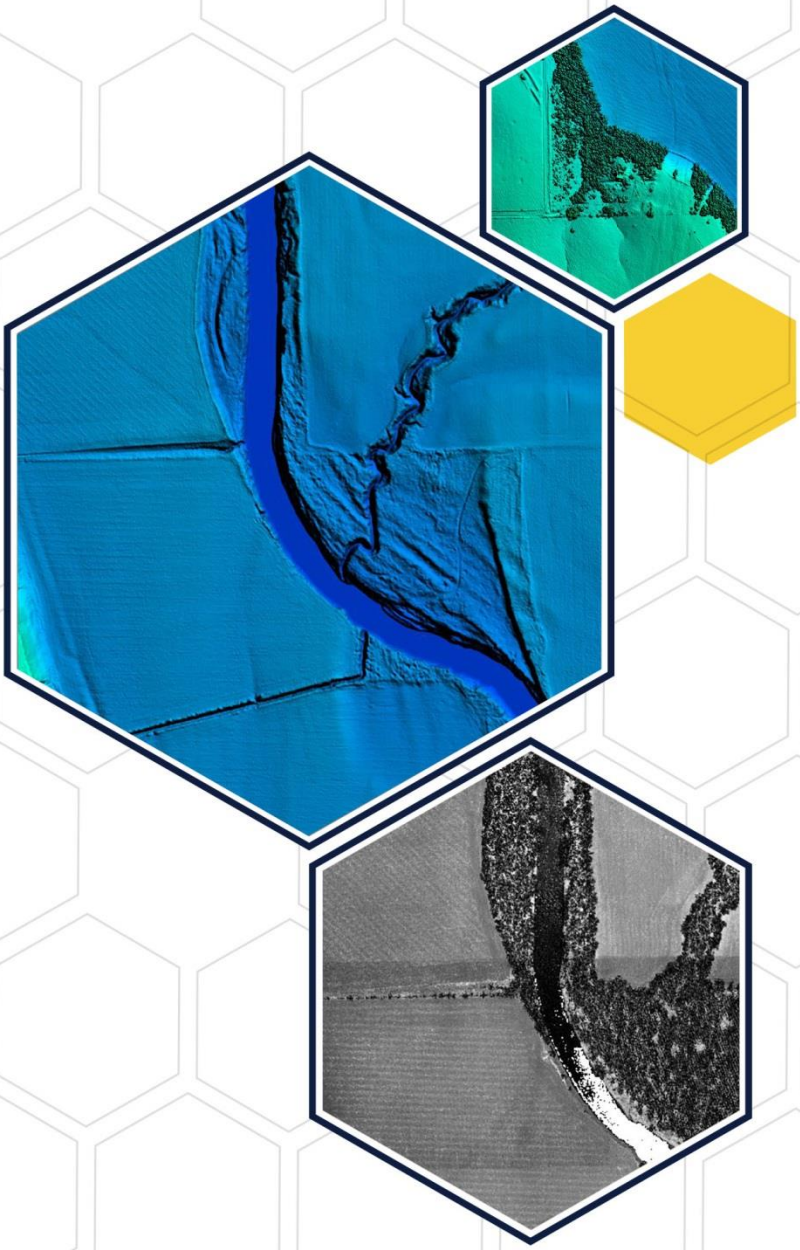


Aerial Lidar Report

18003
United States Geological Survey, Missouri FEMA R7 Lidar
April 2019

Table of Contents

Section 1: Lidar Acquisition 2
1.1 Acquisition 2
1.2 Acquisition Status Report 2
1.3 Acquisition Details 2
1.4 Project Purpose 2
1.5 Lidar Flight-line Orientation 3
1.6 Acquisition Equipment 4
1.7 Lidar System Acquisition Parameters 5
1.8 GNSS Reference Station(s) 6
1.9 Airborne GNSS Kinematic 6
Section 2: Lidar Processing 7
2.1 Lidar Point Cloud Generation 7
2.2 Coordinate Reference System 7
2.3 Lidar Point Cloud Statistics 8
2.4 Expected Horizontal Positional Error 8
2.5 Smooth Surface Repeatability (Intraswath) 9
2.6 Lidar Calibration 10
2.7 Overlap Consistency (Interswath) 11
2.8 Lidar Classification 13
Section 3: Lidar Accuracy 14
3.1 Ground Surveyed Check Points 14
3.2 Vertical Accuracy Requirements 14
3.3 Check Point Distribution 15
3.4 Vertical Accuracy Results 16
3.5 Check Point Assessment 16
Section 4: Certification 31
4.1 Limitations of Use 31
Section 5: GNSS Processing 32

Section 1: Lidar Acquisition

1.1 Acquisition

The Atlantic Group, LLC (Atlantic) has successfully completed lidar acquisition for the Missouri FEMA R7 Area of Interest (AOI). Lidar for this AOI was acquired in twenty (20) flight mission completed on January 1stth, 2018. The project area encompasses 3,657,812 acres, 14,803 square kilometers or 5,715 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 two-hundred and seventy-four (274) 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.

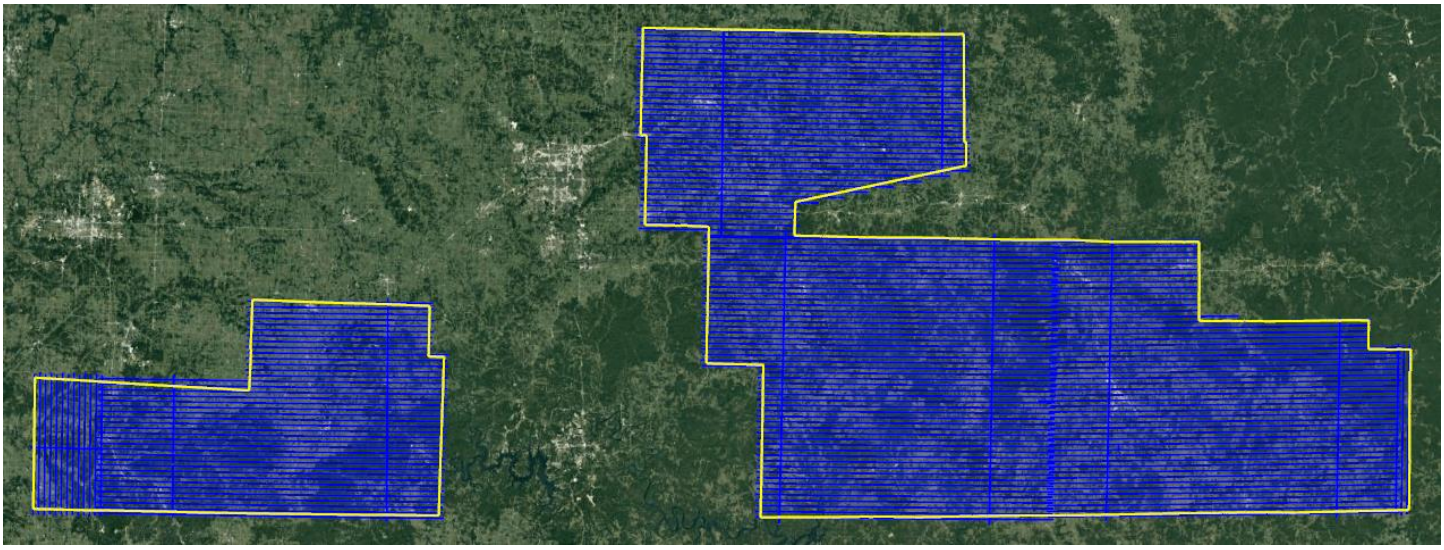


Figure 1: Trajectories as flown by Atlantic

1.6 Acquisition Equipment

Atlantic operated a Cessna 210TL (N732JE) 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)	0.5421
Nominal Pulse Density (pls/m²)	2.2
Nominal Flight Height (AGL meters)	2,255
Nominal Flight Speed (kts)	130
Pass Heading (degree)	90
Sensor Scan Angle (degree)	45
Scan Frequency (Hz)	34.2
Pulse Rate of Scanner (kHz)	256.8
Line Spacing (m)	1,343
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	0.50
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	Yes
Beam Divergence (mrad)	0.22
Nominal Swath Width (m)	1,717
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

Table 2: Atlantic Lidar System Acquisition Parameters

1.8 GNSS Reference Station(s)

Six (6) 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.

GNSS Reference Station Coordinates					
Designation	**Type**	**PID**	**Latitude (N)**	**Longitude (W)**	**Elevation**
MOSE	CORS	DM4690	37 09 20.77940	092 45 14.32526	472.979
MOBR	CORS	DL6012	36 42 35.20129	093 13 23.59212	289.892
MOWS	CORS	DL61445	36 58 11.74756	091 55 11.54866	351.157
MOMG	CORS	DM4680	37 07 51.66935	092 18 39.95093	420.882
MOSF	CORS	DL5388	37 14 30.33446	093 13 47.54327	396.871
MOMF	CORS	DN5832	37 20 45.75190	092 57 01.61543	416.450

Table 3: GNSS Reference Station Coordinates

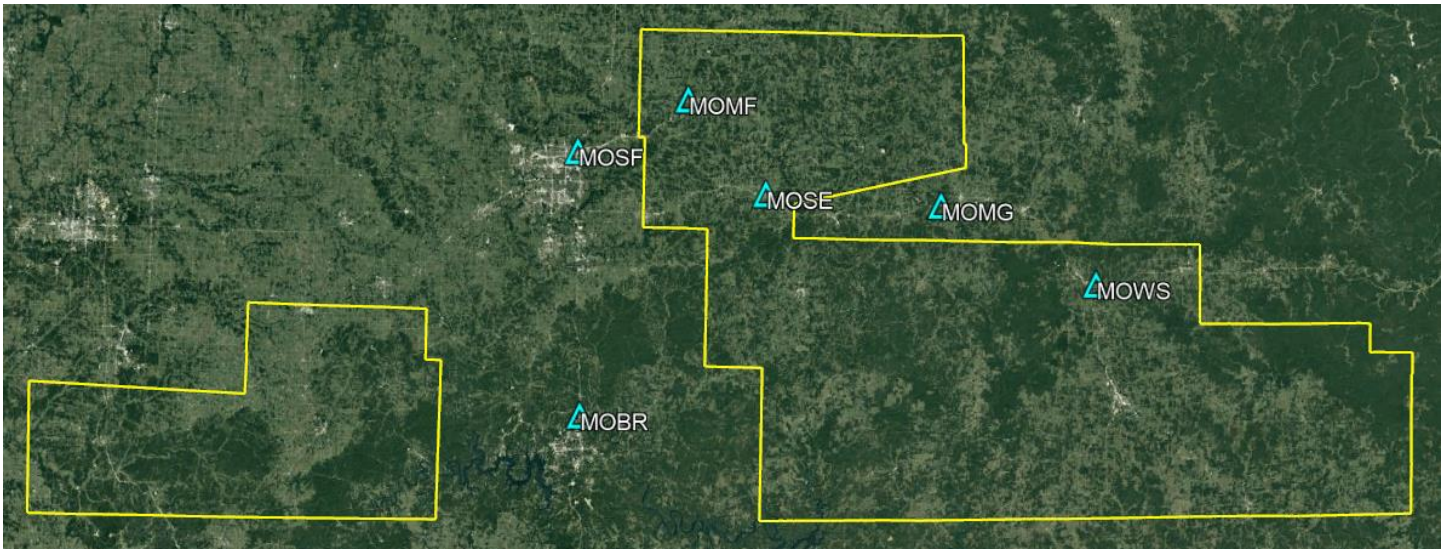


Figure 2: GNSS Reference Station(s)

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.

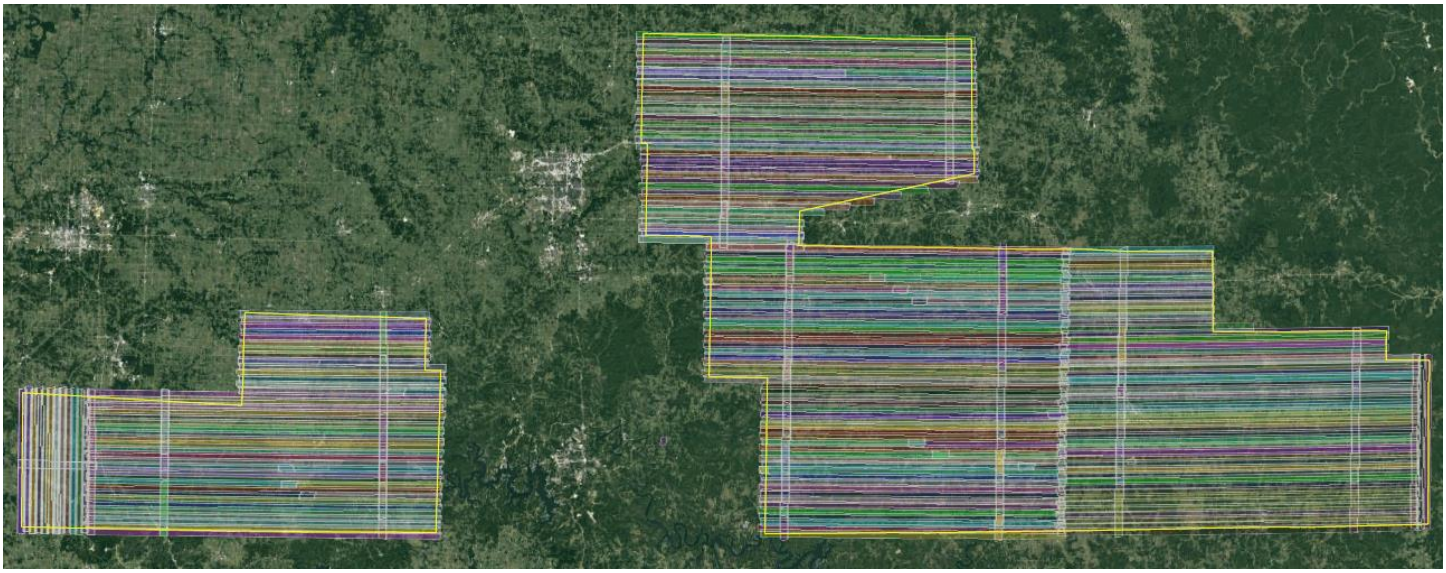


Figure 3: Lidar swath data showing complete coverage

2.2 Coordinate Reference System

Horizontal Datum:	North American Datum of 1983 (2011)
Coordinate System:	Universal Transverse Mercator Zone 15 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	78,477,813,725
Nominal Pulse Spacing (m)	0.5421
Nominal Pulse Density (pls/m²)	3.40
Nominal Pulse Spacing (ft)	1.7786
Nominal Pulse Density (pls/ft²)	0.32
Aggregate Total Points	71,115,801,929
Aggregate Nominal Pulse Spacing (m)	0.4716
Aggregate Nominal Pulse Density (pls/m²)	4.50
Aggregate Nominal Pulse Spacing (ft)	1.5472
Aggregate Nominal Pulse Density (pls/ft²)	0.42

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 2,255m; the expected radial horizontal positional error will be RMSEz = 32.1cm.

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.

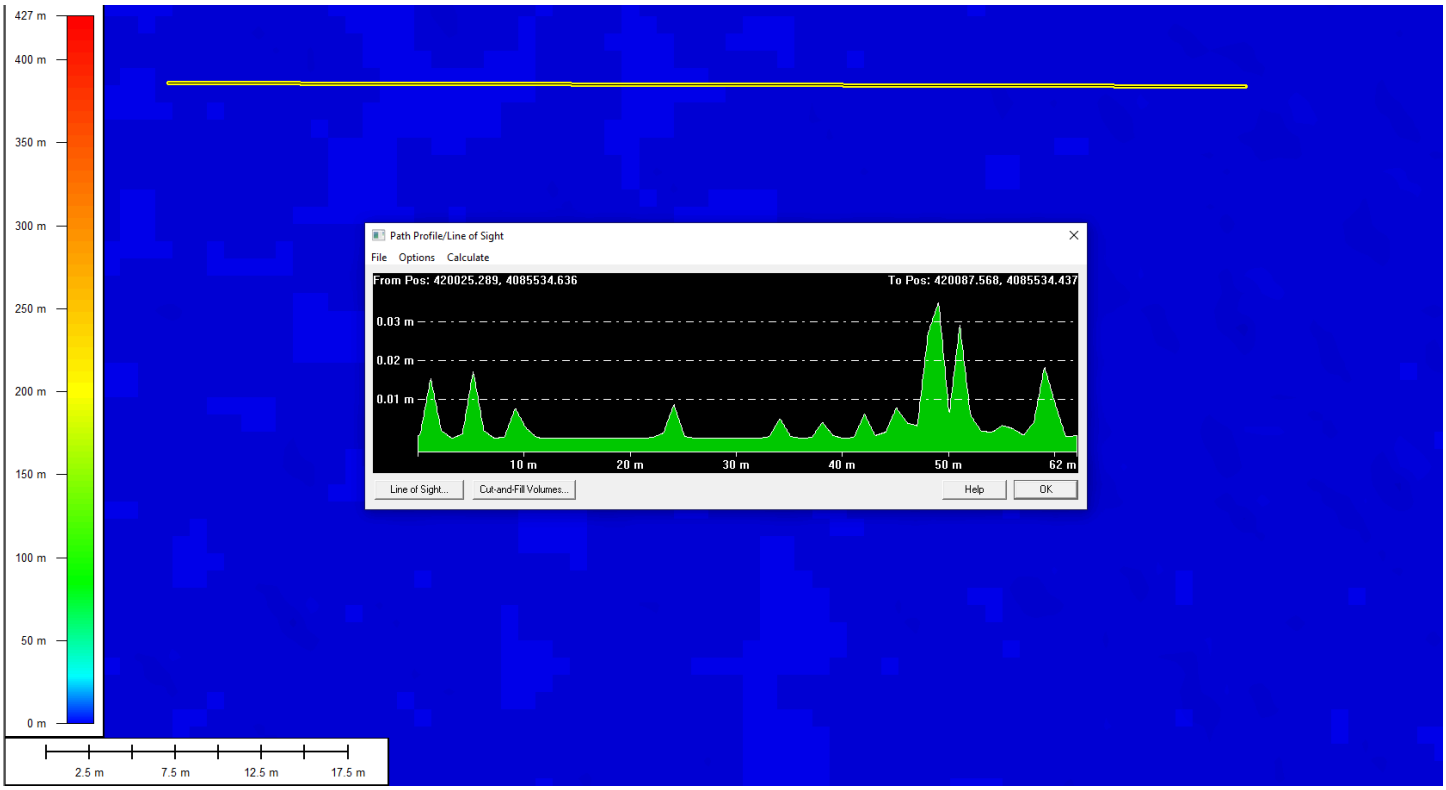


Figure 4: Smooth Surface Repeatability of ≤6cm

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.

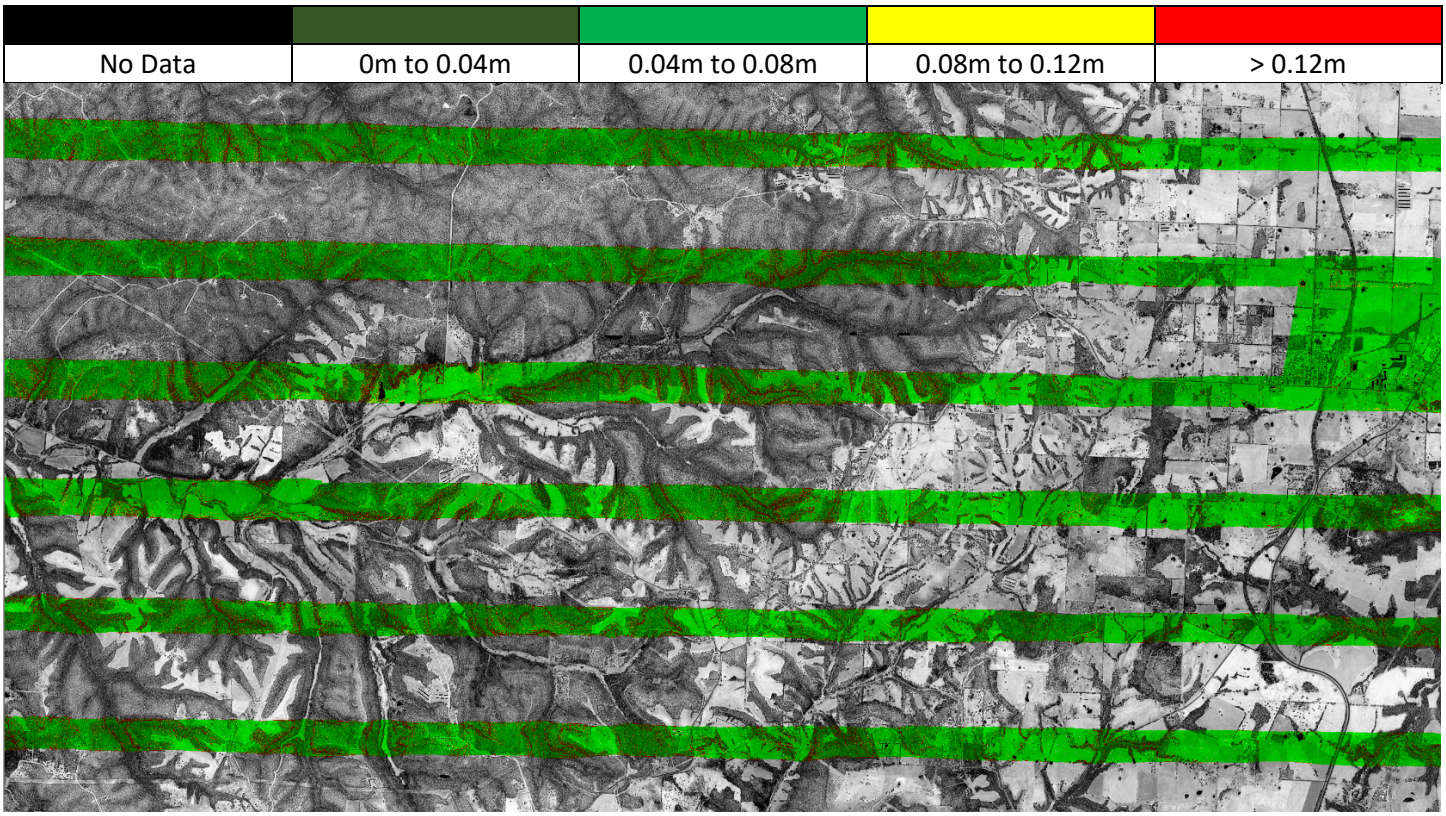


Figure 5: Swath Overlap Difference of ≤8cm, Maximum of ±16cm

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	Line	X	Y	Z
14	0.019	0.018	0.02	218	0.016	0.016	0.015	404	0.03	0.036	0.02
15	0.012	0.021	0.014	219	0.015	0.014	0.014	405	0.024	0.03	0.017
16	0.016	0.022	0.021	220	0.015	0.015	0.015	406	0.029	0.03	0.019
19	0.017	0.021	0.015	221	0.014	0.013	0.015	407	0.025	0.041	0.017
20	0.016	0.024	0.014	267	0.021	0.027	0.022	408	0.029	0.038	0.019
21	0.021	0.024	0.016	268	0.016	0.015	0.012	409	0.024	0.023	0.017
22	0.017	0.027	0.015	269	0.025	0.034	0.018	410	0.033	0.037	0.019
23	0.017	0.029	0.017	270	0.024	0.027	0.017	411	0.029	0.032	0.017
24	0.019	0.022	0.019	271	0.028	0.03	0.016	412	0.034	0.033	0.019
25	0.019	0.023	0.021	272	0.023	0.027	0.014	413	0.024	0.027	0.018
26	0.016	0.02	0.019	273	0.024	0.032	0.015	414	0.029	0.036	0.02
27	0.025	0.025	0.025	274	0.026	0.028	0.014	415	0.031	0.039	0.021
102	0.021	0.026	0.017	275	0.037	0.036	0.023	416	0.019	0.015	0.02
103	0.032	0.046	0.023	276	0.025	0.035	0.018	419	-	-	0.016
118	-	-	0.012	277	0.037	0.033	0.015	420	-	-	0.015
119	-	-	0.014	278	0.017	0.026	0.013	421	-	-	-
120	-	-	0.024	279	0.032	0.036	0.025	422	-	-	0.013
121	-	-	0.017	280	0.029	0.02	0.054	423	-	-	0.017
122	-	-	0.023	281	0.029	0.027	0.05	424	-	-	-
123	-	-	0.03	282	0.023	0.022	0.021	425	-	-	0.017
124	-	-	0.025	283	0.032	0.025	0.036	426	-	-	0.017
125	-	-	0.019	284	0.027	0.035	0.018	427	-	-	0.015
126	-	-	0.012	285	0.031	0.028	0.016	428	0.028	0.024	0.02
127	-	-	0.015	286	0.028	0.026	0.017	428	0.028	0.024	0.02
128	0.075	0.142	0.017	287	0.029	0.026	0.015	429	0.021	0.026	0.018
129	-	-	0.016	288	0.025	0.021	0.033	429	0.021	0.026	0.018
130	-	-	0.016	289	0.025	0.022	0.018	430	0.02	0.022	0.02
131	-	-	0.019	290	0.023	0.019	0.015	430	0.02	0.022	0.02
132	-	-	0.016	291	0.024	0.025	0.028	431	0.018	0.02	0.021
133	-	-	0.018	292	0.029	0.018	0.016	431	0.018	0.02	0.021
134	-	-	0.017	293	0.025	0.028	0.016	432	-	-	-
150	0.02	0.019	0.019	294	0.023	0.03	0.017	433	0.013	0.022	0.027
151	0.022	0.021	0.018	295	0.019	0.019	0.016	434	0.02	0.018	0.014
152	0.029	0.023	0.021	296	0.02	0.02	0.016	435	0.022	0.015	0.027
153	0.017	0.02	0.018	297	0.026	0.023	0.016	436	0.021	0.017	0.015

154	0.023	0.045	0.024	**298**	0.029	0.02	0.016	**437**	0.015	0.019	0.018
155	0.018	0.018	0.018	**299**	0.025	0.016	0.016	**438**	0.016	0.014	0.019
156	0.016	0.023	0.017	**300**	0.023	0.017	0.016	**439**	0.024	0.015	0.02
157	0.018	0.021	0.017	**301**	0.018	0.022	0.013	**440**	0.022	0.012	0.02
158	0.018	0.02	0.018	**344**	0.032	0.035	0.033	**441**	0.024	0.013	0.021
159	0.019	0.02	0.017	**345**	0.028	0.029	0.016	**442**	-	-	-
160	0.019	0.018	0.018	**346**	0.037	0.034	0.034	**443**	0.021	0.012	0.021
161	0.022	0.023	0.021	**347**	0.036	0.037	0.013	**444**	0.024	0.019	0.017
175	0.019	0.018	0.019	**348**	0.024	0.026	0.016	**445**	-	-	-
176	0.02	0.023	0.025	**349**	0.026	0.044	0.016	**446**	-	-	-
177	0.017	0.023	0.02	**350**	0.022	0.032	0.015	**447**	-	-	-
178	0.032	0.021	0.023	**351**	0.025	0.043	0.015	**448**	-	-	-
179	0.019	0.02	0.021	**352**	0.025	0.03	0.018	**449**	0.018	0.022	0.018
180	0.016	0.02	0.019	**353**	0.021	0.043	0.019	**450**	0.015	0.012	0.015
181	0.019	0.025	0.022	**354**	0.023	0.039	0.017	**451**	0.017	0.023	0.015
182	0.017	0.021	0.02	**355**	0.028	0.028	0.019	**452**	0.014	0.012	0.015
183	0.018	0.019	0.024	**356**	0.032	0.024	0.02	**453**	0.021	0.028	0.019
184	0.017	0.018	0.02	**388**	0.021	0.016	0.014	**454**	0.017	0.022	0.016
185	0.019	0.022	0.021	**389**	0.015	0.015	0.022	**455**	0.018	0.029	0.018
186	0.019	0.02	0.018	**390**	0.012	0.014	0.016	**456**	0.017	0.035	0.023
187	0.022	0.027	0.02	**391**	0.013	0.016	0.023	**457**	0.02	0.025	0.02
188	0.02	0.02	0.019	**392**	0.016	0.018	0.02	**458**	0.021	0.023	0.018
205	0.017	0.02	0.018	**393**	0.021	0.013	0.019	**459**	0.016	0.02	0.018
206	0.015	0.019	0.018	**394**	0.018	0.015	0.02	**460**	0.02	0.025	0.019
207	0.015	0.018	0.021	**395**	0.016	0.016	0.018	**461**	0.018	0.039	0.02
208	0.023	0.035	0.022	**396**	0.015	0.014	0.02	**465**	0.027	0.012	0.023
209	0.016	0.019	0.018	**397**	0.02	0.016	0.019	**466**	0.019	0.016	0.021
210	0.019	0.018	0.017	**398**	0.021	0.014	0.019				
211	0.017	0.021	0.017	**399**	0.02	0.012	0.017				
212	0.016	0.015	0.015	**400**	0.016	0.015	0.018				
213	0.021	0.027	0.019	**401**	0.016	0.015	0.017				
214	0.014	0.015	0.014	**402**	0.039	0.03	0.044				
215	0.014	0.016	0.016	**403**	0.021	0.025	0.015				
216	0.015	0.018	0.024	**404**	0.03	0.036	0.02				
217	0.014	0.016	0.015	**403**	0.024	0.03	0.017				

Table 5: Average Tie Line Magnitudes per Line

Internal Observation Statistics			
Category	**X**	**Y**	**Z**
Average Magnitude	0.020	0.024	0.017
RMS Values	0.040	0.046	0.025
Maximum Values	0.391	0.280	0.080
Observation Weight	305559.0	305559.0	4894057.0

Table 6: Tie Line Observation Statistics

Overall Relative Accuracy	
Category	**Mismatch**
Average 3D Mismatch	0.01893
Average XY Mismatch	0.03860
Average Z Mismatch	0.01708

Table 7: Relative Accuracy Results

TerraMatch Tie Lines	
Category	**Observations**
Section Lines	1,809,307
Roof Lines	121,765

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 seventeen (224) check points for this project (135 NVA + 89 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)

*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.

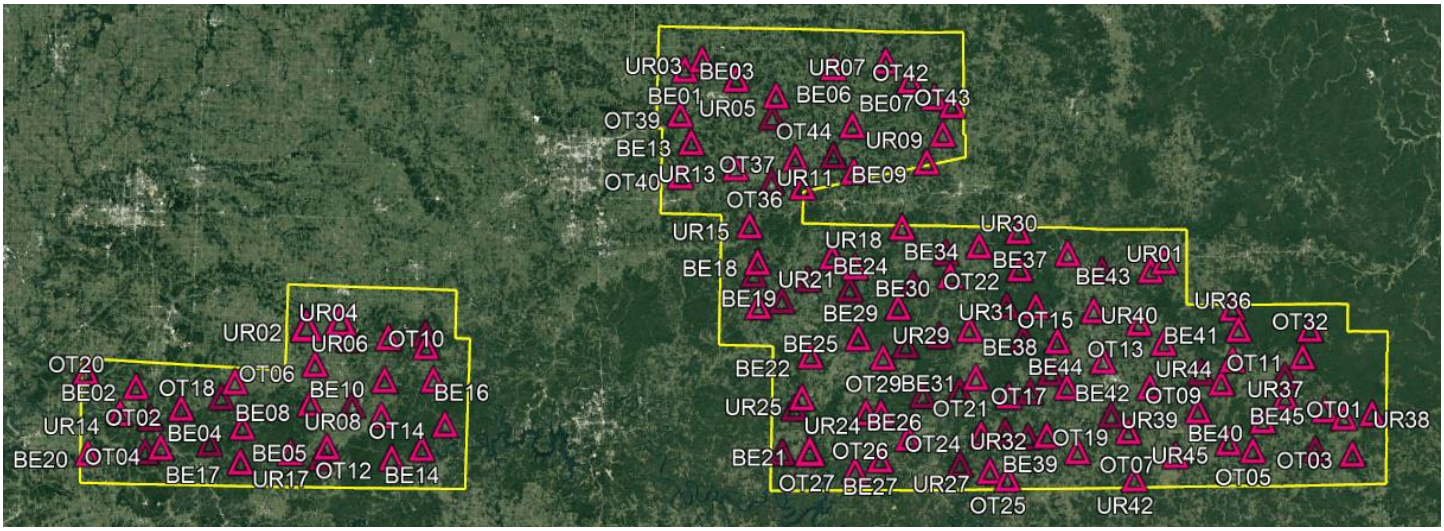


Figure 6: Non-vegetated Vertical Accuracy (NVA) Check Point Distribution

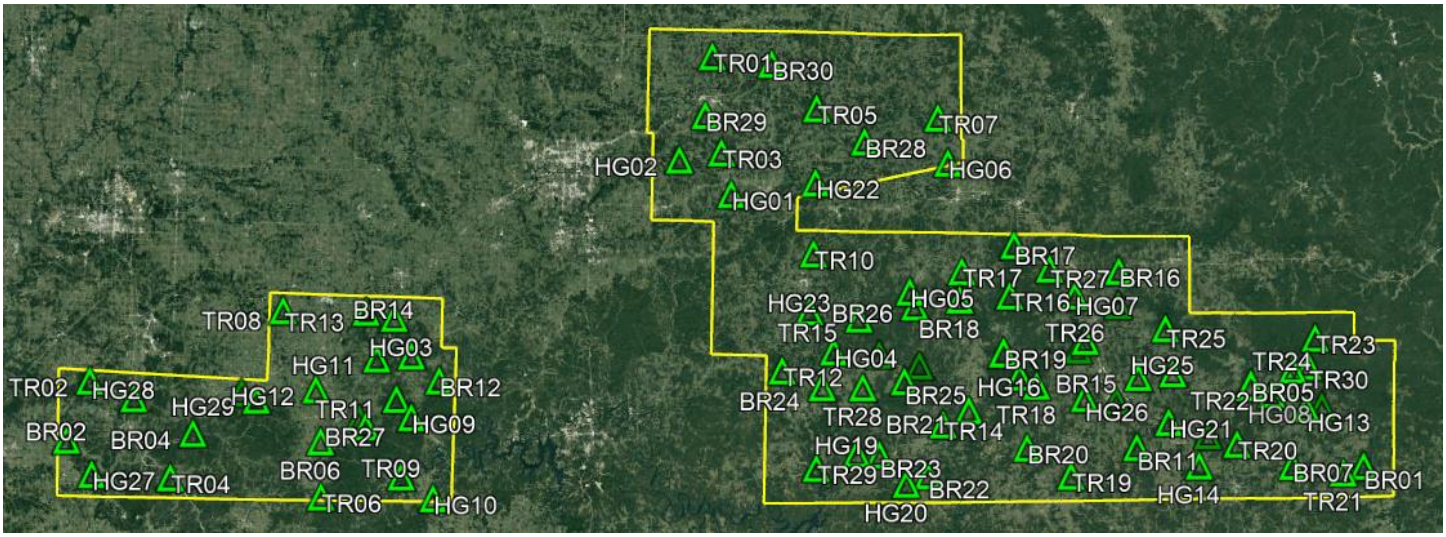


Figure 7: Vegetated Vertical Accuracy (VVA) Check Point Distribution

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	135	0.058	0.113	
NVA of Bare Earth	135	0.058	0.113	
NVA of DEM	135	0.057	0.112	
VVA of DEM	84	0.070		0.144
VVA of Bare Earth	84	0.073		0.144

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

Vegetated Vertical Accuracy (VVA) 5% Outliers > 95th Percentile (0.182m)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
BR10	426185.883	4058543.229	433.590	433.774	Brush	0.184
BR11	607431.114	4052159.904	283.385	283.630	Brush	0.245
BR16	603118.300	4092980.756	364.663	364.867	Brush	0.204
HG27	363397.742	4045533.077	325.176	325.365	High Grass	0.189
HG23	531041.073	4083600.789	394.034	394.219	High Grass	0.185

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, 14,15, and 16 below. The coordinates provided are in NAD83 (2011), UTM Zone 15 North, NAVD88 (Geoid12B), Meters.

Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (Point Cloud)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
BE01	499996.017	4138795.996	414.864	414.853	Bare Earth/Open Terrain	-0.011
BE02	368772.620	4063533.901	361.885	361.849	Bare Earth/Open Terrain	-0.036
BE03	512223.553	4136525.994	418.647	418.728	Bare Earth/Open Terrain	0.081
BE04	394403.686	4054013.910	301.368	301.376	Bare Earth/Open Terrain	0.008
BE05	414701.047	4049351.129	456.971	456.976	Bare Earth/Open Terrain	0.005
BE06	535310.272	4139266.284	404.450	404.477	Bare Earth/Open Terrain	0.027
BE07	559337.803	4132309.203	436.472	436.320	Bare Earth/Open Terrain	-0.152
BE08	410722.045	4059651.992	453.808	453.817	Bare Earth/Open Terrain	0.009
BE09	557556.987	4117003.868	375.382	375.337	Bare Earth/Open Terrain	-0.045
BE10	428504.651	4065265.372	450.986	450.962	Bare Earth/Open Terrain	-0.024
BE11	535337.092	4118462.735	435.568	435.590	Bare Earth/Open Terrain	0.022
BE12	438304.771	4076207.152	390.170	390.177	Bare Earth/Open Terrain	0.007
BE13	501528.352	4121580.538	434.432	434.351	Bare Earth/Open Terrain	-0.081

BE14	437393.886	4049077.913	323.736	323.769	Bare Earth/Open Terrain	0.033
BE15	520662.508	4112122.083	501.906	501.949	Bare Earth/Open Terrain	0.043
BE16	440156.587	4065354.314	316.350	316.325	Bare Earth/Open Terrain	-0.025
BE17	393924.662	4045694.788	432.863	432.879	Bare Earth/Open Terrain	0.016
BE18	517332.996	4093255.908	414.759	414.681	Bare Earth/Open Terrain	-0.078
BE19	517550.848	4082847.382	387.727	387.778	Bare Earth/Open Terrain	0.051
BE20	357126.286	4047579.109	309.170	309.152	Bare Earth/Open Terrain	-0.018
BE21	529825.617	4048542.646	267.400	267.351	Bare Earth/Open Terrain	-0.049
BE22	529936.925	4071201.590	352.126	352.174	Bare Earth/Open Terrain	0.048
BE23	529292.984	4089304.225	381.830	381.791	Bare Earth/Open Terrain	-0.039
BE24	535114.902	4094595.111	408.104	408.103	Bare Earth/Open Terrain	-0.001
BE25	541309.238	4075449.107	394.140	394.095	Bare Earth/Open Terrain	-0.045
BE26	543157.221	4057711.252	317.096	317.067	Bare Earth/Open Terrain	-0.029
BE27	546531.659	4046582.445	347.301	347.344	Bare Earth/Open Terrain	0.043
BE28	556690.569	4061874.096	259.375	259.456	Bare Earth/Open Terrain	0.081
BE29	550806.025	4082664.715	373.864	373.787	Bare Earth/Open Terrain	-0.077
BE30	563216.887	4090116.479	344.165	344.101	Bare Earth/Open Terrain	-0.064
BE31	569363.365	4066117.476	300.543	300.518	Bare Earth/Open Terrain	-0.025
BE32	565593.794	4045491.414	170.708	170.746	Bare Earth/Open Terrain	0.038
BE33	560620.937	4075970.267	282.383	282.362	Bare Earth/Open Terrain	-0.021
BE34	570058.679	4097232.620	377.850	377.871	Bare Earth/Open Terrain	0.021
BE35	580627.608	4075471.570	325.040	325.057	Bare Earth/Open Terrain	0.017
BE36	576368.423	4053321.022	315.751	315.752	Bare Earth/Open Terrain	0.001
BE37	591209.635	4095394.721	386.014	386.005	Bare Earth/Open Terrain	-0.009
BE38	588785.424	4074693.920	335.969	335.987	Bare Earth/Open Terrain	0.018
BE39	593675.726	4048594.979	335.297	335.235	Bare Earth/Open Terrain	-0.062
BE40	638026.099	4055861.491	259.471	259.464	Bare Earth/Open Terrain	-0.007
BE41	632181.241	4077515.445	300.248	300.225	Bare Earth/Open Terrain	-0.023
BE42	610904.092	4063818.223	316.576	316.618	Bare Earth/Open Terrain	0.042
BE43	611028.251	4091479.486	338.249	338.284	Bare Earth/Open Terrain	0.035
BE44	599726.681	4070056.708	342.533	342.580	Bare Earth/Open Terrain	0.047
BE45	652893.282	4058353.714	218.061	218.108	Bare Earth/Open Terrain	0.047
OT01	657582.400	4056637.373	217.894	217.931	Bare Earth/Open Terrain	0.037
OT02	379677.771	4058429.304	371.844	371.835	Bare Earth/Open Terrain	-0.009
OT03	659684.236	4047852.086	176.310	176.382	Bare Earth/Open Terrain	0.072
OT04	374737.098	4049133.688	270.862	270.866	Bare Earth/Open Terrain	0.004
OT05	635658.190	4048765.230	198.960	198.963	Bare Earth/Open Terrain	0.003
OT06	411850.083	4068922.279	412.498	412.589	Bare Earth/Open Terrain	0.091
OT07	617138.439	4047628.703	276.940	276.880	Bare Earth/Open Terrain	-0.060
OT08	419950.354	4074840.156	436.676	436.672	Bare Earth/Open Terrain	-0.004
OT09	628020.814	4064811.437	293.916	293.939	Bare Earth/Open Terrain	0.023
OT10	438383.189	4073196.945	352.910	352.952	Bare Earth/Open Terrain	0.042
OT11	647573.619	4070992.439	266.057	266.036	Bare Earth/Open Terrain	-0.021

OT12	430202.167	4046831.357	338.396	338.385	Bare Earth/Open Terrain	-0.011
OT13	614181.035	4074227.626	320.882	320.964	Bare Earth/Open Terrain	0.082
OT14	442941.320	4054756.179	343.669	343.647	Bare Earth/Open Terrain	-0.022
OT15	597419.740	4081932.071	376.279	376.393	Bare Earth/Open Terrain	0.114
OT16	413284.823	4046793.324	443.841	443.883	Bare Earth/Open Terrain	0.042
OT17	591090.246	4063877.008	301.519	301.612	Bare Earth/Open Terrain	0.093
OT18	392618.542	4064727.811	394.885	394.845	Bare Earth/Open Terrain	-0.040
OT19	605798.783	4053304.789	293.474	293.532	Bare Earth/Open Terrain	0.058
OT20	356670.699	4066916.146	335.034	334.982	Bare Earth/Open Terrain	-0.052
OT21	577210.845	4061729.985	313.901	313.965	Bare Earth/Open Terrain	0.064
OT22	579742.748	4091785.501	372.498	372.490	Bare Earth/Open Terrain	-0.008
OT23	576604.284	4082999.333	326.424	326.413	Bare Earth/Open Terrain	-0.011
OT24	570638.604	4052636.410	277.830	277.876	Bare Earth/Open Terrain	0.046
OT25	576947.184	4042119.186	212.069	211.958	Bare Earth/Open Terrain	-0.111
OT26	553291.350	4051723.713	309.730	309.821	Bare Earth/Open Terrain	0.091
OT27	540598.867	4044094.861	318.801	318.776	Bare Earth/Open Terrain	-0.025
OT28	526111.551	4058843.368	250.202	250.249	Bare Earth/Open Terrain	0.047
OT29	547235.170	4070829.027	274.850	274.861	Bare Earth/Open Terrain	0.011
OT30	554375.269	4088153.890	271.256	271.265	Bare Earth/Open Terrain	0.009
OT31	539291.379	4086945.218	271.641	271.607	Bare Earth/Open Terrain	-0.034
OT32	649268.024	4077521.426	276.865	276.955	Bare Earth/Open Terrain	0.090
OT33	523119.329	4084214.072	399.669	399.771	Bare Earth/Open Terrain	0.102
OT34	516427.223	4090369.260	429.930	429.944	Bare Earth/Open Terrain	0.014
OT35	581784.893	4052045.386	318.219	318.169	Bare Earth/Open Terrain	-0.050
OT36	528039.381	4111067.994	416.482	416.548	Bare Earth/Open Terrain	0.066
OT37	526297.490	4117789.473	463.370	463.361	Bare Earth/Open Terrain	-0.009
OT38	520757.520	4127650.459	441.995	441.908	Bare Earth/Open Terrain	-0.087
OT39	498898.638	4128179.213	451.468	451.423	Bare Earth/Open Terrain	-0.045
OT40	498992.181	4113610.350	419.310	419.341	Bare Earth/Open Terrain	0.031
OT41	643294.691	4066502.321	283.751	283.734	Bare Earth/Open Terrain	-0.017
OT42	553599.629	4136233.427	329.855	329.932	Bare Earth/Open Terrain	0.077
OT43	563593.041	4130390.236	404.936	404.941	Bare Earth/Open Terrain	0.005
OT44	539829.116	4125598.221	462.776	462.748	Bare Earth/Open Terrain	-0.028
UR01	614324.256	4093543.976	363.401	363.393	Urban Terrain	-0.008
UR02	409811.601	4077968.249	399.886	399.897	Urban Terrain	0.011
UR03	504095.414	4141078.981	396.159	396.074	Urban Terrain	-0.085
UR04	417952.649	4079283.589	420.517	420.496	Urban Terrain	-0.021
UR05	521690.964	4132628.419	443.505	443.345	Urban Terrain	-0.160
UR06	429390.441	4075324.339	349.094	349.079	Urban Terrain	-0.015
UR07	547790.335	4140803.899	404.676	404.605	Urban Terrain	-0.071
UR08	427733.895	4056797.660	465.483	465.384	Urban Terrain	-0.099
UR09	561352.853	4123583.530	434.840	434.675	Urban Terrain	-0.165
UR10	420768.601	4059329.529	433.994	433.935	Urban Terrain	-0.059

UR11	540183.001	4114656.369	435.428	435.443	Urban Terrain	0.015
UR12	386525.872	4050076.708	390.580	390.596	Urban Terrain	0.016
UR13	512075.680	4115530.318	497.257	497.338	Urban Terrain	0.081
UR14	364911.985	4057142.260	335.575	335.501	Urban Terrain	-0.074
UR15	515416.372	4101866.802	468.805	468.709	Urban Terrain	-0.096
UR16	389334.654	4061148.594	353.478	353.415	Urban Terrain	-0.063
UR17	405950.823	4048011.323	442.224	442.180	Urban Terrain	-0.044
UR18	551711.339	4101565.850	435.572	435.562	Urban Terrain	-0.010
UR19	370996.614	4048129.726	261.321	261.273	Urban Terrain	-0.048
UR20	372300.776	4056090.122	276.289	276.293	Urban Terrain	0.004
UR21	540560.027	4092223.698	349.669	349.579	Urban Terrain	-0.090
UR22	552586.047	4073647.634	312.110	312.069	Urban Terrain	-0.041
UR23	565466.882	4062923.324	198.538	198.503	Urban Terrain	-0.035
UR24	546790.946	4057655.647	366.548	366.546	Urban Terrain	-0.002
UR25	527957.846	4061267.080	324.087	324.088	Urban Terrain	0.001
UR26	523260.465	4048324.600	294.473	294.389	Urban Terrain	-0.084
UR27	572736.174	4043880.235	255.537	255.430	Urban Terrain	-0.107
UR28	582323.123	4062762.158	316.817	316.875	Urban Terrain	0.058
UR29	567815.867	4077454.297	361.172	361.025	Urban Terrain	-0.147
UR30	579417.741	4100672.889	395.032	394.931	Urban Terrain	-0.101
UR31	583591.137	4082974.062	342.658	342.662	Urban Terrain	0.004
UR32	586288.388	4052411.540	345.299	345.301	Urban Terrain	0.002
UR33	587139.164	4067220.961	329.934	329.927	Urban Terrain	-0.007
UR34	601718.366	4057197.909	329.944	329.930	Urban Terrain	-0.014
UR35	623187.363	4067283.814	300.053	300.014	Urban Terrain	-0.039
UR36	630625.783	4082466.805	286.238	286.258	Urban Terrain	0.020
UR37	643366.673	4061443.041	231.868	231.880	Urban Terrain	0.012
UR38	664386.937	4057513.953	203.370	203.263	Urban Terrain	-0.107
UR39	622466.103	4058238.008	227.245	227.266	Urban Terrain	0.021
UR40	608228.112	4078958.303	327.595	327.583	Urban Terrain	-0.012
UR41	599398.172	4091530.918	344.794	344.797	Urban Terrain	0.003
UR42	607296.056	4042075.385	271.263	271.350	Urban Terrain	0.087
UR43	562160.152	4095619.049	394.117	393.988	Urban Terrain	-0.129
UR44	630694.304	4070310.631	234.838	234.802	Urban Terrain	-0.036
UR45	629784.953	4050630.643	201.966	201.952	Urban Terrain	-0.014
UR46	650712.088	4049056.697	188.864	188.934	Urban Terrain	0.070

Table 12: Lidar Point Cloud NVA Assessment

Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (Bare-Earth)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
BE01	499996.017	4138795.996	414.864	414.853	Bare Earth/Open Terrain	-0.011
BE02	368772.620	4063533.901	361.885	361.849	Bare Earth/Open Terrain	-0.036
BE03	512223.553	4136525.994	418.647	418.728	Bare Earth/Open Terrain	0.081

BE04	394403.686	4054013.910	301.368	301.376	Bare Earth/Open Terrain	0.008
BE05	414701.047	4049351.129	456.971	456.976	Bare Earth/Open Terrain	0.005
BE06	535310.272	4139266.284	404.450	404.477	Bare Earth/Open Terrain	0.027
BE07	559337.803	4132309.203	436.472	436.320	Bare Earth/Open Terrain	-0.152
BE08	410722.045	4059651.992	453.808	453.817	Bare Earth/Open Terrain	0.009
BE09	557556.987	4117003.868	375.382	375.337	Bare Earth/Open Terrain	-0.045
BE10	428504.651	4065265.372	450.986	450.962	Bare Earth/Open Terrain	-0.024
BE11	535337.092	4118462.735	435.568	435.590	Bare Earth/Open Terrain	0.022
BE12	438304.771	4076207.152	390.170	390.177	Bare Earth/Open Terrain	0.007
BE13	501528.352	4121580.538	434.432	434.351	Bare Earth/Open Terrain	-0.081
BE14	437393.886	4049077.913	323.736	323.769	Bare Earth/Open Terrain	0.033
BE15	520662.508	4112122.083	501.906	501.949	Bare Earth/Open Terrain	0.043
BE16	440156.587	4065354.314	316.350	316.325	Bare Earth/Open Terrain	-0.025
BE17	393924.662	4045694.788	432.863	432.879	Bare Earth/Open Terrain	0.016
BE18	517332.996	4093255.908	414.759	414.681	Bare Earth/Open Terrain	-0.078
BE19	517550.848	4082847.382	387.727	387.778	Bare Earth/Open Terrain	0.051
BE20	357126.286	4047579.109	309.170	309.152	Bare Earth/Open Terrain	-0.018
BE21	529825.617	4048542.646	267.400	267.351	Bare Earth/Open Terrain	-0.049
BE22	529936.925	4071201.590	352.126	352.174	Bare Earth/Open Terrain	0.048
BE23	529292.984	4089304.225	381.830	381.791	Bare Earth/Open Terrain	-0.039
BE24	535114.902	4094595.111	408.104	408.103	Bare Earth/Open Terrain	-0.001
BE25	541309.238	4075449.107	394.140	394.095	Bare Earth/Open Terrain	-0.045
BE26	543157.221	4057711.252	317.096	317.067	Bare Earth/Open Terrain	-0.029
BE27	546531.659	4046582.445	347.301	347.344	Bare Earth/Open Terrain	0.043
BE28	556690.569	4061874.096	259.375	259.456	Bare Earth/Open Terrain	0.081
BE29	550806.025	4082664.715	373.864	373.787	Bare Earth/Open Terrain	-0.077
BE30	563216.887	4090116.479	344.165	344.101	Bare Earth/Open Terrain	-0.064
BE31	569363.365	4066117.476	300.543	300.518	Bare Earth/Open Terrain	-0.025
BE32	565593.794	4045491.414	170.708	170.746	Bare Earth/Open Terrain	0.038
BE33	560620.937	4075970.267	282.383	282.362	Bare Earth/Open Terrain	-0.021
BE34	570058.679	4097232.620	377.850	377.871	Bare Earth/Open Terrain	0.021
BE35	580627.608	4075471.570	325.040	325.057	Bare Earth/Open Terrain	0.017
BE36	576368.423	4053321.022	315.751	315.752	Bare Earth/Open Terrain	0.001
BE37	591209.635	4095394.721	386.014	386.005	Bare Earth/Open Terrain	-0.009
BE38	588785.424	4074693.920	335.969	335.987	Bare Earth/Open Terrain	0.018
BE39	593675.726	4048594.979	335.297	335.235	Bare Earth/Open Terrain	-0.062
BE40	638026.099	4055861.491	259.471	259.464	Bare Earth/Open Terrain	-0.007
BE41	632181.241	4077515.445	300.248	300.225	Bare Earth/Open Terrain	-0.023
BE42	610904.092	4063818.223	316.576	316.618	Bare Earth/Open Terrain	0.042
BE43	611028.251	4091479.486	338.249	338.284	Bare Earth/Open Terrain	0.035
BE44	599726.681	4070056.708	342.533	342.580	Bare Earth/Open Terrain	0.047
BE45	652893.282	4058353.714	218.061	218.108	Bare Earth/Open Terrain	0.047
OT01	657582.400	4056637.373	217.894	217.931	Bare Earth/Open Terrain	0.037

OT02	379677.771	4058429.304	371.844	371.835	Bare Earth/Open Terrain	-0.009
OT03	659684.236	4047852.086	176.310	176.382	Bare Earth/Open Terrain	0.072
OT04	374737.098	4049133.688	270.862	270.866	Bare Earth/Open Terrain	0.004
OT05	635658.190	4048765.230	198.960	198.963	Bare Earth/Open Terrain	0.003
OT06	411850.083	4068922.279	412.498	412.589	Bare Earth/Open Terrain	0.091
OT07	617138.439	4047628.703	276.940	276.880	Bare Earth/Open Terrain	-0.060
OT08	419950.354	4074840.156	436.676	436.672	Bare Earth/Open Terrain	-0.004
OT09	628020.814	4064811.437	293.916	293.939	Bare Earth/Open Terrain	0.023
OT10	438383.189	4073196.945	352.910	352.952	Bare Earth/Open Terrain	0.042
OT11	647573.619	4070992.439	266.057	266.036	Bare Earth/Open Terrain	-0.021
OT12	430202.167	4046831.357	338.396	338.385	Bare Earth/Open Terrain	-0.011
OT13	614181.035	4074227.626	320.882	320.964	Bare Earth/Open Terrain	0.082
OT14	442941.320	4054756.179	343.669	343.647	Bare Earth/Open Terrain	-0.022
OT15	597419.740	4081932.071	376.279	376.393	Bare Earth/Open Terrain	0.114
OT16	413284.823	4046793.324	443.841	443.883	Bare Earth/Open Terrain	0.042
OT17	591090.246	4063877.008	301.519	301.612	Bare Earth/Open Terrain	0.093
OT18	392618.542	4064727.811	394.885	394.845	Bare Earth/Open Terrain	-0.040
OT19	605798.783	4053304.789	293.474	293.532	Bare Earth/Open Terrain	0.058
OT20	356670.699	4066916.146	335.034	334.982	Bare Earth/Open Terrain	-0.052
OT21	577210.845	4061729.985	313.901	313.965	Bare Earth/Open Terrain	0.064
OT22	579742.748	4091785.501	372.498	372.490	Bare Earth/Open Terrain	-0.008
OT23	576604.284	4082999.333	326.424	326.413	Bare Earth/Open Terrain	-0.011
OT24	570638.604	4052636.410	277.830	277.876	Bare Earth/Open Terrain	0.046
OT25	576947.184	4042119.186	212.069	211.958	Bare Earth/Open Terrain	-0.111
OT26	553291.350	4051723.713	309.730	309.821	Bare Earth/Open Terrain	0.091
OT27	540598.867	4044094.861	318.801	318.776	Bare Earth/Open Terrain	-0.025
OT28	526111.551	4058843.368	250.202	250.249	Bare Earth/Open Terrain	0.047
OT29	547235.170	4070829.027	274.850	274.861	Bare Earth/Open Terrain	0.011
OT30	554375.269	4088153.890	271.256	271.265	Bare Earth/Open Terrain	0.009
OT31	539291.379	4086945.218	271.641	271.607	Bare Earth/Open Terrain	-0.034
OT32	649268.024	4077521.426	276.865	276.955	Bare Earth/Open Terrain	0.090
OT33	523119.329	4084214.072	399.669	399.771	Bare Earth/Open Terrain	0.102
OT34	516427.223	4090369.260	429.930	429.944	Bare Earth/Open Terrain	0.014
OT35	581784.893	4052045.386	318.219	318.169	Bare Earth/Open Terrain	-0.050
OT36	528039.381	4111067.994	416.482	416.548	Bare Earth/Open Terrain	0.066
OT37	526297.490	4117789.473	463.370	463.361	Bare Earth/Open Terrain	-0.009
OT38	520757.520	4127650.459	441.995	441.908	Bare Earth/Open Terrain	-0.087
OT39	498898.638	4128179.213	451.468	451.423	Bare Earth/Open Terrain	-0.045
OT40	498992.181	4113610.350	419.310	419.341	Bare Earth/Open Terrain	0.031
OT41	643294.691	4066502.321	283.751	283.734	Bare Earth/Open Terrain	-0.017
OT42	553599.629	4136233.427	329.855	329.932	Bare Earth/Open Terrain	0.077
OT43	563593.041	4130390.236	404.936	404.941	Bare Earth/Open Terrain	0.005
OT44	539829.116	4125598.221	462.776	462.748	Bare Earth/Open Terrain	-0.028

UR01	614324.256	4093543.976	363.401	363.393	Urban Terrain	-0.008
UR02	409811.601	4077968.249	399.886	399.897	Urban Terrain	0.011
UR03	504095.414	4141078.981	396.159	396.074	Urban Terrain	-0.085
UR04	417952.649	4079283.589	420.517	420.496	Urban Terrain	-0.021
UR05	521690.964	4132628.419	443.505	443.345	Urban Terrain	-0.160
UR06	429390.441	4075324.339	349.094	349.079	Urban Terrain	-0.015
UR07	547790.335	4140803.899	404.676	404.605	Urban Terrain	-0.071
UR08	427733.895	4056797.660	465.483	465.384	Urban Terrain	-0.099
UR09	561352.853	4123583.530	434.840	434.675	Urban Terrain	-0.165
UR10	420768.601	4059329.529	433.994	433.935	Urban Terrain	-0.059
UR11	540183.001	4114656.369	435.428	435.443	Urban Terrain	0.015
UR12	386525.872	4050076.708	390.580	390.596	Urban Terrain	0.016
UR13	512075.680	4115530.318	497.257	497.338	Urban Terrain	0.081
UR14	364911.985	4057142.260	335.575	335.501	Urban Terrain	-0.074
UR15	515416.372	4101866.802	468.805	468.709	Urban Terrain	-0.096
UR16	389334.654	4061148.594	353.478	353.415	Urban Terrain	-0.063
UR17	405950.823	4048011.323	442.224	442.180	Urban Terrain	-0.044
UR18	551711.339	4101565.850	435.572	435.562	Urban Terrain	-0.010
UR19	370996.614	4048129.726	261.321	261.273	Urban Terrain	-0.048
UR20	372300.776	4056090.122	276.289	276.293	Urban Terrain	0.004
UR21	540560.027	4092223.698	349.669	349.579	Urban Terrain	-0.090
UR22	552586.047	4073647.634	312.110	312.069	Urban Terrain	-0.041
UR23	565466.882	4062923.324	198.538	198.503	Urban Terrain	-0.035
UR24	546790.946	4057655.647	366.548	366.546	Urban Terrain	-0.002
UR25	527957.846	4061267.080	324.087	324.088	Urban Terrain	0.001
UR26	523260.465	4048324.600	294.473	294.389	Urban Terrain	-0.084
UR27	572736.174	4043880.235	255.537	255.430	Urban Terrain	-0.107
UR28	582323.123	4062762.158	316.817	316.875	Urban Terrain	0.058
UR29	567815.867	4077454.297	361.172	361.025	Urban Terrain	-0.147
UR30	579417.741	4100672.889	395.032	394.931	Urban Terrain	-0.101
UR31	583591.137	4082974.062	342.658	342.662	Urban Terrain	0.004
UR32	586288.388	4052411.540	345.299	345.301	Urban Terrain	0.002
UR33	587139.164	4067220.961	329.934	329.927	Urban Terrain	-0.007
UR34	601718.366	4057197.909	329.944	329.930	Urban Terrain	-0.014
UR35	623187.363	4067283.814	300.053	300.014	Urban Terrain	-0.039
UR36	630625.783	4082466.805	286.238	286.258	Urban Terrain	0.020
UR37	643366.673	4061443.041	231.868	231.880	Urban Terrain	0.012
UR38	664386.937	4057513.953	203.370	203.263	Urban Terrain	-0.107
UR39	622466.103	4058238.008	227.245	227.266	Urban Terrain	0.021
UR40	608228.112	4078958.303	327.595	327.583	Urban Terrain	-0.012
UR41	599398.172	4091530.918	344.794	344.797	Urban Terrain	0.003
UR42	607296.056	4042075.385	271.263	271.350	Urban Terrain	0.087
UR43	562160.152	4095619.049	394.117	393.988	Urban Terrain	-0.129

UR44	630694.304	4070310.631	234.838	234.802	Urban Terrain	-0.036
UR45	629784.953	4050630.643	201.966	201.952	Urban Terrain	-0.014
UR46	650712.088	4049056.697	188.864	188.934	Urban Terrain	0.070

Table 13: Bare-Earth Lidar NVA Assessment

Non-vegetated Vertical Accuracy (NVA) Check Point Assessment (DEM)						
PointID	**Easting**	**Northing**	**KnownZ**	**DEMZ**	**Description**	**DeltaZ**
BE01	499996.017	4138795.996	414.864	414.837	Bare Earth/Open Terrain	0.027
BE02	368772.620	4063533.901	361.885	361.828	Bare Earth/Open Terrain	0.057
BE03	512223.553	4136525.994	418.647	418.728	Bare Earth/Open Terrain	-0.081
BE04	394403.686	4054013.910	301.368	301.375	Bare Earth/Open Terrain	-0.007
BE05	414701.047	4049351.129	456.971	456.968	Bare Earth/Open Terrain	0.003
BE06	535310.272	4139266.284	404.450	404.490	Bare Earth/Open Terrain	-0.040
BE07	559337.803	4132309.203	436.472	436.319	Bare Earth/Open Terrain	0.153
BE08	410722.045	4059651.992	453.808	453.796	Bare Earth/Open Terrain	0.012
BE09	557556.987	4117003.868	375.382	375.319	Bare Earth/Open Terrain	0.063
BE10	428504.651	4065265.372	450.986	450.959	Bare Earth/Open Terrain	0.027
BE11	535337.092	4118462.735	435.568	435.601	Bare Earth/Open Terrain	-0.033
BE12	438304.771	4076207.152	390.170	390.191	Bare Earth/Open Terrain	-0.021
BE13	501528.352	4121580.538	434.432	434.356	Bare Earth/Open Terrain	0.076
BE14	437393.886	4049077.913	323.736	323.766	Bare Earth/Open Terrain	-0.030
BE15	520662.508	4112122.083	501.906	501.937	Bare Earth/Open Terrain	-0.031
BE16	440156.587	4065354.314	316.350	316.322	Bare Earth/Open Terrain	0.028
BE17	393924.662	4045694.788	432.863	432.872	Bare Earth/Open Terrain	-0.009
BE18	517332.996	4093255.908	414.759	414.700	Bare Earth/Open Terrain	0.059
BE19	517550.848	4082847.382	387.727	387.751	Bare Earth/Open Terrain	-0.024
BE20	357126.286	4047579.109	309.170	309.165	Bare Earth/Open Terrain	0.005
BE21	529825.617	4048542.646	267.400	267.375	Bare Earth/Open Terrain	0.025
BE22	529936.925	4071201.590	352.126	352.149	Bare Earth/Open Terrain	-0.023
BE23	529292.984	4089304.225	381.830	381.796	Bare Earth/Open Terrain	0.034
BE24	535114.902	4094595.111	408.104	408.085	Bare Earth/Open Terrain	0.019
BE25	541309.238	4075449.107	394.140	394.079	Bare Earth/Open Terrain	0.061
BE26	543157.221	4057711.252	317.096	317.051	Bare Earth/Open Terrain	0.045
BE27	546531.659	4046582.445	347.301	347.342	Bare Earth/Open Terrain	-0.041
BE28	556690.569	4061874.096	259.375	259.478	Bare Earth/Open Terrain	-0.103
BE29	550806.025	4082664.715	373.864	373.776	Bare Earth/Open Terrain	0.088
BE30	563216.887	4090116.479	344.165	344.126	Bare Earth/Open Terrain	0.039
BE31	569363.365	4066117.476	300.543	300.518	Bare Earth/Open Terrain	0.025
BE32	565593.794	4045491.414	170.708	170.742	Bare Earth/Open Terrain	-0.034
BE33	560620.937	4075970.267	282.383	282.350	Bare Earth/Open Terrain	0.033
BE34	570058.679	4097232.620	377.850	377.875	Bare Earth/Open Terrain	-0.025
BE35	580627.608	4075471.570	325.040	325.027	Bare Earth/Open Terrain	0.013
BE36	576368.423	4053321.022	315.751	315.730	Bare Earth/Open Terrain	0.021

BE37	591209.635	4095394.721	386.014	386.008	Bare Earth/Open Terrain	0.006
BE38	588785.424	4074693.920	335.969	335.966	Bare Earth/Open Terrain	0.003
BE39	593675.726	4048594.979	335.297	335.235	Bare Earth/Open Terrain	0.062
BE40	638026.099	4055861.491	259.471	259.441	Bare Earth/Open Terrain	0.030
BE41	632181.241	4077515.445	300.248	300.241	Bare Earth/Open Terrain	0.007
BE42	610904.092	4063818.223	316.576	316.616	Bare Earth/Open Terrain	-0.040
BE43	611028.251	4091479.486	338.249	338.269	Bare Earth/Open Terrain	-0.020
BE44	599726.681	4070056.708	342.533	342.583	Bare Earth/Open Terrain	-0.050
BE45	652893.282	4058353.714	218.061	218.098	Bare Earth/Open Terrain	-0.037
OT01	657582.400	4056637.373	217.894	217.926	Bare Earth/Open Terrain	-0.032
OT02	379677.771	4058429.304	371.844	371.840	Bare Earth/Open Terrain	0.004
OT03	659684.236	4047852.086	176.310	176.390	Bare Earth/Open Terrain	-0.080
OT04	374737.098	4049133.688	270.862	270.867	Bare Earth/Open Terrain	-0.005
OT05	635658.190	4048765.230	198.960	198.961	Bare Earth/Open Terrain	-0.001
OT06	411850.083	4068922.279	412.498	412.599	Bare Earth/Open Terrain	-0.101
OT07	617138.439	4047628.703	276.940	276.884	Bare Earth/Open Terrain	0.056
OT08	419950.354	4074840.156	436.676	436.671	Bare Earth/Open Terrain	0.005
OT09	628020.814	4064811.437	293.916	293.945	Bare Earth/Open Terrain	-0.029
OT10	438383.189	4073196.945	352.910	352.943	Bare Earth/Open Terrain	-0.033
OT11	647573.619	4070992.439	266.057	266.042	Bare Earth/Open Terrain	0.015
OT12	430202.167	4046831.357	338.396	338.427	Bare Earth/Open Terrain	-0.031
OT13	614181.035	4074227.626	320.882	320.942	Bare Earth/Open Terrain	-0.060
OT14	442941.320	4054756.179	343.669	343.662	Bare Earth/Open Terrain	0.007
OT15	597419.740	4081932.071	376.279	376.371	Bare Earth/Open Terrain	-0.092
OT16	413284.823	4046793.324	443.841	443.867	Bare Earth/Open Terrain	-0.026
OT17	591090.246	4063877.008	301.519	301.624	Bare Earth/Open Terrain	-0.105
OT18	392618.542	4064727.811	394.885	394.851	Bare Earth/Open Terrain	0.034
OT19	605798.783	4053304.789	293.474	293.537	Bare Earth/Open Terrain	-0.063
OT20	356670.699	4066916.146	335.034	334.980	Bare Earth/Open Terrain	0.054
OT21	577210.845	4061729.985	313.901	314.000	Bare Earth/Open Terrain	-0.099
OT22	579742.748	4091785.501	372.498	372.483	Bare Earth/Open Terrain	0.015
OT23	576604.284	4082999.333	326.424	326.383	Bare Earth/Open Terrain	0.041
OT24	570638.604	4052636.410	277.830	277.863	Bare Earth/Open Terrain	-0.033
OT25	576947.184	4042119.186	212.069	211.937	Bare Earth/Open Terrain	0.132
OT26	553291.350	4051723.713	309.730	309.802	Bare Earth/Open Terrain	-0.072
OT27	540598.867	4044094.861	318.801	318.764	Bare Earth/Open Terrain	0.037
OT28	526111.551	4058843.368	250.202	250.252	Bare Earth/Open Terrain	-0.050
OT29	547235.170	4070829.027	274.850	274.851	Bare Earth/Open Terrain	-0.001
OT30	554375.269	4088153.890	271.256	271.266	Bare Earth/Open Terrain	-0.010
OT31	539291.379	4086945.218	271.641	271.624	Bare Earth/Open Terrain	0.017
OT32	649268.024	4077521.426	276.865	276.939	Bare Earth/Open Terrain	-0.074
OT33	523119.329	4084214.072	399.669	399.748	Bare Earth/Open Terrain	-0.079
OT34	516427.223	4090369.260	429.930	429.950	Bare Earth/Open Terrain	-0.020

OT35	581784.893	4052045.386	318.219	318.168	Bare Earth/Open Terrain	0.051
OT36	528039.381	4111067.994	416.482	416.555	Bare Earth/Open Terrain	-0.073
OT37	526297.490	4117789.473	463.370	463.358	Bare Earth/Open Terrain	0.012
OT38	520757.520	4127650.459	441.995	441.909	Bare Earth/Open Terrain	0.086
OT39	498898.638	4128179.213	451.468	451.405	Bare Earth/Open Terrain	0.063
OT40	498992.181	4113610.350	419.310	419.339	Bare Earth/Open Terrain	-0.029
OT41	643294.691	4066502.321	283.751	283.735	Bare Earth/Open Terrain	0.016
OT42	553599.629	4136233.427	329.855	329.928	Bare Earth/Open Terrain	-0.073
OT43	563593.041	4130390.236	404.936	404.940	Bare Earth/Open Terrain	-0.004
OT44	539829.116	4125598.221	462.776	462.750	Bare Earth/Open Terrain	0.026
UR01	614324.256	4093543.976	363.401	363.394	Urban Terrain	0.007
UR02	409811.601	4077968.249	399.886	399.901	Urban Terrain	-0.015
UR03	504095.414	4141078.981	396.159	396.080	Urban Terrain	0.079
UR04	417952.649	4079283.589	420.517	420.489	Urban Terrain	0.028
UR05	521690.964	4132628.419	443.505	443.339	Urban Terrain	0.166
UR06	429390.441	4075324.339	349.094	349.083	Urban Terrain	0.011
UR07	547790.335	4140803.899	404.676	404.609	Urban Terrain	0.067
UR08	427733.895	4056797.660	465.483	465.391	Urban Terrain	0.092
UR09	561352.853	4123583.530	434.840	434.683	Urban Terrain	0.157
UR10	420768.601	4059329.529	433.994	433.936	Urban Terrain	0.058
UR11	540183.001	4114656.369	435.428	435.455	Urban Terrain	-0.027
UR12	386525.872	4050076.708	390.580	390.587	Urban Terrain	-0.007
UR13	512075.680	4115530.318	497.257	497.342	Urban Terrain	-0.085
UR14	364911.985	4057142.260	335.575	335.490	Urban Terrain	0.085
UR15	515416.372	4101866.802	468.805	468.711	Urban Terrain	0.094
UR16	389334.654	4061148.594	353.478	353.410	Urban Terrain	0.068
UR17	405950.823	4048011.323	442.224	442.169	Urban Terrain	0.055
UR18	551711.339	4101565.850	435.572	435.545	Urban Terrain	0.027
UR19	370996.614	4048129.726	261.321	261.271	Urban Terrain	0.050
UR20	372300.776	4056090.122	276.289	276.274	Urban Terrain	0.015
UR21	540560.027	4092223.698	349.669	349.574	Urban Terrain	0.095
UR22	552586.047	4073647.634	312.110	312.099	Urban Terrain	0.011
UR23	565466.882	4062923.324	198.538	198.492	Urban Terrain	0.046
UR24	546790.946	4057655.647	366.548	366.515	Urban Terrain	0.033
UR25	527957.846	4061267.080	324.087	324.142	Urban Terrain	-0.055
UR26	523260.465	4048324.600	294.473	294.393	Urban Terrain	0.080
UR27	572736.174	4043880.235	255.537	255.435	Urban Terrain	0.102
UR28	582323.123	4062762.158	316.817	316.854	Urban Terrain	-0.037
UR29	567815.867	4077454.297	361.172	361.039	Urban Terrain	0.133
UR30	579417.741	4100672.889	395.032	394.936	Urban Terrain	0.096
UR31	583591.137	4082974.062	342.658	342.653	Urban Terrain	0.005
UR32	586288.388	4052411.540	345.299	345.304	Urban Terrain	-0.005
UR33	587139.164	4067220.961	329.934	329.935	Urban Terrain	-0.001

UR34	601718.366	4057197.909	329.944	329.923	Urban Terrain	0.021
UR35	623187.363	4067283.814	300.053	300.015	Urban Terrain	0.038
UR36	630625.783	4082466.805	286.238	286.257	Urban Terrain	-0.019
UR37	643366.673	4061443.041	231.868	231.857	Urban Terrain	0.011
UR38	664386.937	4057513.953	203.370	203.278	Urban Terrain	0.092
UR39	622466.103	4058238.008	227.245	227.266	Urban Terrain	-0.021
UR40	608228.112	4078958.303	327.595	327.615	Urban Terrain	-0.020
UR41	599398.172	4091530.918	344.794	344.799	Urban Terrain	-0.005
UR42	607296.056	4042075.385	271.263	271.320	Urban Terrain	-0.057
UR43	562160.152	4095619.049	394.117	393.979	Urban Terrain	0.138
UR44	630694.304	4070310.631	234.838	234.787	Urban Terrain	0.051
UR45	629784.953	4050630.643	201.966	201.946	Urban Terrain	0.020
UR46	650712.088	4049056.697	188.864	188.910	Urban Terrain	-0.046

Table 14: Bare Earth DEM NVA Assessment

Vegetated Vertical Accuracy (VVA) Check Point Assessment (Bare Earth)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
BR01	660766.723	4047750.338	181.308	181.481	Brush	0.173
BR02	357483.120	4053490.752	293.262	293.279	Brush	0.017
BR03	650867.705	4061647.516	256.807	256.818	Brush	0.011
BR04	387264.100	4055150.437	290.863	290.927	Brush	0.064
BR05	634151.263	4066463.941	264.411	264.501	Brush	0.090
BR06	417185.025	4053311.456	436.993	437.138	Brush	0.145
BR07	643965.329	4047741.845	217.480	217.562	Brush	0.082
BR08	398668.608	4064537.040	403.515	403.517	Brush	0.002
BR09	624056.339	4054906.227	241.784	241.904	Brush	0.120
BR12	444864.619	4067455.798	300.834	300.824	Brush	-0.010
BR13	593638.255	4074778.752	335.146	335.273	Brush	0.127
BR14	434375.807	4081933.987	450.899	450.959	Brush	0.060
BR15	607735.039	4068415.328	345.542	345.482	Brush	-0.060
BR17	578632.597	4098938.931	382.377	382.493	Brush	0.116
BR18	566010.139	4086289.376	364.197	364.202	Brush	0.005
BR19	576250.339	4074079.846	223.599	223.648	Brush	0.049
BR20	581781.544	4052041.017	317.854	317.806	Brush	-0.048
BR21	568154.209	4060712.050	291.844	291.903	Brush	0.059
BR22	558691.669	4045633.081	187.845	187.910	Brush	0.065
BR23	547360.502	4050436.023	324.649	324.713	Brush	0.064
BR24	533997.332	4066040.603	313.137	313.316	Brush	0.179
BR25	553151.857	4067422.734	300.776	300.770	Brush	-0.006
BR26	555531.524	4084726.634	300.078	299.958	Brush	-0.120
BR27	427742.365	4056777.009	465.258	465.260	Brush	0.002
BR28	543803.643	4122840.876	348.789	348.847	Brush	0.058
BR29	506748.902	4128903.343	444.654	444.704	Brush	0.050

BR30	522178.136	4140778.465	367.704	367.745	Brush	0.041
HG01	512792.317	4110654.437	498.308	498.389	High Grass	0.081
HG02	500740.897	4118609.671	452.888	453.029	High Grass	0.141
HG03	438383.169	4073221.589	353.626	353.643	High Grass	0.017
HG04	536663.852	4074297.476	389.556	389.604	High Grass	0.048
HG05	554371.745	4088142.345	272.099	272.086	High Grass	-0.013
HG06	563215.033	4117966.676	454.244	454.270	High Grass	0.026
HG07	592851.239	4087277.111	408.068	408.173	High Grass	0.105
HG08	643291.964	4066494.001	283.998	284.040	High Grass	0.042
HG09	438393.988	4058942.417	464.104	464.155	High Grass	0.051
HG10	443444.490	4040184.939	362.222	362.296	High Grass	0.074
HG11	430342.889	4072541.421	432.956	433.052	High Grass	0.096
HG12	416097.210	4065365.176	447.982	447.985	High Grass	0.003
HG13	647183.655	4061110.268	230.443	230.515	High Grass	0.072
HG14	622061.740	4047876.754	267.168	267.203	High Grass	0.035
HG15	602596.894	4062894.912	294.997	294.989	High Grass	-0.008
HG16	579961.106	4068504.673	328.180	328.201	High Grass	0.021
HG17	556610.015	4071104.887	226.471	226.648	High Grass	0.177
HG18	547269.953	4073585.610	316.272	316.349	High Grass	0.077
HG19	542065.878	4050664.576	239.958	240.029	High Grass	0.071
HG20	553629.639	4043698.615	201.828	201.855	High Grass	0.027
HG21	614887.888	4057978.878	298.357	298.428	High Grass	0.071
HG22	532403.584	4113368.634	386.751	386.807	High Grass	0.056
HG24	603022.623	4085063.389	345.199	345.377	High Grass	0.178
HG25	615805.859	4069267.693	308.014	308.137	High Grass	0.123
HG26	595146.649	4063537.242	341.702	341.767	High Grass	0.065
HG28	373363.845	4063194.369	356.370	356.434	High Grass	0.064
HG29	402138.986	4062923.206	420.346	420.427	High Grass	0.081
TR01	508387.385	4142545.411	385.864	385.916	Trees	0.052
TR02	362984.370	4067242.948	271.213	271.230	Trees	0.017
TR03	510535.936	4120268.068	461.698	461.695	Trees	-0.003
TR04	381928.230	4044842.663	333.257	333.274	Trees	0.017
TR05	532668.133	4130544.947	483.334	483.333	Trees	-0.001
TR06	417250.481	4040505.976	482.127	482.032	Trees	-0.095
TR07	560880.024	4128387.466	414.730	414.731	Trees	0.001
TR08	408411.616	4083670.156	383.457	383.484	Trees	0.027
TR09	435995.596	4045218.217	315.577	315.539	Trees	-0.038
TR10	531954.028	4096946.500	428.215	428.158	Trees	-0.057
TR11	434901.203	4063188.389	340.542	340.489	Trees	-0.053
TR12	524698.117	4069894.707	398.436	398.415	Trees	-0.021
TR13	427823.146	4083337.447	460.173	460.069	Trees	-0.104
TR14	562191.727	4057446.506	258.264	258.315	Trees	0.051
TR15	542550.020	4081902.541	351.414	351.382	Trees	-0.032

TR16	577660.721	4087256.904	333.466	333.410	Trees	-0.056
TR17	566479.155	4092871.696	317.719	317.741	Trees	0.022
TR18	583956.833	4066404.227	337.749	337.754	Trees	0.005
TR19	592060.085	4045525.883	313.181	313.247	Trees	0.066
TR20	630919.431	4052906.864	201.877	201.994	Trees	0.117
TR21	655973.485	4046213.713	198.725	198.754	Trees	0.029
TR22	639016.394	4064469.807	285.334	285.348	Trees	0.014
TR23	649258.322	4077518.638	277.003	277.046	Trees	0.043
TR24	643919.550	4070161.997	272.438	272.472	Trees	0.034
TR25	614060.055	4079701.139	328.755	328.680	Trees	-0.075
TR26	595312.356	4076777.005	349.119	349.159	Trees	0.040
TR27	586956.900	4093488.825	396.690	396.716	Trees	0.026
TR28	543446.461	4066006.089	364.713	364.810	Trees	0.097
TR29	532666.755	4047351.430	216.858	216.890	Trees	0.032
TR30	647596.335	4071001.289	266.073	266.039	Trees	-0.034

Table 15: Bare-Earth Lidar VVA Assessment

Vegetated Vertical Accuracy (VVA) Check Point Assessment (DEM)						
PointID	**Easting**	**Northing**	**KnownZ**	**LaserZ**	**Description**	**DeltaZ**
BR01	660766.723	4047750.338	181.308	181.472	Brush	-0.163
BR02	357483.120	4053490.752	293.262	293.273	Brush	-0.011
BR03	650867.705	4061647.516	256.807	256.812	Brush	-0.005
BR04	387264.100	4055150.437	290.863	290.917	Brush	-0.054
BR05	634151.263	4066463.941	264.411	264.461	Brush	-0.050
BR06	417185.025	4053311.456	436.993	437.133	Brush	-0.140
BR07	643965.329	4047741.845	217.480	217.535	Brush	-0.055
BR08	398668.608	4064537.040	403.515	403.585	Brush	-0.070
BR09	624056.339	4054906.227	241.784	241.895	Brush	-0.111
BR12	444864.619	4067455.798	300.834	300.786	Brush	0.048
BR13	593638.255	4074778.752	335.146	335.263	Brush	-0.117
BR14	434375.807	4081933.987	450.899	450.965	Brush	-0.066
BR15	607735.039	4068415.328	345.542	345.485	Brush	0.057
BR17	578632.597	4098938.931	382.377	382.491	Brush	-0.114
BR18	566010.139	4086289.376	364.197	364.217	Brush	-0.020
BR19	576250.339	4074079.846	223.599	223.641	Brush	-0.042
BR20	581781.544	4052041.017	317.854	317.903	Brush	-0.049
BR21	568154.209	4060712.050	291.844	291.945	Brush	-0.101
BR22	558691.669	4045633.081	187.845	187.911	Brush	-0.066
BR23	547360.502	4050436.023	324.649	324.720	Brush	-0.071
BR24	533997.332	4066040.603	313.137	313.273	Brush	-0.136
BR25	553151.857	4067422.734	300.776	300.758	Brush	0.018
BR26	555531.524	4084726.634	300.078	300.029	Brush	0.049
BR27	427742.365	4056777.009	465.258	465.259	Brush	-0.001

BR28	543803.643	4122840.876	348.789	348.848	High Grass	-0.059
BR29	506748.902	4128903.343	444.654	444.689	High Grass	-0.035
BR30	522178.136	4140778.465	367.704	367.741	High Grass	-0.037
HG01	512792.317	4110654.437	498.308	498.371	High Grass	-0.063
HG02	500740.897	4118609.671	452.888	453.033	High Grass	-0.145
HG03	438383.169	4073221.589	353.626	353.657	High Grass	-0.031
HG04	536663.852	4074297.476	389.556	389.595	High Grass	-0.039
HG05	554371.745	4088142.345	272.099	272.085	High Grass	0.014
HG06	563215.033	4117966.676	454.244	454.273	High Grass	-0.029
HG07	592851.239	4087277.111	408.068	408.175	High Grass	-0.107
HG08	643291.964	4066494.001	283.998	284.052	High Grass	-0.054
HG09	438393.988	4058942.417	464.104	464.155	High Grass	-0.051
HG10	443444.490	4040184.939	362.222	362.310	High Grass	-0.088
HG11	430342.889	4072541.421	432.956	433.050	High Grass	-0.094
HG12	416097.210	4065365.176	447.982	447.983	High Grass	-0.001
HG13	647183.655	4061110.268	230.443	230.499	High Grass	-0.056
HG14	622061.740	4047876.754	267.168	267.193	High Grass	-0.025
HG15	602596.894	4062894.912	294.997	295.000	High Grass	-0.003
HG16	579961.106	4068504.673	328.180	328.215	High Grass	-0.035
HG17	556610.015	4071104.887	226.471	226.619	High Grass	-0.148
HG18	547269.953	4073585.610	316.272	316.333	High Grass	-0.061
HG19	542065.878	4050664.576	239.958	240.003	High Grass	-0.045
HG20	553629.639	4043698.615	201.828	201.862	High Grass	-0.034
HG21	614887.888	4057978.878	298.357	298.430	High Grass	-0.073
HG22	532403.584	4113368.634	386.751	386.802	High Grass	-0.051
HG24	603022.623	4085063.389	345.199	345.373	High Grass	-0.174
HG25	615805.859	4069267.693	308.014	308.159	Trees	-0.145
HG26	595146.649	4063537.242	341.702	341.779	Trees	-0.077
HG28	373363.845	4063194.369	356.370	356.432	Trees	-0.062
HG29	402138.986	4062923.206	420.346	420.390	Trees	-0.044
TR01	508387.385	4142545.411	385.864	385.915	Trees	-0.051
TR02	362984.370	4067242.948	271.213	271.221	Trees	-0.008
TR03	510535.936	4120268.068	461.698	461.659	Trees	0.039
TR04	381928.230	4044842.663	333.257	333.267	Trees	-0.010
TR05	532668.133	4130544.947	483.334	483.327	Trees	0.007
TR06	417250.481	4040505.976	482.127	482.016	Trees	0.111
TR07	560880.024	4128387.466	414.730	414.740	Trees	-0.010
TR08	408411.616	4083670.156	383.457	383.472	Trees	-0.015
TR09	435995.596	4045218.217	315.577	315.538	Trees	0.039
TR10	531954.028	4096946.500	428.215	428.173	Trees	0.042
TR11	434901.203	4063188.389	340.542	340.564	Trees	-0.022
TR12	524698.117	4069894.707	398.436	398.420	Trees	0.016
TR13	427823.146	4083337.447	460.173	460.063	Trees	0.110

TR14	562191.727	4057446.506	258.264	258.311	Trees	-0.047
TR15	542550.020	4081902.541	351.414	351.352	Trees	0.062
TR16	577660.721	4087256.904	333.466	333.436	Trees	0.030
TR17	566479.155	4092871.696	317.719	317.735	Trees	-0.016
TR18	583956.833	4066404.227	337.749	337.735	Trees	0.014
TR19	592060.085	4045525.883	313.181	313.234	Trees	-0.053
TR20	630919.431	4052906.864	201.877	202.002	Trees	-0.125
TR21	655973.485	4046213.713	198.725	198.765	Trees	-0.040
TR22	639016.394	4064469.807	285.334	285.361	Trees	-0.027
TR23	649258.322	4077518.638	277.003	277.047	Trees	-0.044
TR24	643919.550	4070161.997	272.438	272.504	Trees	-0.066
TR25	614060.055	4079701.139	328.755	328.688	Trees	0.067
TR26	595312.356	4076777.005	349.119	349.155	Trees	-0.036
TR27	586956.900	4093488.825	396.690	396.750	Trees	-0.060
TR28	543446.461	4066006.089	364.713	364.802	Trees	-0.089
TR29	532666.755	4047351.430	216.858	216.907	Trees	-0.049
TR30	647596.335	4071001.289	266.073	266.043	Trees	0.030

Table 16: Bare-Earth DEM VVA Assessment

Section 4: Certification

4.1 Limitations of Use

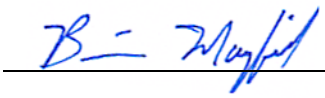
The accuracy assessment confirms that the data may be used for the intended applications stated in the **Project Purpose** section of this document. The dataset may also be used as a topographic input for other applications but the user should be aware that this lidar dataset was designed with a specific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

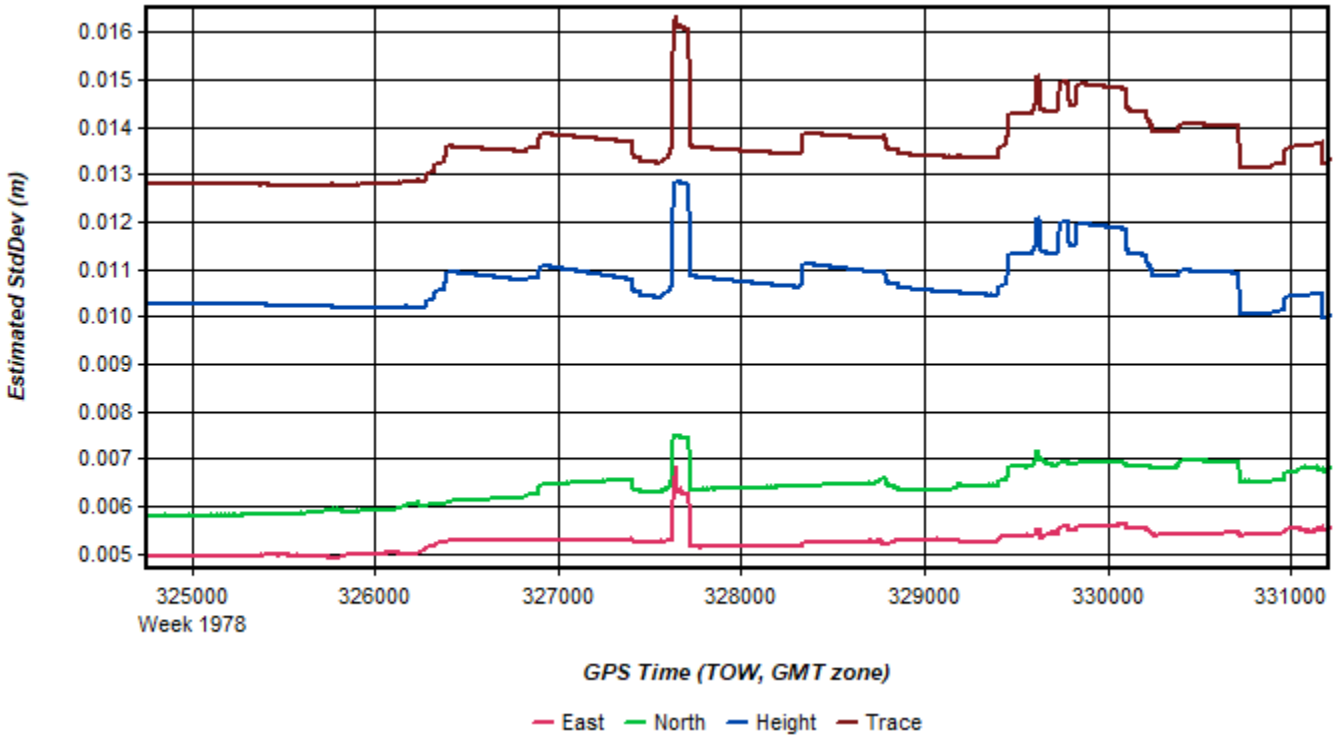
Section 5: GNSS Processing

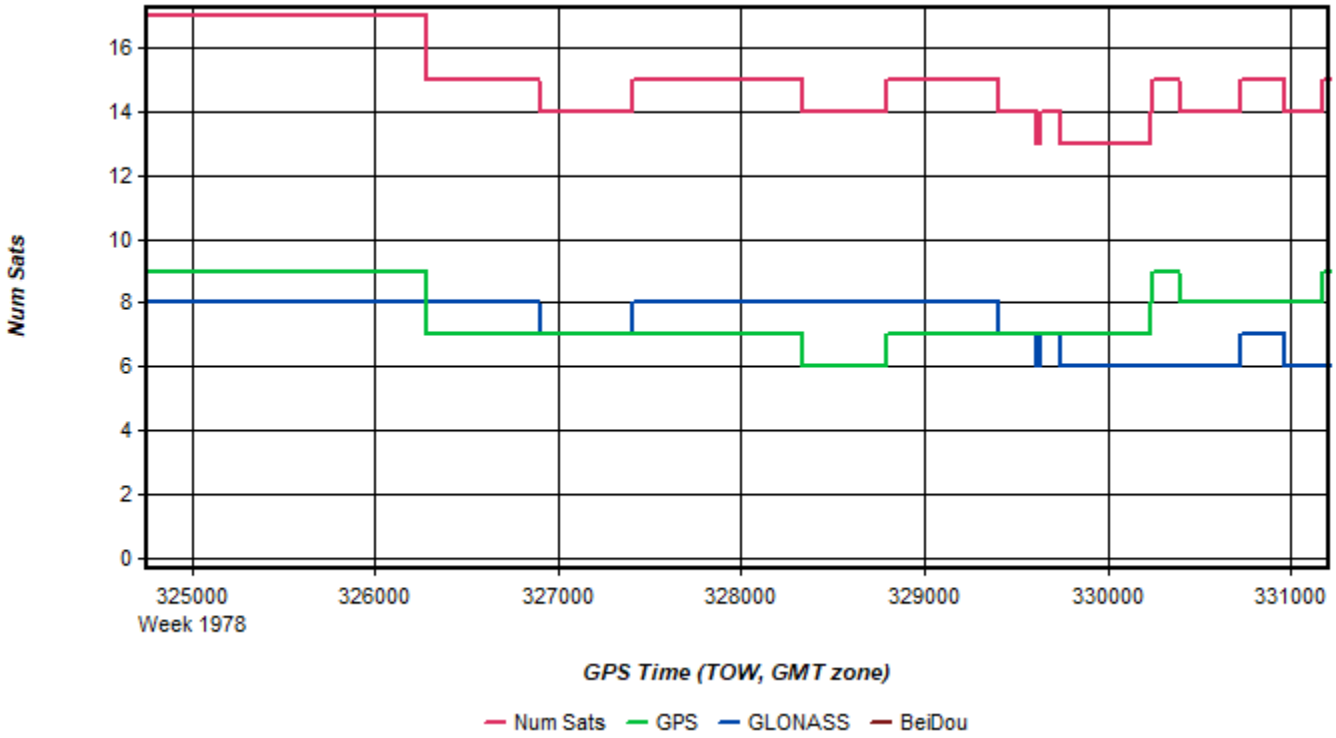
Inertial Explorer version 8.60.6717

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_20171206_1

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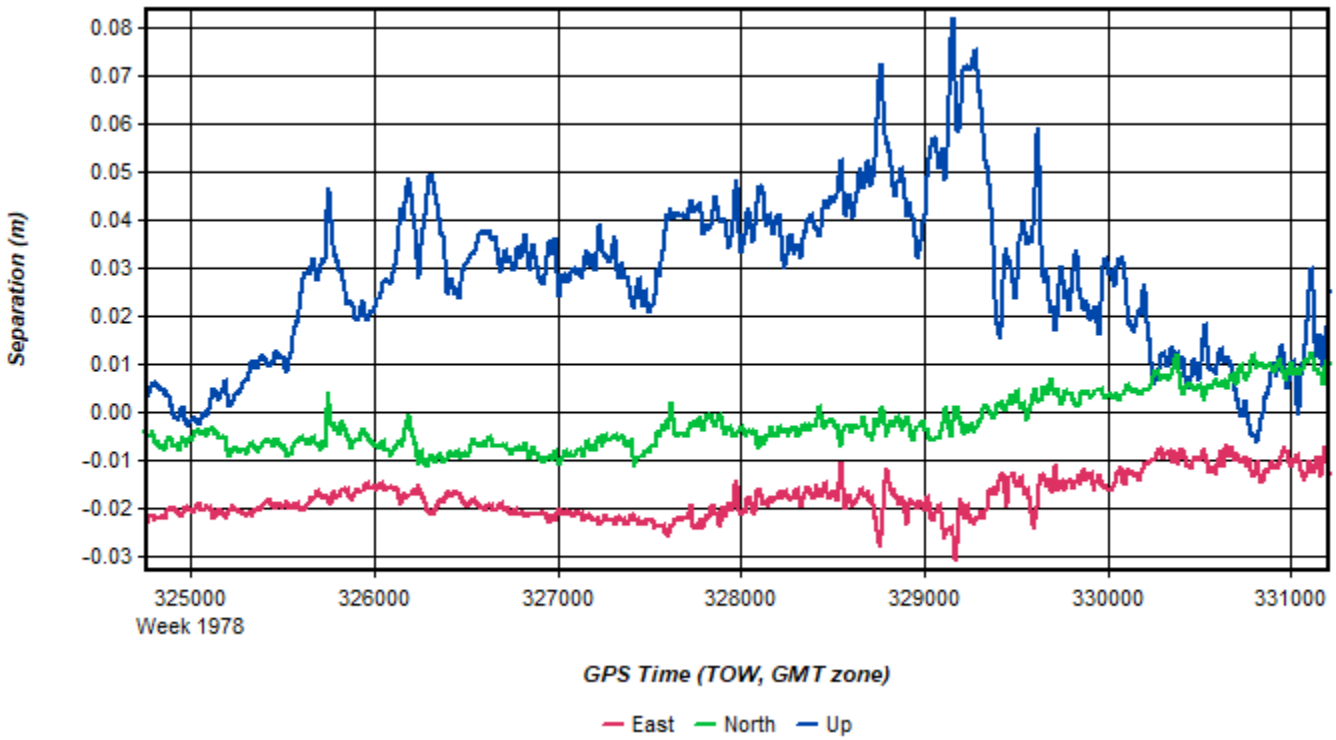
GPS
GLONASS
BeiDou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Week 1978
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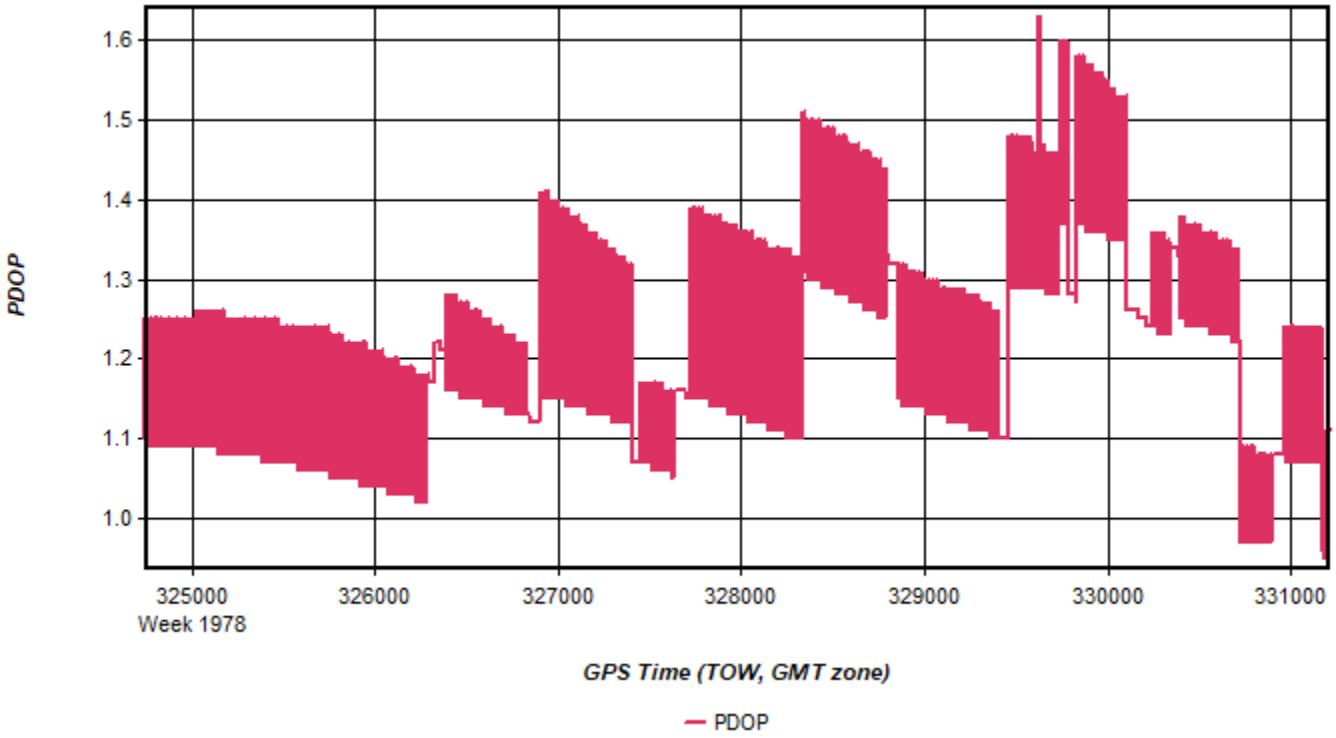
328000
329000
330000
331000
GPS Time (TOW, GMT zone)
East
North
Up



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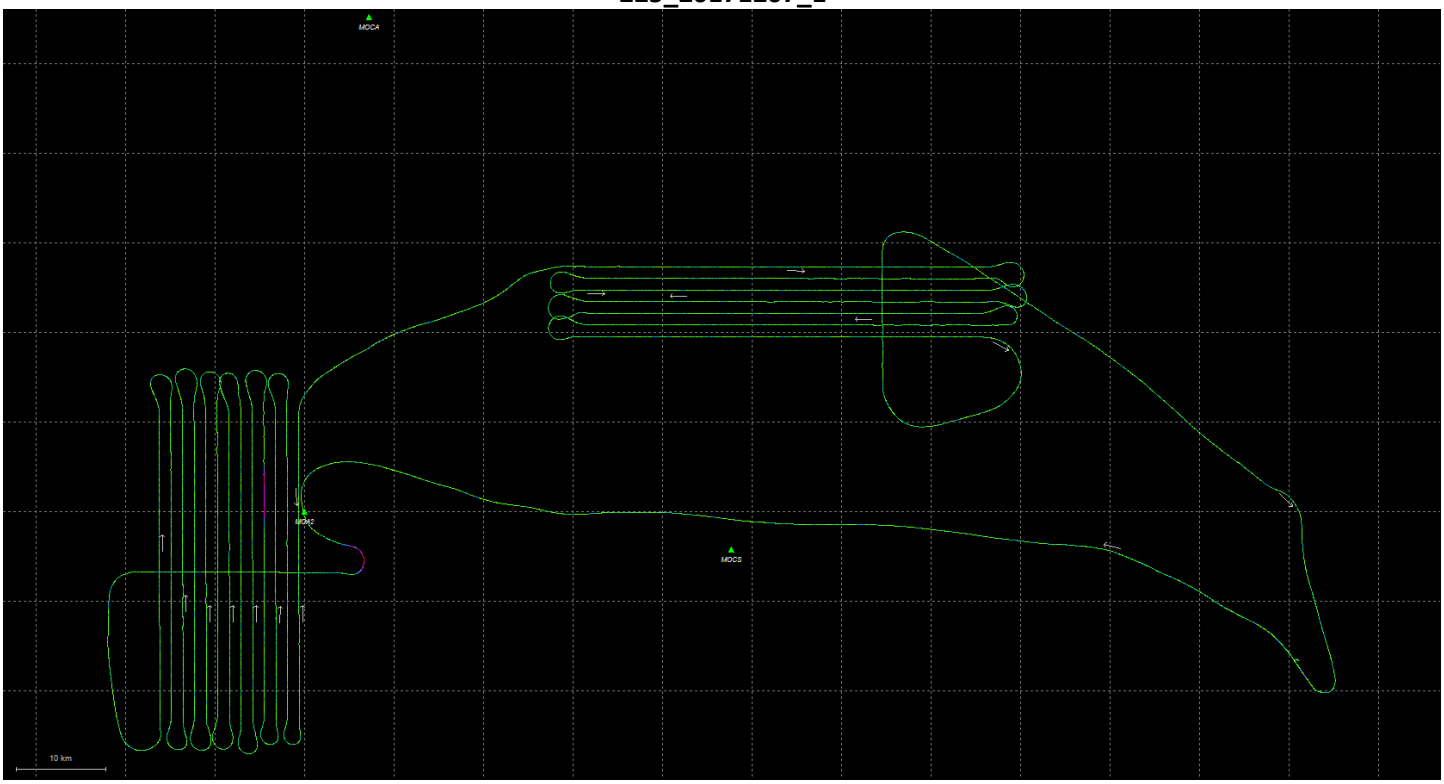

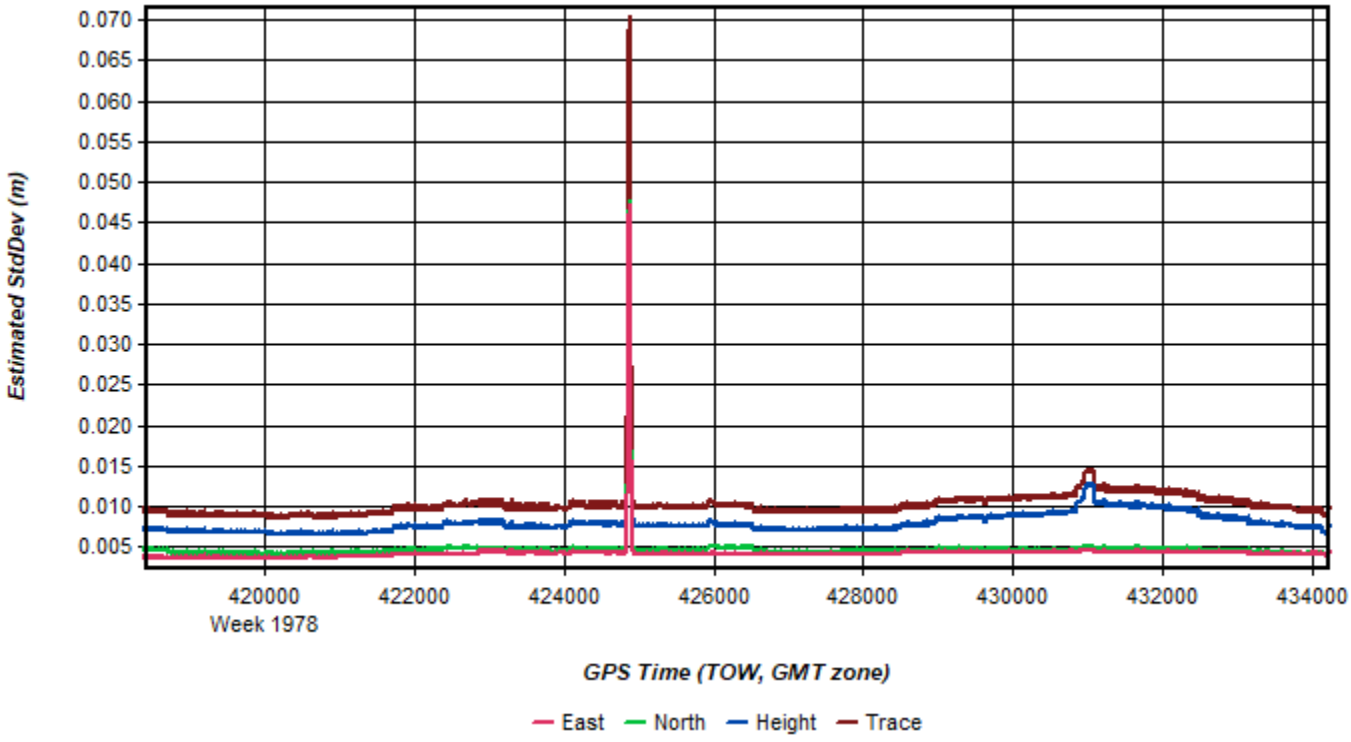
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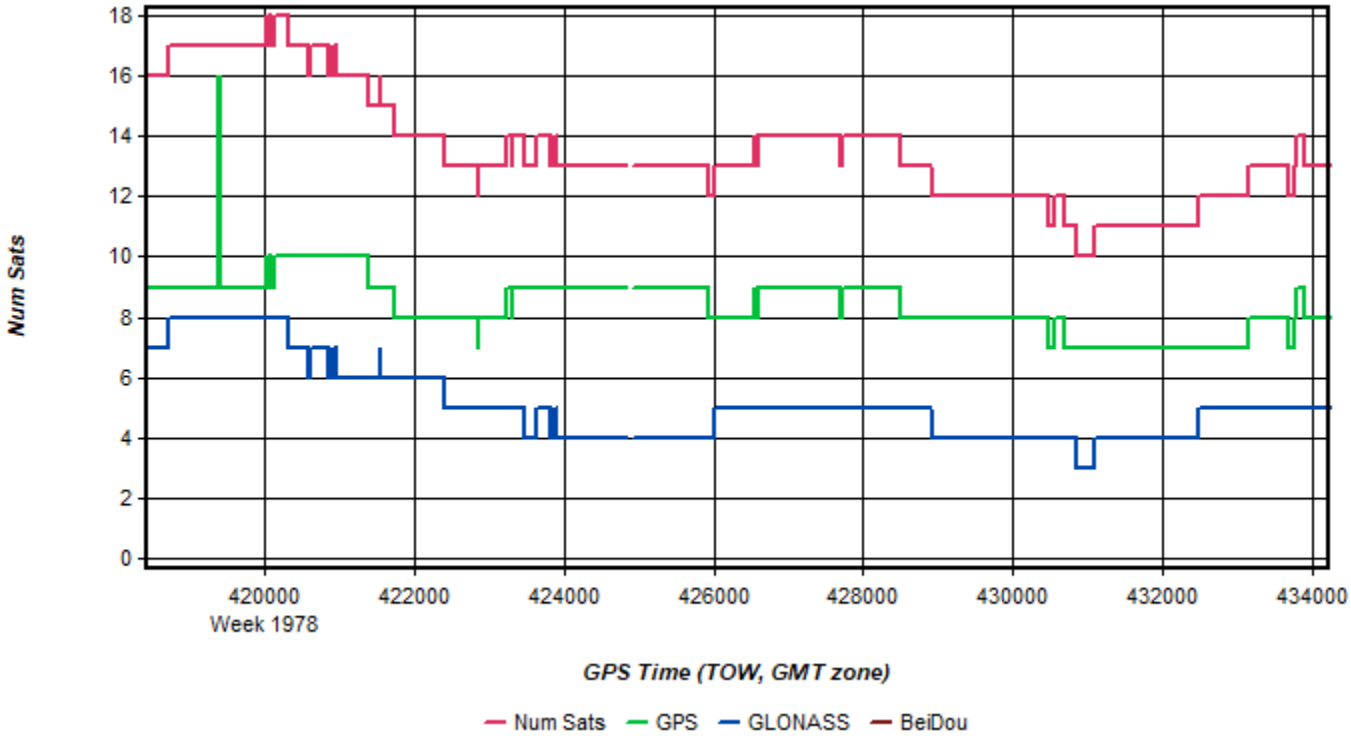
East
North
Height
Trace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GPS
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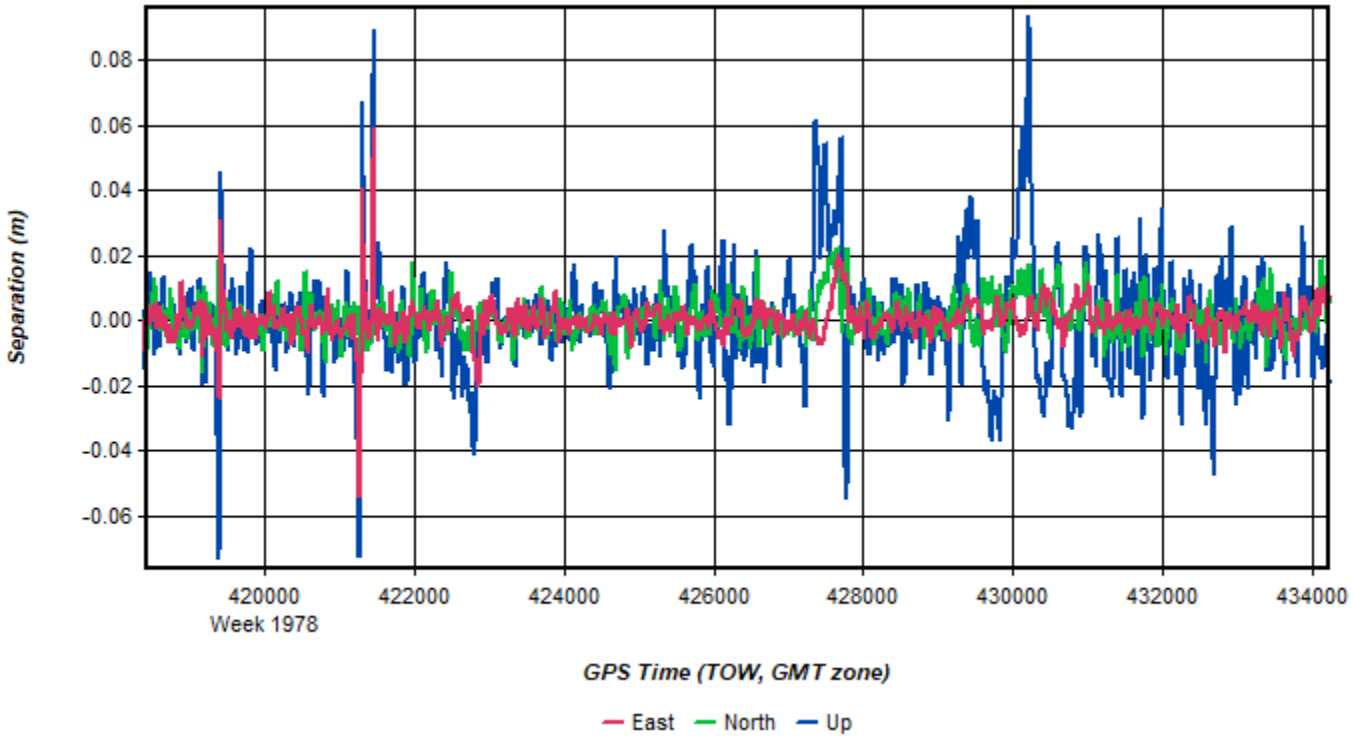
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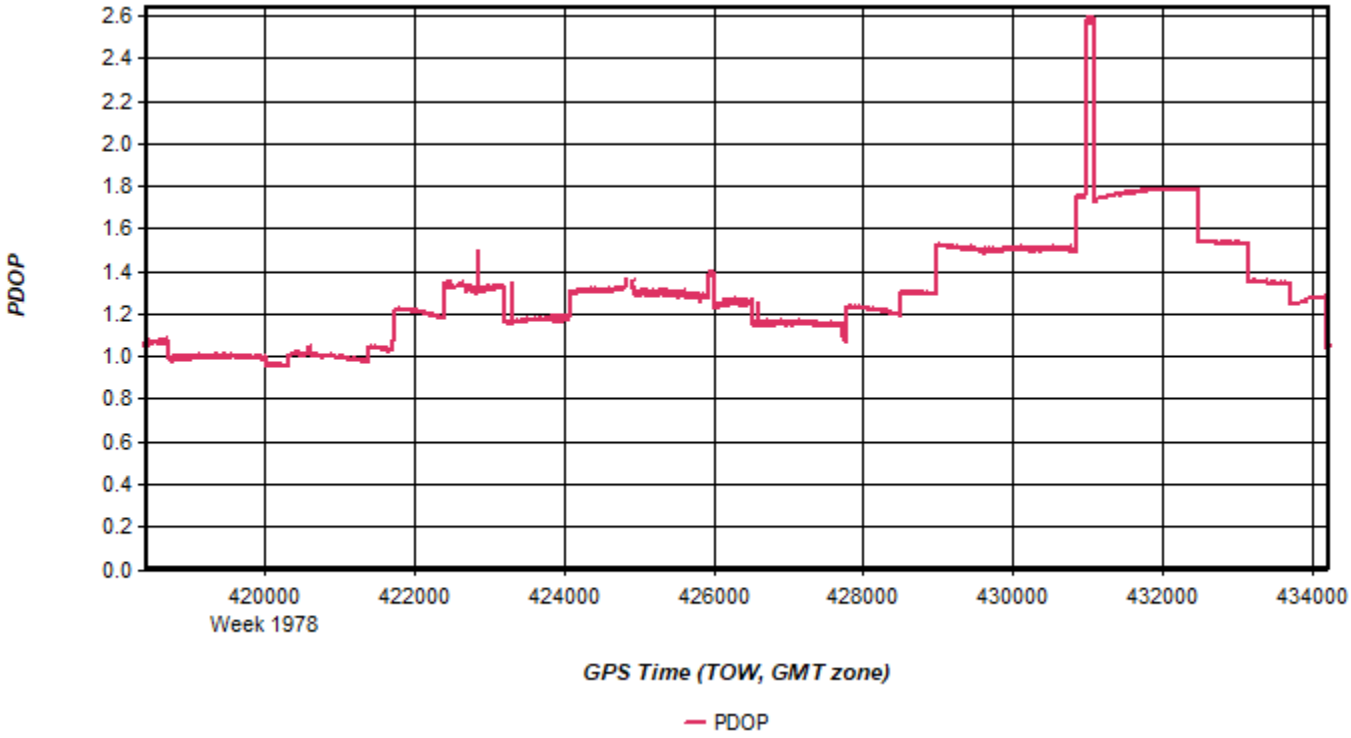
East
North
Up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PDOP

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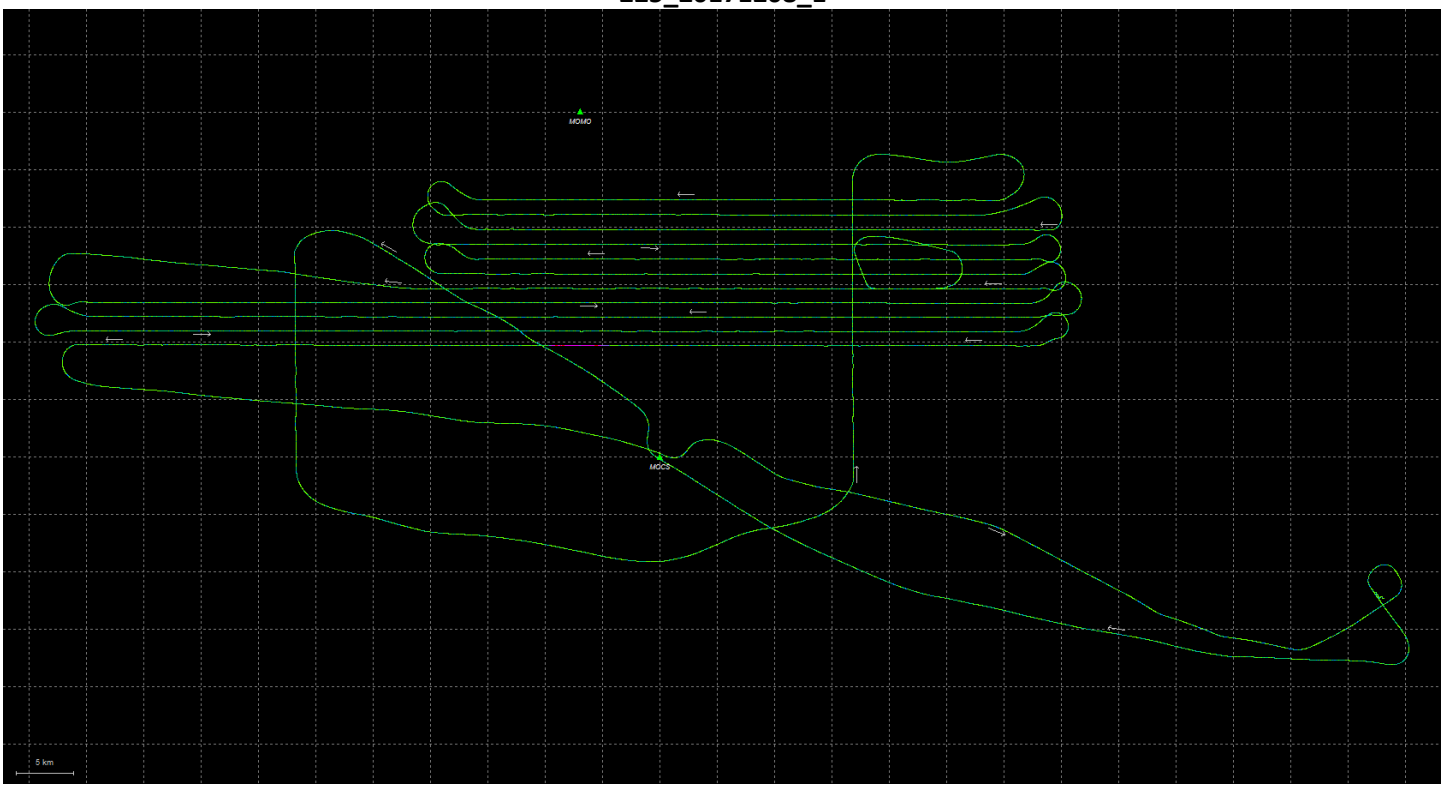

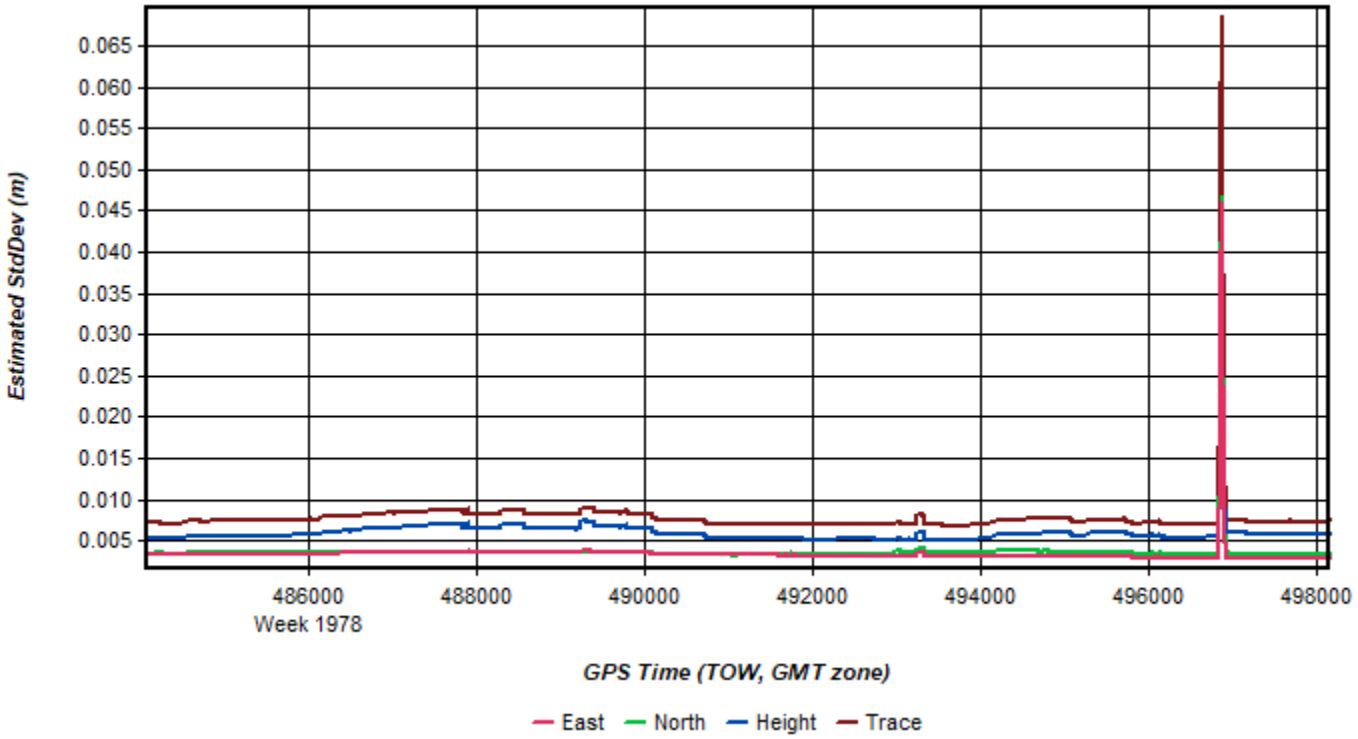

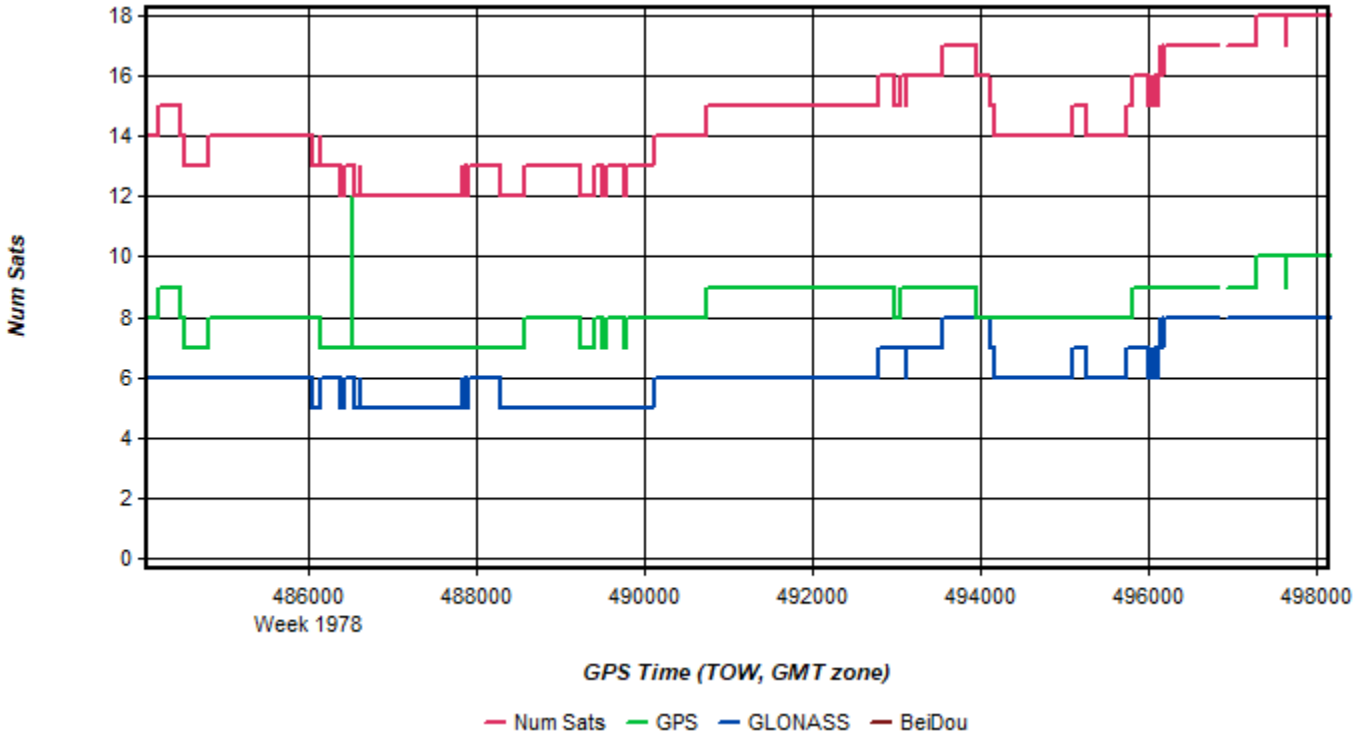
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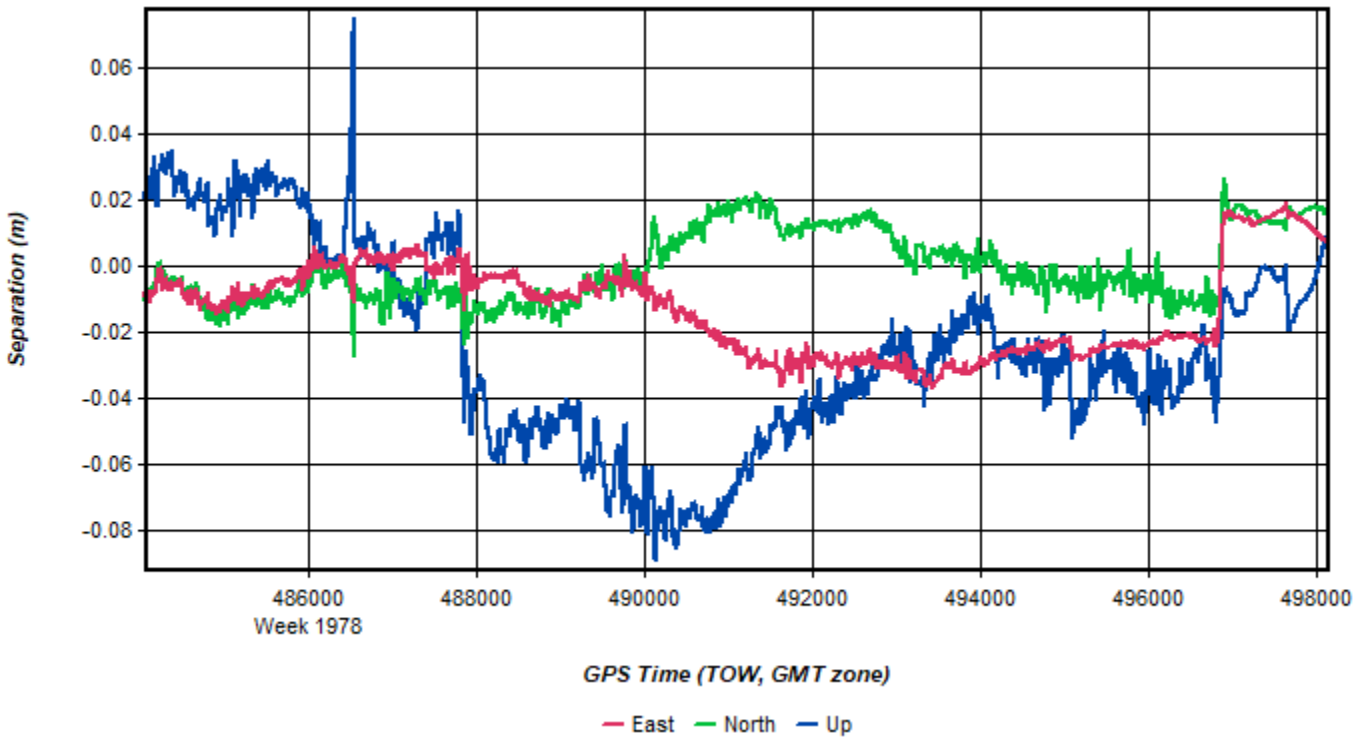
GLONASS
BeiDou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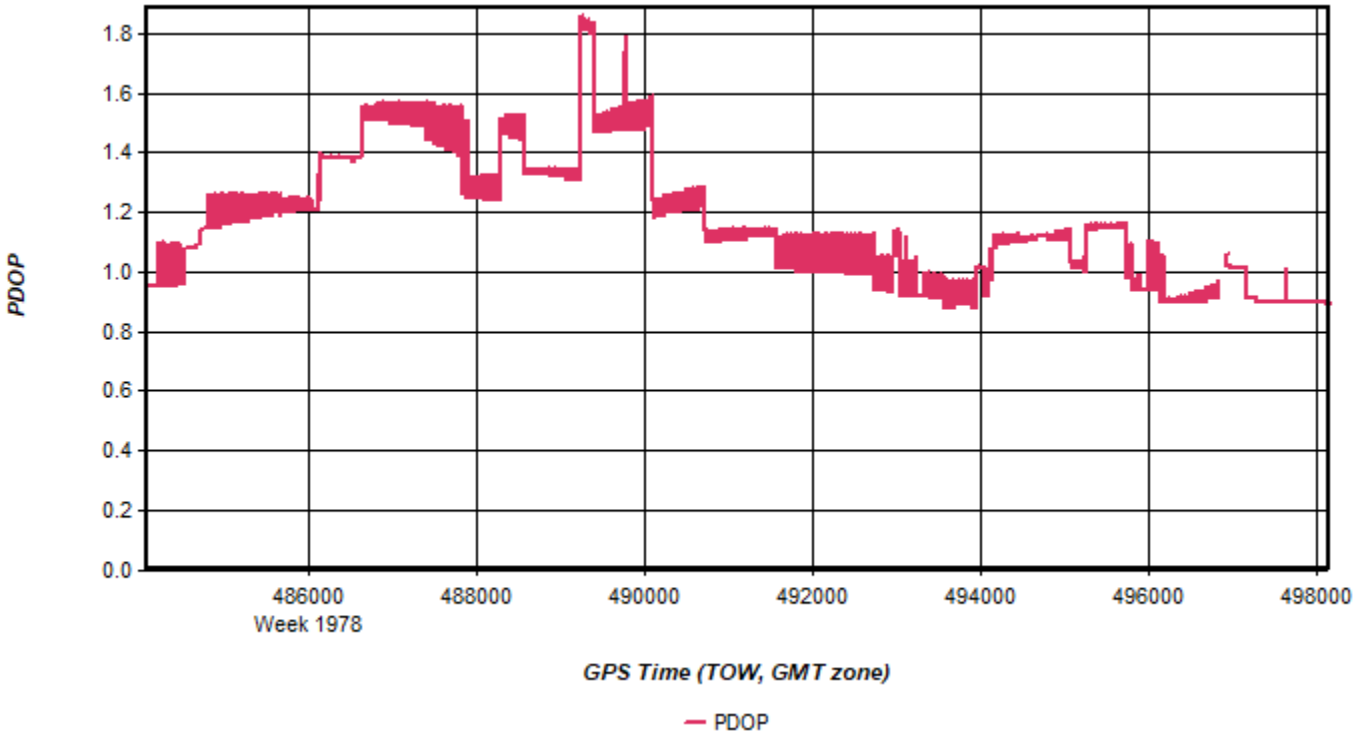
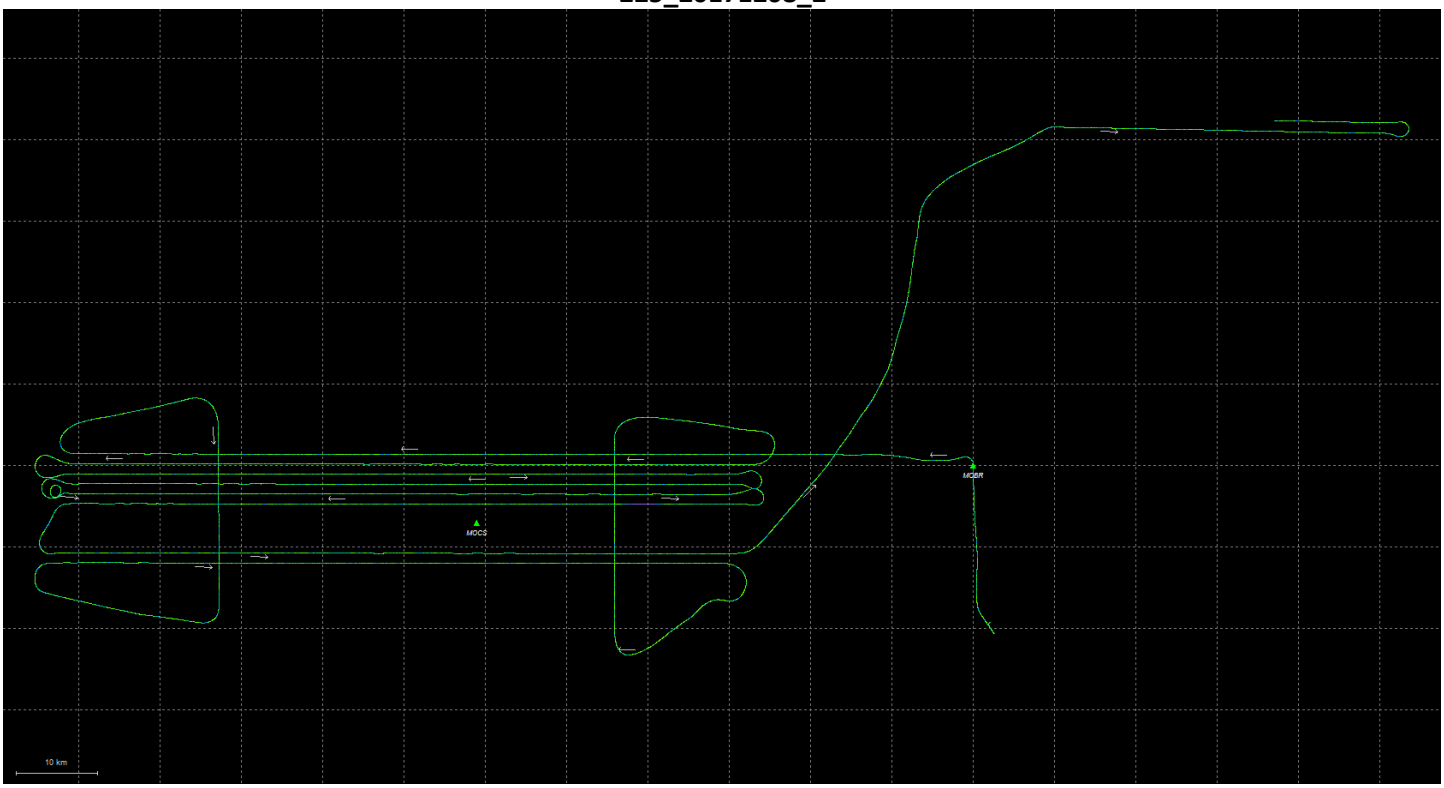
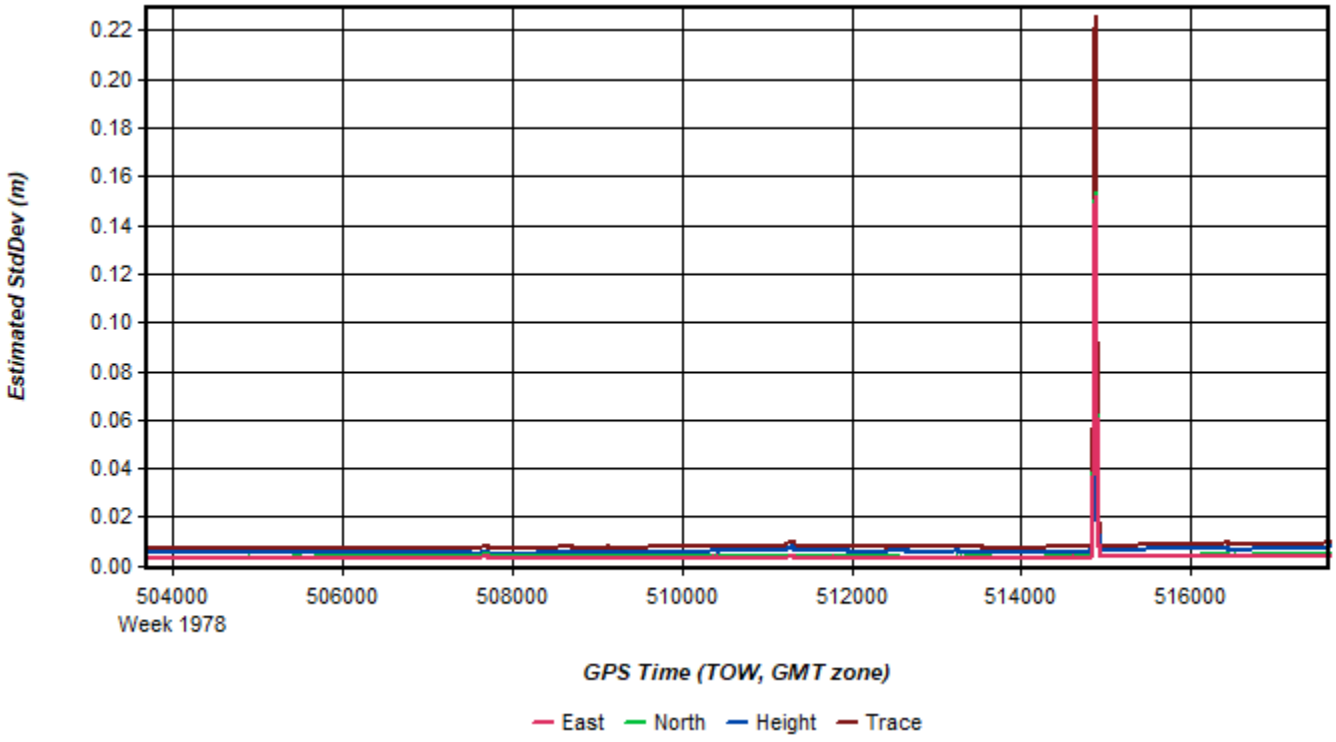
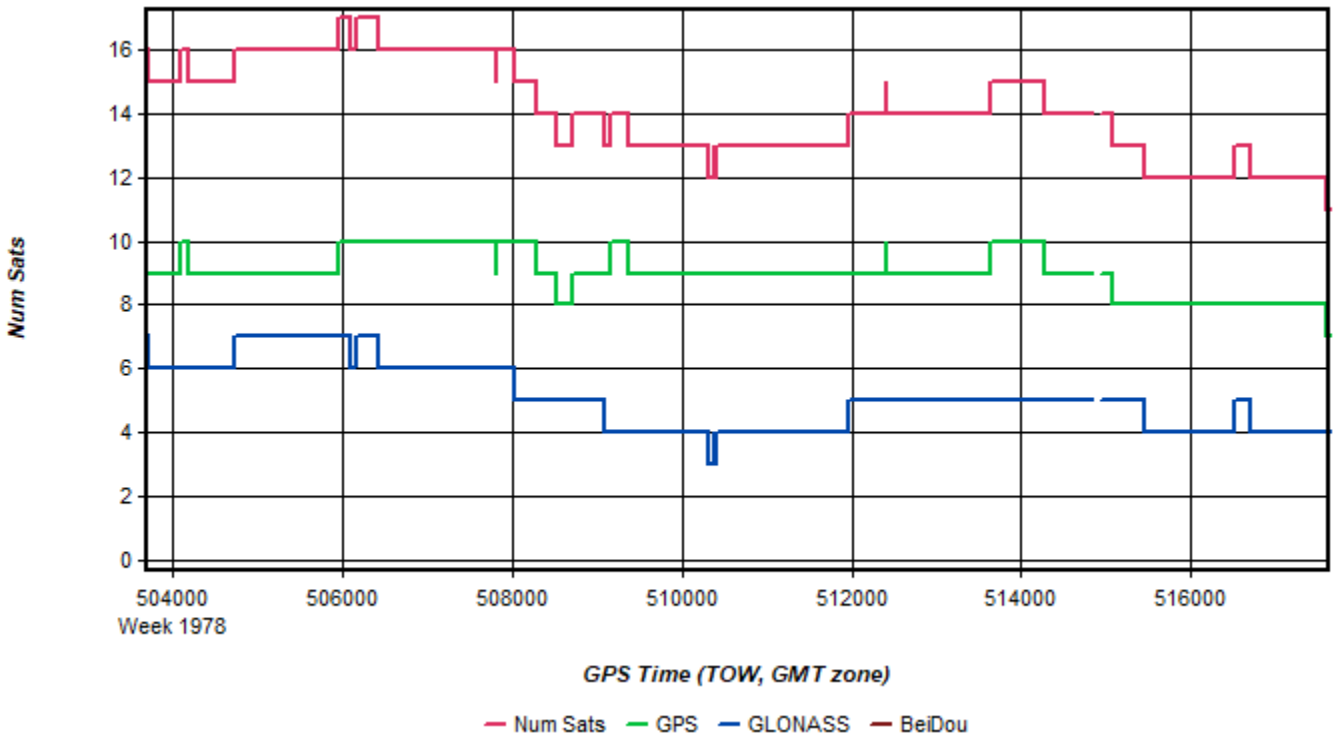
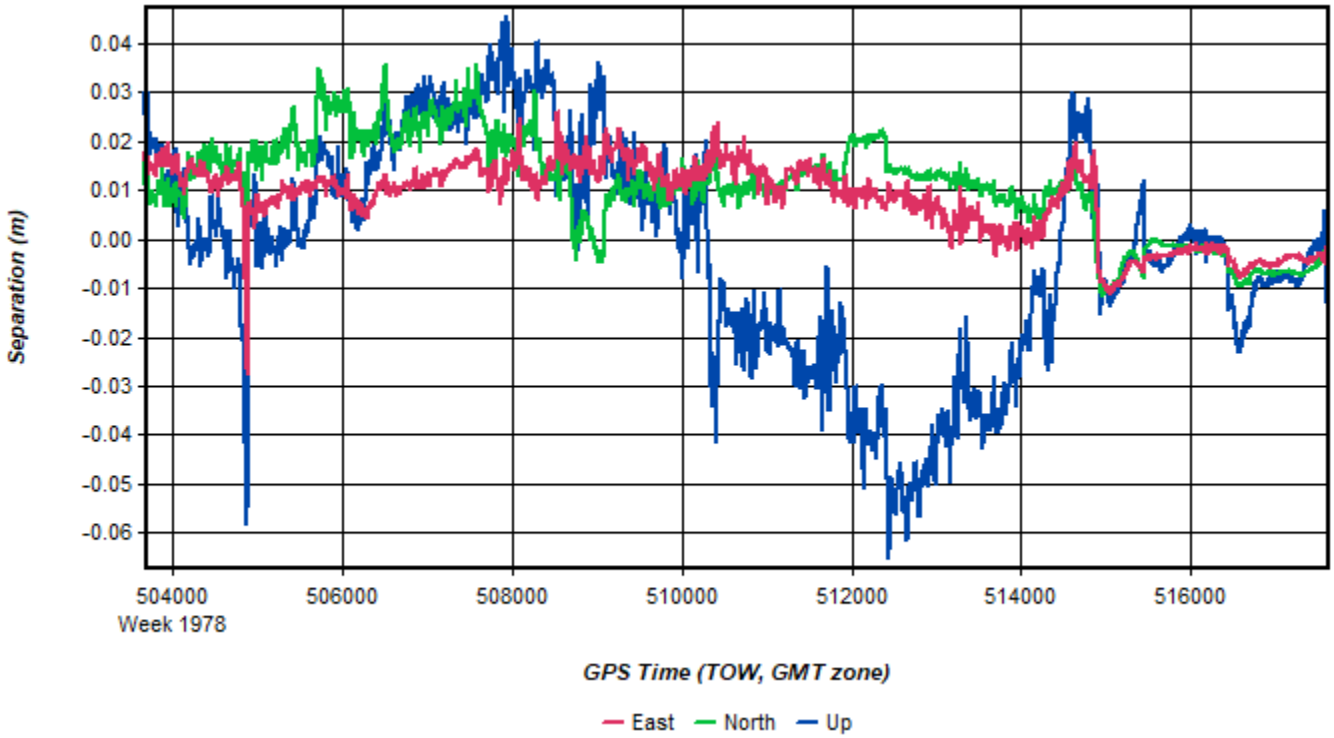


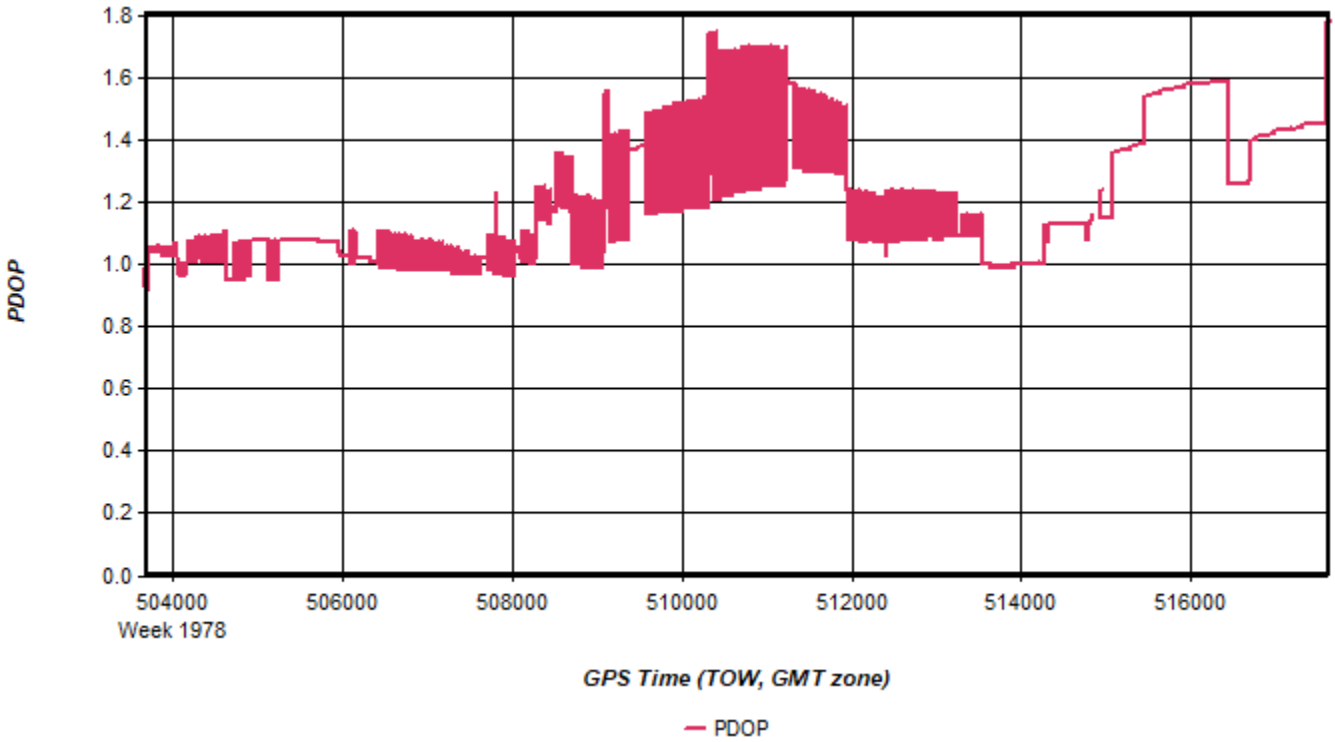
225_20171208_2



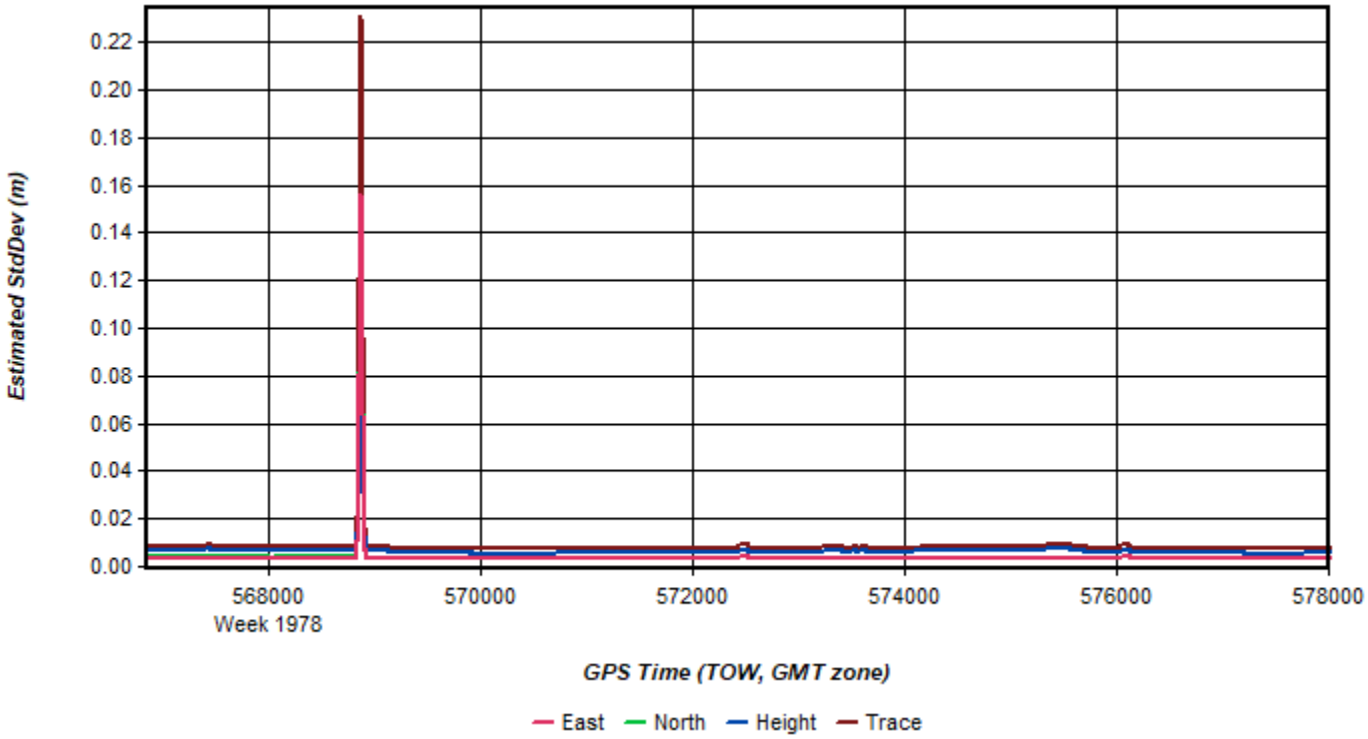

Estimated StdDev (m)
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
504000
506000
508000
510000
512000
514000
516000
Week 1978
GPS Time (TOW, GMT zone)
East
North
Height
Trace

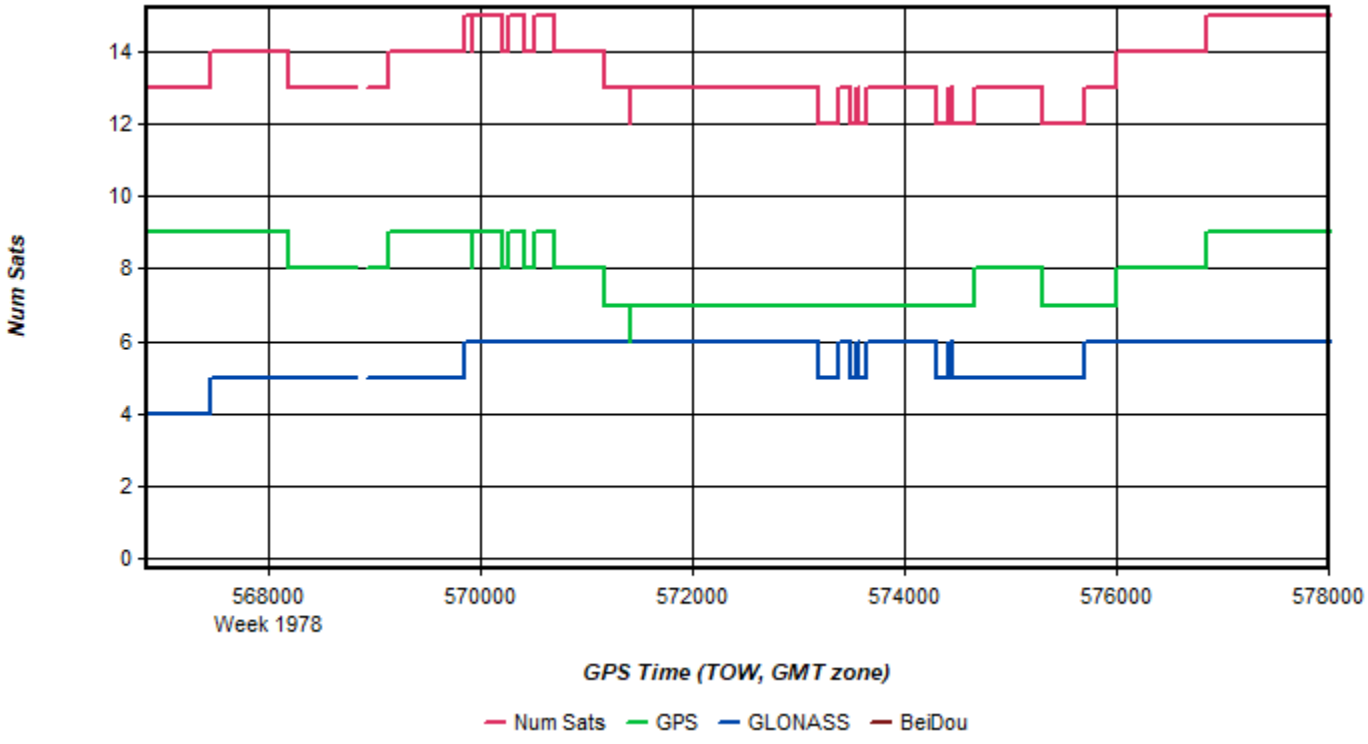

Num Sats
16
14
12
10
8
6
4
2
0
504000
506000
508000
510000
512000
514000
516000
Week 1978
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

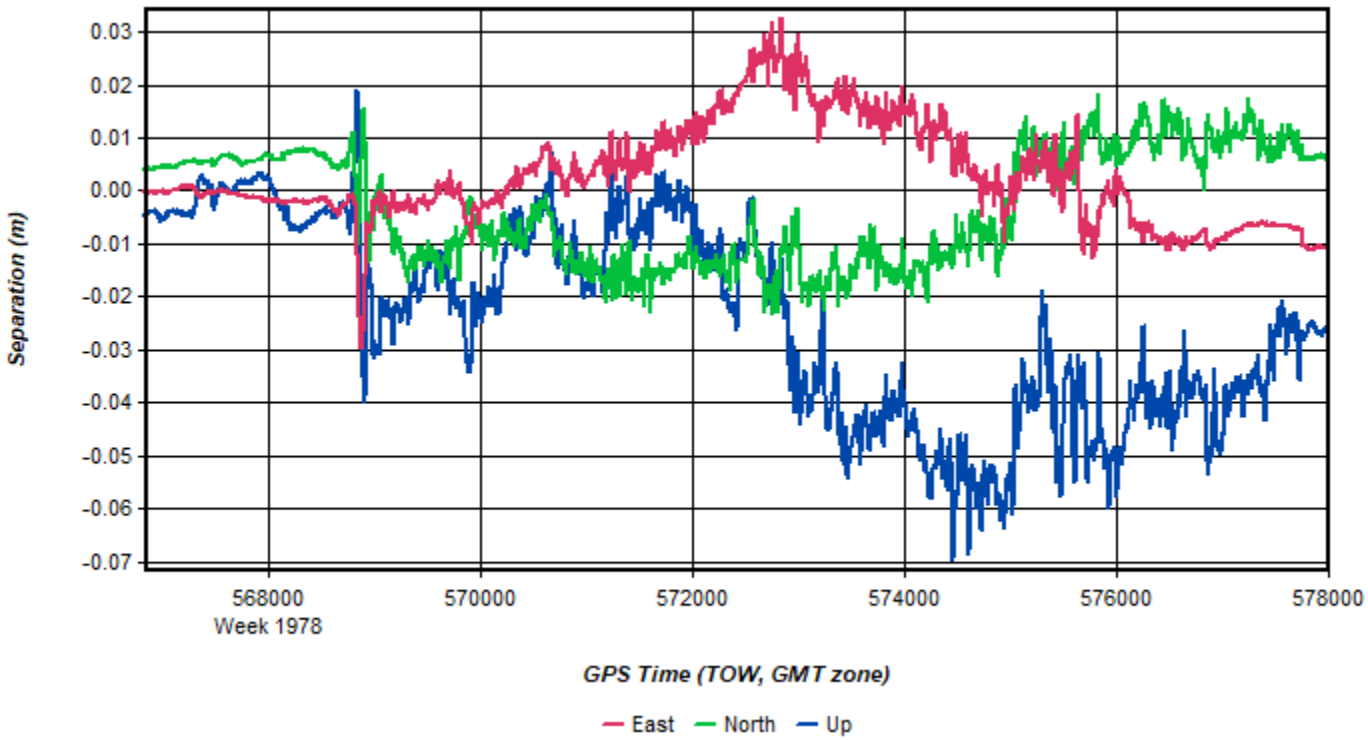

Separation (m)
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
504000
Week 1978
506000
508000
510000
512000
514000
516000
GPS Time (TOW, GMT zone)
East
North
Up

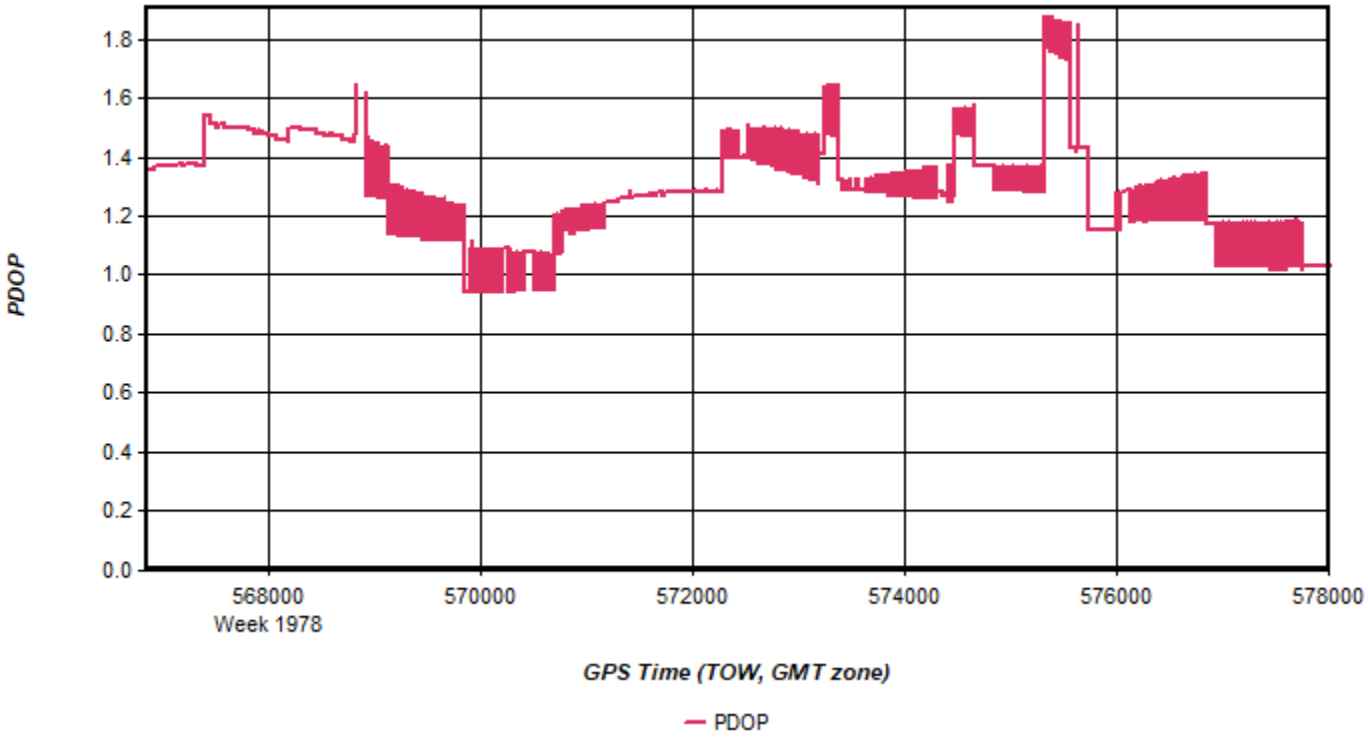

PDOP
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
504000
Week 1978
506000
508000
510000
512000
514000
516000
GPS Time (TOW, GMT zone)
PDOP

225_20171209_1

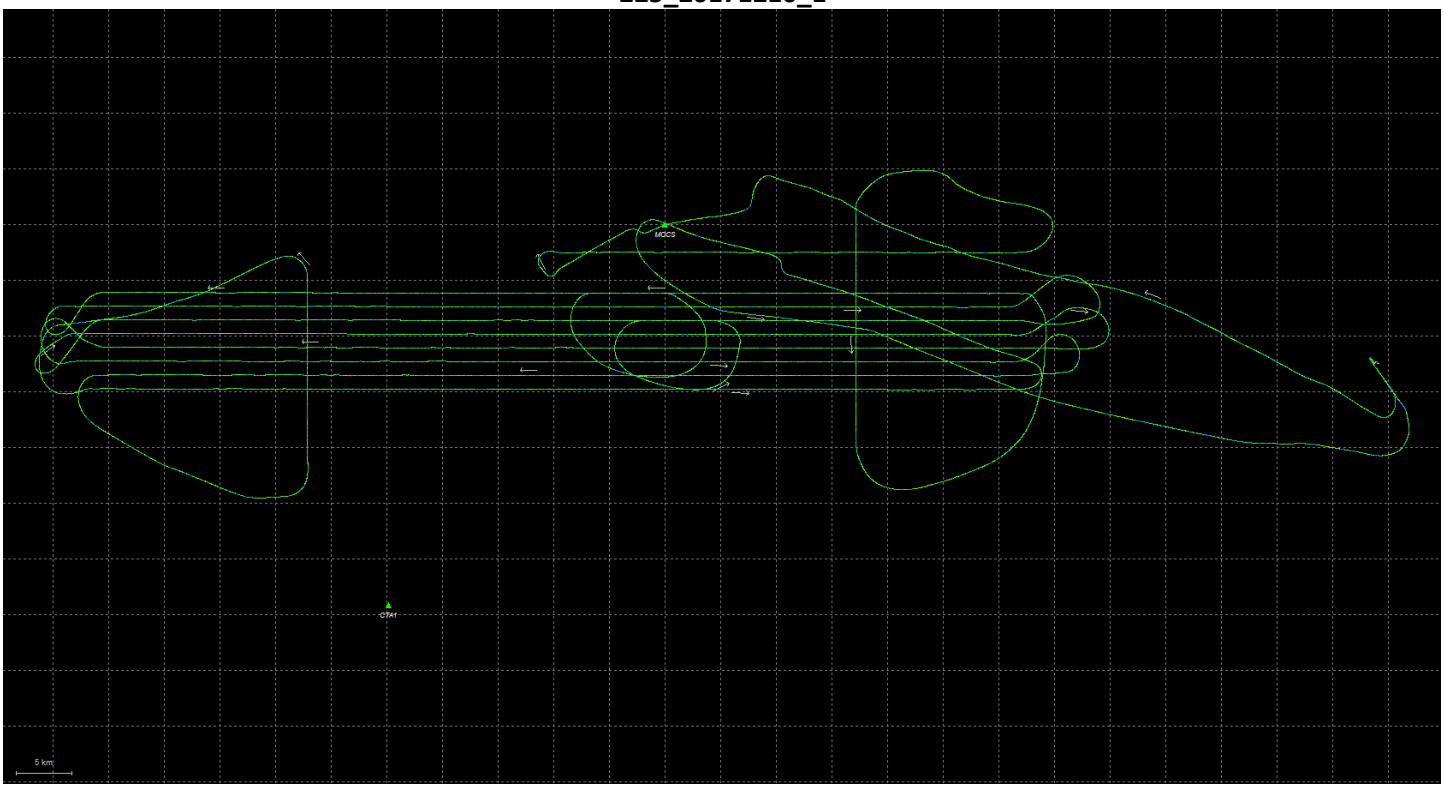


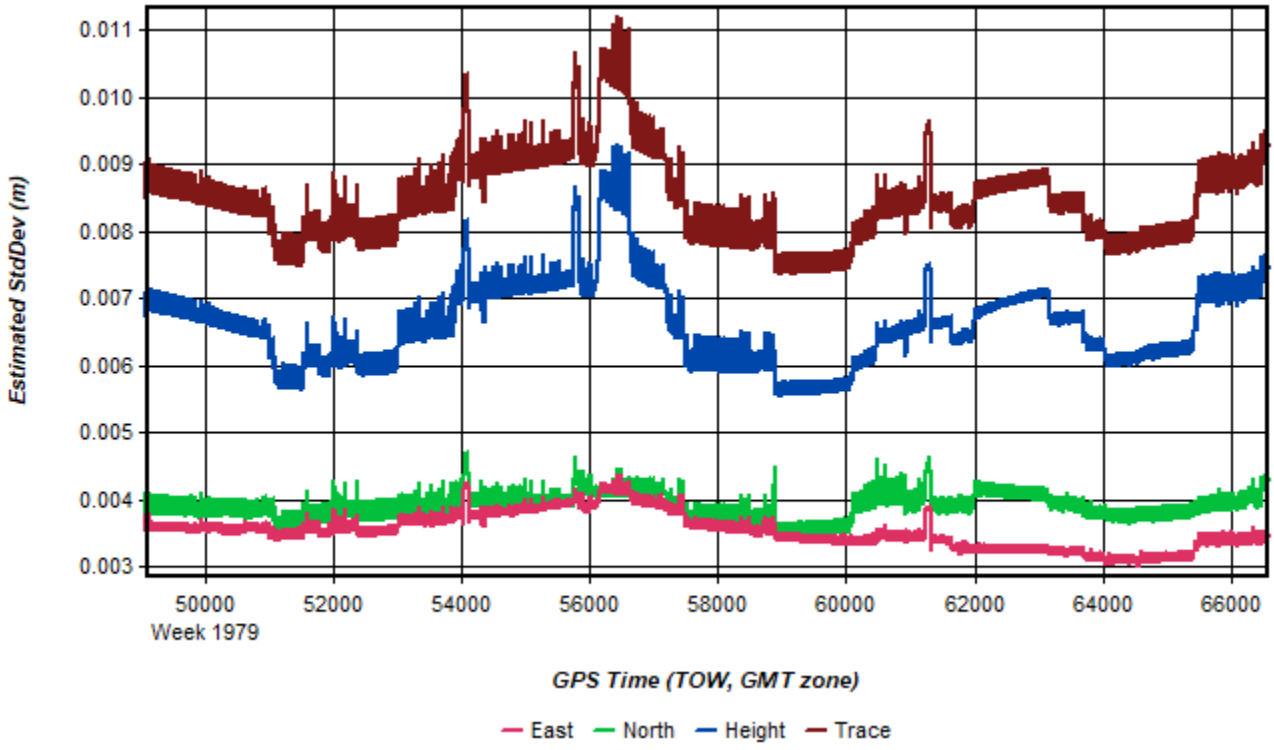

Num Sats
14
12
10
8
6
4
2
0
568000
Week 1978
570000
572000
574000
576000
578000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

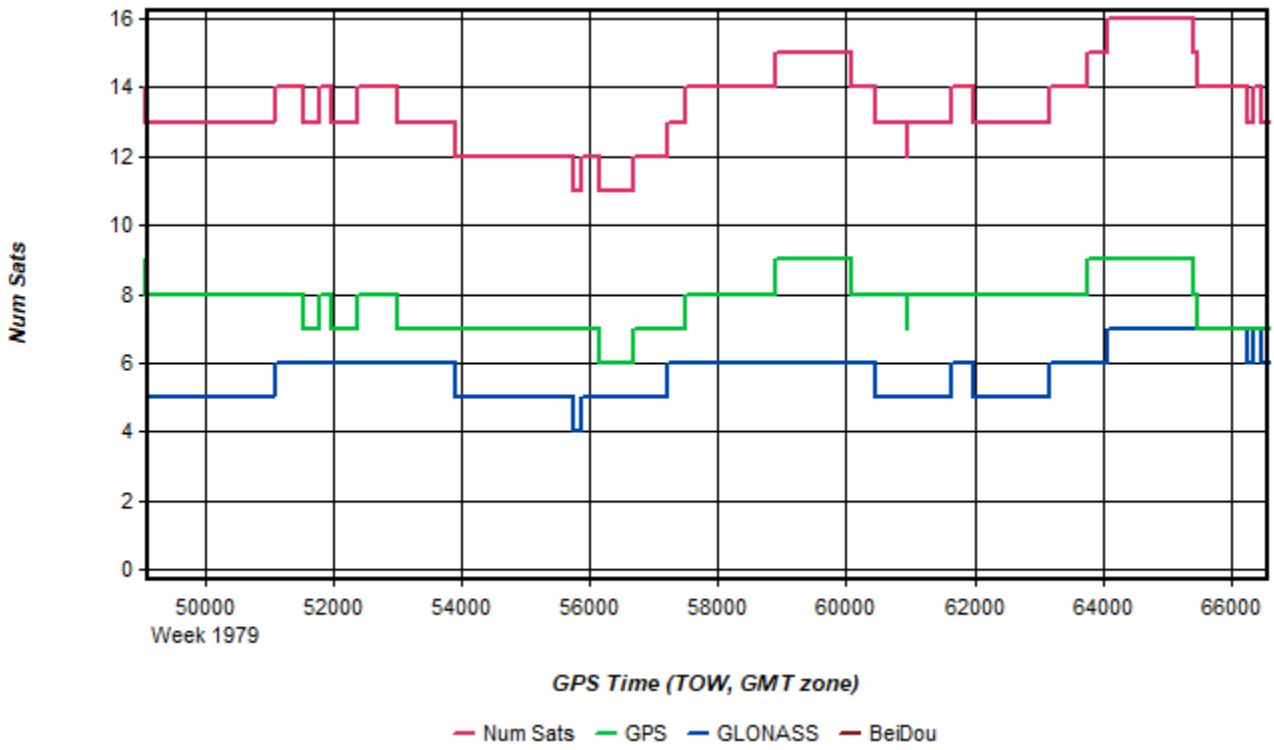

Separation (m)
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
568000
Week 1978
570000
572000
574000
576000
578000
GPS Time (TOW, GMT zone)
East
North
Up

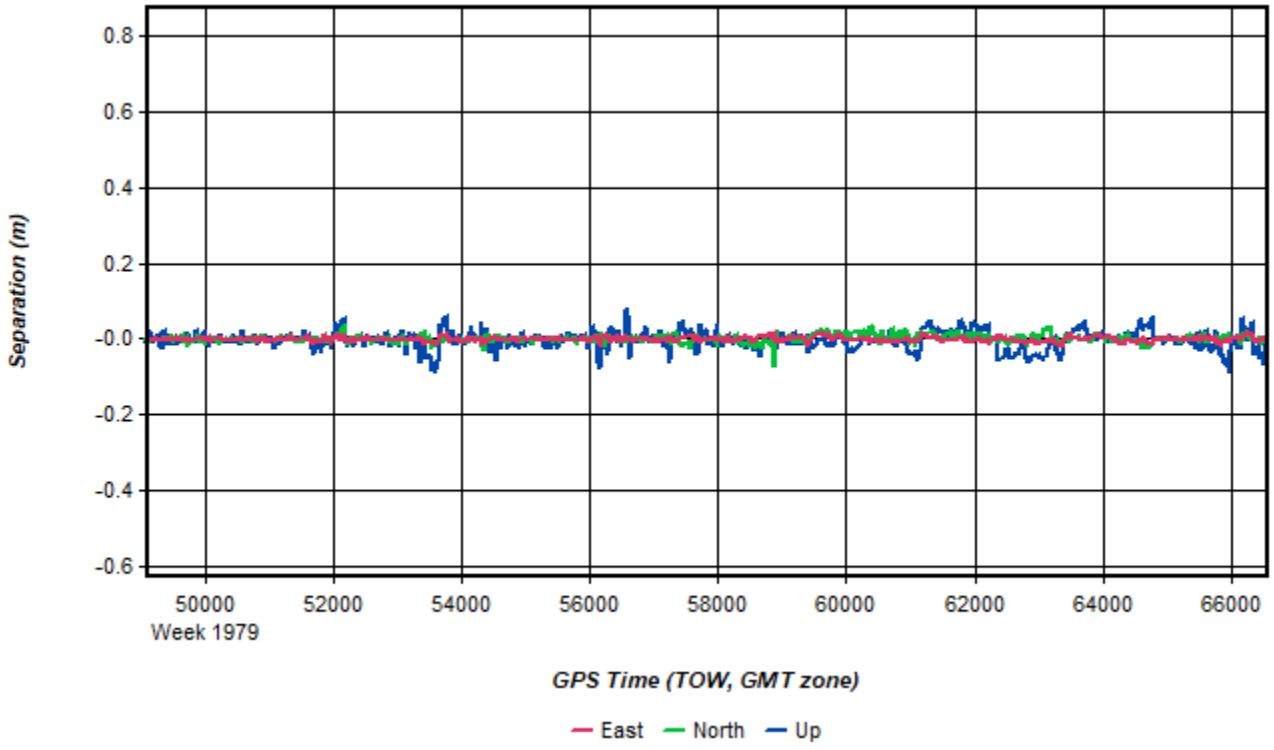


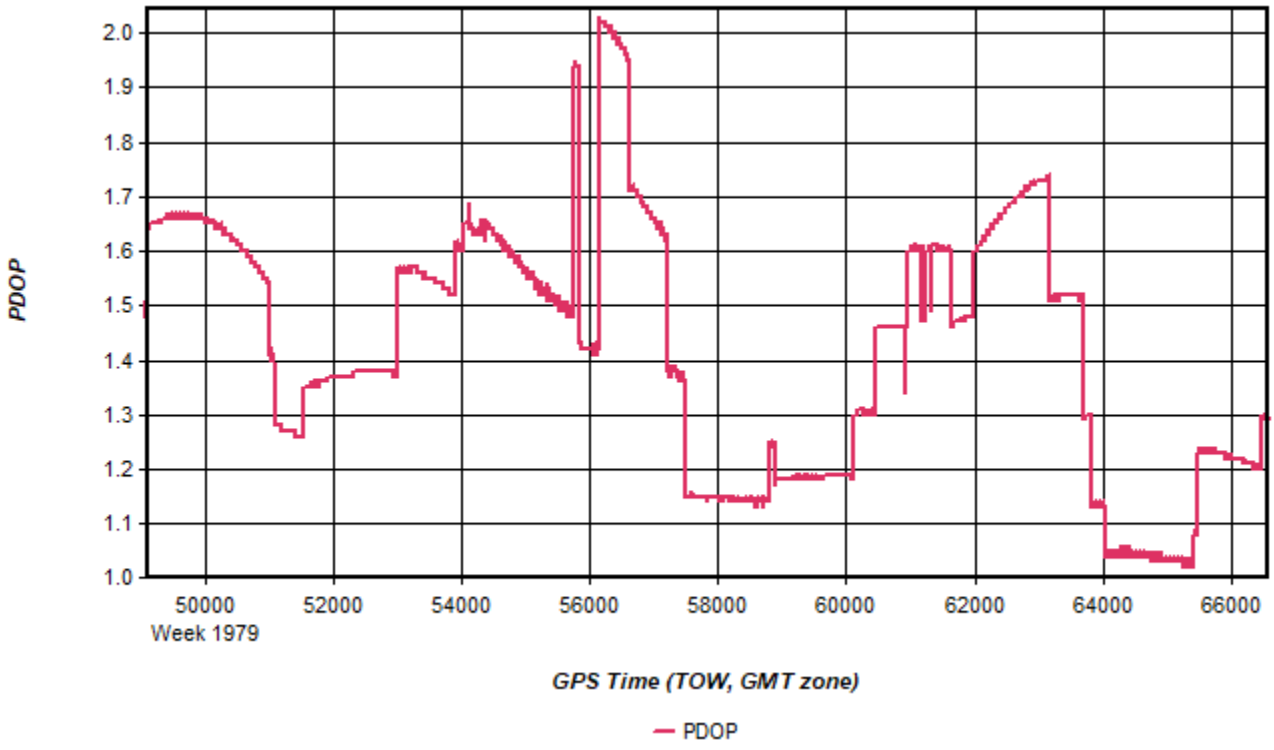
225_20171210_1



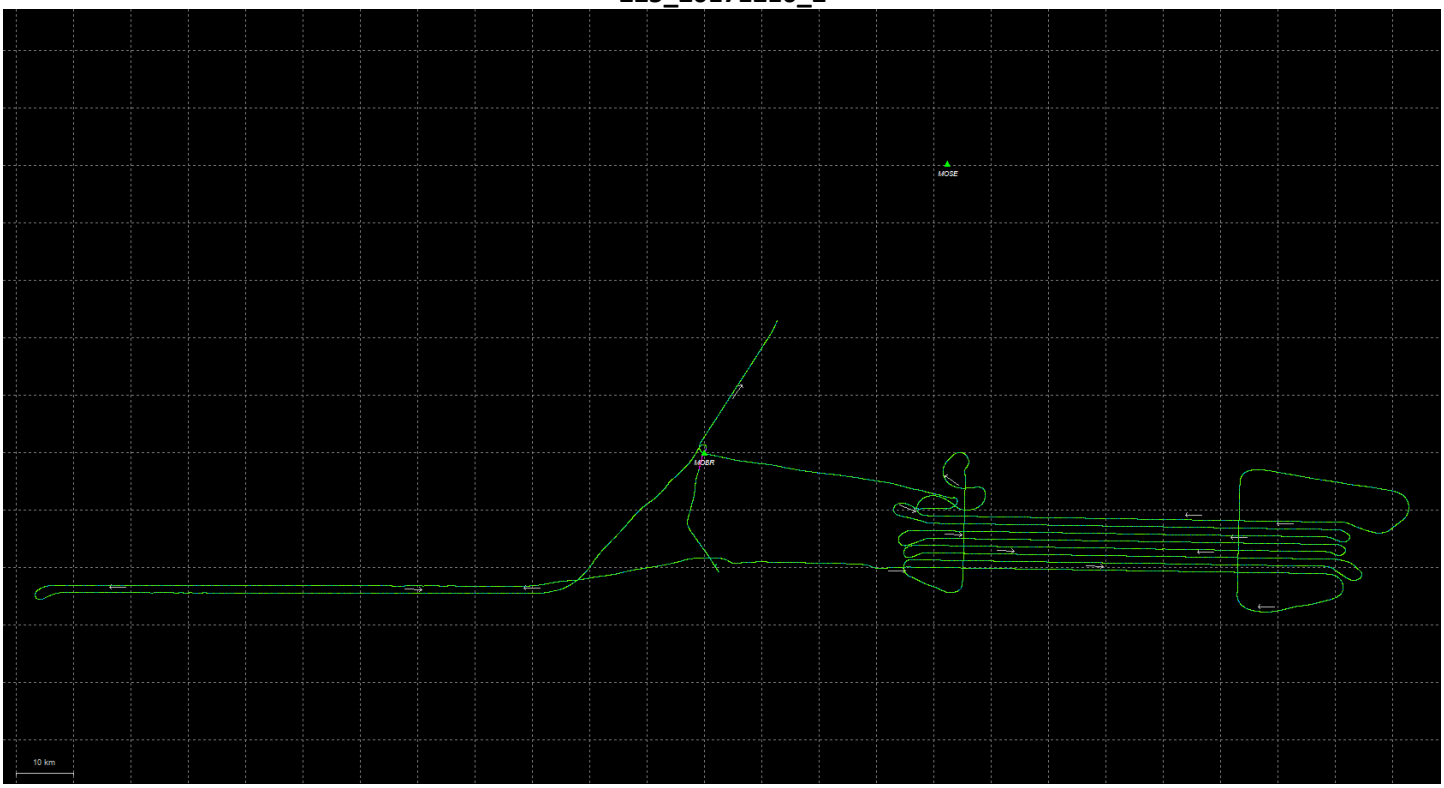

Estimated StdDev (m)
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
50000
52000
54000
56000
58000
60000
62000
64000
66000
Week 1979
GPS Time (TOW, GMT zone)
East
North
Height
Trace

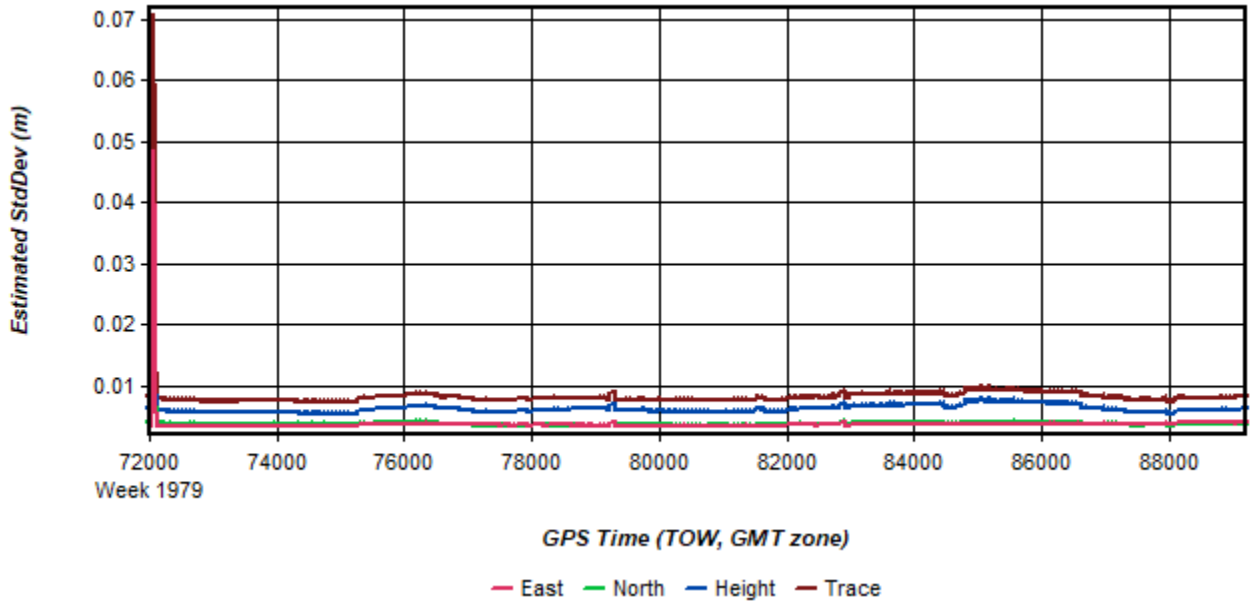

Num Sats
16
14
12
10
8
6
4
2
0
50000
52000
54000
56000
58000
60000
62000
64000
66000
Week 1979
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

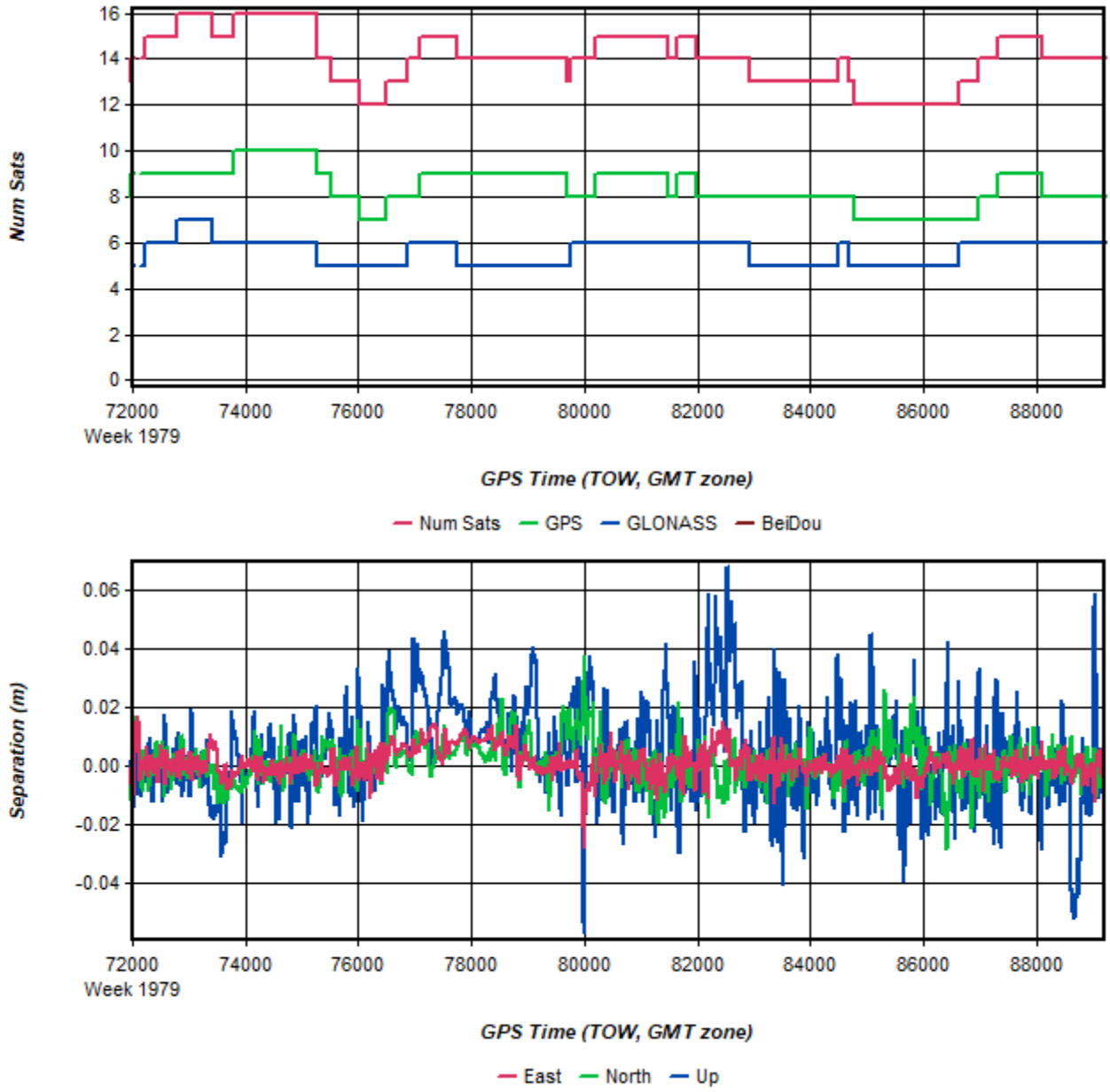

Separation (m)
0.8
0.6
0.4
0.2
-0.0
-0.2
-0.4
-0.6
50000
52000
54000
56000
58000
60000
62000
64000
66000
Week 1979
GPS Time (TOW, GMT zone)
East
North
Up

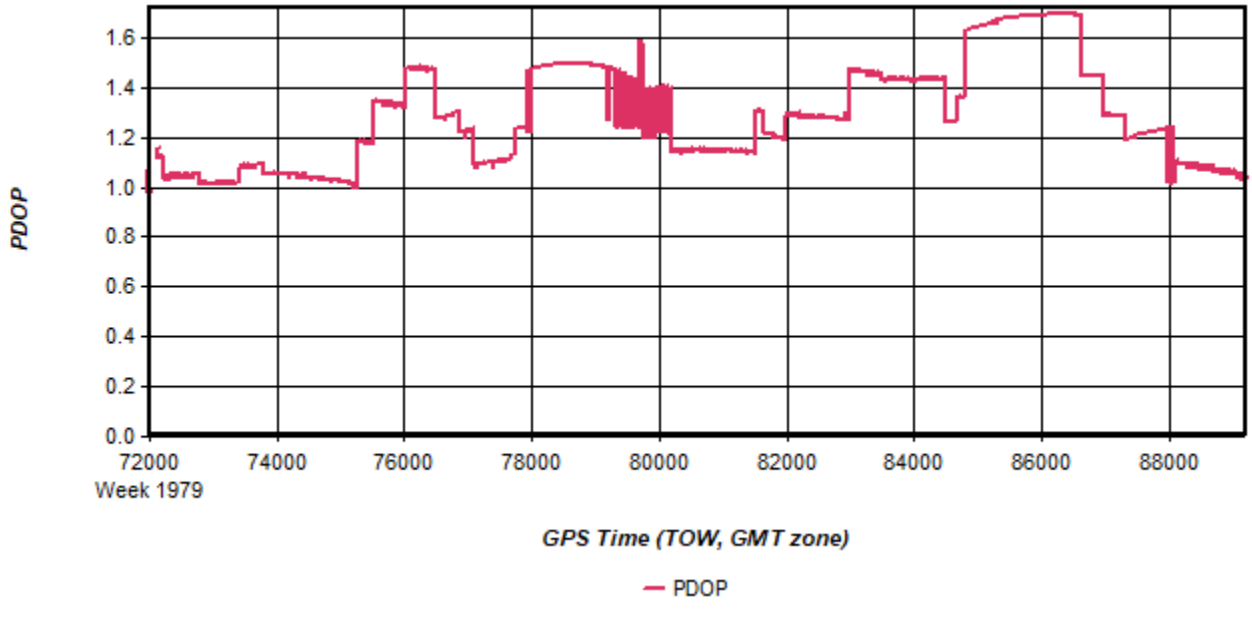

PDOP
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
50000
52000
54000
56000
58000
60000
62000
64000
66000
Week 1979
GPS Time (TOW, GMT zone)
PDOP

225_20171210_2

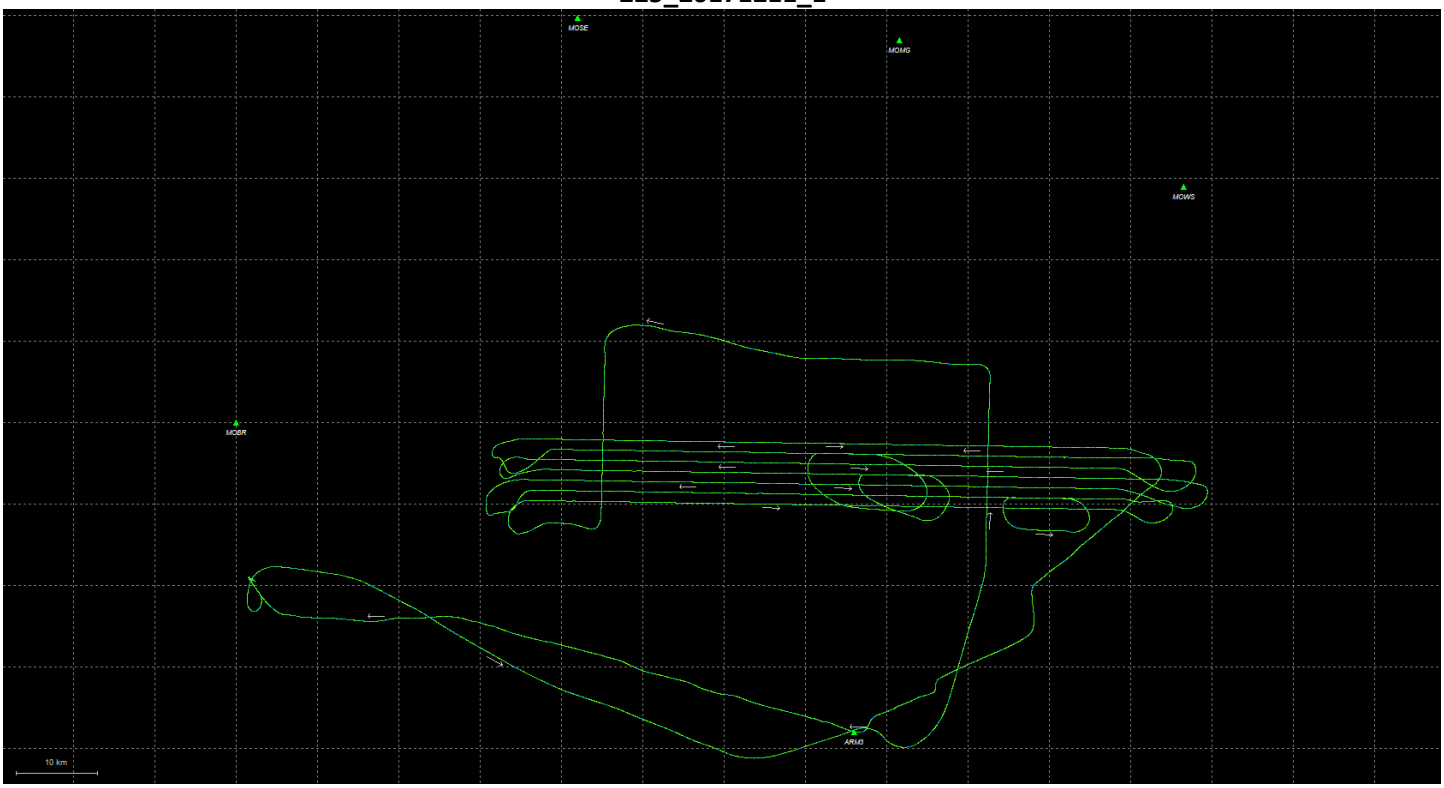


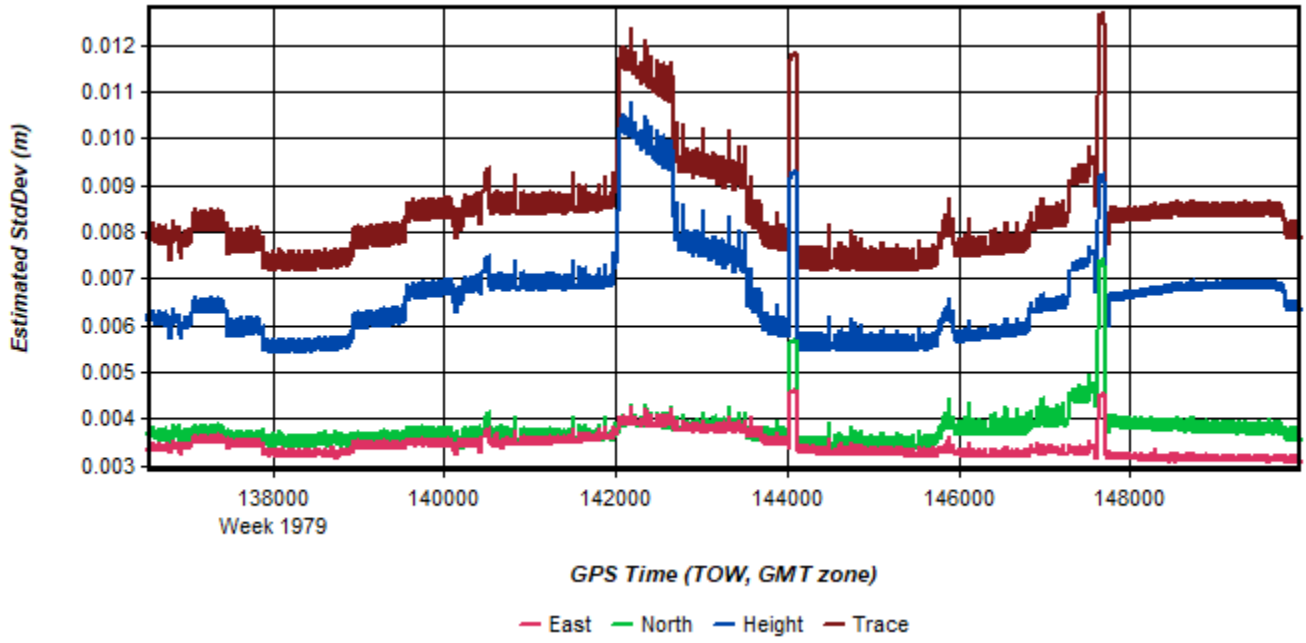


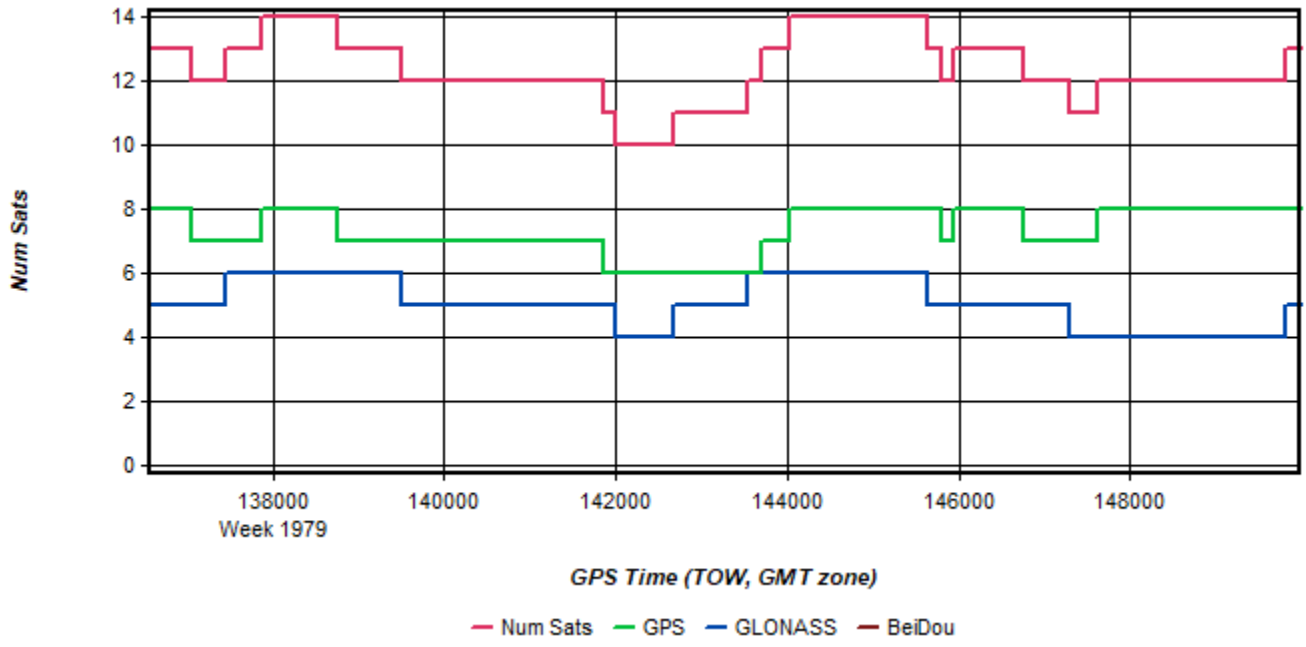

Num Sats
16
14
12
10
8
6
4
2
0
72000
74000
76000
78000
80000
82000
84000
86000
88000
Week 1979
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Separation (m)
0.06
0.04
0.02
0.00
-0.02
-0.04
72000
74000
76000
78000
80000
82000
84000
86000
88000
Week 1979
GPS Time (TOW, GMT zone)
East
North
Up

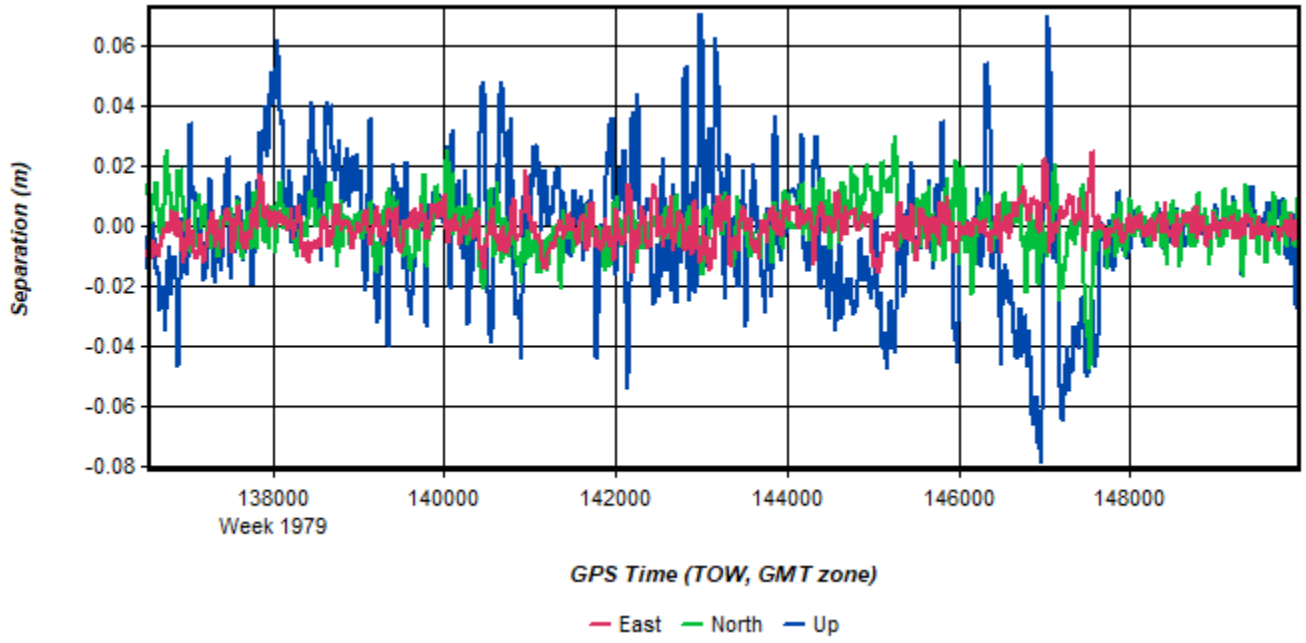


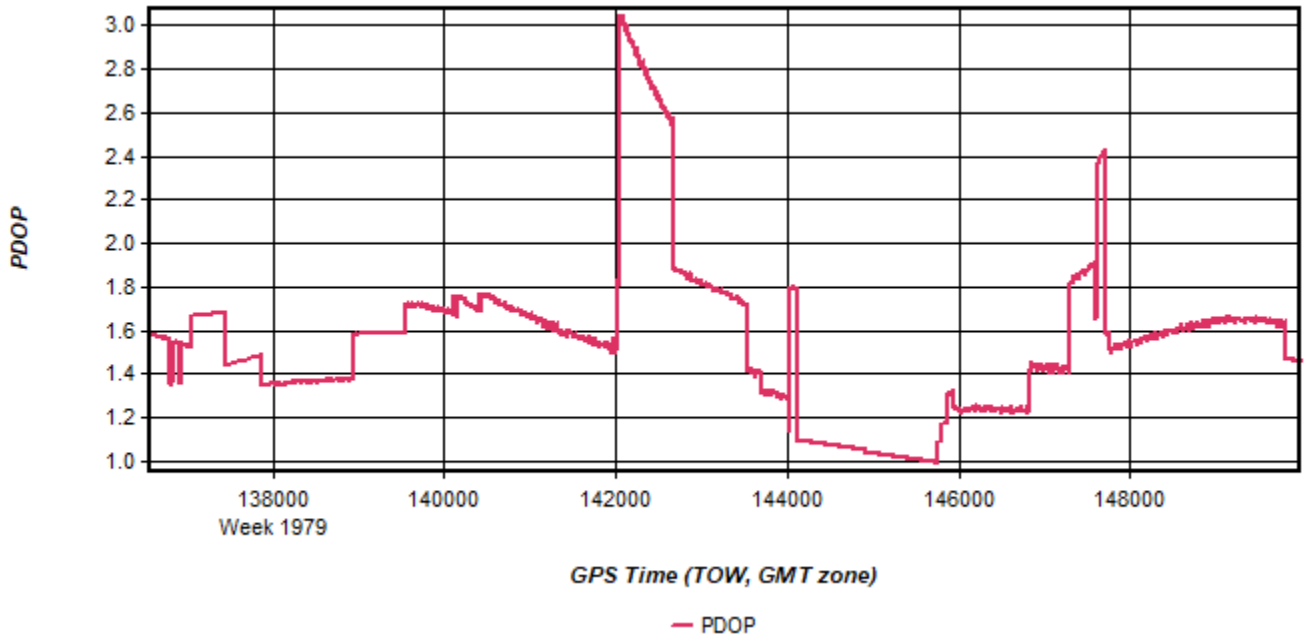
225_20171211_1



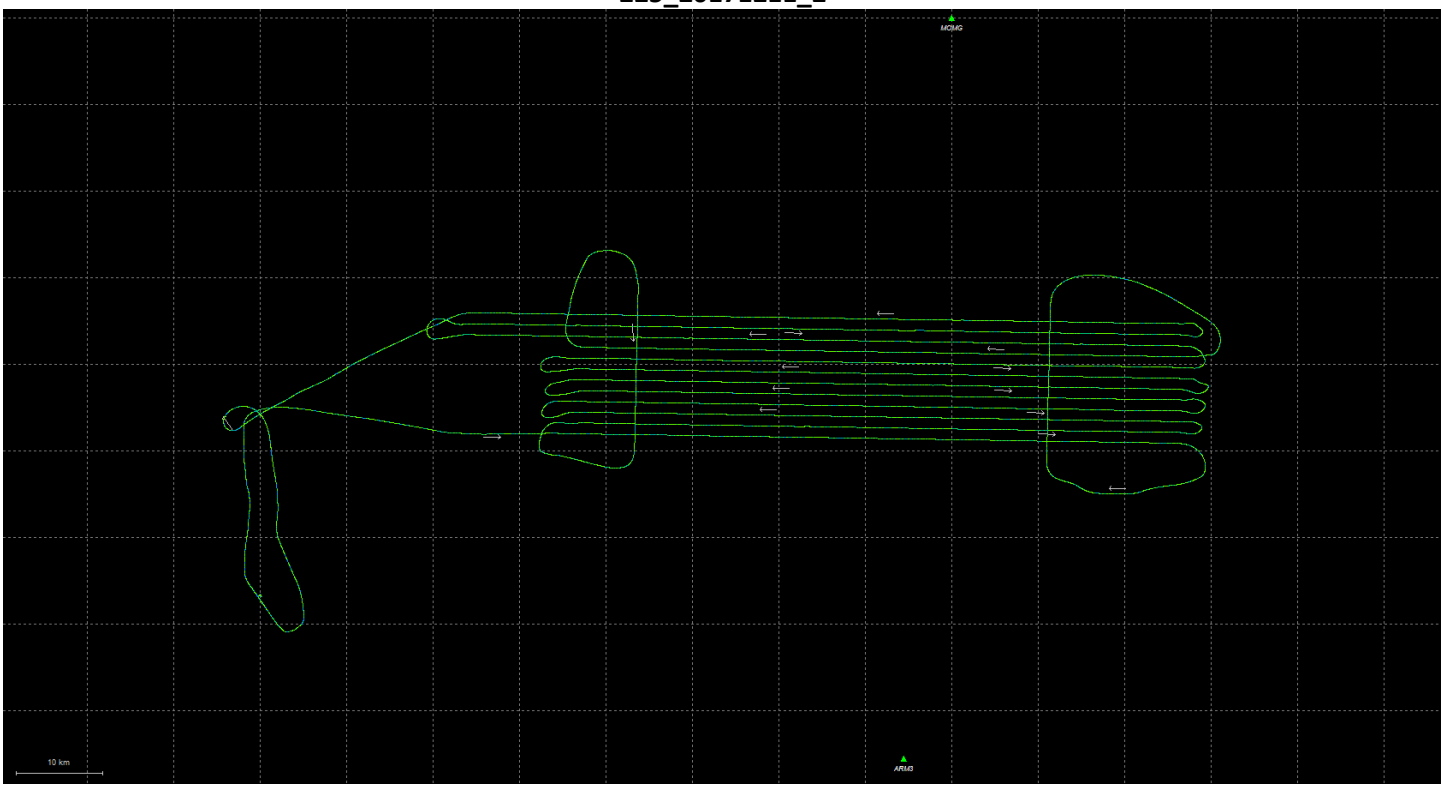

Estimated StdDev (m)
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
138000
Week 1979
140000
142000
144000
146000
148000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

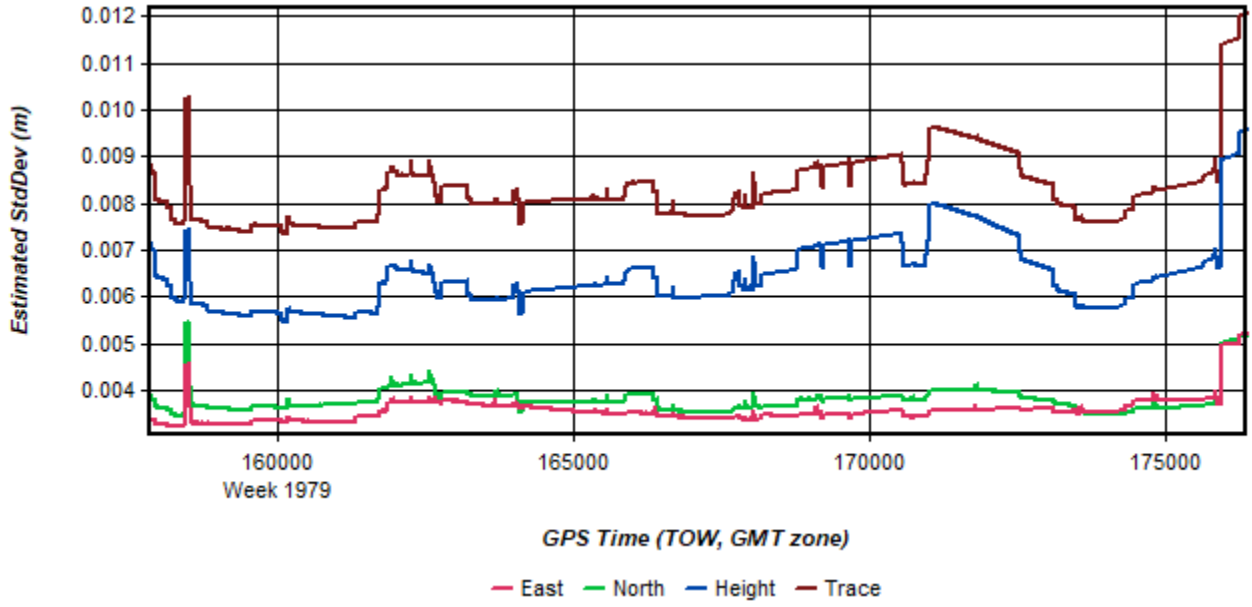

Num Sats
14
12
10
8
6
4
2
0
138000
Week 1979
140000
142000
144000
146000
148000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

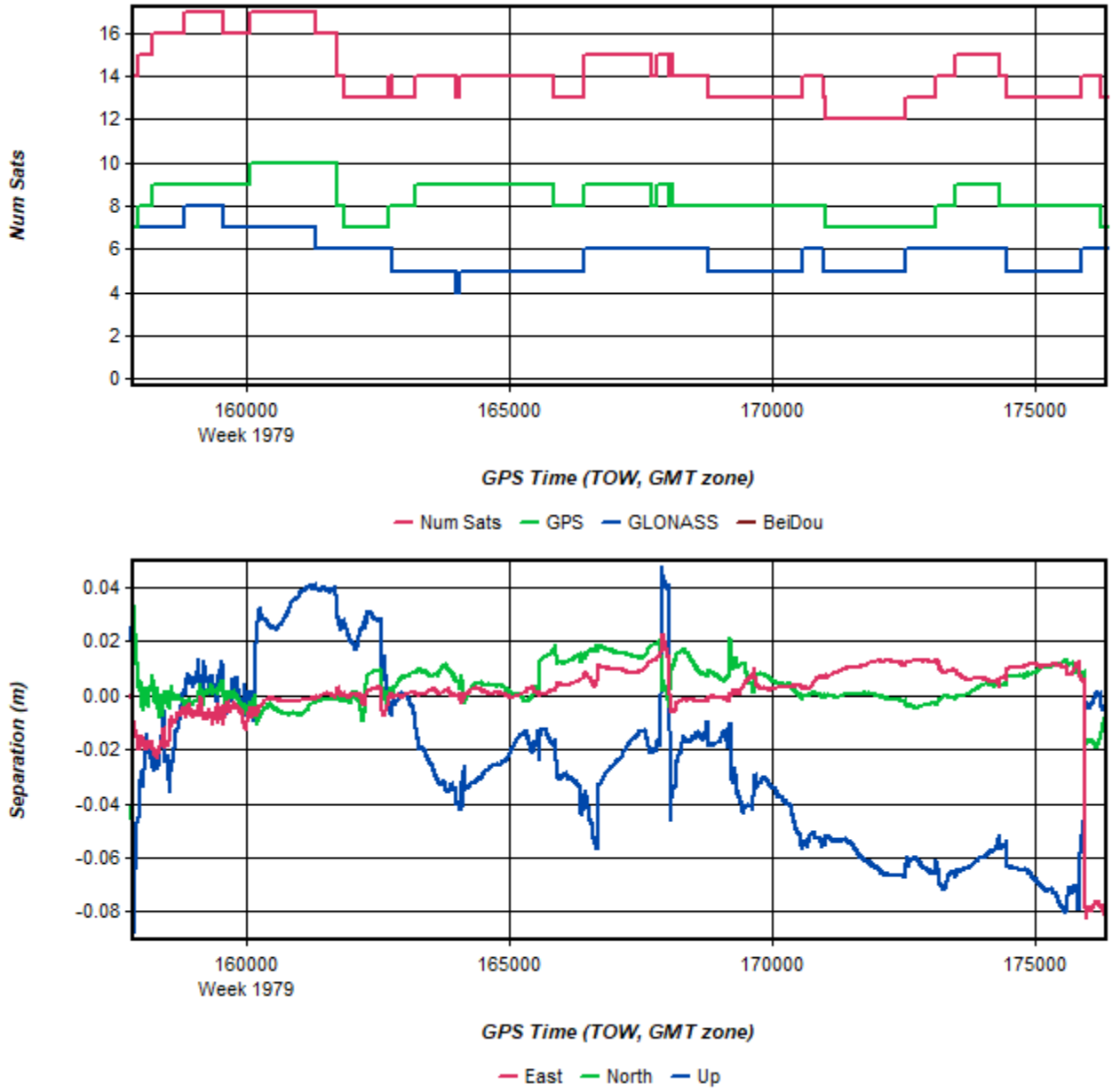

Separation (m)
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
138000
Week 1979
140000
142000
144000
146000
148000
GPS Time (TOW, GMT zone)
East
North
Up

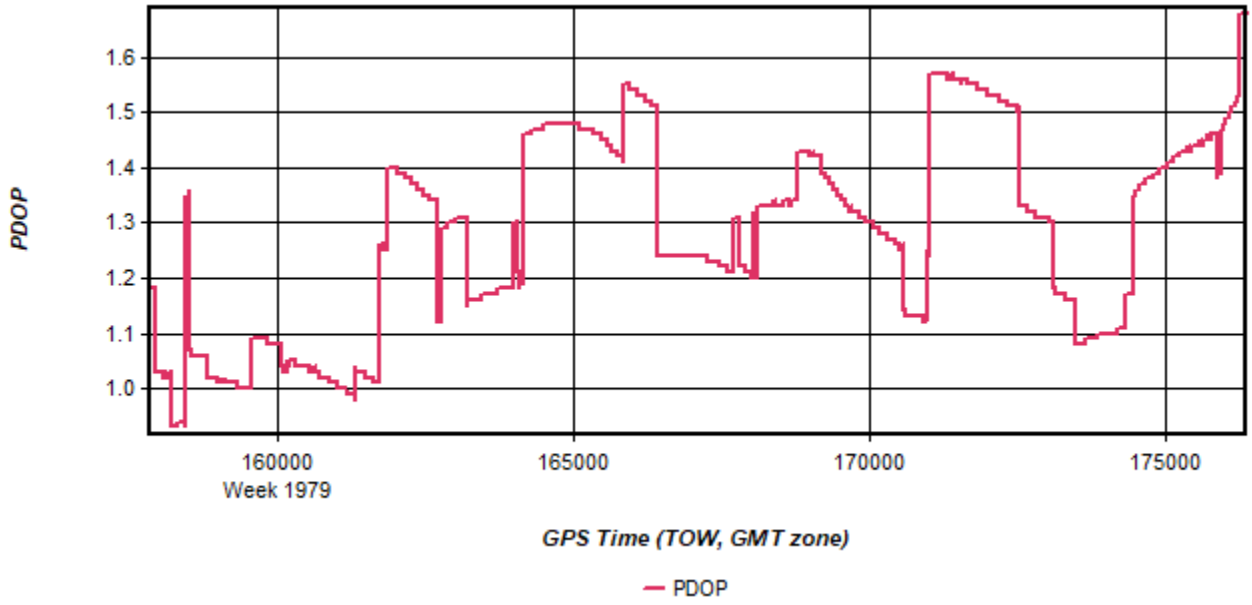

PDOP
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
138000
Week 1979
140000
142000
144000
146000
148000
GPS Time (TOW, GMT zone)
PDOP

225_20171211_2

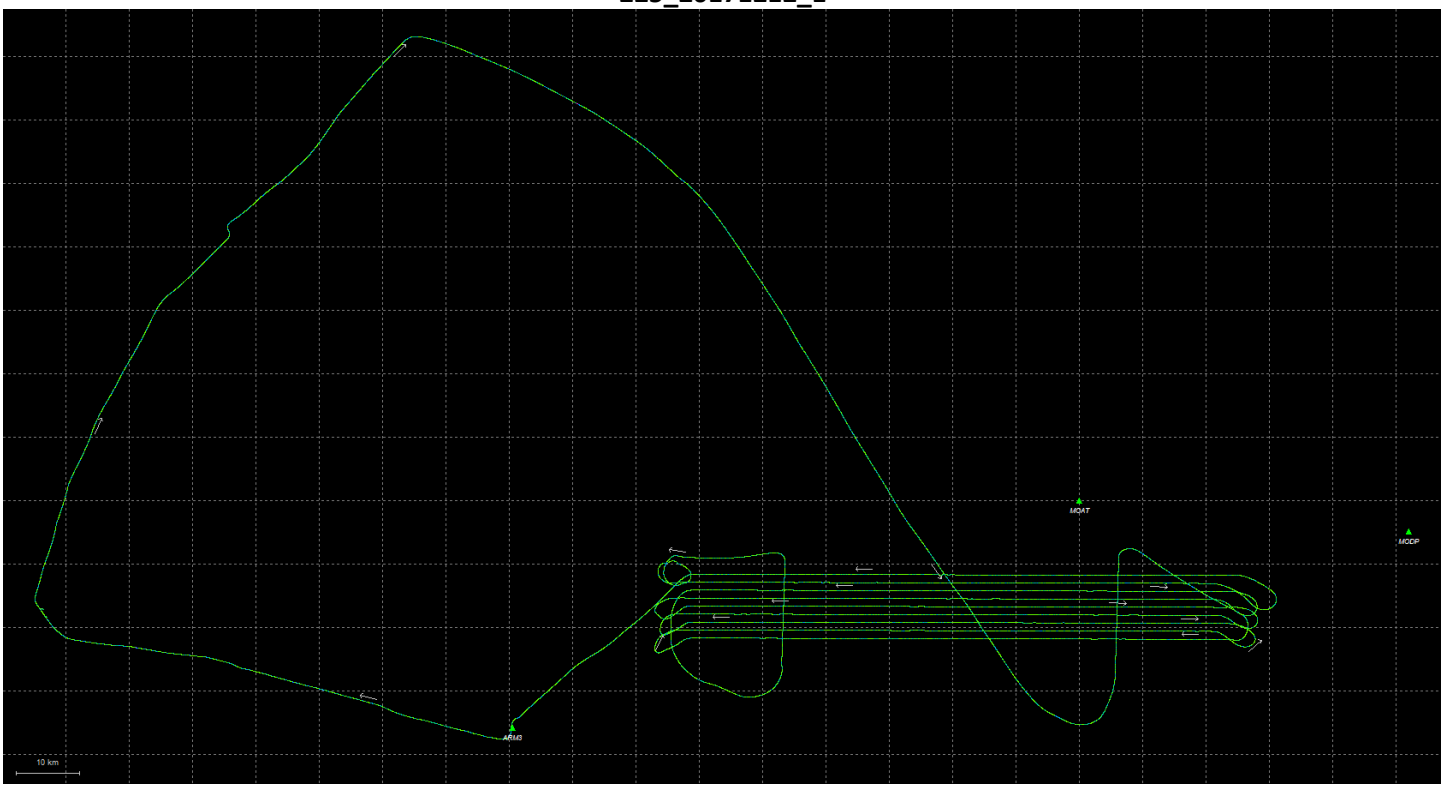


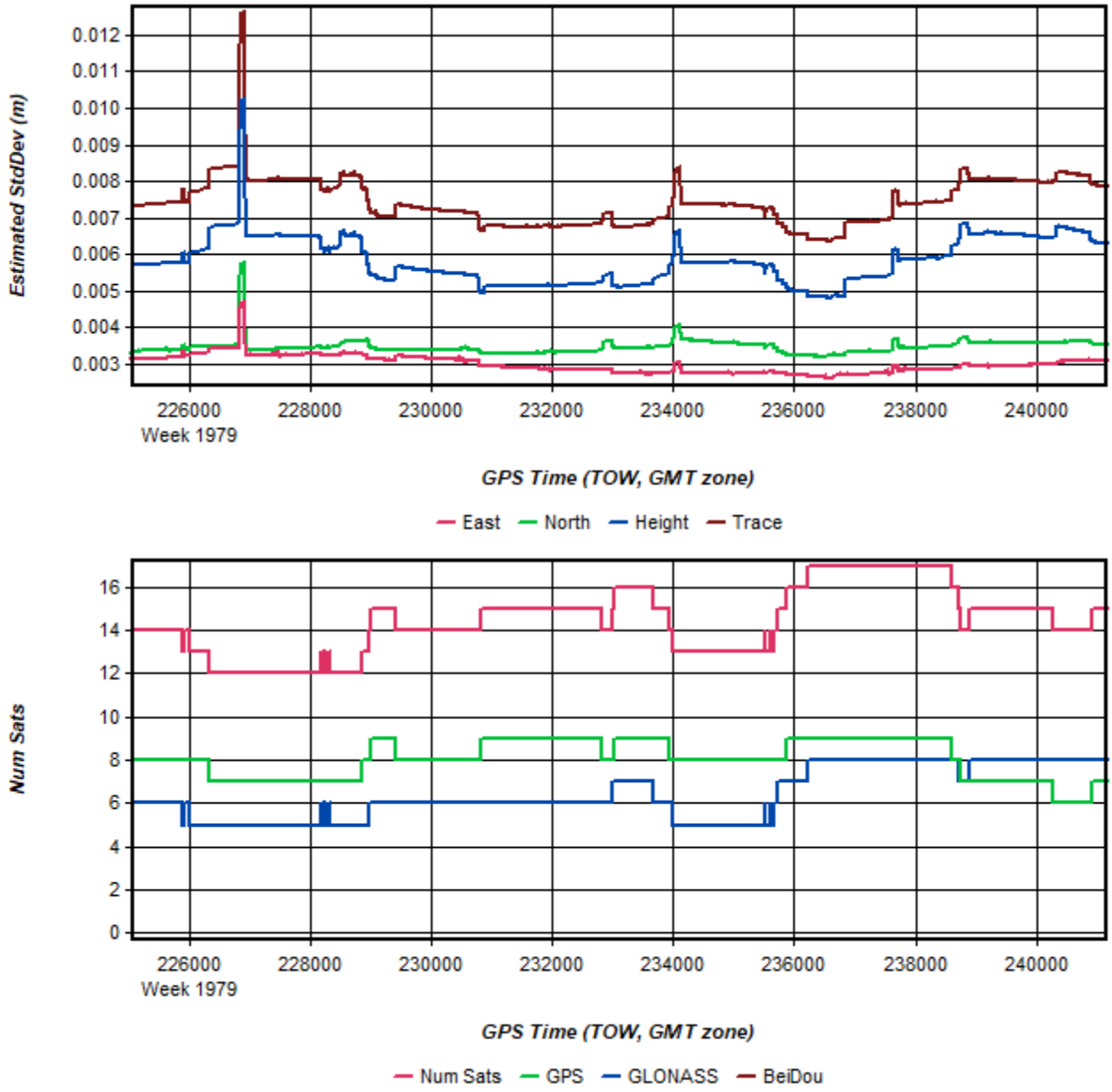


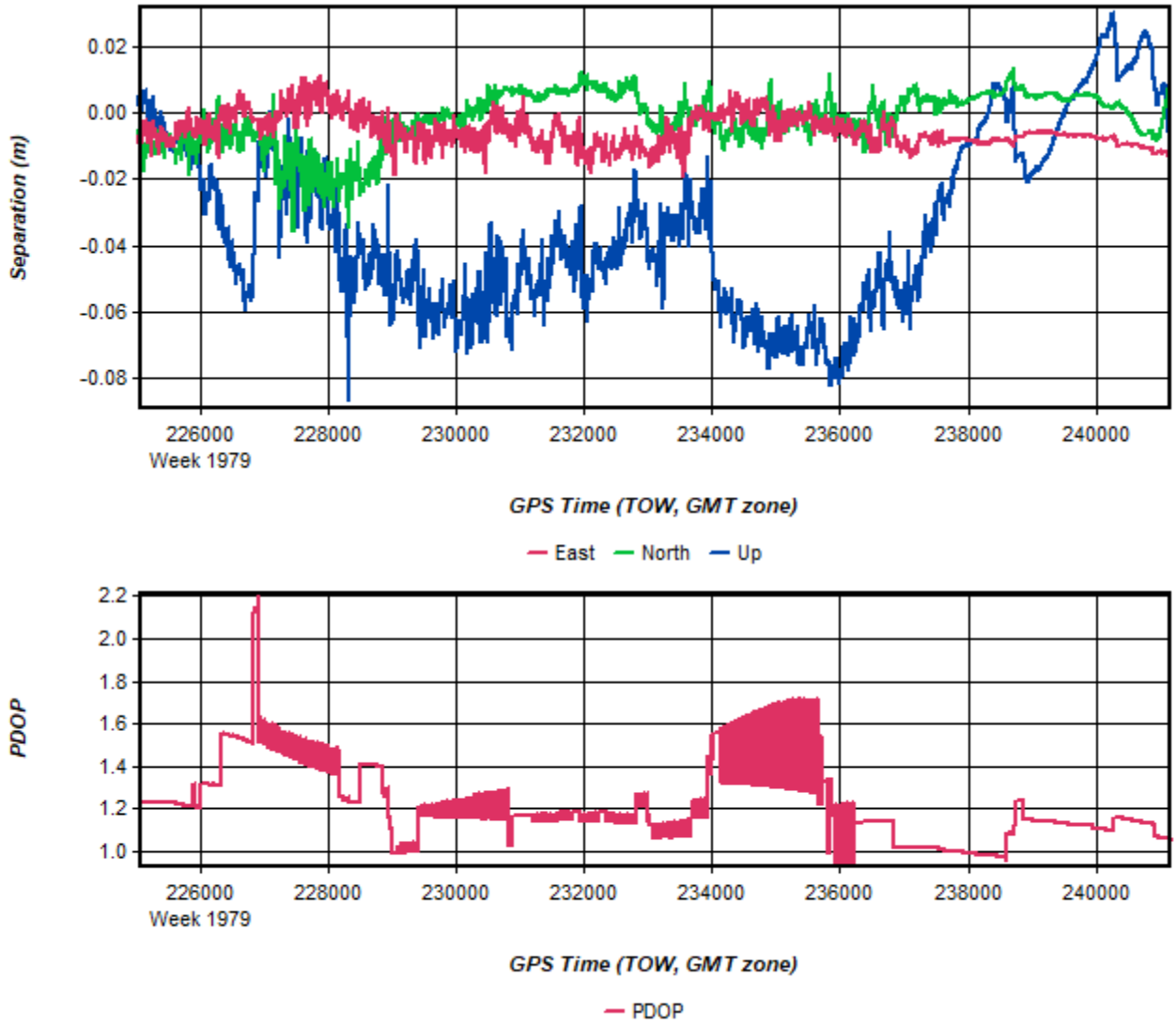

Num Sats
16
14
12
10
8
6
4
2
0
160000
Week 1979
165000
170000
175000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Separation (m)
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
160000
Week 1979
165000
170000
175000
GPS Time (TOW, GMT zone)
East
North
Up



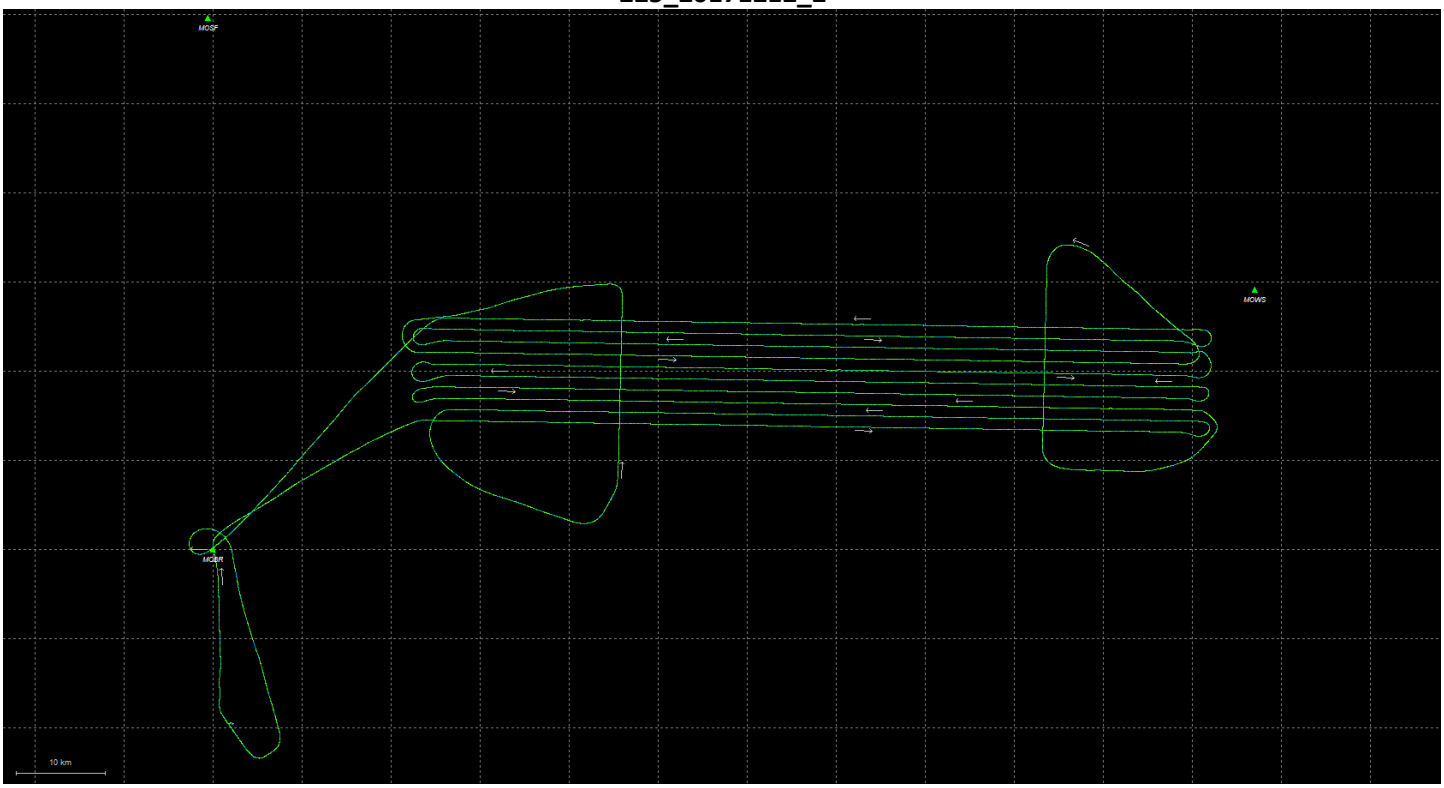
225_20171212_1

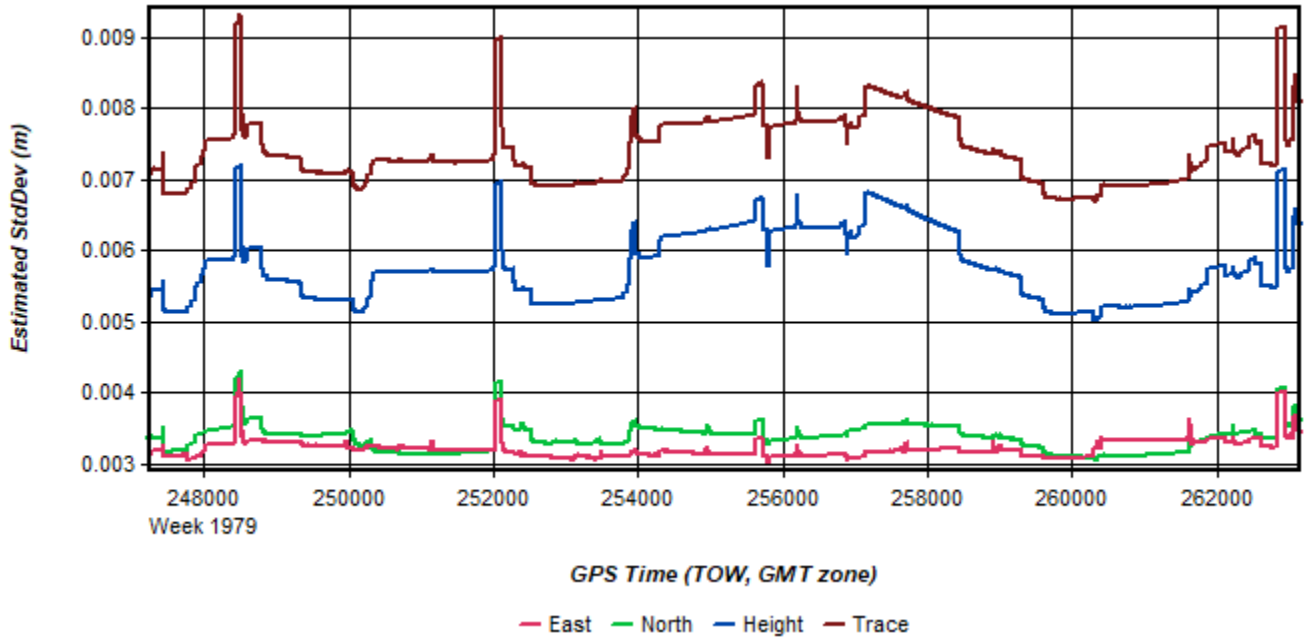


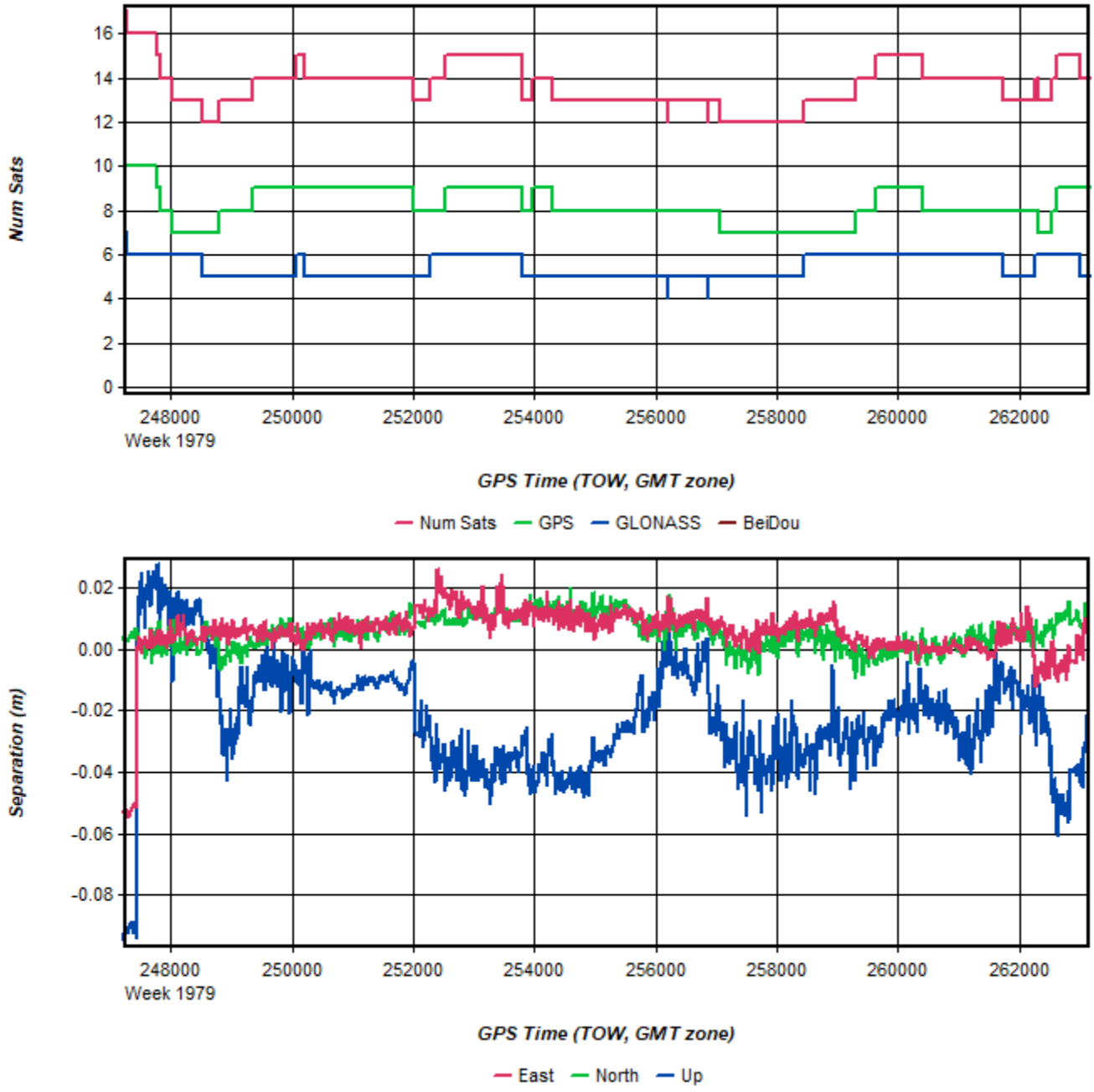

Estimated StdDev (m)
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
226000
Week 1979
228000
230000
232000
234000
236000
238000
240000
GPS Time (TOW, GMT zone)
East
North
Height
Trace
Num Sats
16
14
12
10
8
6
4
2
0
226000
Week 1979
228000
230000
232000
234000
236000
238000
240000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

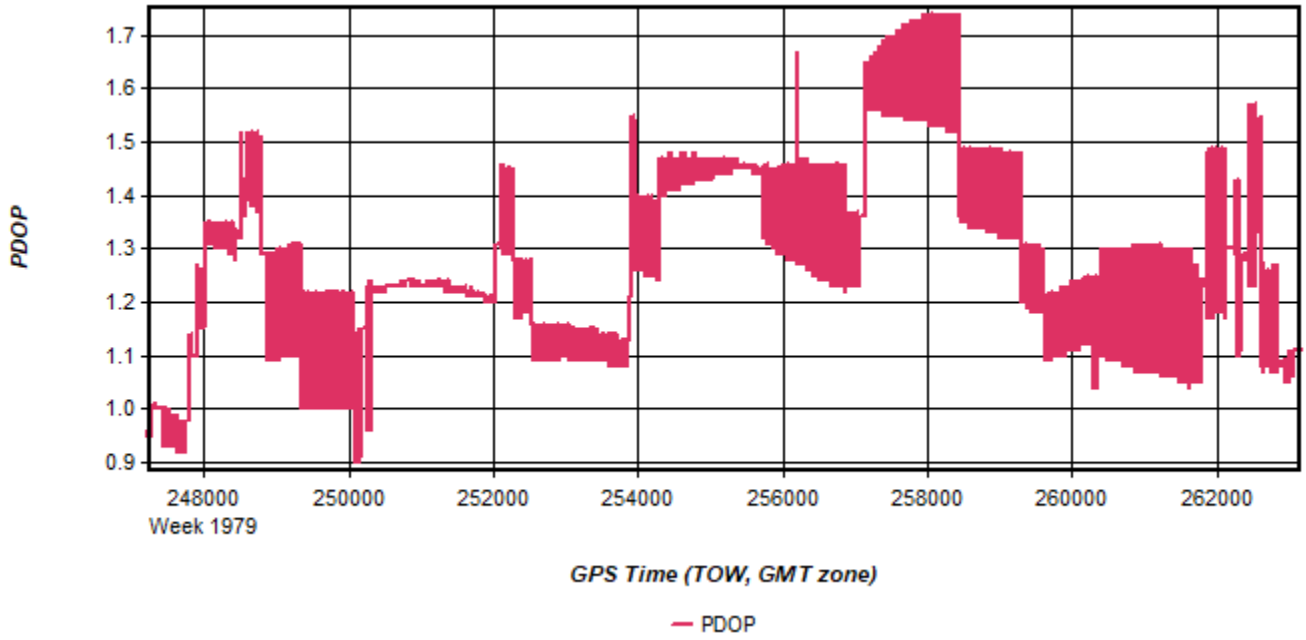

Separation (m)
0.02
0.00
-0.02
-0.04
-0.06
-0.08
226000
228000
230000
232000
234000
236000
238000
240000
Week 1979
GPS Time (TOW, GMT zone)
East
North
Up
PDOP
2.2
2.0
1.8
1.6
1.4
1.2
1.0
226000
228000
230000
232000
234000
236000
238000
240000
Week 1979
GPS Time (TOW, GMT zone)
PDOP

225_20171212_2

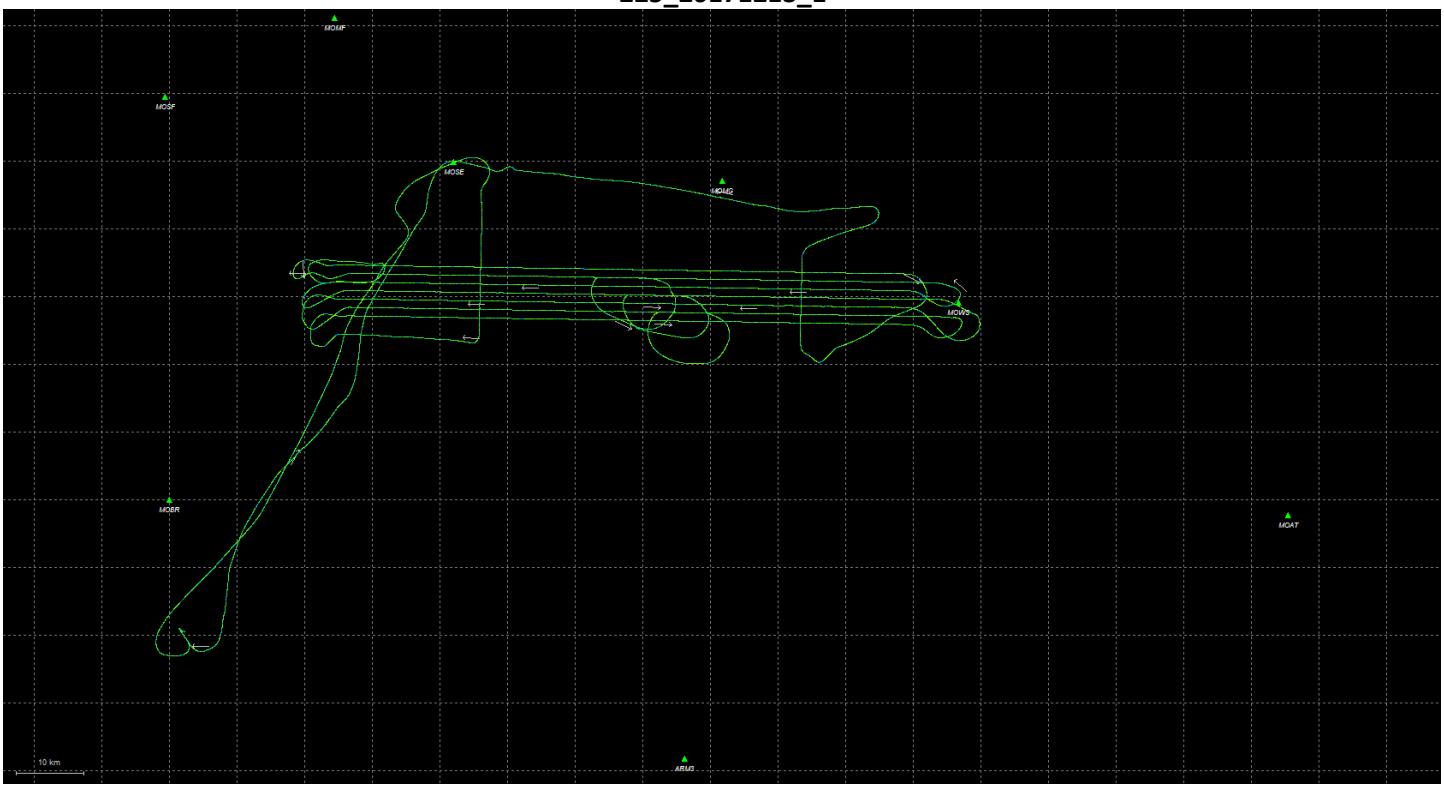


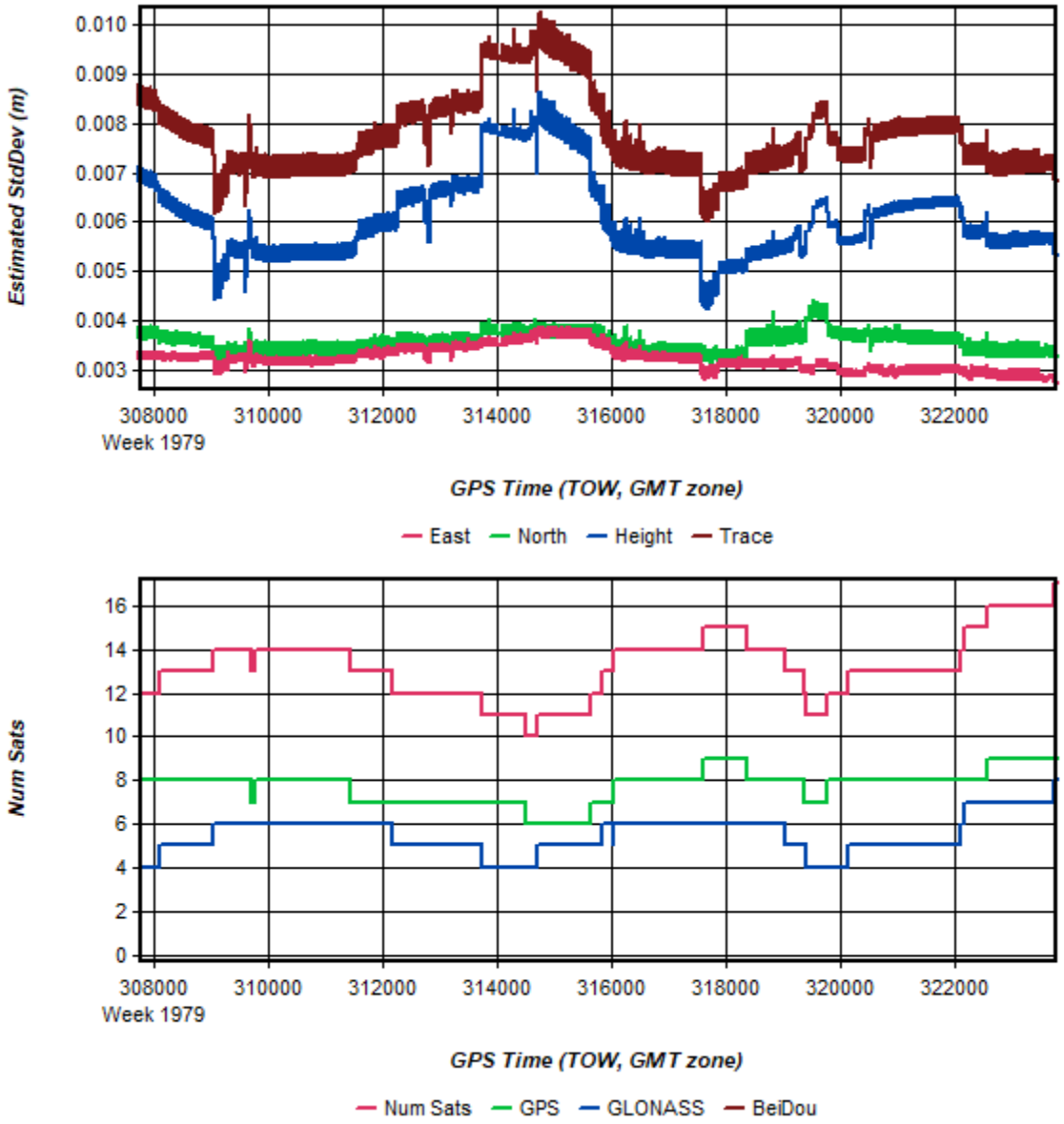


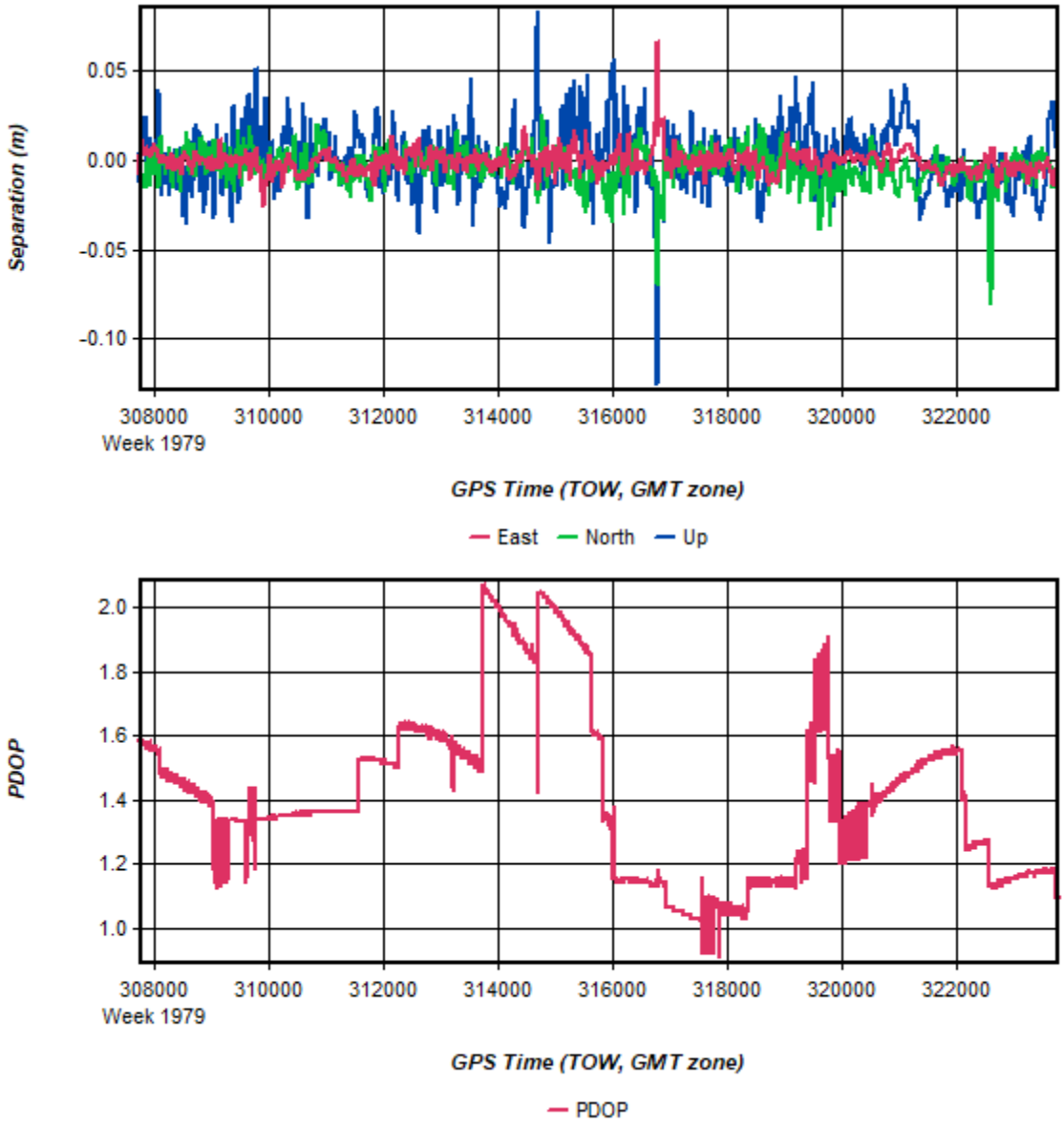

Num Sats
16
14
12
10
8
6
4
2
0
248000
250000
252000
254000
256000
258000
260000
262000
Week 1979
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Separation (m)
0.02
0.00
-0.02
-0.04
-0.06
-0.08
248000
250000
252000
254000
256000
258000
260000
262000
Week 1979
GPS Time (TOW, GMT zone)
East
North
Up



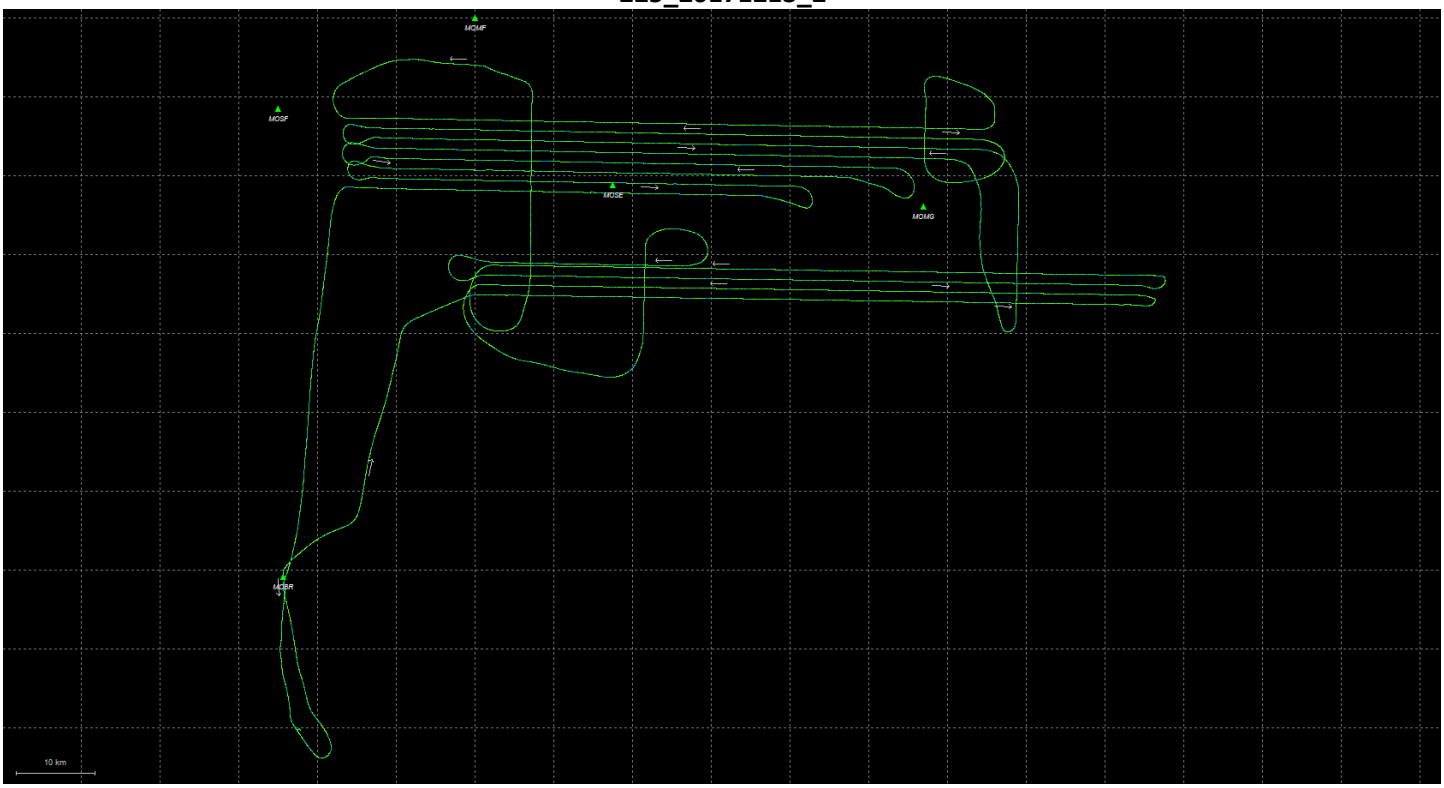
225_20171213_1

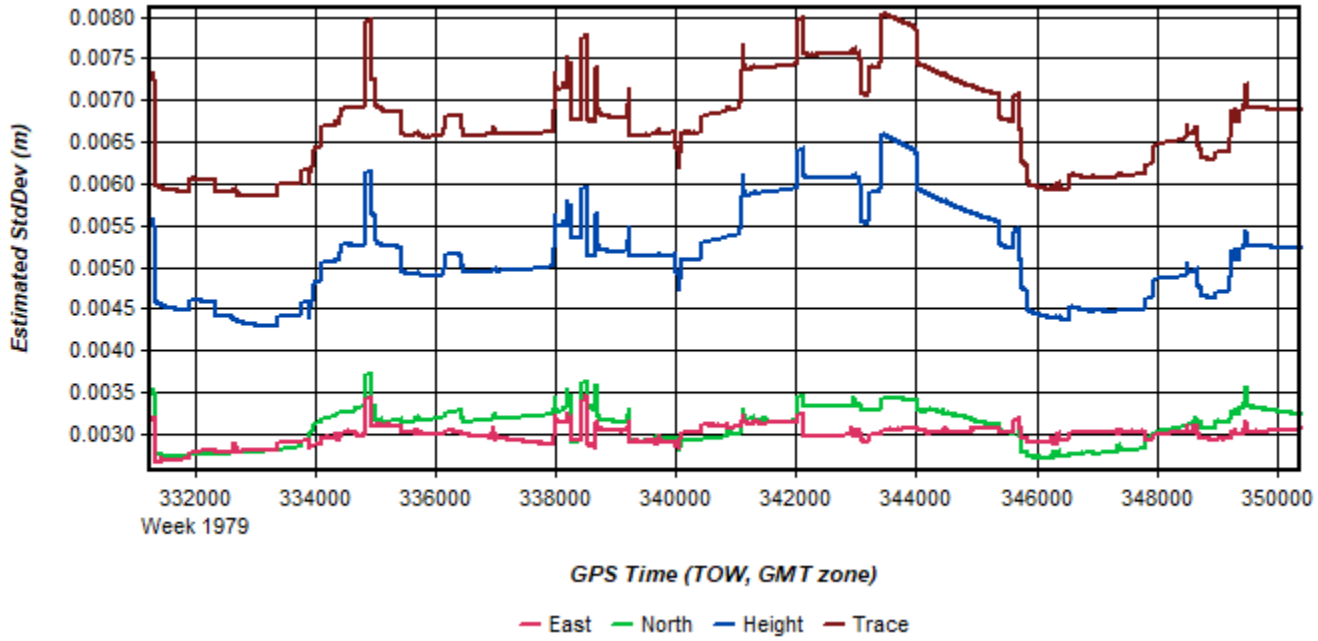


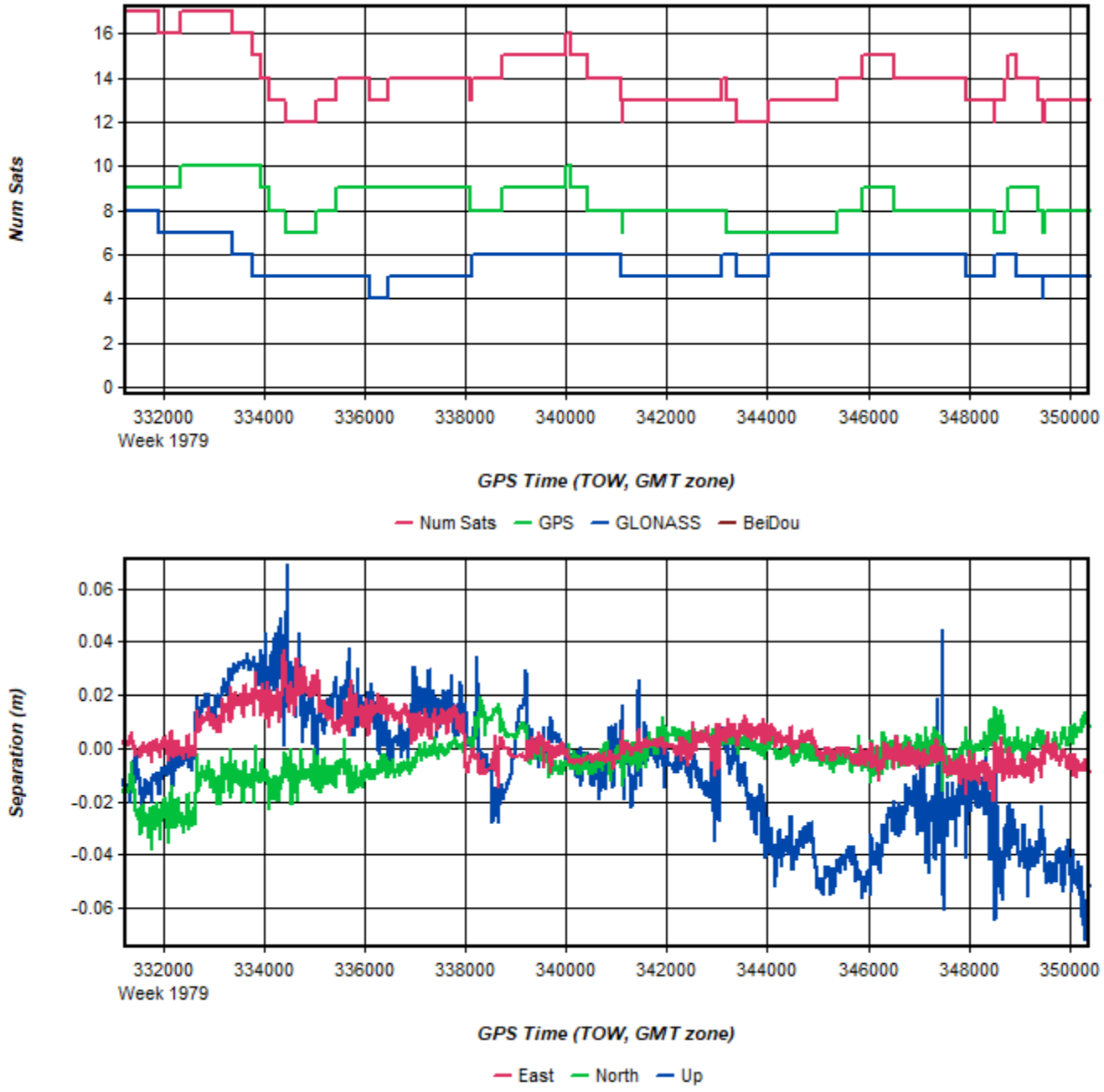

Estimated StdDev (m)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
308000
310000
312000
314000
316000
318000
320000
322000
Week 1979
GPS Time (TOW, GMT zone)
East
North
Height
Trace
Num Sats
16
14
12
10
8
6
4
2
0
308000
310000
312000
314000
316000
318000
320000
322000
Week 1979
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

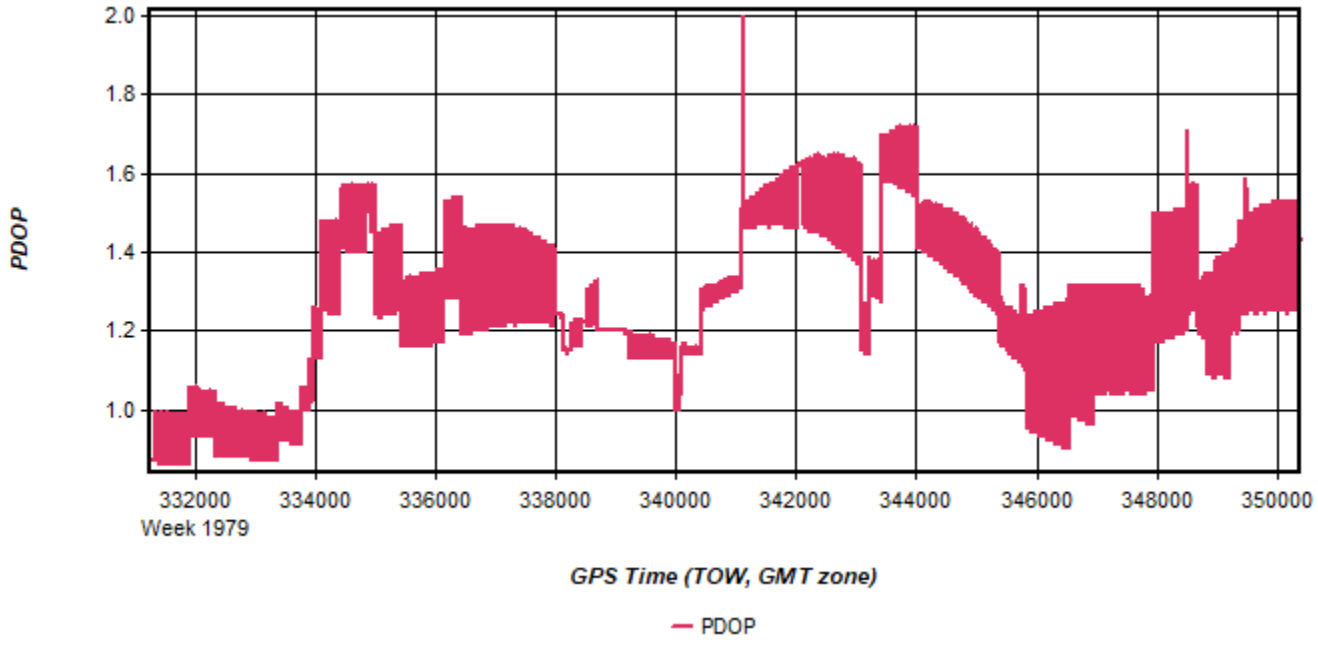

Separation (m)
0.05
0.00
-0.05
-0.10
308000
310000
312000
314000
316000
318000
320000
322000
Week 1979
GPS Time (TOW, GMT zone)
East
North
Up
PDOP
2.0
1.8
1.6
1.4
1.2
1.0
308000
310000
312000
314000
316000
318000
320000
322000
Week 1979
GPS Time (TOW, GMT zone)
PDOP

225_20171213_2

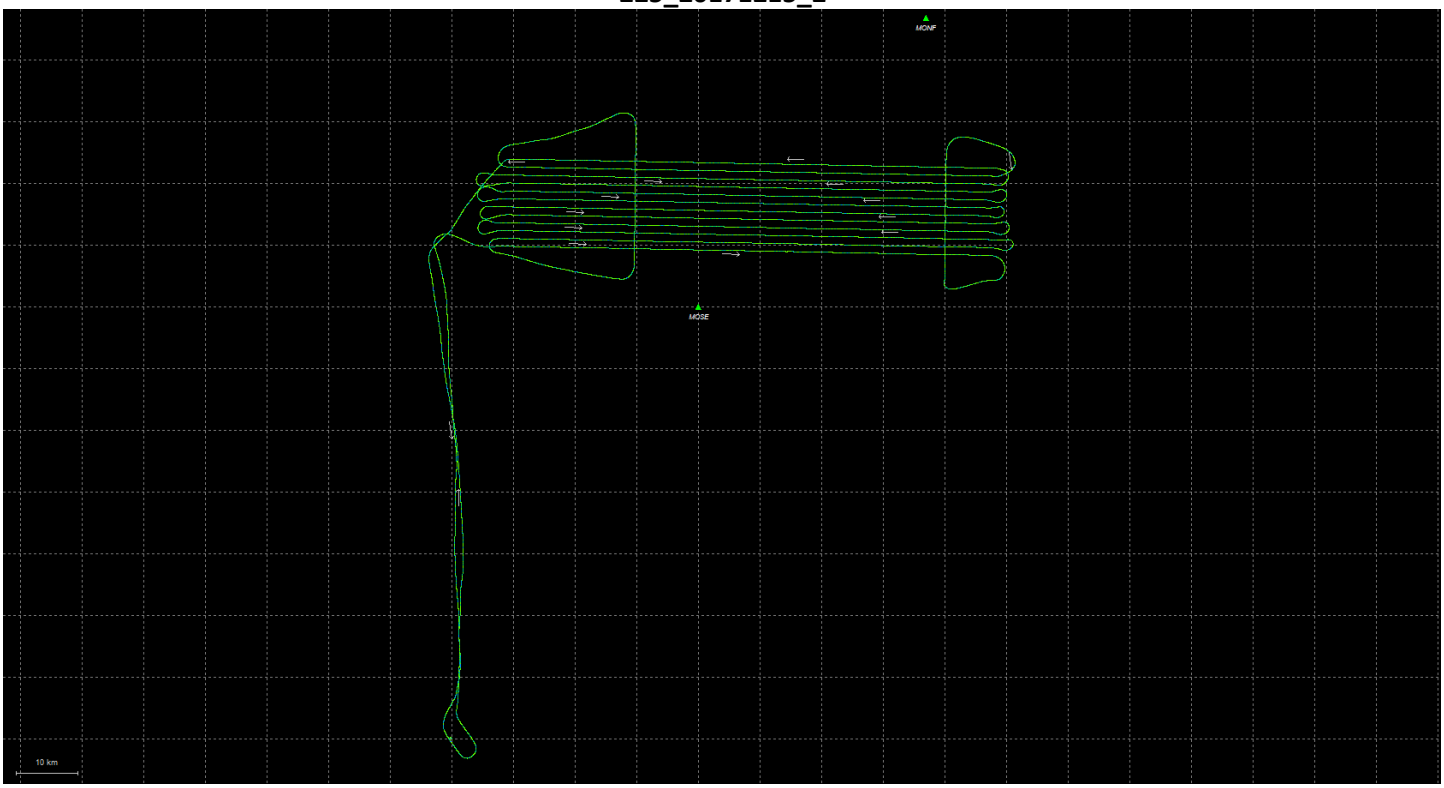


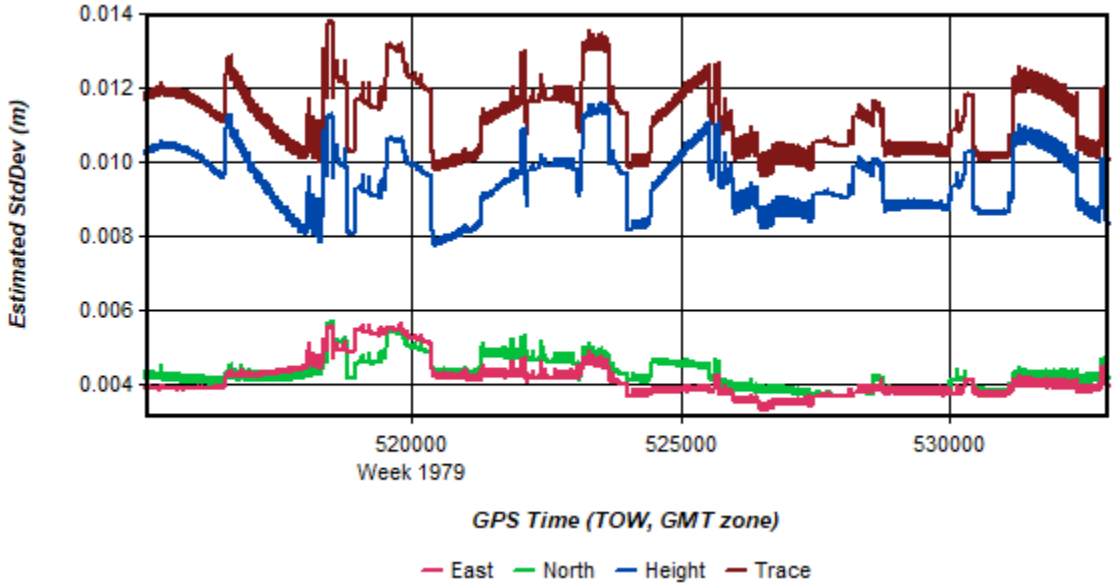


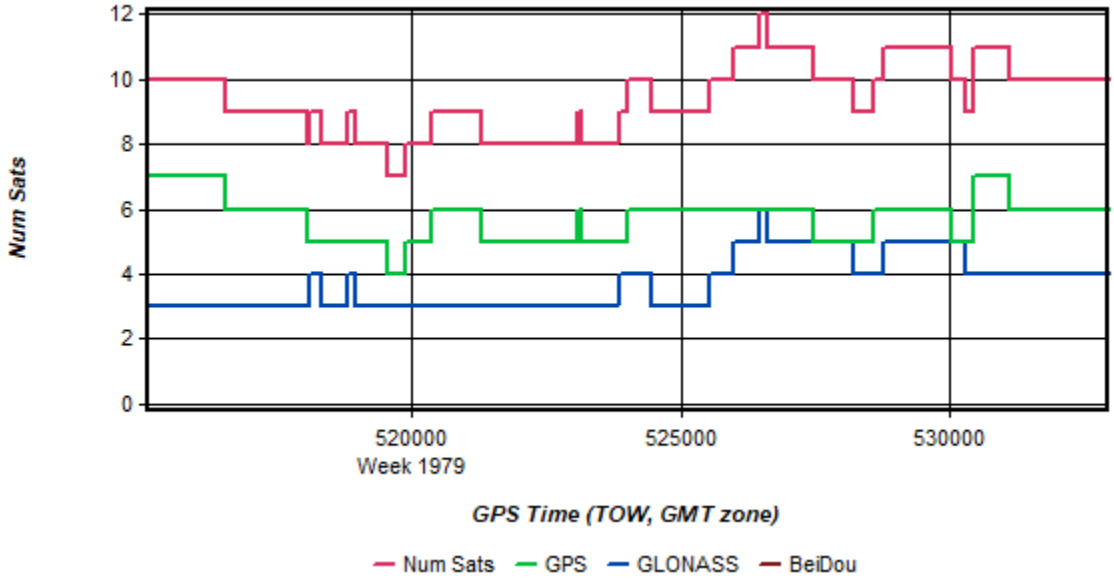

Num Sats
16
14
12
10
8
6
4
2
0
332000
334000
336000
338000
340000
342000
344000
346000
348000
350000
Week 1979
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Separation (m)
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
East
North
Up

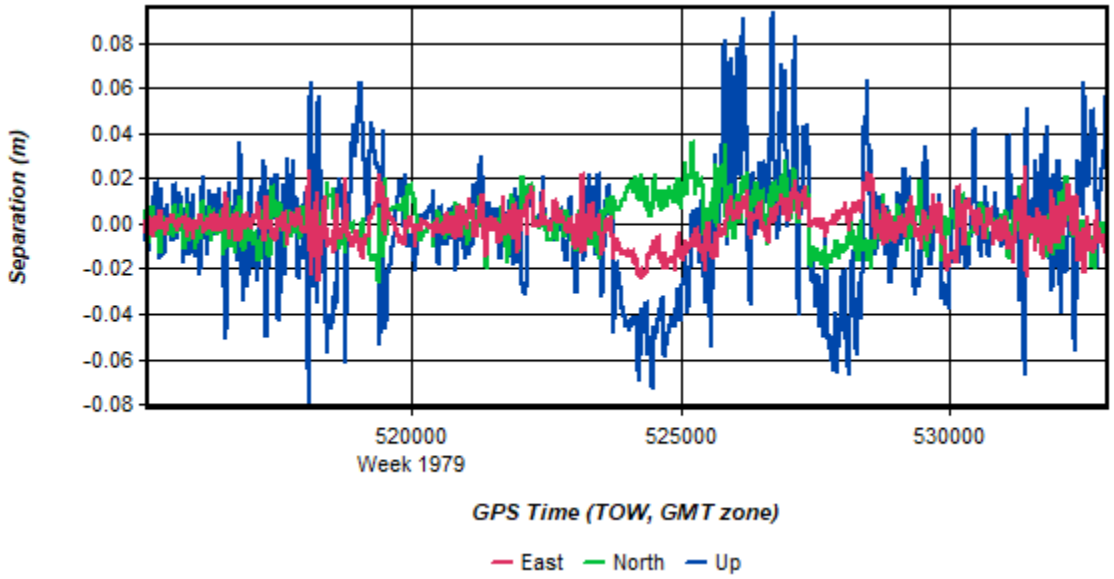


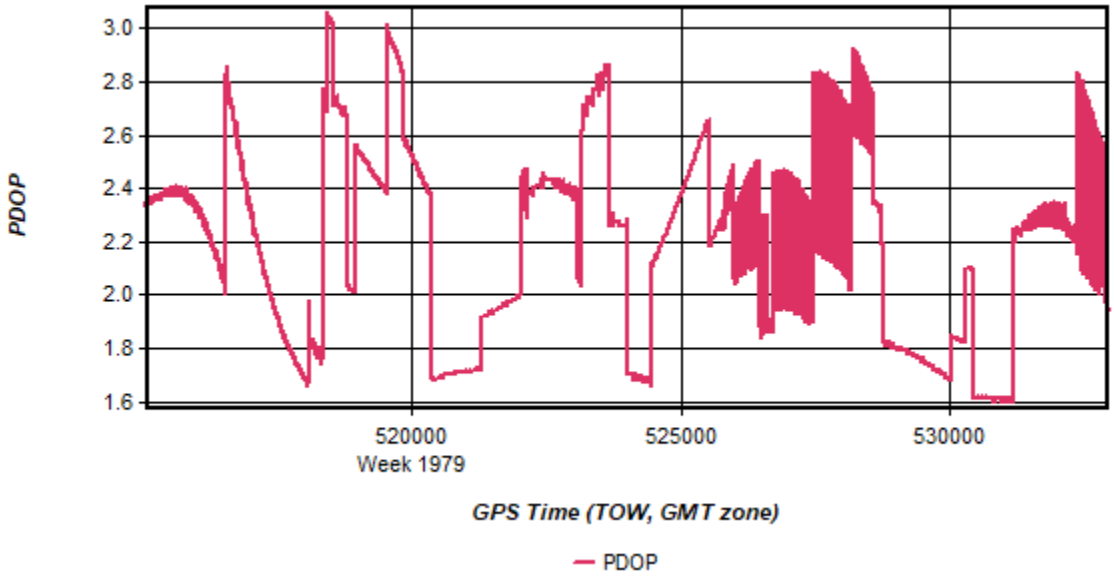
225_20171215_2



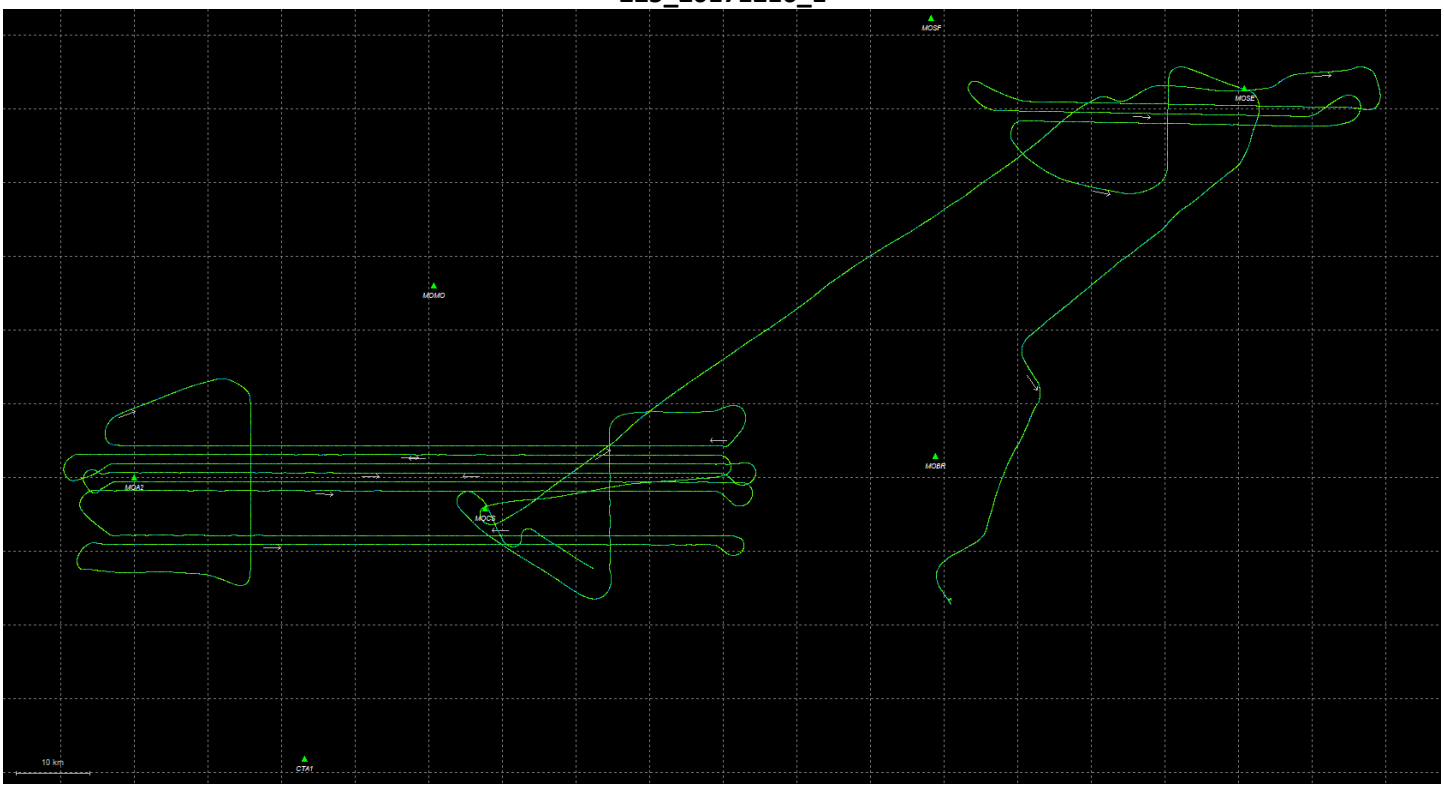

Estimated StdDev (m)
0.014
0.012
0.010
0.008
0.006
0.004
520000
Week 1979
525000
530000
GPS Time (TOW, GMT zone)
East
North
Height
Trace

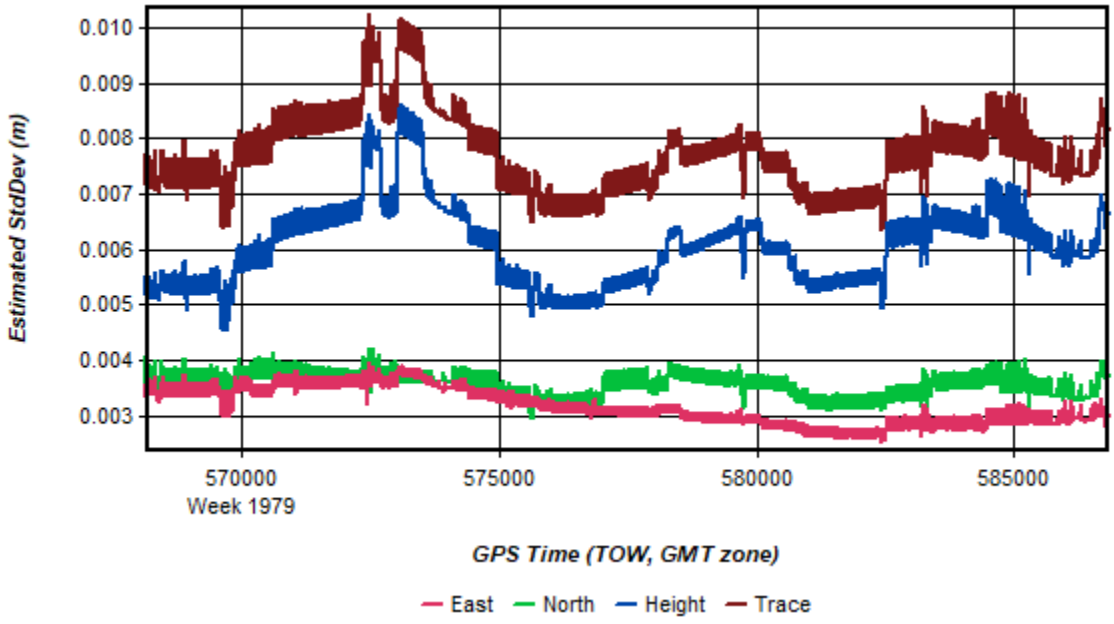

Num Sats
12
10
8
6
4
2
0
520000
Week 1979
525000
530000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

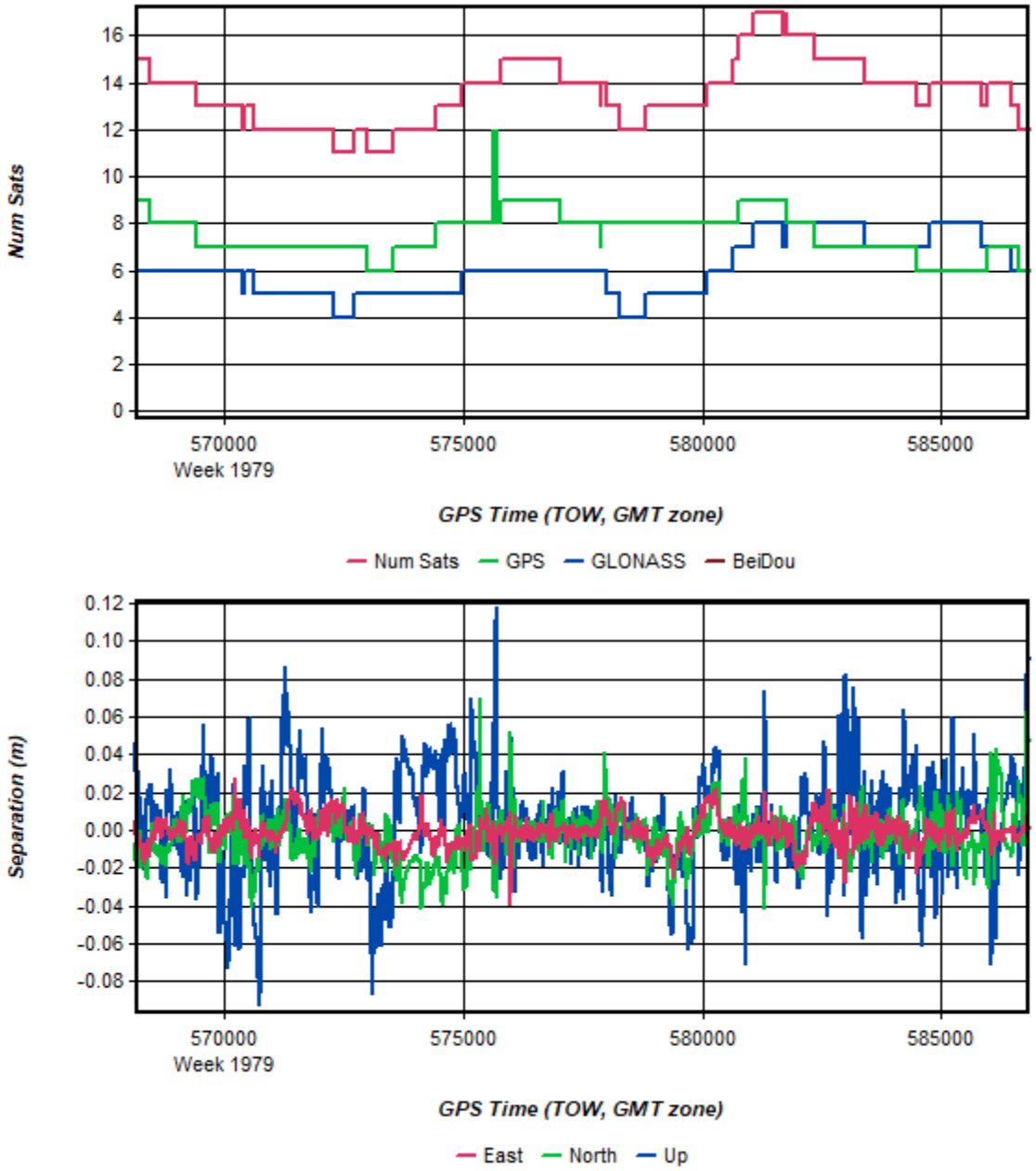

Separation (m)
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
520000
Week 1979
525000
530000
GPS Time (TOW, GMT zone)
East
North
Up

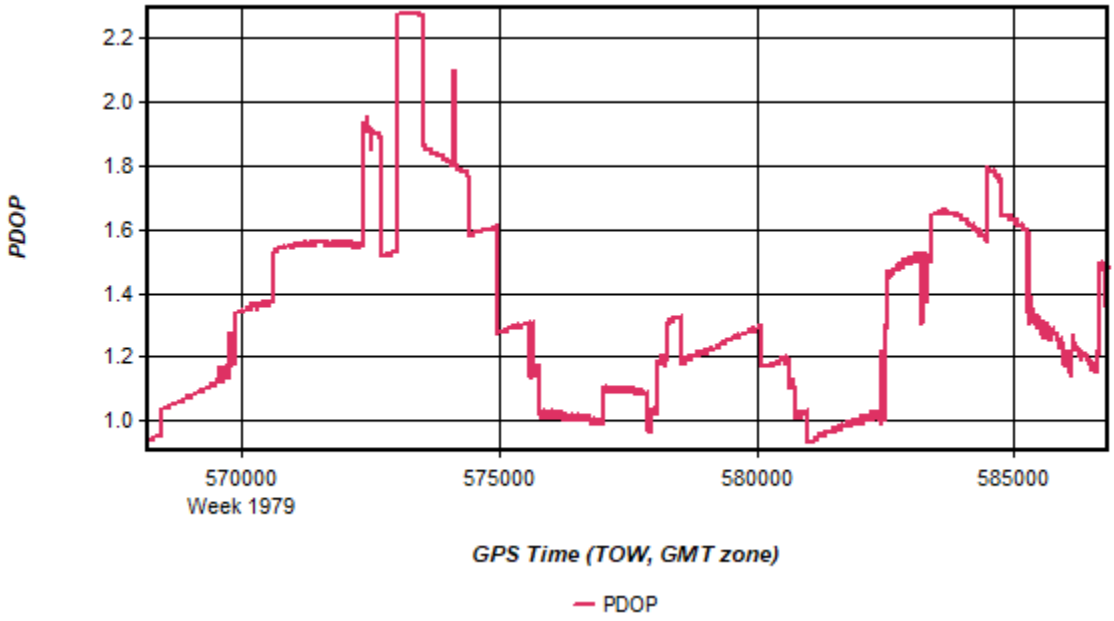

PDOP
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
520000
Week 1979
525000
530000
GPS Time (TOW, GMT zone)
PDOP

225_20171216_1

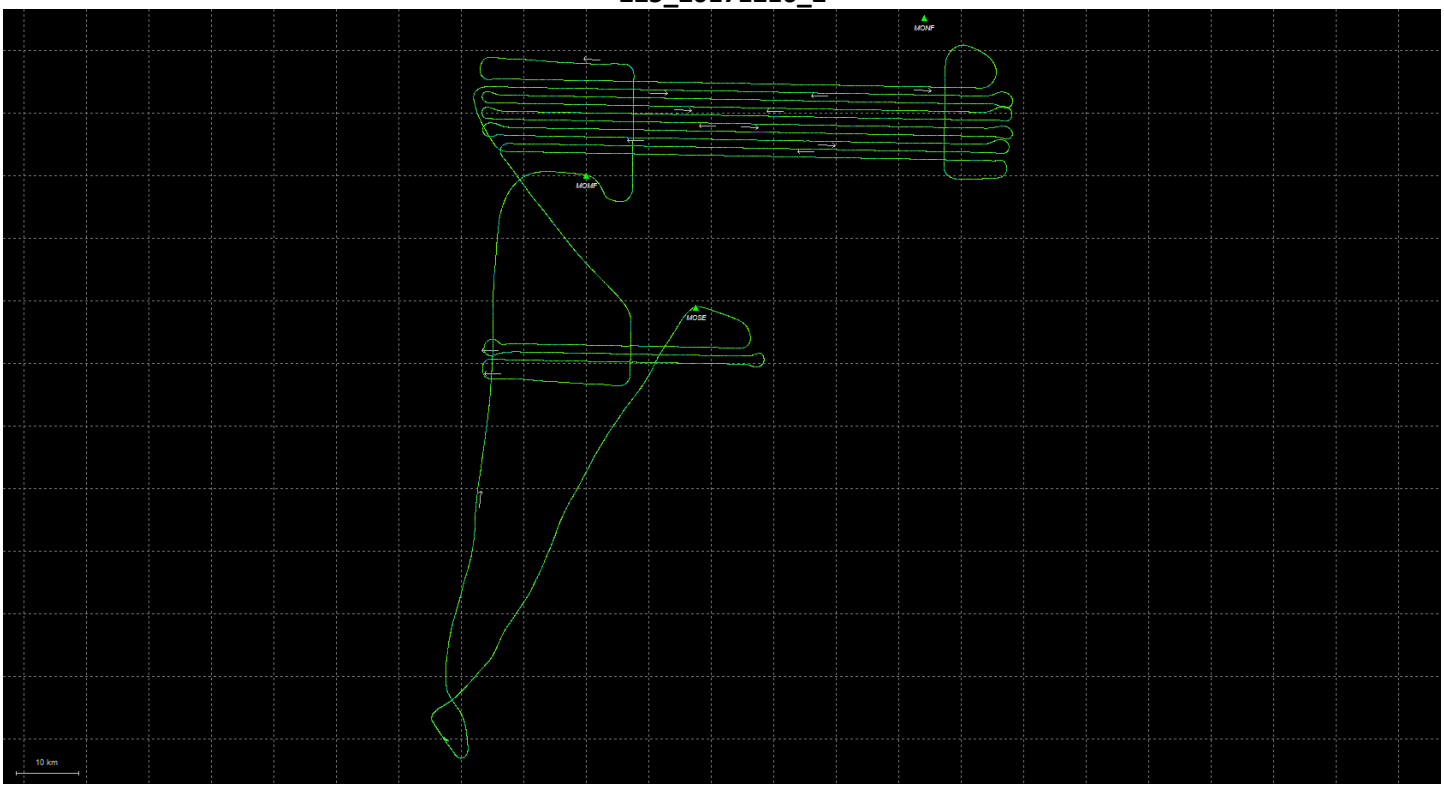


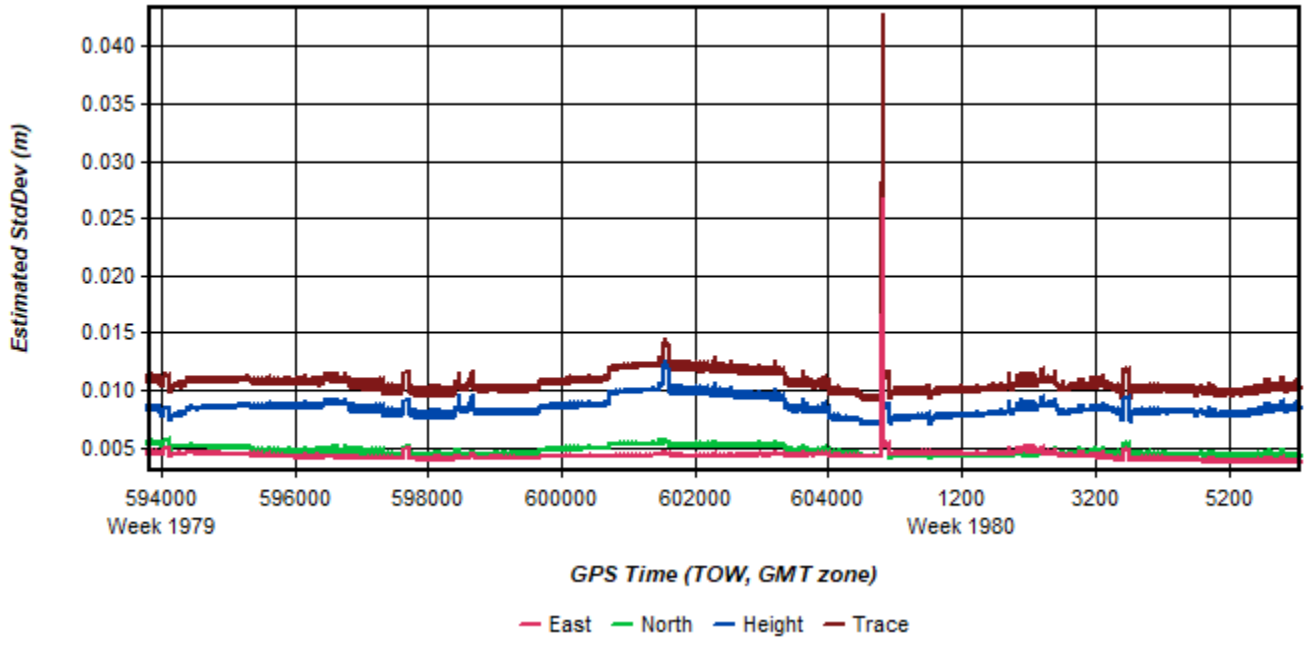


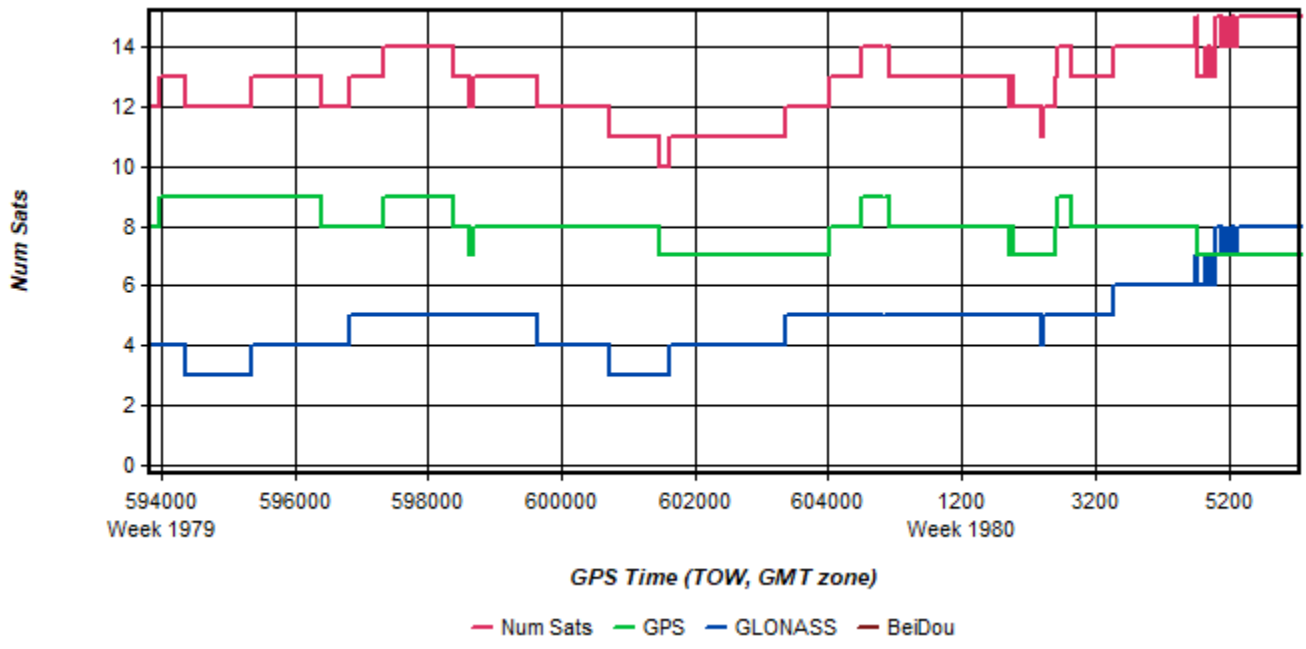

Num Sats
16
14
12
10
8
6
4
2
0
570000
Week 1979
575000
580000
585000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Separation (m)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
570000
Week 1979
575000
580000
585000
GPS Time (TOW, GMT zone)
East
North
Up

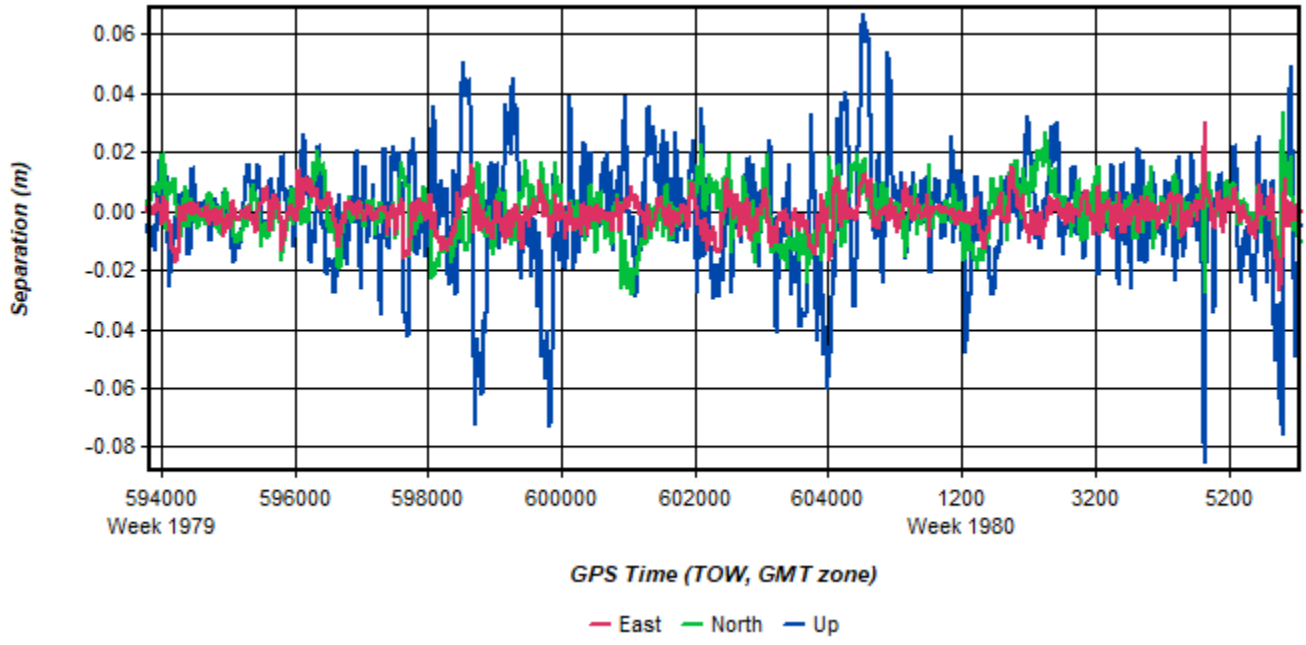


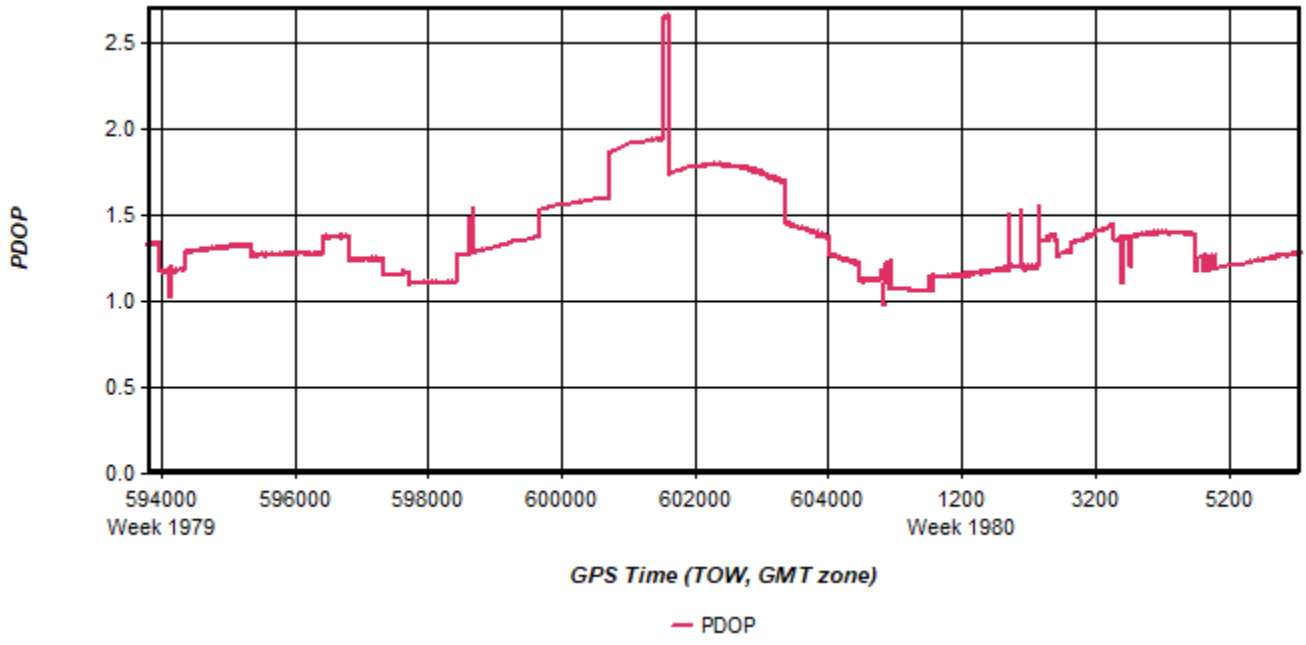
225_20171216_2



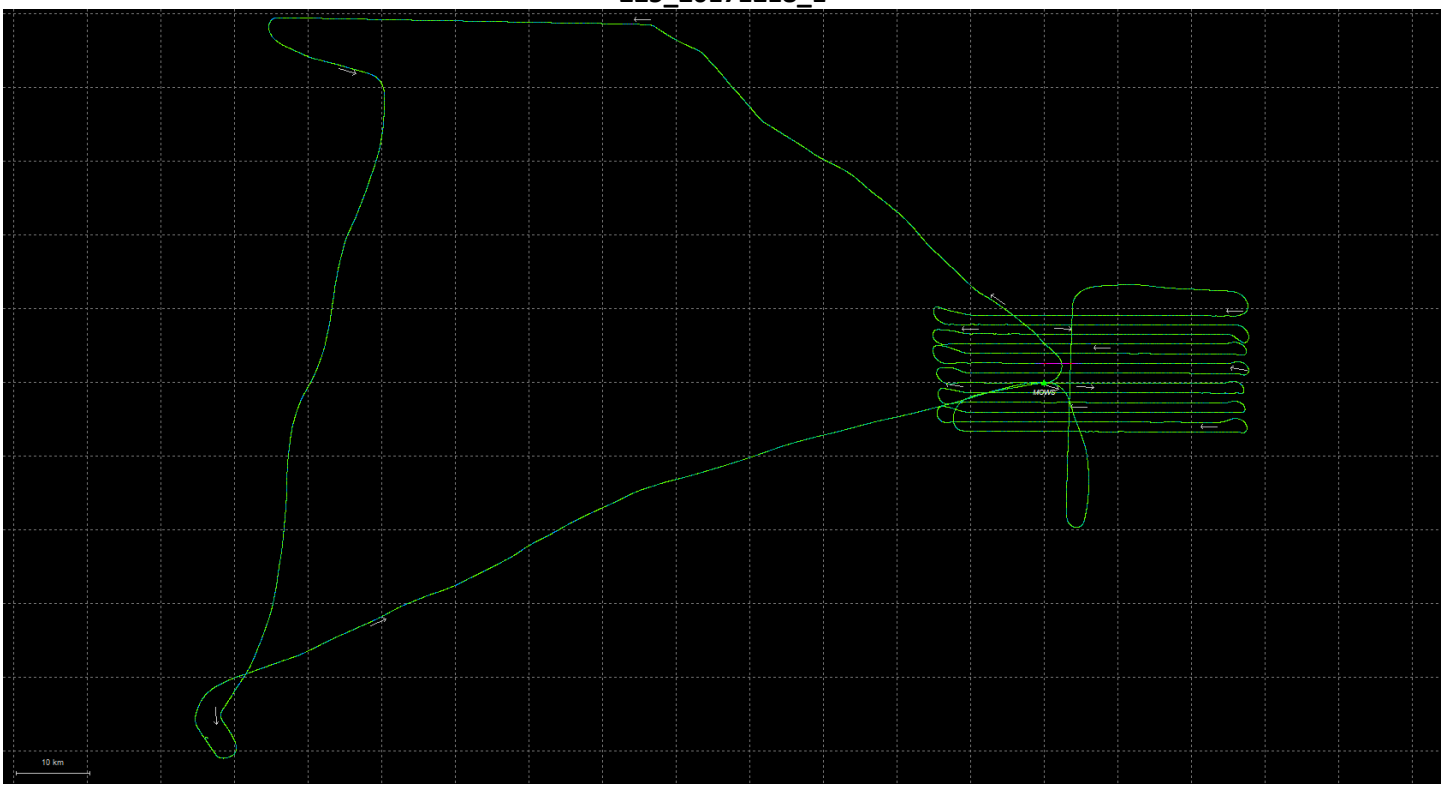

Estimated StdDev (m)
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
594000
596000
598000
600000
602000
604000
1200
3200
5200
Week 1979
Week 1980
GPS Time (TOW, GMT zone)
East
North
Height
Trace

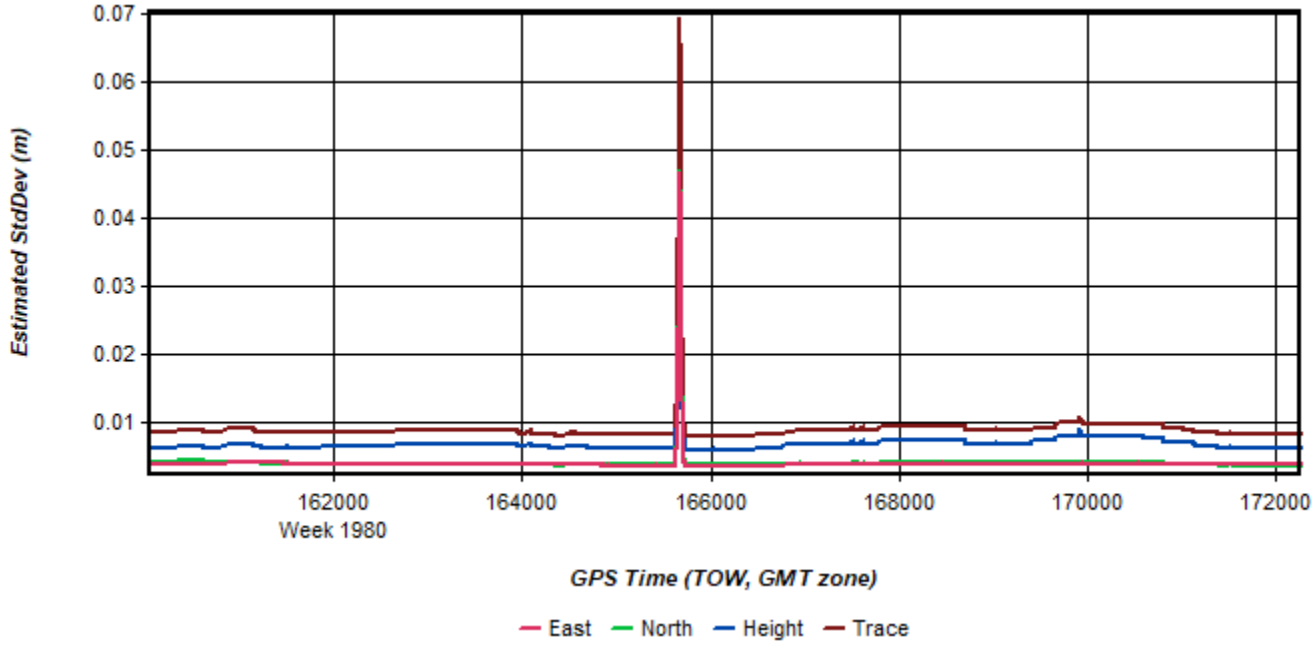

Num Sats
14
12
10
8
6
4
2
0
594000
596000
598000
600000
602000
604000
1200
3200
5200
Week 1979
Week 1980
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

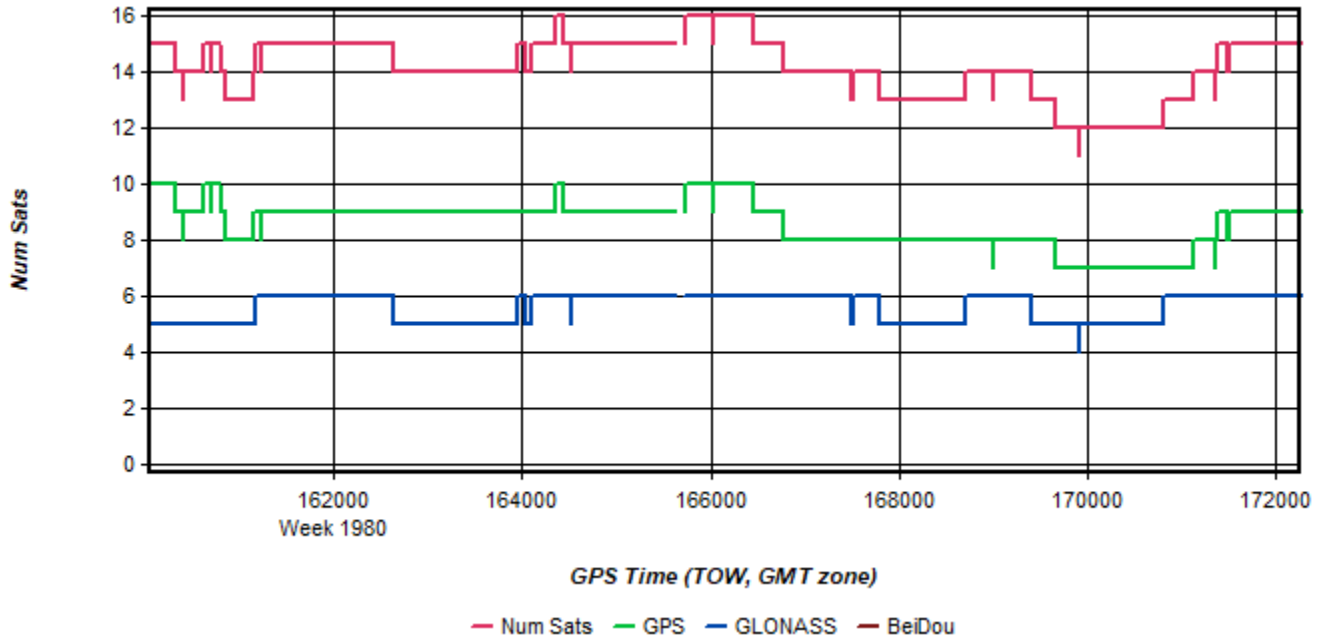

Separation (m)
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
594000
596000
598000
600000
602000
604000
1200
3200
5200
Week 1979
Week 1980
GPS Time (TOW, GMT zone)
East
North
Up

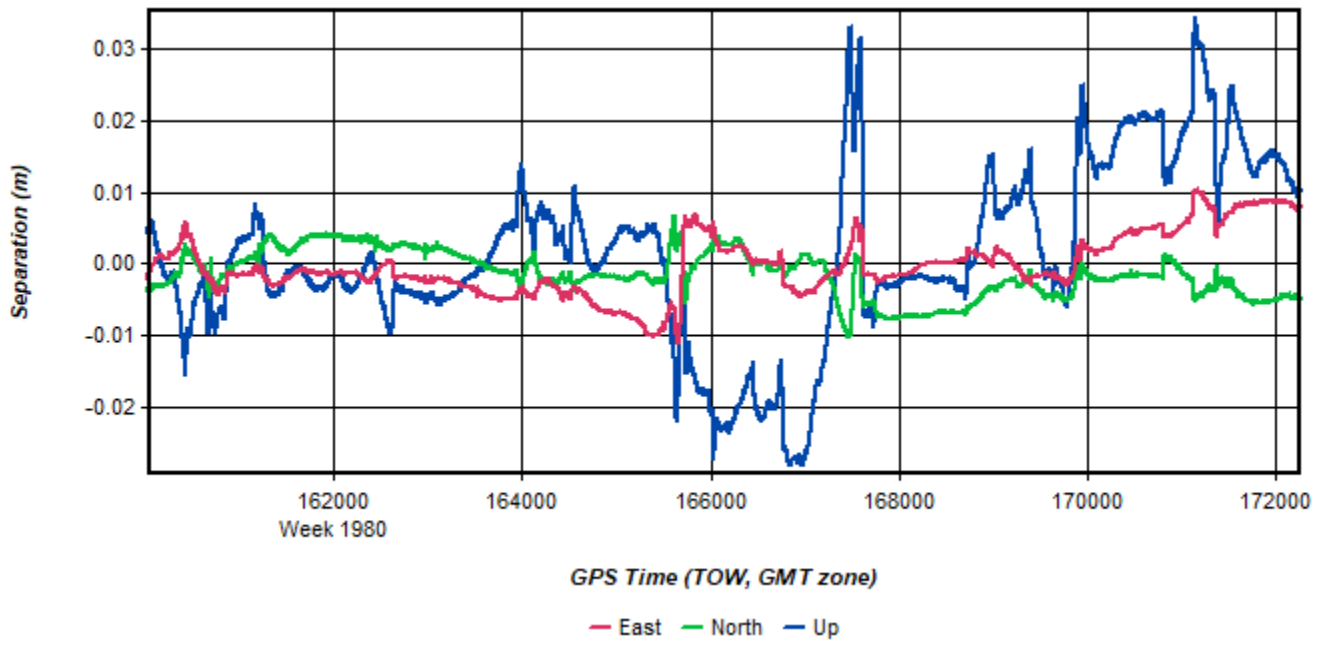

PDOP
2.5
2.0
1.5
1.0
0.5
0.0
594000
596000
598000
600000
602000
604000
1200
3200
5200
Week 1979
Week 1980
GPS Time (TOW, GMT zone)
PDOP

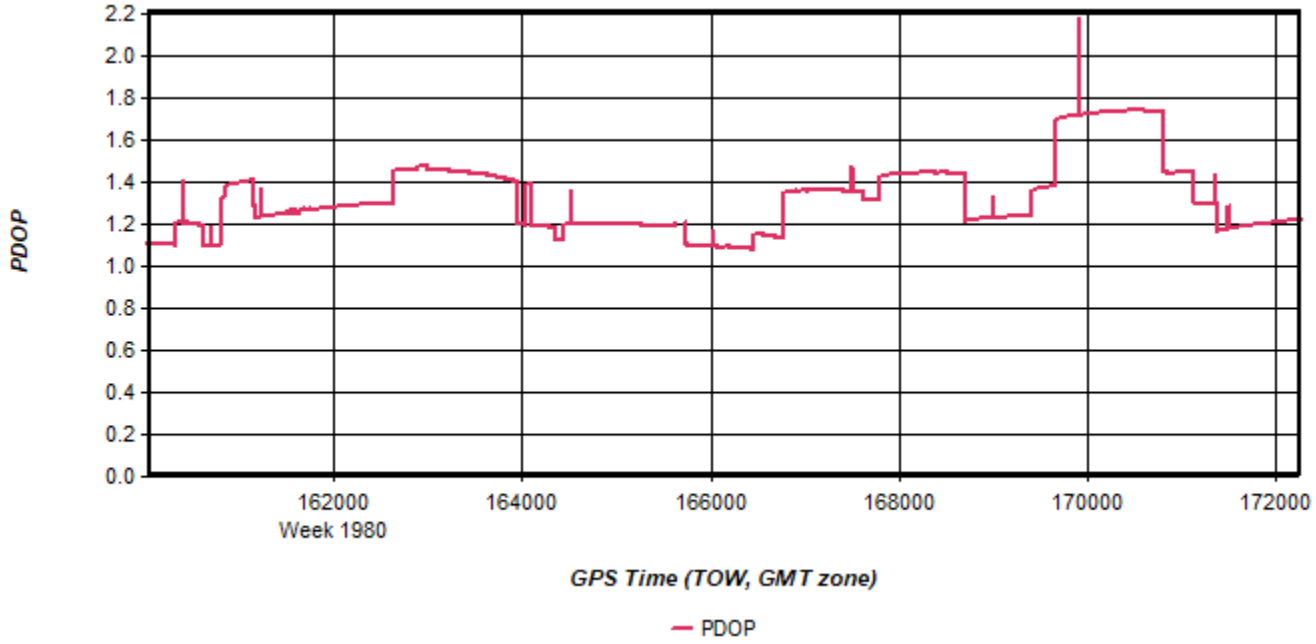
225_20171218_1



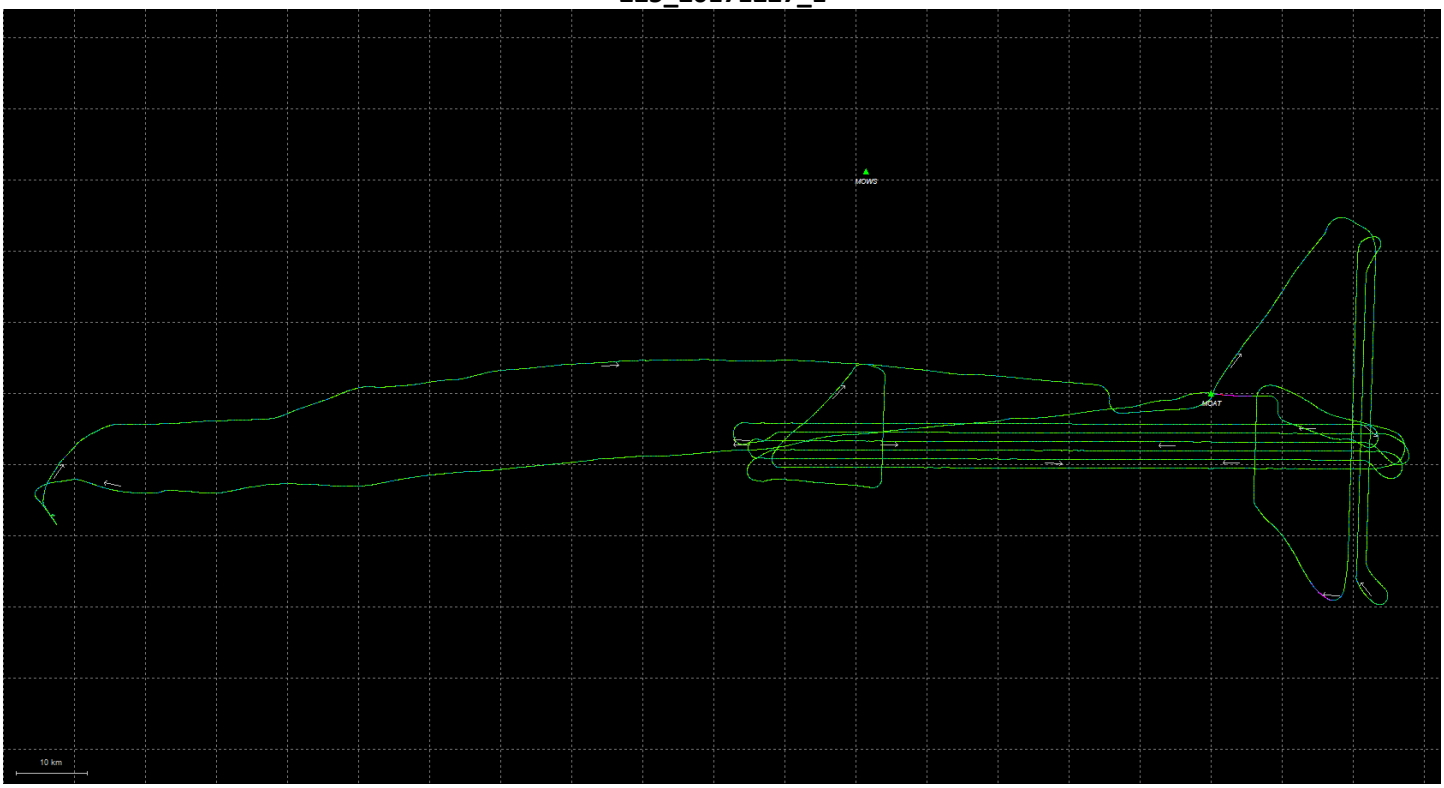


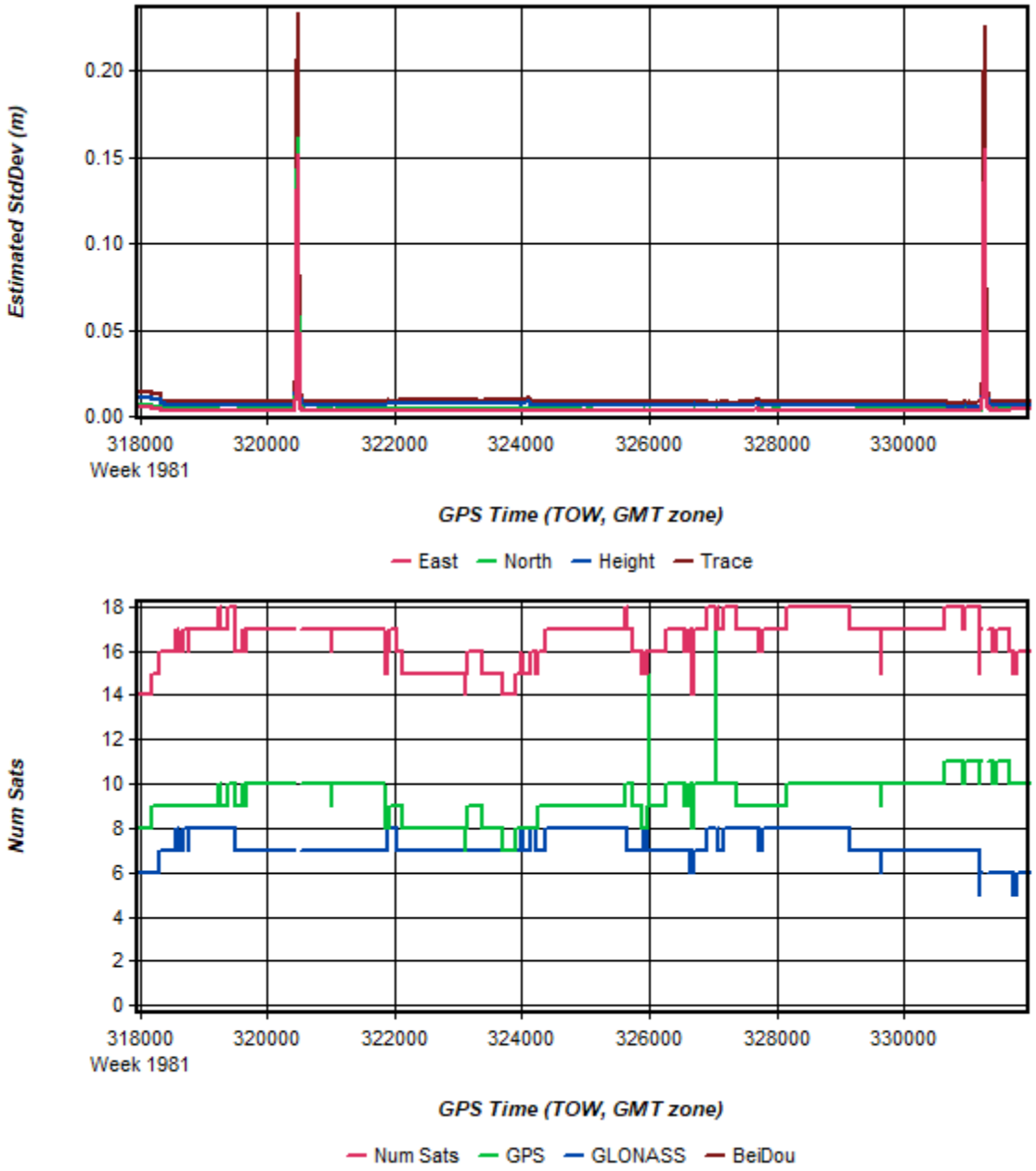

Num Sats
16
14
12
10
8
6
4
2
0
162000
Week 1980
164000
166000
168000
170000
172000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

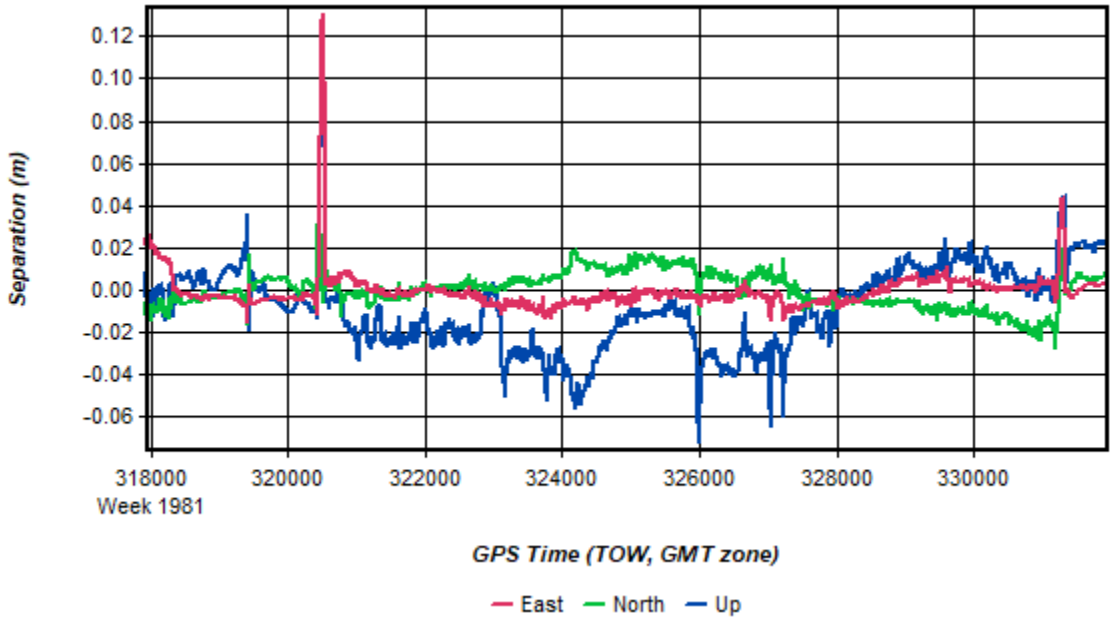

Separation (m)
0.03
0.02
0.01
0.00
-0.01
-0.02
162000
Week 1980
164000
166000
168000
170000
172000
GPS Time (TOW, GMT zone)
East
North
Up

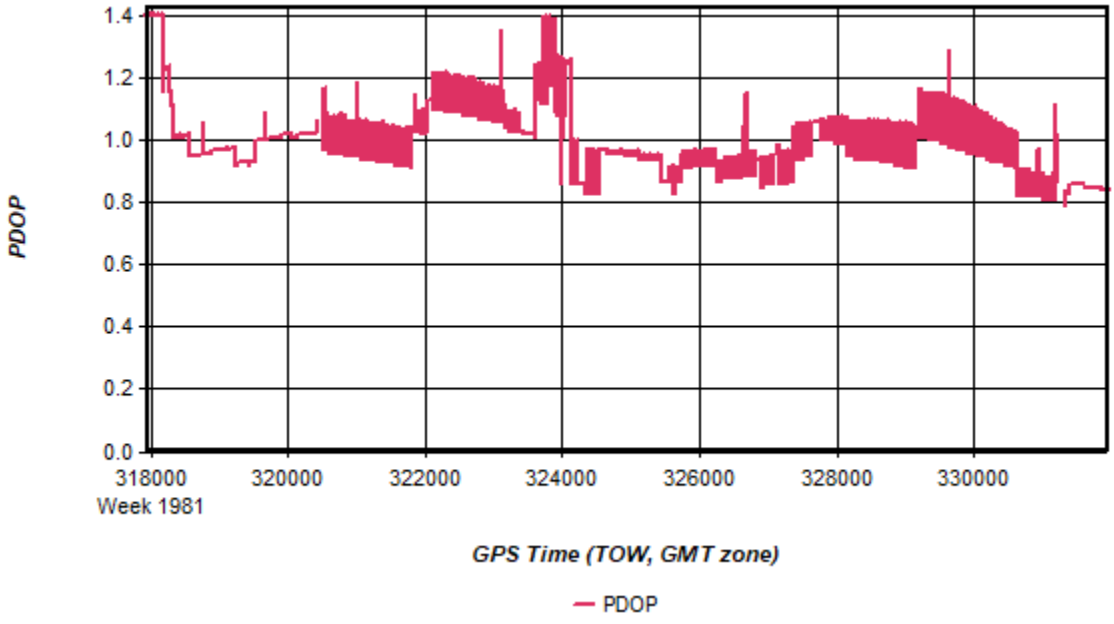


225_20171227_1

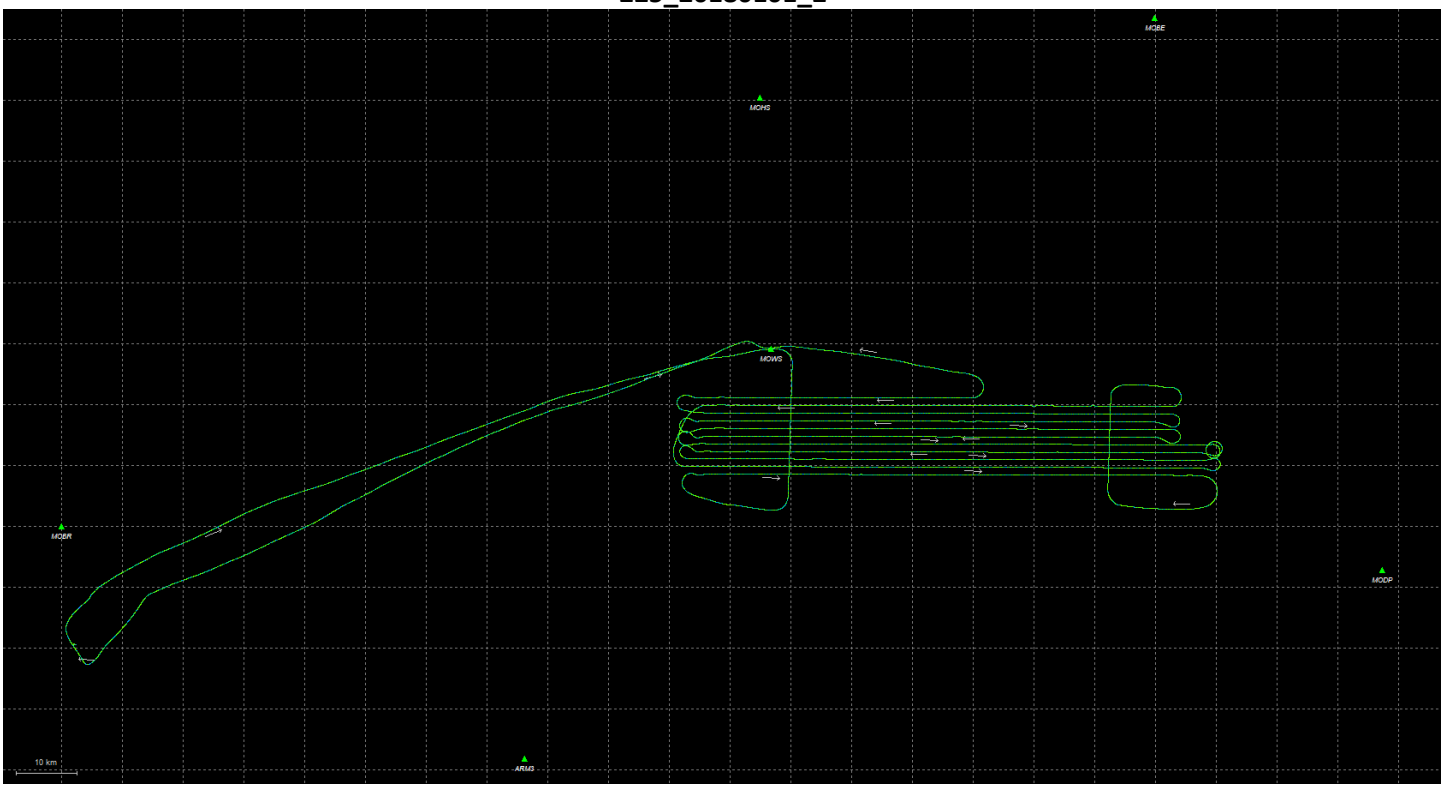


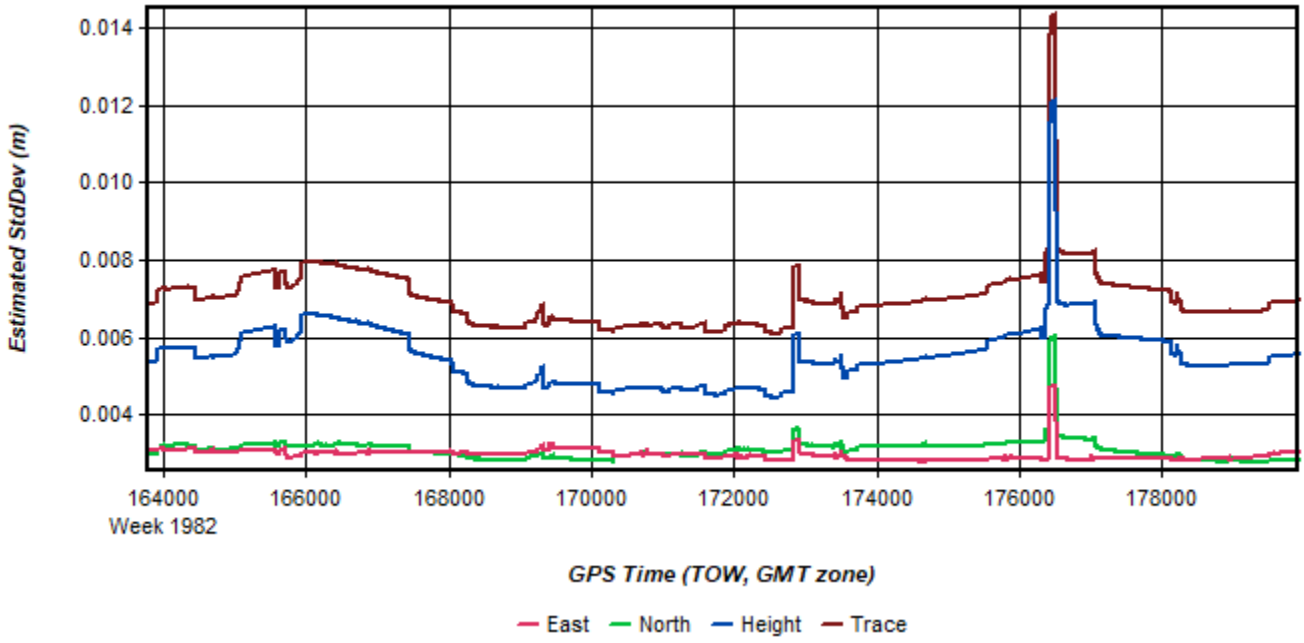

Estimated StdDev (m)
0.20
0.15
0.10
0.05
0.00
318000
320000
322000
324000
326000
328000
330000
Week 1981
GPS Time (TOW, GMT zone)
East
North
Height
Trace
Num Sats
18
16
14
12
10
8
6
4
2
0
318000
320000
322000
324000
326000
328000
330000
Week 1981
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou

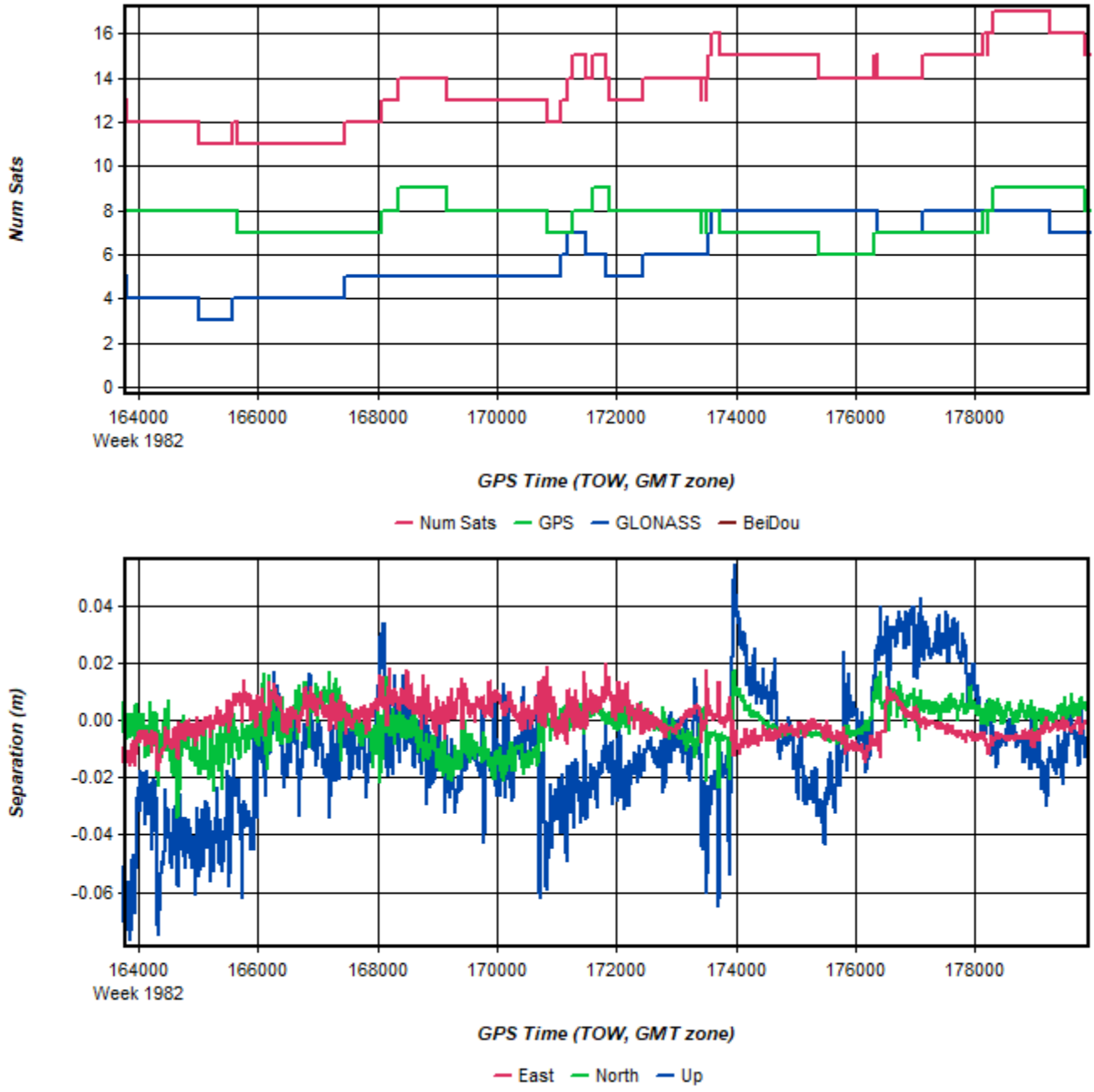

Separation (m)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
318000
320000
322000
324000
326000
328000
330000
Week 1981
GPS Time (TOW, GMT zone)
East
North
Up

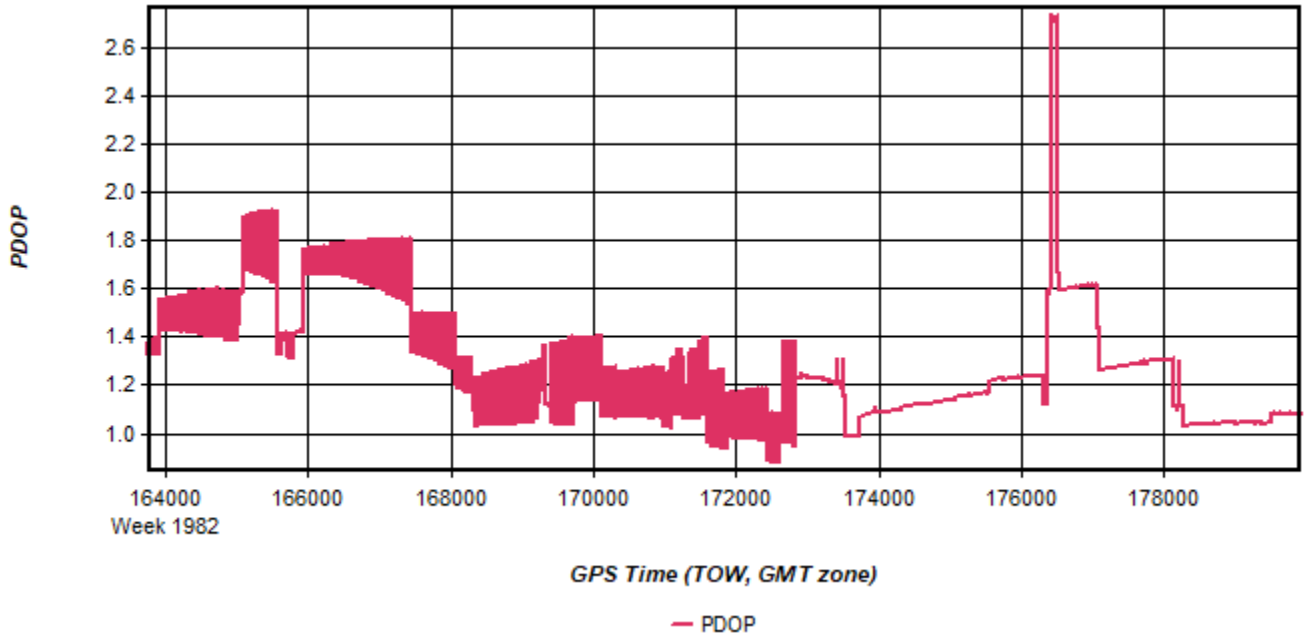

PDOP
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
318000
320000
322000
324000
326000
328000
330000
Week 1981
GPS Time (TOW, GMT zone)
PDOP

225_20180101_2






Num Sats
16
14
12
10
8
6
4
2
0
164000
166000
168000
170000
172000
174000
176000
178000
Week 1982
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Separation (m)
0.04
0.02
0.00
-0.02
-0.04
-0.06
East
North
Up


PDOP
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
164000
166000
168000
170000
172000
174000
176000
178000
Week 1982
GPS Time (TOW, GMT zone)
PDOP