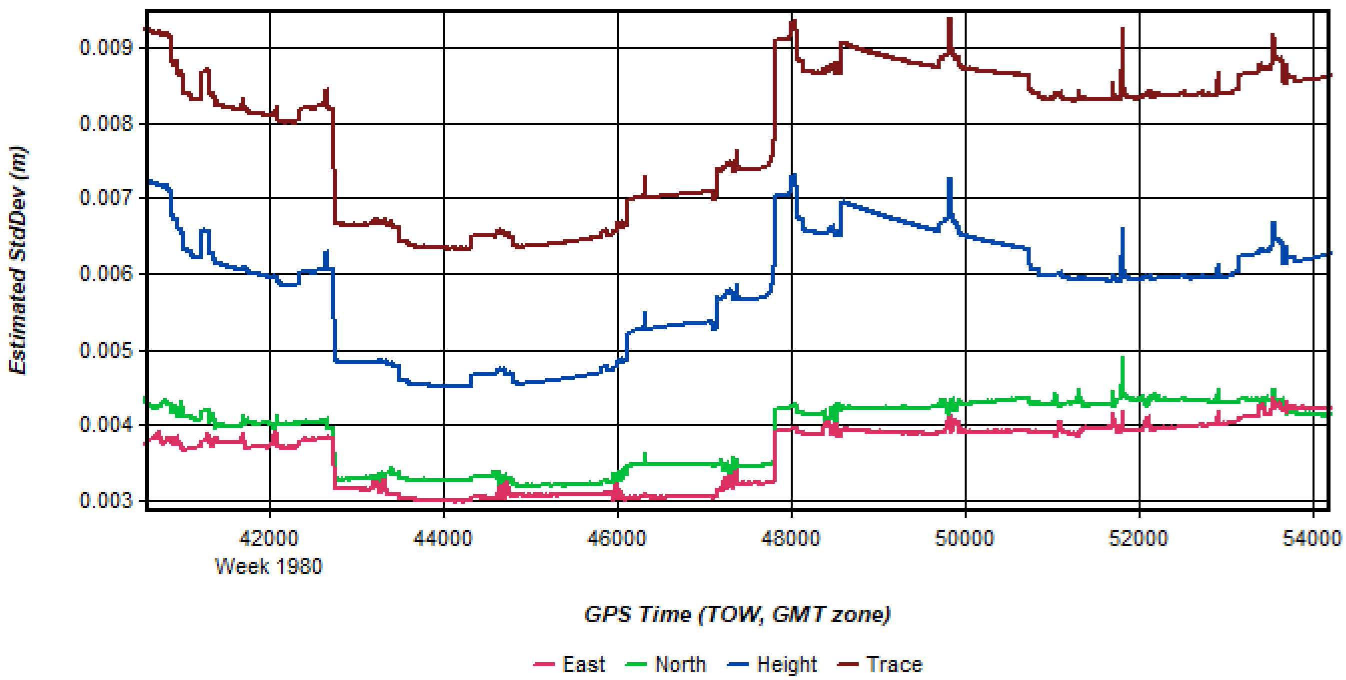
590000
592000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

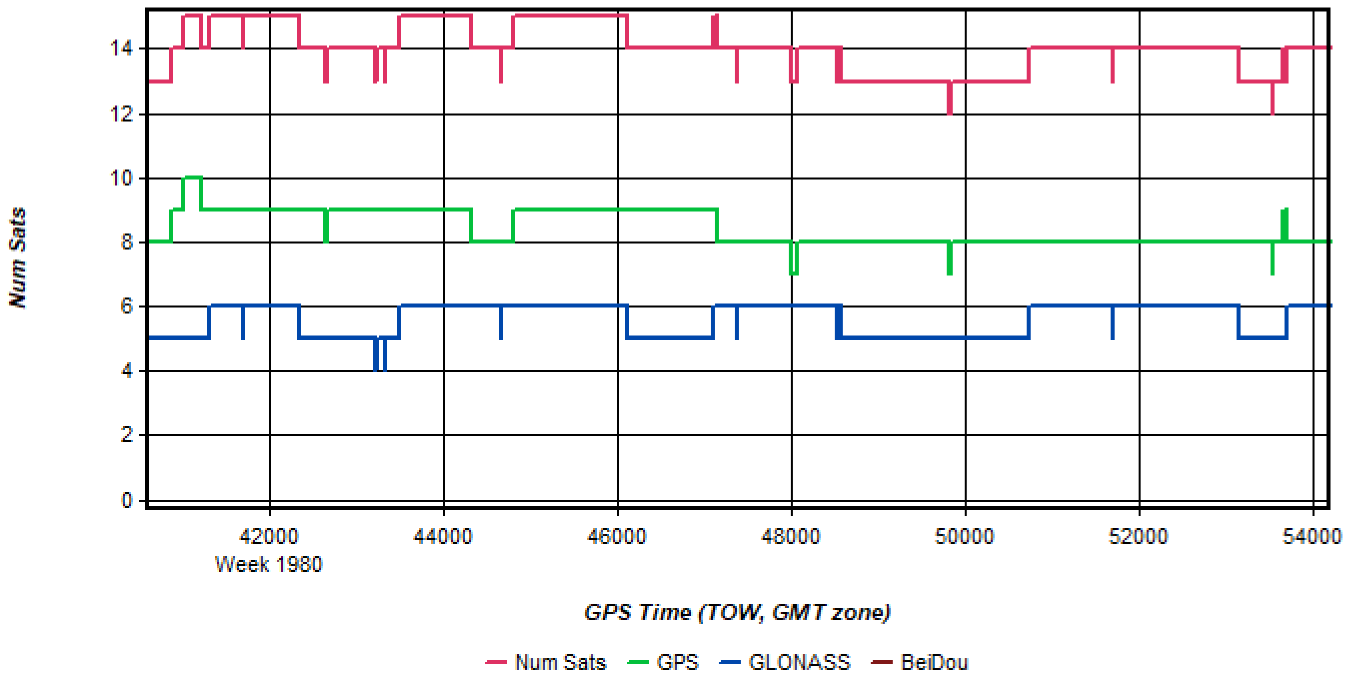


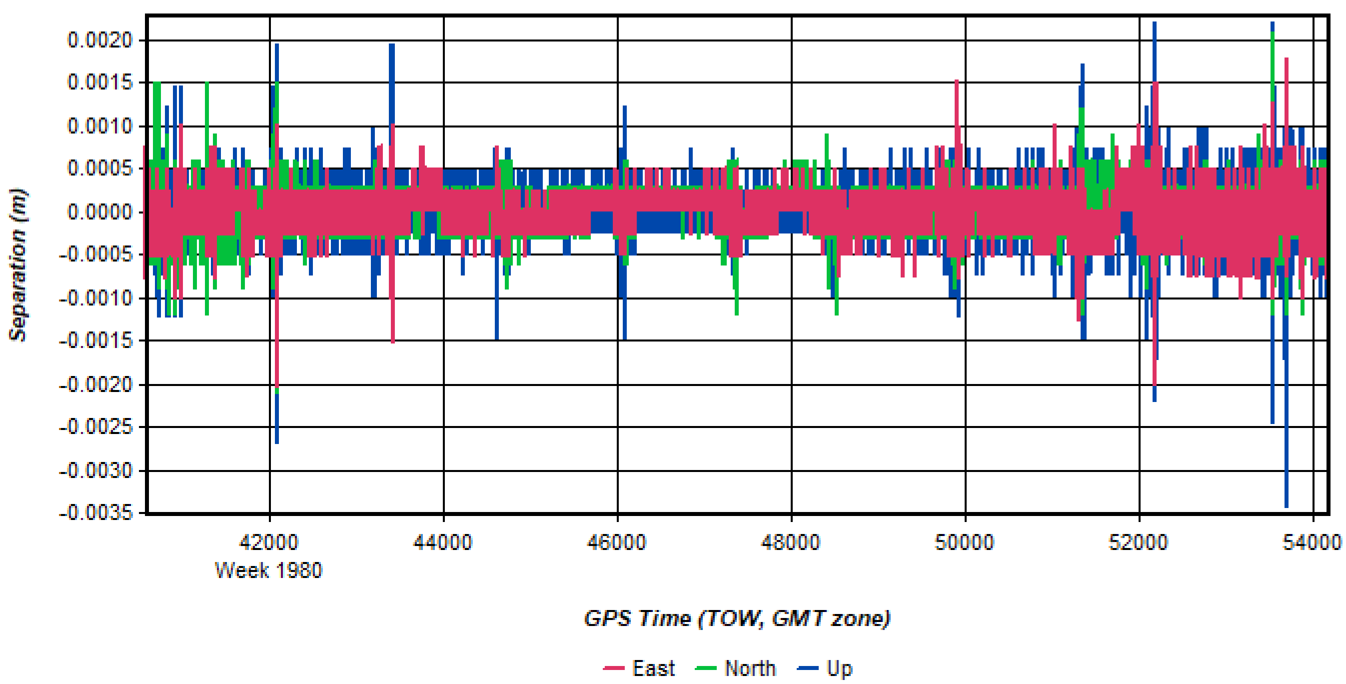


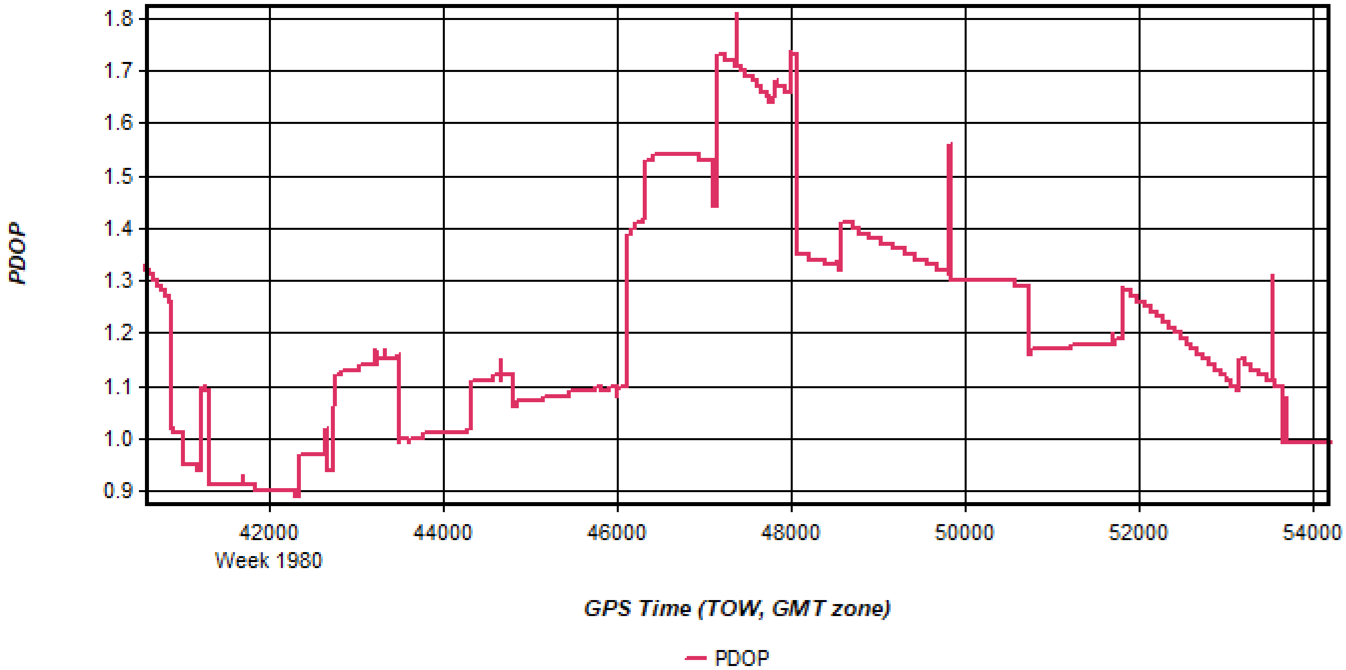
123_20171217_1



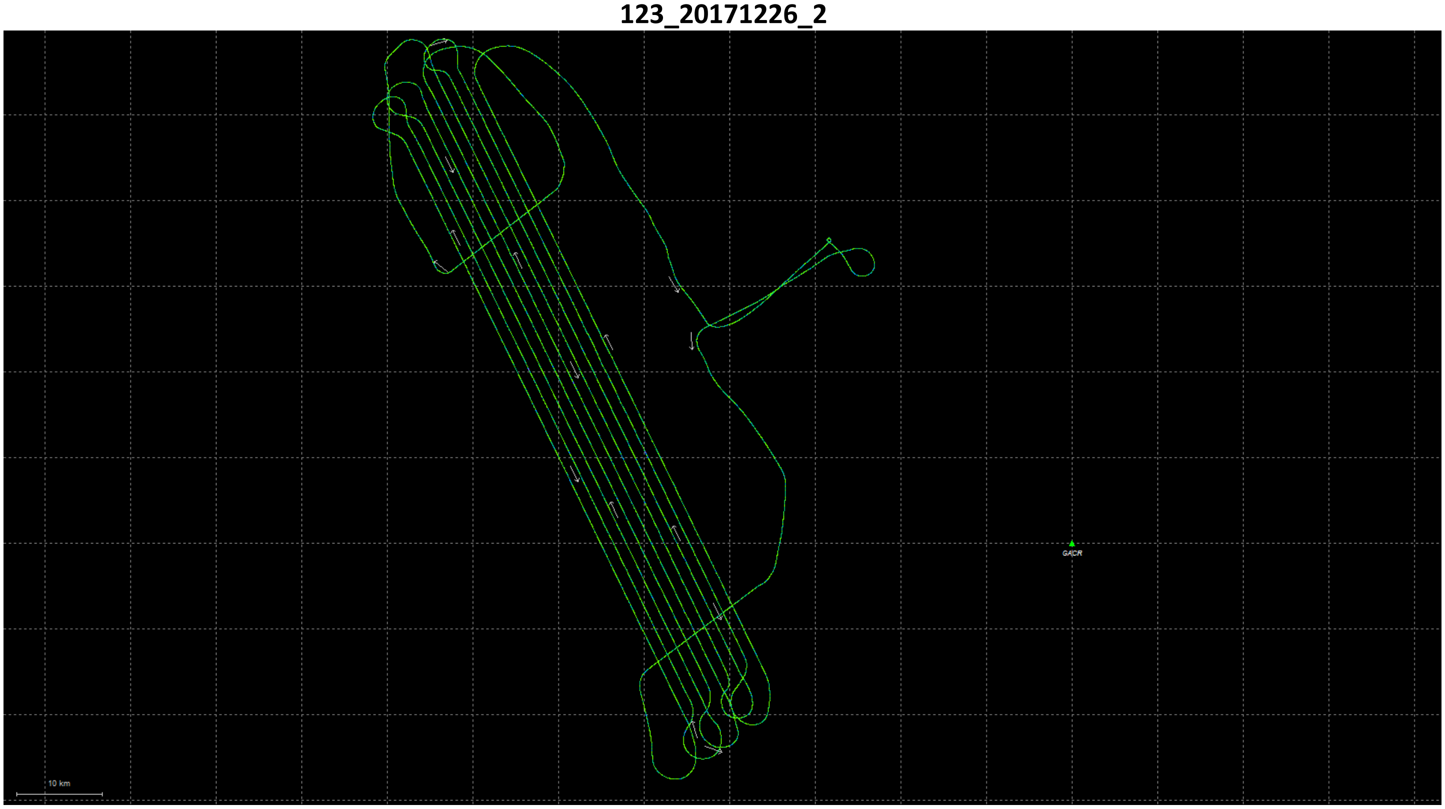

Estimated StdDev (m)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
42000
Week 1980
44000
46000
48000
50000
52000
54000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

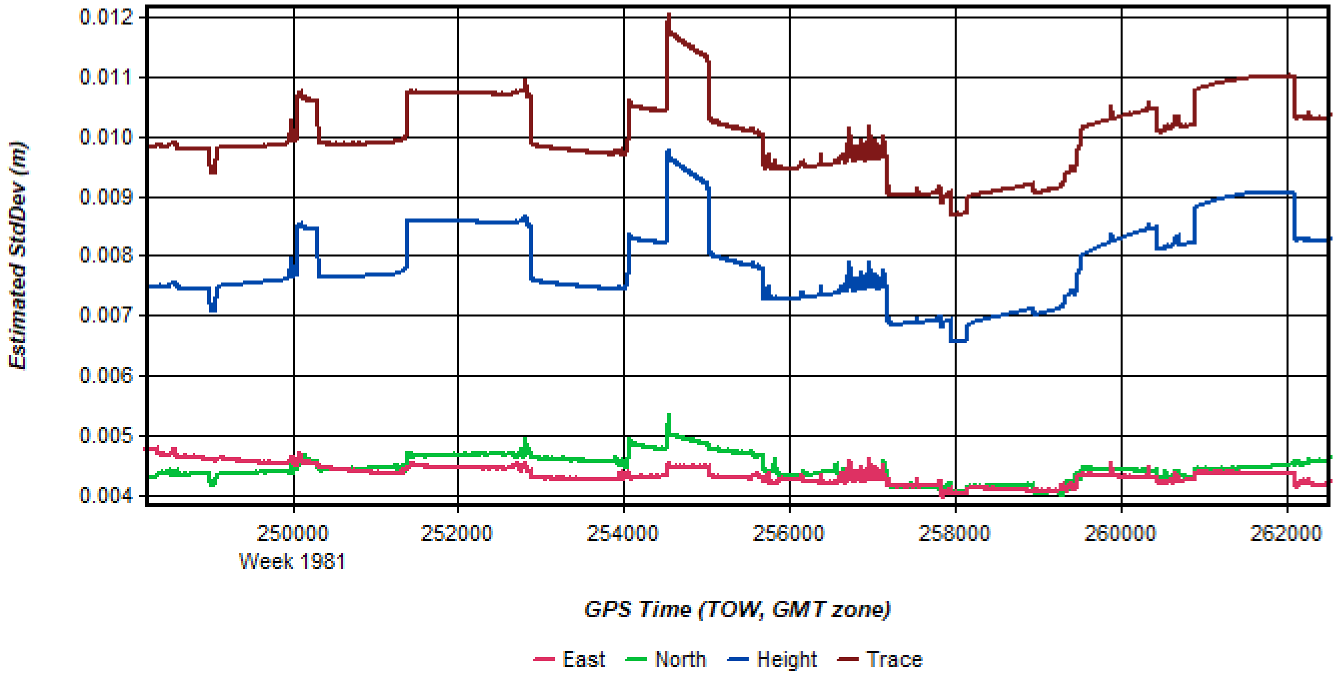

Num Sats
0
2
4
6
8
10
12
14
42000
Week 1980
44000
46000
48000
50000
52000
54000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

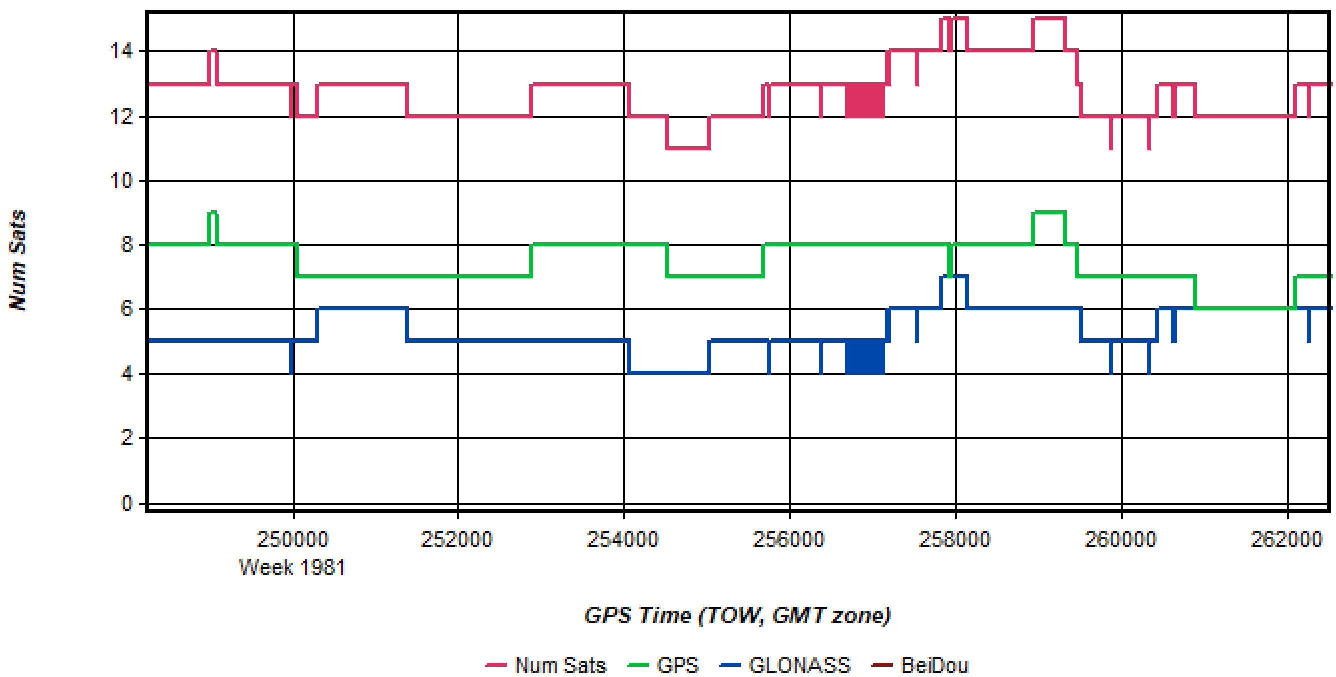

Separation (m)
0.0020
0.0015
0.0010
0.0005
0.0000
-0.0005
-0.0010
-0.0015
-0.0020
-0.0025
-0.0030
-0.0035
42000
Week 1980
44000
46000
48000
50000
52000
54000
GPS Time (TOW, GMT zone)
East
North
Up

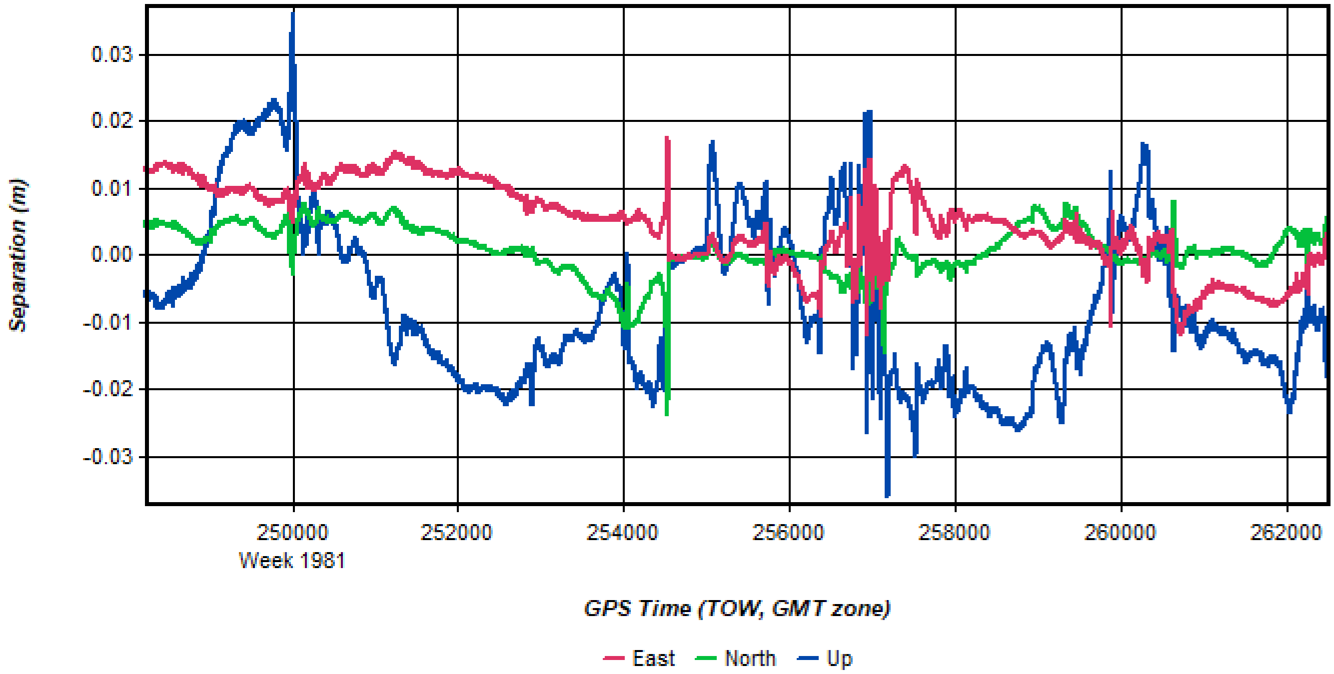


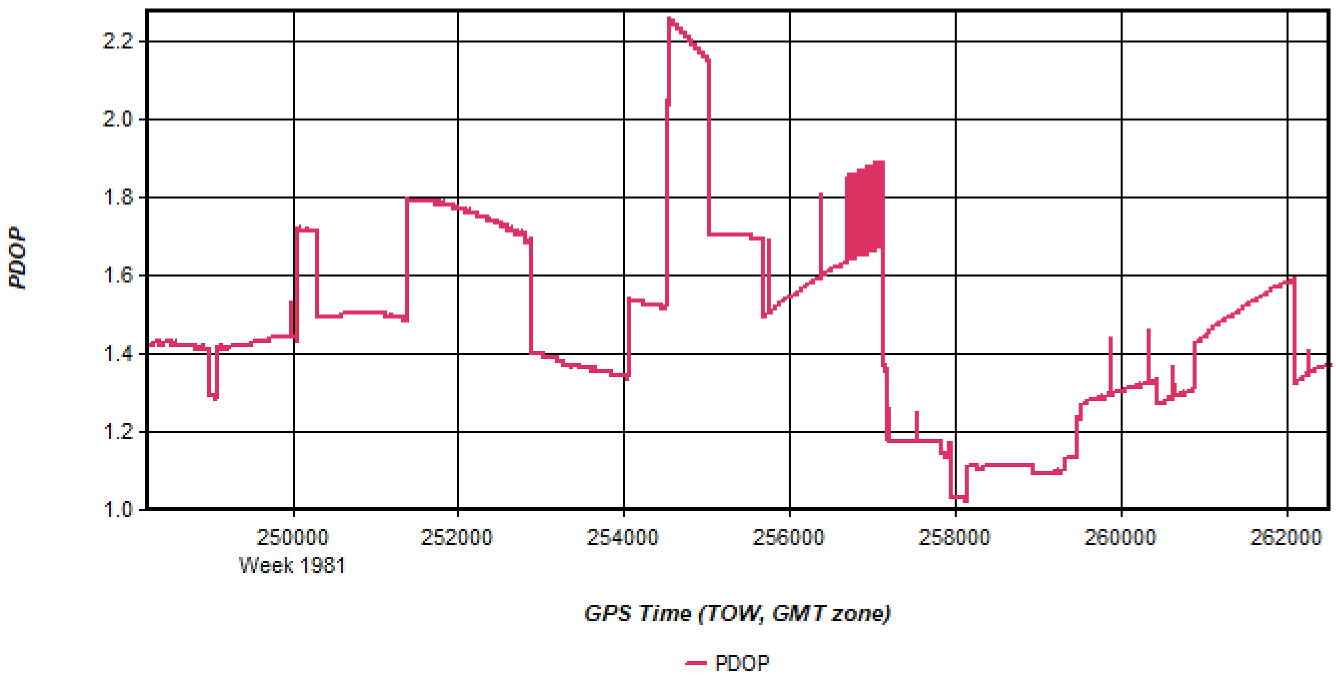
123_20171226_2



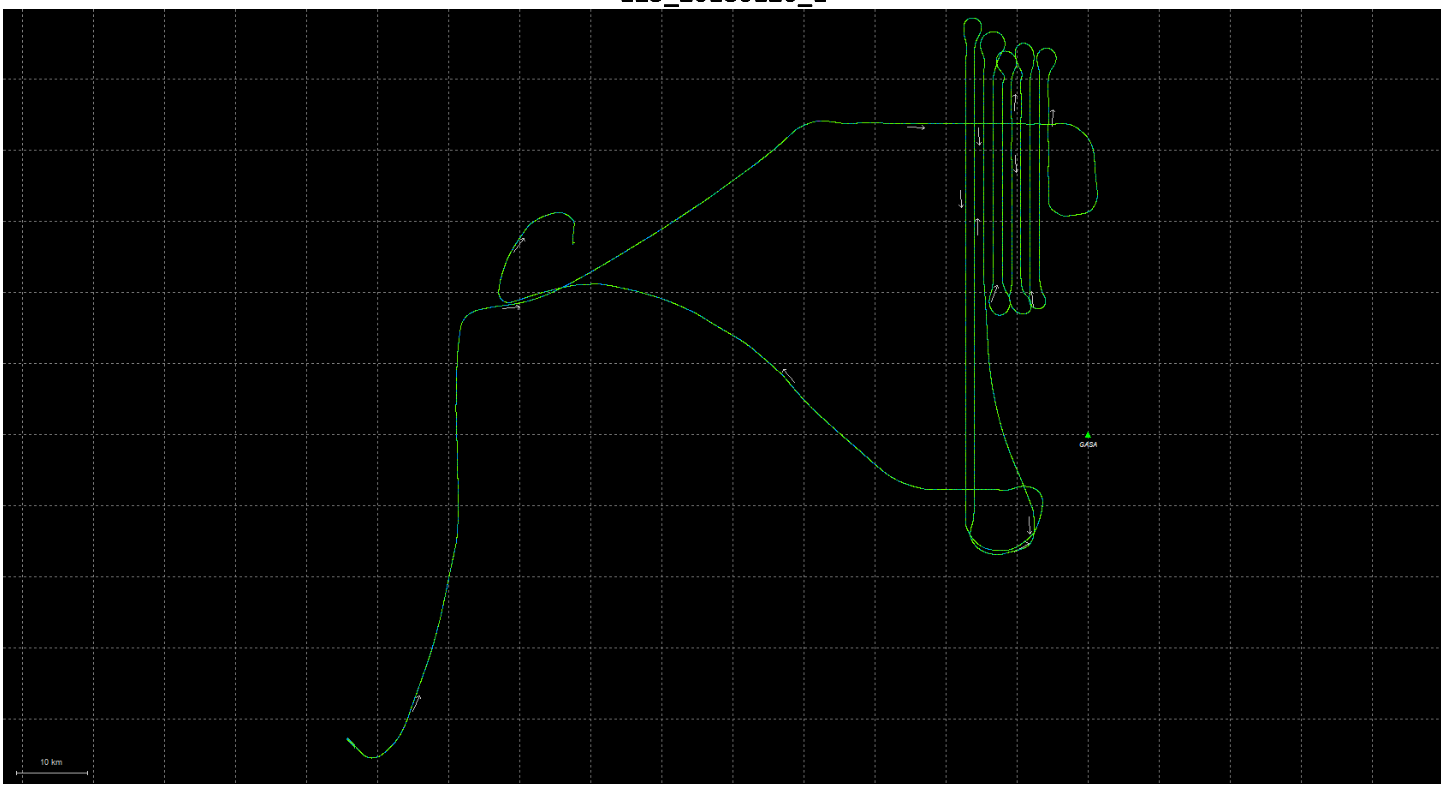

Estimated StdDev (m)
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
250000
Week 1981
252000
254000
256000
258000
260000
262000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

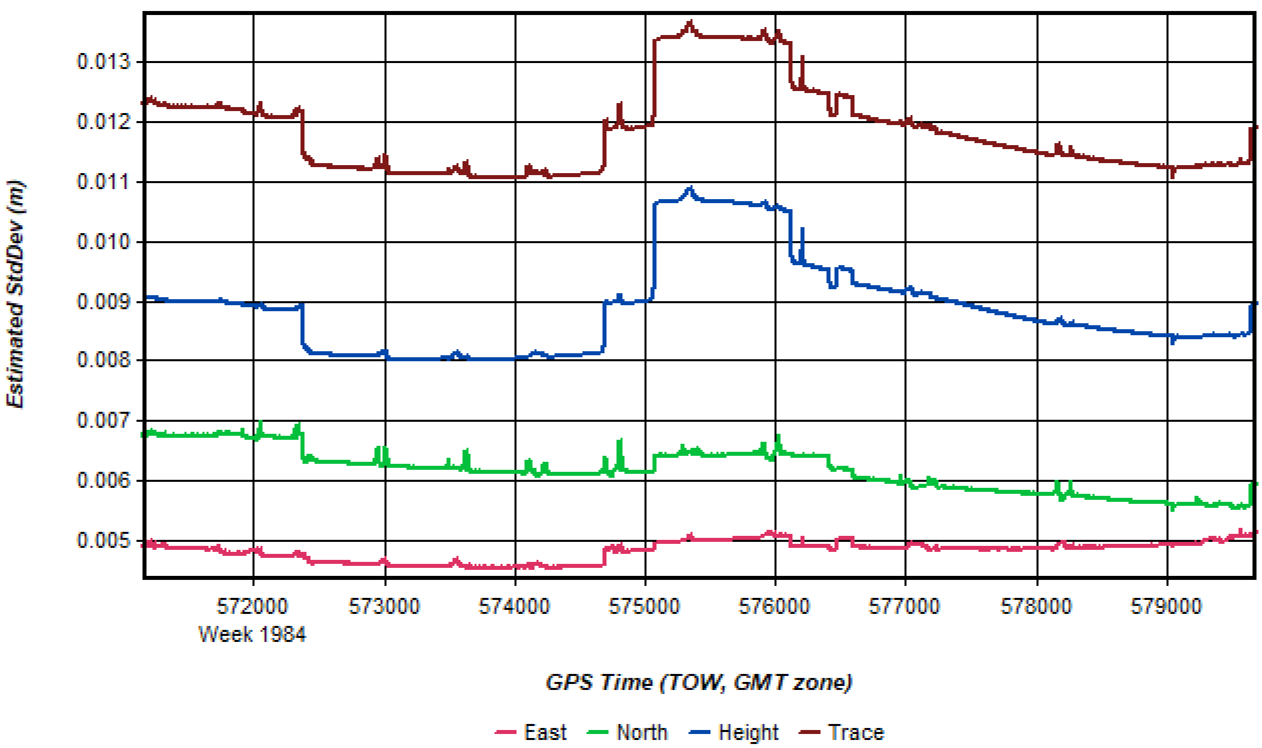

Num Sats
14
12
10
8
6
4
2
0
250000
Week 1981
252000
254000
256000
258000
260000
262000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

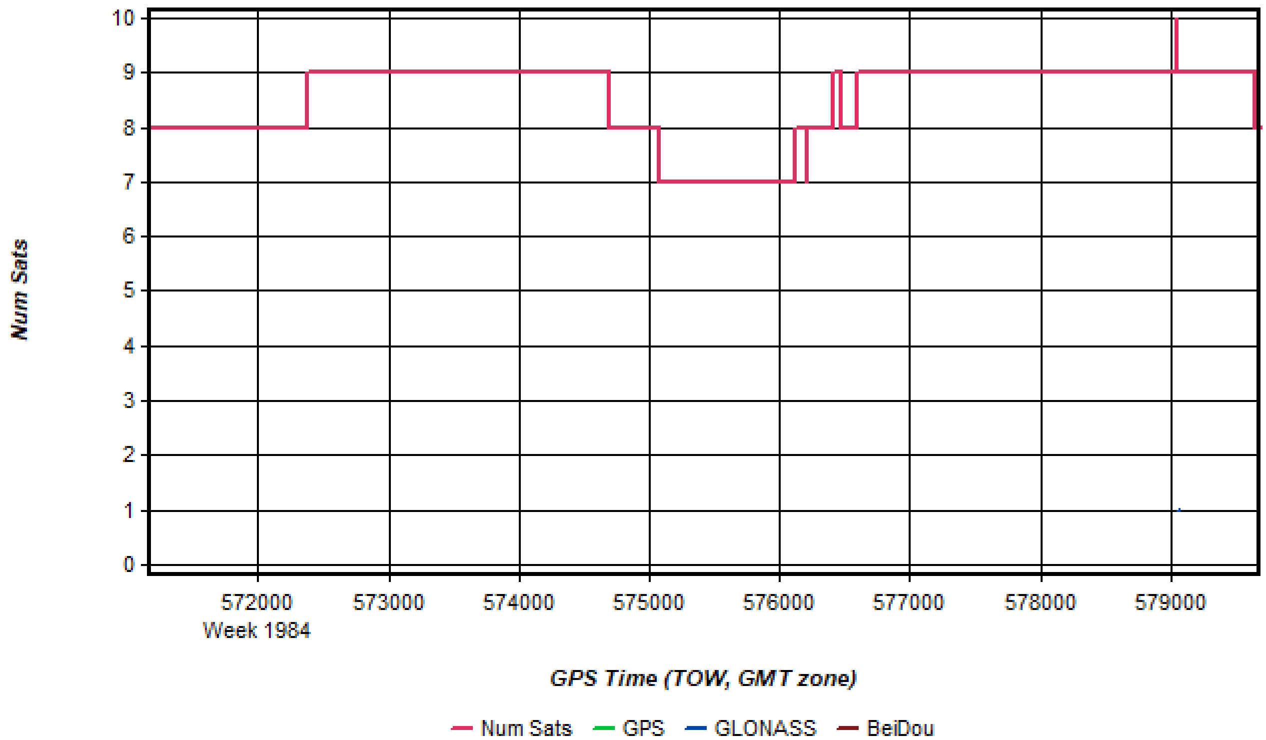

Separation (m)
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
250000
Week 1981
252000
254000
256000
258000
260000
262000
GPS Time (TOW, GMT zone)
East
North
Up

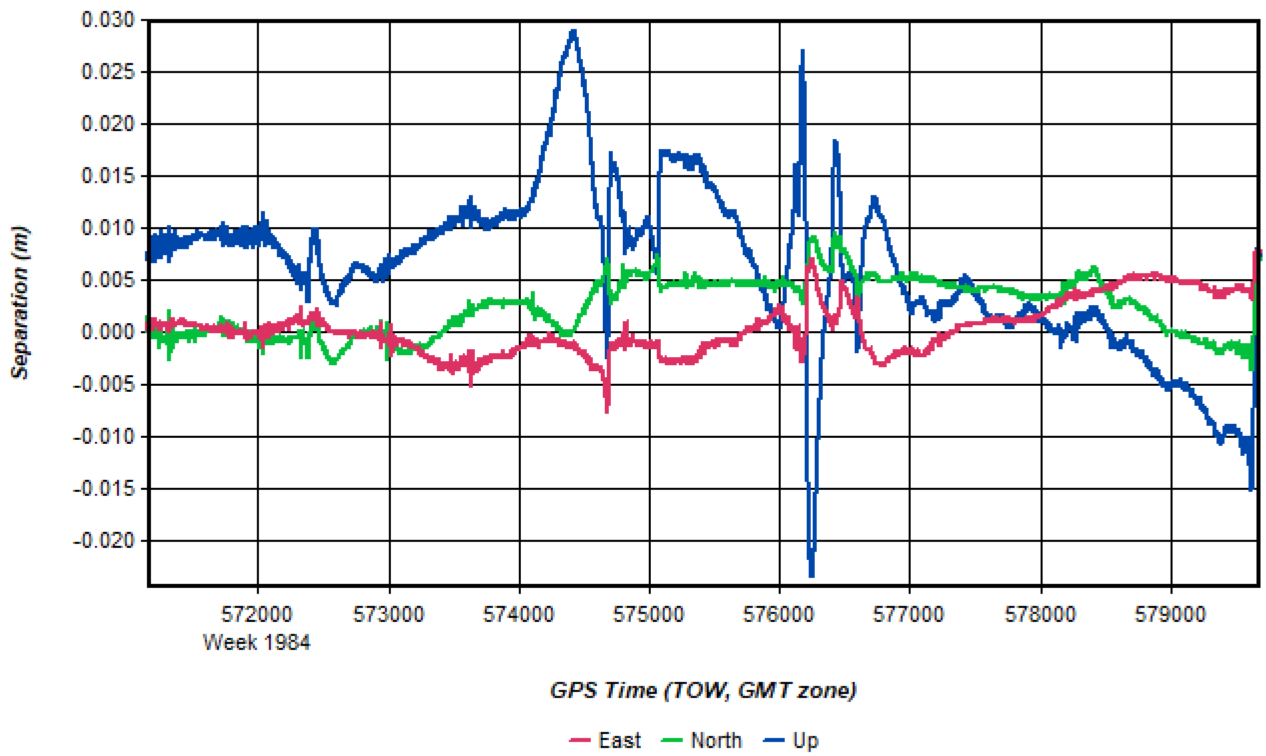

PDOP
2.2
2.0
1.8
1.6
1.4
1.2
1.0
250000
Week 1981
252000
254000
256000
258000
260000
262000
GPS Time (TOW, GMT zone)
PDOP

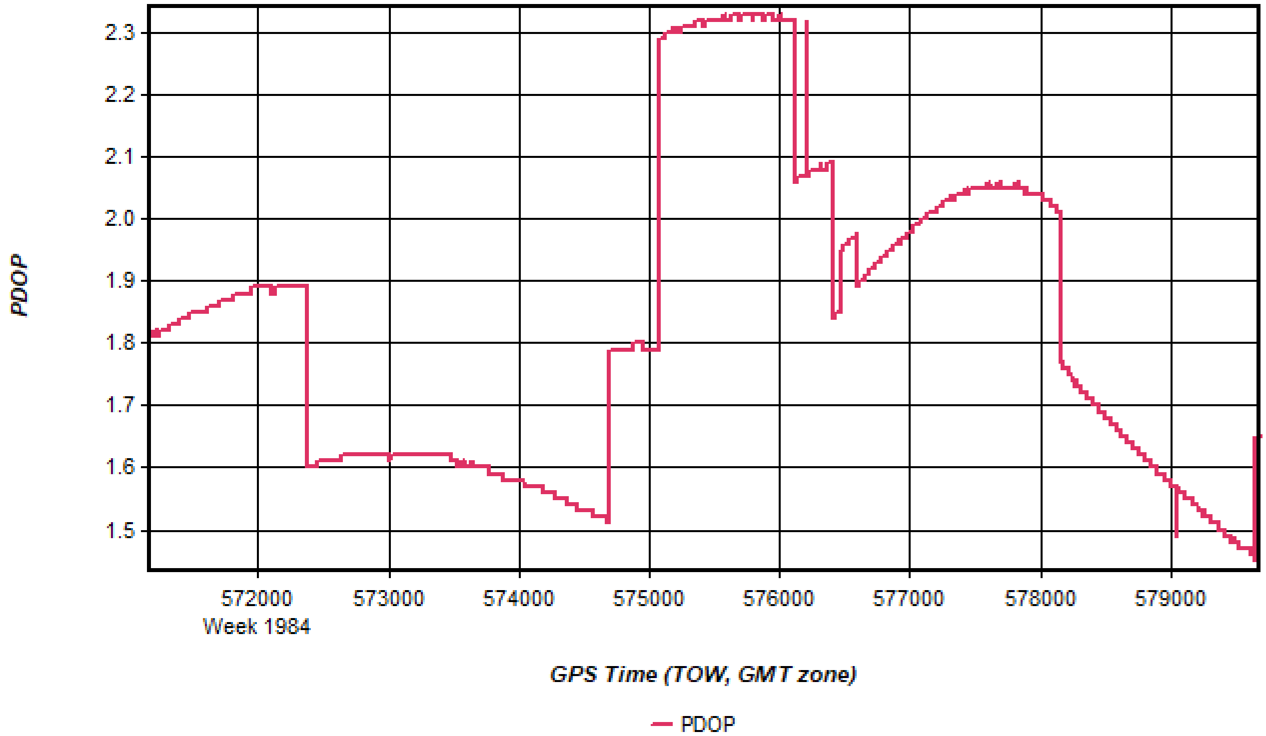
123_20180120_1



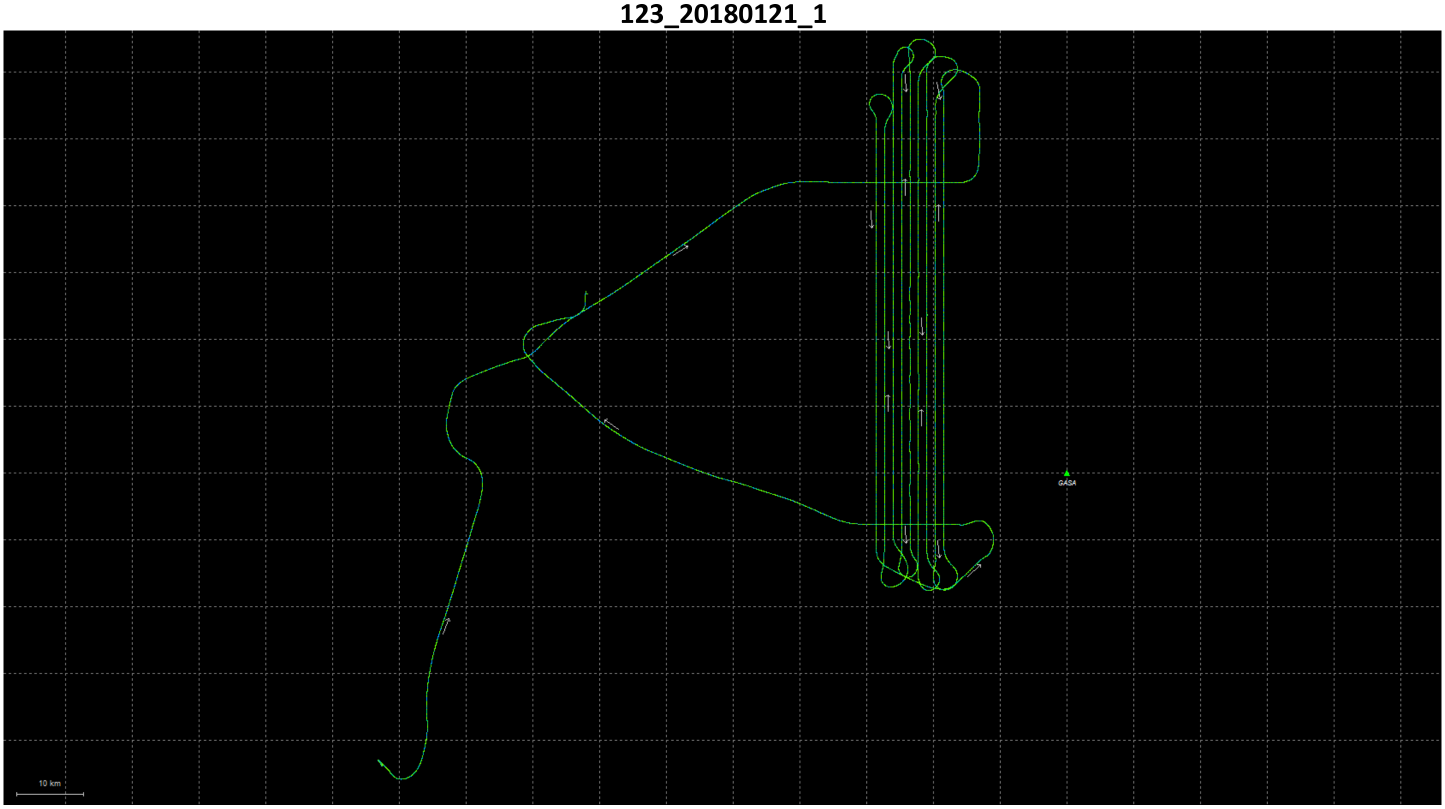


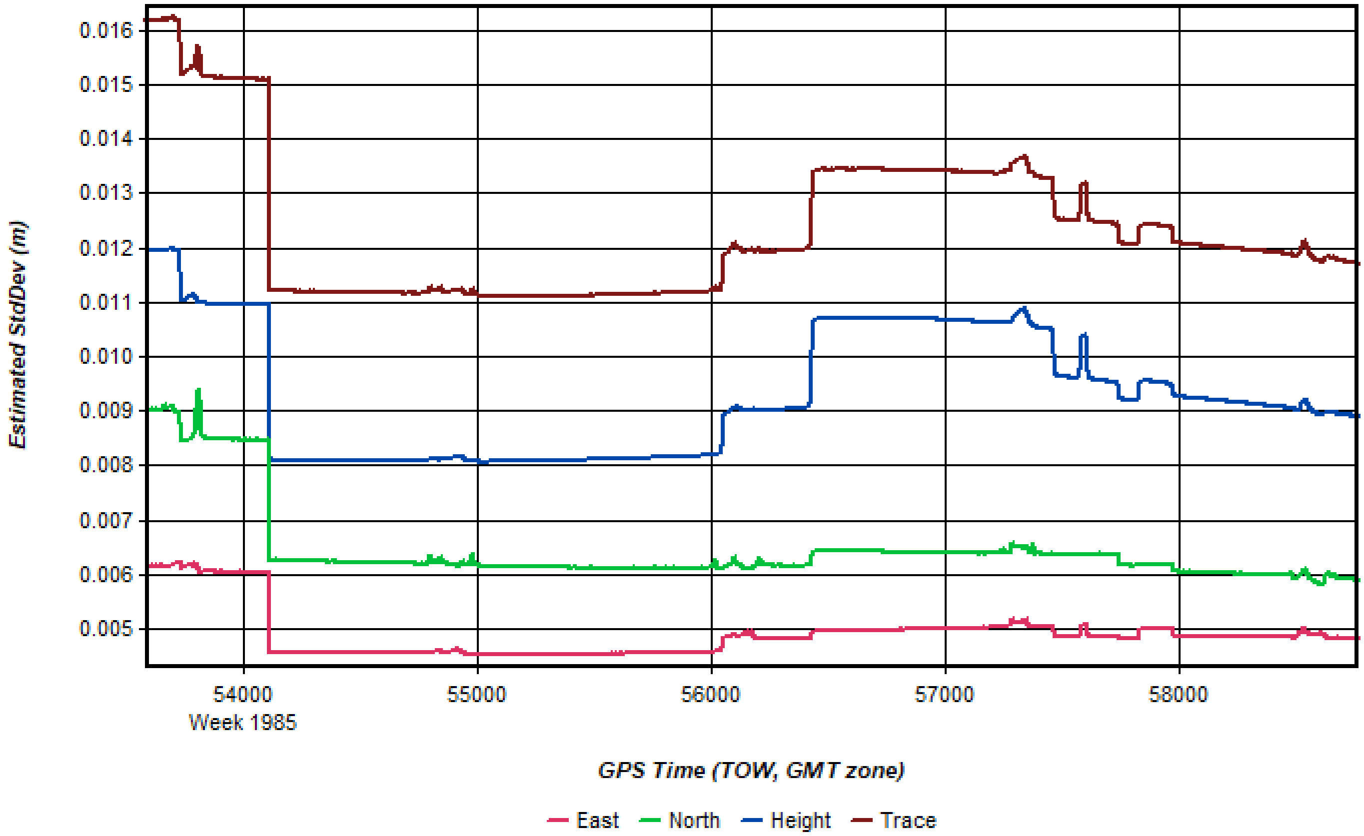

Num Sats
10
9
8
7
6
5
4
3
2
1
0
572000
Week 1984
573000
574000
575000
576000
577000
578000
579000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

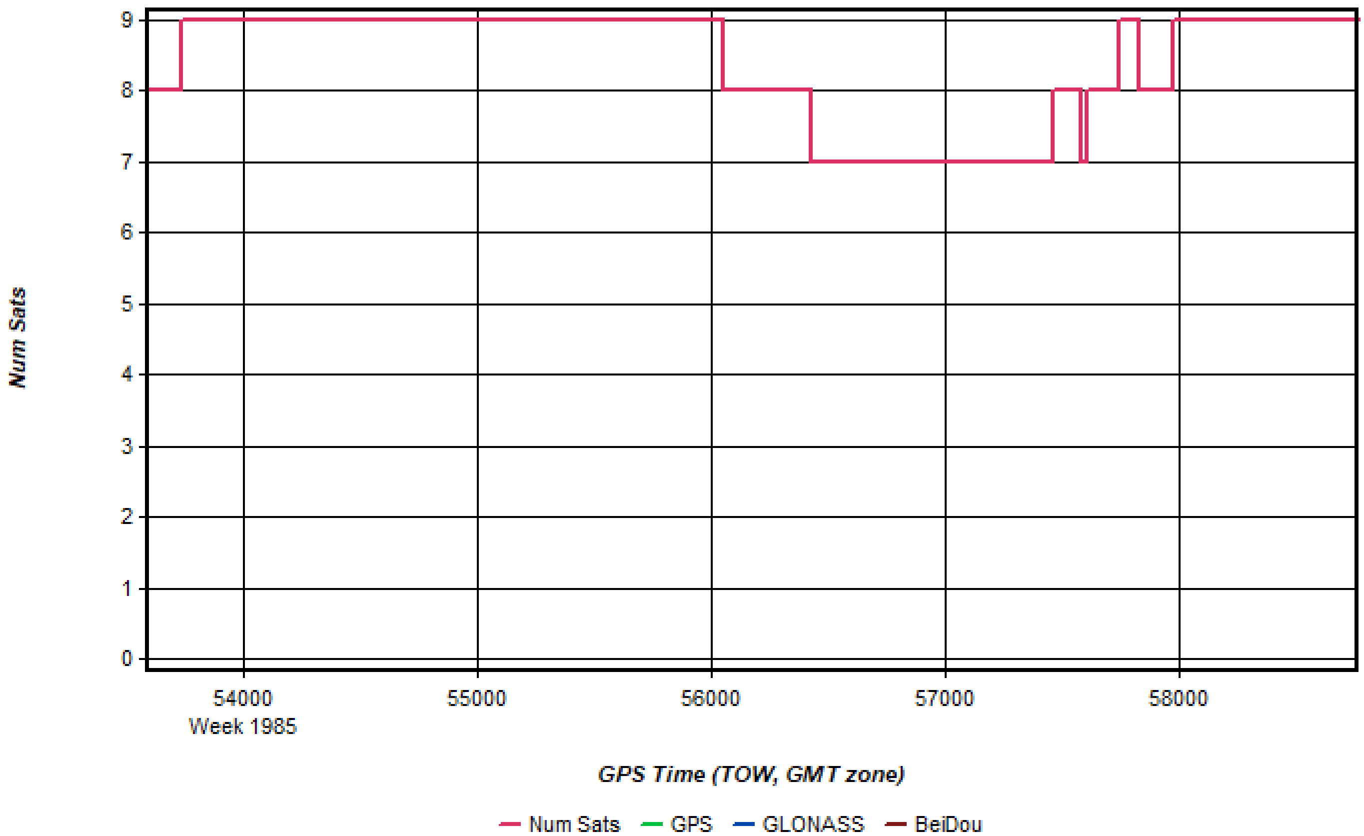

Separation (m)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
572000
Week 1984
573000
574000
575000
576000
577000
578000
579000
GPS Time (TOW, GMT zone)
East
North
Up

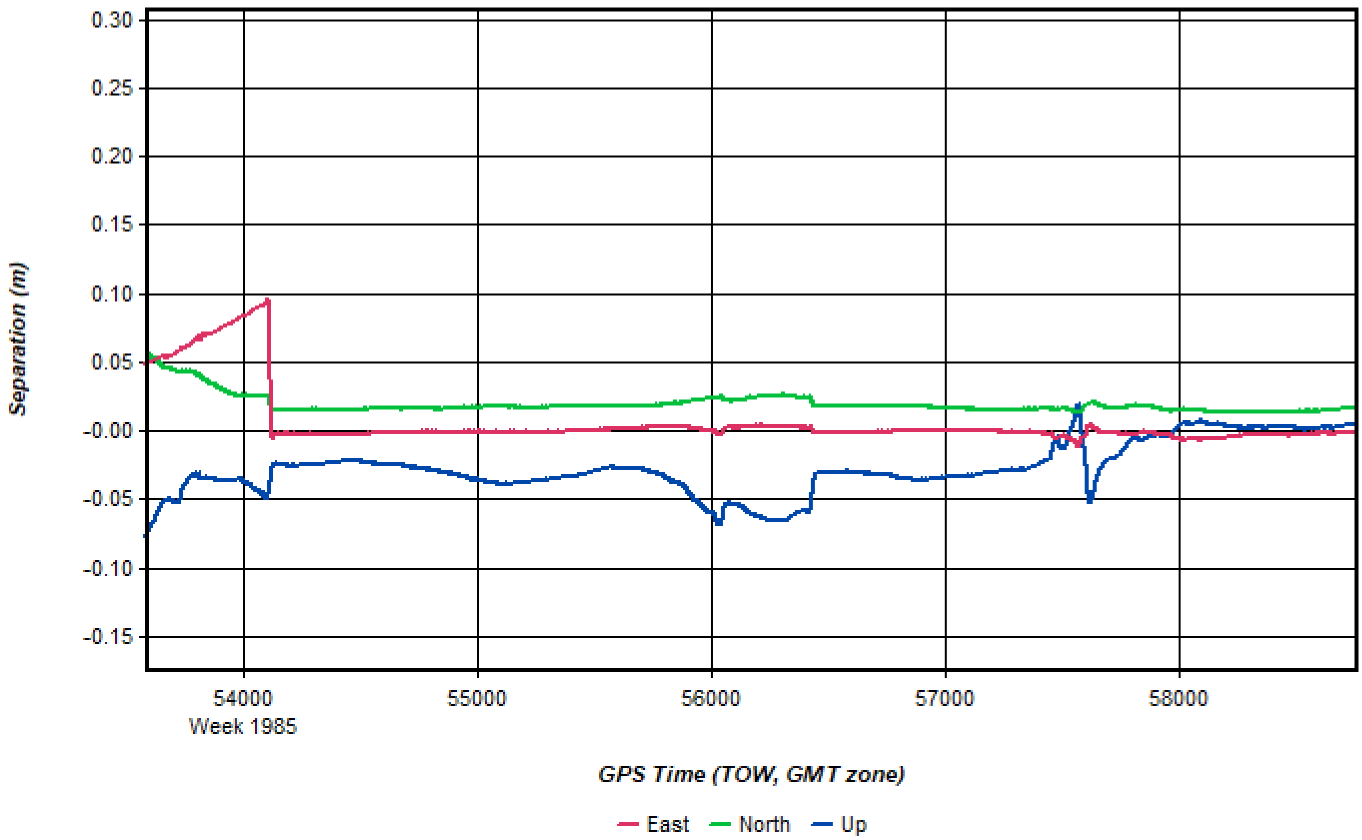


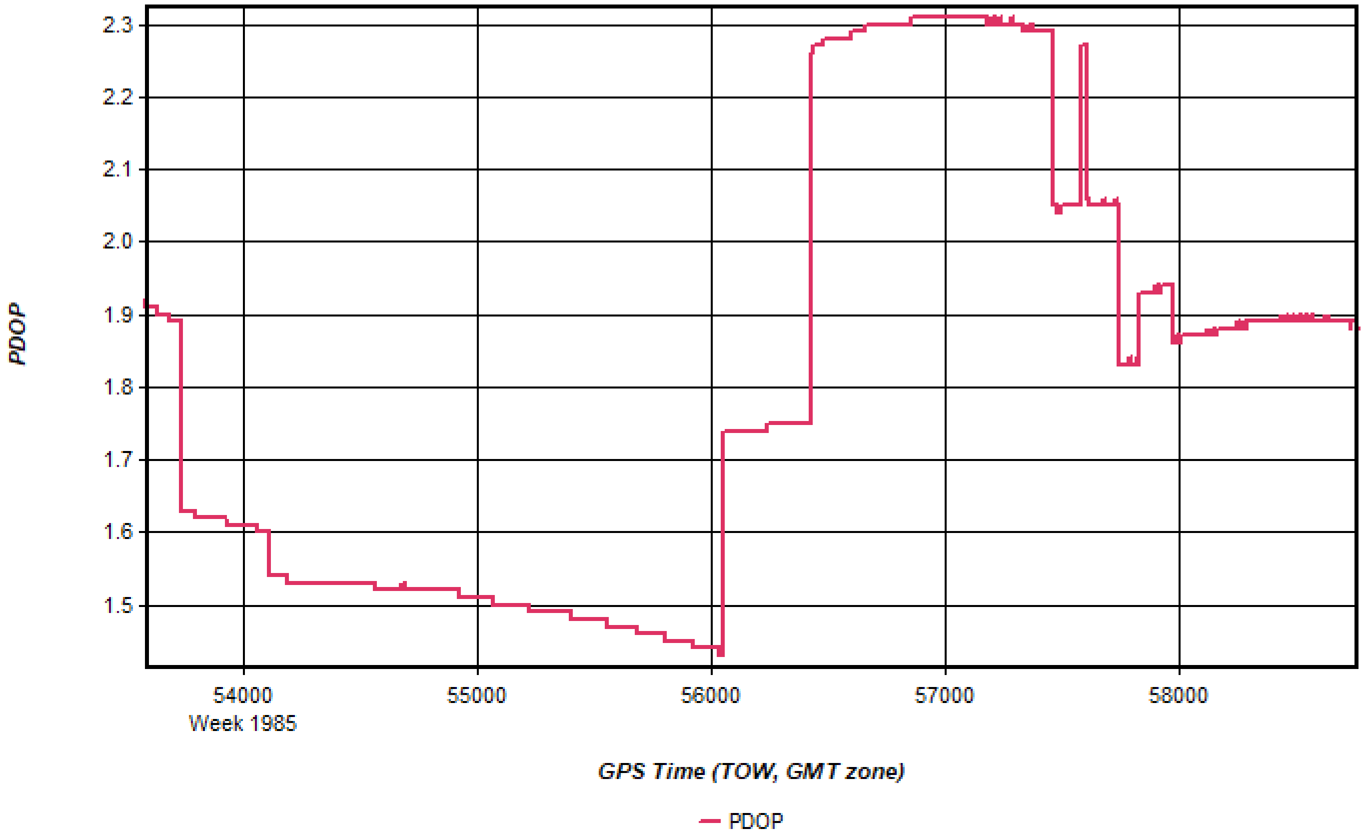
123_20180121_1



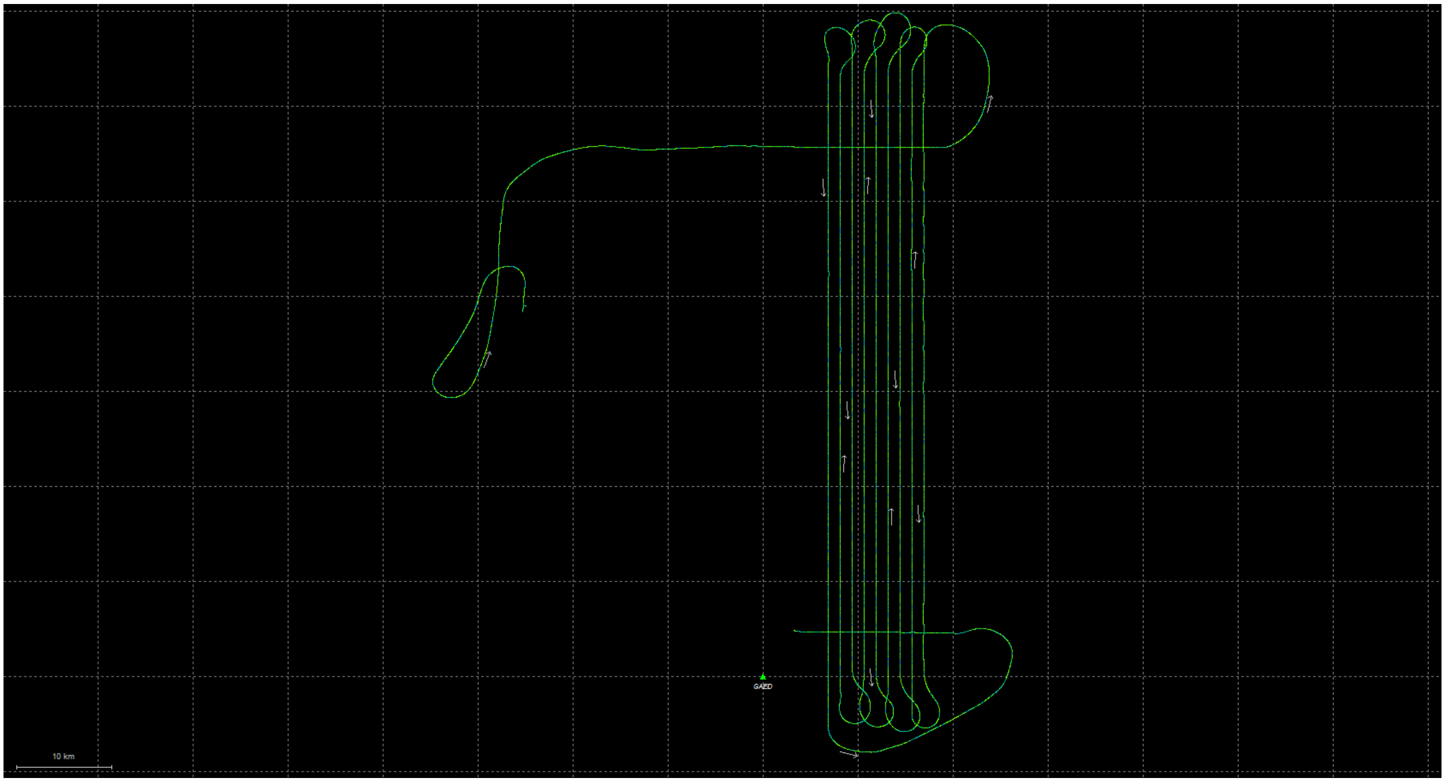

Estimated StdDev (m)
0.016
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
54000
Week 1985
55000
56000
57000
58000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

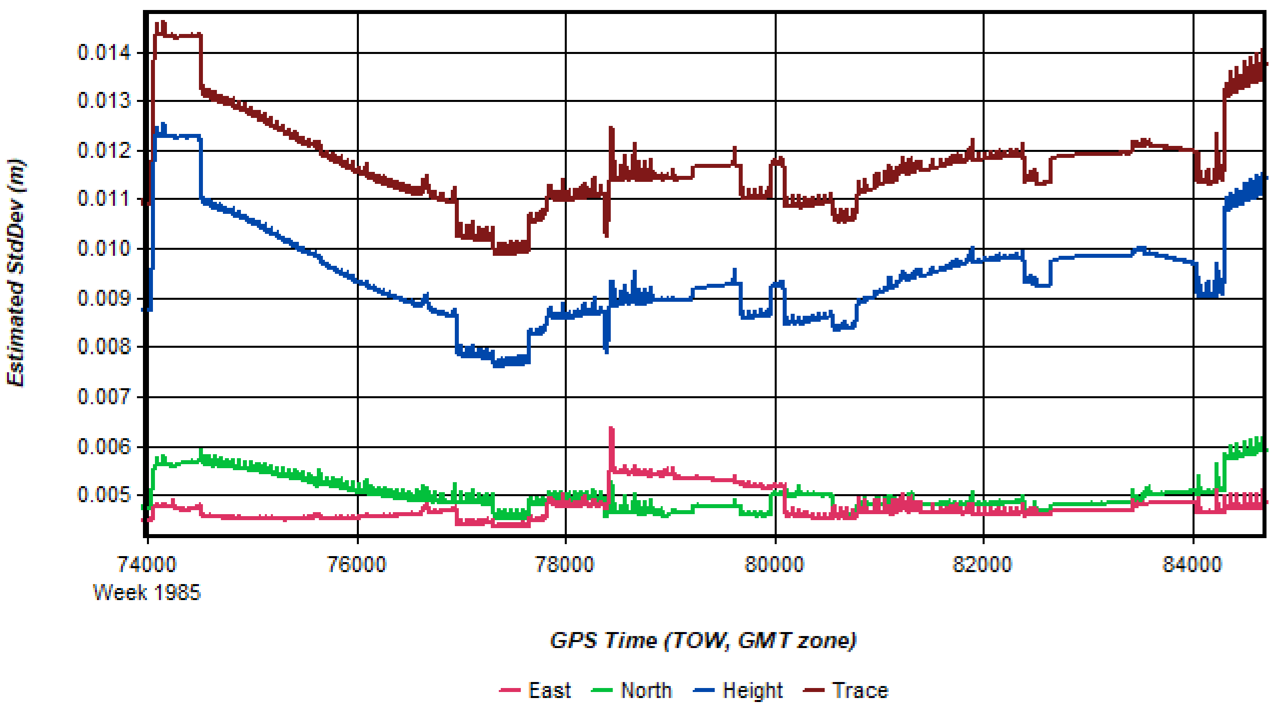

Num Sats
9
8
7
6
5
4
3
2
1
0
54000
Week 1985
55000
56000
57000
58000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

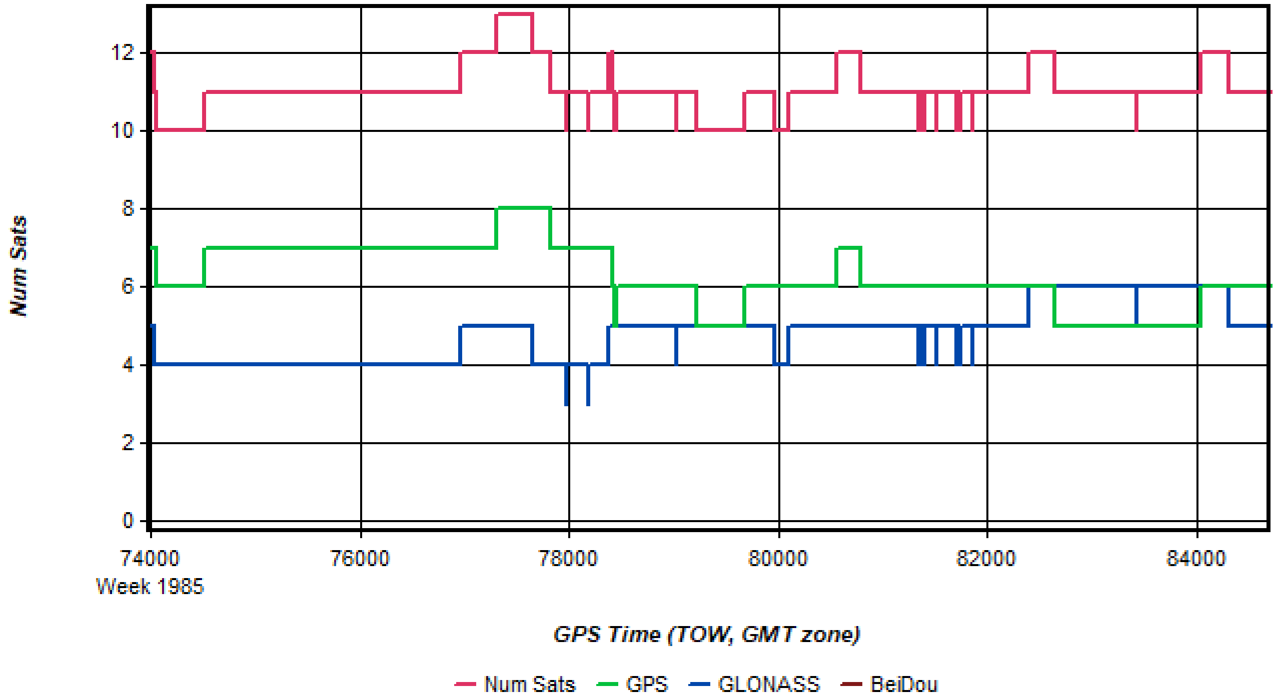

0.30
0.25
0.20
0.15
0.10
0.05
-0.00
-0.05
-0.10
-0.15
Separation (m)
54000
Week 1985
55000
56000
57000
58000
GPS Time (TOW, GMT zone)
East
North
Up

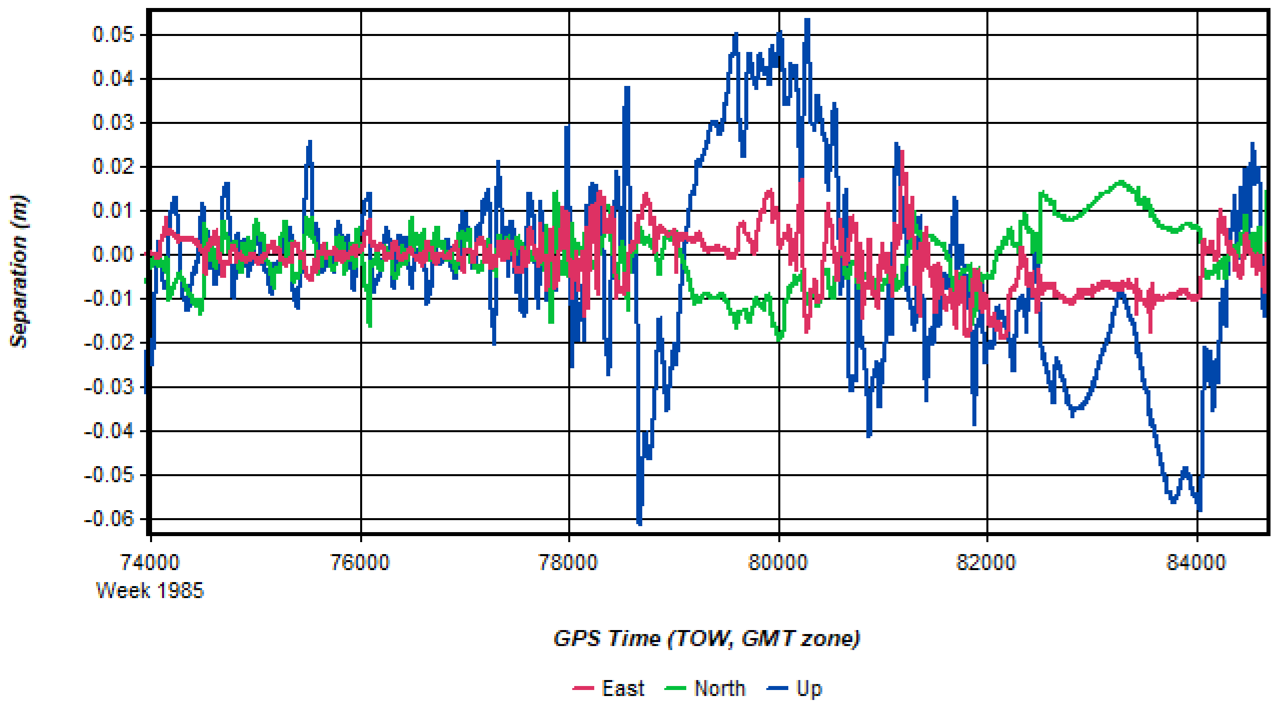


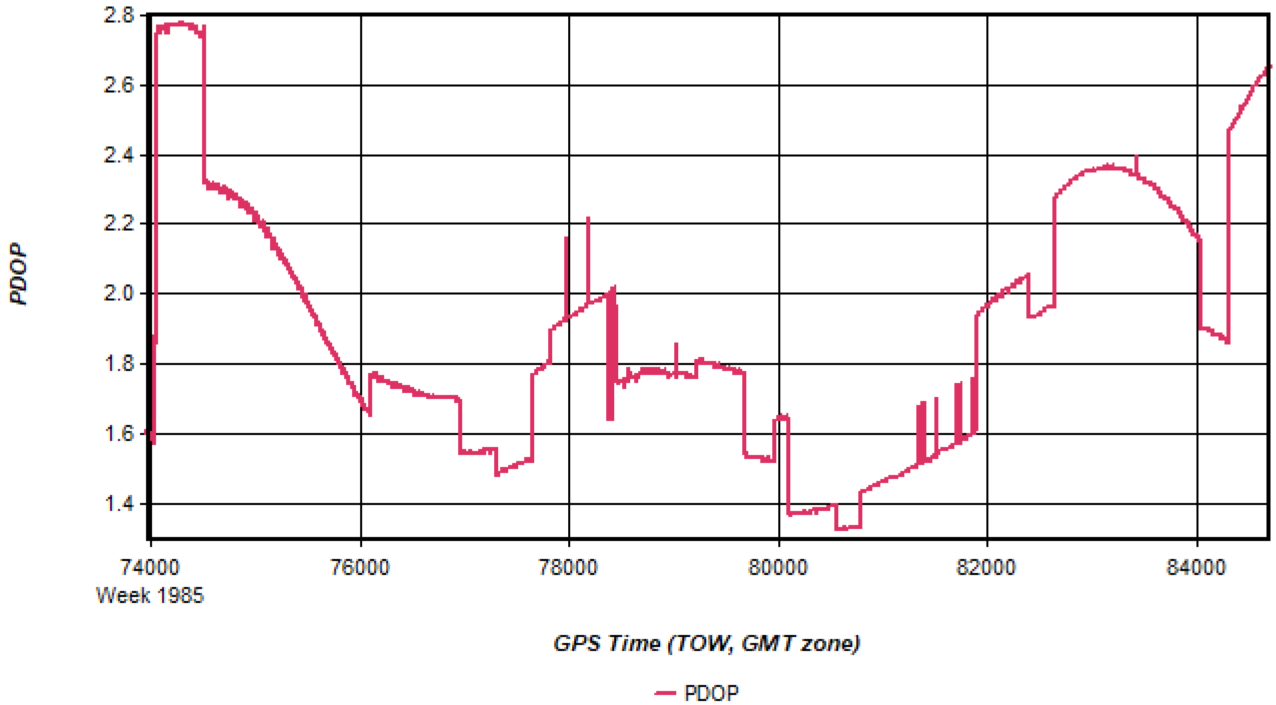
123_20180121_2


10 km
GAED

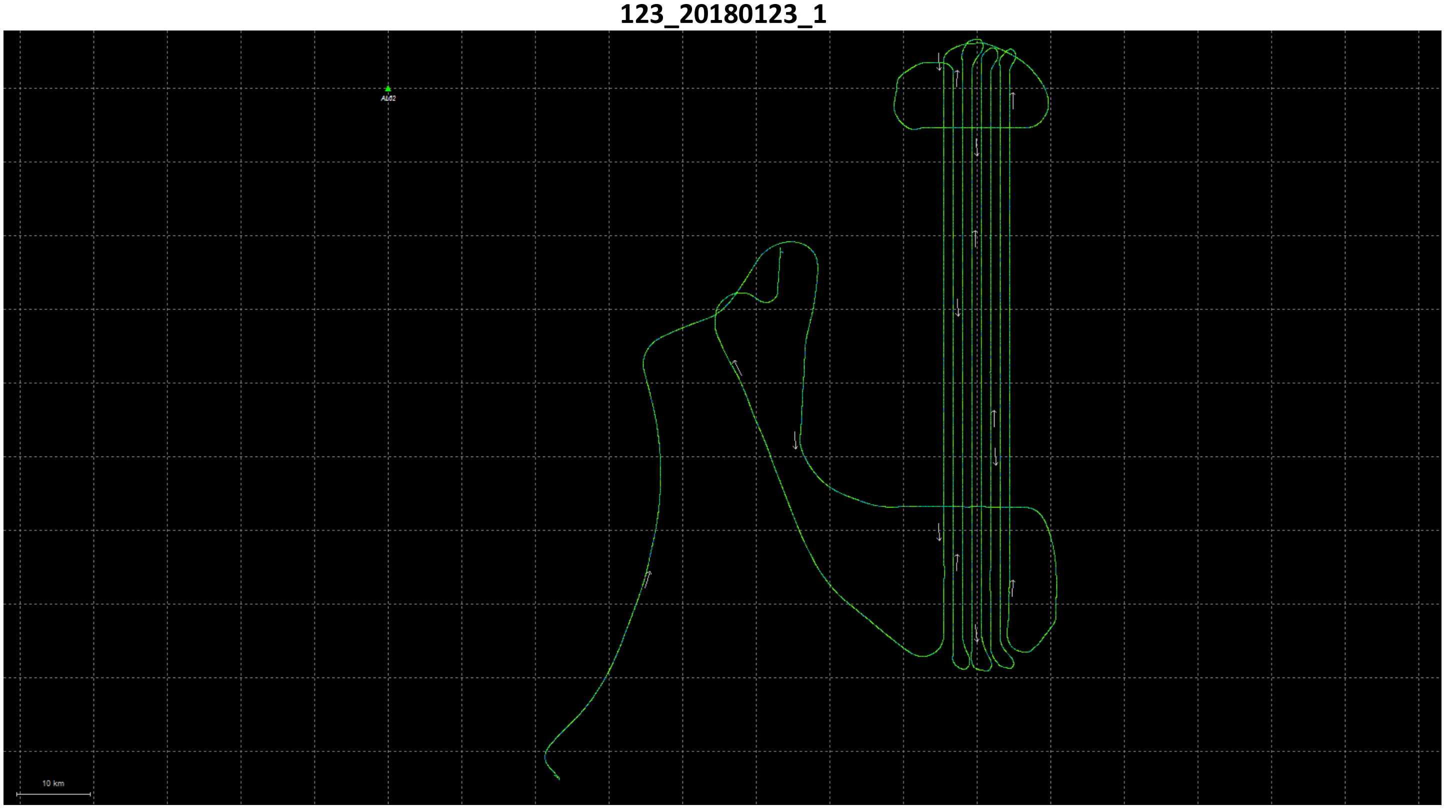

Estimated StdDev (m)
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
74000
Week 1985
76000
78000
80000
82000
84000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

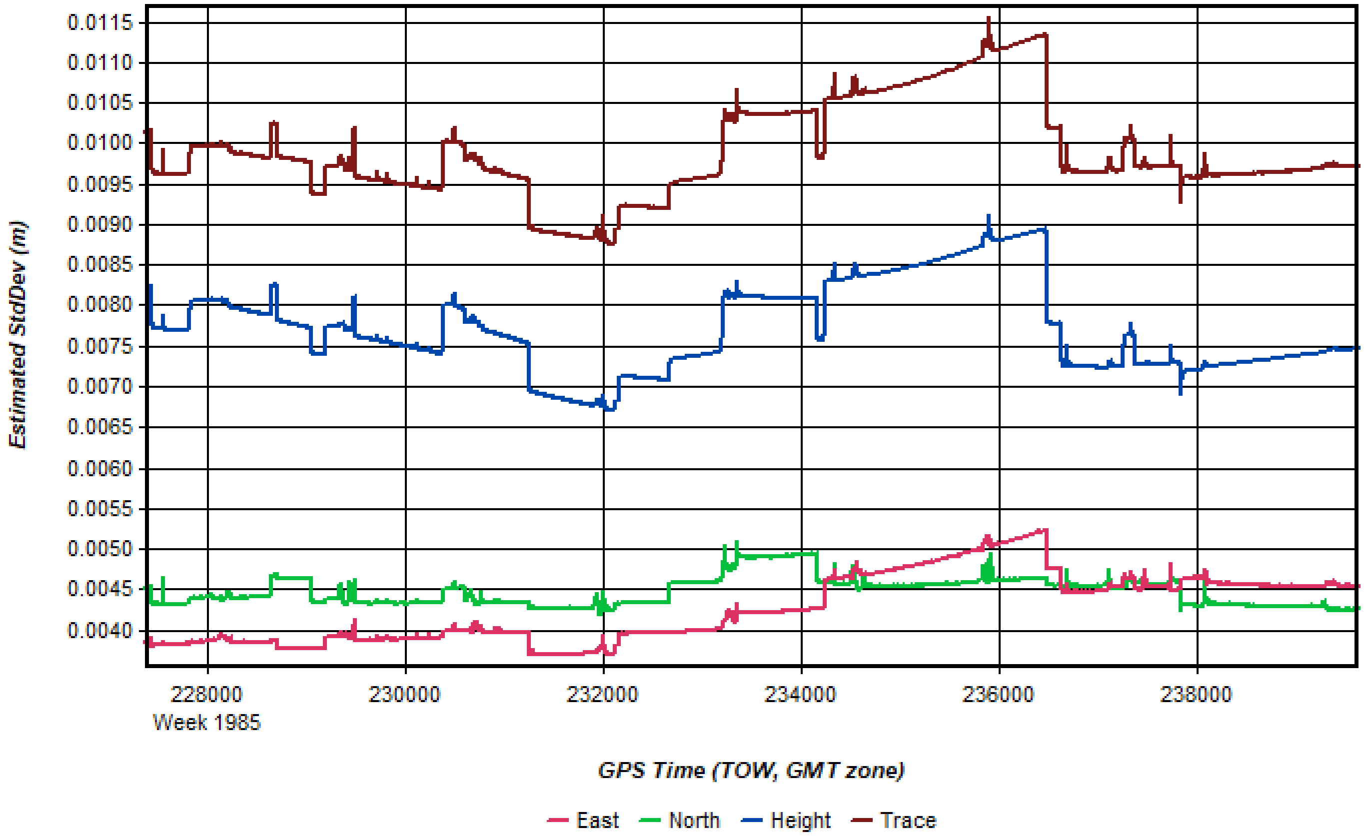

12
10
8
6
4
2
0
Num Sats
74000
Week 1985
76000
78000
80000
82000
84000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

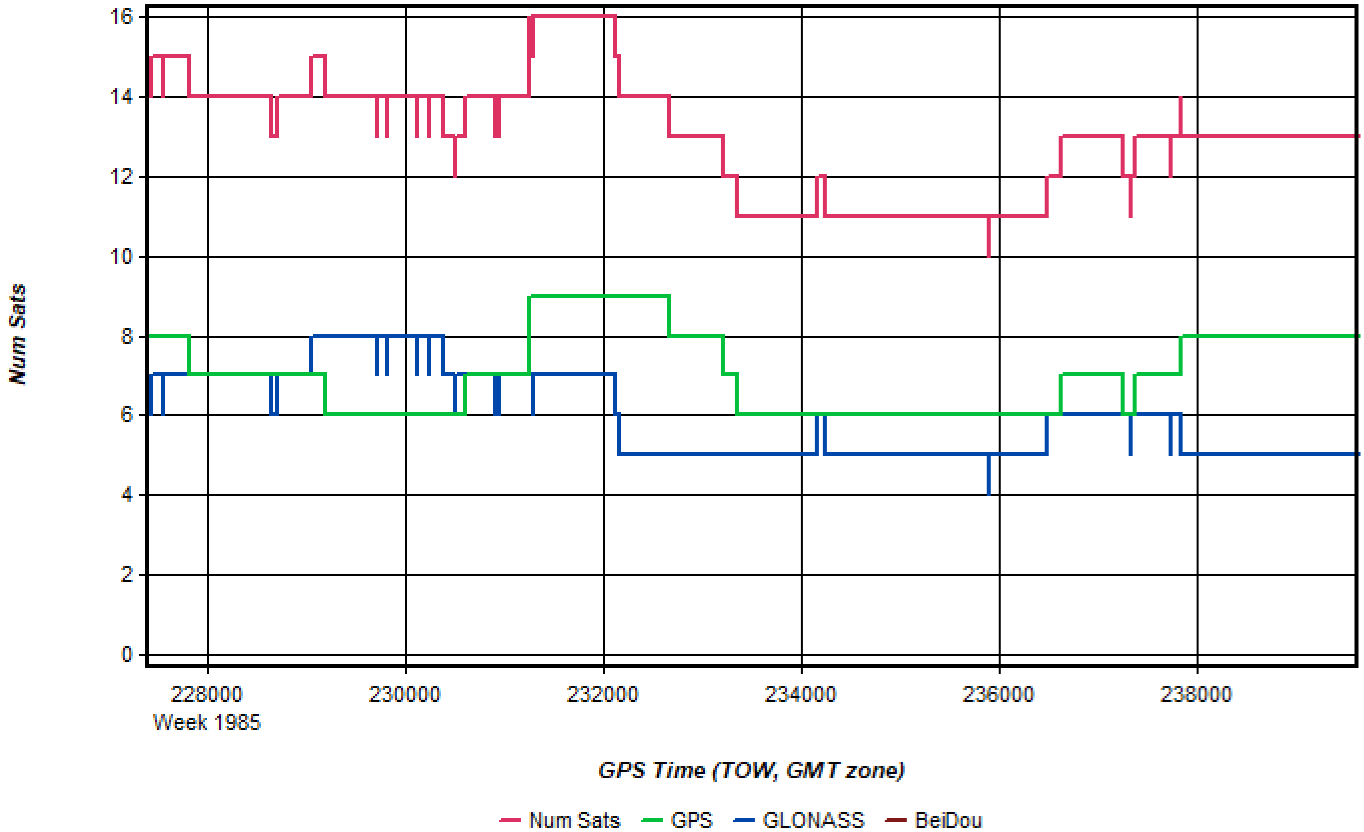

0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
Separation (m)
74000
Week 1985
76000
78000
80000
82000
84000
GPS Time (TOW, GMT zone)
East
North
Up

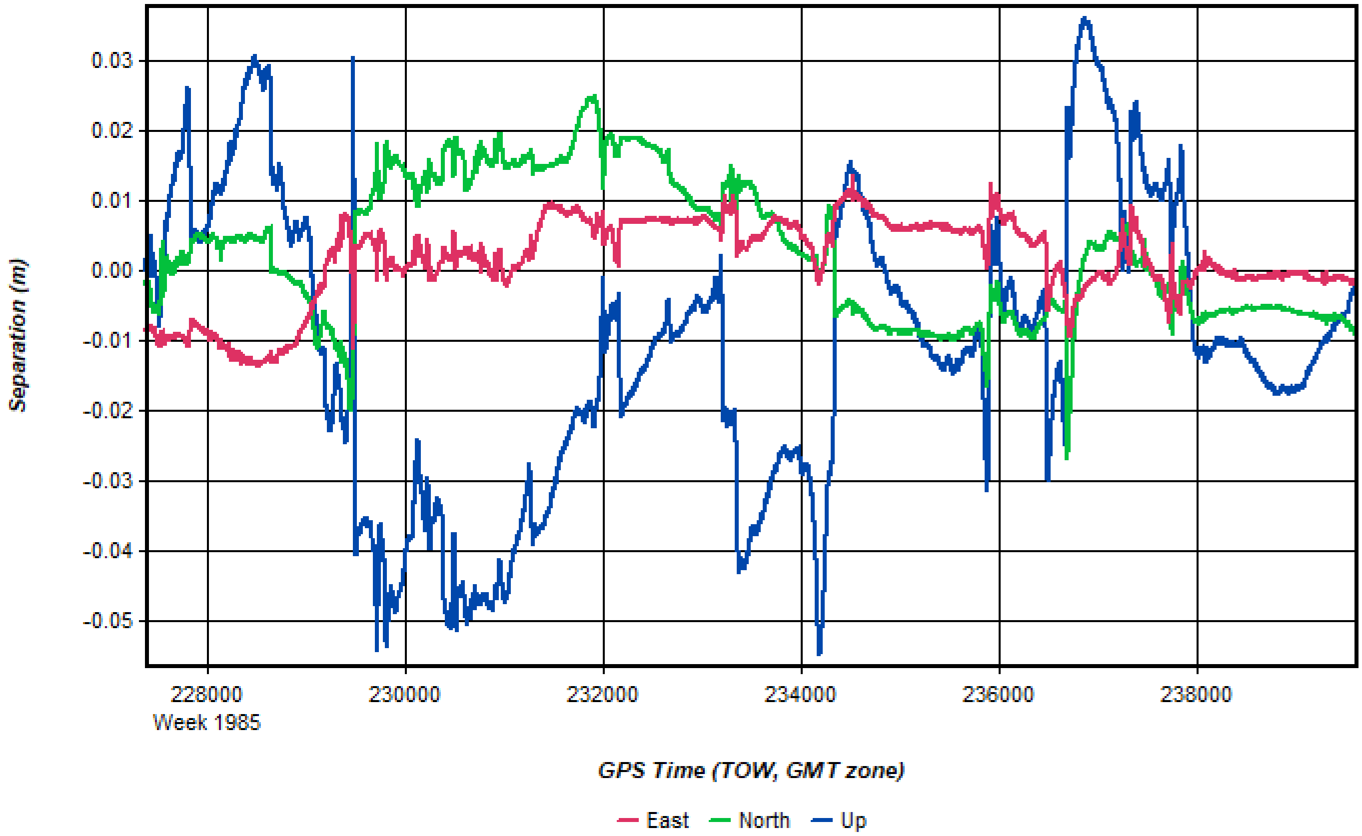


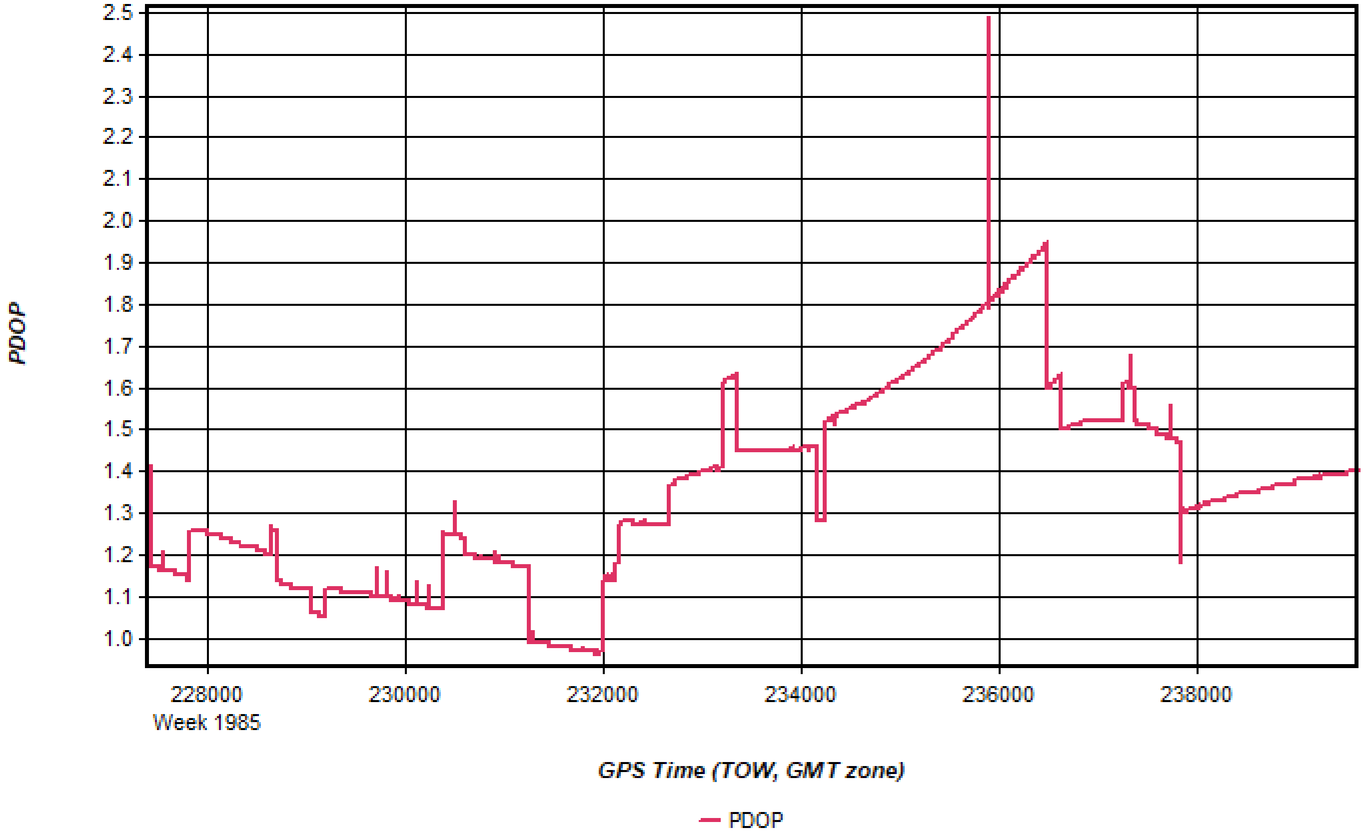
123_20180123_1



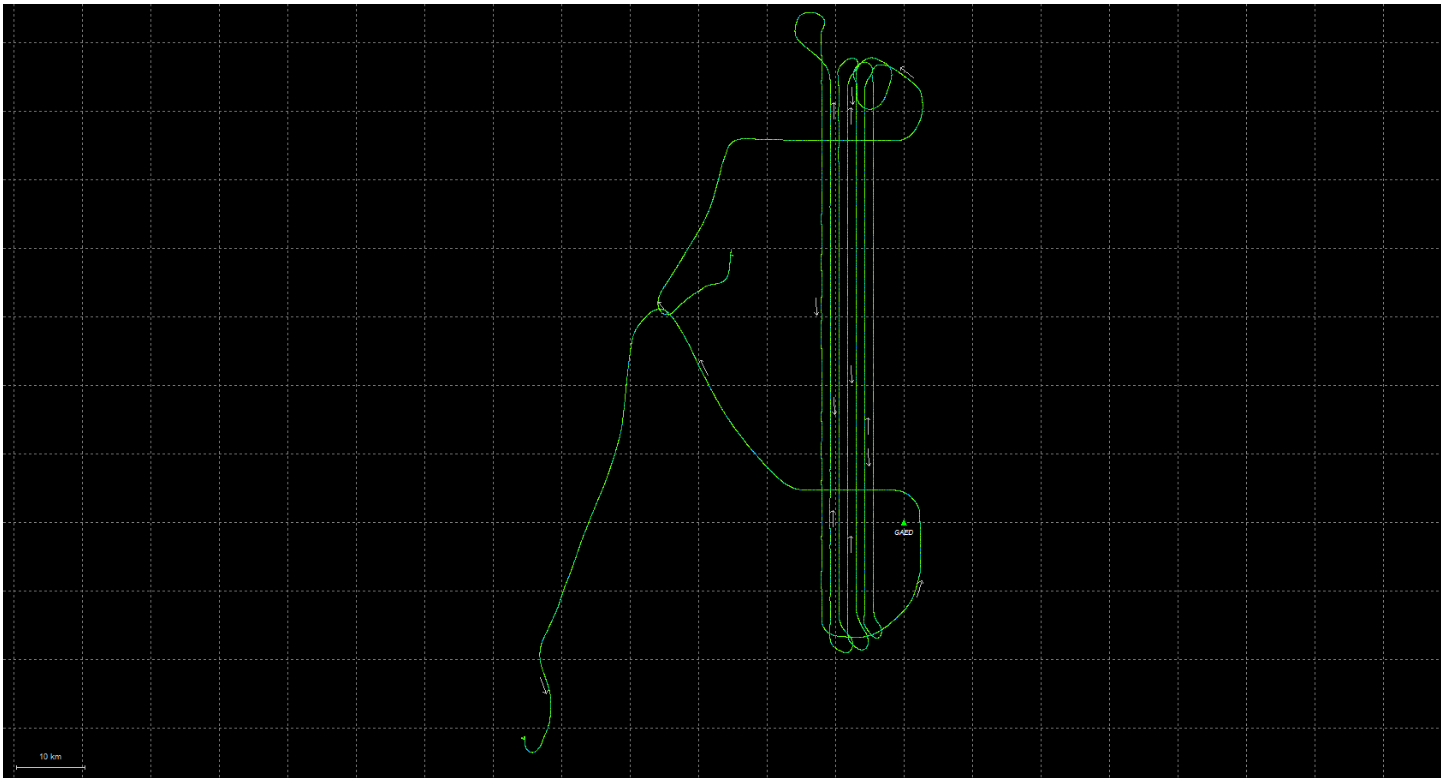

0.0115
0.0110
0.0105
0.0100
0.0095
0.0090
0.0085
0.0080
0.0075
0.0070
0.0065
0.0060
0.0055
0.0050
0.0045
0.0040
Estimated StdDev (m)
228000
Week 1985
230000
232000
234000
236000
238000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

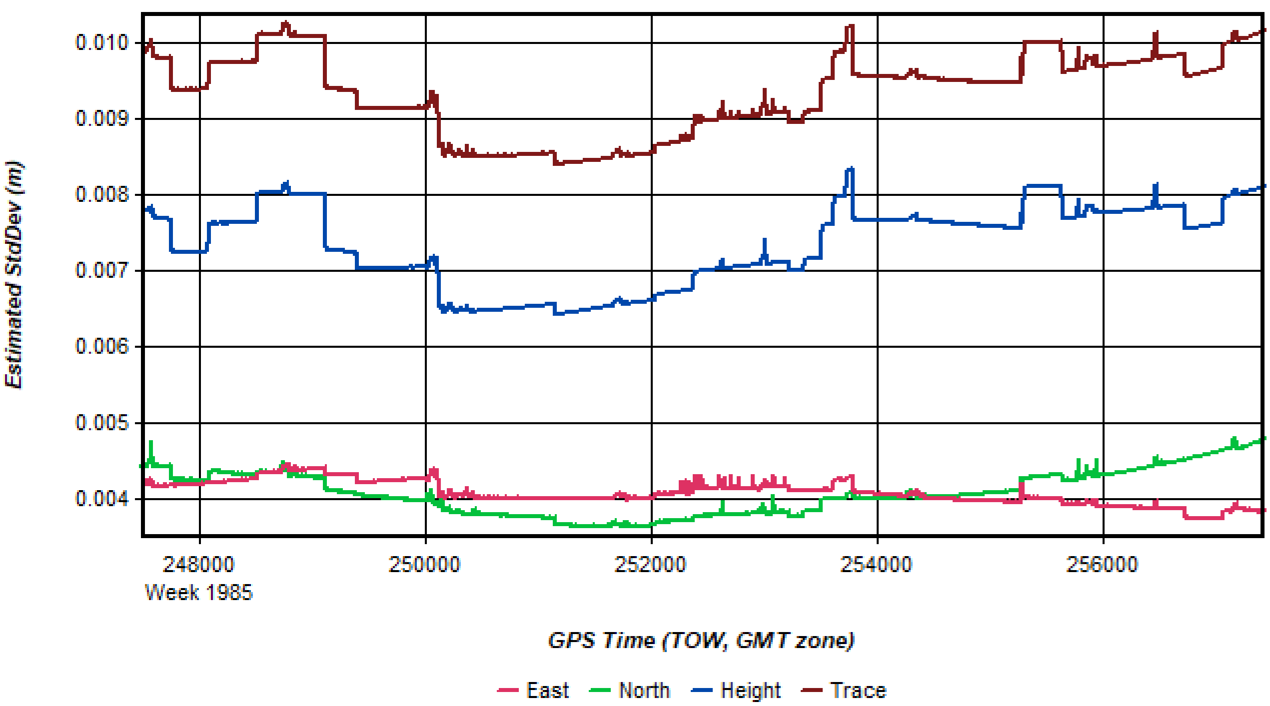

Num Sats
16
14
12
10
8
6
4
2
0
228000
Week 1985
230000
232000
234000
236000
238000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

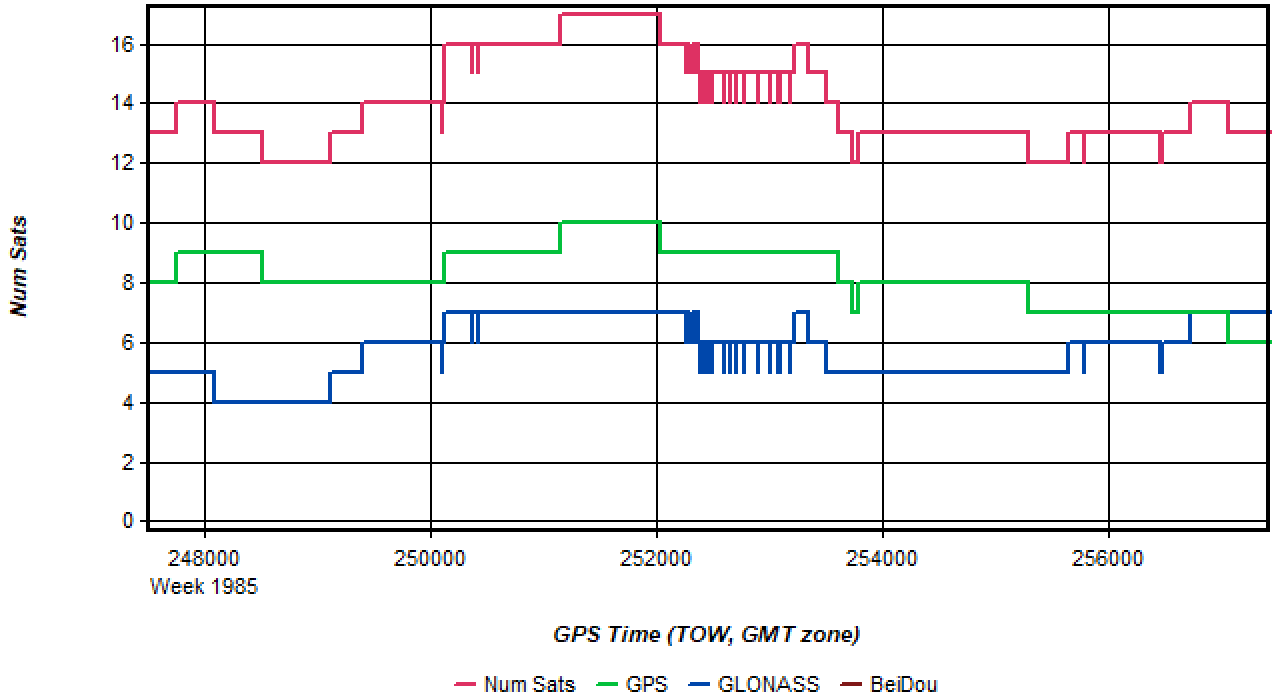

Separation (m)
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
228000
Week 1985
230000
232000
234000
236000
238000
GPS Time (TOW, GMT zone)
East
North
Up

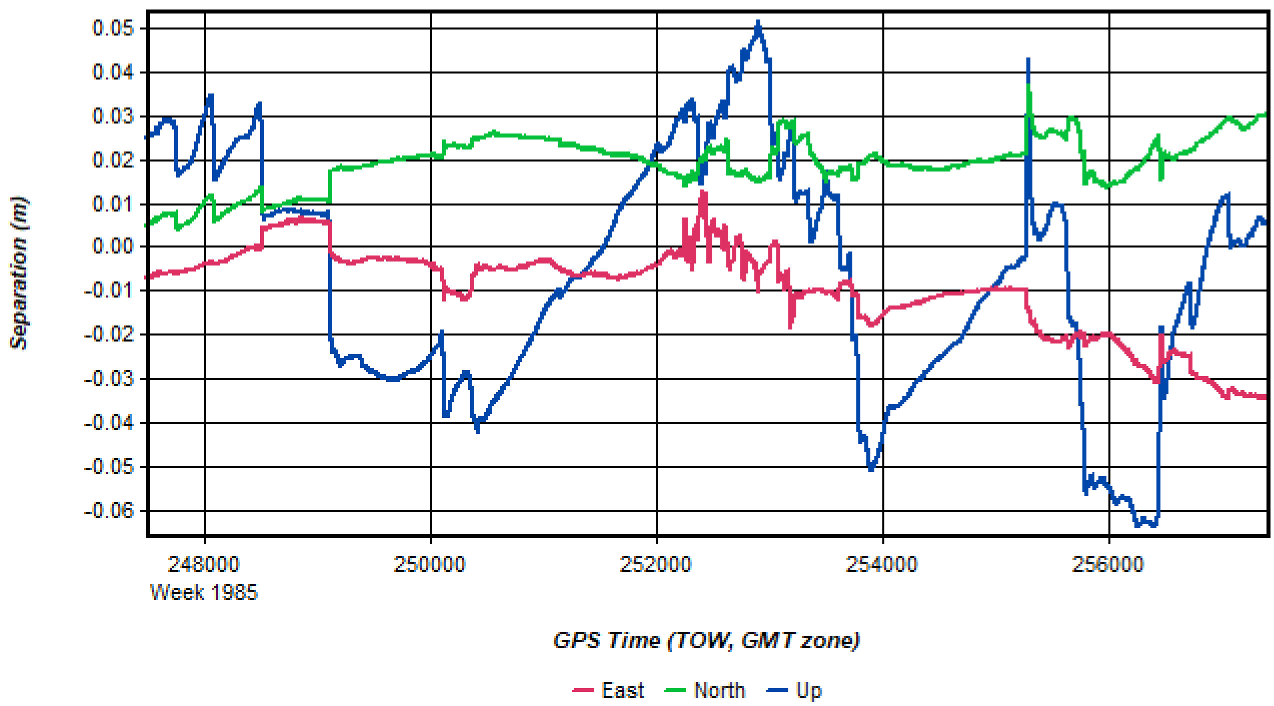


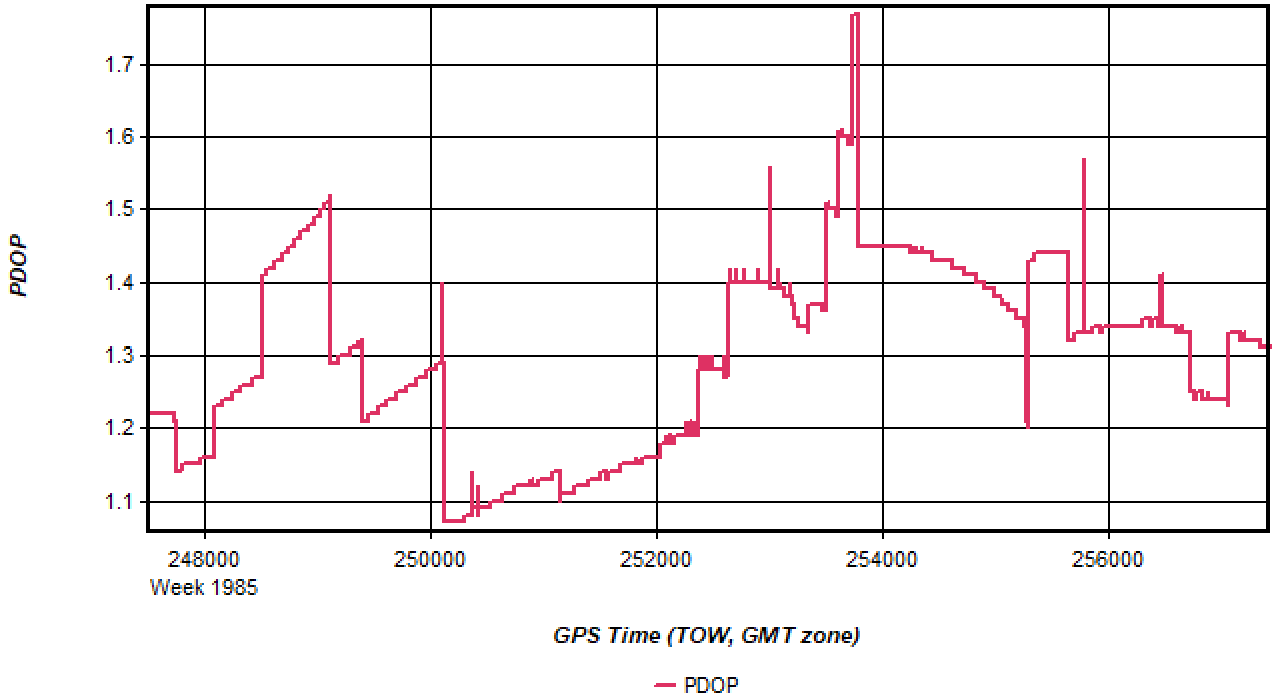
123_20180123_2


10 km
GAED

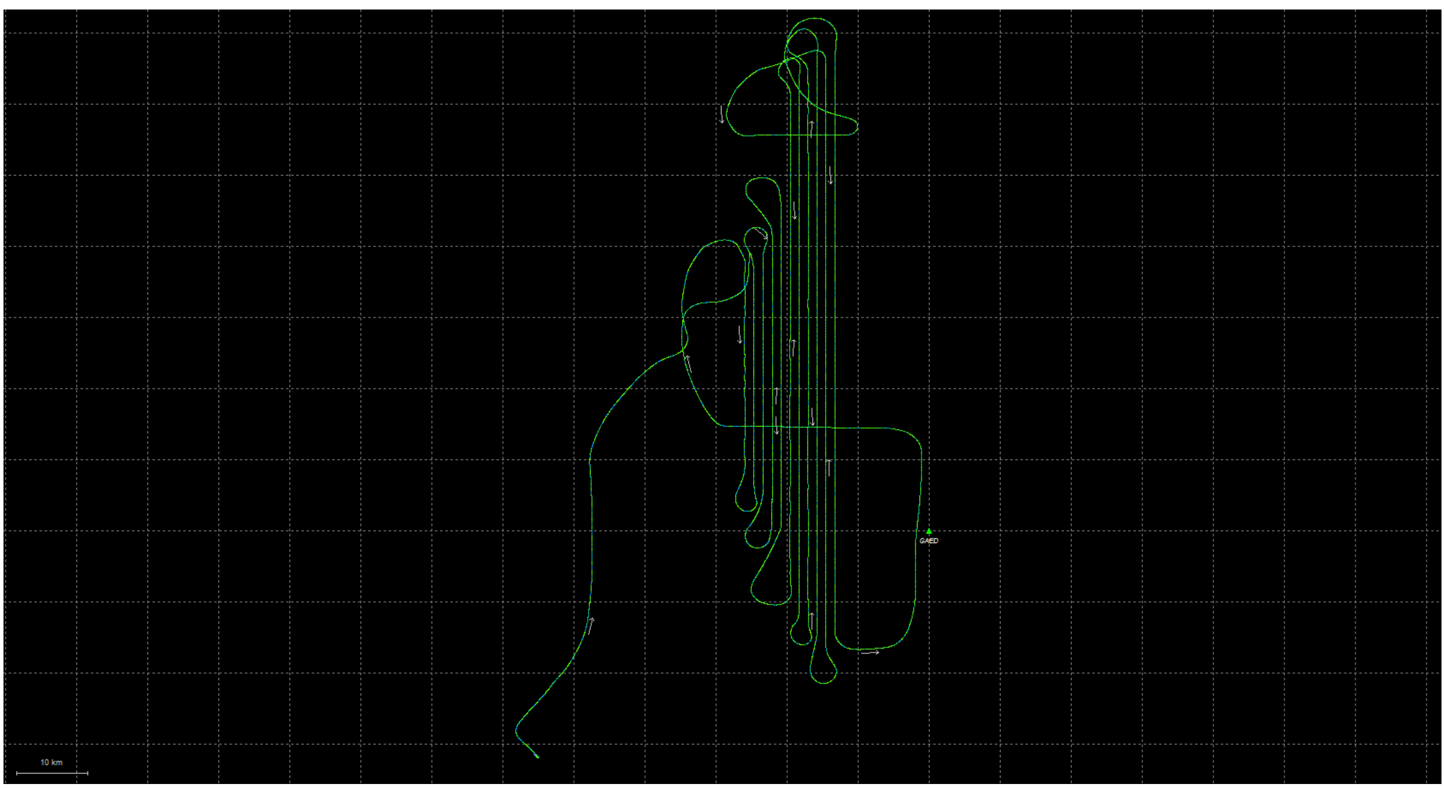

0.010
0.009
0.008
0.007
0.006
0.005
0.004
Estimated StdDev (m)
248000
Week 1985
250000
252000
254000
256000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

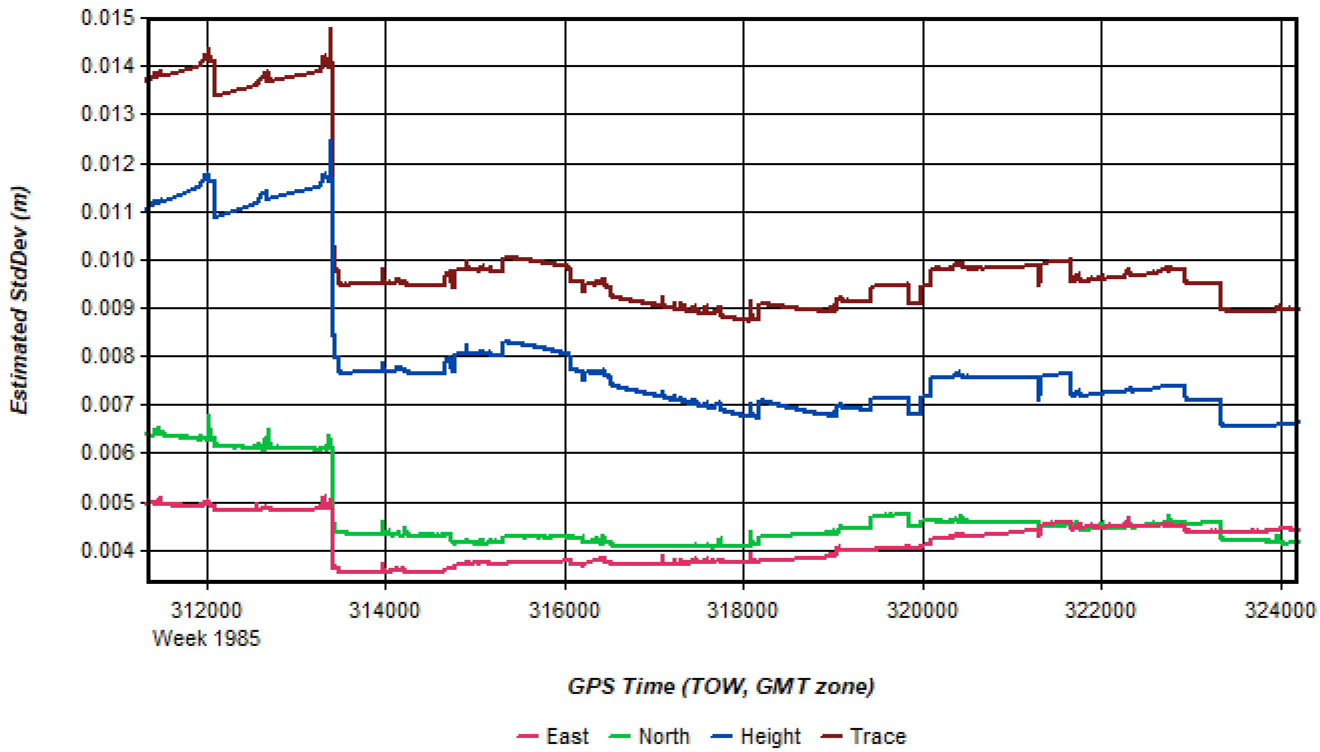

Num Sats
16
14
12
10
8
6
4
2
0
248000
Week 1985
250000
252000
254000
256000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

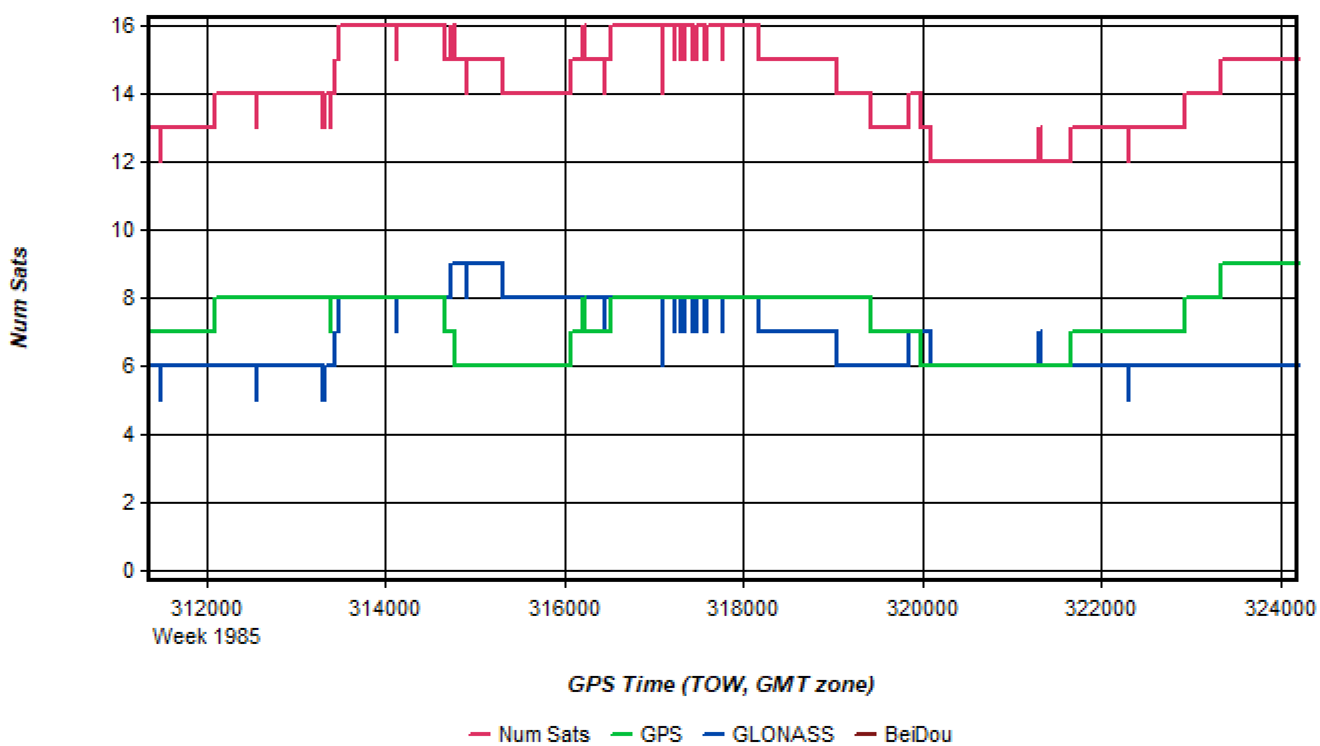

Separation (m)
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
248000
Week 1985
250000
252000
254000
256000
GPS Time (TOW, GMT zone)
East
North
Up

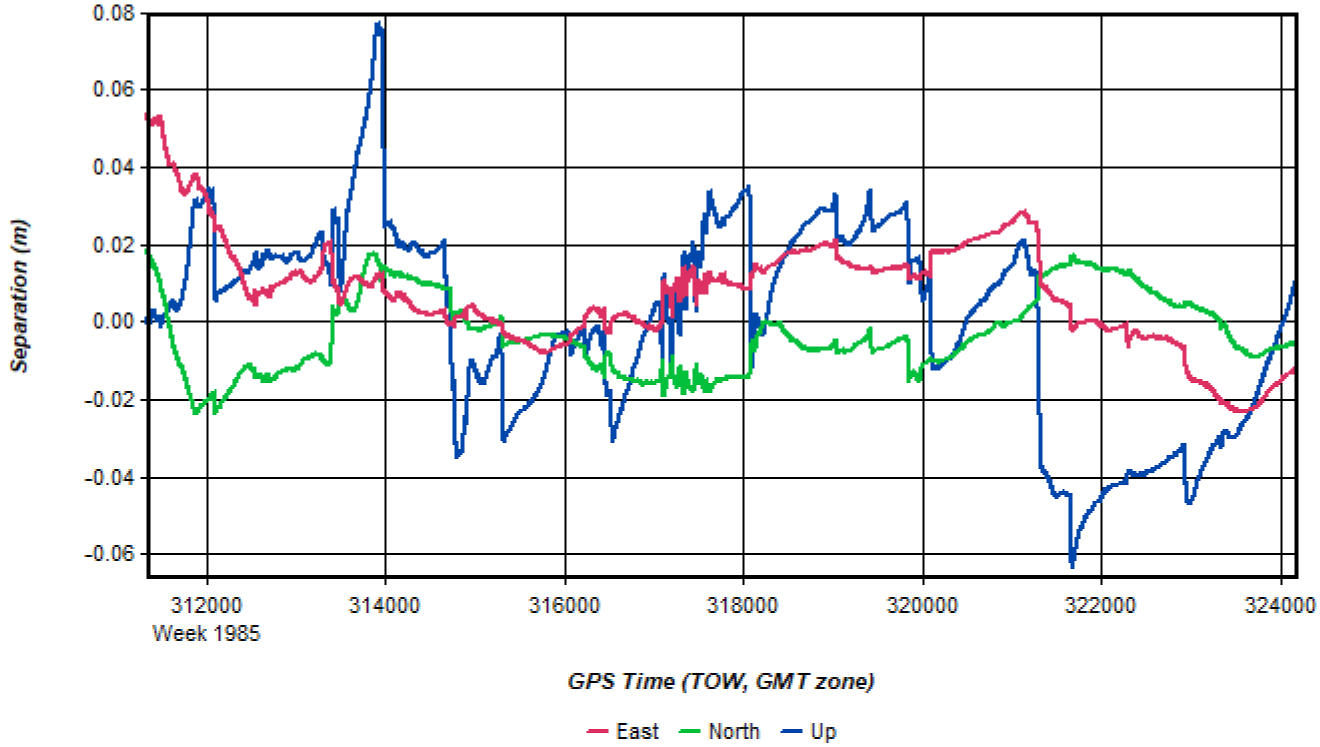


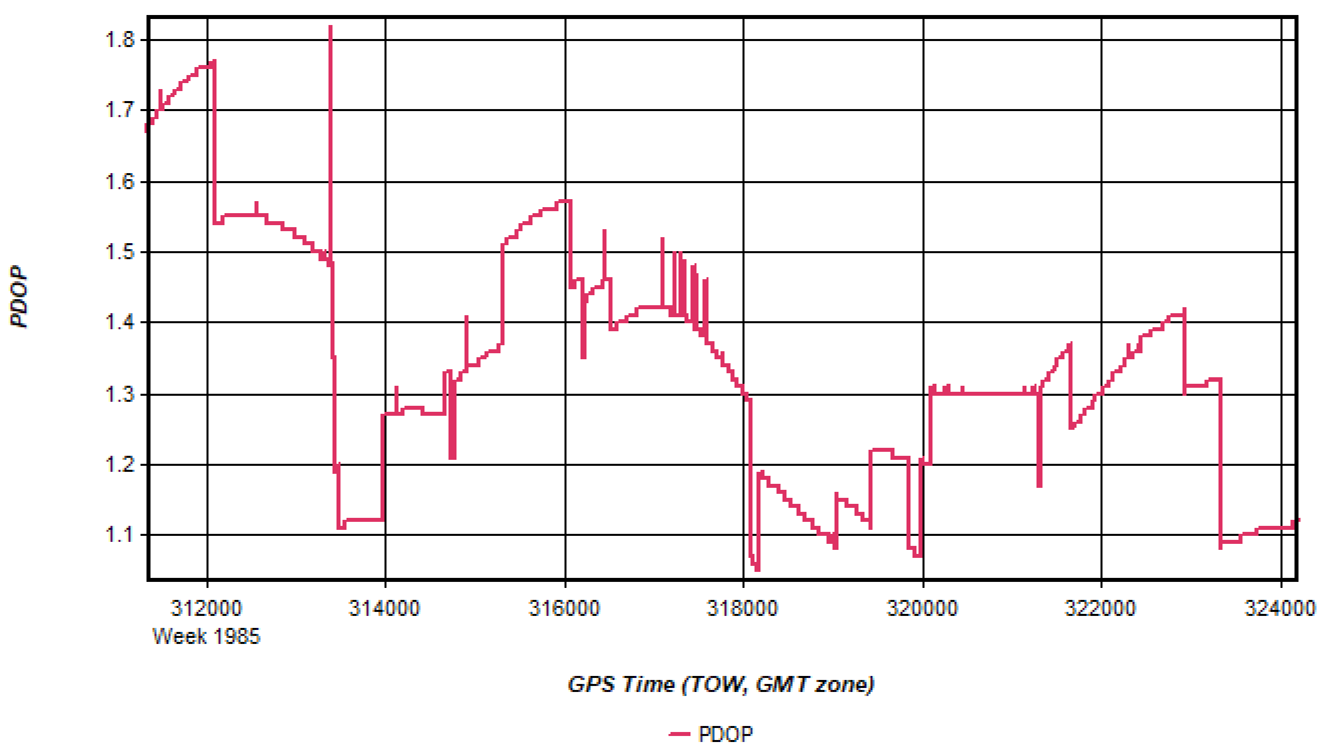
123_20180124_1




Estimated StdDev (m)
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
312000
Week 1985
314000
316000
318000
320000
322000
324000
GPS Time (TOW, GMT zone)
East
North
Height
Trace


Num Sats
16
14
12
10
8
6
4
2
0
312000
Week 1985
314000
316000
318000
320000
322000
324000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou


Separation (m)
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
312000
Week 1985
314000
316000
318000
320000
322000
324000
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
312000
Week 1985
314000
316000
318000
320000
322000
324000
GPS Time (TOW, GMT zone)
PDOP