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LADOTD New Orleans, LA Lidar 2021
312021420

Lidar Mapping Report

August 2022

EXECUTIVE SUMMARY

The Sanborn Map Company, Inc. (Sanborn) was tasked to provide remote sensing services in the form of lidar. Utilizing a multi-return system, Light Detection and Ranging (Lidar) detects 3-dimensional positions and attributes to form a point cloud. The high accuracy airborne system is integrated with both Global Navigation Satellite System (GNSS) and an Inertial Measure Unit (IMU) for accurate position and orientation. Acquisition of the project area's ~2,851mi² was completed on November 19th, 2021.

The Leica TerrainMapper was used to collect data for the aerial survey campaign. The sensor is attached to the aircraft's underside and emits rapid laser pulses that are used to calculate ranges between the aircraft and subsequent terrain below. The Airborne Lidar System (ALS) is boresighted by completing multiple passes over a known ground surface before the project acquisition. During data processing, the system calibration parameters are updated and used during post-processing of the lidar point cloud.

Differential GNSS unit in aircraft sampled positions at 2Hz or higher frequency. Lidar data was only acquired when GNSS PDOP is ≤4 and at least 6 satellites are in view. Collection conditions were for leaf-off vegetation. The atmosphere was free of clouds and fog between the aircraft and ground. The ground was free of snow and extensive flooding or any other type of inundation.

The contents of this report summarize the methods used to establish the base station coordinates, perform the lidar data acquisition and processing as well as the results of these methods.

CONTENTS

1.0 INTRODUCTION

This document contains the technical write-up of the lidar campaign, including system calibration techniques, and the collection and processing of the lidar data.

1.1 Contact Information

Questions regarding the technical aspects of this report should be addressed to:

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1.2 Purpose of Lidar Acquisition

The objective of this project is to collect accurate measurements of the bare-earth surface as well as above ground features to be provided as geometric inputs for surface and/or change modeling as is relates survey assessments.

1.3 Project Location

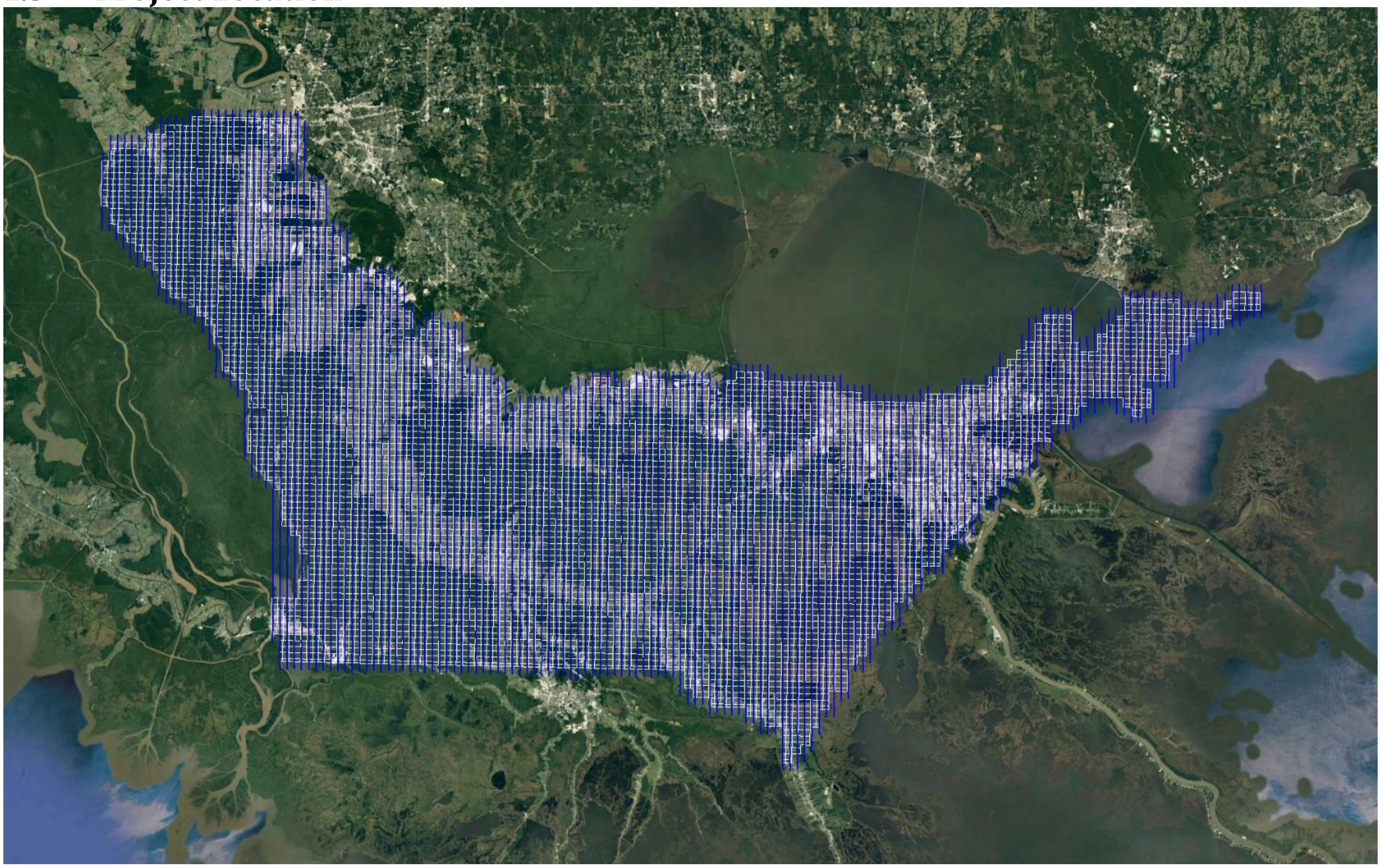


Figure 1: Tile Index and Trajectories As-Flown

2.0 ACQUISITION

2.1 Introduction
This section outlines the lidar system, flight reporting, and data acquisition methodology used during the collection of the lidar campaign. Although Sanborn conducts all lidar missions with the same rigorous and strict procedures and processes, all lidar collections are unique.

2.2 Acquisition Parameters
Sanborn specifically defined the collection parameters to accomplish the desired project specifications. **Table 1** shows the planned acquisition parameters utilized for this aerial survey with the sensor(s) installed.

Planned Acquisition Parameters		
Aircraft	N100NE - PIPER PA-31-310	N278RC - PIPER PA-31-310
Sensor	Leica TerrainMapper	Leica TerrainMapper
Max Number of Returns	15	15
Point Spacing (m)	0.34	0.34
Point Density (pls/m²)	8.9	8.9
Flying Height (AGL) (m)	2100	2100
Air Speed (kts)	160	160
Field of View (degrees)	40	40
Scan Rate (Hz)	150	150
Pulse Rate (kHz)	1760	1760
Laser Footprint (m)	0.49	0.49
Wavelength (nm)	1064	1064
Multi-Pulse	Yes	Yes
Swath Width (m)	1528	1528
Overlap (%)	20	20

Table 1: Lidar Acquisition Parameters

2.3 Field Work Procedures
Sanborn's standard procedure before every mission is to perform pre-flight checks to ensure correct operation of all systems. All cables were checked, and the sensor head glass was cleaned. A three-minute static session was conducted on the ground with the engines running prior to take-off to establish fine-alignment of the IMU and to resolve GNSS ambiguities.

The project acquisition consisted of fifteen (15) mission(s). During the data collection, the operator recorded information on log sheets which includes weather conditions, lidar operation parameters, flight line statistics and PDOP.

Preliminary data processing was performed in the field immediately following the missions for quality control of GNSS data and to ensure sufficient coverage of the project AOI. Any problematic data could then be re-flown immediately as required. Final data processing was completed in the Colorado Springs, CO office. **Table 2** below shows the flight acquisition metrics for the entire collection. **Table 3** contains the base station names and locations in operation during acquisition. Base station coordinates are provided in NAD83 (2011), Geographic Coordinate System, Ellipsoid, Meters.

Date	Sensor	Serial #	Tail #	MissionID	PDOP	Start (UTC)	End (UTC)
11/12/2021	Leica TerrainMapper	TM91520	N278RC	20211112A	1.7	15:13:12	20:09:40
11/12/2021	Leica TerrainMapper	TM91520	N278RC	20211112B	1.8	20:39:00	22:21:07
11/13/2021	Leica TerrainMapper	TM91555	N100NE	20211113A	2.0	16:13:06	20:10:23
11/13/2021	Leica TerrainMapper	TM91555	N100NE	20211113B	2.0	21:50:13	0:50:10
11/13/2021	Leica TerrainMapper	TM91520	N278RC	20211113A	1.7	15:58:00	21:27:02
11/13/2021	Leica TerrainMapper	TM91520	N278RC	20211113B	1.8	22:01:36	0:36:11
11/14/2021	Leica TerrainMapper	TM91555	N100NE	20211114A	1.6	12:28:31	17:14:42
11/14/2021	Leica TerrainMapper	TM91555	N100NE	20211114B	1.7	22:07:42	1:05:50
11/14/2021	Leica TerrainMapper	TM91520	N278RC	20211114A	1.6	15:58:09	20:31:33
11/14/2021	Leica TerrainMapper	TM91520	N278RC	20211114B	1.8	21:07:27	0:26:38
11/15/2021	Leica TerrainMapper	TM91520	N278RC	20211115A	1.5	16:54:33	19:21:53
11/16/2021	Leica TerrainMapper	TM91555	N100NE	20211116A	1.6	15:26:48	19:53:48
11/19/2021	Leica TerrainMapper	TM91555	N100NE	20211119A	1.6	15:58:06	20:38:12
11/19/2021	Leica TerrainMapper	TM91520	N278RC	20211119A	1.6	15:14:12	19:38:27
11/20/2021	Leica TerrainMapper	TM91555	N100NE	20211120A	1.6	18:15:24	19:15:50

Table 2: Collection Date Time by Mission

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
HOUM	CORS	DG5315	29 35 32.10965	090 43 24.98848	-11.333
MSIN	CORS	DN8737	30 18 42.22521	89 36 15.53346	-18.674
SJB1	CORS	DF8160	30 23 45.85039	91 06 25.88268	-3.012

Table 3: GNSS Reference Station Coordinates

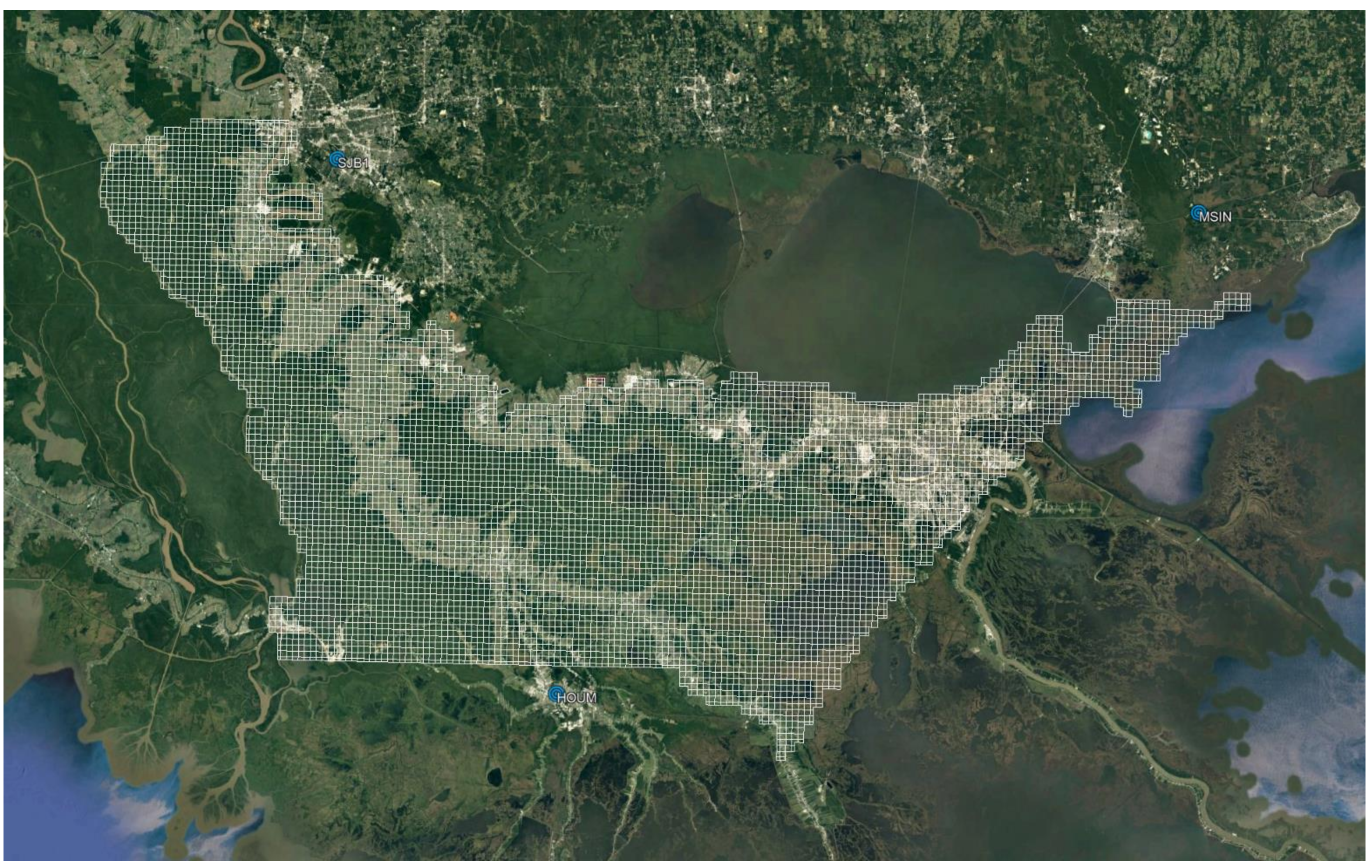


Figure 2: GNSS Reference Stations

3.0 PROCESSING

3.1 Introduction

The GNSS/IMU data was post-processed using Waypoint Inertial Explorer software to create Smoothed Best Estimate Trajectory (SBET) file(s). The SBET was then combined with the laser range measurements in Leica HxMap software to produce the 3-dimensional coordinates resulting in an accurate set of Raw Point Cloud (RPC) mass points. These raw swath (*.las) files are output in WGS84, UTM, Ellipsoid, Meters and transformed to the project Coordinate Reference System (CRS) upon ingest into GeoCue before project wide lidar matching.

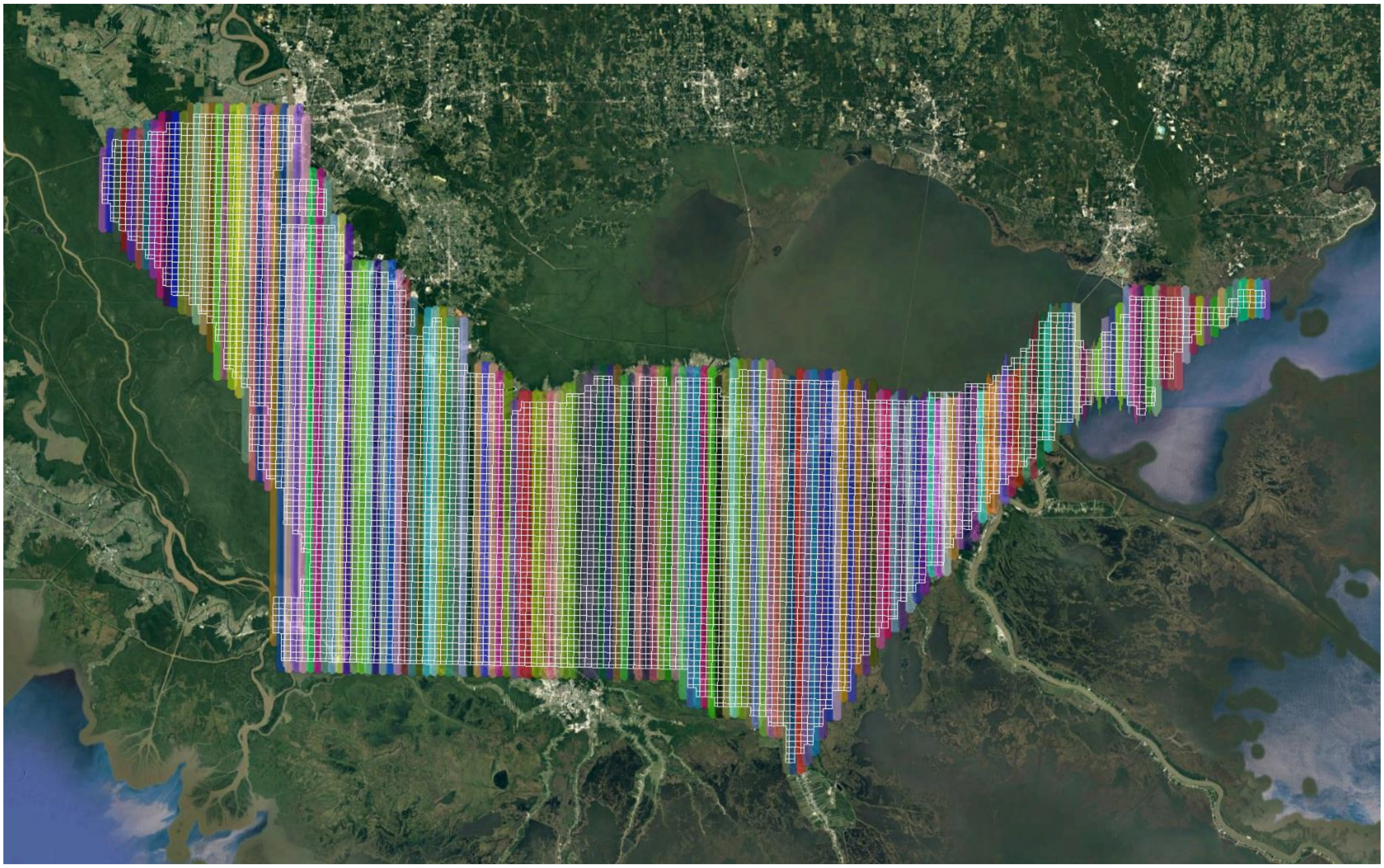


Figure 3: Raw Swath Coverage

The Leica HxMap pre-processing software created raw swath files with all return values. This multi-return information was processed and classified to obtain the required feature for delivery. All lidar data is processed using the ASPRS binary LAS format version 1.4. **Table 4** illustrates the achieved point cloud statistics.

Category	Value
Aggregate Total Points	91,818,812,110
Aggregate Nominal Pulse Spacing (m)	0.37
Aggregate Nominal Pulse Density (pls/m²)	7.2
Aggregate Nominal Pulse Spacing (ft)	1.22
Aggregate Nominal Pulse Density (pls/ft²)	0.7

Table 4: Point Cloud Statistics

*Overall aggregate density and spacing fell below target due to widespread water coverage. Topological land cover density and spacing meets/exceeds project requirements.

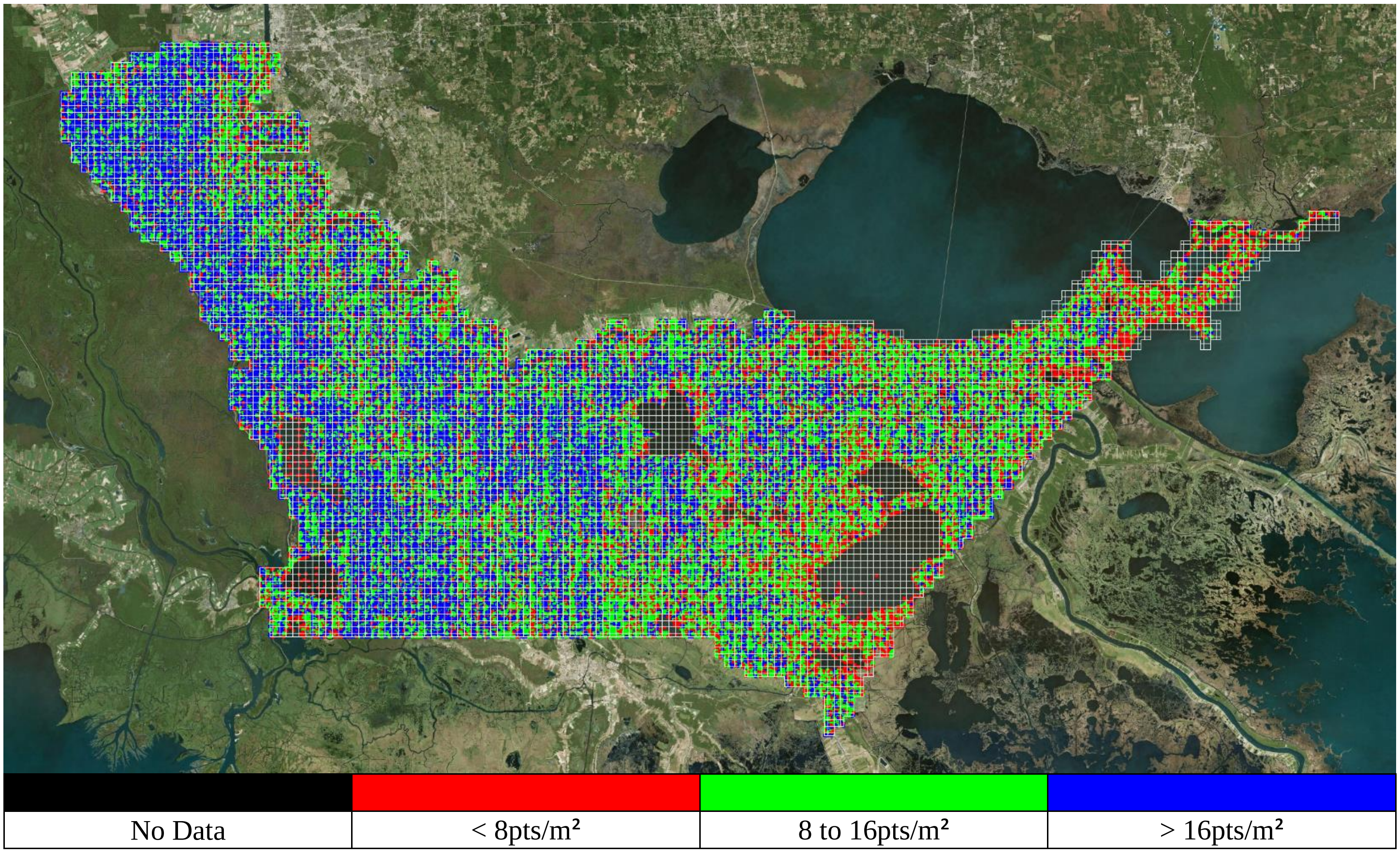


Figure 4: Point Cloud Density

3.2 Coordinate Reference System

Horizontal Datum: North American Datum of 1983 (2011)
Projection: Universal Transverse Mercator Zone 15 North
Vertical Datum: North American Vertical Datum of 1988
Geoid Model: Geoid18
Units: Meters

3.3 Lidar Matching

Sanborn uses pre-processing software and the latest boresight values to combine the processed SBET with the laser scan files to produce the lidar point cloud. The data is processed by mission and/or block and is output in ASPRS LASv1.4 Point Data Record Format (PDRF) 6 with 16bit linearly scaled intensities to the nearest 0.001 3D position. Each mission is produced in WGS84, UTM, Ellipsoid, Meters and transformed to the project CRS upon import into GeoCue.

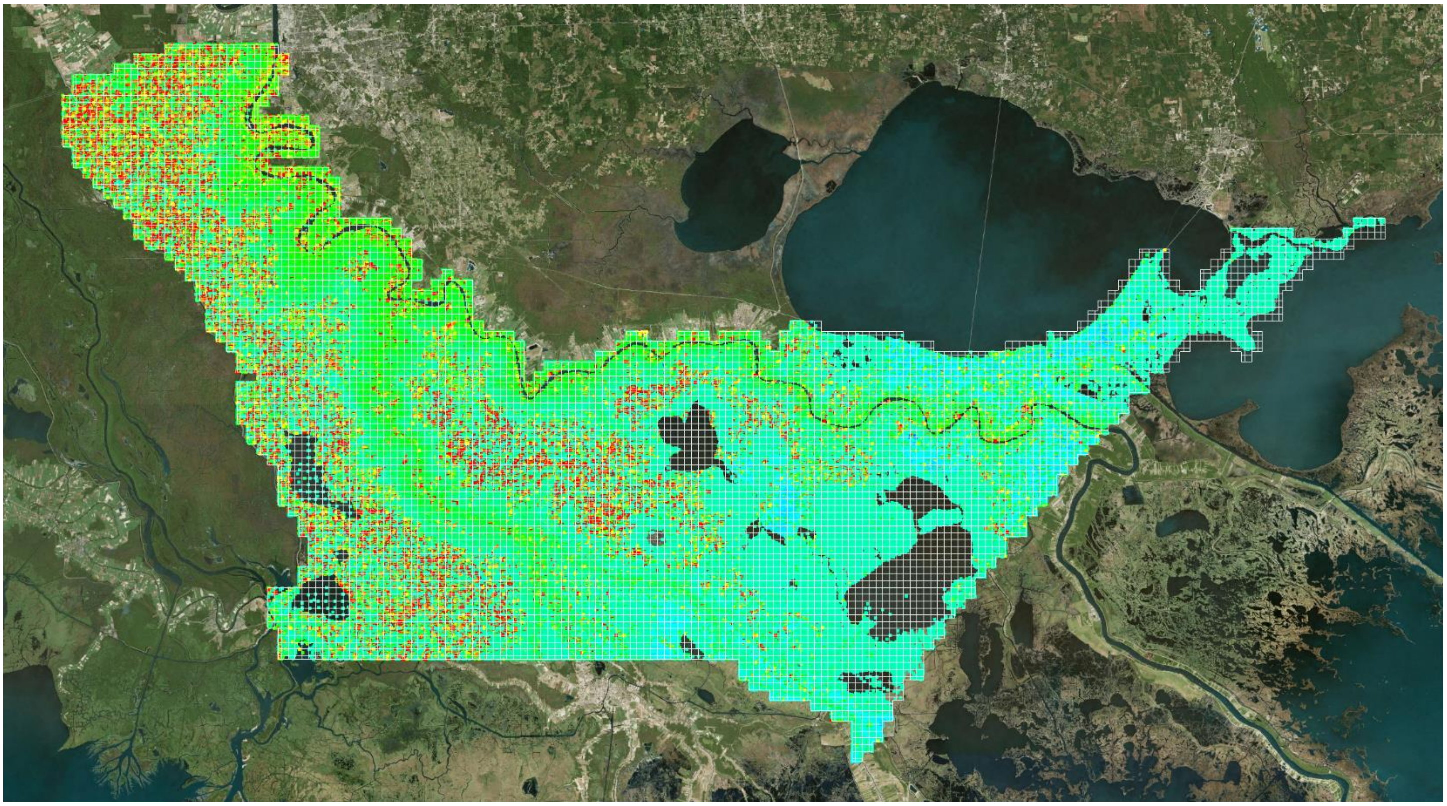


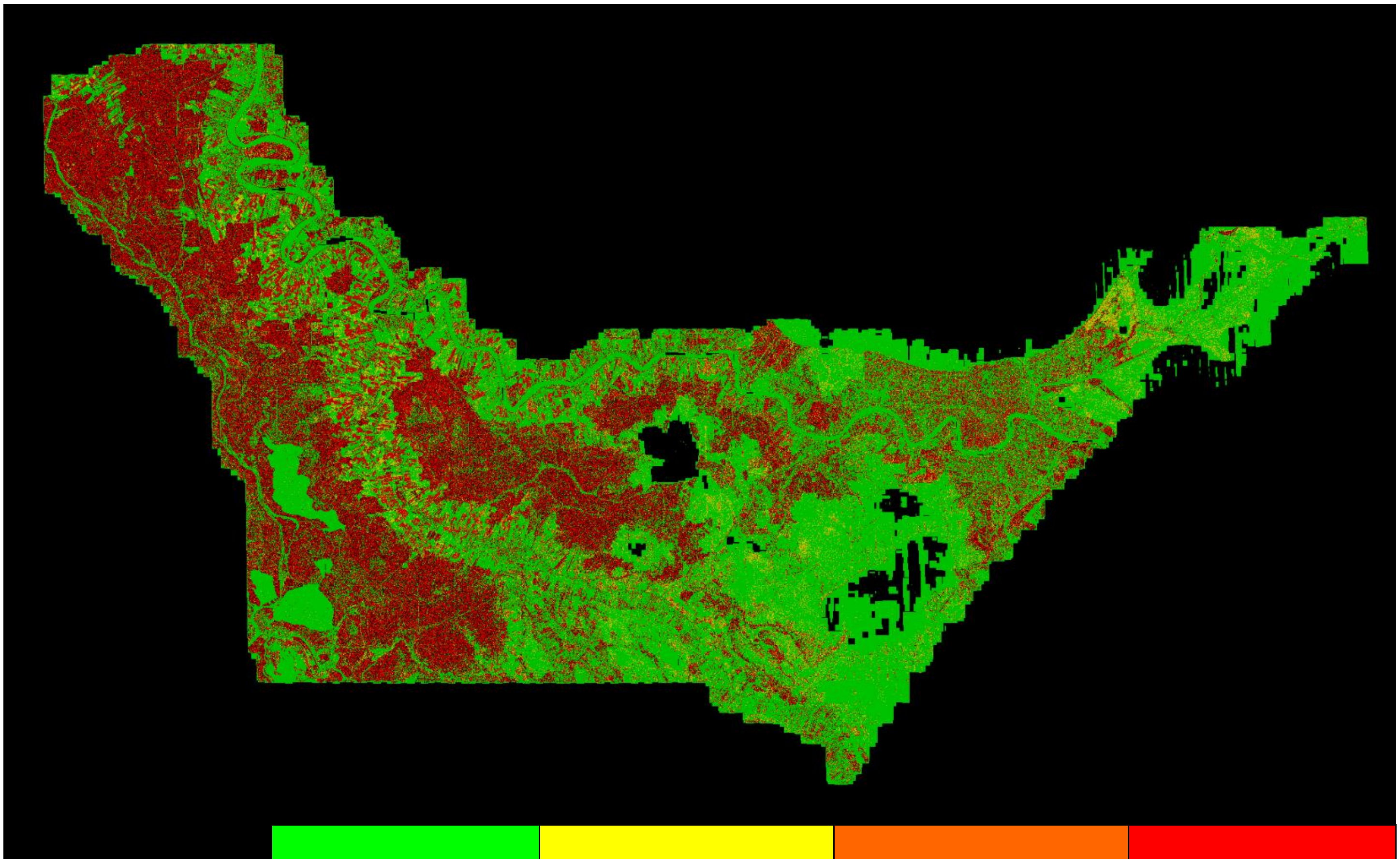
Figure 5: Point Cloud Elevation

Each mission is imported into GeoCue where each individual flight line is assigned a unique Source ID number. The SBET is cut per swath into TerraScan Trajectory files based on Source ID number and timestamp; these are utilized during the lidar matching process. The project area(s) are broken into logical blocks based on AOIs or predetermined delivery blocks and the individual flight lines are populated into lidar matching tile grids. These lidar matching tile grids are prepared for scanner, line, mission, block and eventual project wide lidar matching routines by first running point cloud filters to identify ground and building features to be used during any TerraMatch processes.

Sanborn takes advantage of both visual and statistical validation methodologies to review and ensure both the individual precision and alignment of the lidar dataset. Swath Precision Images modulated by Intensity are representative of the intraswath alignment and provide a holistic qualitative look at the goodness of fit within each swath. Swath Separation Images modulated by Intensity are representative of the interswath alignment and provide a holistic qualitative look at the positional quality of the point cloud. The images are reviewed in their entirety. Furthermore, the set of TerraMatch Tie Lines are used to produce a Tie Line Report to statistically assess the X. Y. and Z offset averages and magnitudes for the whole project including each line individually. This visual and statistical review guarantees the relative accuracy of the lidar dataset. **Table 5** outlines the relative accuracy requirements of the project. **Tables 6 – 9** are the relative accuracies achieved.

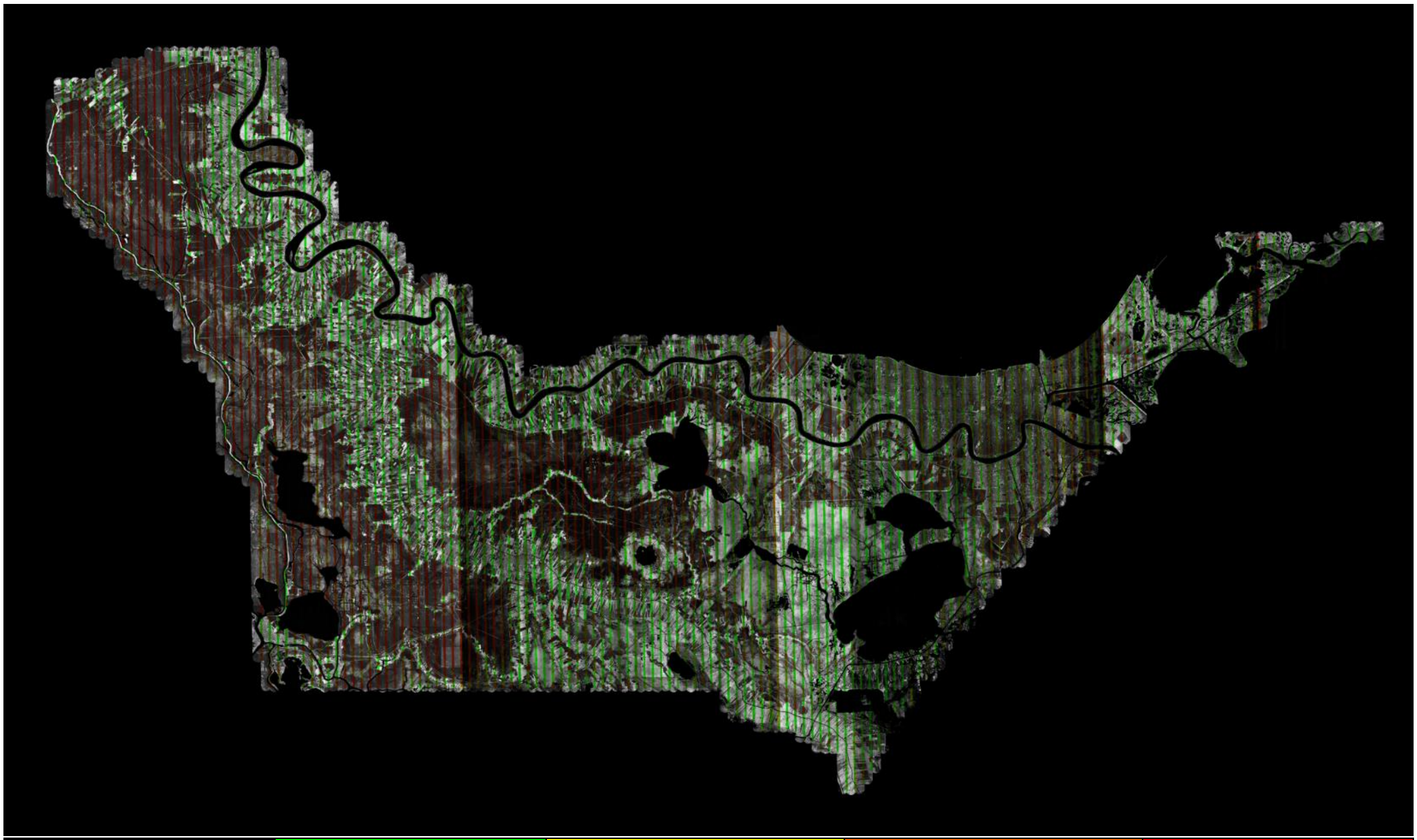
Category	Value (m)	Value (ft)
Smooth Surface Repeatability	≤0.060	≤0.197
Swath overlap difference, RMSDz	≤0.080	≤0.262

Table 5: Relative Accuracy Requirements



No Data	< 0.06m	0.06m to 0.12m	0.12m to 0.18m	> 0.18m
No Data	< 0.197ft	0.197ft to 0.394ft	0.394ft to 0.591ft	> 0.591ft

Figure 6: Swath Precision



No Data	< 0.08m	0.08m to 0.16m	0.16m to 0.24m	> 0.24m
No Data	< 0.262ft	0.262ft to 0.524ft	0.524ft to 0.786ft	> 0.786ft

Figure 7: Swath Separation

Line	X	Y	Z	Line	X	Y	Z	Line	X	Y	Z
1	0.011	0.005	0.007	**55**	0.034	0.017	0.016	**109**	0.028	0.017	0.015
2	0.008	0.006	0.009	**56**	0.032	0.018	0.016	**110**	0.026	0.016	0.017
3	0.014	0.012	0.009	**57**	0.032	0.021	0.017	**111**	0.028	0.017	0.014
4	0.024	0.027	0.010	**58**	0.031	0.023	0.016	**112**	0.026	0.016	0.013
5	0.019	0.024	0.009	**59**	0.031	0.023	0.015	**113**	0.024	0.017	0.013
6	0.013	0.015	0.009	**60**	0.030	0.025	0.014	**114**	0.027	0.016	0.014
7	0.009	0.008	0.009	**61**	0.026	0.024	0.014	**115**	0.027	0.015	0.016
8	0.011	0.012	0.009	**62**	0.026	0.023	0.015	**116**	0.028	0.017	0.014
9	0.013	0.014	0.008	**63**	0.027	0.025	0.015	**117**	0.028	0.016	0.015
10	0.014	0.012	0.008	**64**	0.029	0.028	0.015	**118**	0.029	0.015	0.017
11	0.020	0.016	0.009	**65**	0.034	0.026	0.017	**119**	0.028	0.016	0.018
12	0.005	0.010	0.009	**66**	0.034	0.022	0.014	**120**	0.035	0.013	0.018
13	0.009	0.011	0.009	**67**	0.008	0.006	0.010	**121**	0.037	0.012	0.019
14	0.031	0.020	0.010	**68**	0.045	0.035	0.017	**122**	0.033	0.014	0.021
15	0.021	0.011	0.009	**69**	0.041	0.016	0.016	**123**	0.033	0.013	0.022
16	0.012	0.008	0.010	**70**	0.042	0.013	0.018	**124**	0.045	0.024	0.022
17	0.010	0.008	0.009	**71**	0.033	0.028	0.018	**125**	0.049	0.029	0.026
18	0.011	0.008	0.009	**72**	0.032	0.022	0.017	**126**	0.041	0.030	0.022
19	0.011	0.011	0.010	**73**	0.031	0.021	0.015	**127**	0.041	0.029	0.023
20	0.008	0.009	0.009	**74**	0.030	0.022	0.014	**128**	0.010	0.014	0.010
21	0.009	0.009	0.007	**75**	0.041	0.038	0.016	**129**	0.011	0.015	0.009
22	0.010	0.010	0.008	**76**	0.034	0.032	0.014	**130**	0.017	0.024	0.010
23	0.010	0.010	0.007	**77**	0.024	0.026	0.014	**131**	0.023	0.016	0.010
24	0.011	0.012	0.008	**78**	0.029	0.026	0.015	**132**	0.014	0.015	0.010
25	0.013	0.012	0.008	**79**	0.029	0.020	0.013	**133**	0.010	0.009	0.013
26	0.011	0.011	0.008	**80**	0.028	0.022	0.014	**134**	0.007	0.003	0.014
27	0.010	0.010	0.007	**81**	0.030	0.029	0.014	**135**	0.008	0.009	0.009
28	0.009	0.010	0.008	**82**	0.030	0.027	0.018	**136**	0.008	0.009	0.012
29	0.010	0.011	0.007	**83**	0.029	0.025	0.016	**137**	0.016	0.020	0.009
30	0.021	0.013	0.008	**84**	0.027	0.024	0.013	**138**	0.016	0.020	0.009
31	0.016	0.011	0.007	**85**	0.029	0.027	0.013	**139**	-	-	0.010
32	0.014	0.013	0.006	**86**	0.050	0.038	0.018	**140**	-	-	0.014
33	0.014	0.013	0.007	**87**	0.030	0.022	0.017	**141**	0.008	0.026	0.012
34	0.011	0.011	0.007	**88**	0.013	0.015	0.011	**142**	0.008	0.020	0.009
35	0.012	0.010	0.007	**89**	0.008	0.008	0.008	**143**	0.009	0.017	0.009
36	0.017	0.013	0.007	**90**	0.009	0.009	0.007	**144**	0.026	0.033	0.010
37	0.022	0.019	0.009	**91**	0.011	0.011	0.007	**145**	0.031	0.030	0.011
38	0.011	0.012	0.007	**92**	0.009	0.009	0.007	**146**	0.000	0.000	0.025
39	0.010	0.010	0.008	**93**	0.010	0.011	0.006	**147**	-	-	0.014
40	0.010	0.009	0.007	**94**	0.014	0.015	0.007	**148**	-	-	0.012
41	0.011	0.009	0.008	**95**	0.014	0.015	0.007	**149**	-	-	0.027
42	0.013	0.011	0.007	**96**	0.019	0.019	0.012	**150**	-	-	0.010
43	0.010	0.009	0.007	**97**	0.029	0.024	0.015	**151**	-	-	0.010
44	0.011	0.010	0.008	**98**	0.078	0.053	0.016	**152**	-	-	0.011
45	0.014	0.013	0.009	**99**	0.072	0.037	0.015	**153**	-	-	0.013
46	0.012	0.011	0.008	**100**	0.028	0.008	0.014	**154**	-	-	0.010
47	0.013	0.014	0.008	**101**	0.029	0.009	0.013	**155**	-	-	0.008

48	0.010	0.015	0.010	**102**	0.035	0.014	0.014	**156**	-	-	0.009
49	0.013	0.018	0.012	**103**	0.031	0.015	0.015	**157**	-	-	0.012
50	0.051	0.052	0.019	**104**	0.026	0.017	0.014	**158**	-	-	0.008
51	0.050	0.030	0.019	**105**	0.025	0.018	0.014	**159**	-	-	0.010
52	0.048	0.028	0.018	**106**	0.028	0.017	0.014	**160**	-	-	0.012
53	0.036	0.028	0.017	**107**	0.027	0.017	0.015	**161**	-	-	0.012
54	0.035	0.028	0.017	**108**	0.026	0.016	0.015				

Table 6: Average Magnitudes by Line (Meters)

Category	X	Y	Z
Average Magnitude	0.020	0.015	0.012
RMS Values	0.031	0.024	0.018
Maximum Values	0.159	0.158	0.160
Observation Weight	85947.0	85947.0	774749.0

Table 7: Internal Observation Statistics (Meters)

Category	Mismatch
Average 3D Mismatch	0.01435
Average XY Mismatch	0.02876
Average Z Mismatch	0.01174

Table 8: Overall Relative Accuracy (Meters)

Category	Observations
Section Lines	300,422
Roof Lines	42,972

Table 9: Vector Observations

3.4 Lidar Classification

Lidar filtering was accomplished using GeoCue with TerraSolid processing and modeling software. The filtering process reclassifies all the data into classes within the point cloud classification scheme. Once the data is classified, the entire dataset is reviewed and manually edited for anomalies that are outside the required guidelines of the product specification or contract requirements. This can include, but is not limited to, classifying bridges, structures, filling culverts, and manually analyzing the bare-earth surface by classifying features that belong in non-extraneous classification codes. **Table 10** outlines a statistical summary of the point classes leveraged in the lidar dataset.

Code	Class	Points
1	Unclassified	68,239,922,215
2	Ground	21,704,722,116
7	Low Noise	1,558,322,325
9	Water	112,173,265
17	Bridge Decks	51,894,303
18	High Noise	146,754,587
20	Ignored Ground	5,023,185
Flag	Withheld	1,705,076,912

Table 10: Lidar Classification Statistics

3.5 Accuracy Assessment

The lidar dataset was evaluated using a total of one hundred and fifty (150) check points (85 NVA + 65 VVA). The result provided a vertical accuracy that fell within project specifications. Please see the **Attachment A** for the full Vertical Accuracy Report and the project *Metadata* for an in-depth accuracy assessment. **Table 11** outlines the absolute accuracy requirements of the project. **Table 12** shows high level statistics and mean errors for the area processed by Sanborn.

Category	Value (m)	Value (ft)
RMSEz	≤0.100	≤0.328
@ 95-Percent Confidence Level	≤0.196	≤0.643
@ 95^{th} Percentile	≤0.300	≤0.984

Table 11: Absolute Accuracy Requirements

Broad Land Cover Type	# of Points	RMSEz	95% Confidence Level	95th Percentile
NVA of Point Cloud	85	0.078	0.153	
NVA of Bare Earth	85	0.079	0.154	
NVA of DEM	85	0.078	0.153	
VVA of Bare Earth	65	0.090		0.180
VVA of DEM	65	0.090		0.178

Table 12: Vertical Accuracy Assessment of Check Points (Meters)

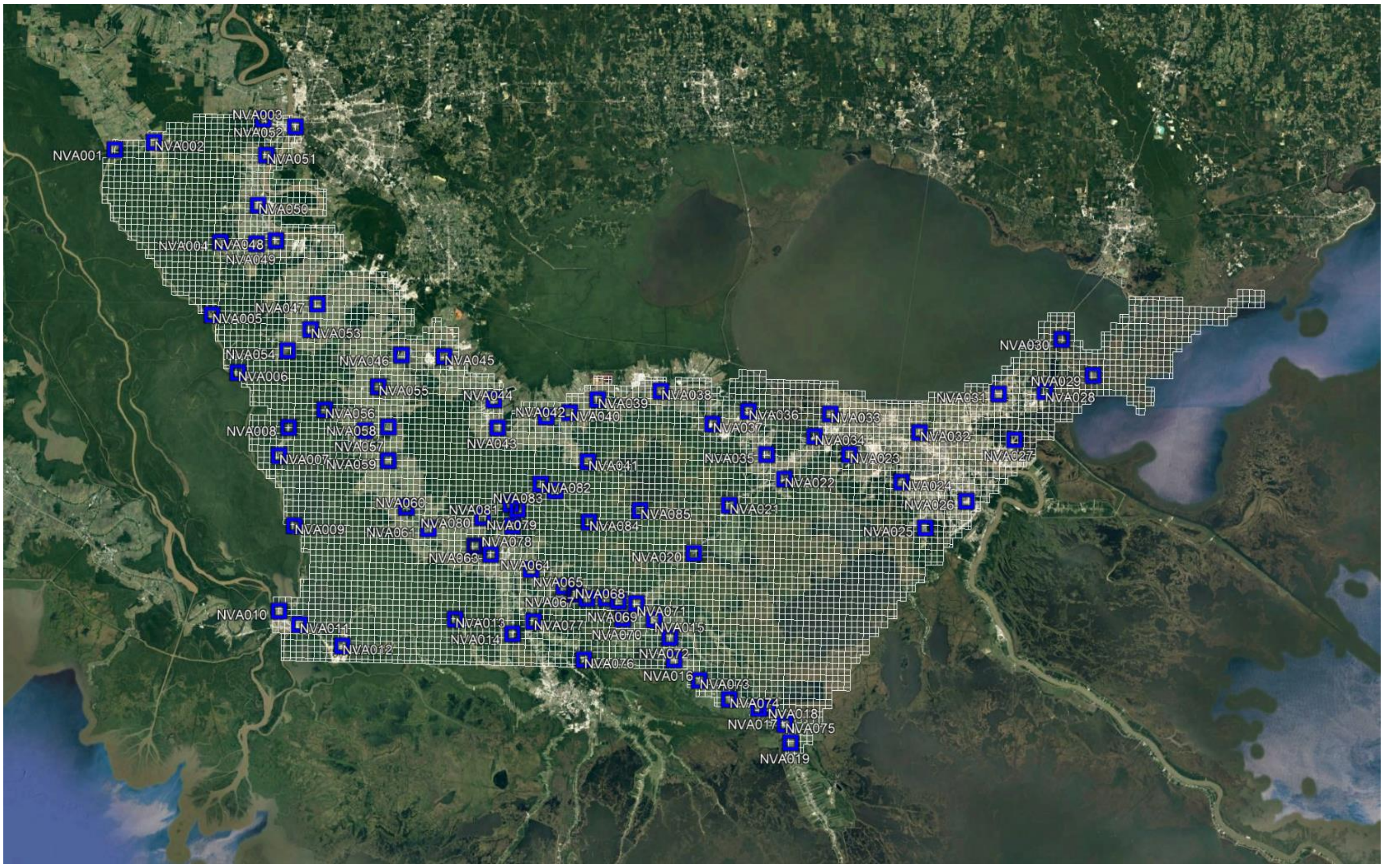


Figure 8: Non-vegetated Check Point Distribution

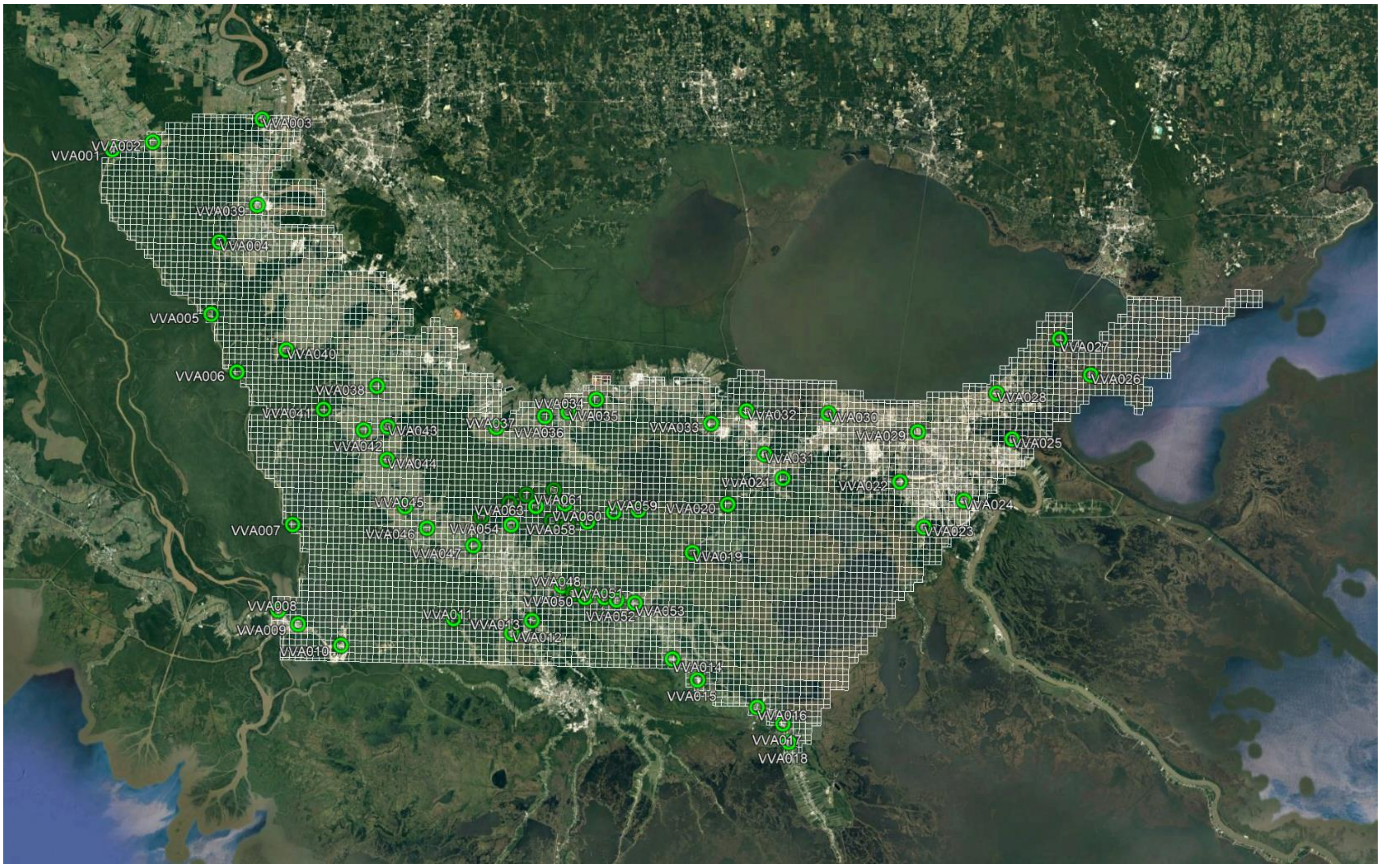


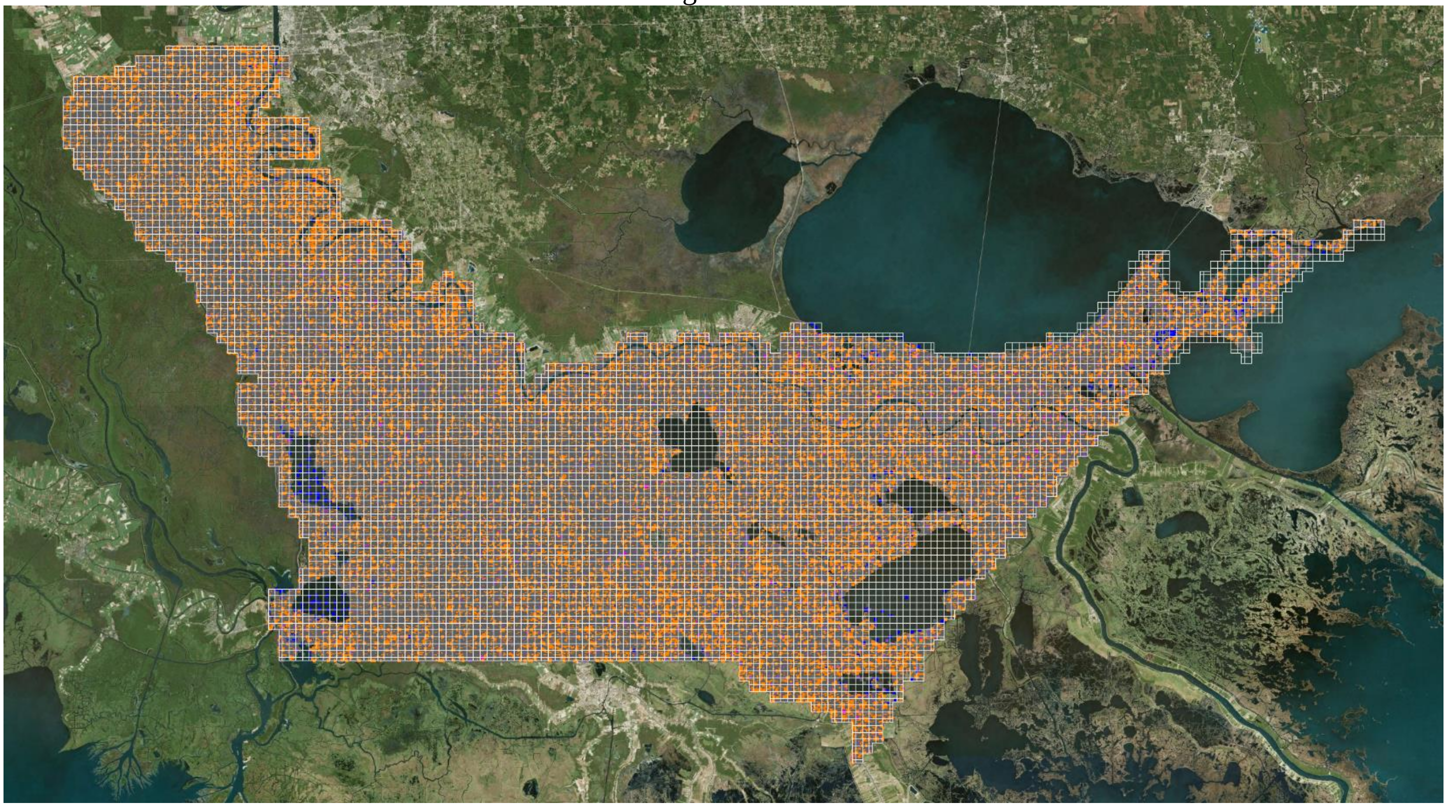
Figure 9: Vegetated Check Point Distribution

4.0 PRODUCT GENERATION

The following products were generated using the final coordinate system as defined in the contract:

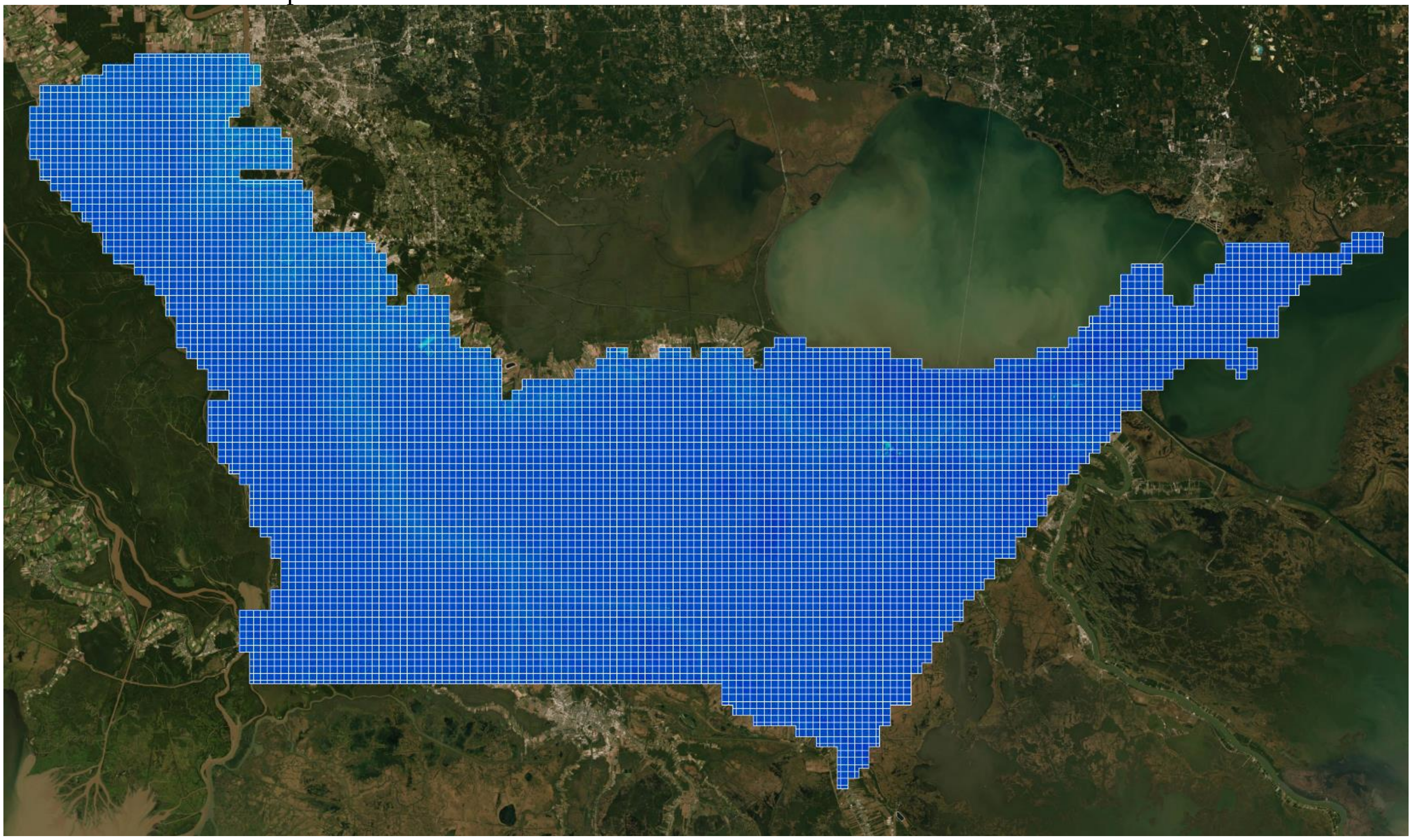
Classified Point Cloud

The Classified Point Cloud, containing all returns, is delivered in LASv1.4 (*.las) format and meets project specifications. The Classified Point Cloud contains file names referencing the tile index.



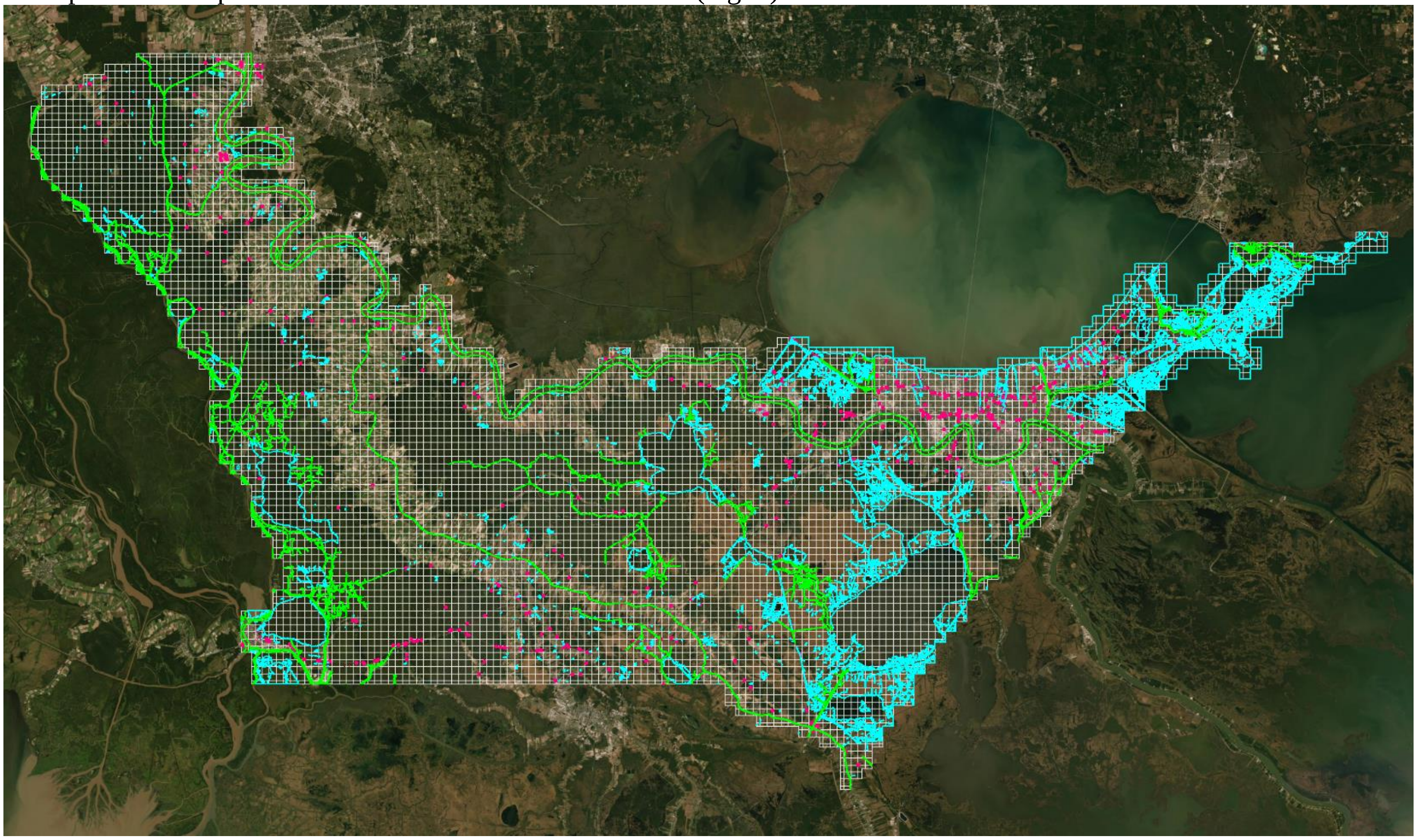
Bare-earth Digital Elevation Model (DEM)

32-bit GeoTIFF (*.tif) elevation rasters were created from the bare-earth points in the processed lidar dataset and hydro-flattened breaklines. Bare-earth rasters were produced the bilinear interpolation methodology and GDAL v2.4.0 was used to define the CRS. Each pixel contains an elevation.



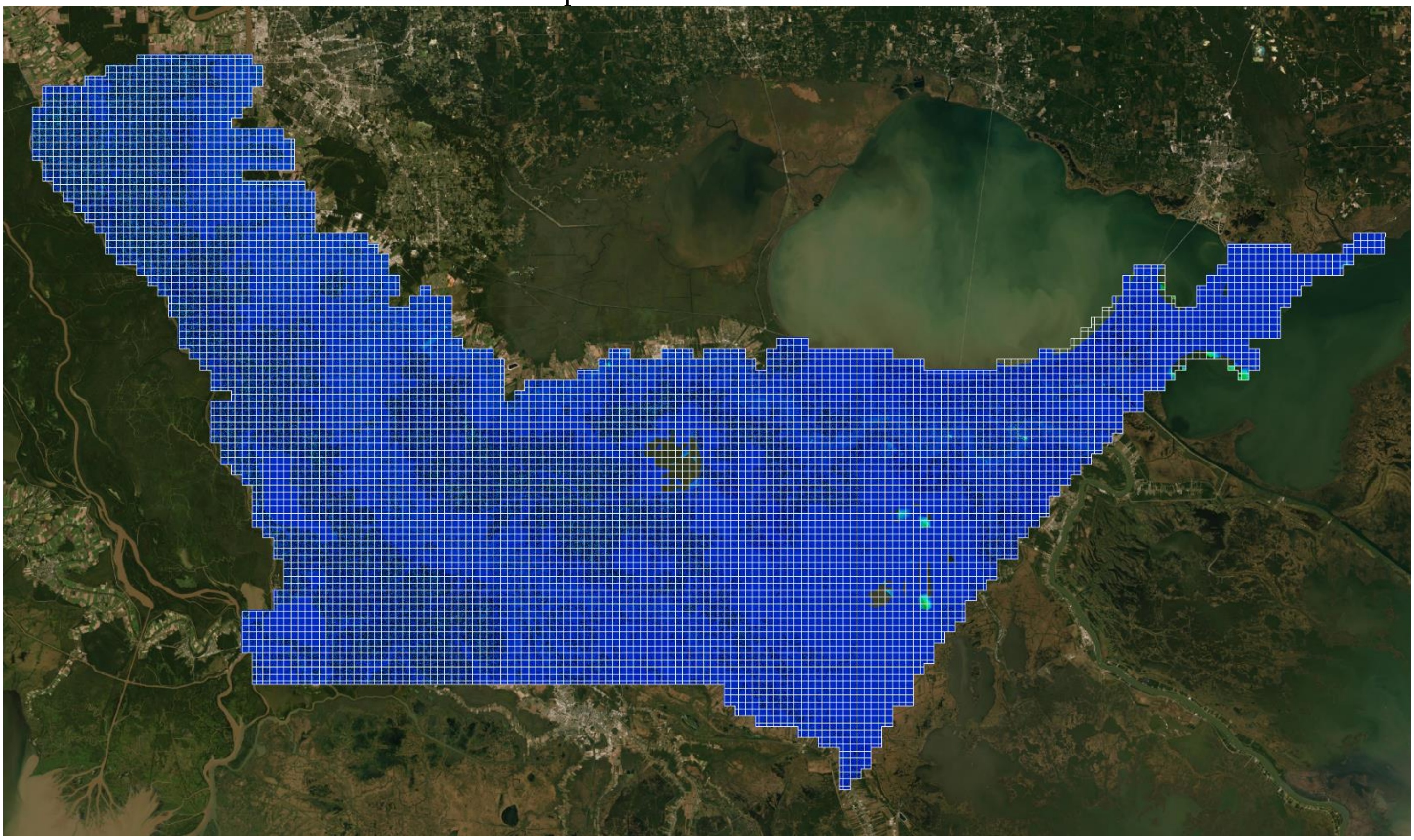
Breaklines

Hydro-flattened breaklines were generated from digitized water features conflated to the elevations derived from the bare-earth points in the processed lidar dataset. Delivered in Esri (*.gdb) format.



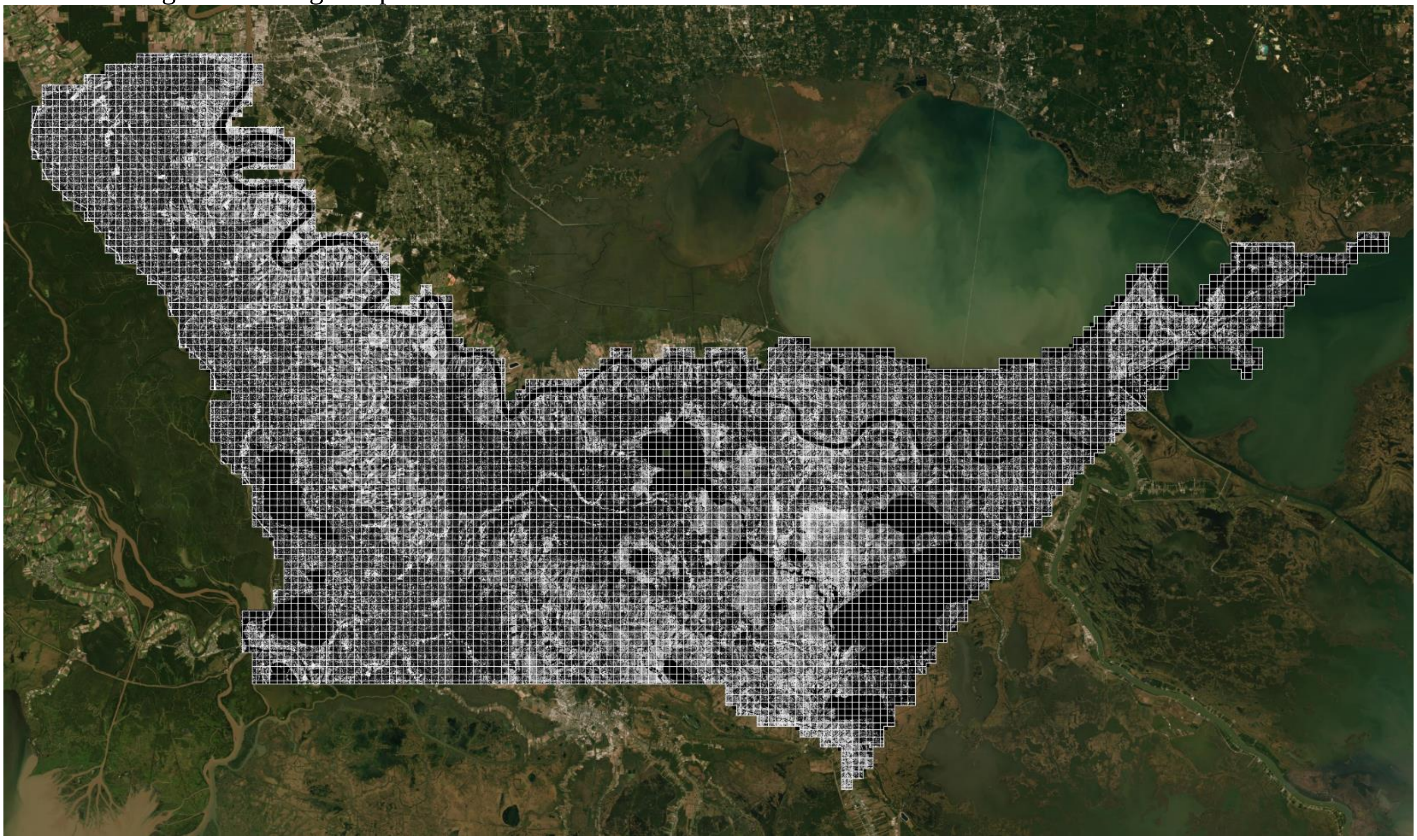
First-return Digital Surface Model (DSM)

32-bit GeoTIFF (*.tif) elevation rasters were created from the first-return points in the processed lidar dataset. All overlap classes were ignored during this process. First-return rasters were produced the bilinear interpolation methodology and GDAL v2.4.0 was used to define the CRS. Each pixel contains an elevation.



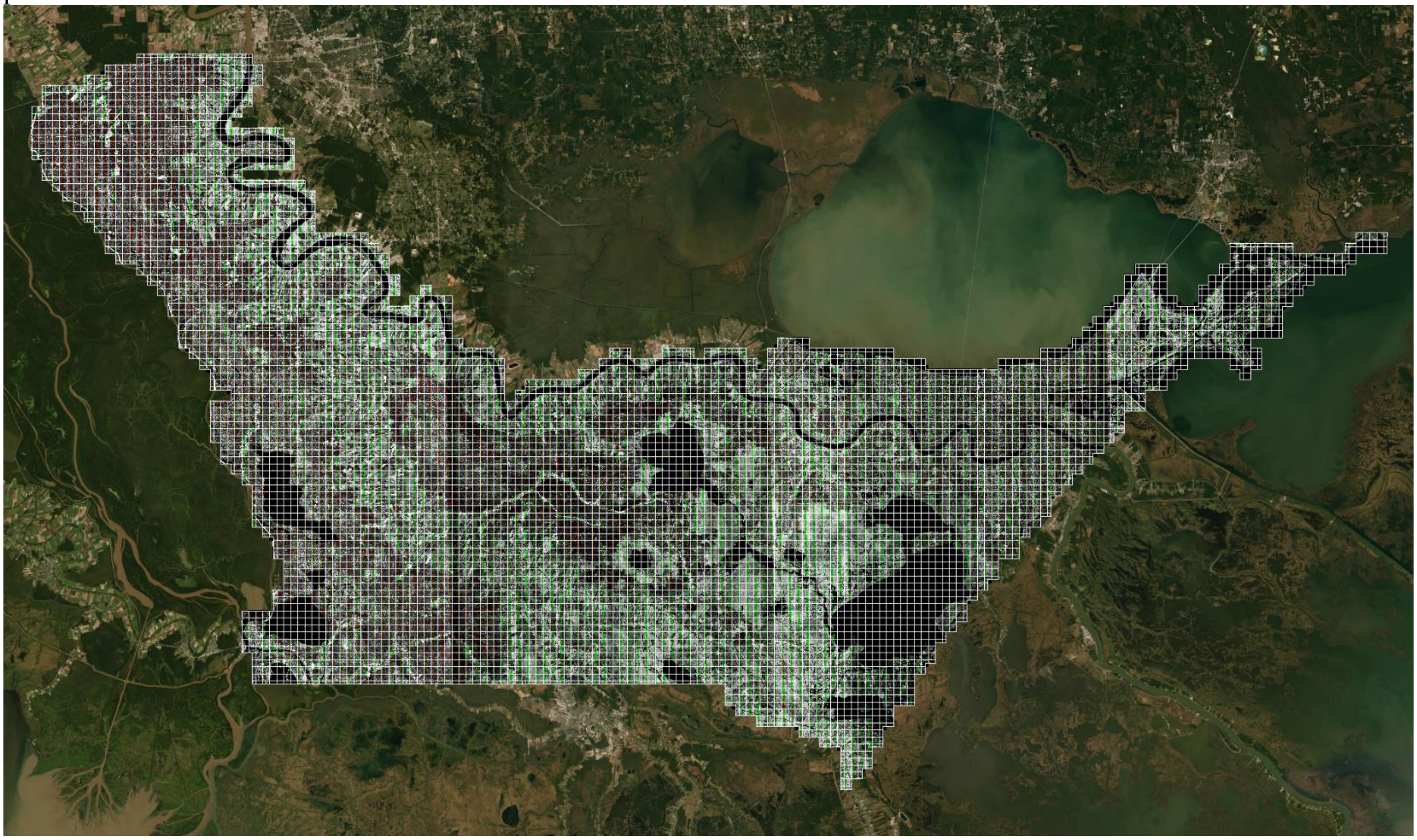
First-return Intensity Images

8-bit GeoTIFF (*.tif) intensity rasters were created from the first-return points in the processed lidar dataset. All overlap classes were ignored during this process. GDAL v2.4.0 was used to define the CRS.



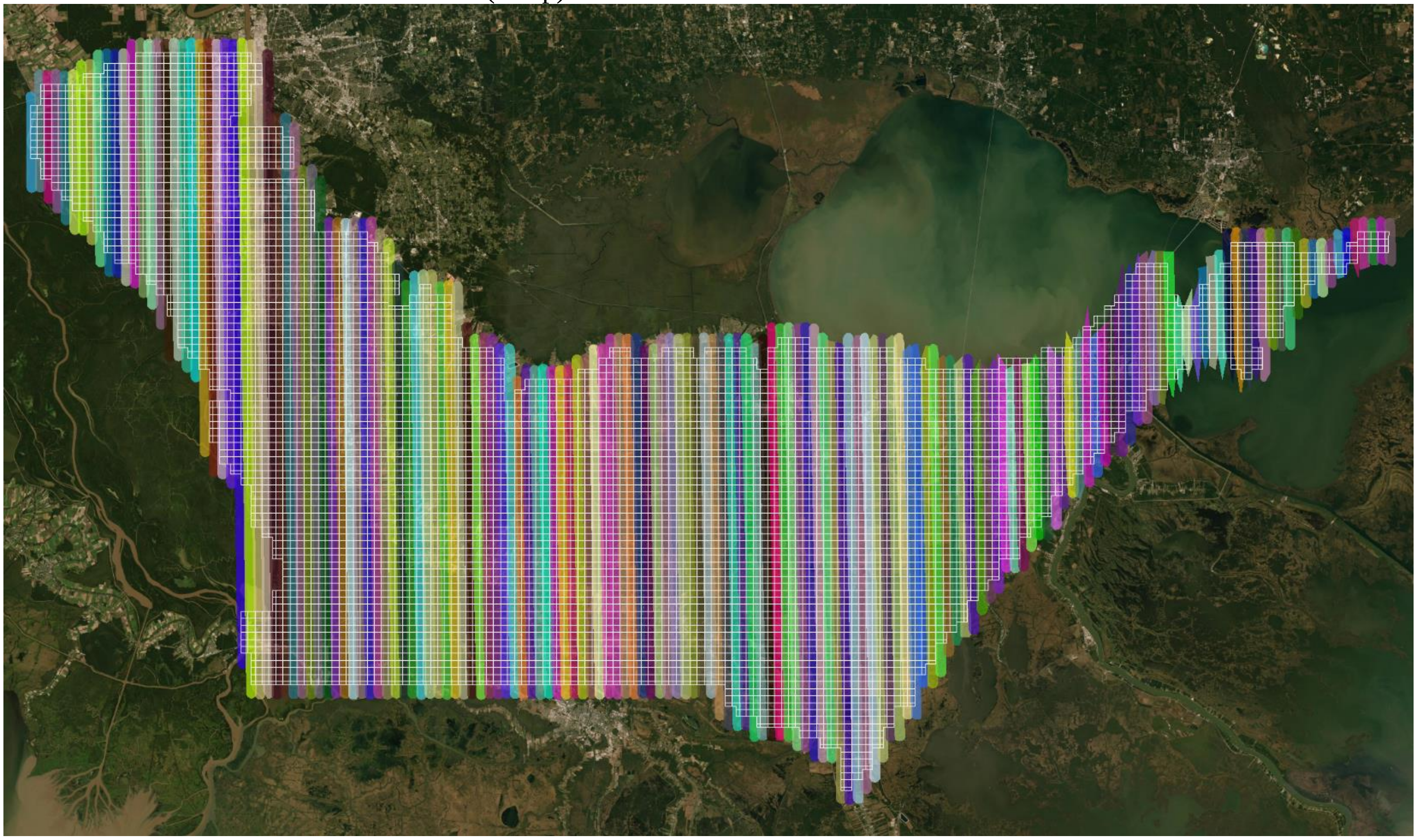
Last-return Swath Separation Images

24-bit GeoTIFF (*.tif) swath separation images modulated by intensity were created from the last-return points in the processed lidar dataset. GDAL v2.4.0 was used to define the CRS.



Swath Polygons

Polygons features representing either the convex or concave hull of swaths, where each record is an individual swath or channel within a swath. Delivered in Esri (*.shp) format.



Other Deliverables

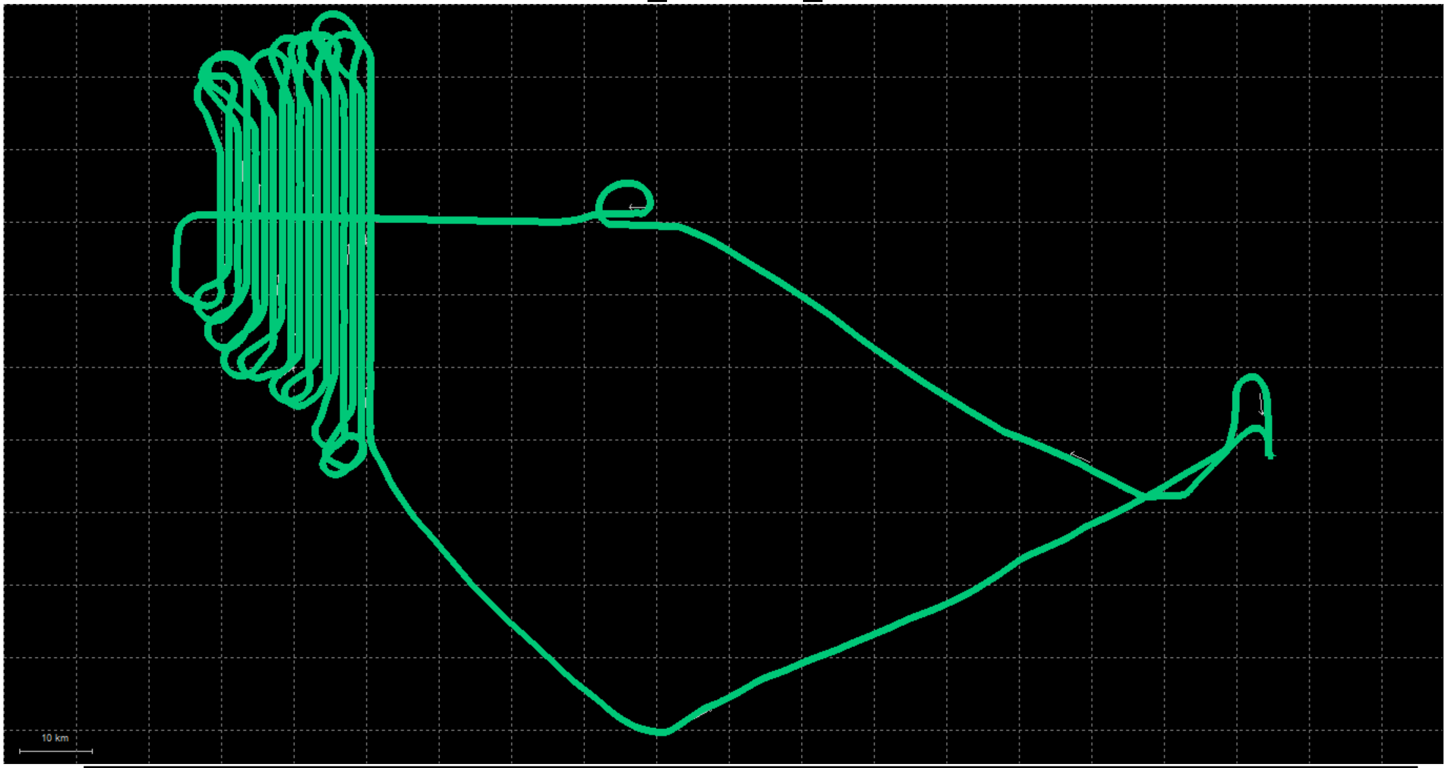
Metadata
Vertical Accuracy Report

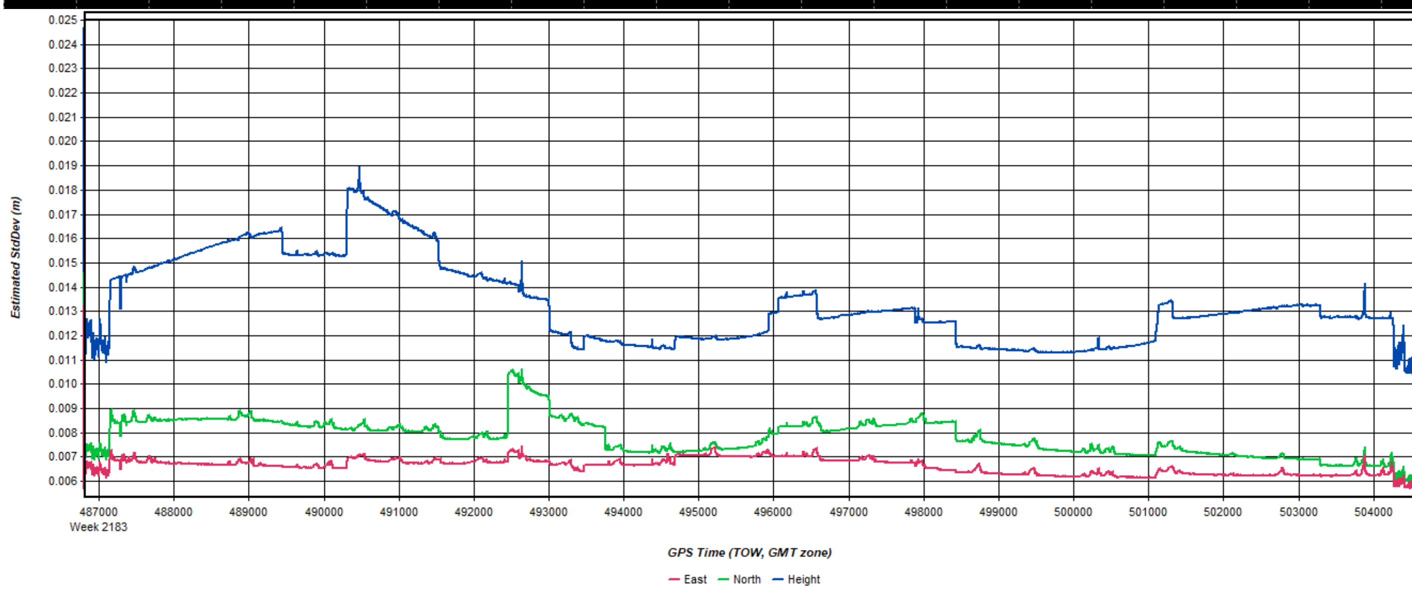
A final quality assurance process was undertaken to validate all deliverables for the project. Prior to release of data for delivery, Sanborn's Quality Control/Quality Assurance department reviews the data and then releases it for delivery.

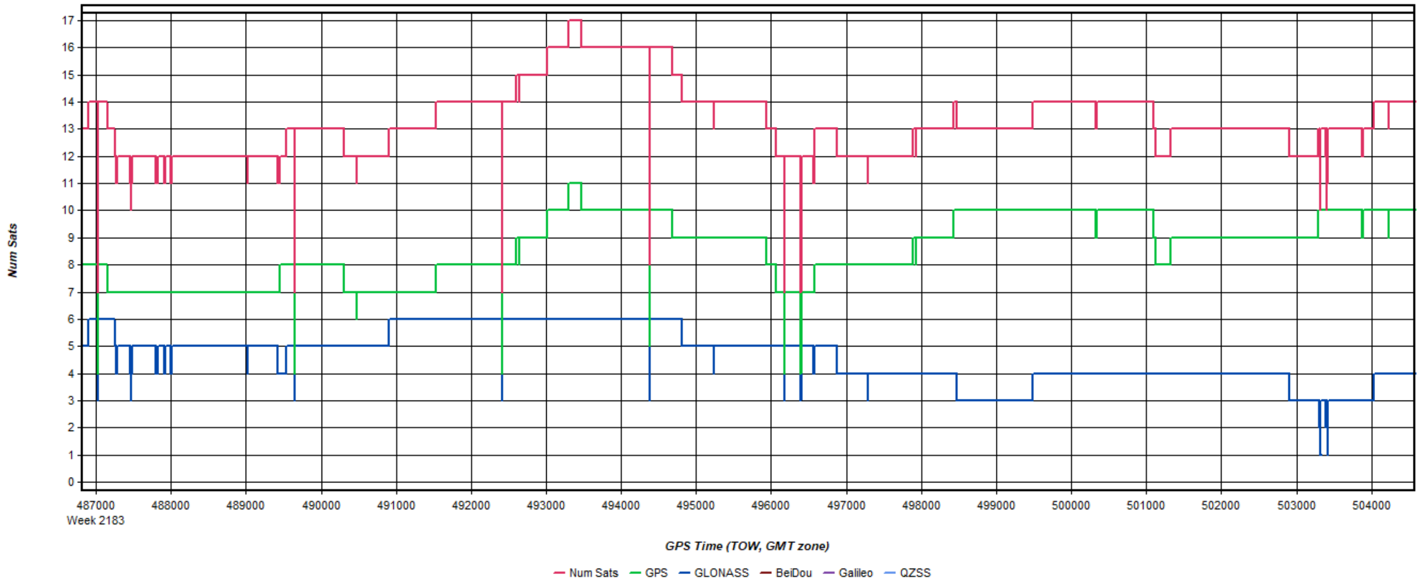
APPENDIX A – ABGNSS/IMU PLOTS

Coverage Map	Plots the Aircraft GNSS-IMU Trajectory in reference to localized GNSS Reference Stations.
Estimated Position Accuracy	Plots 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, GLONASS, and the total number of satellites are distinguished with separate color coded lines.
Combined Separation	Plots the north, east, and height position difference between any two solutions loaded into the project. These are 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 unitless 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.

20211112A_N278RC_TM91520



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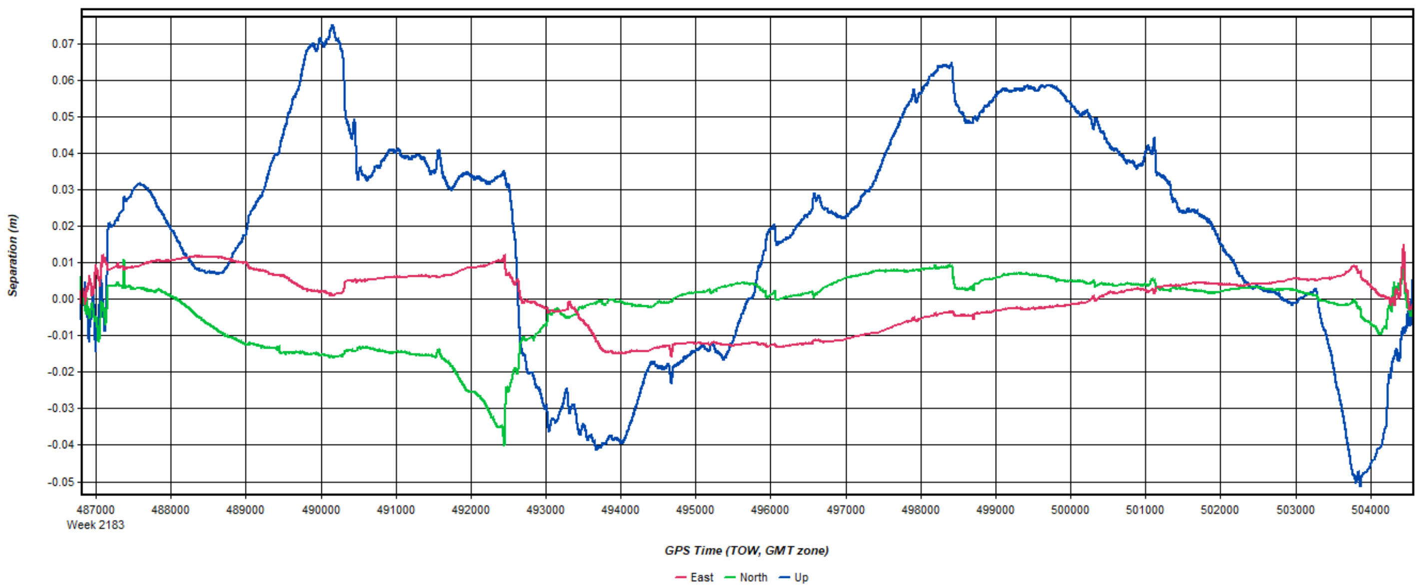
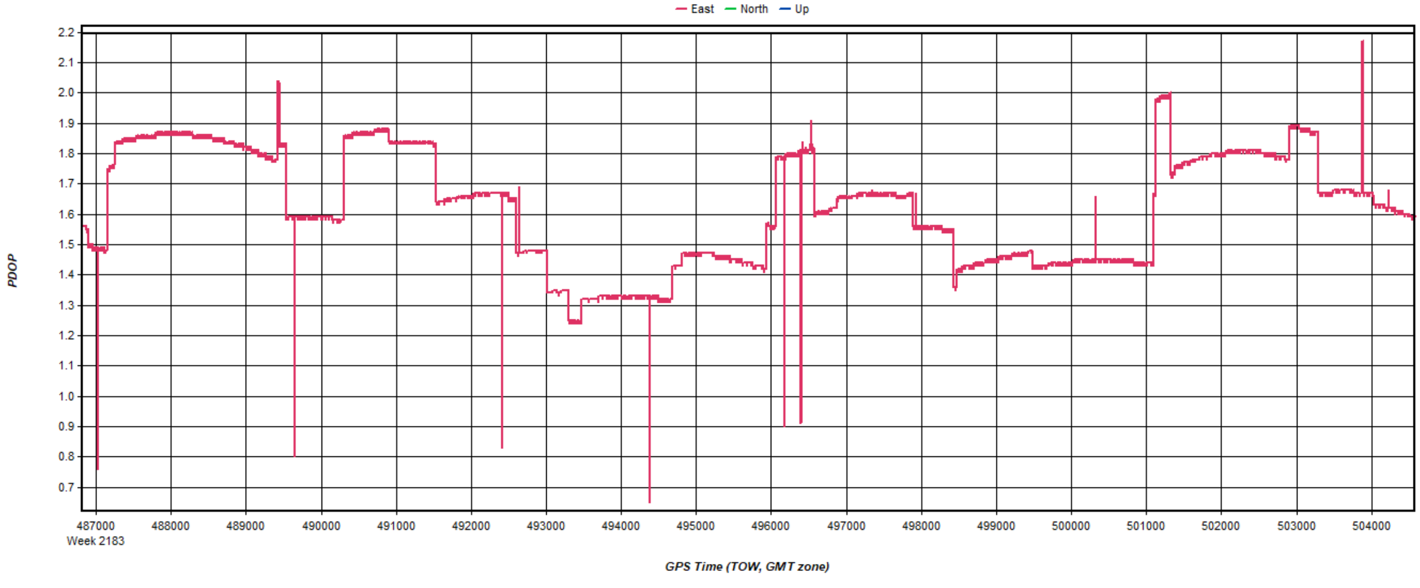
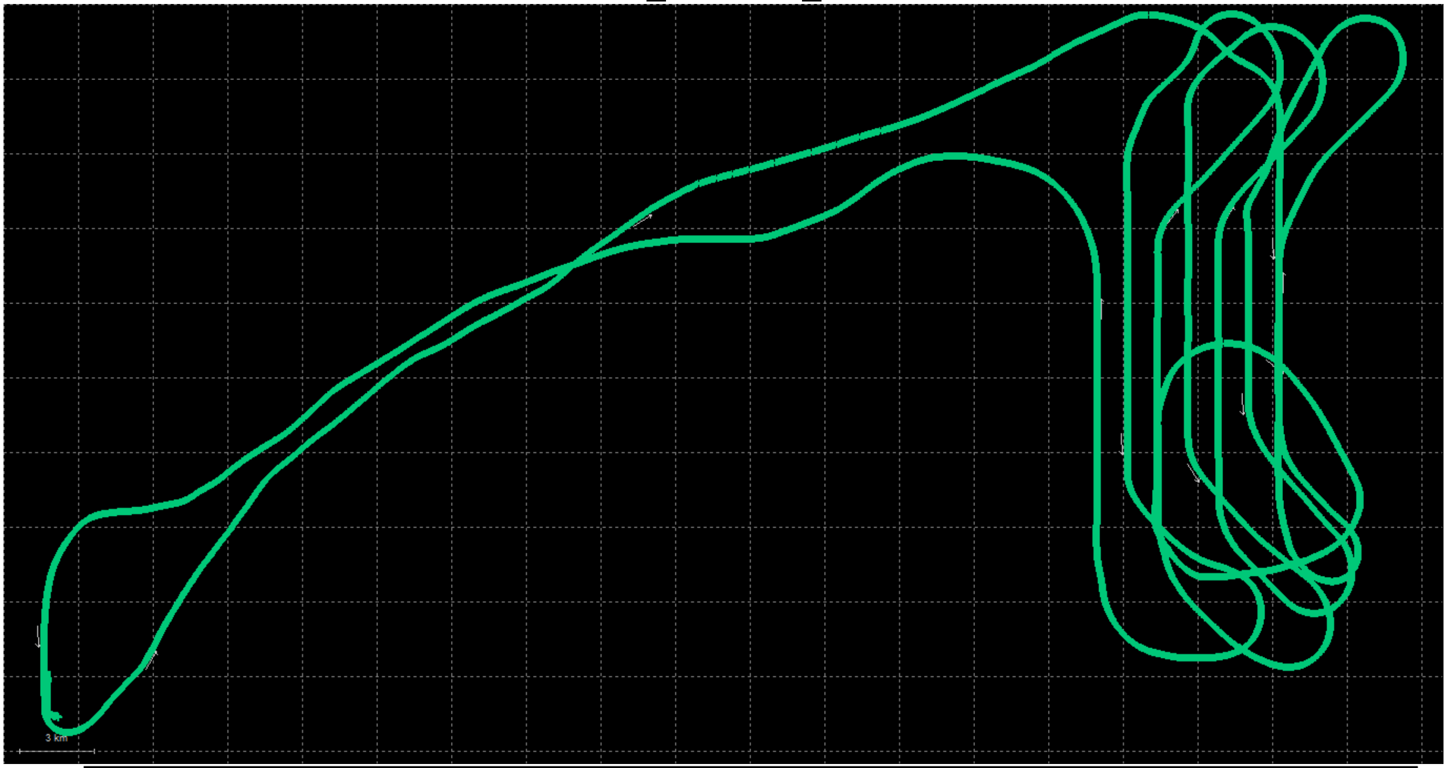
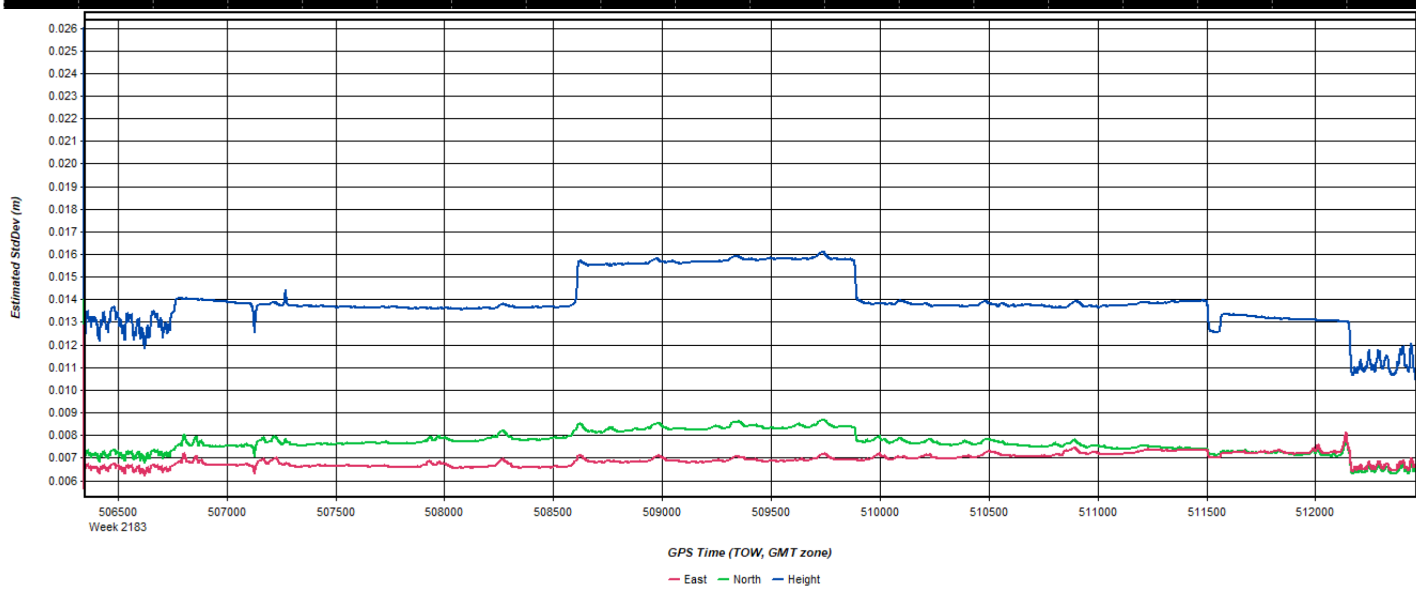
487000
Week 2183
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

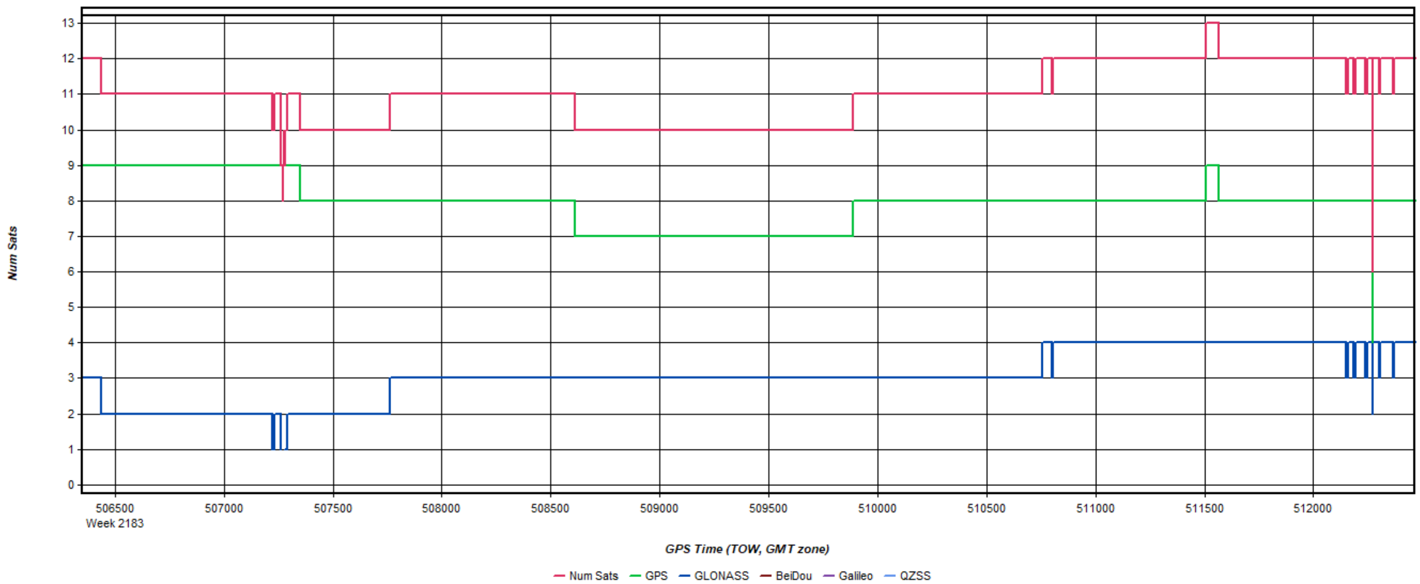

Separation (m)
487000
Week 2183
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
487000
Week 2183
GPS Time (TOW, GMT zone)
PDOP

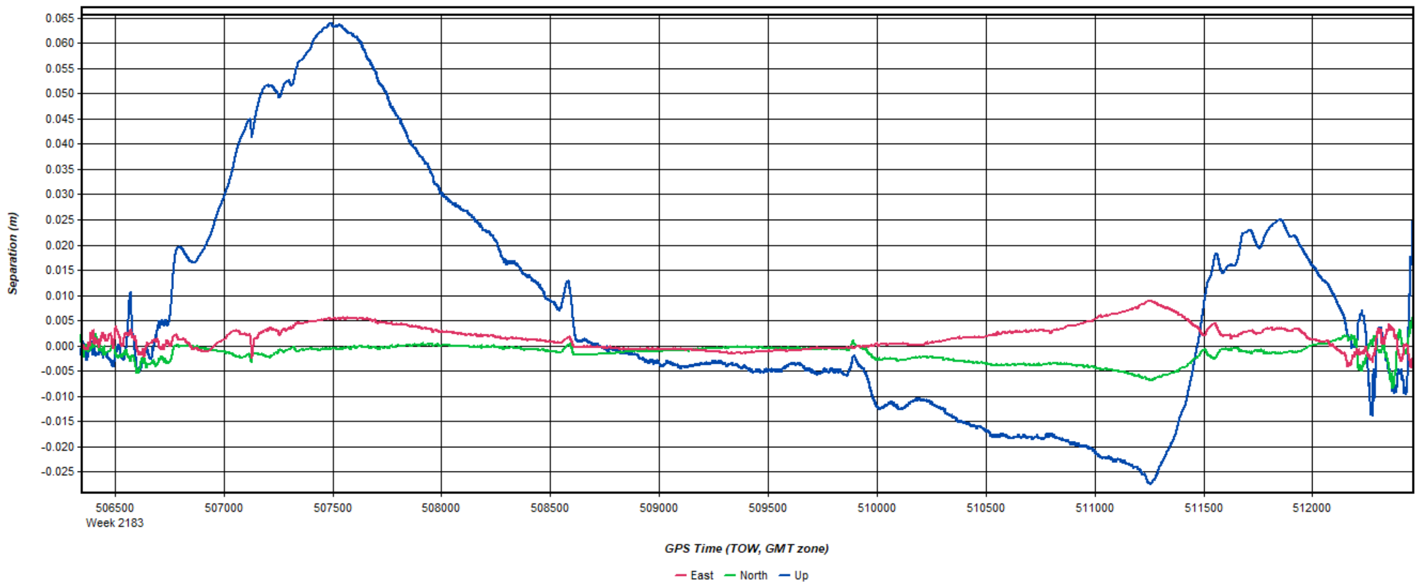
20211112B_N278RC_TM91520







Num Sats
13
12
11
10
9
8
7
6
5
4
3
2
1
0
506500
Week 2183
507000
507500
508000
508500
509000
509500
510000
510500
511000
511500
512000
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS



Separation (m)
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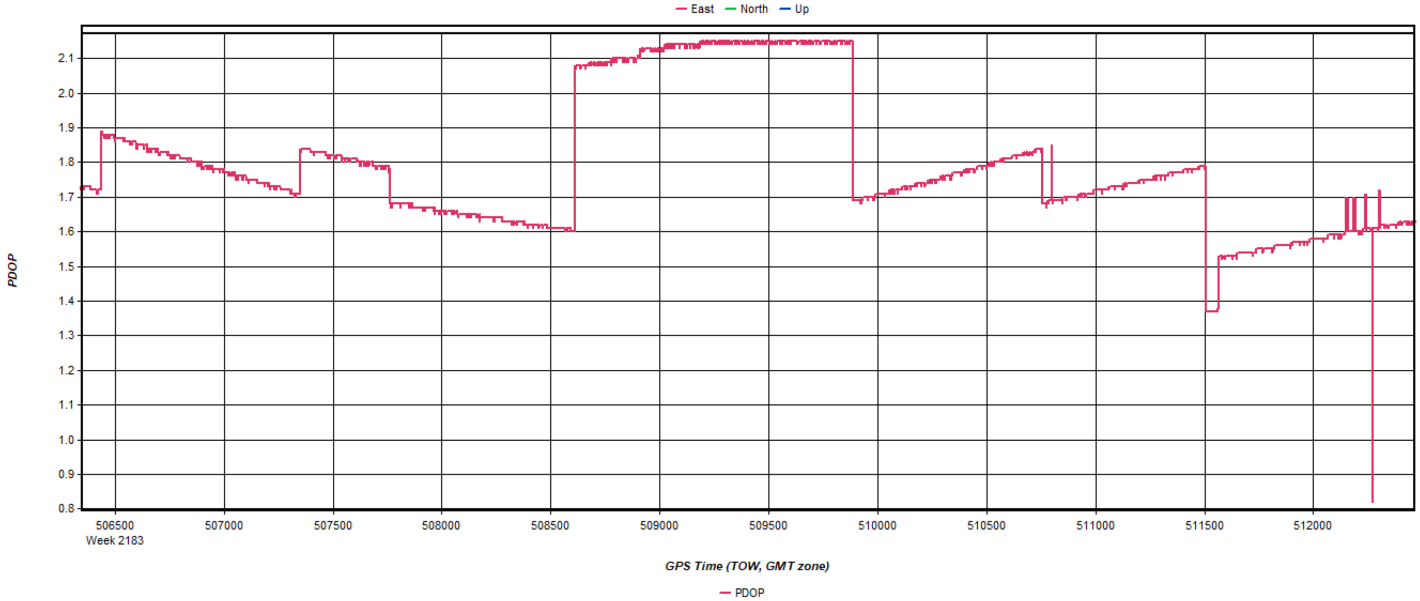
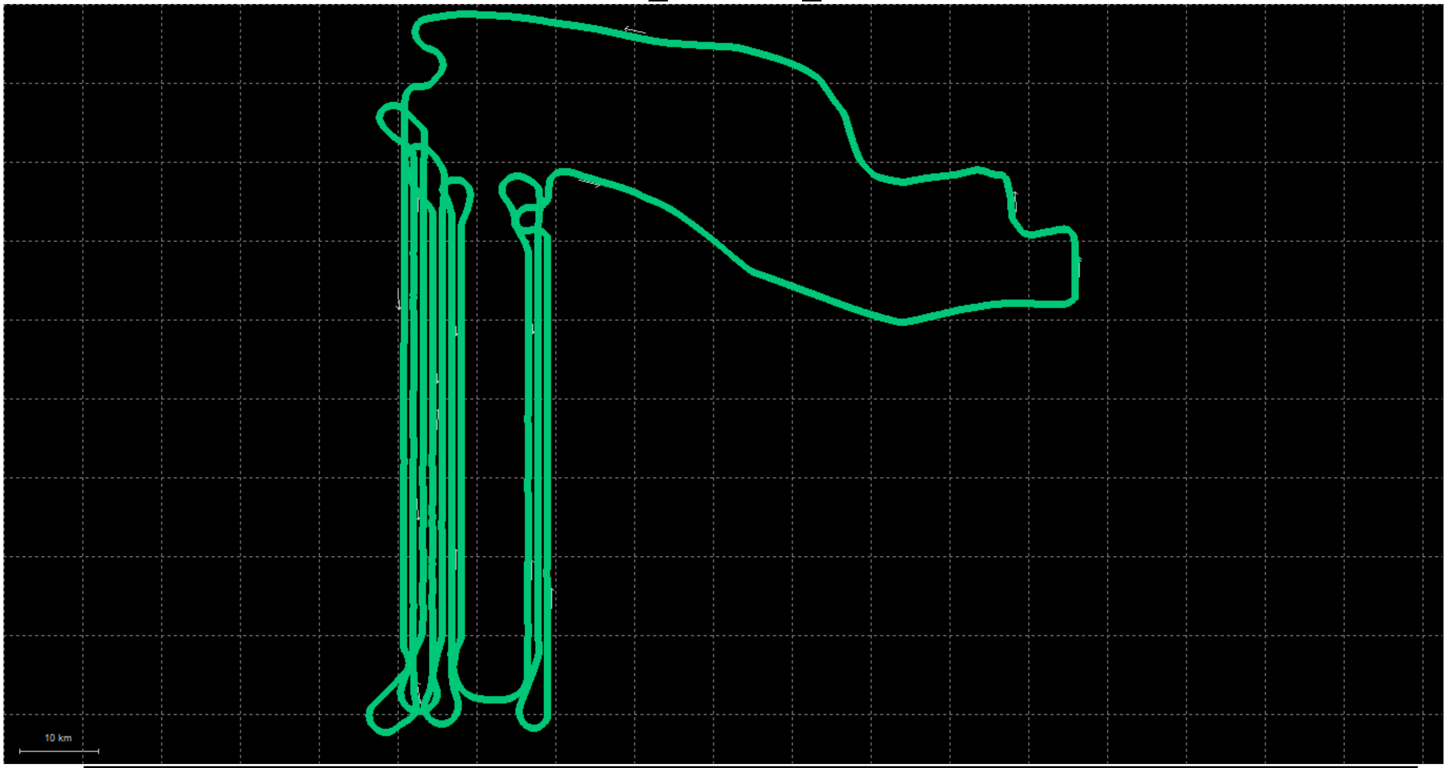
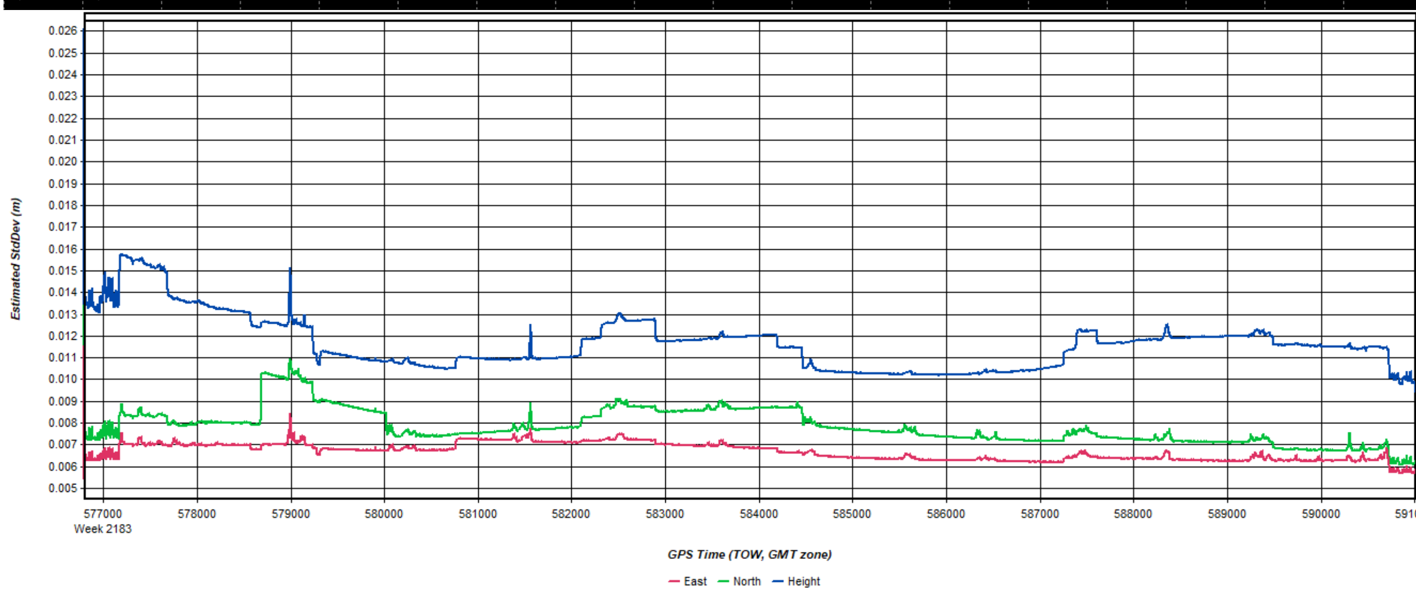
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
506500
Week 2183
507000
507500
508000
508500
509000
509500
510000
510500
511000
511500
512000
GPS Time (TOW, GMT zone)
East
North
Up

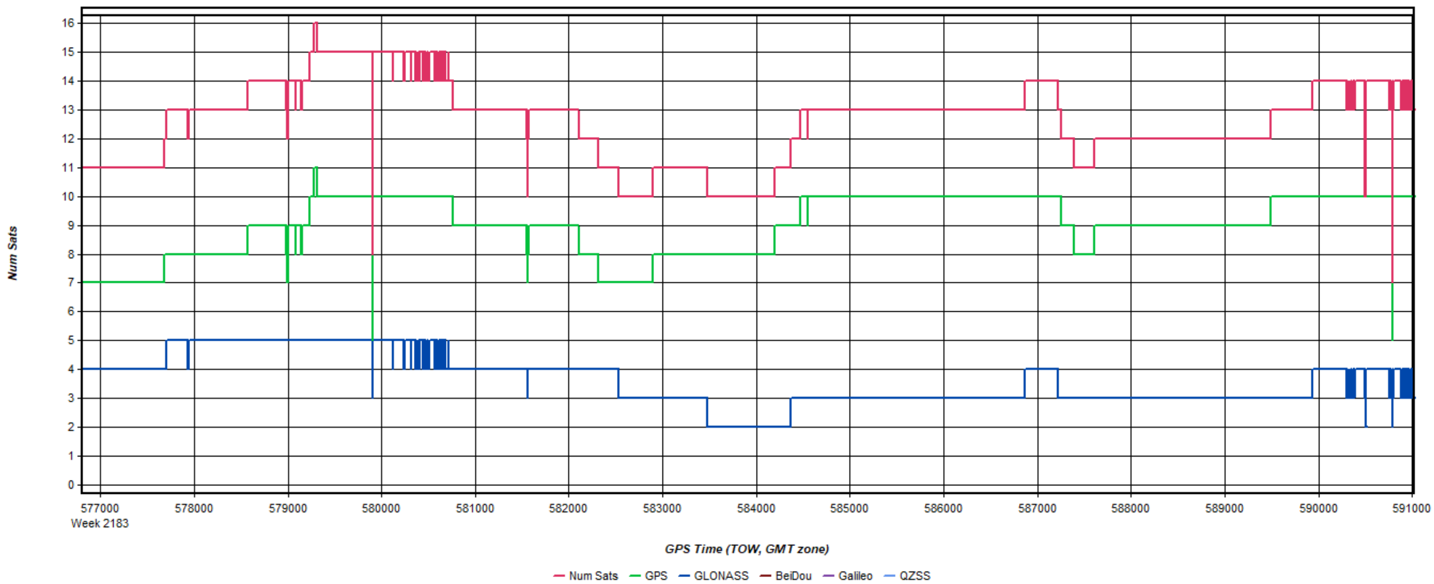


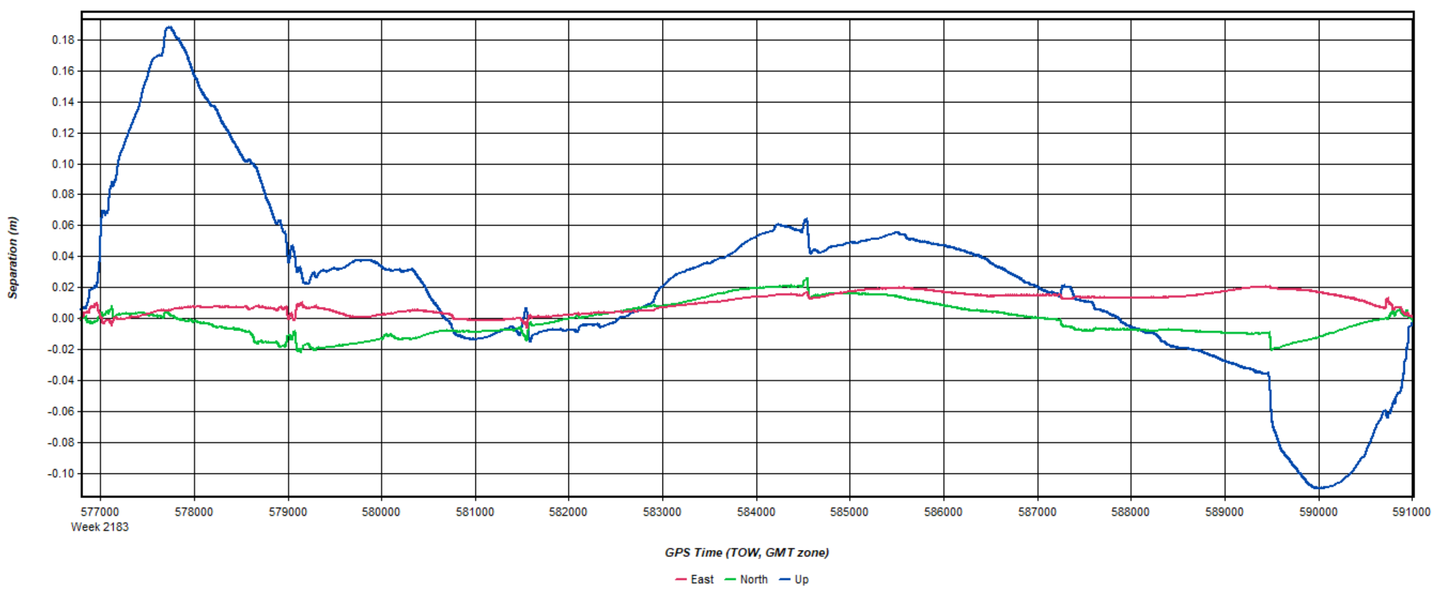
PDOP
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
506500
Week 2183
507000
507500
508000
508500
509000
509500
510000
510500
511000
511500
512000
GPS Time (TOW, GMT zone)
PDOP

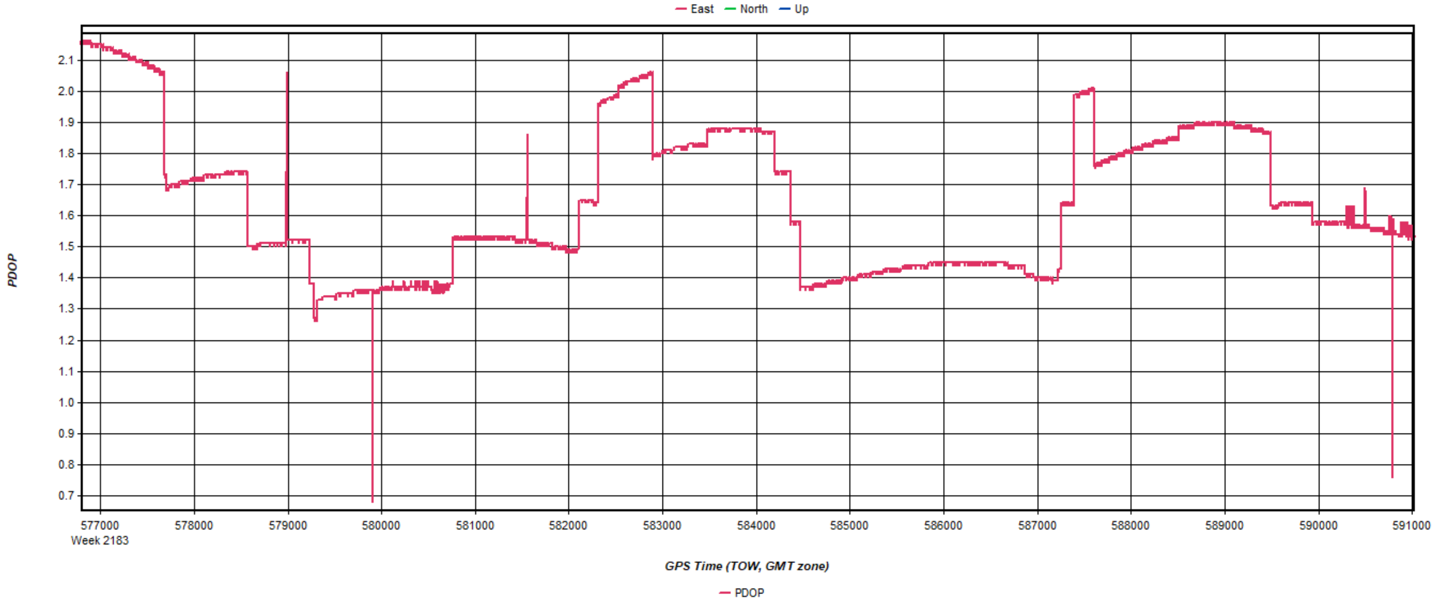
20211113A_N100NE_TM91555



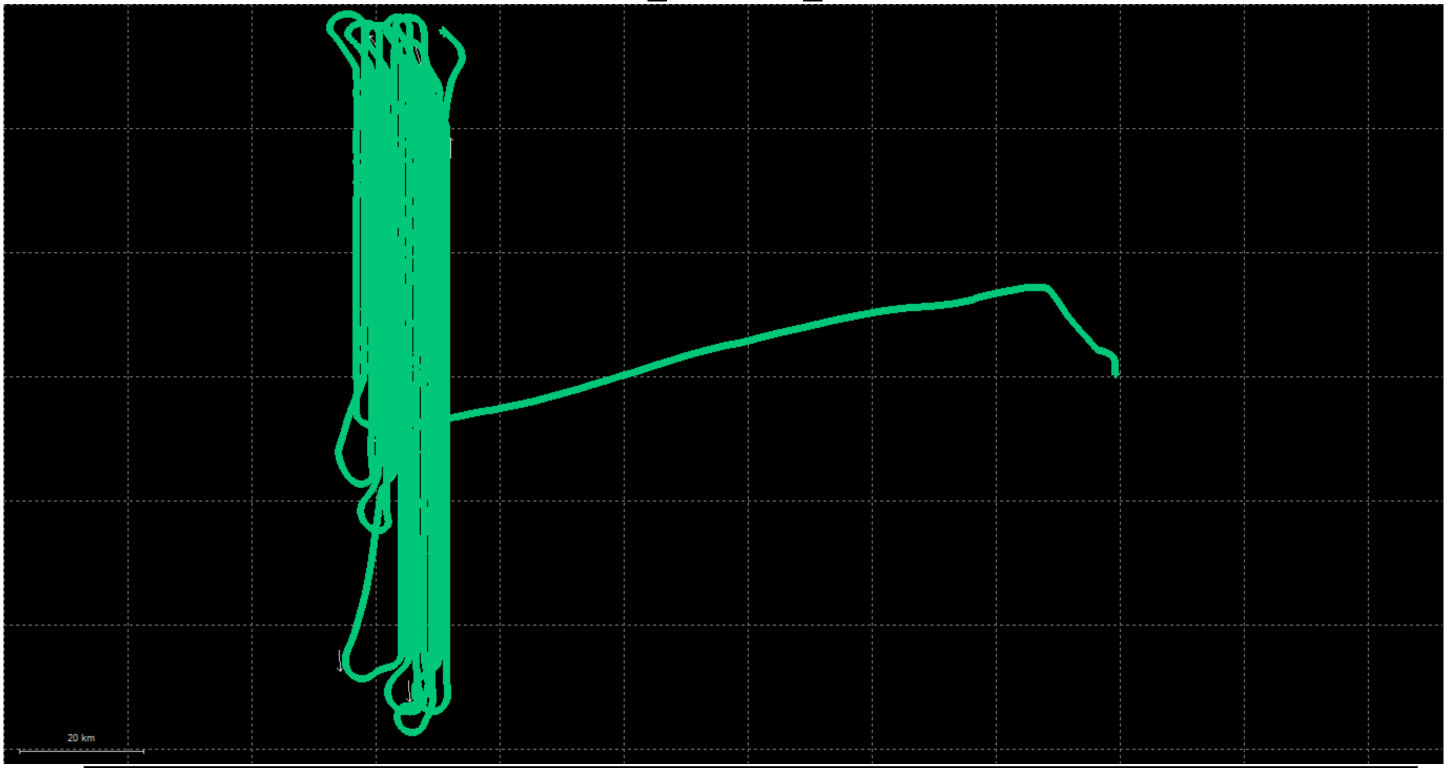


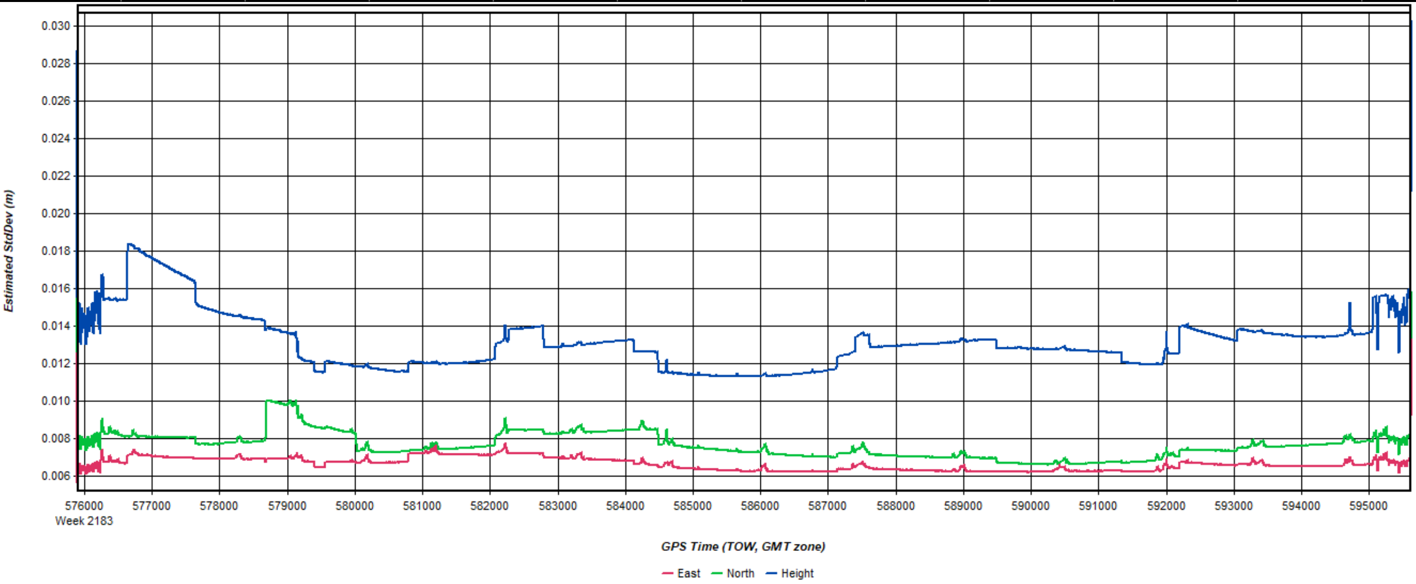

Num Sats
GPS Time (TOW, GMT zone)
Week 2183
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

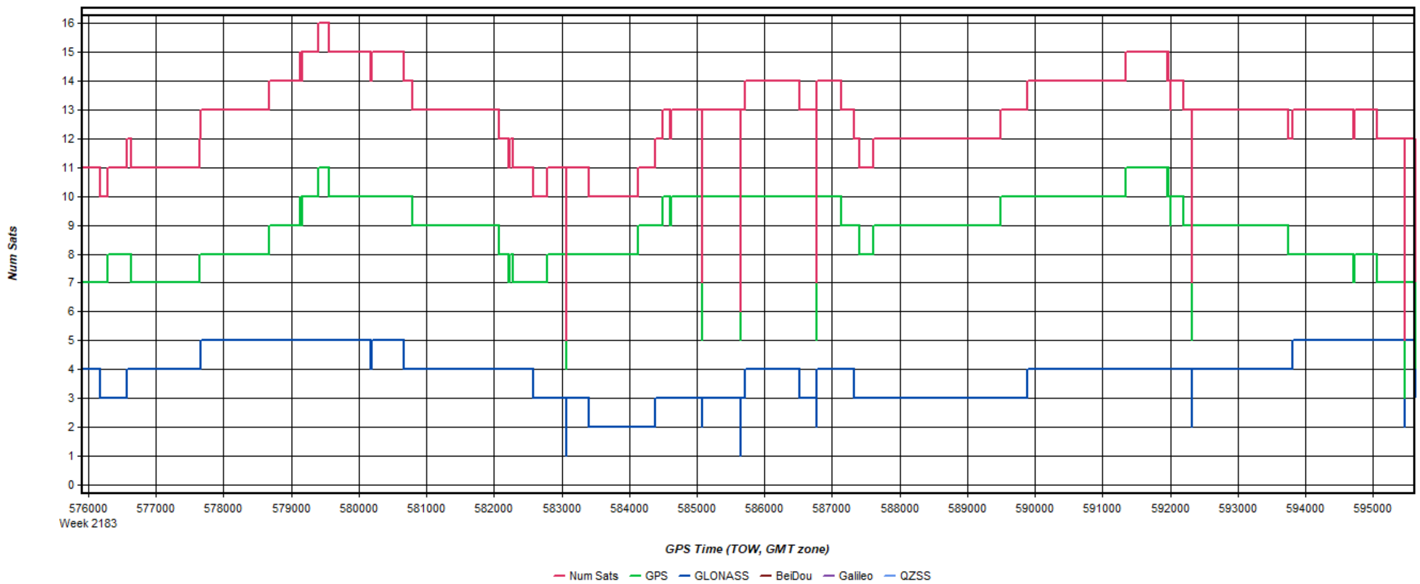

Separation (m)
GPS Time (TOW, GMT zone)
Week 2183
East
North
Up

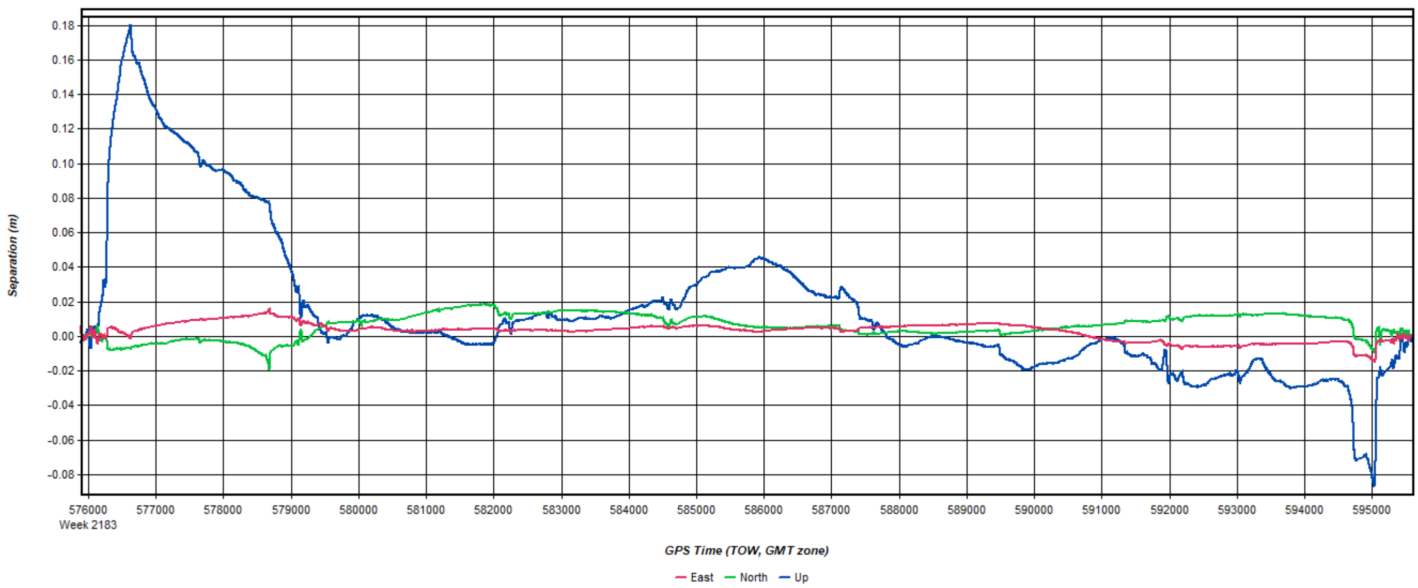

PDOP
GPS Time (TOW, GMT zone)
Week 2183
PDOP

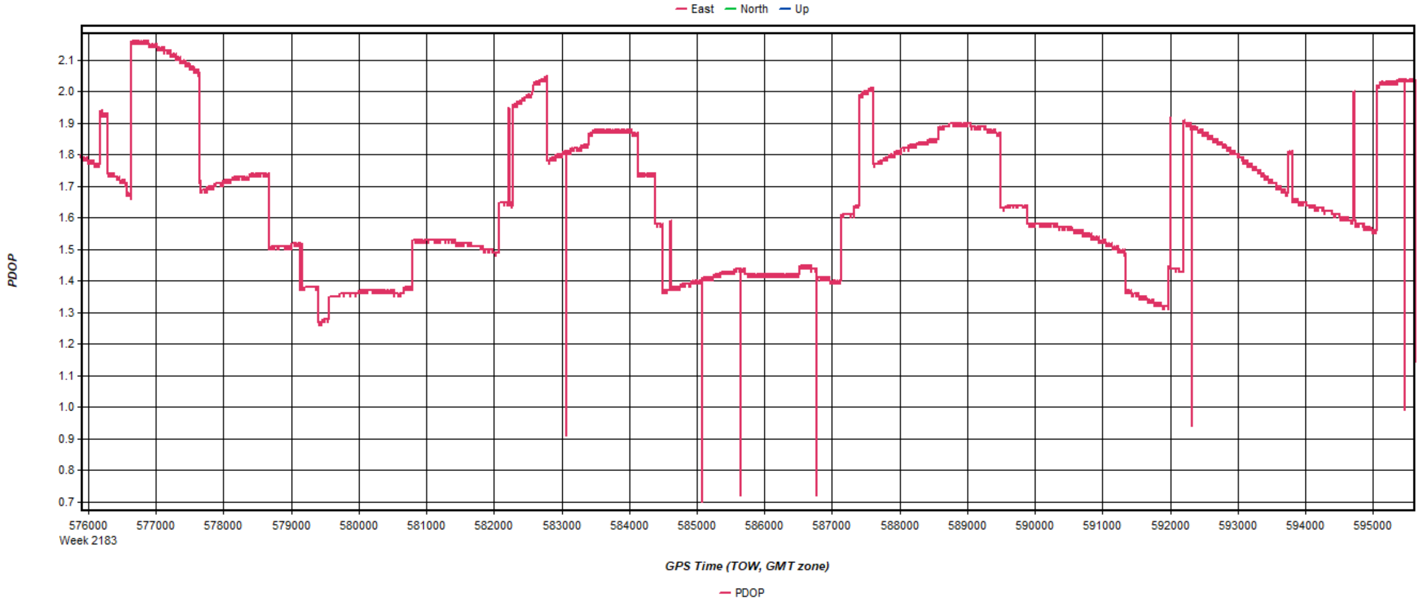
20211113A_N278RC_TM91520



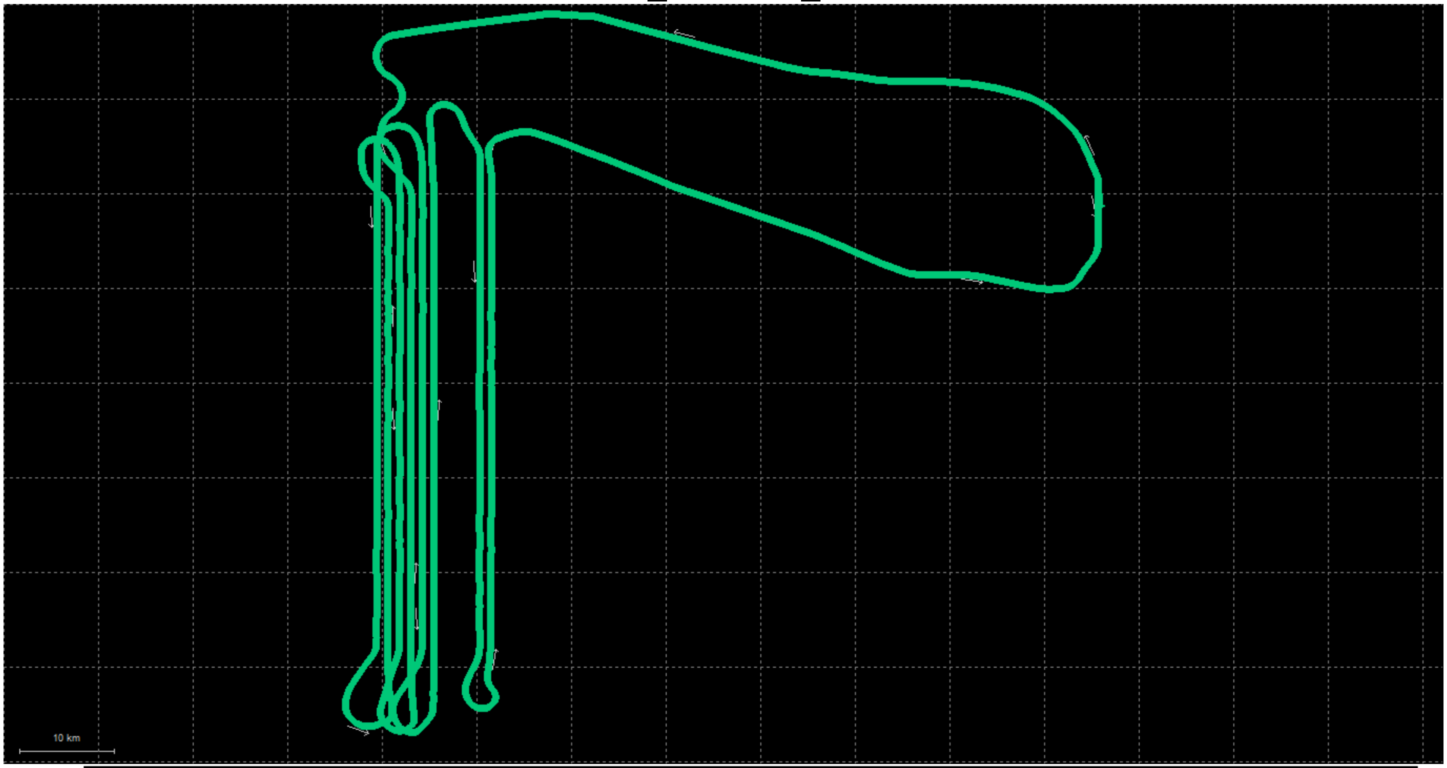


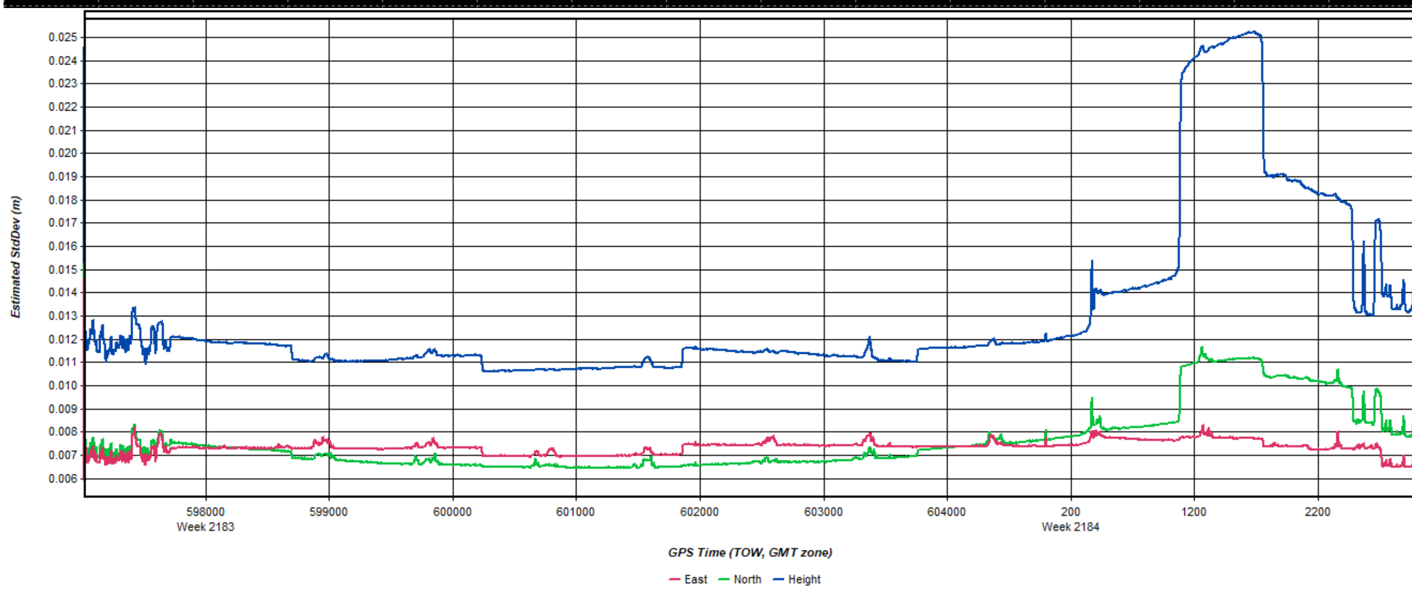

Num Sats
Week 2183
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

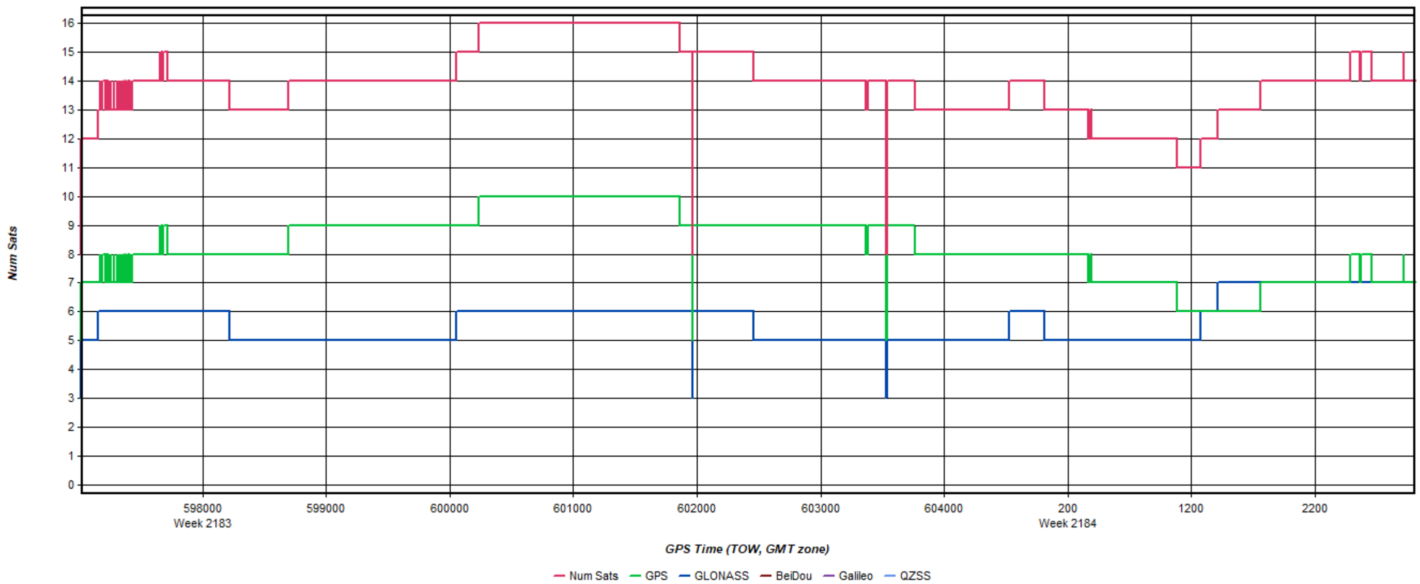

Separation (m)
Week 2183
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
Week 2183
GPS Time (TOW, GMT zone)
PDOP

20211113B_N100NE_TM91555






Num Sats
16
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14
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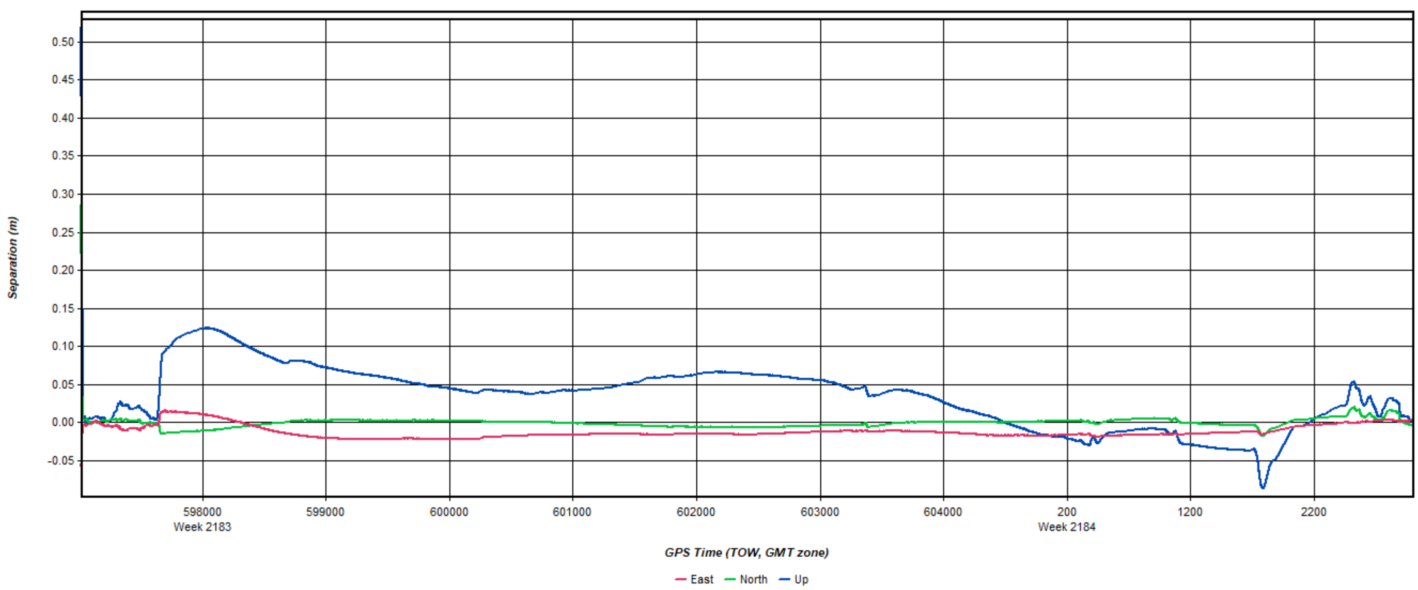
12
11
10
9
8
7
6
5
4
3
2
1
0
598000
Week 2183
599000
600000
601000
602000
603000
604000
200
Week 2184
1200
2200
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS


Separation (m)
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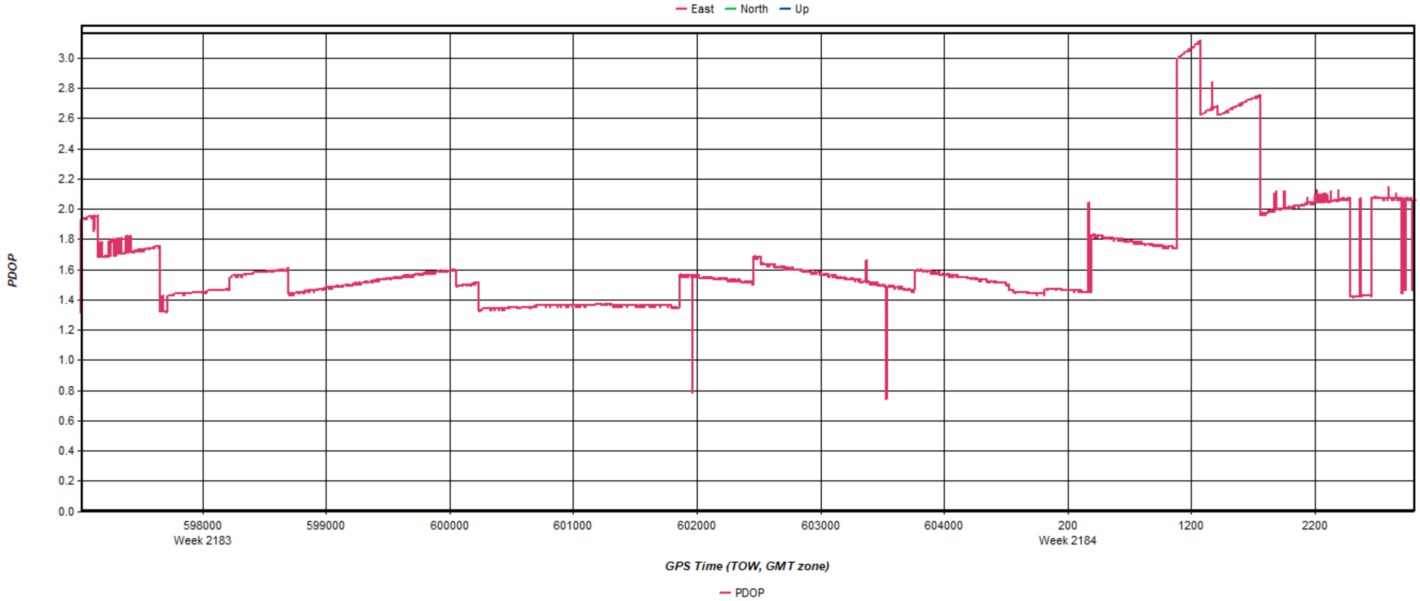
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
598000
Week 2183
599000
600000
601000
602000
603000
604000
200
Week 2184
1200
2200
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
598000
Week 2183
599000
600000
601000
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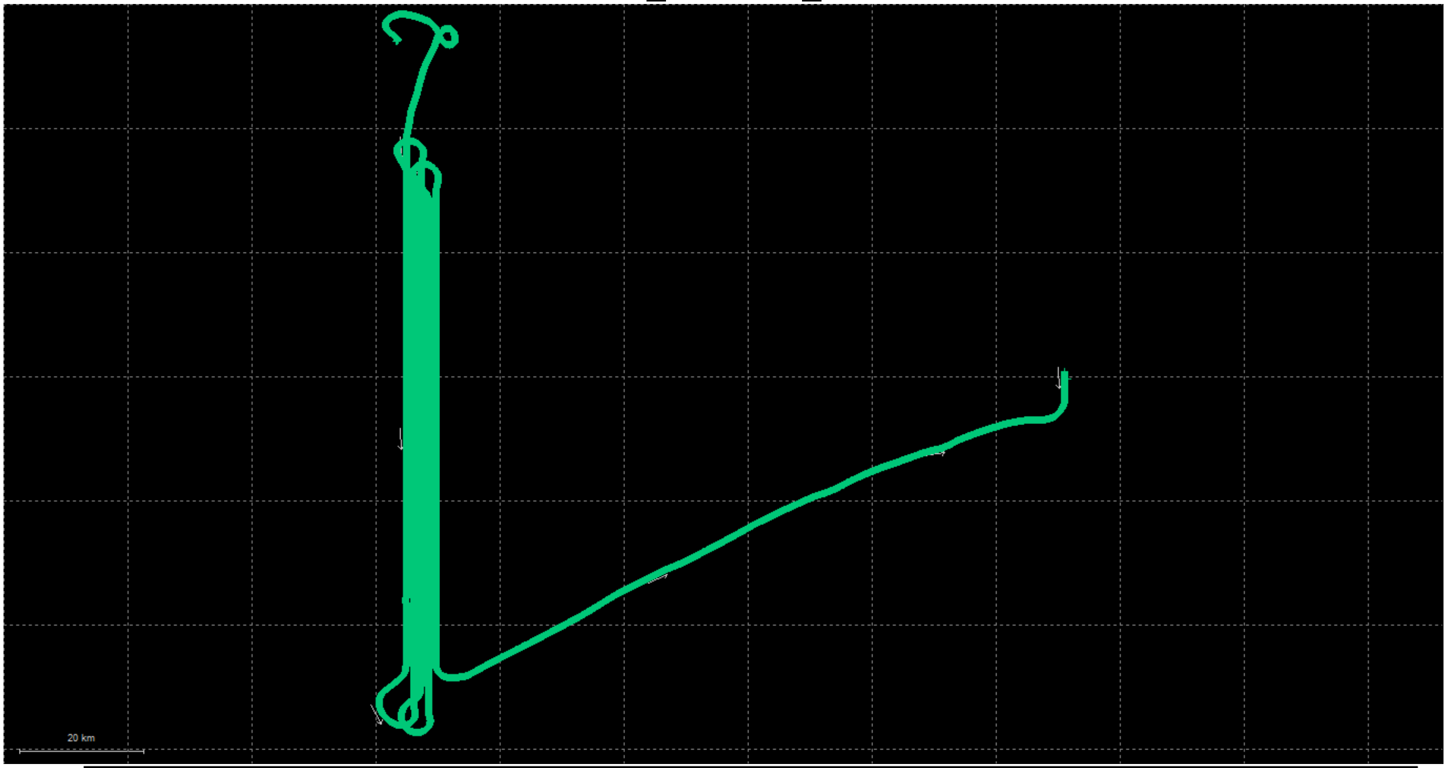
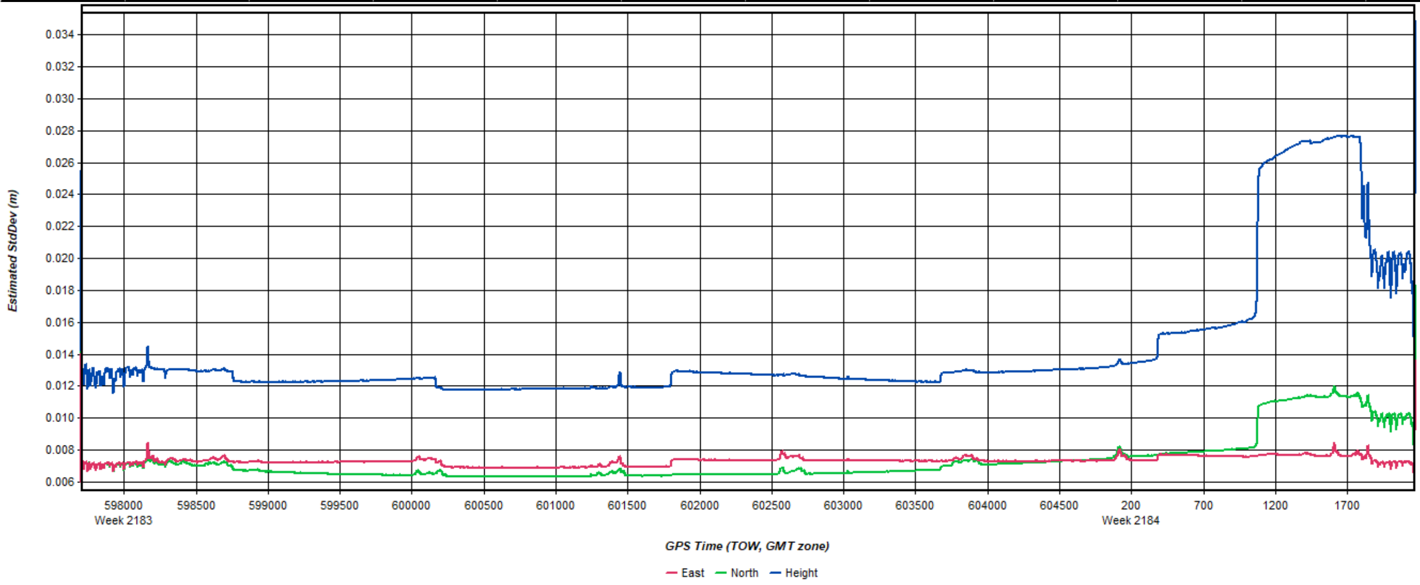
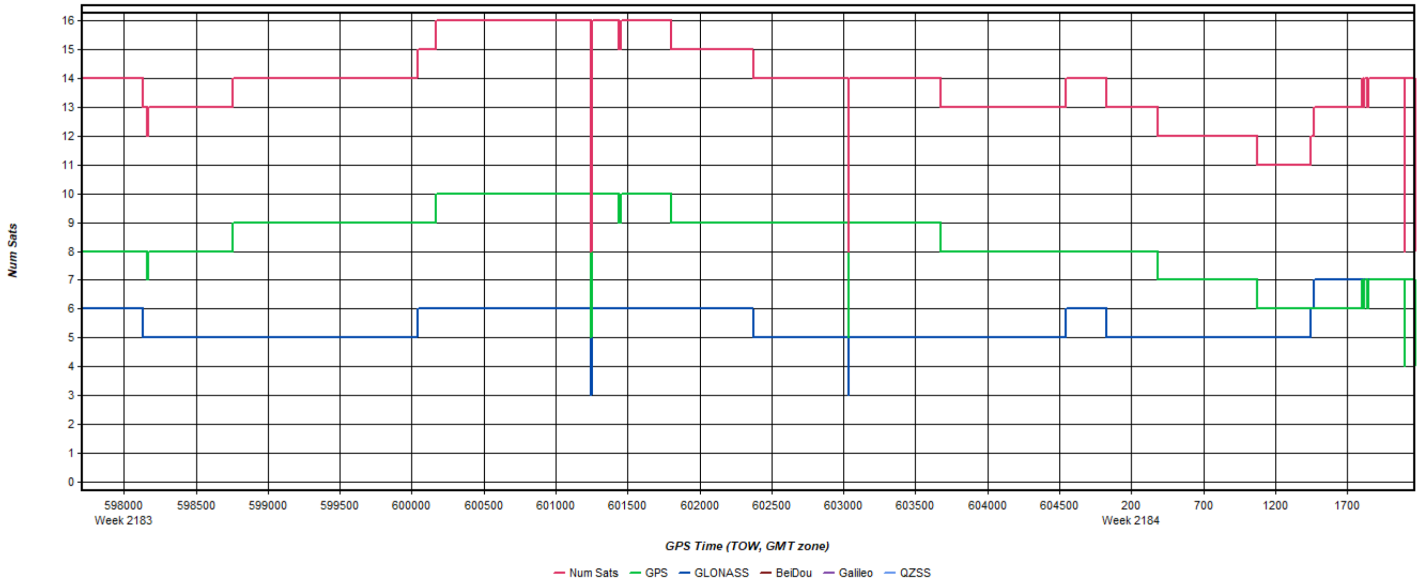
603000
604000
200
Week 2184
1200
2200
GPS Time (TOW, GMT zone)
PDOP

20211113B_N278RC_TM91520






Num Sats
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Week 2183
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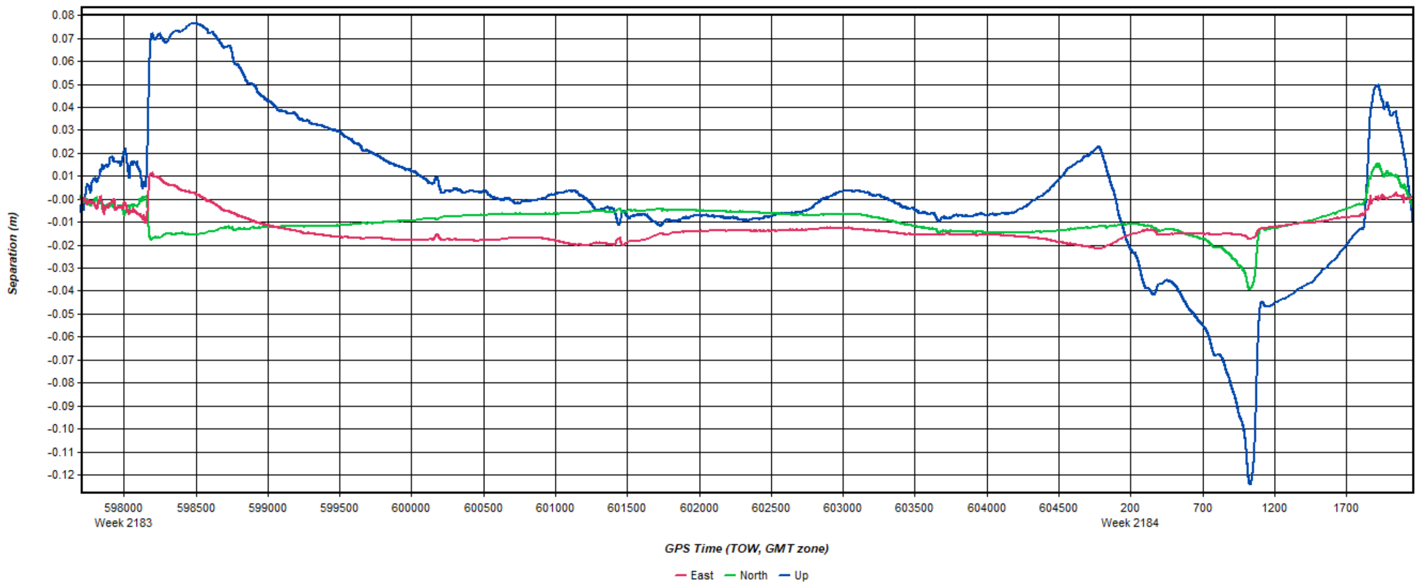
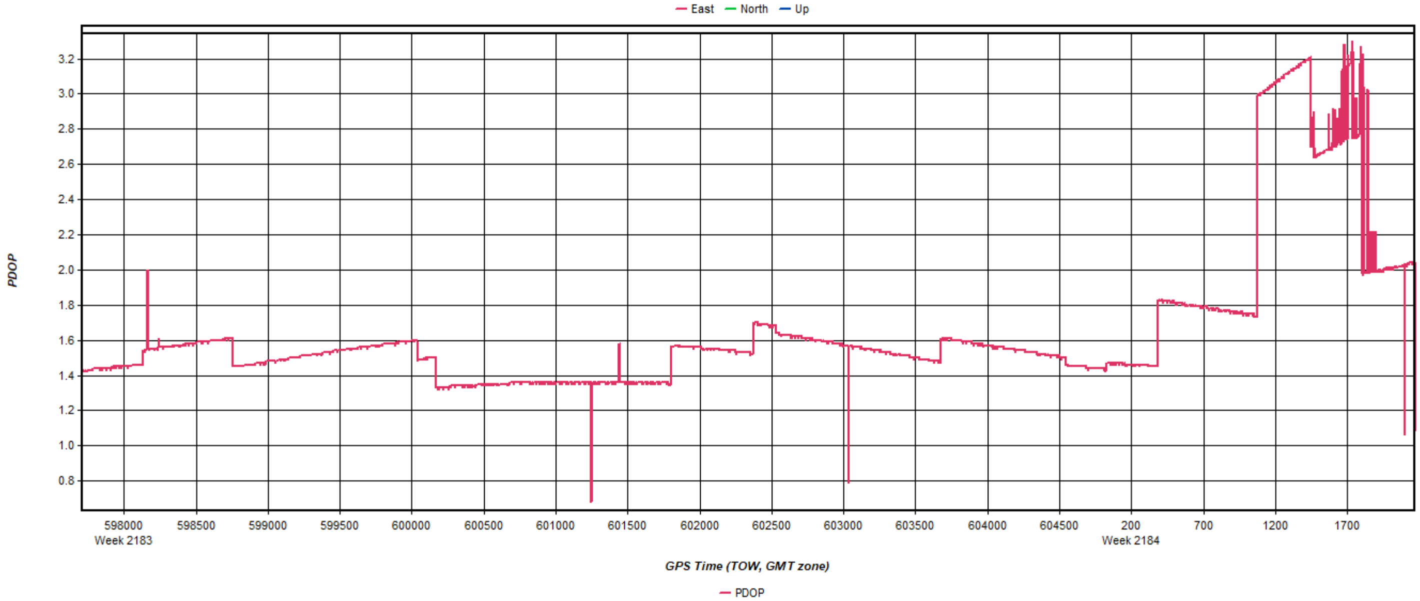
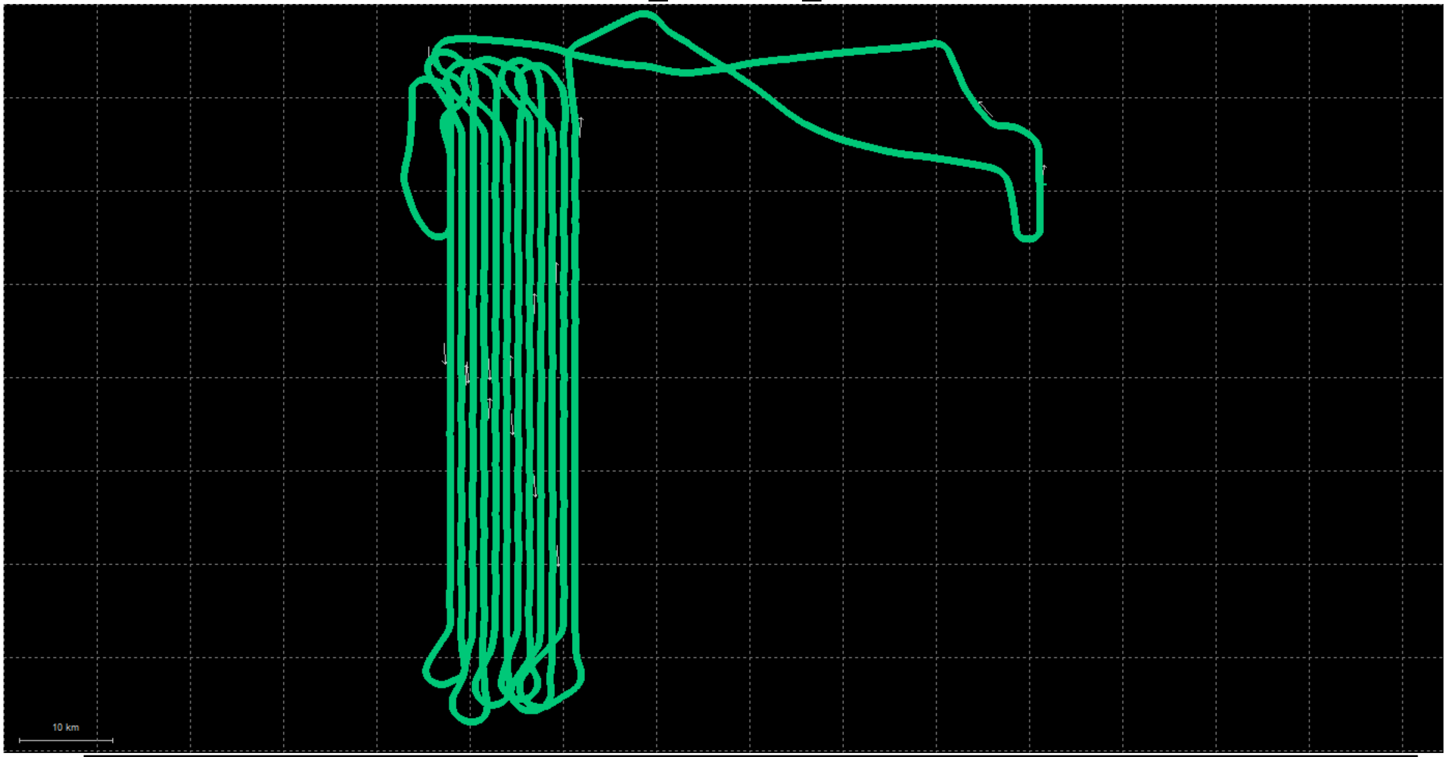
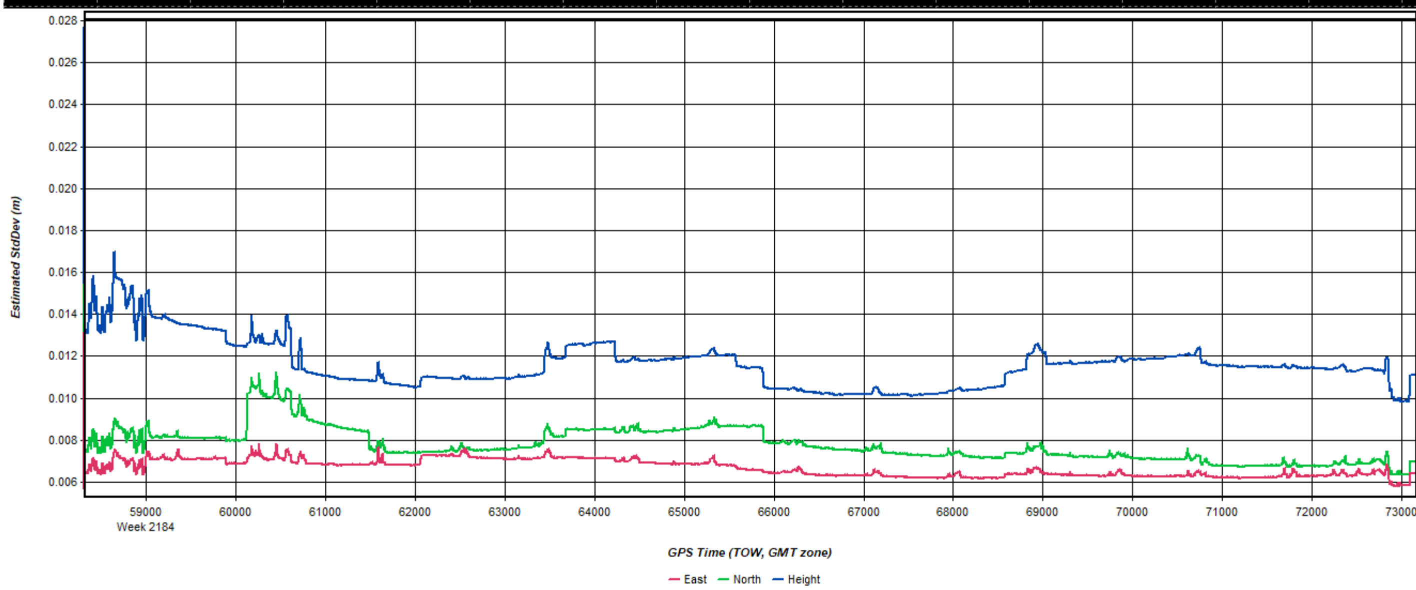
599000
599500
600000
600500
601000
601500
602000
602500
603000
603500
604000
604500
200
Week 2184
700
1200
1700
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

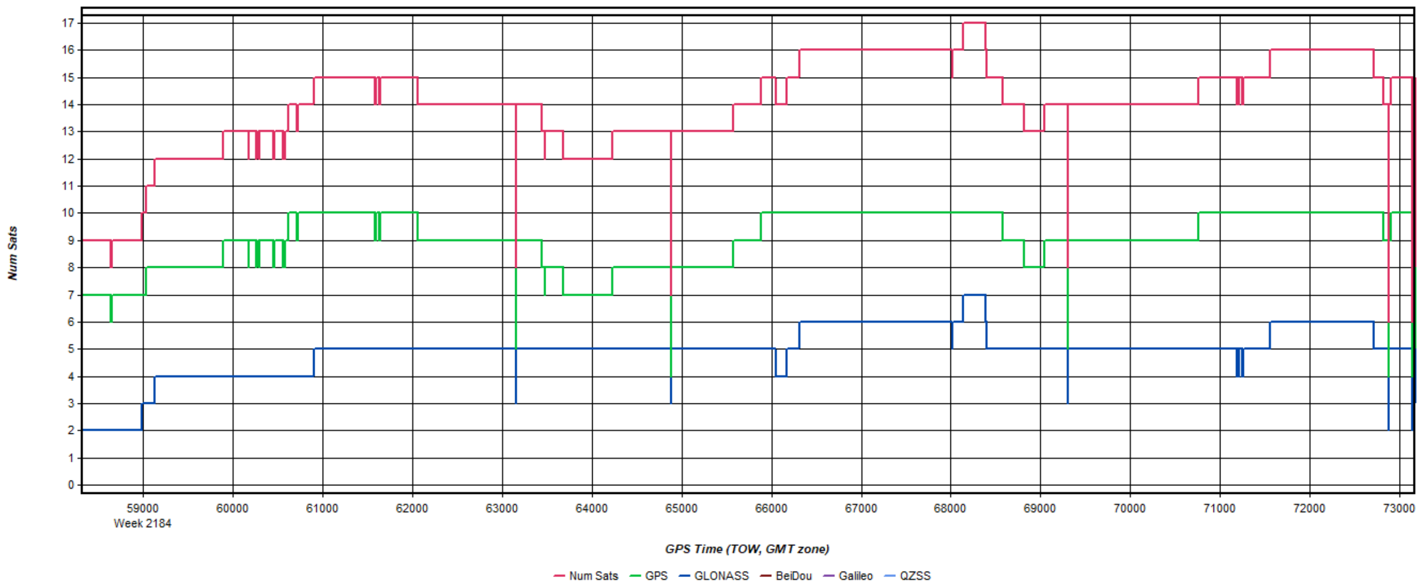

Separation (m)
GPS Time (TOW, GMT zone)
East
North
Up

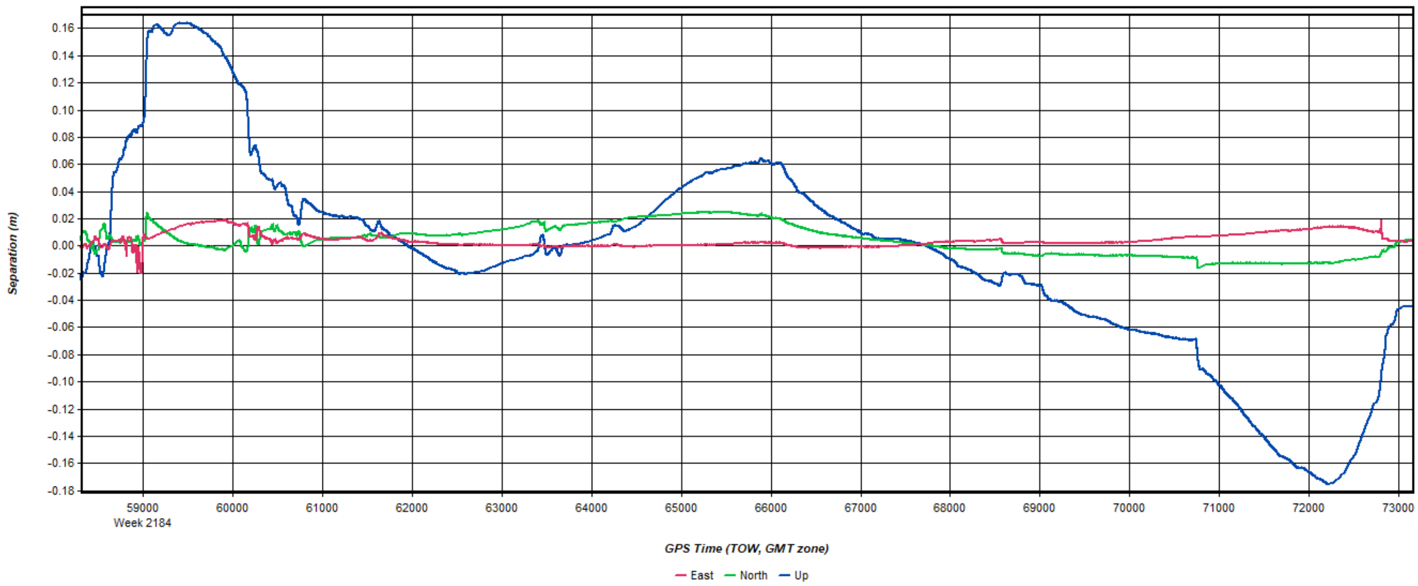

PDOP
GPS Time (TOW, GMT zone)
PDOP

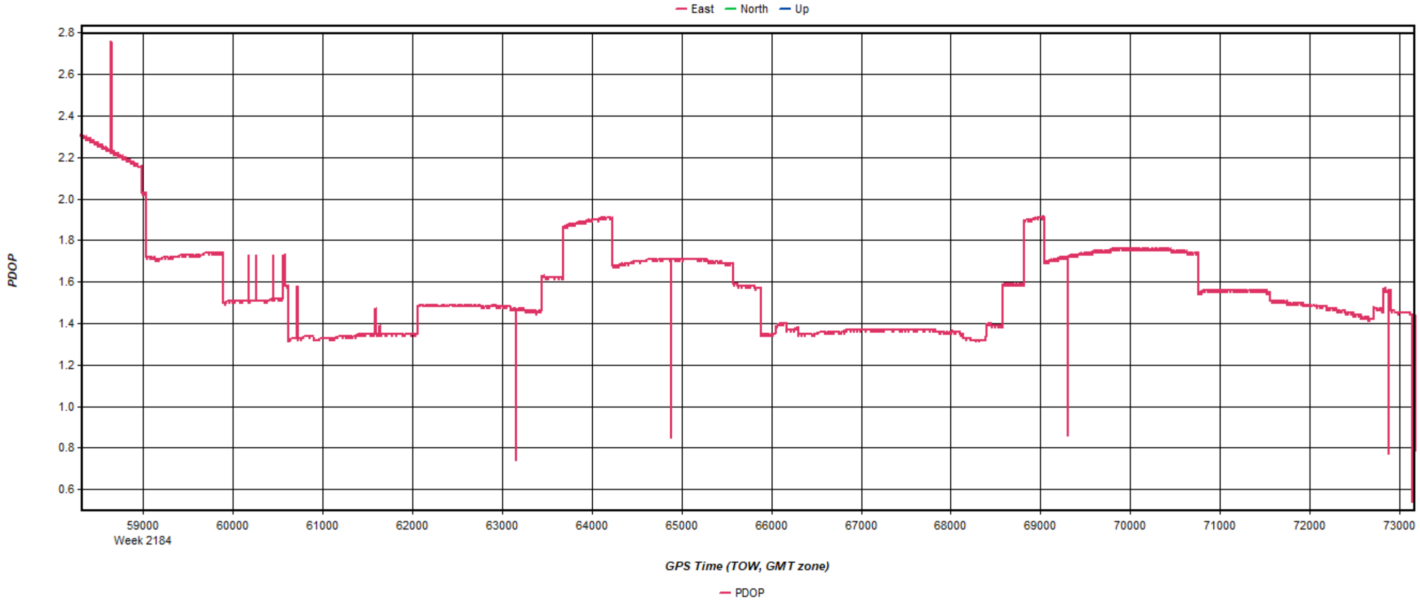
20211114A_N100NE_TM91555



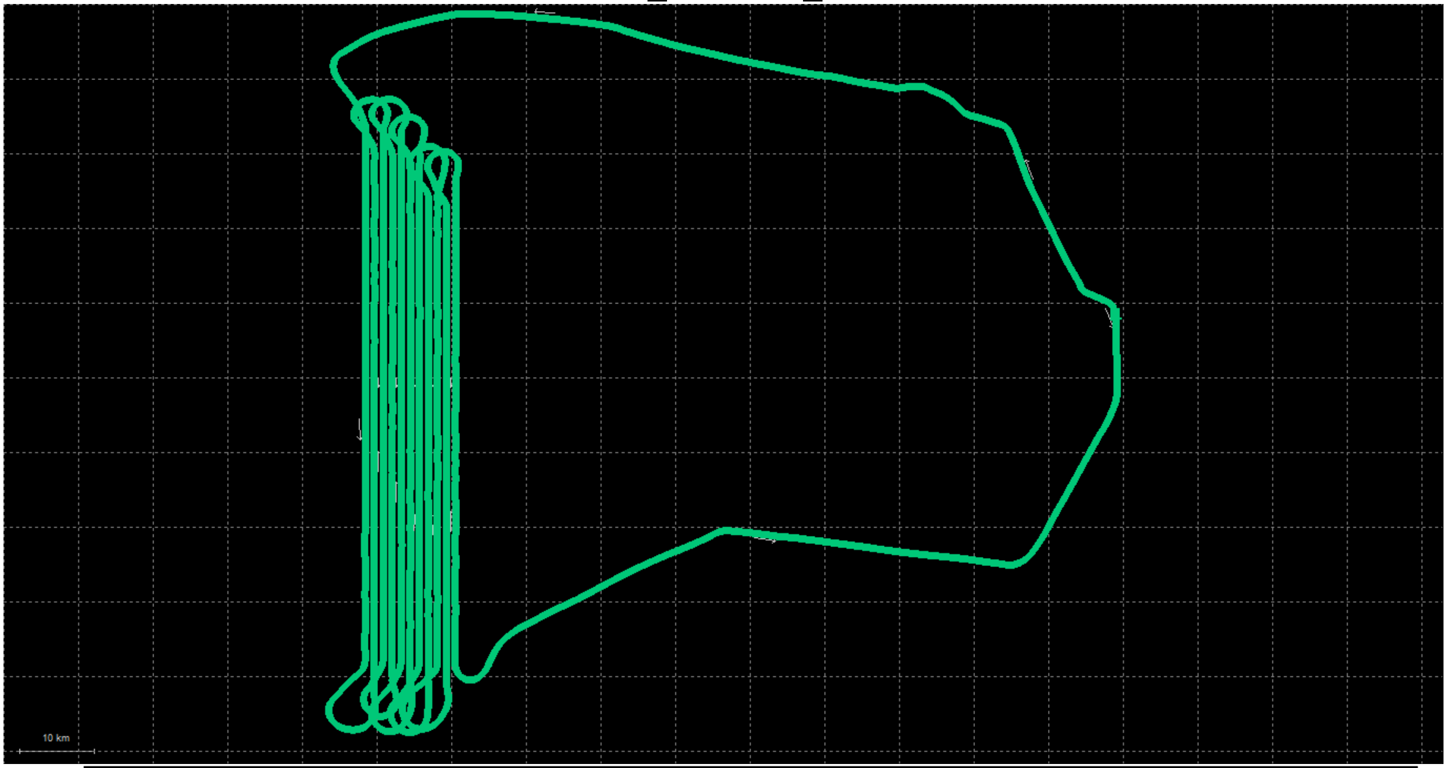


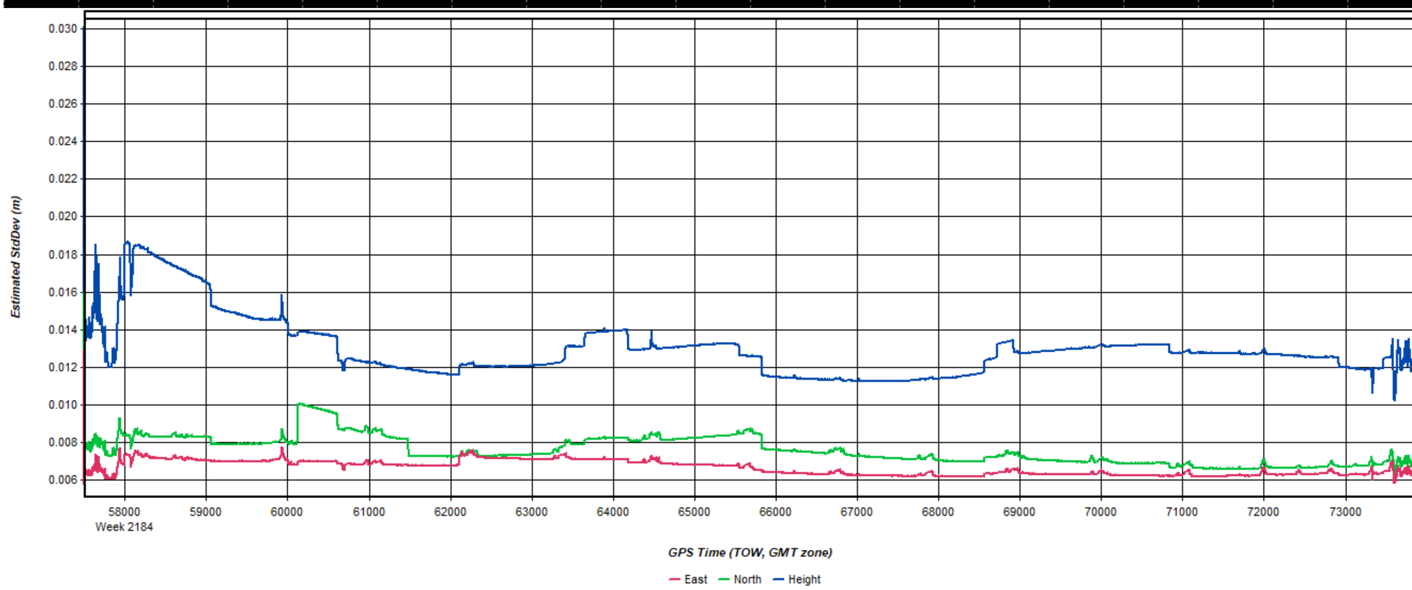

Num Sats
Week 2184
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

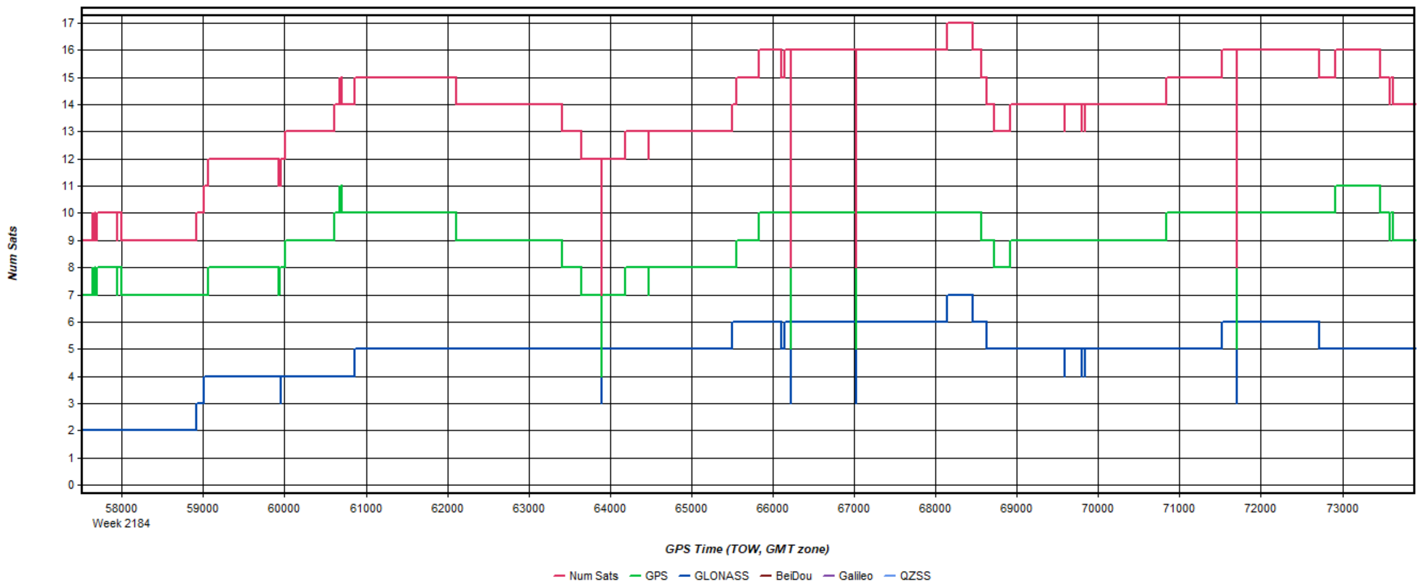

Separation (m)
Week 2184
GPS Time (TOW, GMT zone)
East
North
Up

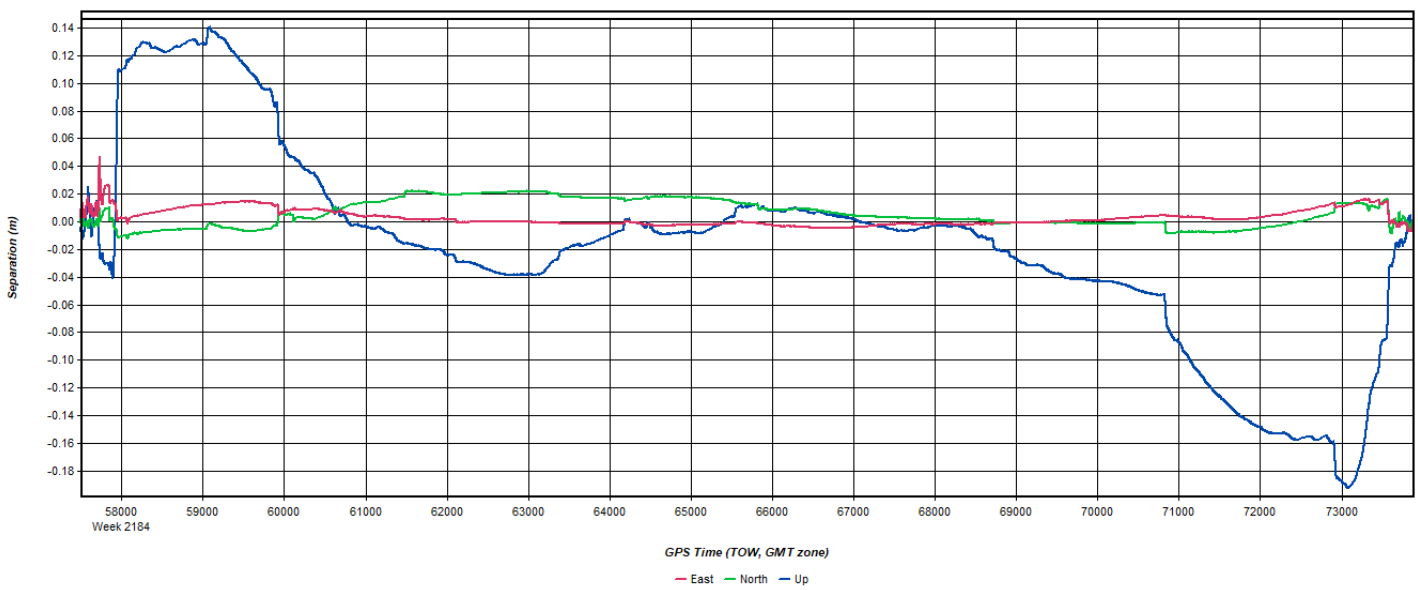

PDOP
Week 2184
GPS Time (TOW, GMT zone)
PDOP

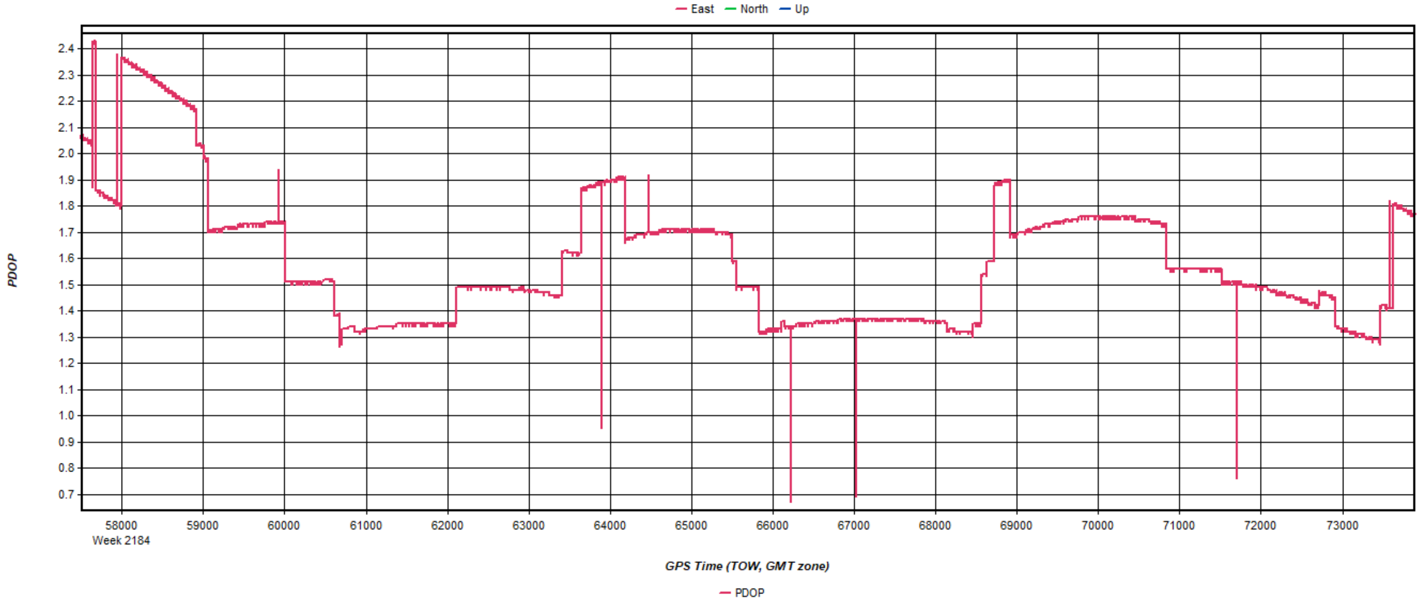
20211114A_N278RC_TM91520



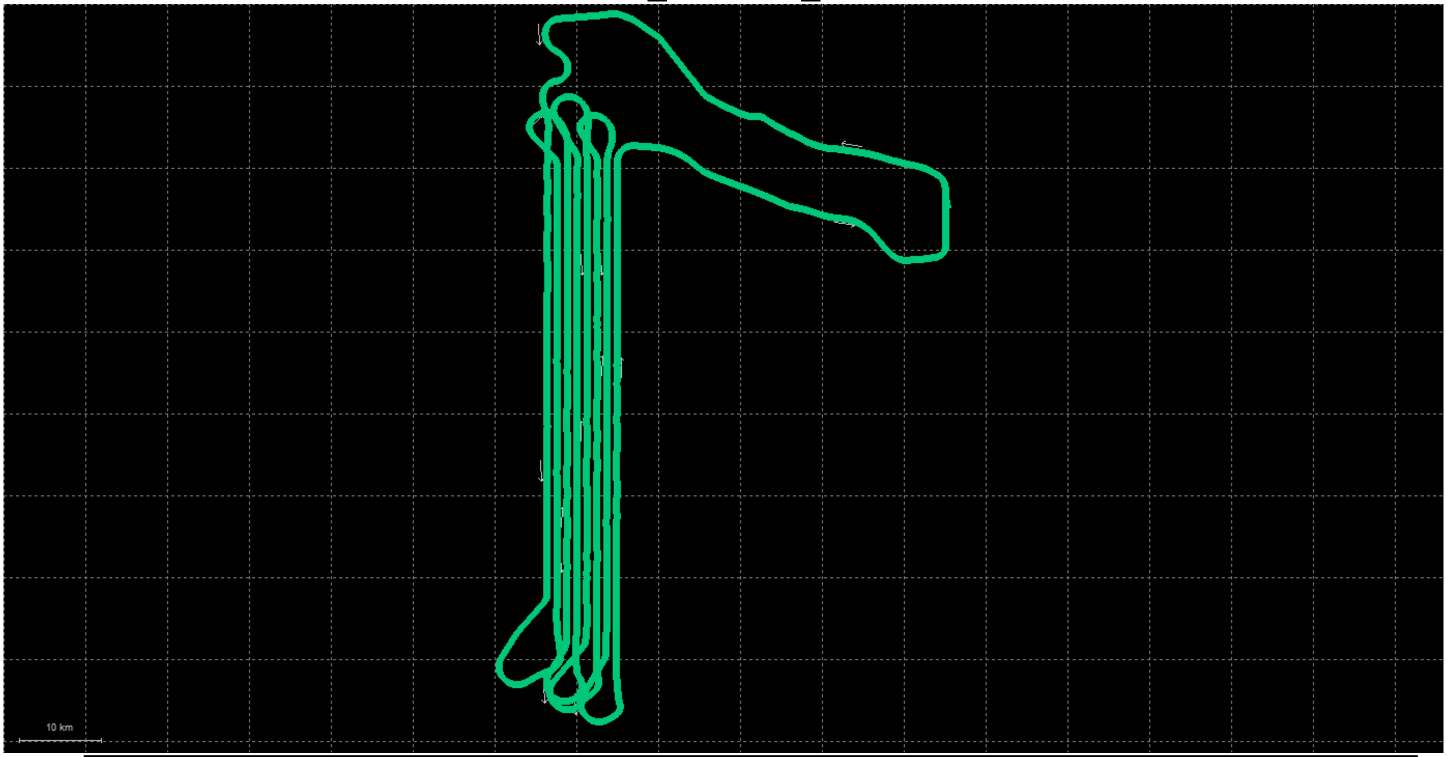


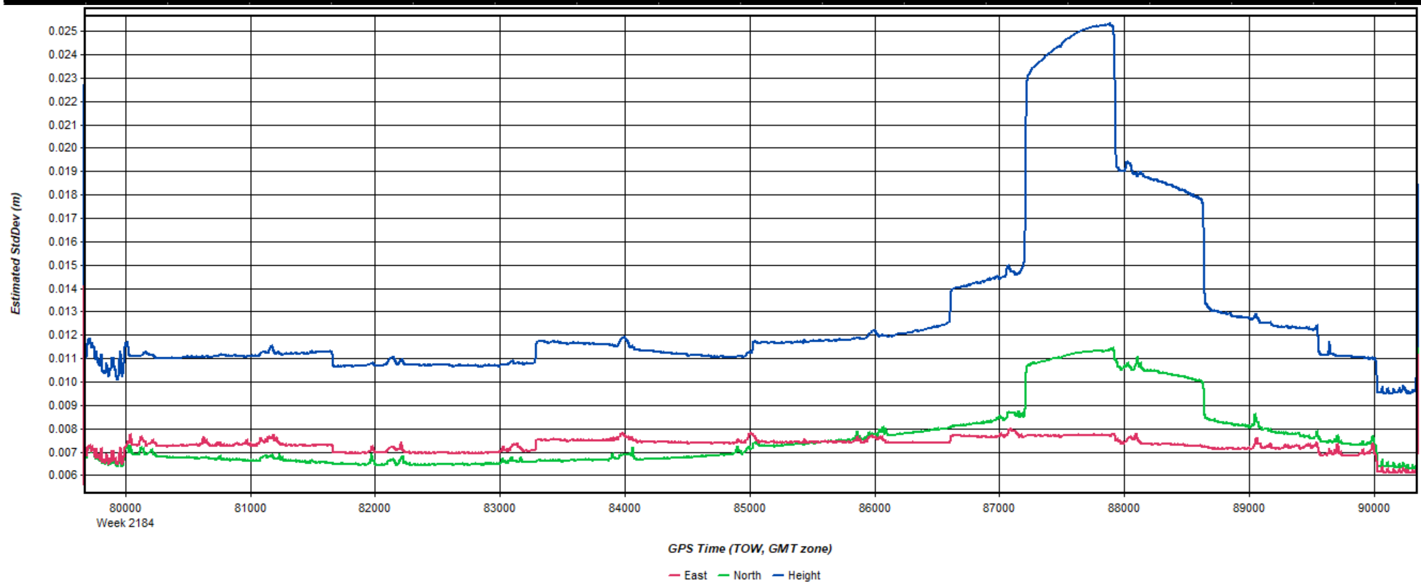

Num Sats
GPS Time (TOW, GMT zone)
Week 2184
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

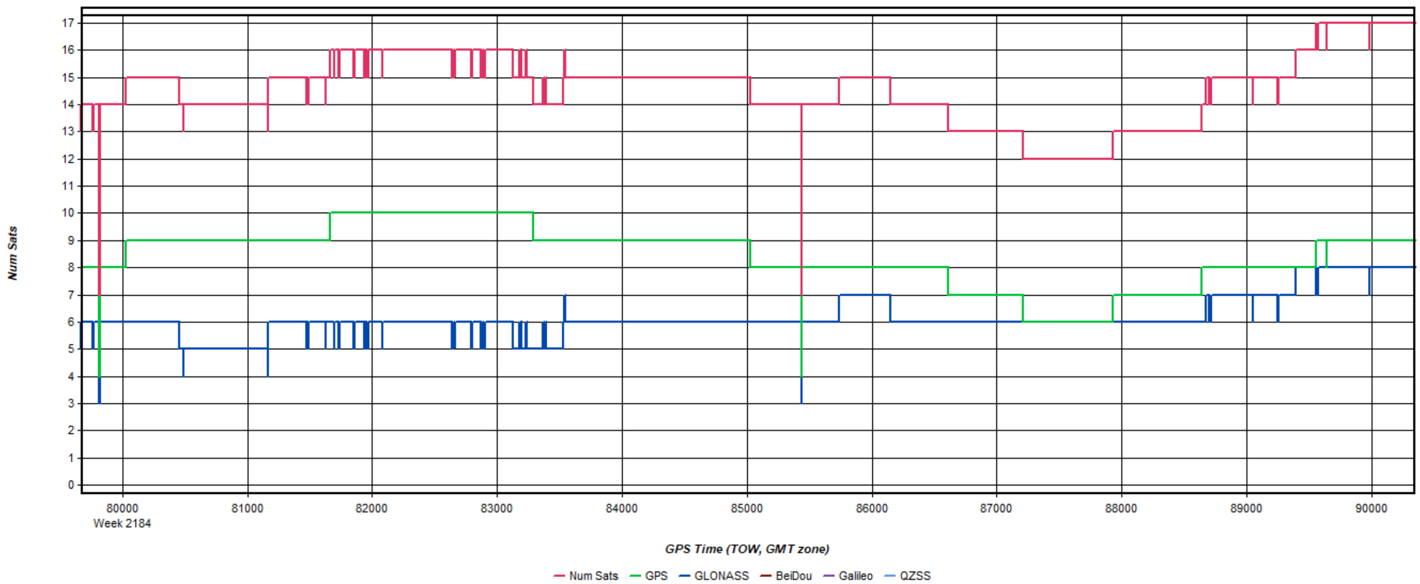

Separation (m)
GPS Time (TOW, GMT zone)
Week 2184
East
North
Up


PDOP
GPS Time (TOW, GMT zone)
Week 2184
PDOP

20211114B_N100NE_TM91555

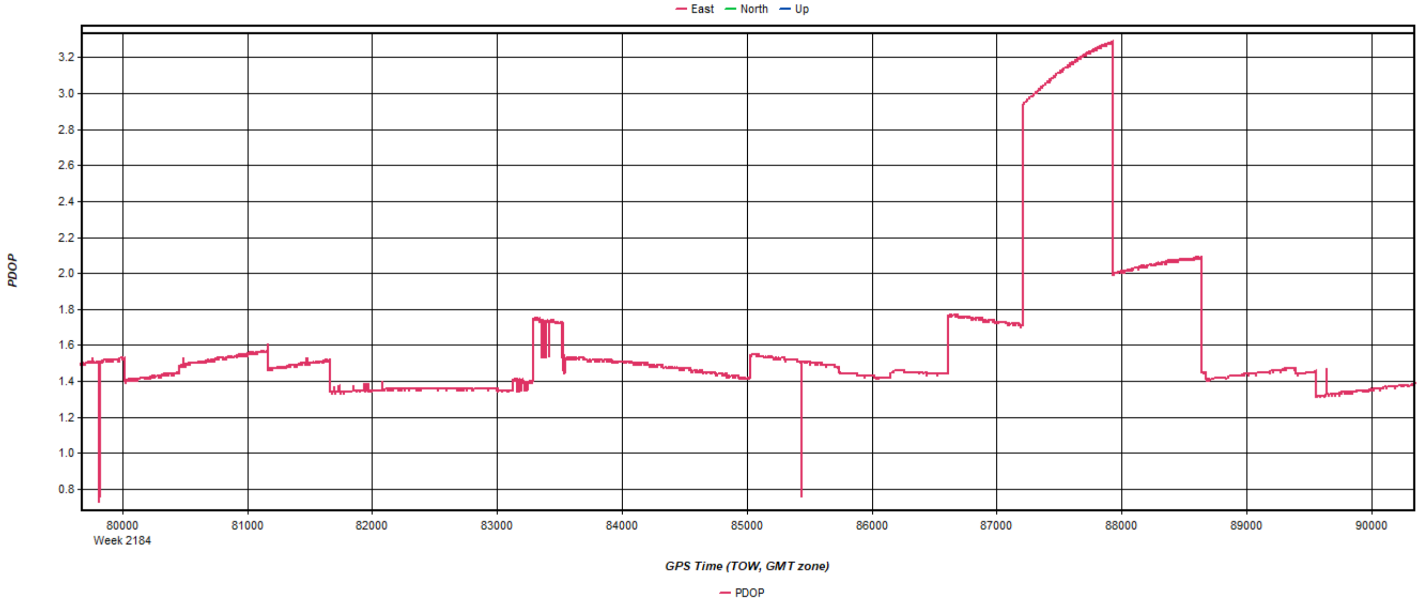






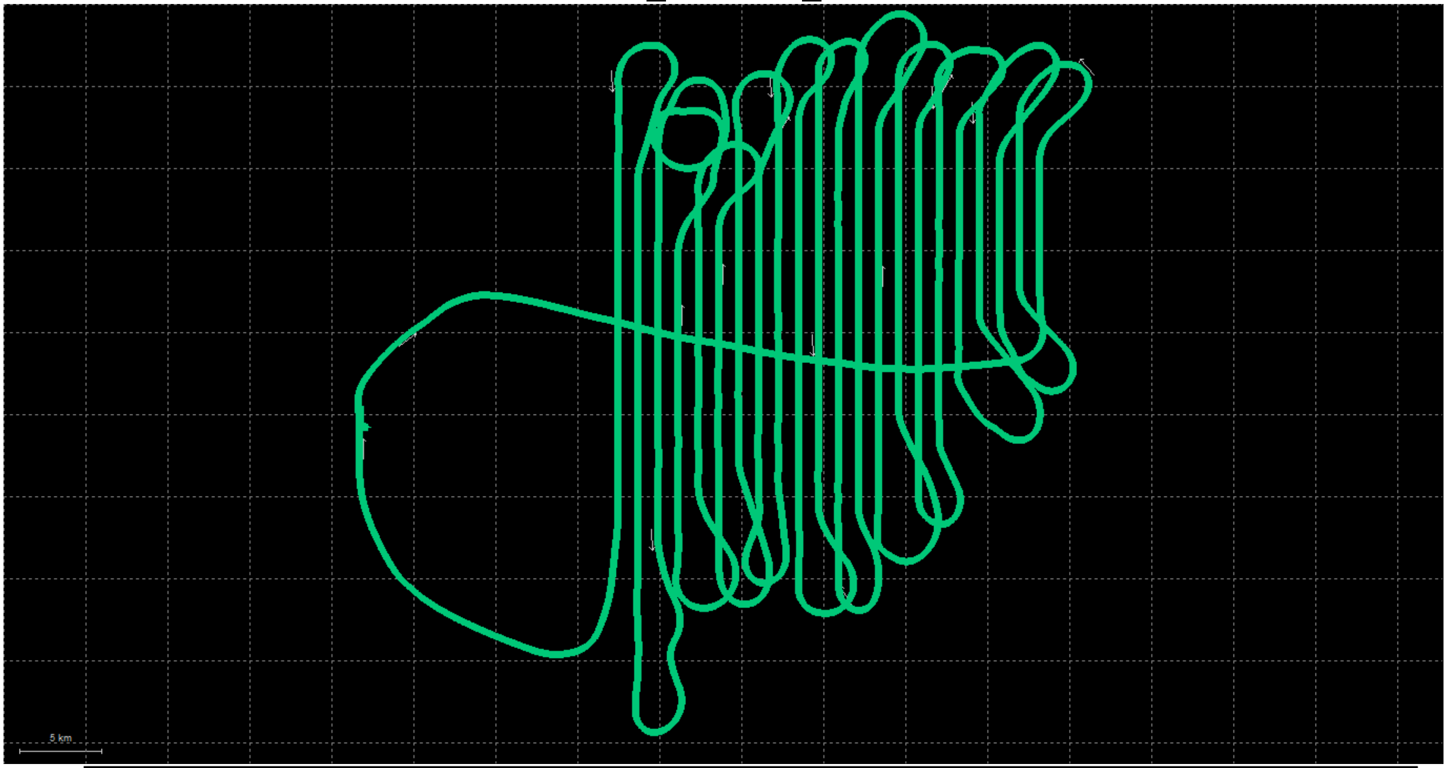
Num Sats
GPS Time (TOW, GMT zone)
Week 2184
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

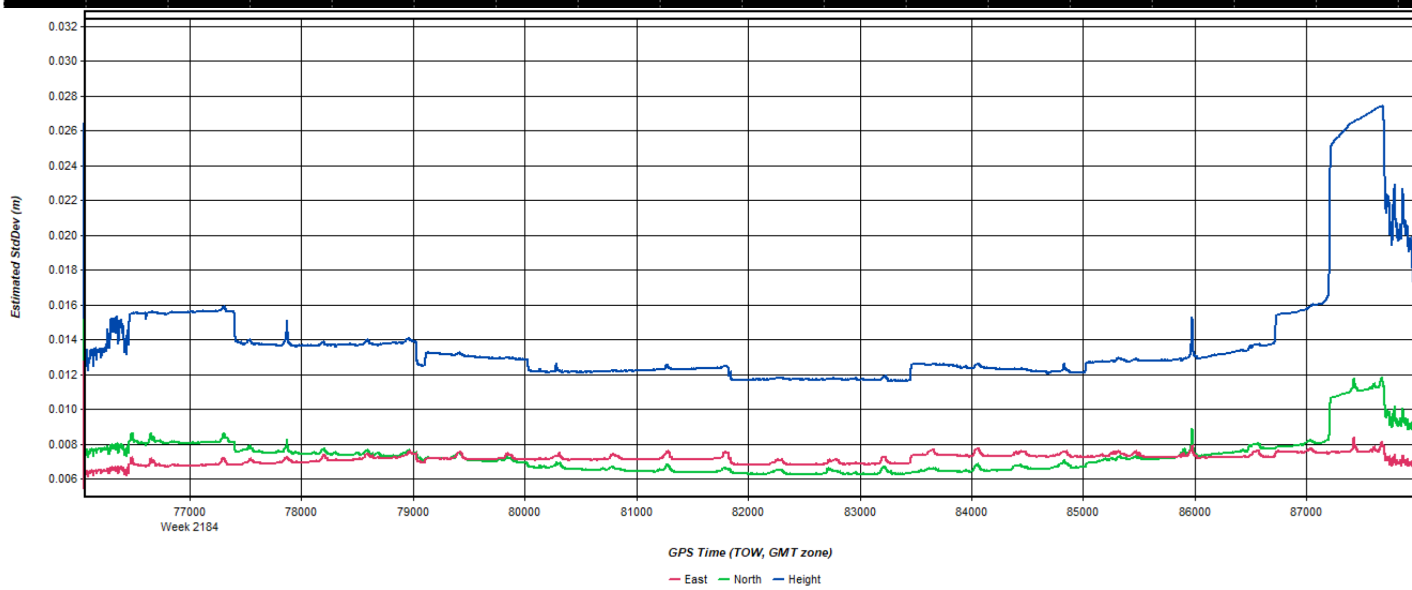
Separation (m)
GPS Time (TOW, GMT zone)
Week 2184
East
North
Up

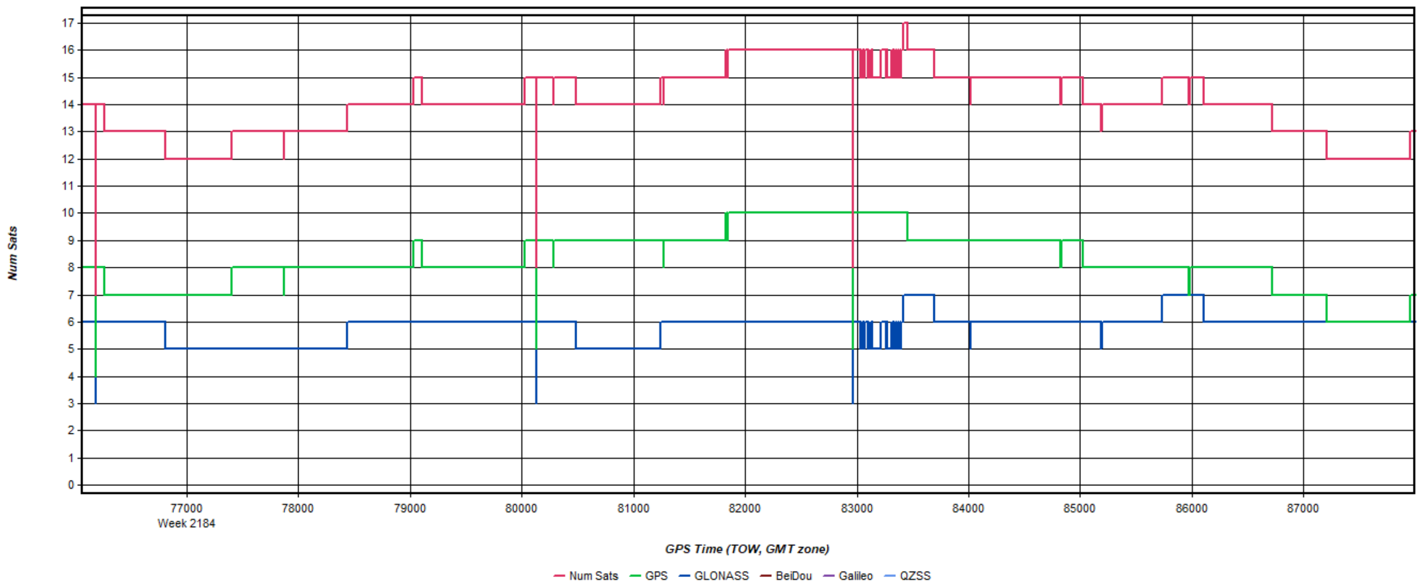


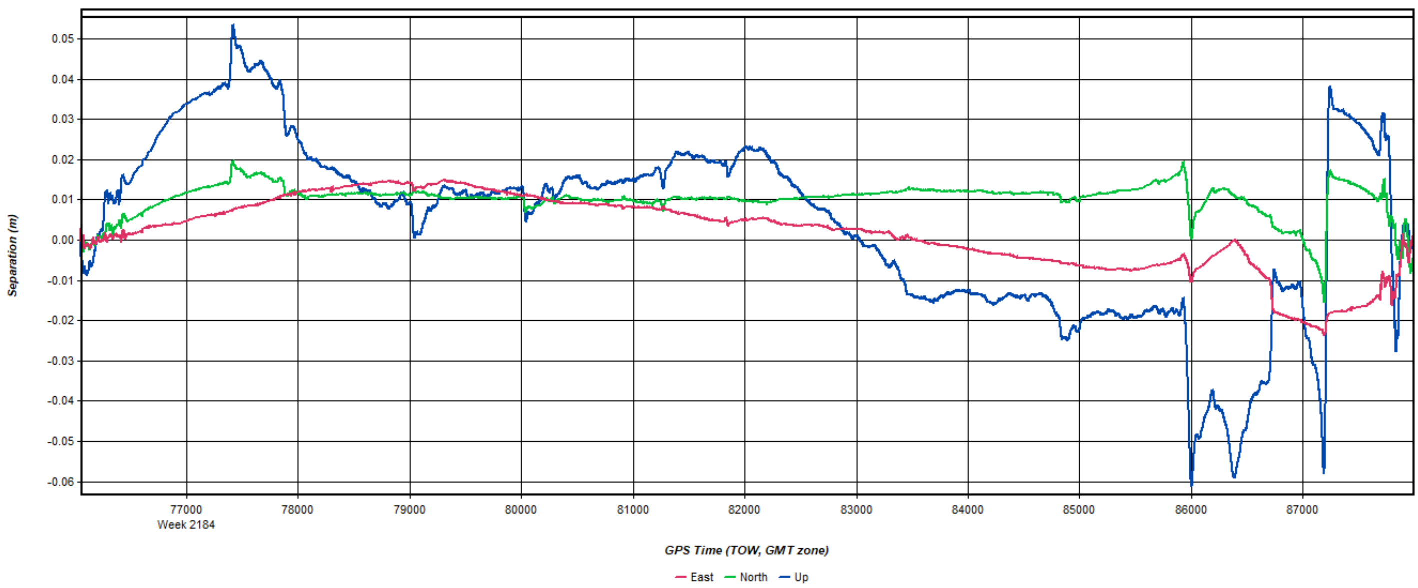
PDOP
GPS Time (TOW, GMT zone)
Week 2184
PDOP

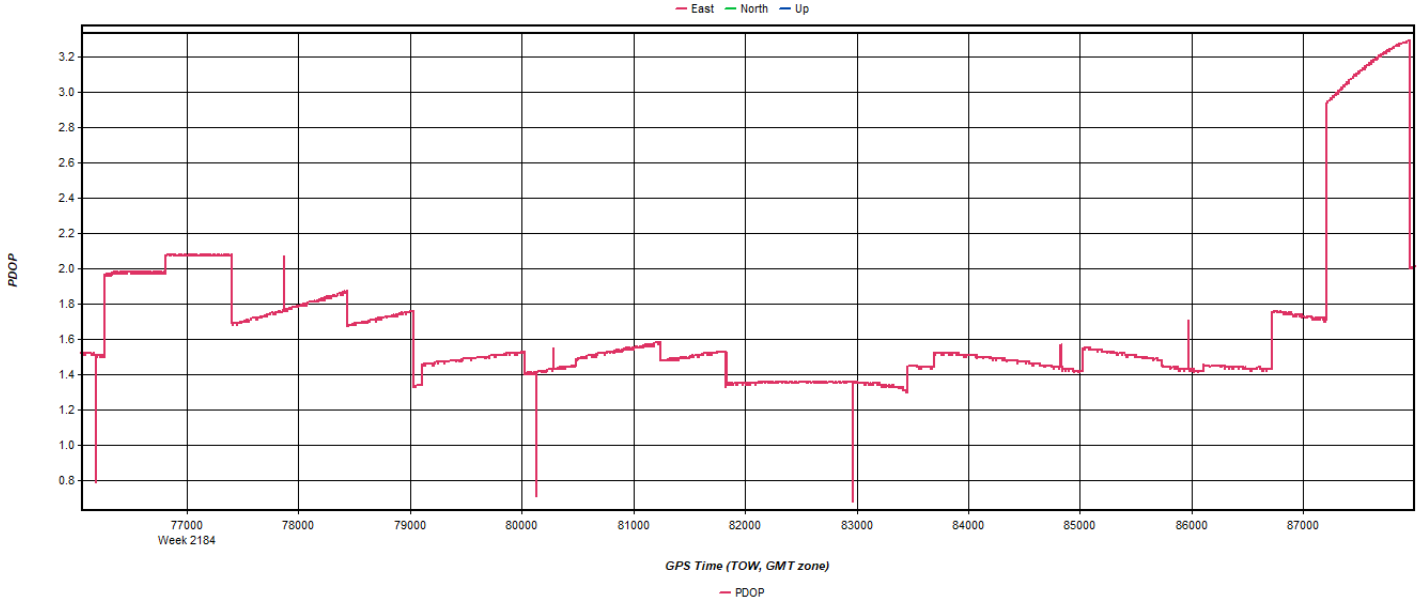
20211114B_N278RC_TM91520



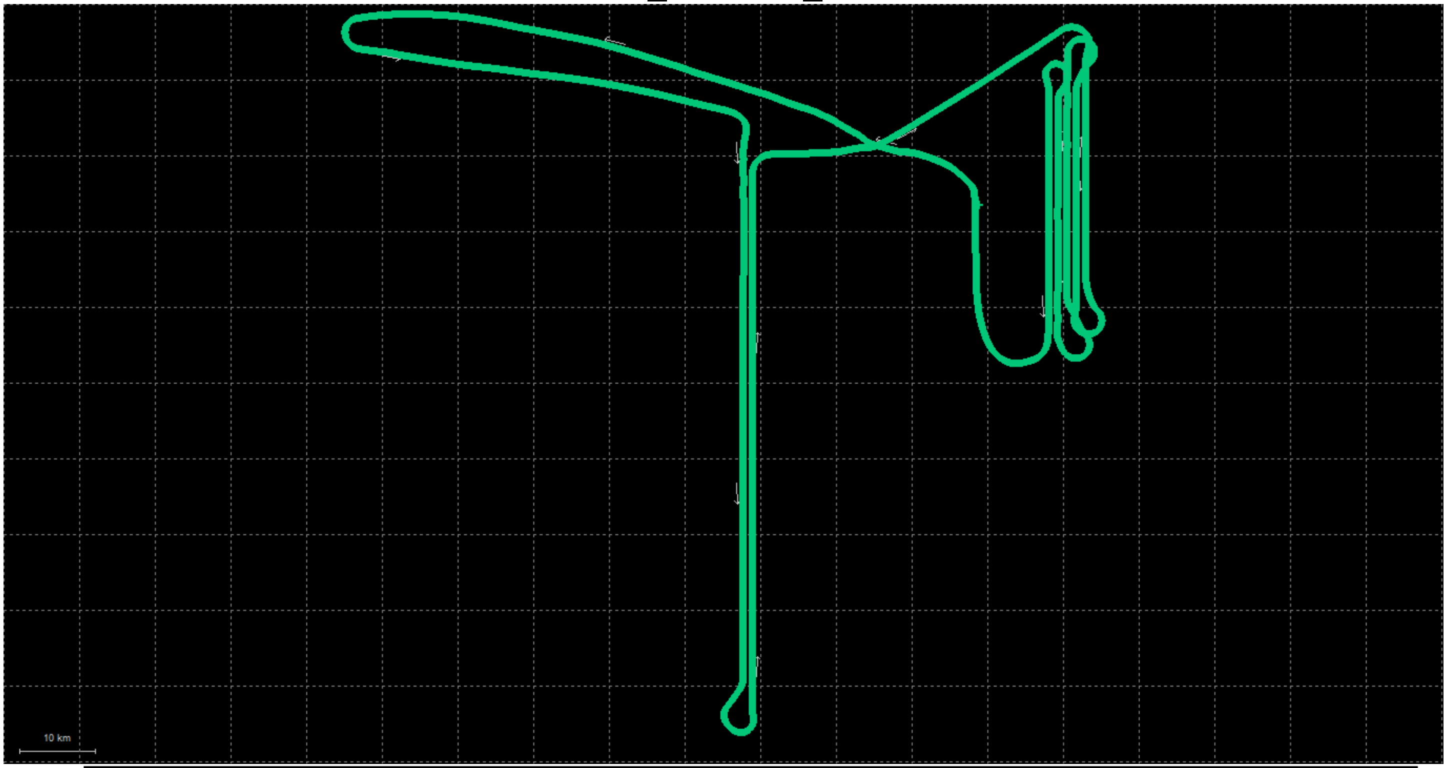


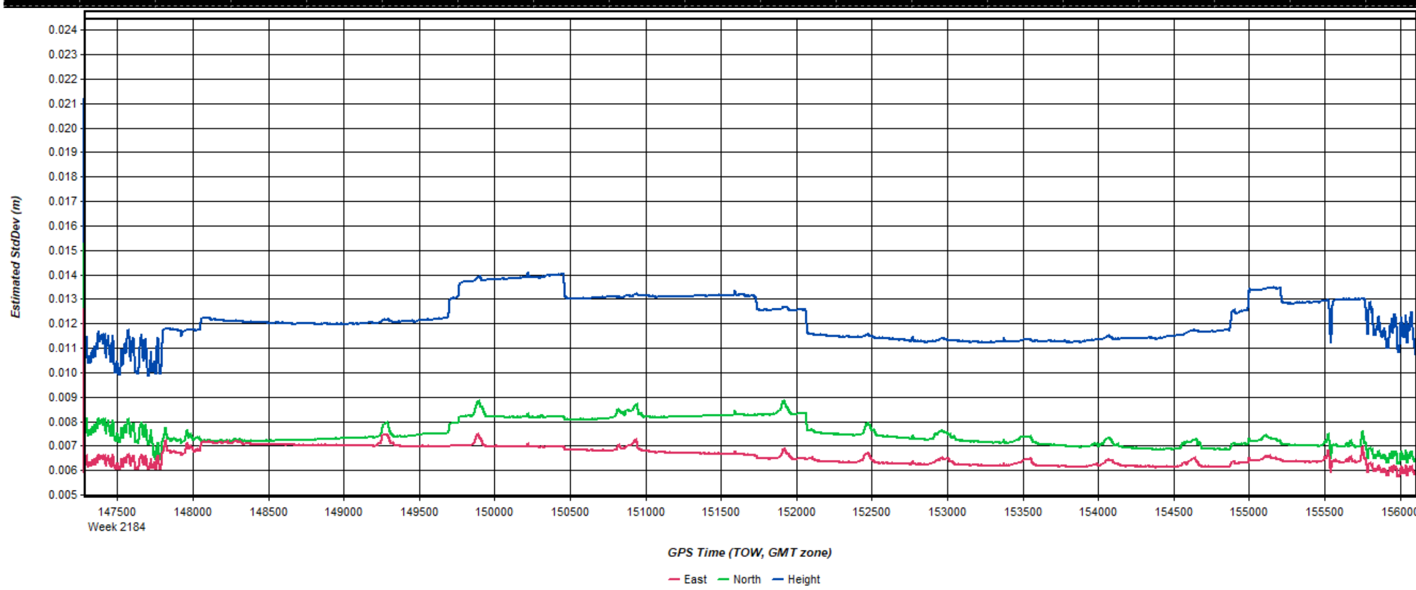

Num Sats
Week 2184
GPS Time (TOW, GMT zone)
Num Sats GPS GLONASS BeiDou Galileo QZSS


Separation (m)
Week 2184
GPS Time (TOW, GMT zone)
East North Up

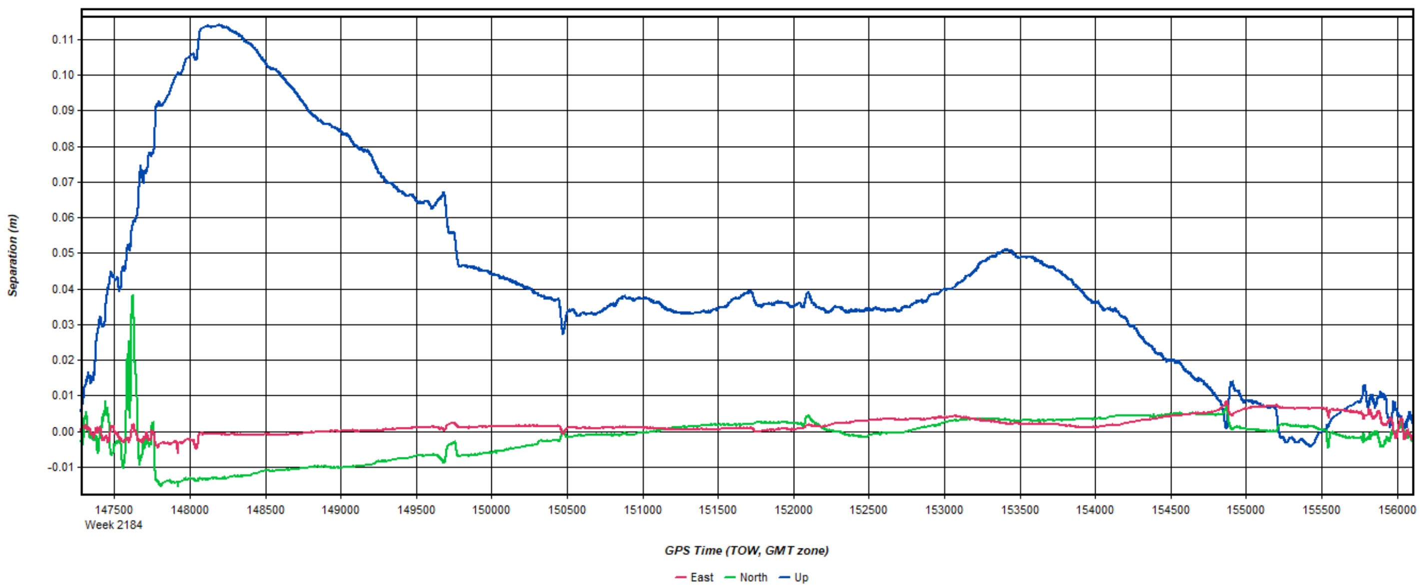

PDOP
Week 2184
GPS Time (TOW, GMT zone)
PDOP

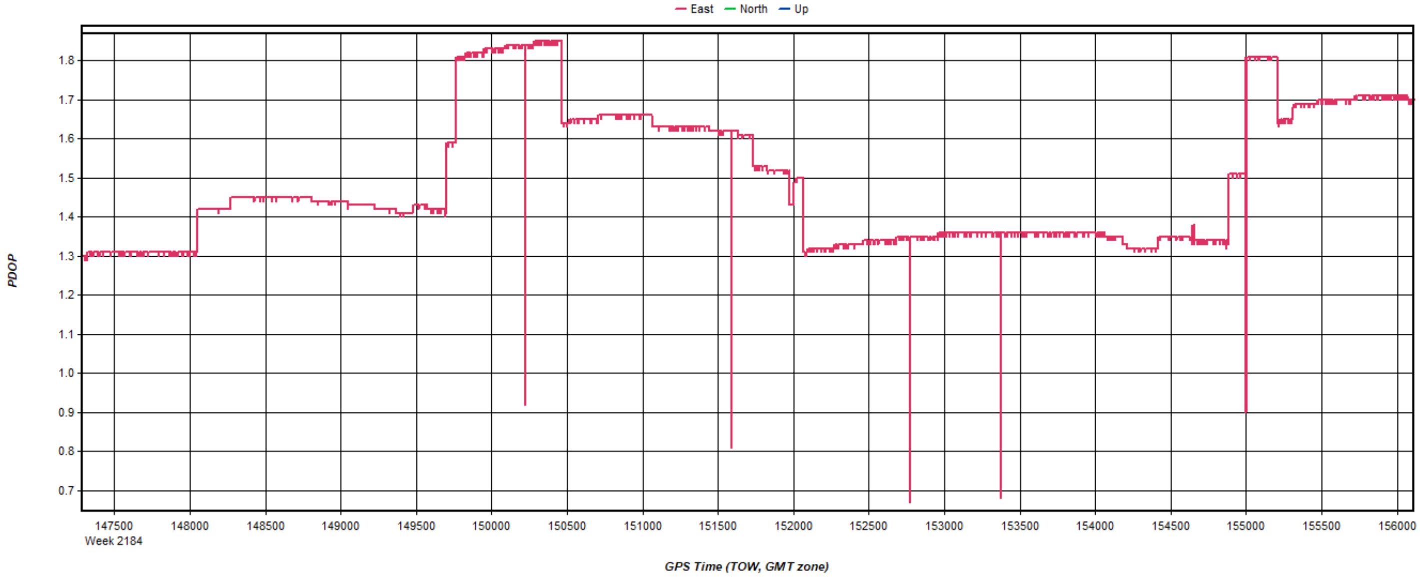
20211115A_N278RC_TM91520



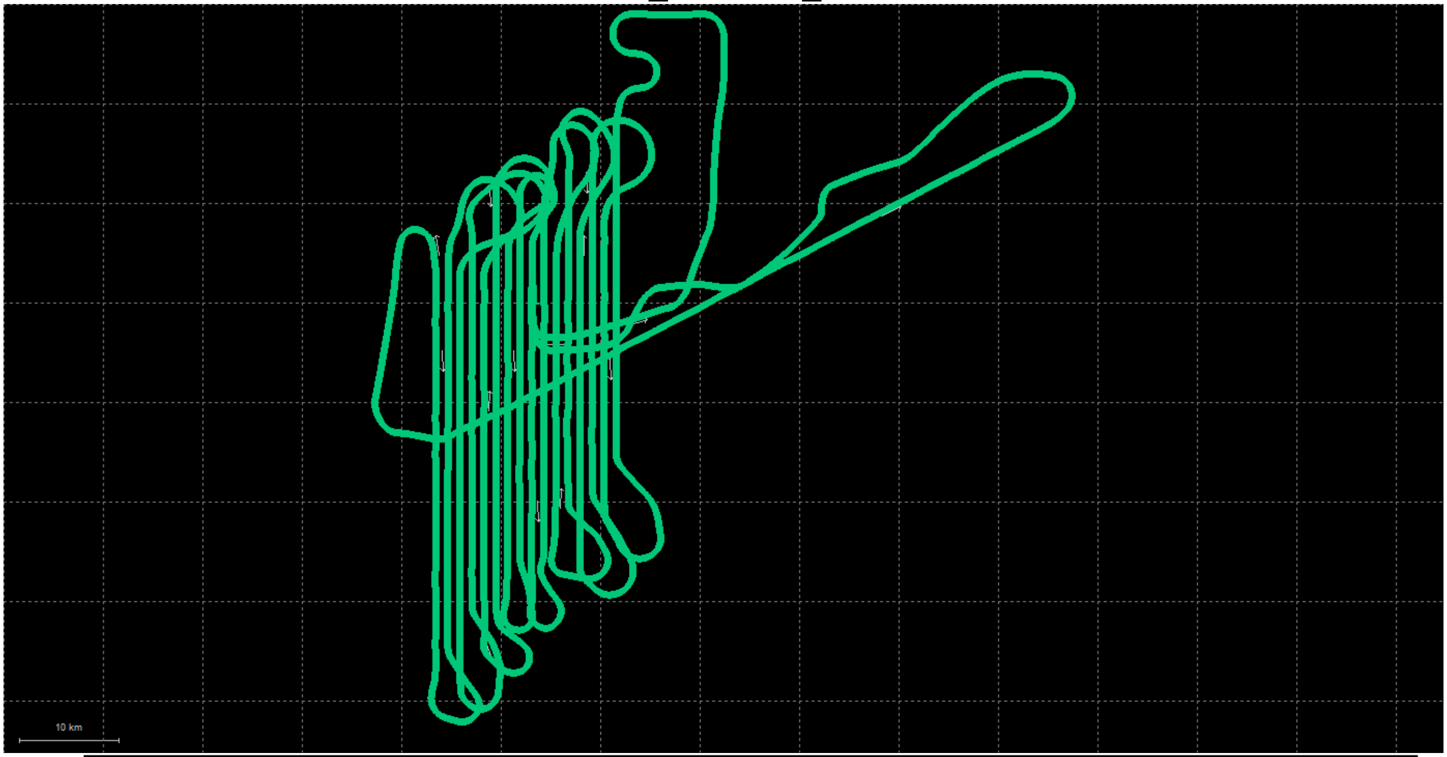


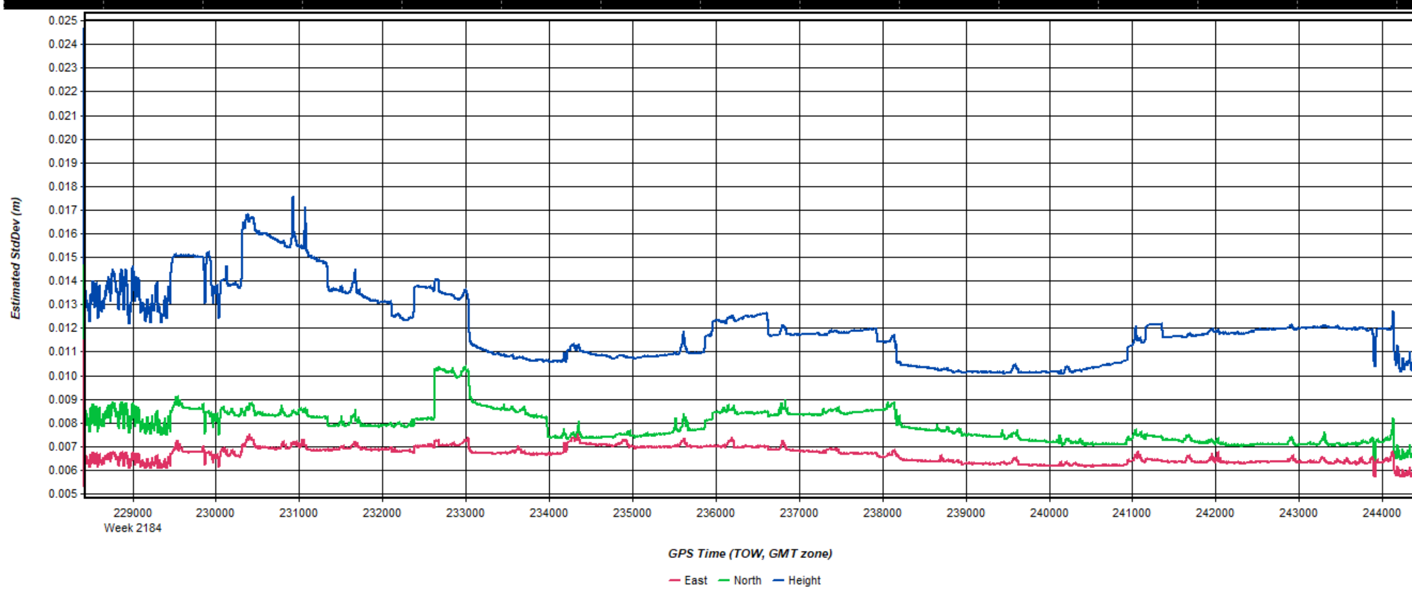

Num Sats
Week 2184
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

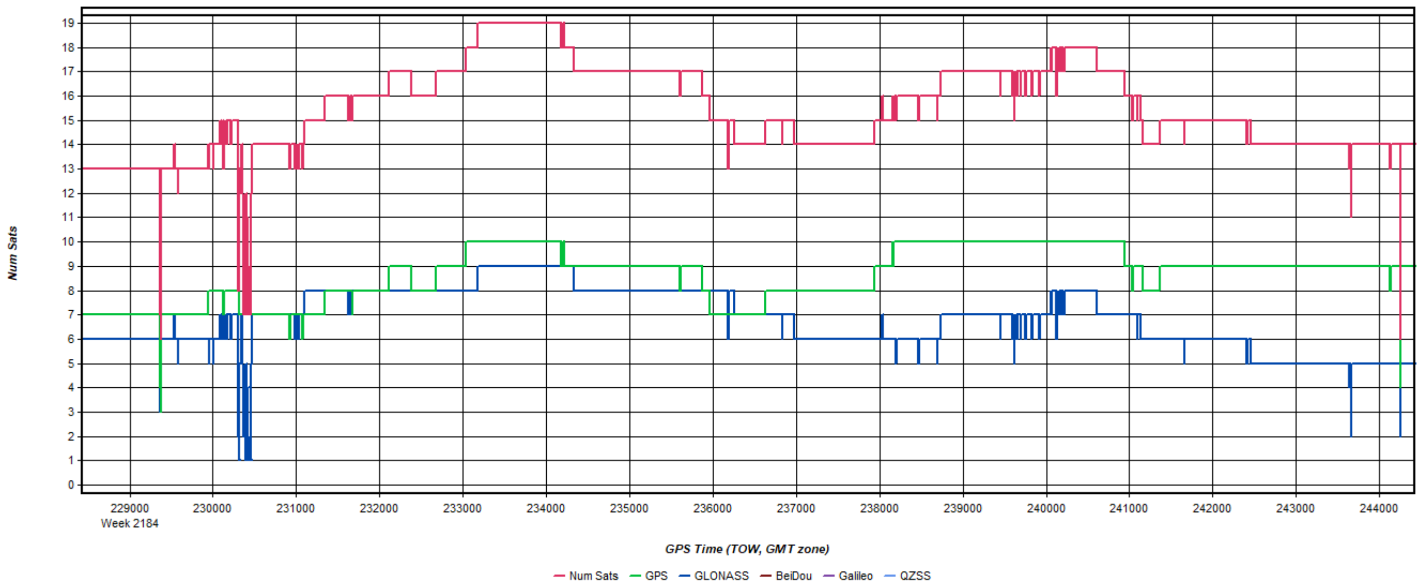

Separation (m)
Week 2184
GPS Time (TOW, GMT zone)
East
North
Up

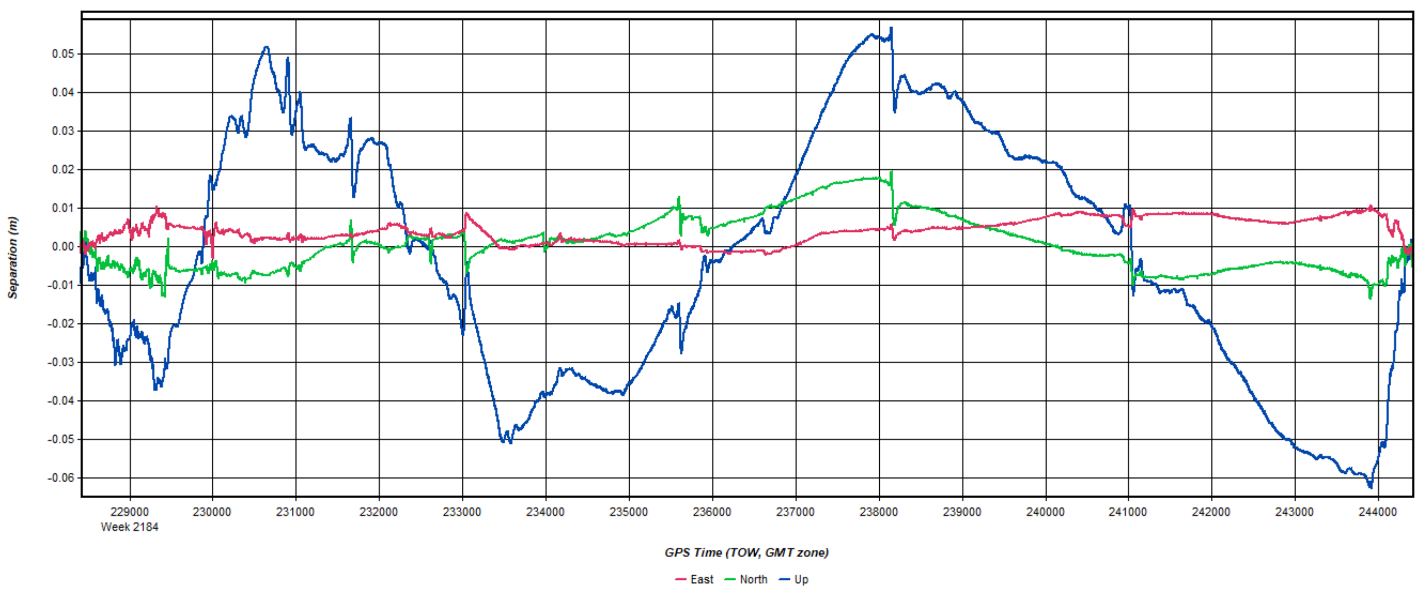

PDOP
Week 2184
GPS Time (TOW, GMT zone)
PDOP

20211116A_N100NE_TM91555



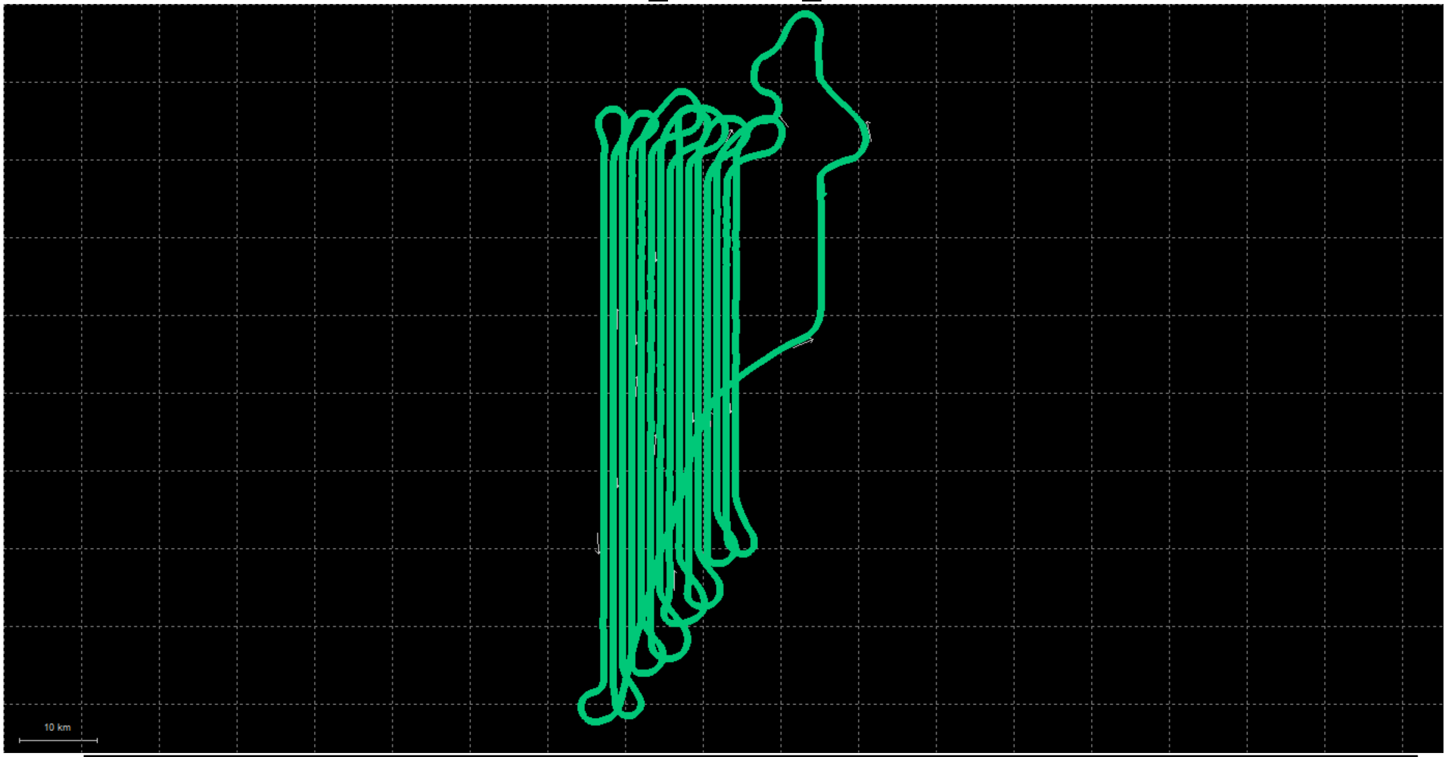


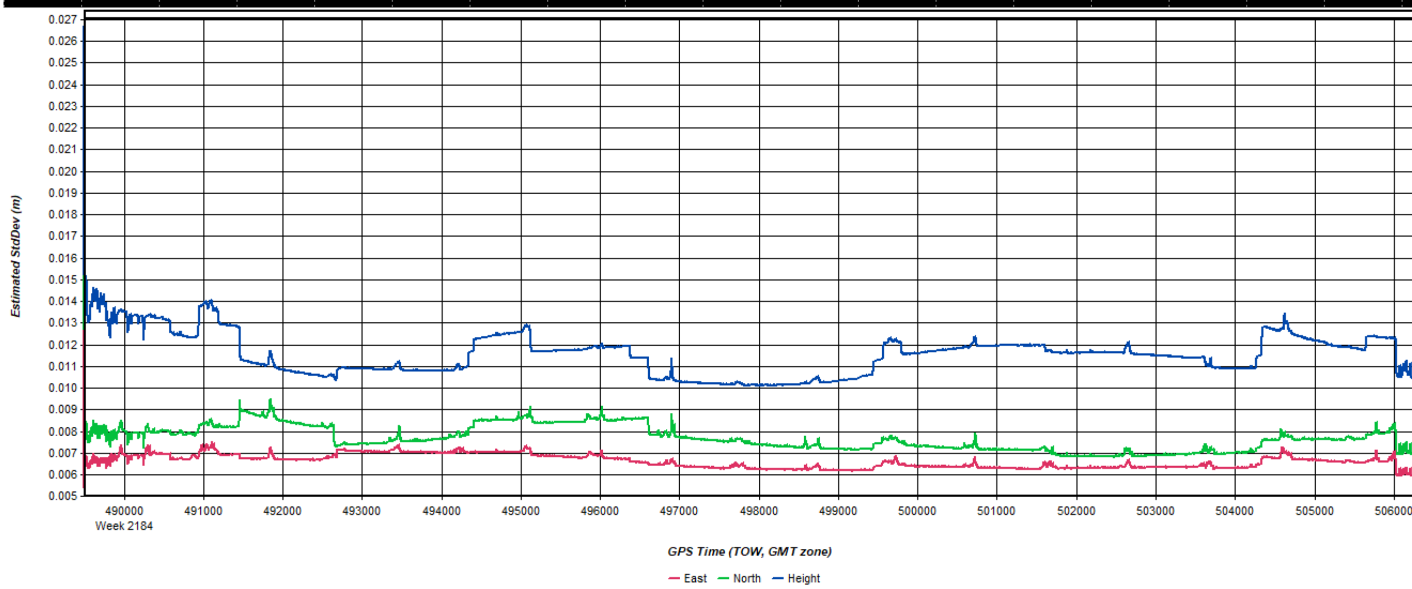

Num Sats
GPS Time (TOW, GMT zone)
Week 2184
Num Sats GPS GLONASS BeiDou Galileo QZSS

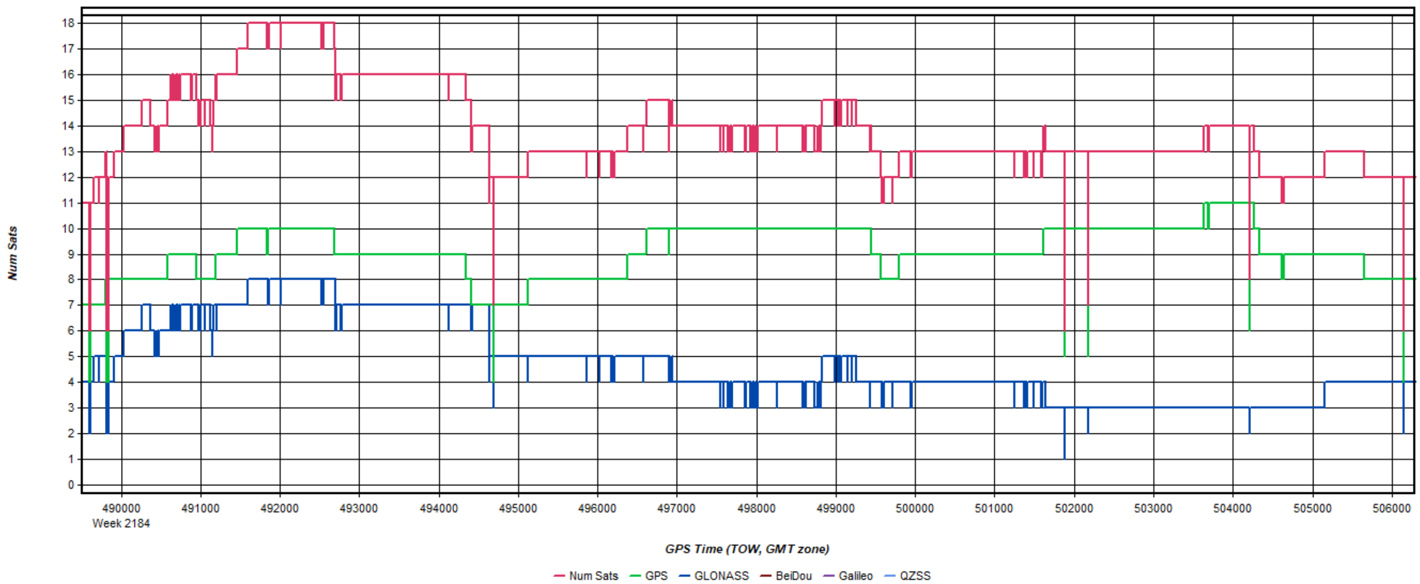

Separation (m)
GPS Time (TOW, GMT zone)
Week 2184
East North Up

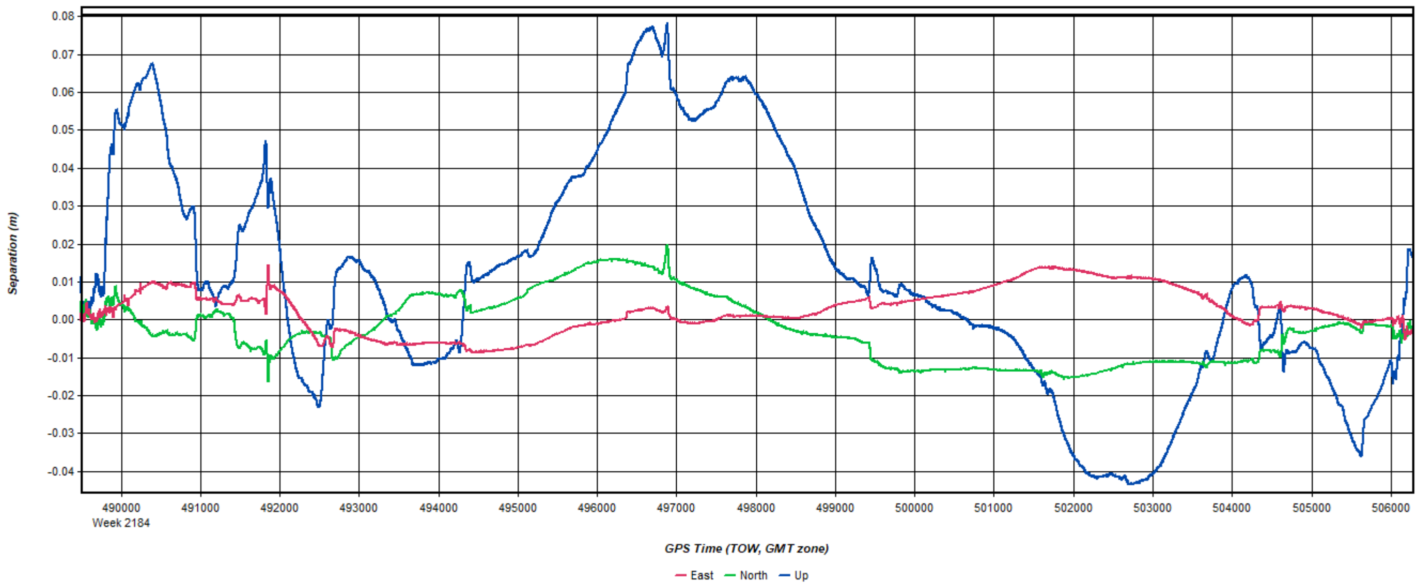

PDOP
GPS Time (TOW, GMT zone)
Week 2184
PDOP

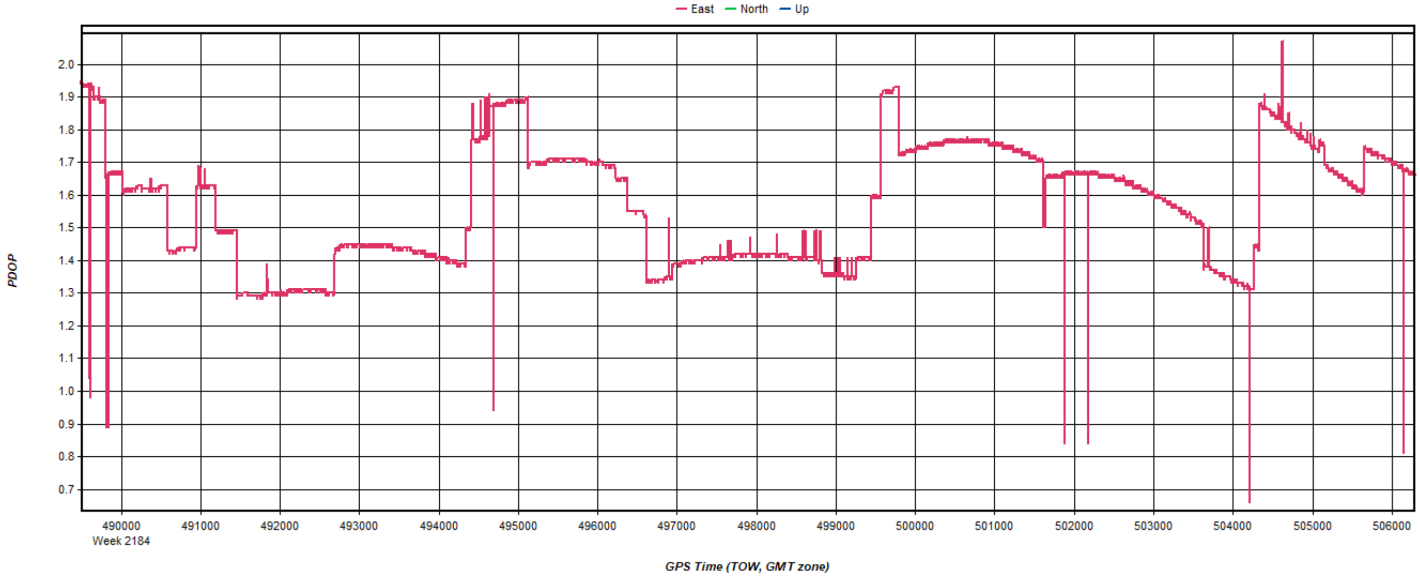
20211119A_N100NE_TM91555



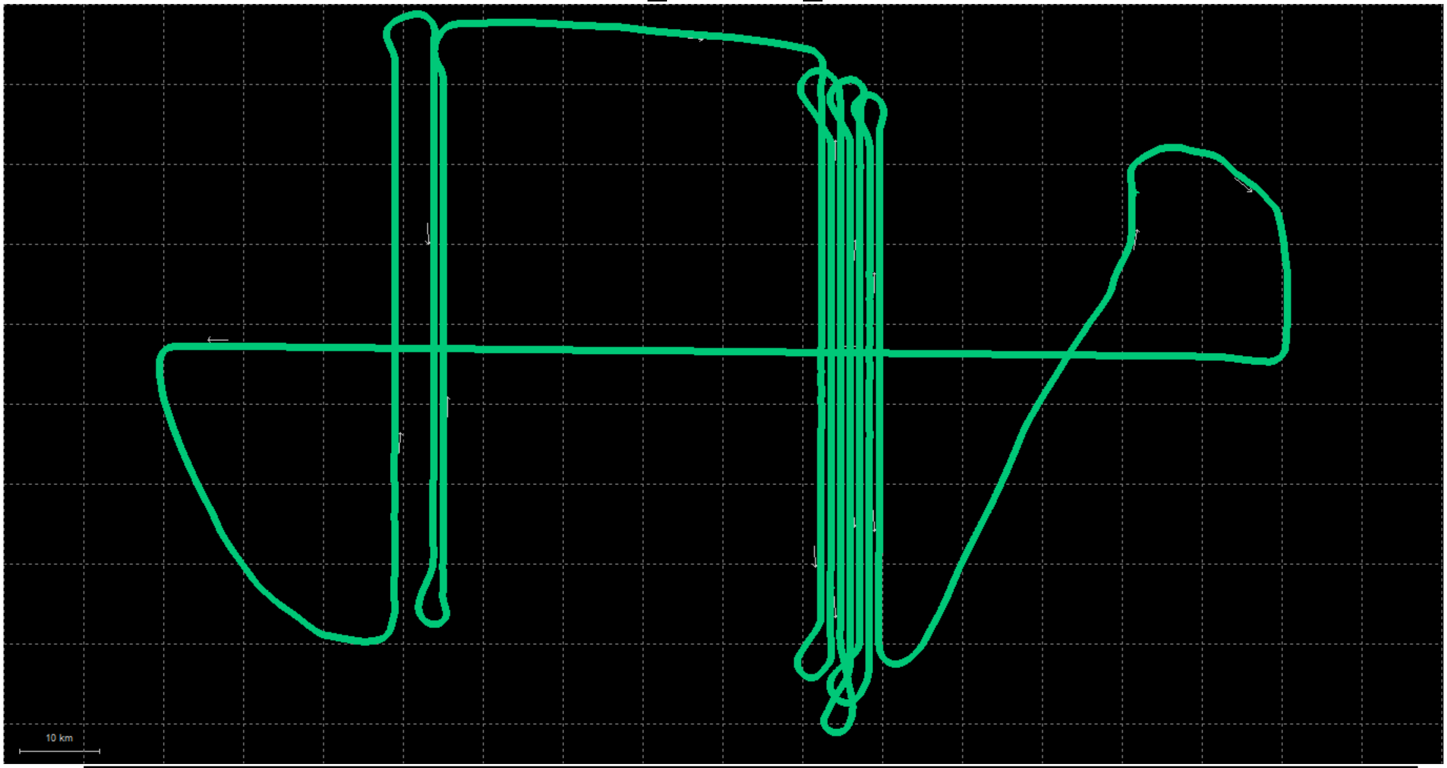


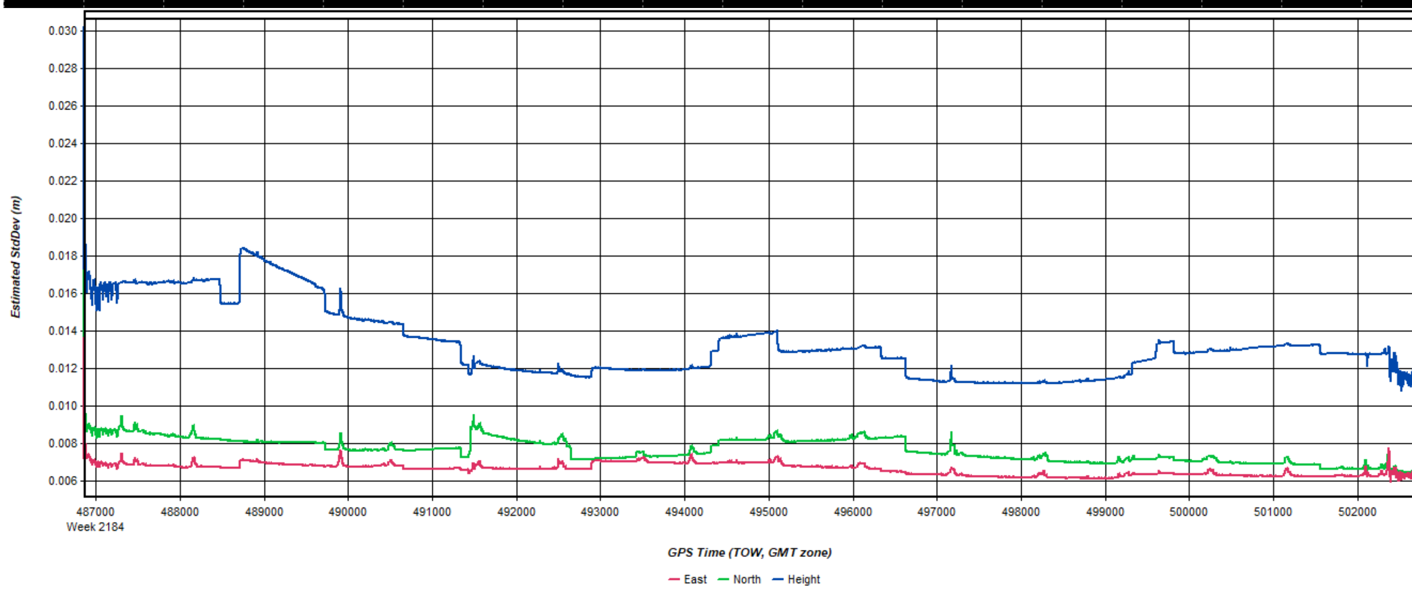

Num Sats
Week 2184
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS

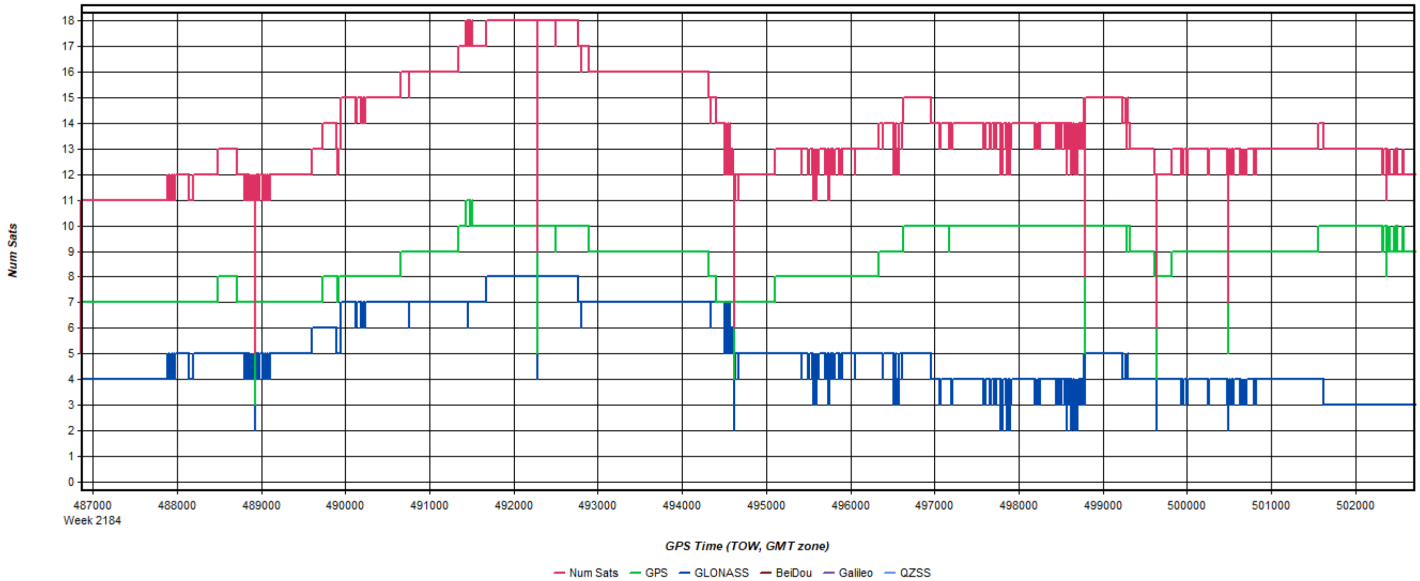

Separation (m)
Week 2184
GPS Time (TOW, GMT zone)
East
North
Up

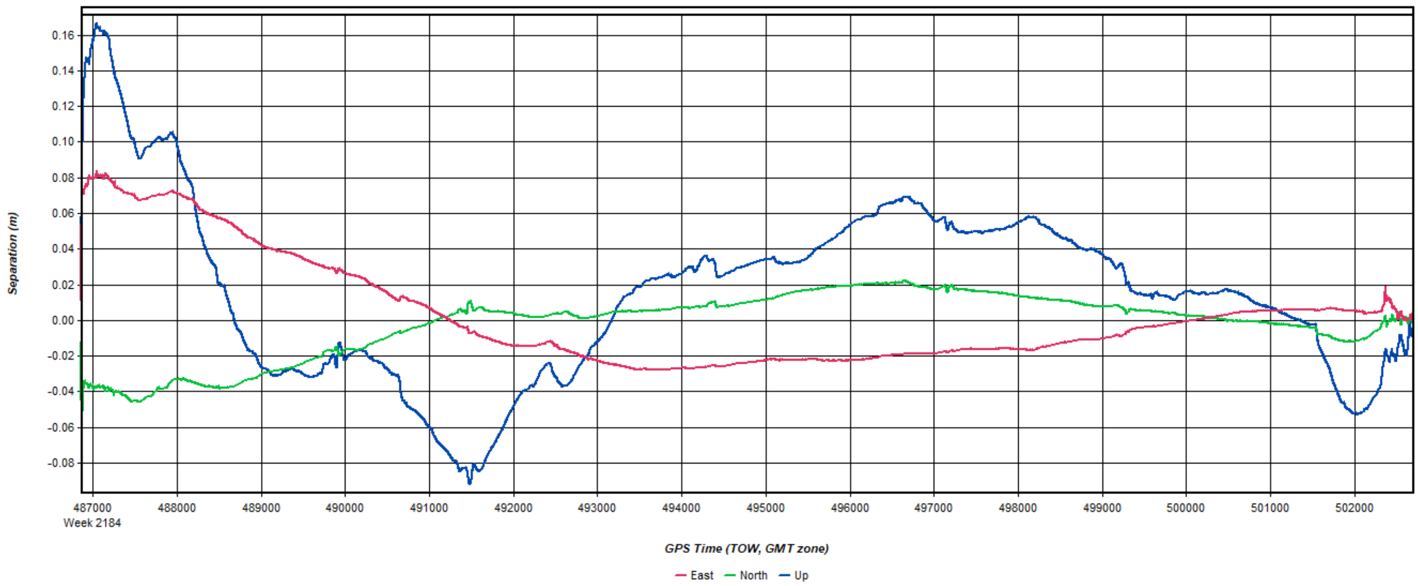

PDOP
Week 2184
GPS Time (TOW, GMT zone)
PDOP

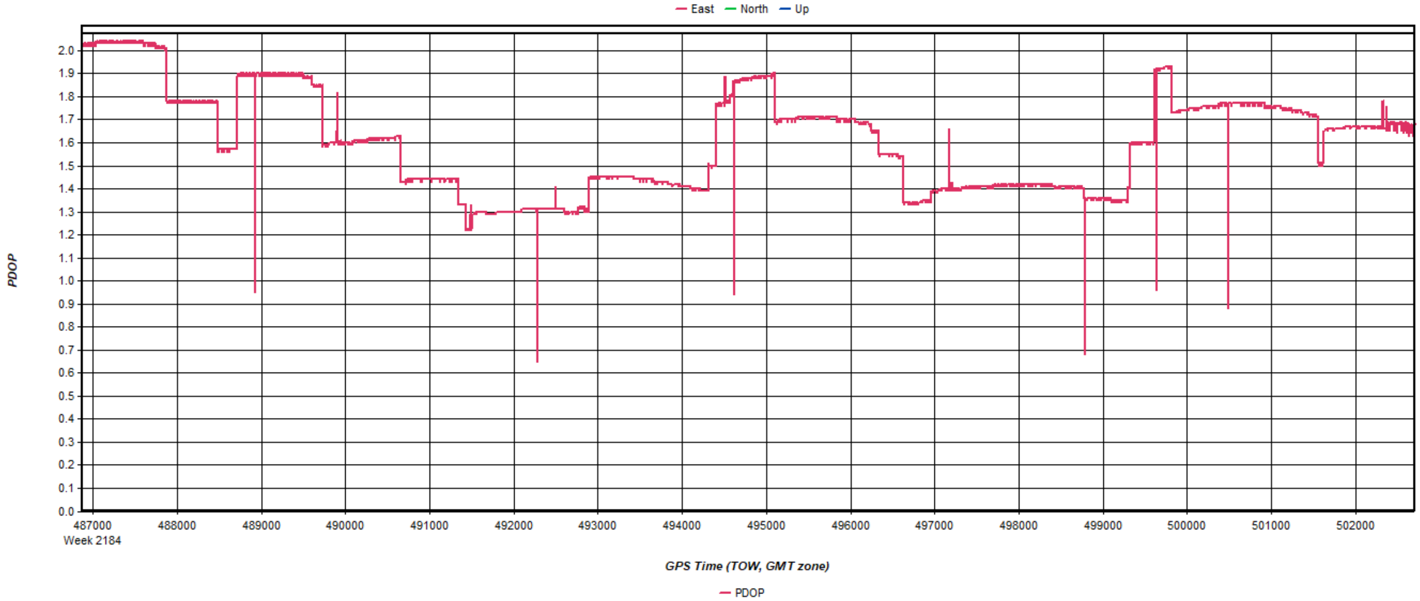
20211119A_N278RC_TM91520



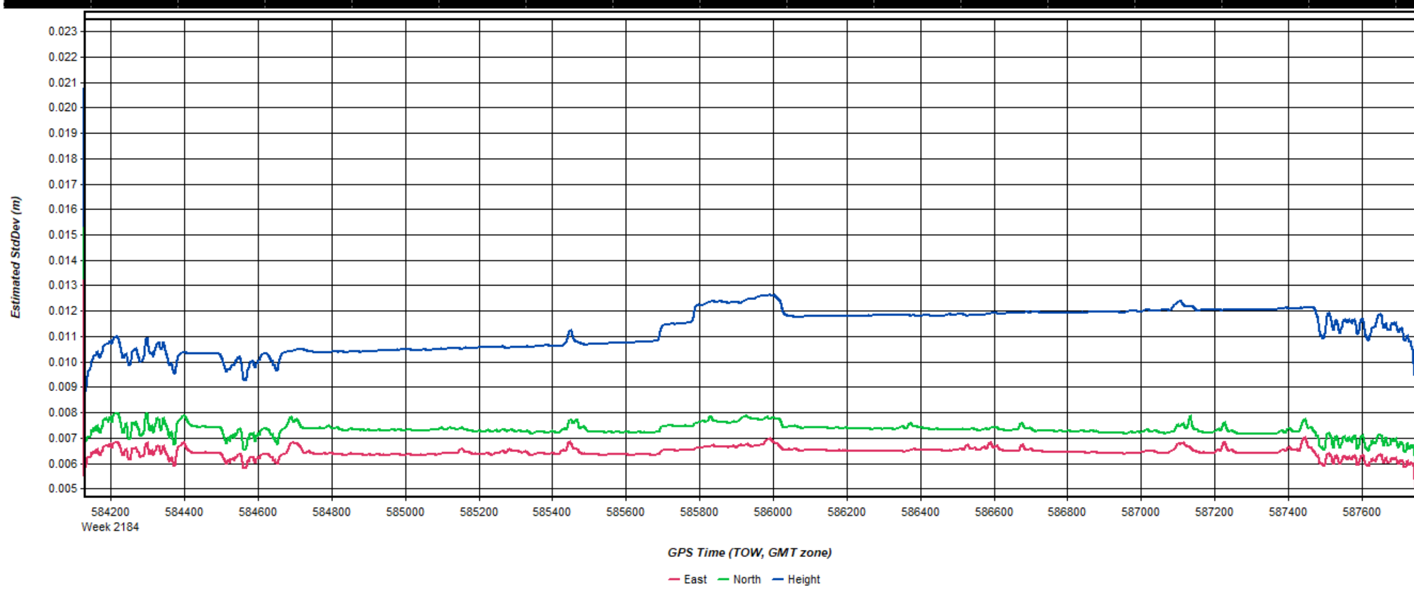


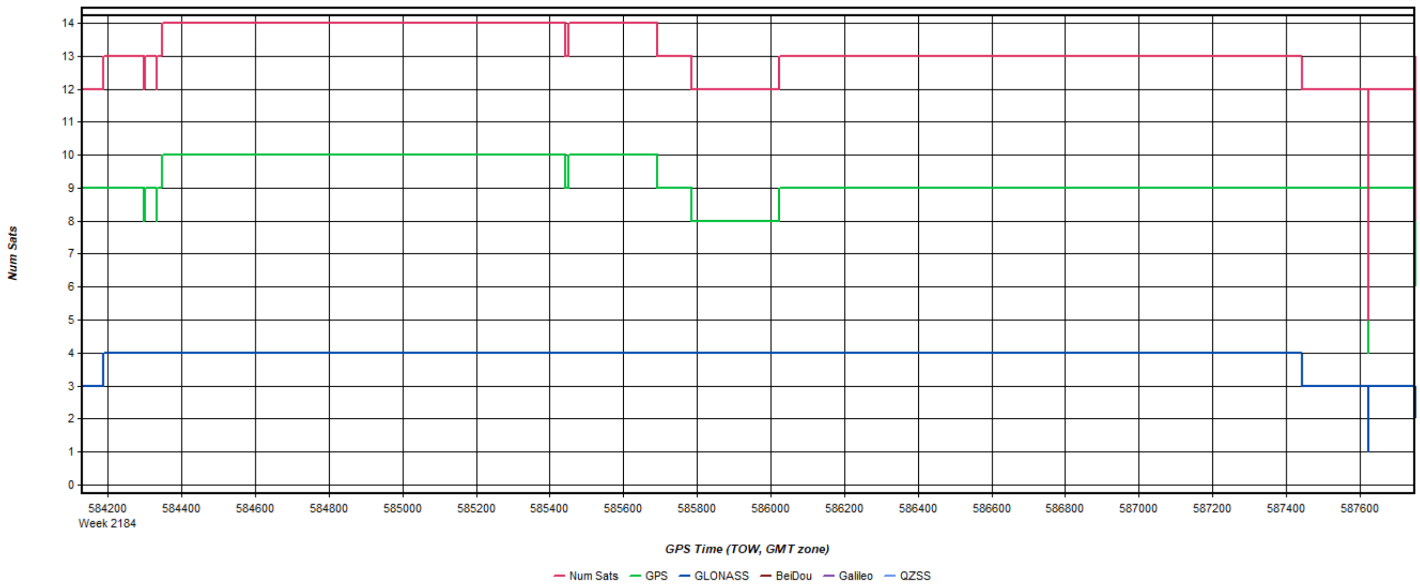

Num Sats
GPS Time (TOW, GMT zone)
Week 2184
Num Sats GPS GLONASS BeiDou Galileo QZSS

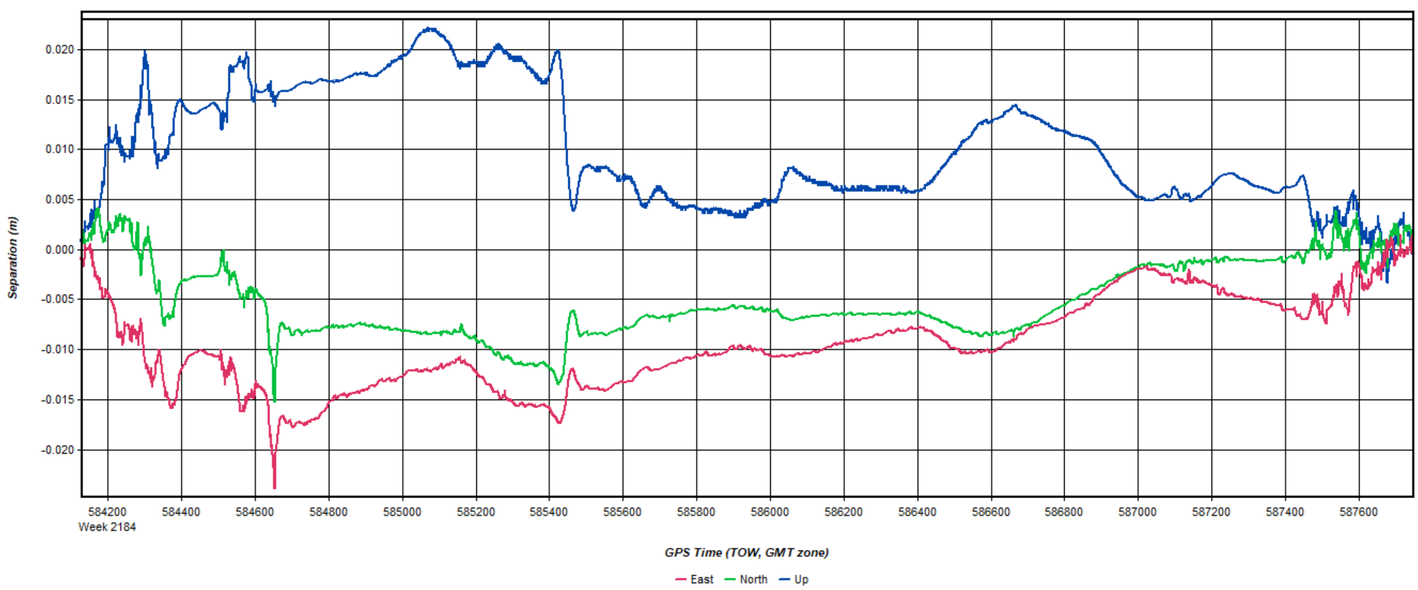

Separation (m)
GPS Time (TOW, GMT zone)
Week 2184
East North Up

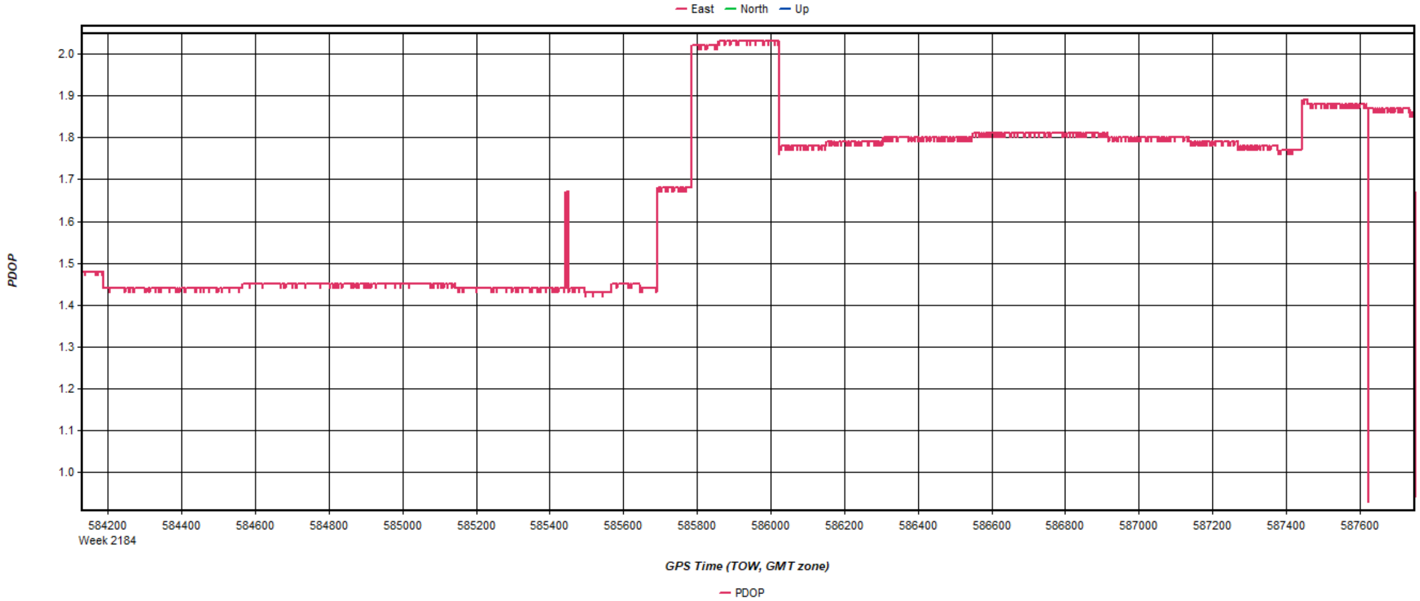

PDOP
GPS Time (TOW, GMT zone)
Week 2184
PDOP

20211120A_N100NE_TM91555




Num Sats
Week 2184
GPS Time (TOW, GMT zone)
Num Sats
GPS
GLONASS
BeiDou
Galileo
QZSS


Separation (m)
Week 2184
GPS Time (TOW, GMT zone)
East
North
Up


PDOP
Week 2184
GPS Time (TOW, GMT zone)
PDOP