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**Mer Bleue, Ontario, Arctic Surrogate Study Site Project
2018: Global Navigation Satellite System survey report**

C. Prévost and H.P. White

2019

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Mer Bleue, Ontario Arctic Surrogate Study Site Project
2018: Global Navigation Satellite System survey report

Note:

This document, strictly orientated toward high precision GNSS survey results, falls within the framework of a much larger project involving calibration and validation of various types of remote sensing data using *in situ* environmental surveys. The survey site, located in the Mer Bleue bog, east of Ottawa, provides a surrogate for Arctic environment.

This project is undertaken as part of the Mer Bleue Arctic Surrogate Simulation Study (MBASSS) project under an *ad hoc* partnership with the National Research Council of Canada (NRC), LOOKNorth, and McGill University.

This document describes GNSS surveys undertaken in 2018. Similar surveys were performed in 2016 and 2017 and are referred to in the Publication section.

Collaborators – 2018 Co-op students:

Carin Loker-Fulcher

Jeffrey Wong

Table Of Contents

-Abstract	5
-List of Tables	6
-List of Figures	8
1) Introduction	9
2) Positional Result Summary	10
3) Survey site location and materials used	25
4) Data Acquisition – GNSS survey in May 2018	31
5) Data Acquisition – GNSS survey in August 2018	55
6) Vertical movement of points through time established using various methods	79
7) Altimetric Trends	81
8) Conclusion and Future Considerations	89
9) Related Publications	90
10) Bibliography	92
Appendix: MBR-4 platform layout	93

Abstract

Natural Resources Canada (NRCan) has the mandate of providing essential geographic information. An improved knowledge of our physical environment represents one of the cores of this mandate. The Arctic is an important but challenging region to study, especially for wetland monitoring. To reduce survey costs, researchers often use surrogate sites located in less remote areas when evaluating and developing applications. The Mer Bleue Bog Peatlands, a conveniently accessible sub-arctic wetland similar to many wetlands found in the Arctic environment, is being used as arctic surrogate study site for the MBASSS Project.

This study site is used for the calibration and validation of various types of optical (spectral) remote sensing data acquired by several project partners using satellite, airborne and Unmanned Aerial Vehicle (UAV) platforms. Precisely geo-located products require ground control points (reference points) which are visible to the sensor on the platform and whose geographic location is known with precision. To fulfill this need, high precision GNSS surveys are required.

This highly illustrated document describes in detail the methods and results of the GNSS surveys required for the geographic rectification of imagery, including Unmanned Aerial Vehicle photographs, airborne hyperspectral imagery, and space borne multi-spectral imagery acquired within the scope of MBASSS during 2018.

Keywords: GNSS survey, UAV, UAV target, Peatland, Mer Bleue Bog.

List of Tables

Table 2.1	Summary of Results – GNSS positions – May 2016 Survey	10
Table 2.2	Summary of Results – GNSS positions – July 2016 survey	11
Table 2.3	Summary of Results – GNSS positions – August 2016 survey	11
Table 2.4	Summary of Results – GNSS positions – September 2016 survey	12
Table 2.5	Summary of Results – GNSS positions – November 2016 survey	12
Table 2.6	Summary of Results – GNSS positions – December 2016 survey	13
Table 2.7	Summary of Results – GNSS positions – June 2017 survey	13
Table 2.8	Summary of Results – GNSS positions – May 2018 survey	14
Table 2.9	Summary of Results – GNSS positions – August 2018 survey	14
Table 2.10	Summary of Results – GPS positions for the MBR-2	15
Table 2.11	Summary of Results – GPS positions for the MBR-3	16
Table 2.12	Summary of Results – GPS positions for the MBR-4	17
Table 2.13	Summary of Results – GPS positions for the MBR-5	18
Table 2.14	Summary of Results – GPS positions for the MBR-6	19
Table 2.15	Summary of Results – GPS positions for the MBR-7	20
Table 2.16	Summary of Results – GPS positions for the MBR-8	21
Table 2.17	Summary of Results – GPS positions for the Base	22
Table 2.18	Summary of Results – Height difference between surveys (ellipsoidal)	23
Table 2.19	Summary of Results – NRC CACS station height variation through time	24
Table 3.1	GNSS acquisition time	28
Table 4.1	GNSS acquisition details of point MBR-2	35
Table 4.2.	GNSS acquisition details of point MBR-3	37
Table 4.3	GNSS acquisition details of point MBR-4	39
Table 4.4	GNSS acquisition details of point MBR-5	41
Table 4.5	GNSS acquisition details of point MBR-6	43
Table 4.6	GNSS acquisition details of point MBR-7	45
Table 4.7	GNSS acquisition details of point MBR-8	47
Table 4.8	GNSS acquisition details of point “Base station”	49
Table 4.9	GNSS acquisition details of point ”Base NRC Drone”	51
Table 4.10	GNSS acquisition details of point “Base McGill Drone”	53
Table 5.1	GNSS acquisition details of point MBR-2	59
Table 5.2.	GNSS acquisition details of point MBR-3	61
Table 5.3	GNSS acquisition details of point MBR-4	63
Table 5.4	GNSS acquisition details of point MBR-5	65
Table 5.5	GNSS acquisition details of point MBR-6	67
Table 5.6	GNSS acquisition details of point MBR-7	69

Table 5.7	GNSS acquisition details of point MBR-8	71
Table 5.8	GNSS acquisition details of point "Base station"	73
Table 5.9	GNSS acquisition details of point "Base NRC Drone"	75
Table 5.10	GNSS acquisition details of point "Base McGill Drone"	77
Table 6.1	Seasonal variations of NRC station at time of survey	80

List of Figures

Figure 3.1	Mer Bleue bog and location of GNSS Surveys	25
Figure 3.2	GNSS points locations	26
Figure 3.3	Base station site	27
Figure 3.4	MBR-8 site	27
Figure 3.5	GNSS receivers and associated components	29
Figure 3.6	Position of NRC Canadian Active Control System Station	30
Figure 4.1	Field view of MBR 2-3	32
Figure 4.2	Field view of MBR 4-5	32
Figure 4.3	Field view of MBR 6-7	33
Figure 4.4	Field view of MBR 8 & Base station	33
Figure 4.5	Field view of NRC-Drone and McGill drone	34
Figure 4.6	Position of point MBR-2 from NRCan – PPP Service	36
Figure 4.7	Position of point MBR-3 from NRCan – PPP Service	38
Figure 4.7	Position of point MBR-4 from NRCan – PPP Service	40
Figure 4.7	Position of point MBR-5 from NRCan – PPP Service	42
Figure 4.10	Position of point MBR-6 from NRCan – PPP Service	44
Figure 4.11	Position of point MBR-7 from NRCan – PPP Service	46
Figure 4.12	Position of point MBR-8 from NRCan – PPP Service	48
Figure 4.13	Position of point " Base station" from NRCan – PPP Service	50
Figure 4.14	Position of point " Base NRC drone" from NRCan – PPP Service	52
Figure 4.15	Position of point " Base McGill drone" from NRCan – PPP Service	54
Figure 5.1	Field view of MBR 2-3	56
Figure 5.2	Field view of MBR 4-5	56

Figure 5.3	Field view of MBR 6-7	57
Figure 5.4	Field view of MBR 8 & Base station	57
Figure 5.5	Field view of NRC-Drone and McGill drone	58
Figure 5.6	Position of point MBR-2 from NRCan – PPP Service	60
Figure 5.7	Position of point MBR-3 from NRCan – PPP Service	62
Figure 5.8	Position of point MBR-4 from NRCan – PPP Service	64
Figure 5.9	Position of point MBR-5 from NRCan – PPP Service	66
Figure 5.10	Position of point MBR-6 from NRCan – PPP Service	68
Figure 5.11	Position of point MBR-7 from NRCan – PPP Service	70
Figure 5.12	Position of point MBR-8 from NRCan – PPP Service	72
Figure 5.13	Position of point “ Base station” from NRCan – PPP Service	74
Figure 5.14	Position of point “ Base NRC drone” from NRCan – PPP Service	76
Figure 5.15	Position of point “ Base McGill drone” from NRCan – PPP Service	78
Figure 6.1	Seasonal variation in height of NRC CACS station	79
Figure 7.1 to 7.8	Altimetric trend estimation 2016-2017-2018	81
Figure 7.9 to 7.15	Vertical motion of points in relation to the base	86

1) Introduction

Natural Resources Canada (NRCan) has a priority to provide essential geographic information (Natural Resources Canada 2016). An improved knowledge of our physical environment represents one of the foundations of this mandate. The Canadian Arctic is an important, but difficult, area to study especially for wetland monitoring. To reduce survey costs, researchers can use surrogate sites at more conveniently accessed locations; this is why the Mer Bleue Bog Peatlands, featuring open space / low tree coverage and similar to many wetlands found in an arctic environment, is used as an arctic surrogate study site (Figure 3.1).

This study site is used for the calibration and validation of various types of remote sensing data, acquired by several *ad hoc* project partners, and using satellite, airborne and UAV platforms. Project partners include the National Research Council of Canada (NRC), LOOKNorth and McGill University. The site has been used to calibrate and validate European Sentinel-2a satellite data, NRC visible and infrared airborne hyperspectral imagery and, principally, unmanned aerial vehicle (UAV) imagery as part of the Mer Bleue Arctic Surrogate Simulation Study (MBASSS) project (Soffer, et al. 2016).

For the last few years, versatile and low-cost UAVs (also referred to as Unmanned Aerial Systems (UAS), or drones) allow for multi-temporal aerial surveys of an environment. Obtaining products that are geographically located and validated with precision requires establishing ground control points (reference points) that are visible to the sensors, and for which geographic locations are known with precision (Figure 3.2). To fulfill this need, a high precision GNSS survey of reference points is required. A high precision GNSS survey campaign was undertaken in the area of the Mer Bleue Research Boardwalk (MBR), maintained by the Mer Bleue Peatland Observatory (MBPO), starting in 2016 and repeated several times in 2017 and 2018 (See Section 7 Related Publications). These surveys were pursued to: i) establish the position of manmade ground targets that could be used to georeference imagery acquired by UAV and aircraft during the project; and ii) confirm the positional stability of the Mer Bleue Research Boardwalk site during the campaign.

Exceptionally, 2018 surveys also includes the positioning of a large size target for NRC and a large size target for McGill University.

2) Positional Result Summary 2016-2017-2018

Tables 2-1 to 2-19 provide summary information of the GNSS survey results for each target point during the campaign. As will be later expanded upon, the position of the MBR-Base Station site is determined using various methodologies [the NRCan Precision Point Processing (PPP) and baseline processing using the NRCan Canadian Active Control System (CACS) station located approximately 9 km away from the Research Boardwalk]. Two height indicators are provided, the ellipsoidal height (height above the reference ellipsoid that approximates the Earth's surface) and the orthometric height (the height above the geoid as determined by the Earth's gravity which can be approximated by the mean sea level, or MSL). Further details on each site (including potential variations in altitude) and each campaign are expanded upon after this summary.

Table 2.1: Summary of Results – GNSS positions – May 2016 survey

Position established by NRCan - PPP	Easting (metres)	Northing (metres)	Height Ellipsoidal (metres)	Height Orthometric (metres)
UTM Zone 18	NAD-83-CSRS			CGVD28
MBR-2	459467.545	5028530.204	37.318	69.901
MBR-3	459426.437	5028647.469	37.858	70.442
MBR-4	459609.062	5028674.863	37.422	70.003
MBR-5	459292.857	5028403.057	37.083	69.670
MBR-6	459149.756	5028426.087	37.144	69.733
MBR-7	459396.056	5028377.023	38.307	70.892
Base station (PPP) ¹	459390.920	5028226.528	39.760	72.345
Base station (b-line) ²	459390.919	5028226.527	39.758	72.343

¹: GNSS data processed using NRCan Precision Point Processing from static survey

²: GNSS data processed using baseline method from NRC – CACS station

Table 2.2: Summary of Results – GNSS positions – July 2016 survey

Position established by NRCan - PPP	Easting (metres)	Northing (metres)	Height Ellipsoidal (metres)	Height Orthometric (metres)
UTM Zone 18	NAD-83-CSRS			CGVD28
MBR-2	459467.537	5028530.207	37.337	69.920
MBR-3	459426.435	5028647.479	37.875	70.459
MBR-4	459609.071	5028674.866	37.420	70.001
MBR-5	459292.859	5028403.057	37.094	69.681
MBR-6	459149.748	5028426.093	37.164	69.753
MBR-7	459396.054	5028377.026	38.313	70.898
Base station (PPP) ¹	459390.925	5028226.528	39.758	72.343
Base station (b-line) ²	459390.921	5028226.525	39.762	72.347

¹: GNSS data processed using NRCan Precision Point Processing from static survey

²: GNSS data processed using baseline method from NRC – CACS station

Table 2.3: Summary of Results – GNSS positions – August 2016 survey

Position established by NRCan - PPP	Easting (metres)	Northing (metres)	Height Ellipsoidal (metres)	Height Orthometric (metres)
UTM Zone 18	NAD-83-CSRS			CGVD28
MBR-2	459467.545	5028530.204	37.318	69.901
MBR-3	459426.435	5028647.469	37.865	70.449
MBR-4	459609.060	5028674.860	37.409	69.990
MBR-5	459292.859	5028403.060	37.089	69.676
MBR-6	459149.752	5028426.090	37.150	69.739
MBR-7	459396.060	5028377.029	38.311	70.896
MBR-8	459199.879	5028219.273	39.655	72.243
Base station (PPP) ¹	459390.922	5028226.525	39.758	72.343
Base station (b-line) ²	459390.922	5028226.524	39.760	72.345

¹: GNSS data processed using NRCan Precision Point Processing from static survey

²: GNSS data processed using baseline method from NRC – CACS station

Table 2.4: Summary of Results – GNSS positions – September 2016 survey

Position established by NRCan - PPP	Easting (metres)	Northing (metres)	Height Ellipsoidal (metres)	Height Orthometric (metres)
UTM Zone 18	NAD-83-CSRS			CGVD28
MBR-2	459467.548	5028530.207	37.340	69.923
MBR-3	459426.437	5028647.479	37.876	70.460
MBR-4	459609.064	5028674.863	37.425	70.006
MBR-5	459292.857	5028403.054	37.104	69.691
MBR-6	459149.750	5028426.093	37.169	69.758
MBR-7	459396.067	5028377.010	38.323	70.908
MBR-8	459199.875	5028219.276	39.675	72.263
Base station (PPP) ¹	459390.920	5028226.528	39.773	72.358
Base station (b-line) ²	459390.918	5028226.525	39.762	72.347

¹: GNSS data processed using NRCan Precision Point Processing from static survey

²: GNSS data processed using baseline method from NRC – CACS station

Table 2.5: Summary of Results – GNSS positions – November 2016 survey

Position established by NRCan - PPP	Easting (metres)	Northing (metres)	Height Ellipsoidal (metres)	Height Orthometric (metres)
UTM Zone 18	NAD-83-CSRS			CGVD28
MBR-2	459467.545	5028530.204	37.331	69.914
MBR-3	459426.435	5028647.479	37.881	70.465
MBR-4	5028674.860	5028674.860	37.425	70.006
MBR-5	459292.857	5028403.054	37.110	69.697
MBR-6	459149.750	5028426.093	37.175	69.764
MBR-7	459396.065	5028377.023	38.322	70.907
MBR-8	459199.870	5028219.279	39.670	72.258
Base station (PPP) ¹	459390.920	5028226.528	39.771	72.356
Base station (b-line) ²	459390.919	5028226.522	39.760	72.345

¹: GNSS data processed using NRCan Precision Point Processing from static survey

²: GNSS data processed using baseline method from NRC – CACS station

Table 2.6: Summary of Results – GNSS positions – December 2016 survey

Position established by NRCan - PPP	Easting (metres)	Northing (metres)	Height Ellipsoidal (metres)	Height Orthometric (metres)
UTM Zone 18	NAD-83-CSRS			CGVD28
MBR-2	459467.548	5028530.195	37.321	69.904
MBR-3	459426.441	5028647.476	37.872	70.456
MBR-4	459609.073	5028674.857	37.416	69.997
MBR-5	459292.861	5028403.051	37.091	69.678
MBR-6	459149.750	5028426.090	37.156	69.745
MBR-7	459396.071	5028377.001	38.316	70.901
MBR-8	459199.879	5028219.270	39.667	72.255
Base station (PPP) ¹	459390.924	5028226.522	39.760	72.345
Base station (b-line) ²	459390.918	5028226.523	39.759	72.344

¹: GNSS data processed using NRCan Precision Point Processing from static survey

²: GNSS data processed using baseline method from NRC – CACS station

Table 2.7 - Summary of Results – GNSS positions – June 2017 survey

Position established by NRCan - PPP	Easting (metres)	Northing (metres)	Height Ellipsoidal (metres)	Height Orthometric (metres)
UTM Zone 18	NAD-83-CSRS			CGVD28
MBR-2	459467.539	5028530.201	37.319	69.902
MBR-3	459426.432	5028647.479	37.861	70.445
MBR-4	459609.066	5028674.860	37.393	69.974
MBR-5	459292.861	5028403.057	37.093	69.680
MBR-6	459149.752	5028426.084	37.150	69.739
MBR-7	459396.069	5028376.998	38.304	70.889
MBR-8	459199.872	5028219.270	39.656	72.244
Base station (PPP) ¹	459390.921	5028226.525	39.761	72.346
Base station (b-line) ²	459390.921	5028226.524	39.751	72.336

¹: GNSS data processed using NRCan Precision Point Processing from static survey

²: GNSS data processed using baseline method from NRC – CACS station

Table 2.8: Summary of Results – GNSS positions – May 2018 survey

Position established by NRCan - PPP	Easting (metres)	Northing (metres)	Height Ellipsoidal (metres)	Height Orthometric (metres)
UTM Zone 18	NAD-83-CSRS			CGVD28
MBR-2	459467.550	5028530.198	37.317	69.900
MBR-3	459426.443	5028647.472	37.874	70.458
MBR-4 – Moved ³	459609.514	5028675.511	37.407	69.988
MBR-5	459292.863	5028403.051	37.101	69.688
MBR-6	459149.761	5028426.084	37.160	69.749
MBR-7	459396.097	5028377.001	38.305	70.890
MBR-8	459199.885	5028219.276	39.655	72.243
Base station (PPP) ¹	459390.927	5028226.519	39.756	72.341
Base station (b-line) ²	459390.917	5028226.521	39.771	72.356

¹: GNSS data processed using NRCan Precision Point Processing from static survey

²: GNSS data processed using baseline method from NRC – CACS station

³: This point is a new installation for 2018, offset from previous years

Table 2.9: Summary of Results – GNSS positions – August 2018 survey

Position established by NRCan - PPP	Easting (metres)	Northing (metres)	Height Ellipsoidal (metres)	Height Orthometric (metres)
UTM Zone 18	NAD-83-CSRS			CGVD28
MBR-2	459467.540	5028530.201	37.314	69.851
MBR-3	459426.434	5028647.475	37.866	70.403
MBR-4 – Moved ³	459609.495	5028675.513	37.389	69.923
MBR-5	459292.857	5028403.052	37.096	69.636
MBR-6	459149.754	5028426.084	37.163	69.705
MBR-7	459396.071	5028376.998	38.300	70.838
MBR-8	459199.872	5028219.275	39.654	72.196
Base station (PPP) ¹	459390.917	5028226.521	39.755	72.294
Base station (b-line) ²	459390.919	5028226.519	39.766	72.305

¹: GNSS data processed using NRCan Precision Point Processing from static survey

²: GNSS data processed using baseline method from NRC – CACS station

³: This point is a new installation for 2018, offset from previous years

Table 2.10: Summary of Results – GPS positions for the MBR-2 Station determined using NRCan Precision Point Processing (PPP) from static survey

MBR-2 established positions		Easting (metres)	Northing (metres)	Height <u>Ellipsoidal</u> (metres)	Height <u>Orthometric</u> (metres)
UTM Zone 18		NAD-83-CSRS			
May 2016		459467.545	5028530.204	37.318	69.901
July 2016		459467.537	5028530.207	37.337	69.920
August 2016		459467.545	5028530.204	37.318	69.901
September 16		459467.548	5028530.207	37.340	69.923
November 16		459467.545	5028530.204	37.331	69.914
December 16		459467.548	5028530.195	37.321	69.904
June 2017		459467.539	5028530.201	37.319	69.902
May 2018		459467.550	5028530.198	37.317	69.900
August 2018		459467.540	5028530.201	37.314	69.851 ^{new}
Maximum Delta (PPP) ¹		0.013	0.012	0.026	
	(b-line) ²			0.019	
	(l-line) ³			0.020	

¹: GPS data processed using NRCan Precision Point Processing from static survey

²: GPS data processed using baseline method from NRC –CACS station

³: GPS data processed using baseline method from the local MBR-Base Station

^{New}: refers to a modification of PPP software – see p. 31

Table 2.11: Summary of Results – GPS positions for the MBR-3 Station determined using NRCan Precision Point Processing from static survey

MBR-3 established positions		Easting (metres)	Northing (metres)	Height <u>Ellipsoidal</u> (metres)	Height <u>Orthometric</u> (metres)
UTM Zone 18		NAD-83-CSRS			
May 2016		459426.437	5028647.469	37.858	70.442
July 2016		459426.435	5028647.479	37.875	70.459
August 2016		459426.435	5028647.469	37.865	70.449
September 16		459426.437	5028647.479	37.876	70.460
November 16		459426.435	5028647.479	37.881	70.465
December 16		459426.441	5028647.476	37.872	70.456
June 2017		459426.432	5028647.479	37.861	70.445
May 2018		459426.443	5028647.472	37.874	70.458
August 2018		459426.434	5028647.475	37.866	70.403 ^{new}
Maximum Delta (PPP) ¹		0.011	0.010	0.023	
(b-line) ²				0.019	
(l-line) ³				0.009	

¹: GPS data processed using NRCan Precision Point Processing from static survey

²: GPS data processed using baseline method from NRC –CACS station

³: GPS data processed using baseline method from the local MBR-Base Station

^{New}: refers to a modification of PPP software – See p. 31

Table 2.12: Summary of Results – GPS positions for the MBR-4 Station determined using NRCan Precision Point Processing from static survey

MBR-4 established positions		Easting (metres)	Northing (metres)	Height <u>Ellipsoidal</u> (metres)	Height <u>Orthometric</u> (metres)
UTM Zone 18		NAD-83-CSRS			
May 2016		459609.062	5028674.863	37.422	70.003
July 2016		459609.071	5028674.866	37.420	70.001
August 2016		459609.060	5028674.860	37.409	69.990
September 16		459609.064	5028674.863	37.425	70.006
November 16		459609.060	5028674.860	37.425	70.006
December 16		459609.073	5028674.857	37.416	69.997
June 2017		459609.066	5028674.860	37.393	69.974
May 2018		459609.514*	5028675.511*	37.407*	69.988*
August 2018		459609.495*	5028675.513*	37.389*	69.923 ^{new}
Maximum Delta	(PPP) ¹	0.013	0.009	0.032	
	(b-line) ²			0.031	
	(l-line) ³			0.019	

¹: GPS data processed using NRCan Precision Point Processing from static survey

²: GPS data processed using baseline method from NRC –CACS station

³: GPS data processed using baseline method from the local MBR-Base Station

New: refers to a modification of PPP software – See p. 31

* MB-4 location and height was modified in 2018. Maximum delta does not include 2018.

Table 2.13: Summary of Results – GPS positions for the MBR-5 Station determined using NRCan Precision Point Processing from static survey

MBR-5 established positions		Easting (metres)	Northing (metres)	Height <u>Ellipsoidal</u> (metres)	Height <u>Orthometric</u> (metres)
UTM Zone 18		NAD-83-CSRS			
May 2016		459292.857	5028403.057	37.083	69.670
July 2016		459292.859	5028403.057	37.094	69.681
August 2016		459292.859	5028403.060	37.089	69.676
September 16		459292.857	5028403.054	37.104	69.691
November 16		459292.857	5028403.054	37.110	69.697
December 16		459292.861	5028403.051	37.091	69.678
June 2017		459292.861	5028403.057	37.093	69.680
May 2018		459292.863	5028403.051	37.101	69.688
August 2018		459292.857	5028403.052	37.096	69.636 ^{new}
Maximum Delta	(PPP) ¹	0.006	0.009	0.027	
	(b-line) ²			0.022	
	(l-line) ³			0.013	

¹: GPS data processed using NRCan Precision Point Processing from static survey

²: GPS data processed using baseline method from NRC –CACS station

³: GPS data processed using baseline method from the local MBR-Base Station

^{new}: refers to a modification of PPP software – See p. 31

Table 2.14: Summary of Results – GPS positions for the MBR-6 Station determined using NRCan Precision Point Processing from static survey

MBR-6 established positions		Easting (metres)	Northing (metres)	Height <u>Ellipsoidal</u> (metres)	Height <u>Orthometric</u> (metres)
UTM Zone 18		NAD-83-CSRS			
May 2016		459149.756	5028426.087	37.144	69.733
July 2016		459149.748	5028426.093	37.164	69.753
August 2016		459149.752	5028426.090	37.150	69.739
September 16		459149.750	5028426.093	37.169	69.758
November 16		459149.750	5028426.093	37.175	69.764
December 16		459149.750	5028426.090	37.156	69.745
June 2017		459149.752	5028426.084	37.150	69.739
May 2018		459149.761	5028426.084	37.160	69.749
August 2018		459149.754	5028426.084	37.163	69.705 ^{new}
Maximum Delta	(PPP) ¹	0.013	0.009	0.031	
	(b-line) ²			0.018	
	(l-line) ³			0.010	

¹: GPS data processed using NRCan Precision Point Processing from static survey

²: GPS data processed using baseline method from NRC –CACS station

³: GPS data processed using baseline method from the local MBR-Base Station

^{New}: refers to a modification of PPP software – See p. 31

Table 2.15: Summary of Results – GPS positions for the MBR-7 Station determined using NRCan Precision Point Processing from static survey

MBR-7 established positions		Easting (metres)	Northing (metres)	Height <u>Ellipsoidal</u> (metres)	Height <u>Orthometric</u> (metres)
UTM Zone 18		NAD-83-CSRS			
May 2016		459396.056	5028377.023	38.307	70.892
July 2016		459396.054	5028377.026	38.313	70.898
August 2016		459396.060	5028377.029	38.311	70.896
September 16		459396.067	5028377.010	38.323	70.908
November 16		459396.065	5028377.023	38.322	70.907
December 16		459396.071	5028377.001	38.316	70.901
June 2017		459396.069	5028376.998	38.304	70.889
May 2018		459396.097	5028377.001	38.305	70.890
August 2018		459396.071	5028376.998	38.300	70.838 ^{new}
Maximum Delta	(PPP) ¹	0.043	0.031	0.023	
	(b-line) ²			0.017	
	(l-line) ³			0.012	

¹: GPS data processed using NRCan Precision Point Processing from static survey

²: GPS data processed using baseline method from NRC –CACS station

³: GPS data processed using baseline method from the local MBR-Base Station

^{New}: refers to a modification of PPP software – See p. 31

Table 2.16: Summary of Results – GPS positions for the MBR-8 Station determined using NRCan Precision Point Processing from static survey

MBR-8 established positions	Easting (metres)	Northing (metres)	Height <u>Ellipsoidal</u> (metres)	Height <u>Orthometric</u> (metres)
UTM Zone 18	Site not yet established.			
NAD-83-CSRS				
May 2016				
July 2016				
August 2016	459199.879	5028219.273	39.655	72.243
September 16	459199.875	5028219.276	39.675	72.263
November 16	459199.870	5028219.279	39.670	72.258
December 16	459199.879	5028219.270	39.667	72.255
June 2017	459199.872	5028219.270	39.656	72.244
May 2018	459199.885	5028219.276	39.655	72.243
August 2018	459199.872	5028219.275	39.654	72.196 ^{new}
Maximum Delta (PPP) ¹	0.015	0.009	0.021	
(b-line) ²			0.012	
(l-line) ³			0.004	

¹: GPS data processed using NRCan Precision Point Processing from static survey

²: GPS data processed using baseline method from NRC –CACS station

³: GPS data processed using baseline method from the local MBR-Base Station

^{New}: refers to a modification of PPP software – See p. 31

Table 2.17: Summary of Results – GPS positions for the MBR-Base Station

MBR-Base Station established positions		Easting (metres)	Northing (metres)	Height <u>Ellipsoidal</u> (metres)	Height <u>Orthometric</u> (metres)
UTM Zone 18		Not yet installed.			
NAD-83-CSRS					
May 2016	(PPP) ¹	459390.920	5028226.528	39.760	72.345
	(b-line) ²	459390.919	5028226.527	39.758	72.343
July 2016	(PPP) ¹	459390.925	5028226.528	39.758	72.343
	(b-line) ²	459390.921	5028226.525	39.762	72.347
August 2016	(PPP) ¹	459390.922	5028226.525	39.758	72.343
	(b-line) ²	459390.922	5028226.524	39.760	72.345
September 16	(PPP) ¹	459390.920	5028226.528	39.773	72.358
	(b-line) ²	459390.918	5028226.525	39.762	72.347
November 16	(PPP) ¹	459390.920	5028226.528	39.771	72.356
	(b-line) ²	459390.919	5028226.522	39.760	72.345
December 16	(PPP) ¹	459390.924	5028226.522	39.760	72.345
	(b-line) ²	459390.918	5028226.523	39.759	72.344
June 2017	(PPP) ¹	459390.921	5028226.525	39.761	72.346
	(b-line) ²	459390.920	5028226.523	39.755	72.340
May 2018	(PPP) ¹	459390.927	5028226.519	39.756	72.341
	(b-line) ²	459390.917	5028226.521	39.771	72.356
August 2018	(PPP) ¹	459390.917	5028226.521	39.755	72.294 ^{new}
	(b-line) ²	459390.919	5028226.519	39.766	72.305
Maximum Delta	(PPP) ¹	0.010	0.009	0.015	
	(b-line) ²	0.006	0.008	0.007	

¹: GPS data processed using NRCan Precision Point Processing from static survey

²: GPS data processed using baseline method from NRC – CACS station

^{new}: refers to a modification of PPP software – See p. 31

Table 2.18: Summary of Results – Height difference between surveys (ellipsoidal)

	Height (metres)	Height (metres)	Height (metres)	Height (metres)	Height (metres)	Height (metres)	Height (metres)	Height (metres)	Height (metres)
	May 2016	July 2016	August 2016	Sept. 2016	Nov. 2016	Dec 2016	June 2017	May 2018	August 2018
MBR-2 - PPP	37.318	37.337	37.318	37.340	37.331	37.321	37.319	37.317	37.314
MBR-2 - NRC	37.320	37.328	37.312	37.315	37.323	37.318	37.309	37.315	37.312
MBR-2 - Base	Not installed	37.323	37.311	37.311	37.317	37.321	37.307	37.303	37.306
MBR-3 - PPP	37.858	37.875	37.865	37.876	37.881	37.872	37.861	37.874	37.866
MBR-3 - NRC	37.864	37.869	37.864	37.867	37.872	37.864	37.858	37.867	37.877
MBR-3 - Base	Not installed	37.871	37.862	37.863	37.868	37.869	37.863	37.868	37.870
MBR-4 - PPP	37.422	37.420	37.409	37.425	37.425	37.416	37.393	37.407*	37.389*
MBR-4 - NRC	37.429	37.427	37.413	37.418	37.419	37.415	37.396	37.400*	37.415*
MBR-4 - Base	Not installed	No data	37.411	37.413	37.417	37.420	37.401	37.399*	37.407*
MBR-5 - PPP	37.083	37.094	37.089	37.104	37.110	37.091	37.093	37.101	37.096
MBR-5 - NRC	37.081	37.088	37.085	37.085	37.095	37.093	37.087	37.103	37.099
MBR-5 - Base	37.085	No data	No data	37.082	37.093	37.095	37.092	37.091	37.092
MBR-6 - PPP	37.144	37.164	37.150	37.169	37.175	37.156	37.150	37.160	37.163
MBR-6 - NRC	37.147	37.159	37.153	37.154	37.162	37.157	37.152	37.165	37.165
MBR-6 - Base	37.151	37.154	No data	37.152	37.160	37.161	37.149	37.153	37.158
MBR-7 - PPP	38.307	38.313	38.311	38.323	38.322	38.316	38.304	38.305	38.300
MBR-7 - NRC	38.302	38.306	38.310	38.312	38.316	38.304	38.306	38.299	38.304
MBR-7 - Base	38.306	38.307	No data	38.308	38.309	38.309	38.303	38.299	38.297
MBR-8 - PPP	Not installed	Not install	39.655	39.675	39.670	39.667	39.656	39.655	39.654
MBR-8 NRC	Not installed	Not installed	39.661	39.658	39.661	39.658	39.658	39.670	39.662
MBR-8 - Base	Not installed	Not installed	No data	39.657	39.658	39.659	39.657	39.657	39.655
Base sta. P	39.760	39.758	39.758	39.773	39.771	39.760	39.761	39.756	39.755
Base sta. - N	39.762	39.761	39.760	39.762	39.760	39.759	39.755	39.771	39.766

* MB-4 location and height was modified in 2018.

Table 2.19: Summary of Results – NRC CACS station height variation through time

	May 2016	June 2016	July 2016	Aug. 2016	Sept. 2016	Nov. 2016	Dec. 2016	June 2017	May 2018	August 2018
metre	-.015	-.010	.001	-.010	.003	.000	-.011	-.003	-.003	-.003

Source: Geodetic Survey Division, Canadian Active Control System.

Several figures illustrating the height variation of each point, established using various methods are show in Section 6 and 7.

3) Survey site location and materials used

Mer Bleue (Figure 3.1) is a protected ombrotrophic bog with a hummock-hollow-lawn microtopography. It is located at the eastern boundary of the City of Ottawa, Ontario, Canada at 45.4°N and 75.5°W. This wetlands area has an east–west orientation dissected by two longitudinal sections of fluvial sand/gravel separating three distinct arms of the peatland (Lafleur, et al. 2005). The bog is slightly domed, with a peat depth greater than 5-6 m across most of the area. In the northern arm, this decreases to 0.3 m towards the edge where narrow beaver ponds are inundated year-round (Lafleur, et al. 2005) (Roulet, et al. 2007).

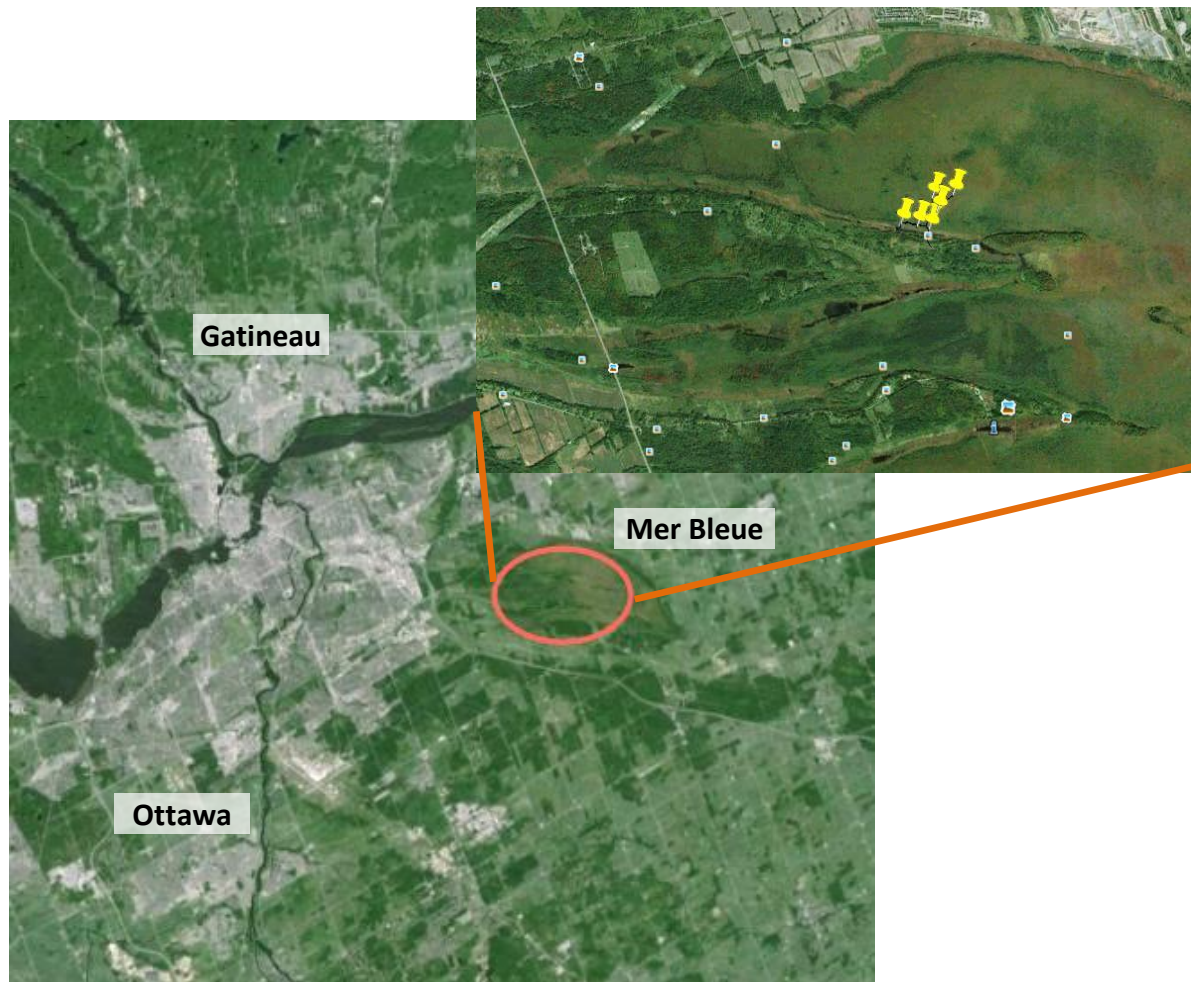


Figure 3.1: Mer Bleue Bog and locations of GNSS Survey site targets at the Mer Bleue Peatland Observatory in Ottawa, Ontario, Canada. Image: Google Earth™

The Mer Bleue Bog is home to the Mer Bleue Peatland Observatory (MBPO), providing infrastructure for research activities since its inception in 1998. The MBPO has restricted access with a neighbouring grassland area and various pedestrian

boardwalks protecting the peat surface. Proximity of the Mer Bleue Bog to the city of Ottawa provides convenient deployment of field teams and equipment.

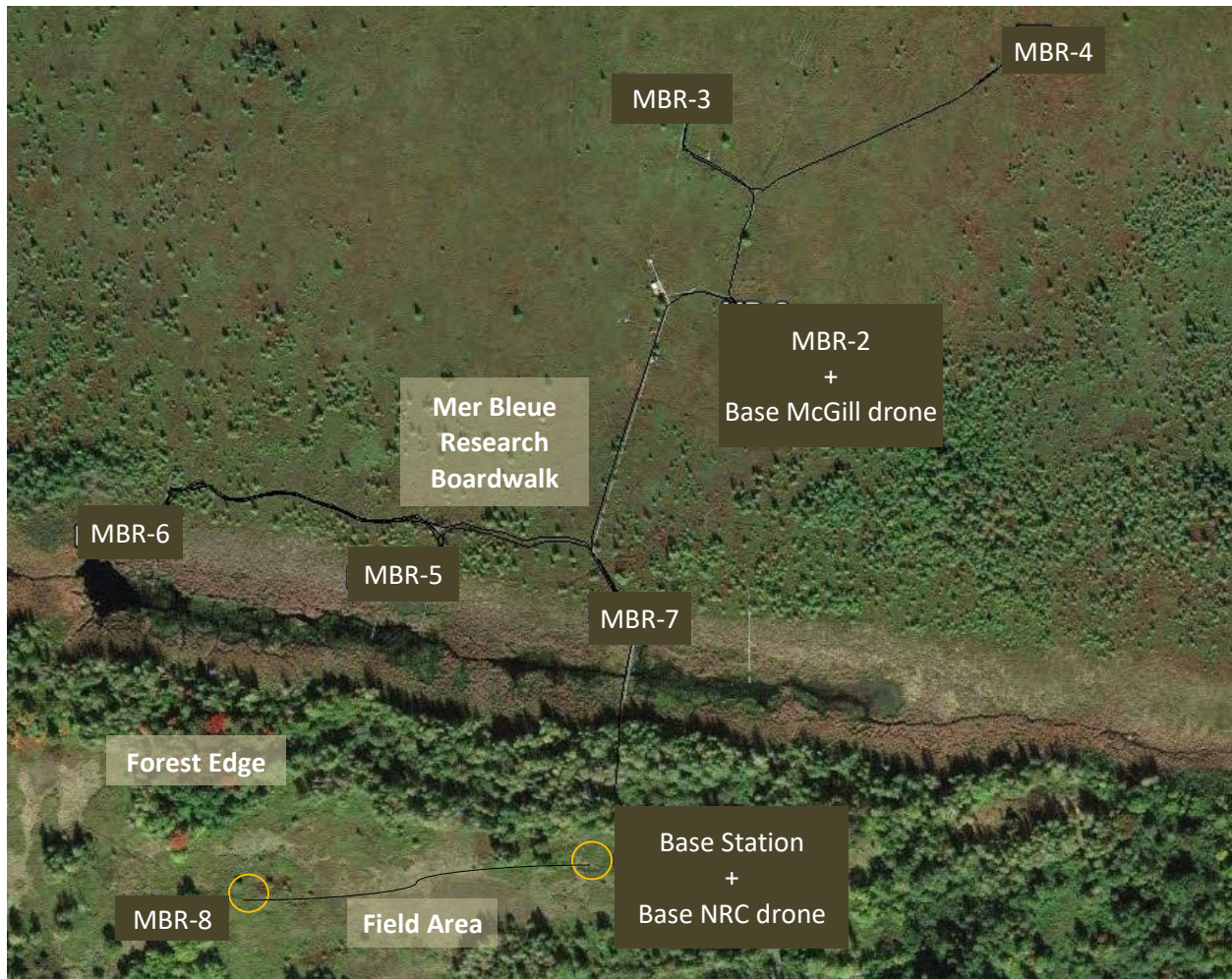


Figure 3.2: GNSS Point locations at the Mer Bleue Research Boardwalk area. MBR-8 and the Base Station are located on dry, upper ground while the others are located on stable but floating supports on the boardwalk itself.

Eight GPS survey points (Figure 3.2) were established on or near the MBPO. Six of these points are located in the bog itself using boardwalk structural supports mounted into the peat (but not reaching the sedimentary layer beneath the peat). Two other points are located outside of the bog on dry, upper ground to act as permanent stable points. These two points consist of a steel rod hammered several meters down in soft sediment below the frost line.

The MBR Base Station target site (Figure 3.3) was installed in May 2016. In early August 2016 it was agreed by team members that an additional reference point should be defined further west of the actual set of points to take into account the extended area covered by the airborne and UAV surveys, including the light drone survey for which the coverage limit extends outside the existing work zone.



Figure 3.3: MBR Base Station site with (left) and without (right) the pipe cap.



Figure 3.4: MBR-8 site with (left) and without (right) the pipe cap.

To that effect, a new point (MBR-8) was established outside of the bog itself on dry, upper ground (Figure 3.4). This new point also acts as a permanent stable point similar to the Base Station. MBR-8 is made of a steel rod hammered 6.1 m down into the soft sediment below the frost line. A large diameter steel pipe 60 cm long was hammered over the steel rod to stabilize it. Since there is no bedrock in the area, it is expected that this point will be as stable as possible in this type of ground and location. The Base Station and MBR-8 sites being both stable points, can be used for phase difference GNSS. Having two stable points allows one to validate that no relative height variations occur with these base locations.

In June 2017, two new points were established following requests from NRC and McGill partners, especially for their drone surveys. These two points are named “Base NRC drone” and ‘Base McGill drone” and are reported in this year’s report. It must be noted that “Base NRC drone” target is simply laid on the ground. Its position may vary with frost or accidental movement of the whole target.

The positions (latitude-longitude-altitude) of the of the six points on the peatland boardwalk, and the two points on the upper ground were all established based on long (~24 – 40 hour) static GNSS surveys using Ashtech™ Choke Ring antennas with either Ashtech™ dual frequency Zxtreme™ receivers or Trimble NetR9™ receivers (Table 3.1). Other materials required for the survey included antenna cables, power cables, internal and external batteries, painted plywood targets, bolts and nuts, and camera (Figure 3.5).

Table 3.1: GNSS acquisition time for individual surveys - Rounded to the hour

	May 2018			August 2018	
Site					
MBR-2	23 h	GPS only		24 h	GPS only
MBR-3	23 h	GPS only		26 h	GPS only
MBR-4	23 h	GPS+Glonass		12 h	GPS only
MBR-5	23 h	GPS only		27 h	GPS only
MBR-6	22 h	GPS only		26 h	GPS only
MBR-7	23 h	GPS only		27 h	GPS only
MBR-8	19 h	GPS only		26 h	GPS + Glonass
Base Station	47 h	GPS only		27 h	GPS + Glonass
Base NRC Drone	23 h	GPS+Glonass		20 h	GPS only
Base McGill drone	8 h	GPS+Glonass		9 h	GPS only



Figure 3.5: GNSS receivers and associated components

Processing of the resulting RINEX files (the receiver raw output files) was performed days after acquisition by NRCan Precision Point Processing (PPP) Service. A processing report summary page is included for each point and acquisition. MBR-2 to MBR-7 are located on “semi-stable” ground (i.e. on posts used to support the boardwalk used by scientists to circulate throughout the site). None of the points are on rock, bedrock or solid concrete. Latitude and longitude (planimetric) positions should be used with caution.

With respect to the altitude of each location, a few considerations must be noted. The altitude of any of those positions is, as by design of the set-up, the altitude of the top face of the plywood target (as illustrated in site pictures). No attempt was made to estimate the ground altitude as the moss creates a very rough and seasonally variable microtopography, potentially changing with moisture levels, phenological state, etc. The plywood target height would however provide a base location to determine the altitude of the vegetation layer using the UAV surveys. It is the responsibility of the user to measure the plywood target height above “ground” to obtain the ground altitude. As the altitude estimated of the MBR points during this GNSS survey could also vary

seasonally as the posts base do not reach the “solid” bottom beneath the bog, these points are compared to the MBR-8 and Base Station positions. We should note that there have been no anecdotal reports of the boardwalk vertical motion impacting any of the MBPO infrastructure, so it was assumed stable as a start.

In brief, the 3D positions of these points are not of geodetic accuracy but they are the best position estimates obtainable in this type of physical environment.

In order to increase the confidence of the height estimation, point heights were also estimated using baseline processing in relation to the NRCan Canadian Active Control System (CACS) station located 9 km away in Ottawa (Figure 3.6), and also using baseline processing in relation to the Base Station Site.

Top Screenshot (May Survey):

La coordonnée de la station ci-dessous sera automatiquement mise à jour après un changement de ces champs.

Coordonnées	Géοide	Cadre de référence	Époque	Date (YYYY-MM-DD)
UTM	HT2_0	NAD83(SCRS)	Choisir par la d:	05/23/2018
Zone	Abscisse (mètres)		Ordonnée (mètres)	
UTM18	451223.140 ± 0.0000		5033592.289 ± 0.0000	
h (mètres)	Échelle		Échelle combinée	
83.620 ± 0.0000	0.999629		0.999616	
Convergence				
0° 26' 40.56"				
N ₁ (mètres)	H ₁ (mètres)		Date publié et ID du projet	
-32.744	116.364		2013-04-18 M12700	

Bottom Screenshot (August Survey):

Changing these fields will auto-update the station coordinate information below.

Coordinates	Geoid	Reference Frame	Epoch	Date (YYYY-MM-DD)
UTM	HT2_0	NAD83(CSRs)	Select by date	08/23/2018
Zone	Easting (metres)		Northing (metres)	
UTM18	451223.141 ± 0.0000		5033592.288 ± 0.0000	
h (metres)	Scale		Combined	
83.621 ± 0.0000	0.999629		0.999616	
Convergence				
0° 26' 40.56"				
N ₁ (metres)	H ₁ (metres)		Published date and project ID	
-32.744	116.365		2013-04-18 M12700	

Vertical Data

Figure 3.6: Position of the Natural Resources Canada - Canadian Active Control System (CACS) Station NRC-1 which is used for the baseline processing method at time of the May and August survey.

4) Data Acquisition – GNSS survey in May 2018

Presented here are the precision GNSS survey reports for the May 2018 campaign (to the limits discussed above), as well as sample photos, of the MBR site targets and drone targets (Figure 4.1 to 4.5). Information provided in these detailed reports include the latitude, longitude and altitude (both ellipsoidal and orthometric representing sea level) of the base of the antenna as installed on the target, the UTM zone, and the UTM Easting and Northing. Planimetric positions are in NAD 83 CSRS, and the Geoid model is CGVD28.

It is worth mentioning that during the summer of 2018, between the May and August surveys, a subset of the NRCan PPP software used to calculate the orthometric height from the ellipsoidal height, CGDV28, was lightly modified. As a result, orthometric height are ~ 4 cm higher for the August 2018 survey onward.

MB-4 target was moved in early 2018. Therefore 3D positions differ from previous years.

For the purpose of the baseline processing between the base station and individual MB points, the base station position was set at the following values, which represent the average over time since 2017.

Easting and Northing are set at 459390.920 metres and 5028226.526 metres, in UTM zone 18. Ellipsoidal height is set at 39.760 metres above sea level.



Figure 4.1: Field views of GPS locations MBR-2 (left) and MBR-3 (right) (May, 2018).



Figure 4.2: Field views of GPS locations MBR-4 (left) and MBR-5 (right) (May, 2018).



Figure 4.3: Field views of GPS locations MBR-6 (left) and MBR-7 (right) (May, 2018).



Figure 4.4: Field views of GPS locations MBR-8 (left) and MBR-Base (right) (May, 2018).

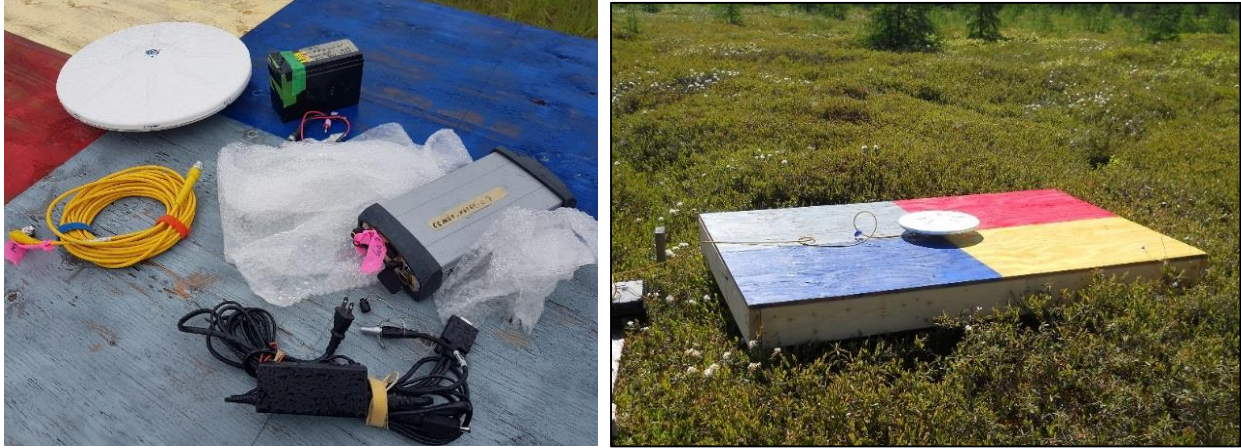


Figure 4.5: Field views of GPS locations NRC-drone (left) and McGill drone (right) (May, 2018).

Table 4.1 to 4.10 report the acquisition detail of all 10 points for the month of May 2018. Figures 4.6 to 4.15 report the position associated with each point.

Table 4.1: GNSS acquisition details of point MBR-2- May 2018

Site :	MBR-2			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 s/n 1205 CCRS: # 5			
Antenna	Ashtech Chokering "D"			
	ASH701945C_M NONE (4 caract. between M and None).			
Antenna height	0 (See note above)			
Acquisition start	2018 05 22 16 h 17 min. 30 sec. (jour 142)			
Acquisition end	2018 05 23 15 h 06 min 30 sec.			
Duration	22 h 49 m 00 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	1205142C.t02			
Rinex files	12051420C.18N			
	12051420C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 32.8204"	-75° 31' 04.6950"	37.317	69.900
UTM	5028530.198	459467.550		
Error ellipse @95%	.7 cm	1.6 cm		
	±0.006m	±0.012m	±0.020m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028530.199	459467.535	37.315	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028530.205	459467.538	37.303	



SCRS-PPP (V 1.05 11216)



MB-2

Début des données	Fin des données	Durée des observations
2018-05-22 16:17:30.000	2018-05-23 15:06:30.000	22h 48m 60.00s
Dév. std. apri / apost - Porteuse		Dév. std. apri / apost - Pseudo-distances
0.020m / 0.007m		2.0m / 0.903m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupure d'élévation	Données rejetées	Intervalles des observations & estimés
10.000 degrés	0.00 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1= 0.090 m L2= 0.119 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 12051420C.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 32.8204''	-75° 31' 04.6950''	37.317 m
Sigmas(95%)	0.005 m	0.012 m	0.020 m
Apriori	45° 24' 32.875''	-75° 31' 04.739''	37.540 m
Position calculée - Apriori	-1.677 m	0.958 m	-0.224 m

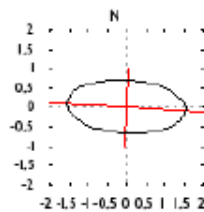
H Ortho CGVD28 (HTv2.0)

Ellipse d'erreur 95% (cm)
 semi-majeur: 1.551cm
 semi-mineur: 0.681cm
 azimut de l'axe semi-majeur: 93° 34' 20.09''

UTM (Nord) Zone 18

69.900 m
 (lien pour la référence altimétrique)

5028530.198m (N) 459467.550m (E)



Facteurs échelle
 0.99962020 (point)
 0.99961434 (combiné)

(Position apriori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.6: Position of point MBR-2 from NRCan – PPP Service – May 2018. Orange circles represent most frequently requested information.

Table 4.2: GNSS acquisition details of point MBR-3 - May 2018

Site :	MBR-3			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 s/n 1059 CCRS: # 1			
Antenna	Ashtech Chokering 2735			
Antenna height	ASH701945C_M NONE (4 caract. between M and None). 0 (See note above)			
Acquisition start	2018 05 23 16 h 11 min. 30 sec. (jour 143)			
Acquisition end	2018 05 24 15 h 08 min 30 sec.			
Duration	22 h 57 m 00 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	10591430C.t02			
Rinex files	10591430C.18N 10591430C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 36.6119"	-75° 31' 06.6208"	37.874	70.458
UTM	5028647.472	459426.443		
Error ellipse @95%	.6 cm	1.3 cm		
	±0.005m	±0.010m	±0.010m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028647.472	459426.434	37.867	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028647.476	459426.438	37.868	



SCRS-PPP (V 1.05 11216)



MB-3

Début des données	Fin des données	Durée des observations
2018-05-23 16:11:30.000	2018-05-24 15:08:30.000	22h 56m 60.00s
Dév. std. a priori / apost - Porteuse		Dév. std. a priori / apost - Pseudo-distances
0.020m / 0.006m		2.0m / 0.971m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupure d'élévation	Données rejetées	Intervalles des observations & estimés
10.000 degrés	0.00 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1= 0.090 m L2= 0.119 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 10591430c.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 36.6119''	-75° 31' 06.6208''	37.874 m
Sigmas(95%)	0.005 m	0.010 m	0.018 m
Apriori	45° 24' 36.661''	-75° 31' 06.648''	37.000 m
Position calculée - Apriori	-1.506 m	0.599 m	0.873 m

H Ortho CGVD28 (HTv2.0)	Ellipse d'erreur 95% (cm) semi-majeur: 1.263cm semi-mineur: 0.571cm azimut de l'axe semi-majeur: 86° 47' 36.32''	UTM (Nord) Zone 18
70.458 m (lien pour la référence altimétrique)		5028647.472m (N) 459426.443m (E)

Facteurs échelle
 0.99962024 (point)
 0.99961430 (combiné)

(Position a priori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.7: Position of point MBR-3 from NRCan – PPP Service – May 2018

Table 4.3: GNSS acquisition details of point MBR-4 - May 2018

Site :	MBR-4			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
	This point is a new installation for May 2018. Point is offset from previous lat-long measurements.			
Receiver (GNSS)	Trimble NetR-9 s/n 0352 CCRS: # 6			
Antenna	Ashtech Chokering # 1125			
	ASH701945C_M NONE (4 caract. between M and None).			
Antenna height	0 (See note above)			
Acquisition start	2018 05 23 16 h 44 min. 30 sec. (jour 143)			
Acquisition end	2018 05 24 15 h 29 min 30 sec.			
Duration	22 h 45 m 00 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	0352143C.t02			
Rinex files	03521430C.18N .18g .18h			
	03521430C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 37.5586"	-75° 30' 58.2071"	37.407	69.988
UTM	5028675.511	459609.514		
Error ellipse @95%	.6 cm	1.3 cm		
	±0.005m	±0.010m	±0.019m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028675.514	459609.515	37.400	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028675.518	459609.519	37.399	



SCRS-PPP (V 1.05 11216)



MB-4

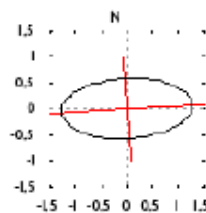
Début des données	Fin des données	Durée des observations
2018-05-23 16:44:30.000	2018-05-24 15:29:30.000	22h 45m 0.00s
Dév. std. apri / apost - Porteuse		Dév. std. apri / apost - Pseudo-distances
0.020m / 0.006m		2.0m / 1.177m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupure d'élévation	Données rejetées	Intervalles des observations & estimés
10.000 degrés	0.07 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1= 0.090 m L2= 0.119 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 03521430C.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 37.5586''	-75° 30' 58.2071''	37.407 m
Sigmas(95%)	0.005 m	0.010 m	0.019 m
Apriori	45° 24' 37.605''	-75° 30' 58.235''	36.425 m
Position calculée - Apriori	-1.420 m	0.611 m	0.983 m

H Ortho CGVD28 (HTv2.0)	Ellipse d'erreur 95% (cm) semi-majeur: 1.275cm semi-mineur: 0.584cm azimut de l'axe semi-majeur: 86° 54' 6.16''	UTM (Nord) Zone 18
69.988 m (lien pour la référence altimétrique)		5028675.511m (N) 459609.514m (E)



Facteurs échelle
0.99962006 (point)
0.99961419 (combiné)

(Position apriori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.8: Position of point MBR-4 from NRCan – PPP Service- May 2018

Table 4.4: GNSS acquisition details of point MBR-5 - May 2018

Site :	MBR-5			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 S/N 1059 CCRS: # 1			
Antenna	Ashtech Chokering 2735			
Antenna height	ASH701945C_M NONE (4 caract. between M and None). 0 (See note above)			
Acquisition start	2018 05 22 16 h 37 min. 30 sec. (jour 142)			
Acquisition end	2018 05 23 15 h 27 min 00 sec.			
Duration	22 h 49 m 30 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	1059142C.t02			
Rinex files	10591420C.18N 10591420C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 28.6639"	-75° 31' 12.6933"	37.101	69.688
UTM	5028403.051	459292.863		
Error ellipse @95%	.6 cm	1.3 cm		
	±0.005m	±0.011m	±0.019m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028403.052	459292.860	37.103	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028403.058	459292.863	37.091	



SCRS-PPP (V 1.05 11216)



MB-5

Début des données	Fin des données	Durée des observations
2018-05-22 16:37:30.000	2018-05-23 15:27:00.000	22h 49m 30.00s
Dév. std. a priori / apost - Porteuse		Dév. std. a priori / apost - Pseudo-distances
0.020m / 0.006m		2.0m / 1.364m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupure d'élévation	Données rejetées	Intervalles des observations & estimés
10.000 degrés	0.00 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1= 0.090 m L2= 0.119 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 10591420c.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 28.6639''	-75° 31' 12.6933''	37.101 m
Sigmas(95%)	0.005 m	0.011 m	0.019 m
Apriori	45° 24' 28.706''	-75° 31' 12.732''	36.986 m
Position calculée - Apriori	-1.305 m	0.836 m	0.115 m

H Ortho CGVD28 (HTv2.0)

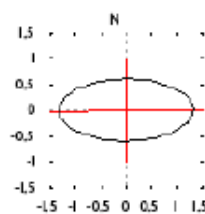
Ellipse d'erreur 95% (cm)
 semi-majeur: 1.324cm
 semi-mineur: 0.599cm
 azimut de l'axe semi-majeur: 89° 32' 35.19''

UTM (Nord) Zone 18

69.688 m

[\(lien pour la référence altimétrique\)](#)

5028403.051m (N) 459292.863m (E)



Facteurs échelle
 0.99962037 (point)
 0.99961455 (combiné)

(Position a priori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.9: Position of point MBR-5 from NRCan – PPP Service – May 2018

Table 4.5: GNSS acquisition details of point MBR-6 - May 2018

Site :	MBR-6			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 S/N 1072 CCRS: # 2			
Antenna	Ashtech Chokering # 1125			
Antenna height	ASH701945C_M NONE (4 caract. between M and None). 0 (See note above)			
Acquisition start	2018 05 22 16 h 43 min. 30 sec. (jour 142)			
Acquisition end	2018 05 23 14 h 35 min 00 sec.			
Duration	21 h 51 m 30 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	1072142C.t02			
Rinex files	10721420C.18N 10721420C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 29.3802"	-75° 31' 19.2832"	37.160	69.749
UTM	5028426.084	459149.761		
Error ellipse @95%	.6 cm	1.4 cm		
	±0.005m	±0.011m	±0.019m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028426.084	459149.757	37.165	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028426.090	459149.760	37.153	



SCRS-PPP (V 1.05 11216)



MB-6

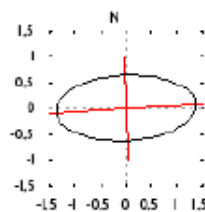
Début des données	Fin des données	Durée des observations
2018-05-22 16:43:30.000	2018-05-23 14:35:00.000	21h 51m 30.00s
Dév. std. apri / apost - Porteuse		Dév. std. apri / apost - Pseudo-distances
0.020m / 0.006m		2.0m / 1.454m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupure d'élévation	Données rejetées	Intervalles des observations & estimés
10.000 degrés	0.11 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1= 0.090 m L2= 0.119 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 10721420C.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 29.3802''	-75° 31' 19.2832''	37.160 m
Sigmas(95%)	0.005 m	0.011 m	0.019 m
Apriori	45° 24' 29.427''	-75° 31' 19.329''	37.474 m
Position calculée - Apriori	-1.458 m	1.003 m	-0.314 m

H Ortho CGVD28 (HTv2.0)	Ellipse d'erreur 95% (cm) semi-majeur: 1.387cm semi-mineur: 0.634cm azimut de l'axe semi-majeur: 87° 15' 55.31''	UTM (Nord) Zone 18
69.749 m (lien pour la référence altimétrique)		5028426.084m (N) 459149.761m (E)



Facteurs échelle
0.99962052 (point)
0.99961469 (combiné)

(Position apriori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.10: Position of point MBR-6 from NRCan – PPP Service – May 2018

Table 4.6: GNSS acquisition details of point MBR-7 - May 2018

Site :	MBR-7			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 S/N 1205 CCRS: # 5			
Antenna	Ashtech Chokering # 5850			
Antenna height	ASH701945C_M NONE (4 caract. between M and None). 0 (See note above)			
Acquisition start	2018 05 23 15 h 32 min. 00 sec. (jour 143)			
Acquisition end	2018 05 24 14 h 49 min 00 sec.			
Duration	23 h 17 m 00 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	1205143C.t02			
Rinex files	12051430C.18N 12051430C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 27.8414"	-75° 31' 07.9366"	38.305	70.890
UTM	5028377.001	459396.097		
Error ellipse @95%	.6 cm	1.3 cm		
	±0.005m	±0.010m	±0.018m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028377.002	459396.085	38.299	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028377.006	459396.088	38.299	



SCRS-PPP (V 1.05 11216)



MB-7

Début des données	Fin des données	Durée des observations
2018-05-23 15:32:00.000	2018-05-24 14:49:00.000	23h 17m 0.00s
Dév. std. a priori / a posteriori - Porteuse		Dév. std. a priori / a posteriori - Pseudo-distances
0.020m / 0.007m		2.0m / 1.320m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupeure d'élévation	Données rejetées	Intervalles des observations & estimés
10.000 degrés	0.21 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1= 0.090 m L2= 0.119 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 12051430C.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 27.8414''	-75° 31' 07.9366''	38.305 m
Sigmas(95%)	0.005 m	0.010 m	0.018 m
Apriori	45° 24' 27.884''	-75° 31' 07.965''	37.520 m
Position calculée - Apriori	-1.313 m	0.624 m	0.786 m

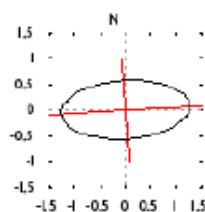
H Ortho CGVD28 (HTv2.0)

Ellipse d'erreur 95% (cm)
 semi-majeur: 1.263cm
 semi-mineur: 0.570cm
 azimut de l'axe semi-majeur: 86° 31' 49.22''

UTM (Nord) Zone 18

70.890 m
[\(lien pour la référence altimétrique\)](#)

5028377.001m (N) 459396.097m (E)



Facteurs échelle
 0.99962027 (point)
 0.99961426 (combiné)

(Position a priori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.11: Position of point MBR-7 from NRCan – PPP Service- May 2018

Table 4.7: GNSS acquisition details of point MBR-8 - May 2018

Site :	MBR-8			
Installation Type	Antenna reference point (ARP) in physical contact with top of vertical steel rod coupler.			
Receiver (GNSS)	Trimble NetR-9 S/N 1297 CCRS: # 4			
Antenna	Ashtech Chokering # 5875			
	Internal battery only (Burned fuse on external battery)			
	ASH701945C_M NONE (4 caract. between M and None).			
Antenna height	0 (See note above)			
Acquisition start	2018 05 22 15 h 34 min. 00 sec. (jour 142)			
Acquisition end	2018 05 23 10 h 33 min 30 sec.			
Duration	18 h 59 m 30 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	1297142C.t02			
Rinex files	12971420C.18N			
	12971420C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 22.6895"	-75° 31' 16.9157"	39.655	72.243
UTM	5028219.276	459199.885		
Error ellipse @95%	.7 cm	1.7 cm		
	±0.006m	±0.014m	±0.023m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028219.274	459199.878	39.670	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028219.280	459199.881	39.657	



SCRS-PPP (V 1.05 11216)



MB-8 session debut 22 mai

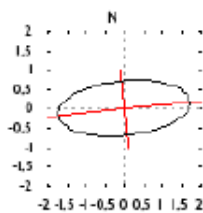
Début des données	Fin des données	Durée des observations
2018-05-22 15:34:00.000	2018-05-23 10:33:30.000	18h 59m 30.00s
Dév. std. apri / apost - Porteuse		Dév. std. apri / apost - Pseudo-distances
0.020m / 0.006m		2.0m / 1.618m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupure d'élévation	Données rejetées	Intervalles des observations & estimés
10.000 degrés	0.09 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1= 0.090 m L2= 0.119 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 12971420C.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 22.6895''	-75° 31' 16.9157''	39.655 m
Sigmas(95%)	0.006 m	0.014 m	0.023 m
Apriori	45° 24' 22.710''	-75° 31' 16.949''	36.814 m
Position calculée - Apriori	-0.646 m	0.727 m	2.841 m

H Ortho CGVD28 (HTv2.0)	Ellipse d'erreur 95% (cm) semi-majeur: 1.730cm semi-mineur: 0.708cm azimut de l'axe semi-majeur: 84° 23' 14.23''	UTM (Nord) Zone 18
72.243 m (lien pour la référence altimétrique)		5028219.276m (N) 459199.885m (E)



Facteurs échelle
0.99962047 (point)
0.99961425 (combiné)

(Position apriori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.12: Position of point MBR-8 from NRCan – PPP Service – May 2018

Table 4.8: GNSS acquisition details of point “Base station” - May 2018

Site :	Base station			
Installation Type	Antenna reference point (ARP) in physical contact with top of vertical steel rod coupler.			
Receiver (GNSS)	Trimble Net-R9 # 03 S/N 1216 External Battery : large deep charge.			
Antenna	Ashtech Chokering			
	ASH701945C_M NONE (4 caract. between M and None).			
Antenna height	0 (See note above)			
Acquisition start	2018 05 22 16 h 12 min. 30 sec. (jour 142)			
Acquisition end	2018 05 24 15 h 16 min 30 sec.			
Duration	47 h. 04 min.			
Acquisition interval	30 seconds			
Raw GNSS files	12161420D.t02			
Rinex files	12161420D.18O 18N			
Position established by PPP	Latitude (average)	Longitude (average)	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 22.9642”	-75° 31' 08.1298”	39.756	72.341
UTM	5028226.519	459390.927		
Error ellipse @95 %	.4 cm	.9 cm		
	±0.003m	±0.007m	±0.013m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028226.521	459390.917	39.771	.



SCRS-PPP (V 1.05 11216)



Base

Début des données	Fin des données	Durée des observations
2018-05-22 16:12:30.000	2018-05-24 15:16:30.000	47h 4m 0.00s
Dév. std. a priori / a posteriori - Porteuse		Dév. std. a priori / a posteriori - Pseudo-distances
0.020m / 0.007m		2.0m / 1.977m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupure d'élévation	Données rejetées	Intervalles des observations & estimés
10.000 degrés	0.00 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1= 0.090 m L2= 0.119 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 12161420D.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 22.9642''	-75° 31' 08.1298''	39.756 m
Sigmas(95%)	0.003 m	0.007 m	0.013 m
Apriori	45° 24' 23.015''	-75° 31' 08.156''	38.077 m
Position calculée - Apriori	-1.559 m	0.570 m	1.679 m

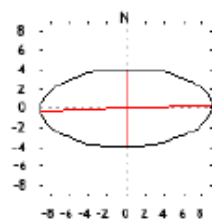
H Ortho CGVD28 (HTv2.0)

Ellipse d'erreur 95% (mm)
 semi-majeur: 8.993mm
 semi-mineur: 3.993mm
 azimut de l'axe semi-majeur: 88° 53' 57.86''

UTM (Nord) Zone 18

72.341 m
 (lien pour la référence altimétrique)

5028226.519m (N) 459390.927m (E)



Facteurs échelle
 0.99962028 (point)
 0.99961404 (combiné)

(Position a priori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.13: Position of point "Base station" from NRCan – PPP Service- May 2018

Table 4.9: GNSS acquisition details of point “ Base NRC Drone May 2018

Site :	Base NRC-drone			
Installation Type	Antenna reference point (ARP) in physical contact with top of plywood (drone target). Centered on 4 colors junction.			
Receiver (GNSS)	Trimble NetR-9 # 7 S/N 0126 Battery: 7.5 amps			
Antenna	Trimble Zephyr Geodetic 2 RoHS			
	TRM57971.00			
Antenna height	0 (See note above)			
Acquisition start	2018 05 22 16 h 05 min. 00 sec. (jour 142)			
Acquisition end	2018 05 23 14 h 46 min 00 sec.			
Duration	22 h 41 min			
Acquisition interval	30 seconds			
Raw GNSS files	0126142C.T02			
Rinex files	01261420C.17o 17n 17g			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 22.9938"	-75° 31' 10.3722"	40.442	73.028
UTM	5028227.747	459342.188		
Error ellipse @95 %	.6 cm	1.4 cm		
	±0.005m	±0.011m	±0.019m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028227.748	459342.184	40.482	.

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028227.753	459342.187	40.471	.



SCRS-PPP (V 1.05 11216)



Base NRC drone

Début des données	Fin des données	Durée des observations
2018-05-22 16:05:00.000	2018-05-23 14:46:00.000	22h 41m 0.00s
Dév. std. a priori / apost - Porteuse		Dév. std. a priori / apost - Pseudo-distances
0.020m / 0.007m		2.0m / 2.026m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupure d'élévation	Données rejetées	Intervalle des observations & estimés
10.000 degrés	0.04 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
TRM57971.00	L1= 0.067 m L2= 0.058 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 01261420C.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 22.9938''	-75° 31' 10.3722''	40.442 m
Sigmas(95%)	0.005 m	0.011 m	0.019 m
Apriori	45° 24' 23.038''	-75° 31' 10.402''	40.152 m
Position calculée - Apriori	-1.351 m	0.640 m	0.290 m

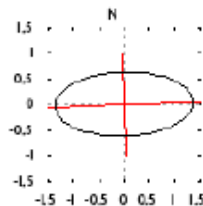
H Ortho CGVD28 (HTv2.0)

Ellipse d'erreur 95% (cm)
semi-majeur: 1.374cm
semi-mineur: 0.623cm
azimut de l'axe semi-majeur: 87° 58' 40.87''

UTM (Nord) Zone 18

73.028 m
[\(lien pour la référence altimétrique\)](#)

5028227.747m (N) 459342.188m (E)



Facteurs échelle
0.99962032 (point)
0.99961397 (combiné)

(Position a priori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.14: Position of point " Base NRC Drone" from NRCan – PPP Service. May 2018

Table 4.10: GNSS acquisition details of point " Base McGill Drone May 2018 "

Site :		Base McGill-drone		
Installation Type		Antenna reference point (ARP) in physical contact with top of plywood (drone target). Centered on 4 colors junction.		
Receiver (GNSS)		Trimble NetR-9 # 7 S/N 0126 No external battery		
Antenna		Trimble Zephyr Geodetic 2 RoHS		
		TRM57971.00		
Antenna height		0 (See note above)		
Acquisition start		2018 05 23 15 h 08 min. 30 sec. (jour 143)		
Acquisition end		2018 05 23 22 h 39 min 00 sec.		
Duration		7 h 30 m 30.00 sec.		
Acquisition interval		30 seconds		
Raw GNSS files		0126143C.T02		
Rinex files		01261430C.17o 17n 17g		
Position established by PPP		Latitude	Longitude	Ellipsoidal Height (m)
Geographic		45° 24' 32.7716"	-75° 31' 04.6707"	37.454
UTM		5028528.688	459468.068	
Error ellipse @95 %		1 cm	2.7 cm	
		±0.008m	±0.022m	±0.030m

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028528.688	459468.070	37.472	.

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028528.689	459468.074	37.472	.



SCRS-PPP (V 1.05 11216)



Base Mc Gill drone

Début des données	Fin des données	Durée des observations
2018-05-23 15:08:30.000	2018-05-23 22:39:00.000	7h 30m 30.00s
Dév. std. a priori / apost - Porteuse		Dév. std. a priori / apost - Pseudo-distances
0.020m / 0.007m		2.0m / 0.884m
Observations	Fréquence	Mode
Porteuse et pseudo-distances	L1 et L2	Statique
Coupure d'élévation	Données rejetées	Intervalles des observations & estimés
10.000 degrés	0.00 %	30.00 sec / 30.00 sec
Antenne	CPA au PRA	PRA au Repère
TRM57971.00	L1= 0.067 m L2= 0.058 m	0.000 m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 01261430C.18o

	Latitude (+n)	Longitude (+e)	Hauteur Ell.
NAD83(SCRS) (2018)	45° 24' 32.7716''	-75° 31' 04.6707''	37.454 m
Sigmas(95%)	0.008 m	0.022 m	0.030 m
Apriori	45° 24' 32.807''	-75° 31' 04.694''	36.139 m
Position calculée - Apriori	-1.087 m	0.497 m	1.315 m

H Ortho CGVD28 (HTv2.0)

Ellipse d'erreur 95% (cm)
semi-majeur: 2.715cm
semi-mineur: 0.959cm
azimut de l'axe semi-majeur: 86° 6' 27.39''

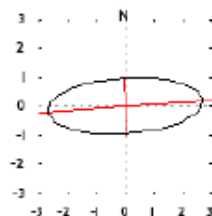
UTM (Nord) Zone 18

70.037 m

[\(lien pour la référence altimétrique\)](#)

5028528.688m (N) 459468.068m (E)

Facteurs échelle
0.99962020 (point)
0.99961432 (combiné)



(Position a priori initialisée à partir des coordonnées du fichier RINEX)

Figure 4.15: Position of point " Base Mc Gill Drone" from NRCan – PPP Service. May 2018

5) Data Acquisition – GNSS survey in August 2018

Presented here are the precision GNSS survey reports for the August 2018 campaign (to the limits discussed above), as well as sample photos, of the MBR site targets (Figures 5.1 to 5.5). Information provided in these detailed reports include the latitude, longitude and altitude (both ellipsoidal and orthometric representing sea level) of the base of the antenna as installed on the target, the UTM zone, and the UTM Easting and Northing.

As well, MB-4 target was moved in early 2018. Therefore 3D positions differ from previous years.

For the purpose of the baseline processing between the base station and individual MB points, the base station position was fixed at the following values, which represent the average over time since 2017: UTM zone = 18, easting = 459390.920, northing = 5028226.526, and ellipsoidal height = 39.760.



Figure 5.1: Field views of GPS locations MBR-2 (left) and MBR-3 (right) (August, 2018).



Figure 5.2: Field views of GPS locations MBR-4 (left) and MBR-5 (right) (August, 2018).



Figure 5.3: Field views of GPS locations MBR-6 (left) and MBR-7 (right) (August, 2018).



Figure 5.4: Field views of GPS locations MBR-8 (left) and MBR-Base (right) (August, 2018).

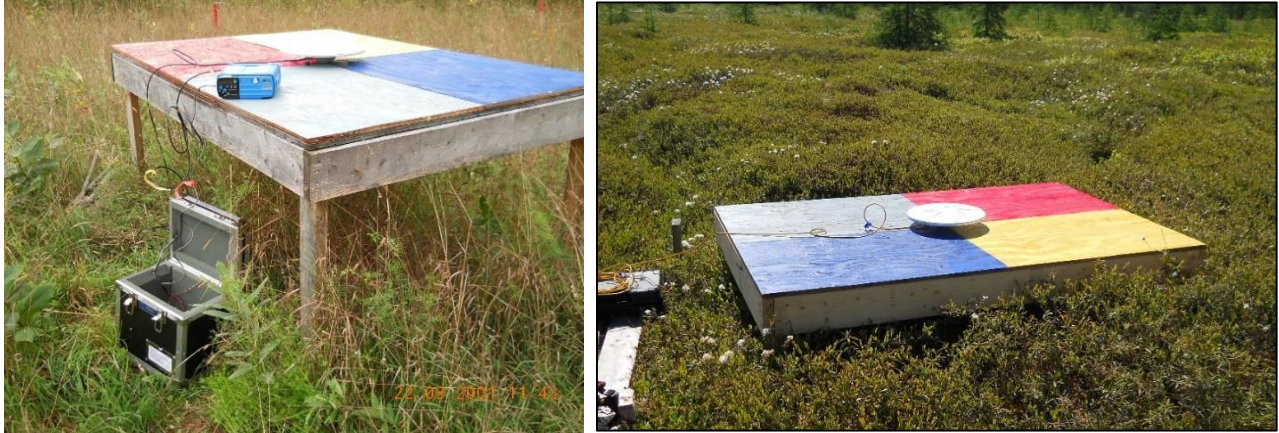


Figure 5.5: Field views of GPS locations NRC-drone (left) and McGill drone (right) (August, 2018).

Table 5.1 to 5.10 report the acquisition detail of all 10 points for the month of August 2018. Figures 5.6 to 5.15 report the position associated with each point.

Table 5.1: GNSS acquisition details of point MBR-2- August 2018

Site :	MBR-2			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 s/n 1059 CCRS: # 1			
Antenna	Ashtech Chokering			
	ASH701945C_M NONE (4 caract. between M and None).			
Antenna height	0 (See note above)			
Acquisition start	2018 08 22 16 h 26 min. 00 sec. (jour 234)			
Acquisition end	2018 08 23 17 h 07 min 00 sec.			
Duration	24 h 00 m 41 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	1059234C.t02			
Rinex files	10592340C.18N			
	10592340C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 32.82052"	-75° 31' 4.69546"	37.314	69.851
UTM	5028530.201	459467.540		
Error ellipse @95%	.4 cm	.8 cm		
	±0.003m	±0.006m	±0.011m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028530.199	459467.545	37.312	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028530.207	459467.547	37.306	



SCRS-PPP 2.11.0 (2018-07-26)



10592340c.18o
MB-2

Début des données 2018-08-22 16:26:00.00	Fin des données 2018-08-23 17:07:00.00	Durée des observations 1 jour, 0:41:00
Heure de traitement 13:39:53 UTC 2018/08/27		Type de produits RNCAN rapide
Observations Porteuse et pseudo-distance	Fréquence Double	Mode Statique
Masque d'élévation 7.5 degrés	Données rejetées 0.03 %	Intervalle des estimés 30.00 sec
Antenne ASH701945C_M NONE	CPA au PRA L1 = 0.090 m L2 = 0.119 m	PRA au Repère H:0.000m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

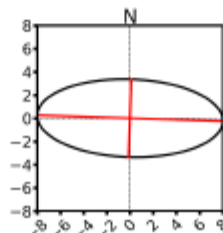
Positions estimées pour 10592340c.18o

	Latitude (+n)	Longitude (+e)	Altitude Ell.
NAD83(SCRS) (2018)	45° 24' 32.82052"	-75° 31' 4.69546"	37.314 m
Sigmas(95%)	0.003 m	0.006 m	0.011 m
A priori*	45° 24' 32.84532"	-75° 31' 4.73099"	35.679 m
Position calculée – A priori	-0.766 m	0.773 m	1.635 m

Altitude orthométrique CGVD28 (HTv2.0) Ellipse d'erreur 95% (mm) UTM (Nord) Zone 18
 (HTv2.0) demi-grand axe: 7.998 mm
demi-petit axe: 3.359 mm
azimut du demi-grand axe: 91° 53' 39.34"

69.851 m

(lien pour la référence altimétrique)



5028530.201 m (N)

459467.540 m (E)

Facteurs échelle
0.999620 (point)
0.999614 (combiné)

*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

Figure 5.6: Position of point MBR-2 from NRCAN – PPP Service – August 2018. Orange circles represent most frequently requested information.

Table 5.2: GNSS acquisition details of point MBR-3 – August 2018

Site :	MBR-3			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 s/n 1072 CCRS: # 2			
Antenna	Ashtech Chokering			
	ASH701945C_M NONE (4 caract. between M and None).			
Antenna height	0 (See note above)			
Acquisition start	2018 08 22 15 h 52 min. 30 sec. (jour 234)			
Acquisition end	2018 08 23 18 h 14 min 30 sec.			
Duration	26 h 22 m 00 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	10722340C.t02			
Rinex files	10722340C.18N			
	10722340C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 36.61199"	-75° 31' 6.62123"	37.866	70.403
UTM	5028647.475	459426.434		
Error ellipse @95%	.3 cm	.8 cm		
	±0.003m	±0.006m	±0.010m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028647.467	459426.438	37.877	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028647.474	459426.440	37.870	



SCRS-PPP 2.18.0 (2018-10-09)



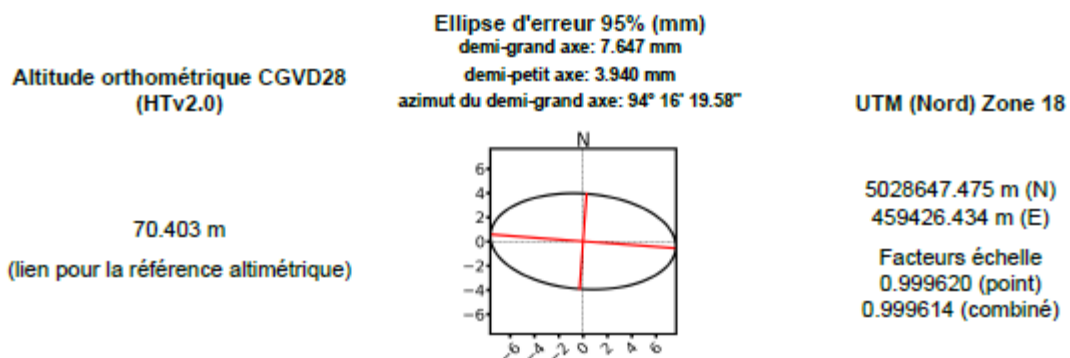
10722340C.18o
MB-3

Début des données 2018-08-22 15:52:30.00	Fin des données 2018-08-23 18:14:30.00	Durée des observations 1 jour, 2:22:00
Heure de traitement 15:05:05 UTC 2018/12/06		Type de produits IGS finale
Observations Porteuse et pseudo-distance	Fréquence Double	Mode Statique
Masque d'élévation 7.5 degrés	Données rejetées 0.03 %	Intervalle des estimés 30.00 sec
Antenne ASH701945C_M NONE	CPA au PRA L1 = 0.090 m L2 = 0.119 m	PRA au Repère H:0.016m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 10722340C.18o

	Latitude (+n)	Longitude (+e)	Altitude Ell.
NAD83(SCRS) (2018)	45° 24' 36.61199"	-75° 31' 6.62121"	37.866 m
Sigmas(95%)	0.003 m	0.006 m	0.010 m
A priori*	45° 24' 36.62433"	-75° 31' 6.65232"	36.731 m
Position calculée – A priori	-0.381 m	0.676 m	1.135 m



*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

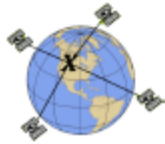
Figure 5.7: Position of point MBR-3 from NRCan – PPP Service – August 2018

Table 5.3: GNSS acquisition details of point MBR-4 - August 2018

Site :	MBR-4			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
	This point is a new installation for May and August 2018. Point is offset from previous years measurements.			
Receiver (GNSS)	Ashtech Zxtreme CCRS: # 1			
Antenna	Trimble geodetic TRM57971.00			
Antenna height	0 (See note above)			
Acquisition start	2018 08 22 16 h 10 min. 30 sec. (jour 234)			
Acquisition end	2018 08 23 04 h 06 min 30 sec.			
Duration	11 h 56 m 00 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	B__A18.234			
Rinex files	__2341.18N			
	__2341.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 37.55865"	-75° 30' 58.20796"	37.389	69.923
UTM	5028675.513	459609.495		
Error ellipse @95%	.6 cm	1.4 cm		
	±0.005m	±0.011m	±0.018m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028675.510	459609.509	37.415	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028675.517	459609.512	37.407	



SCRS-PPP 2.11.0 (2018-07-26)



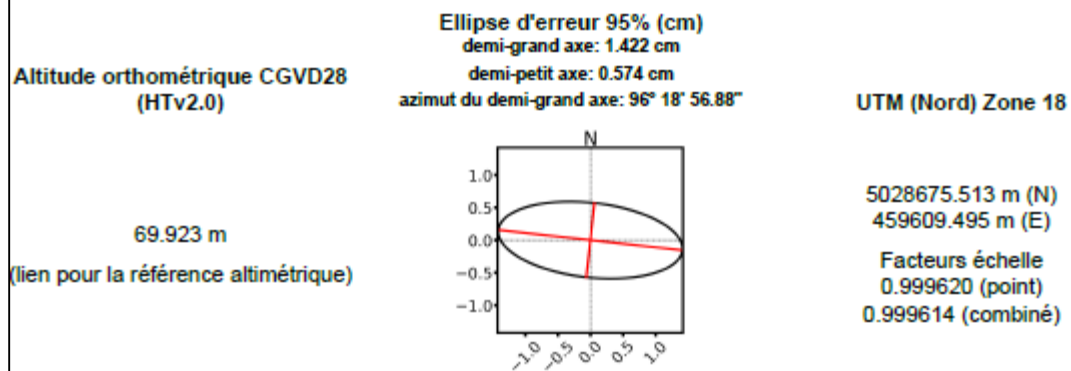
____2341.180
Zxtreme 1 MB-4

Début des données 2018-08-22 16:10:30.00	Fin des données 2018-08-23 04:06:30.00	Durée des observations 11:56:00
Heure de traitement 12:41:21 UTC 2018/08/24		Type de produits RNCAN rapide
Observations Porteuse et pseudo-distance	Fréquence Double	Mode Statique
Masque d'élévation 7.5 degrés	Données rejetées 0.14 %	Intervalle des estimés 30.00 sec
Antenne TRM57971.00	CPA au PRA L1 = 0.065 m L2 = 0.058 m	PRA au Repère H:0.000m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour ____2341.180

	Latitude (+n)	Longitude (+e)	Altitude EIL
NAD83(SCRS) (2018)	45° 24' 37.55865"	-75° 30' 58.20796"	37.389 m
Sigmas(95%)	0.005 m	0.011 m	0.018 m
A priori*	45° 24' 37.61073"	-75° 30' 58.24296"	47.367 m
Position calculée – A priori	-1.608 m	0.761 m	-9.978 m



*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

Figure 5.8: Position of point MBR-4 from NRCAN – PPP Service- August 2018

Table 5.4: GNSS acquisition details of point MBR-5- August 2018

Site :	MBR-5			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 S/N 1216 CCRS: # 3			
Antenna	Ashtech Chokering			
	ASH701945C_M NONE (4 caract. between M and None).			
Antenna height	0 (See note above)			
Acquisition start	2018 08 22 15 h 20 min. 00 sec. (jour 234)			
Acquisition end	2018 08 23 18 h 00 min 30 sec.			
Duration	26 h 40 m 30 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	12162340D.t02			
Rinex files	12162340D.18N			
	12162340D.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 28.66395"	-75° 31' 12.69357"	37.096	69.636
UTM	5028403.052	459292.857		
Error ellipse @95%	.3 cm	.8 cm		
	±0.003 m	±0.006 m	±0.010 m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028403.051	459292.862	37.099	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028403.059	459292.864	37.092	



SCRS-PPP 2.11.0 (2018-07-26)



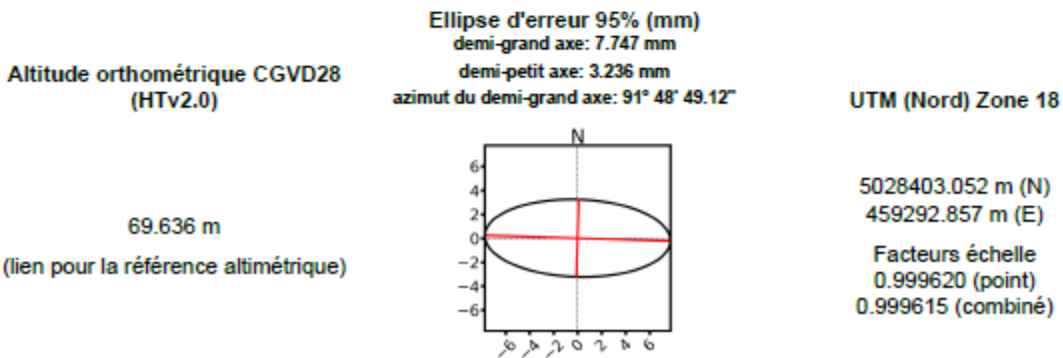
12162340D.18o
MB-5

Début des données	Fin des données	Durée des observations
2018-08-22 15:20:00.00	2018-08-23 18:00:30.00	1 jour, 2:40:30
Heure de traitement		Type de produits
14:03:22 UTC 2018/08/27		RNCan rapide
Observations	Fréquence	Mode
Porteuse et pseudo-distance	Double	Statique
Masque d'élévation	Données rejetées	Intervalle des estimés
7.5 degrés	0.00 %	30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1 = 0.090 m L2 = 0.119 m	H:0.000m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 12162340D.18o

	Latitude (+n)	Longitude (+e)	Altitude Ell.
NAD83(SCRS) (2018)	45° 24' 28.66395"	-75° 31' 12.69357"	37.096 m
Sigmas(95%)	0.003 m	0.006 m	0.010 m
A priori*	45° 24' 28.68233"	-75° 31' 12.73872"	34.475 m
Position calculée – A priori	-0.567 m	0.982 m	2.620 m



*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

Figure 5.9: Position of point MBR-5 from NRCan – PPP Service – August 2018

Table 5.5: GNSS acquisition details of point MBR-6 - August 2018

Site :	MBR-6			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 S/N 1297 CCRS: # 4			
Antenna	Ashtech Chokering			
Antenna height	ASH701945C_M NONE (4 caract. between M and None). 0 (See note above)			
Acquisition start	2018 08 22 15 h 40 min. 00 sec. (jour 234)			
Acquisition end	2018 08 23 18 h 05 min 00 sec.			
Duration	26 h 25 m 00 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	12972340C.t02			
Rinex files	12972340C.18N			
	12972340C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 29.38023"	-75° 31' 19.28350"	37.163	69.705
UTM	5028426.084	459149.754		
Error ellipse @95%	.3 cm	.8 cm		
	±0.003 m	±0.006 m	±0.011 m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028426.082	459149.759	37.165	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028426.089	459149.760	37.158	



SCRS-PPP 2.11.0 (2018-07-26)



12972340C.18o
MB-6

Début des données	Fin des données	Durée des observations
2018-08-22 15:40:00.00	2018-08-23 18:05:00.00	1 jour, 2:25:00
Heure de traitement		Type de produits
14:13:10 UTC 2018/08/27		RNCan rapide
Observations	Fréquence	Mode
Porteuse et pseudo-distance	Double	Statique
Masque d'élévation	Données rejetées	Intervalle des estimés
7.5 degrés	0.09 %	30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1 = 0.090 m L2 = 0.119 m	H:0.000m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 12972340C.18o

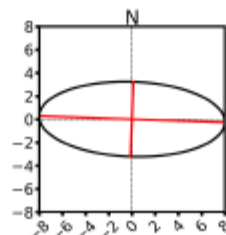
	Latitude (+n)	Longitude (+e)	Altitude Ell.
NAD83(SCRS) (2018)	45° 24' 29.38023"	-75° 31' 19.28350"	37.163 m
Sigmas(95%)	0.003 m	0.006 m	0.011 m
A priori*	45° 24' 29.39908"	-75° 31' 19.32308"	34.769 m
Position calculée – A priori	-0.582 m	0.861 m	2.393 m

Altitude orthométrique CGVD28
(HTv2.0)

69.705 m

(lien pour la référence altimétrique)

Ellipse d'erreur 95% (mm)
demi-grand axe: 7.998 mm
demi-petit axe: 3.232 mm
azimut du demi-grand axe: 92° 1' 7.95"



UTM (Nord) Zone 18

5028426.084 m (N)
459149.754 m (E)

Facteurs échelle
0.999621 (point)
0.999615 (combiné)

*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

Figure 5.10: Position of point MBR-6 from NRCAN – PPP Service – August 2018

Table 5.6: GNSS acquisition details of point MBR-7 – August 2018

Site :	MBR-7			
Installation Type	Antenna reference point (ARP) in physical contact with top face of plywood UAV target. Plywood target bottom face in physical contact with top of post (See photos)			
Receiver (GNSS)	Trimble NetR-9 S/N 1205 CCRS: # 5			
Antenna	Ashtech Chokering			
Antenna height	ASH701945C_M NONE (4 caract. between M and None). 0 (See note above)			
Acquisition start	2018 08 22 15 h 29 min. 30 sec. (jour 234)			
Acquisition end	2018 08 23 18 h 42 min 30 sec.			
Duration	27 h 13 m 00 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	12052340C.t02			
Rinex files	12052340C.18N 1205234C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 27.84129"	-75° 31' 7.93778"	38.300	70.838
UTM	5028376.998	459396.071		
Error ellipse @95%	.3 cm	.7 cm		
	±0.003 m	±0.006 m	±0.010m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028376.994	459396.075	38.304	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028377.001	459396.076	38.297	



SCRS-PPP 2.11.0 (2018-07-26)



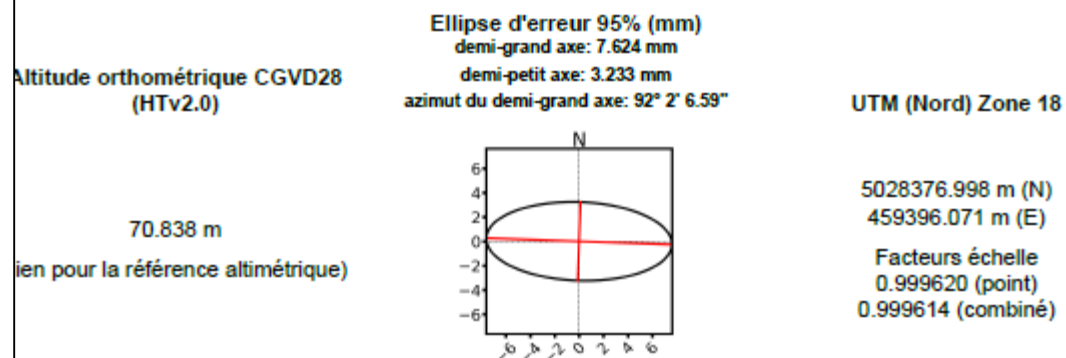
12052340C.18o
MB-7

Début des données	Fin des données	Durée des observations
2018-08-22 15:29:30.00	2018-08-23 18:42:30.00	1 jour, 3:13:00
Heure de traitement		Type de produits
14:17:25 UTC 2018/08/27		RNCan rapide
Observations	Fréquence	Mode
Porteuse et pseudo-distance	Double	Statique
Masque d'élévation	Données rejetées	Intervalle des estimés
7.5 degrés	0.00 %	30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1 = 0.090 m L2 = 0.119 m	H:0.000m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 12052340C.18o

	Latitude (+n)	Longitude (+e)	Altitude Ell.
NAD83(SCRS) (2018)	45° 24' 27.84129"	-75° 31' 7.93778"	38.300 m
Sigmas(95%)	0.003 m	0.006 m	0.010 m
A priori*	45° 24' 27.84353"	-75° 31' 7.96365"	36.955 m
Position calculée – A priori	-0.069 m	0.563 m	1.345 m



*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

Figure 5.11: Position of point MBR-7 from NRCan – PPP Service- August 2018.

Table 5.7: GNSS acquisition details of point MBR-8 - August 2018

Site :	MBR-8			
Installation Type	Antenna reference point (ARP) in physical contact with top of vertical steel rod coupler.			
Receiver (GNSS)	Trimble NetR-9 S/N 0352 CCRS: # 6			
Antenna	Ashtech Chokering			
Antenna height	ASH701945C_M NONE (4 caract. between M and None). 0 (See note above)			
Acquisition start	2018 08 22 16 h 35 min. 30 sec. (jour 234)			
Acquisition end	2018 08 23 18 h 21 min 00 sec.			
Duration	25 h 45 m 30 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	03522340C.t02			
Rinex files	03522340C.18N .18G .18H 03522340C.18O			
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 22.68946"	-75° 31' 16.91631"	39.654	72.196
UTM	5028219.275	459199.872		
Error ellipse @95%	.3 cm	.8 cm		
	±0.003 m	±0.007 m	±0.012 m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028219.272	459199.879	39.662	

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
	5028219.279	459199.881	39.655	



SCRS-PPP 2.11.0 (2018-07-26)



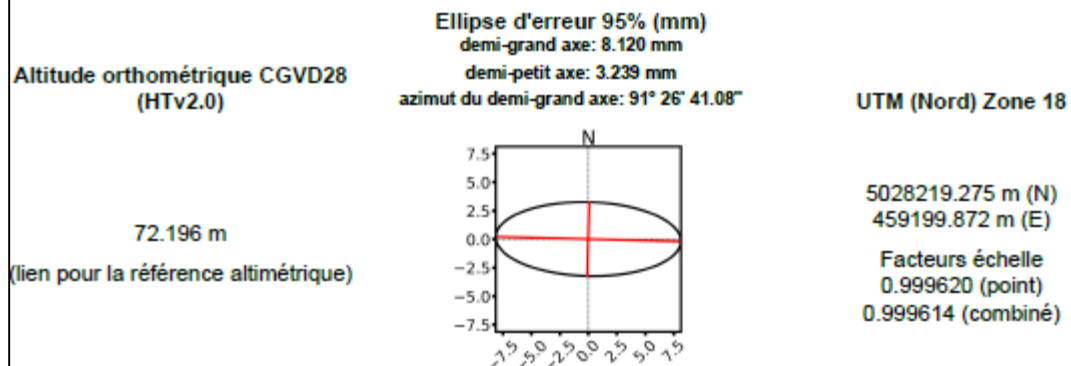
03522340C.18o
MB-8

Début des données	Fin des données	Durée des observations
2018-08-22 16:35:30.00	2018-08-23 18:21:00.00	1 jour, 1:45:30
Heure de traitement		Type de produits
14:28:27 UTC 2018/08/27		RNCan rapide
Observations	Fréquence	Mode
Porteuse et pseudo-distance	Double	Statique
Masque d'élévation	Données rejetées	Intervalle des estimés
7.5 degrés	0.03 %	30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1 = 0.090 m L2 = 0.119 m	H:0.000m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 03522340C.18o

	Latitude (+n)	Longitude (+e)	Altitude EIL
NAD83(SCRS) (2018)	45° 24' 22.68946"	-75° 31' 16.91631"	39.654 m
Sigmas(95%)	0.003 m	0.006 m	0.012 m
A priori*	45° 24' 22.72833"	-75° 31' 16.93892"	38.371 m
Position calculée – A priori	-1.200 m	0.492 m	1.283 m



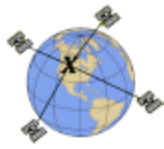
*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

Figure 5.12: Position of point MBR-8 from NRCan – PPP Service – August 2018.

Table 5.8: GNSS acquisition details of point “Base station” - August 2018

Site :	Base station			
Installation Type	Antenna reference point (ARP) in physical contact with top of vertical steel rod coupler.			
Receiver (GNSS)	Trimble Net-R9 # 07 S/N 1216 External Battery : Deep charge type.			
Antenna	Ashtech Chokering			
	ASH701945C_M NONE (4 caract. between M and None).			
Antenna height	0 (See note above)			
Acquisition start	2018 08 22 15 h 05 min. 30 sec. (jour 234)			
Acquisition end	2018 08 23 17 h 56 min 00 sec.			
Duration	26 h. 50 min. 30 sec.			
Acquisition interval	30 seconds			
Raw GNSS files	12162340C.t02			
Rinex files	12162340C.18O 18N 18G 18H			
Position established by PPP	Latitude (average)	Longitude (average)	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 22.96428"	-75° 31' 8.13025"	39.755	72.294
UTM	5028226.521	459390.917		
Error ellipse @95 %	.3 cm	.8 cm		
	±0.003m	±0.006m	±0.012m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028226.519	459390.919	39.766	.



SCRS-PPP 2.11.0 (2018-07-26)



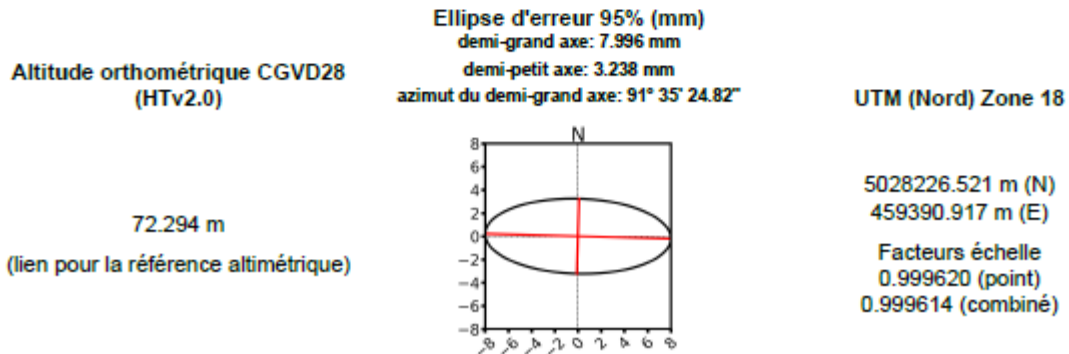
01262340C.18o
Base

Début des données	Fin des données	Durée des observations
2018-08-22 15:05:30.00	2018-08-23 17:56:00.00	1 jour, 2:50:30
Heure de traitement		Type de produits
14:33:51 UTC 2018/08/27		RNCan rapide
Observations	Fréquence	Mode
Porteuse et pseudo-distance	Double	Statique
Masque d'élévation	Données rejetées	Intervalle des estimés
7.5 degrés	0.06 %	30.00 sec
Antenne	CPA au PRA	PRA au Repère
ASH701945C_M NONE	L1 = 0.090 m L2 = 0.119 m	H:0.000m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour 01262340C.18o

	Latitude (+n)	Longitude (+e)	Altitude Ell.
NAD83(SCRS) (2018)	45° 24' 22.96428"	-75° 31' 8.13025"	39.755 m
Sigmas(95%)	0.003 m	0.006 m	0.012 m
A priori*	45° 24' 23.00541"	-75° 31' 8.15151"	38.409 m
Position calculée – A priori	-1.270 m	0.462 m	1.346 m



*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

Figure 5.13: Position of point "Base station" from NRCan – PPP Service- August 2018

Table 5.9: GNSS acquisition details of point " Base NRC Drone August 2018 "

Site :		Base NRC-drone		
Installation Type		Antenna reference point (ARP) in physical contact with top of plywood (drone target). Centered on 4 colors junction.		
Receiver (GNSS)		Ashtech Zxtreme # 2		
Antenna		Trimble Zephyr Geodetic 2 RoHS		
		TRM57971.00		
Antenna height		0 (See note above)		
Acquisition start		2018 08 22 15 h 56 min. 30 sec. (jour 234)		
Acquisition end		2018 08 23 11 h 49 min 30 sec.		
Duration		19 h. 53 min. 00 sec		
Acquisition interval		30 seconds		
Raw GNSS files		B__A18.234		
Rinex files		__2341.18O .18N		
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 22.99367"	-75° 31' 10.37247"	40.453	72.992
UTM	5028227.743	459342.182		
Error ellipse @95 %	.4 cm	1. cm		
	±0.003 m	±0.008 m	±0.015 m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028227.741	459342.189	40.486	.

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028227.748	459342.191	40.479	.



SCRS-PPP 2.11.0 (2018-07-26)



____2341.180
Xtreme no 2 NRC Platform

Début des données	Fin des données	Durée des observations
2018-08-22 15:56:30.00	2018-08-23 11:49:30.00	19:53:00
Heure de traitement		Type de produits
12:55:27 UTC 2018/08/24		RNCan rapide
Observations	Fréquence	Mode
Porteuse et pseudo-distance	Double	Statique
Masque d'élévation	Données rejetées	Intervalle des estimés
7.5 degrés	0.08 %	30.00 sec
Antenne	CPA au PRA	PRA au Repère
TRM57971.00	L1 = 0.065 m L2 = 0.058 m	H:0.000m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour ____2341.180

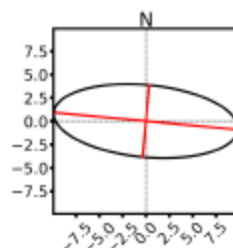
	Latitude (+n)	Longitude (+e)	Altitude Ell.
NAD83(SCRS) (2018)	45° 24' 22.99367"	-75° 31' 10.37247"	40.453 m
Sigmas(95%)	0.003 m	0.008 m	0.015 m
A priori*	45° 24' 23.02386"	-75° 31' 10.34587"	44.789 m
Position calculée – A priori	-0.932 m	-0.578 m	-4.337 m

Altitude orthométrique CGVD28
(HTv2.0)

72.992 m

(lien pour la référence altimétrique)

Ellipse d'erreur 95% (mm)
demi-grand axe: 9.918 mm
demi-petit axe: 3.865 mm
azimut du demi-grand axe: 95° 21' 21.01"



UTM (Nord) Zone 18

5028227.743 m (N)
459342.182 m (E)

Facteurs échelle
0.999620 (point)
0.999614 (combiné)

*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

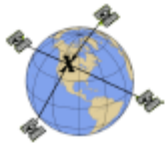
Figure 5.14: Position of point " Base NRC Drone" from NRCan – PPP Service. August 2018

Table 5.10: GNSS acquisition details of point " Base McGill Drone August 2018 "

Site :		Base McGill-drone		
Installation Type		Antenna reference point (ARP) in physical contact with top of plywood (drone target). Centered on 4 colors junction.		
Receiver (GNSS)		Ashtech Zxtreme # 4		
Antenna		Trimble Zephyr Geodetic 2 RoHS		
		TRM57971.00		
Antenna height		0 (See note above)		
Acquisition start		2018 08 22 16 h 22 min. 30 sec. (jour 234)		
Acquisition end		2018 08 23 01 h 12 min 30 sec.		
Duration		8 h 50 m 00.00 sec.		
Acquisition interval		30 seconds		
Raw GNSS files		B___A18.234		
Rinex files		___2341.18O .18N		
Position established by PPP	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
Geographic	45° 24' 32.77171"	-75° 31' 4.67142"	37.456	69.993
UTM	5028528.692	459468.053		
Error ellipse @95 %	.7 cm	2.1 cm		
	±0.007 m	±0.017 m	±0.025 m	

Position established by baseline-NRC	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028528.684	459468.076	37.476	.

Position established by baseline-Base	Latitude	Longitude	Ellipsoidal Height (m)	Orthometric Height (m)
UTM	5028528.690	459468.079	37.464	.



SCRS-PPP 2.11.0 (2018-07-26)



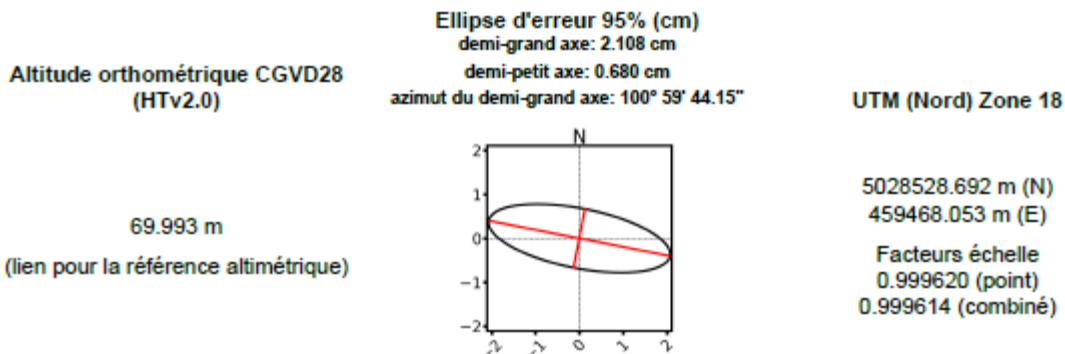
____ 2341.180
ZExtreme no 4 Mc Gill Platform

Début des données 2018-08-22 16:22:30.00	Fin des données 2018-08-23 01:12:30.00	Durée des observations 8:50:00
Heure de traitement 13:01:48 UTC 2018/08/24		Type de produits RNCAN rapide
Observations Porteuse et pseudo-distance	Fréquence Double	Mode Statique
Masque d'élévation 7.5 degrés	Données rejetées 0.19 %	Intervalle des estimés 30.00 sec
Antenne TRM57971.00	CPA au PRA L1 = 0.065 m L2 = 0.058 m	PRA au Repère H:0.000m / E:0.000m / N:0.000m

(CPA = centre de phase de l'antenne; PRA = point de référence de l'antenne)

Positions estimées pour ____ 2341.180

	Latitude (+n)	Longitude (+e)	Altitude Ell.
NAD83(SCRS) (2018)	45° 24' 32.77171"	-75° 31' 4.67142"	37.456 m
Sigmas(95%)	0.006 m	0.017 m	0.025 m
A priori*	45° 24' 32.88696"	-75° 31' 4.70268"	43.505 m
Position calculée – A priori	-3.558 m	0.680 m	-6.049 m



*(Position a priori initialisée à partir des coordonnées de l'en-tête du RINEX)

Figure 5.15: Position of point " Base McGill Drone" from NRCAN – PPP Service. August 2018

6) Vertical movement of points through time established using various methods.

As the Mer Bleue Peatland is a relatively flat site with significant microtopography, specific attention was given to potential causes of height variations of individual survey points related to the Research Boardwalk. Such vertical motion can be estimated from three different methods: Precision Point Processing (PPP), baseline processing using the Natural Resources Canada (NRCan) CACS station located 9 km away, and baseline processing using the installed MBR Base Station located ~150 meters away from the peatland, on upper dry ground as discussed above.

The diachronic baseline height trend from the MBR Base Station located close to the peatland would represent the altimetric movement of the site in relation to its close surrounding. For example, a lowering trend would indicate that the site is getting lower in relation to the surrounding upper ground, perhaps caused by moisture variations within the peatland.

The diachronic baseline height trend from the NRCan CACS station located 9 km away would represent the altimetric movement of the point in relation to its remote surrounding and may reflect a regional altimetric trend. A lowering temporal trend indicates that the point is getting lower in relation to the CACS station.

Finally, it should be noted that the PPP processing system does not use a baseline for comparison. It uses precise ephemeris and GNSS clock information to estimate the position and height of the target. A diachronic height trend from PPP processing represents the altimetric alteration of the point for reasons which could be related to seasonal changes in the environment.

In the high precision world of GNSS height estimation, it must be noted that there already exists an apparent seasonality in the height estimation (Ferland R., 2000). Figure 6.1 and Table 6.1 illustrate, based on PPP, the seasonality height movement of the NRCan CACS station, which is physically very stable through time. Further discussion on the fine height variations are beyond the scope of this document, however any change of vertical position uniformly by all GNSS targets (including the Base Station) of less than 5 cm over several weeks would be considered a within-experimental design uncertainty, and not due to a vertical upheaval of the entire Mer Bleue Research Boardwalk and surrounding region. Relative vertical change between points however could still indicate motion within the peatland.

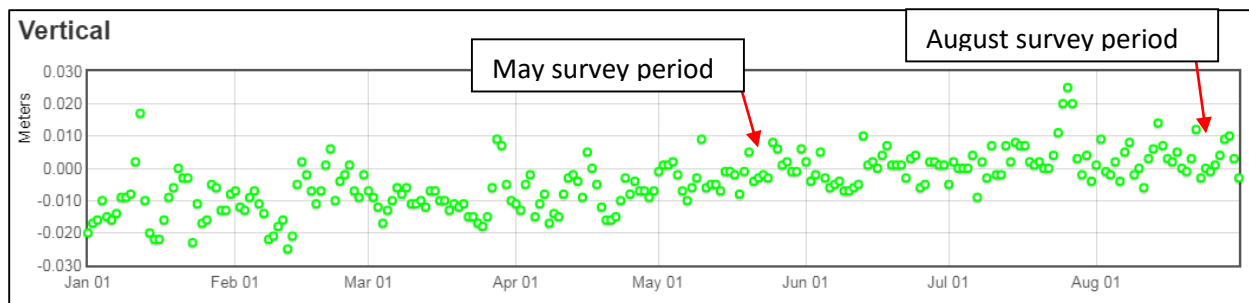


Figure 6.1: Seasonal variation in height of the NRC-CACS station, 2018 (Source: RNCAN GSD)

Table 6.1: Seasonal variation of NRC CACS station at time of survey (in metres)

Date of survey	Latitude	Longitude	Vertical
22 May 2018	-0.004	0.003	-0.003
23 May 2018	-0.005	0.001	-0.002
24 May 2018	-0.004	0.003	-0.003
22 August 2018	-0.004	-0.004	0.012
23 August 2018	-0.005	0.003	-0.003

Source: Geodetic Survey Division, RNCAN 2018

7) Altimetric Trends

Most of the high precision GPS target points at MBR show a similar behaviour in a way that derived point altimetry movement is more stable when estimated using the NRCan and the Base Station methods (The PPP method provides more varied results). In all three methods, the MBR target points in the peatland appear to shift in the same manner as the more stable Base Station points, indicating that this apparent motion is due more to the hardware and processing methodology rather than actual motion of the Mer Bleue Peatland. As well, the Base Station and the NRCan CACS station provide similar results. This confirms the advantage of using a Base Station type method in determining vertical position, either a CACS station or a local base station when there is no CACS station in the vicinity.

Figures 7.1 to 7.8 illustrate the altimetric trend of each point throughout the survey period. Vertical and horizontal scales are similar for all graphs.

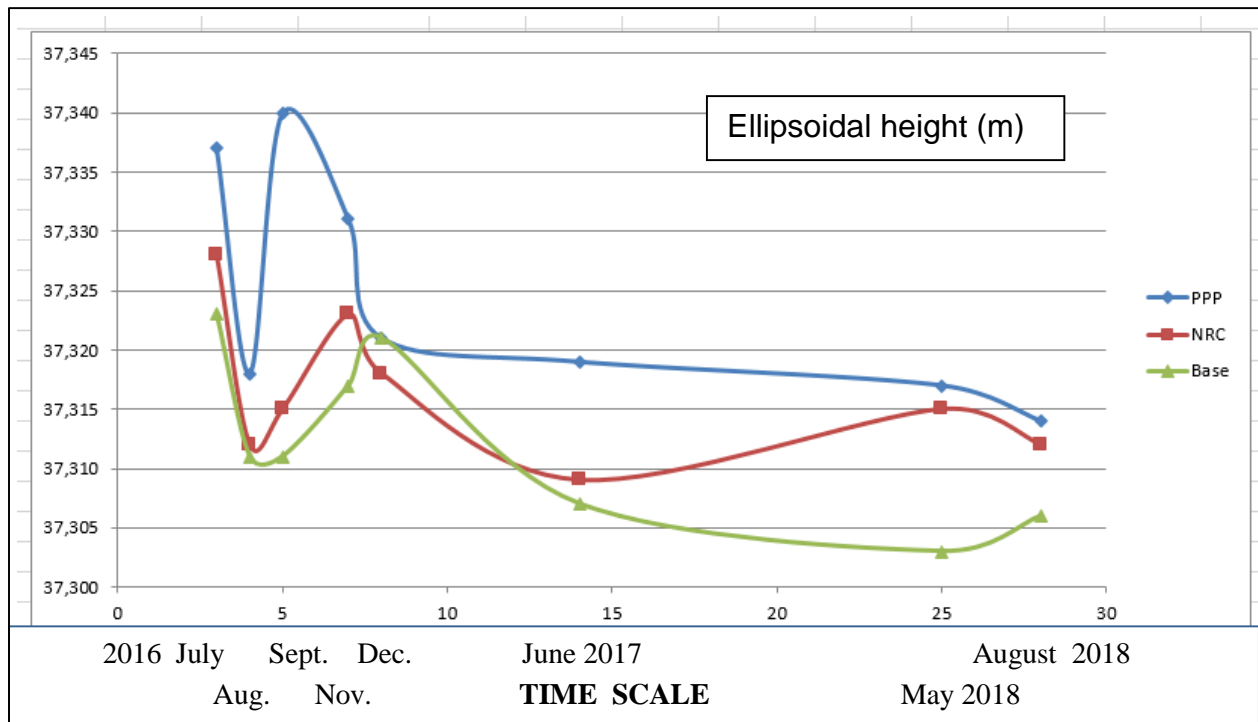


Figure 7.1: Altimetric trend estimation of MBR-2 in 2016-2017-2018 using various methods

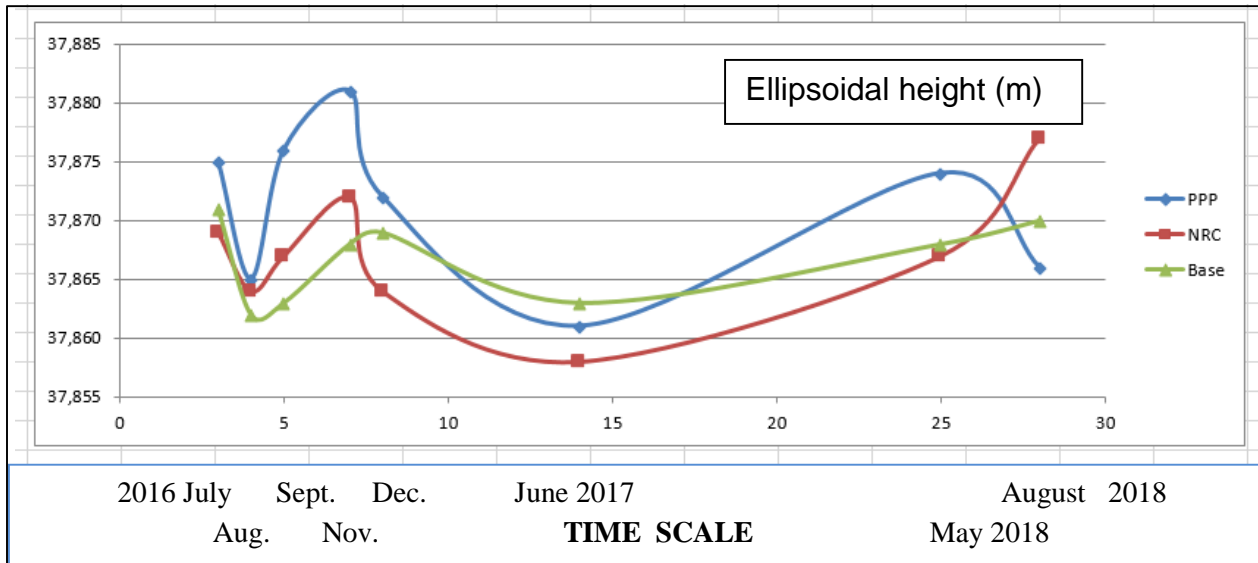


Figure 7.2: Altimetric trend estimation of MBR-3 in 2016-2017-2018 using various methods

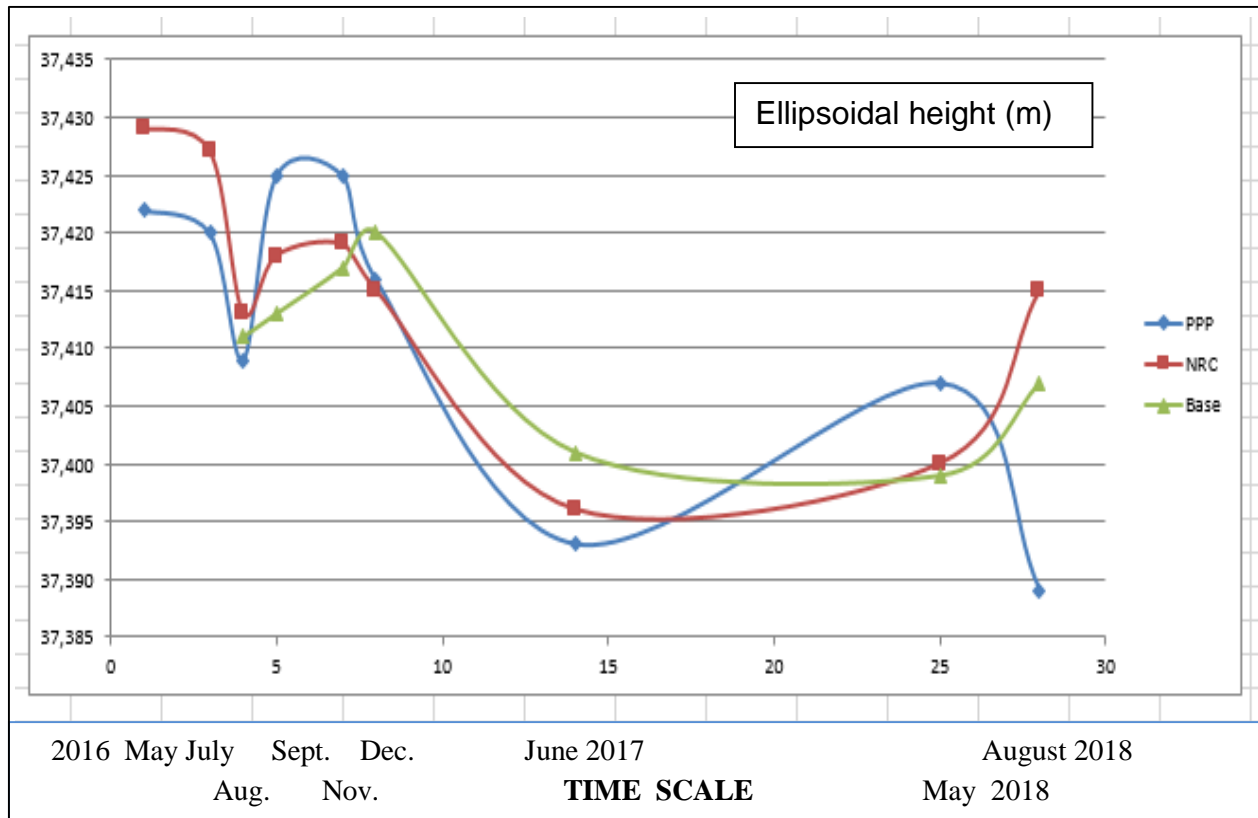


Figure 7.3: Altimetric trend estimation of MBR-4 in 2016-2017-2018 using various methods

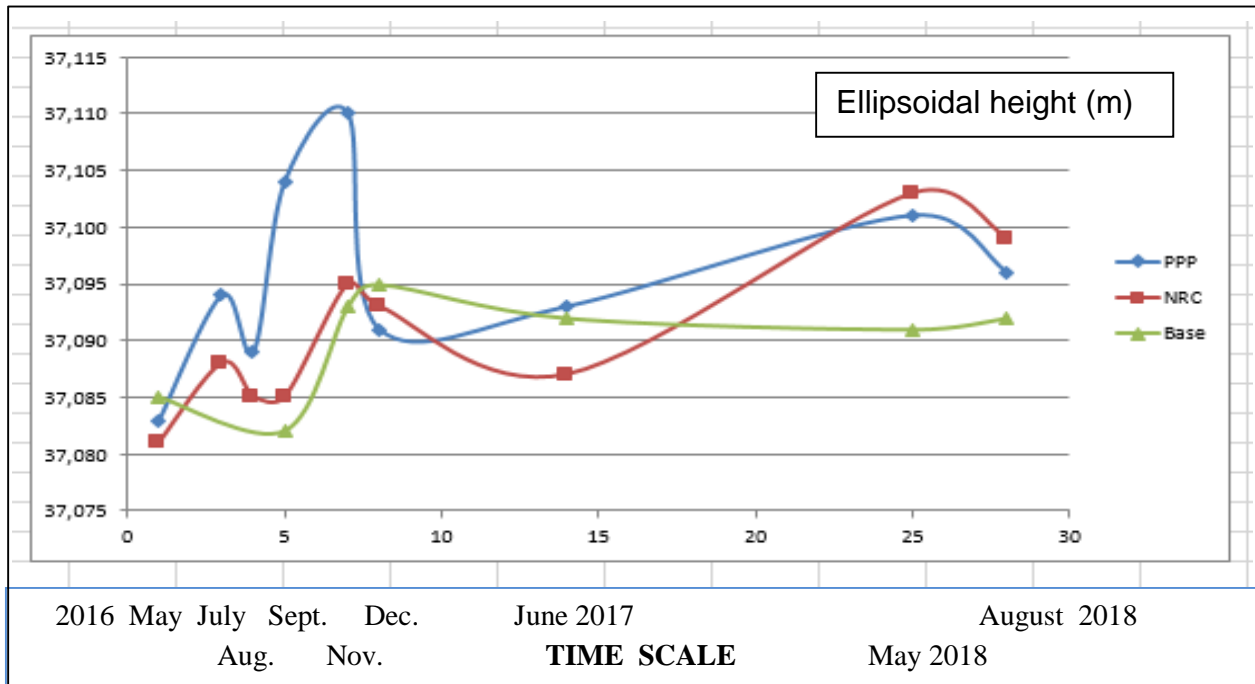


Figure 7.4: Altimetric trend estimation of MBR-5 in 2016-2017-2018 using various methods

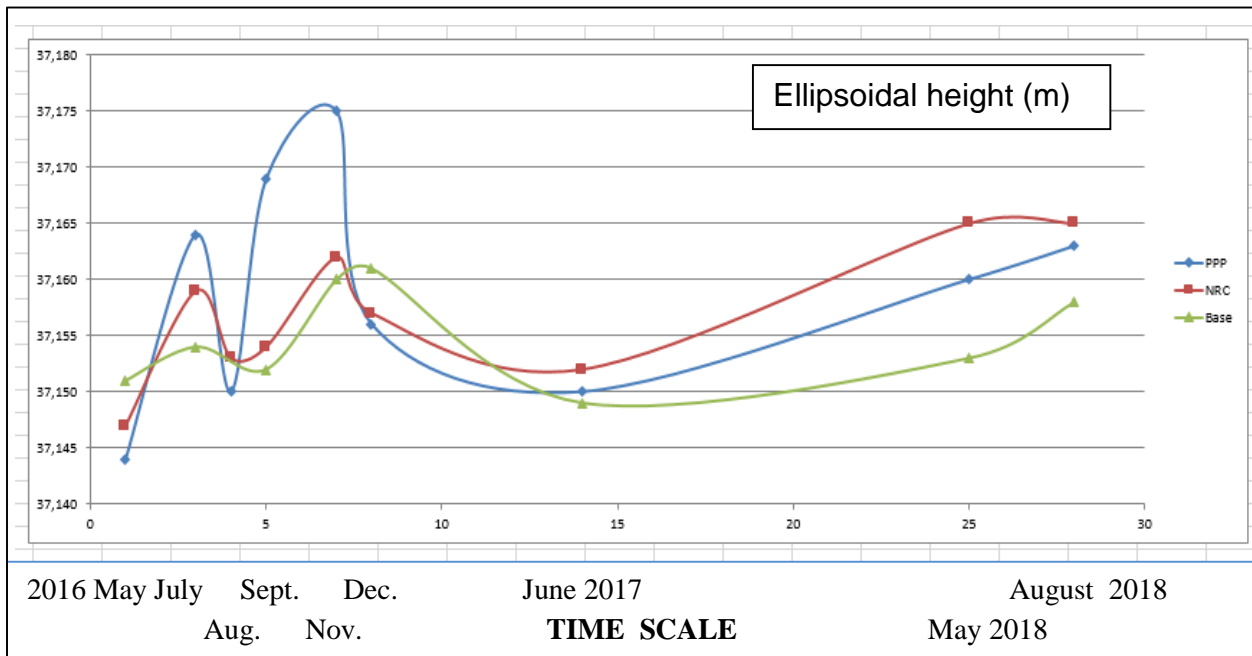


Figure 7.5: Altimetric trend estimation of MBR-6 in 2016-2017-2018 using various methods

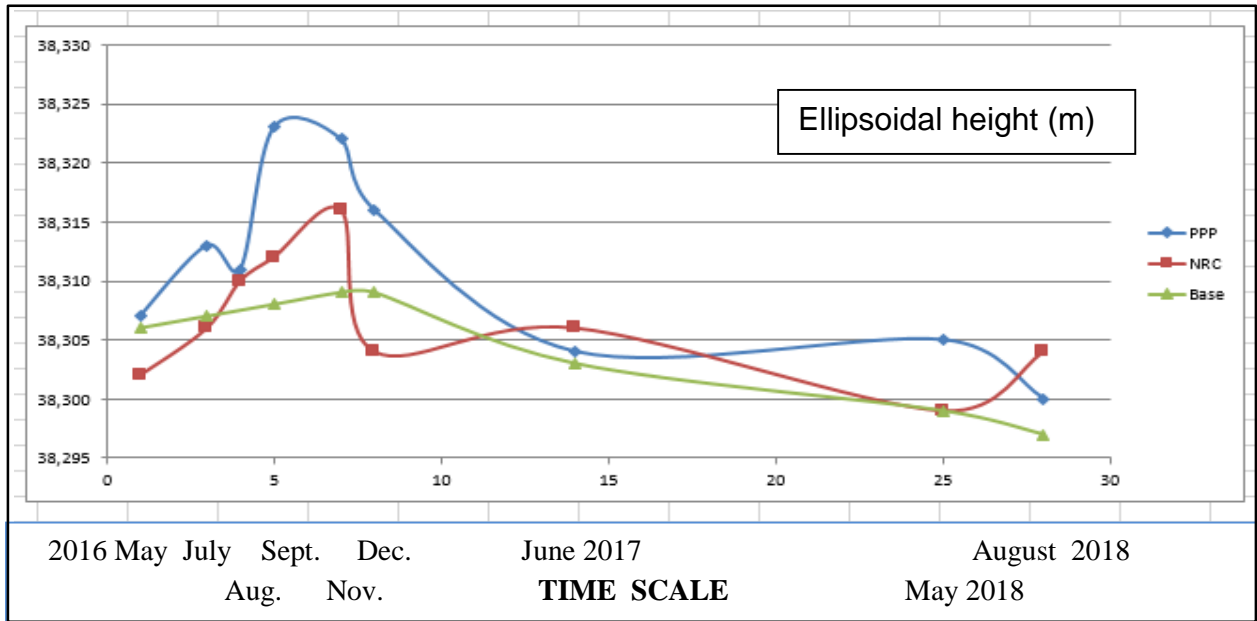


Figure 7.6: Altimetric trend estimation of MBR-7 in 2016-2017-2018 using various methods

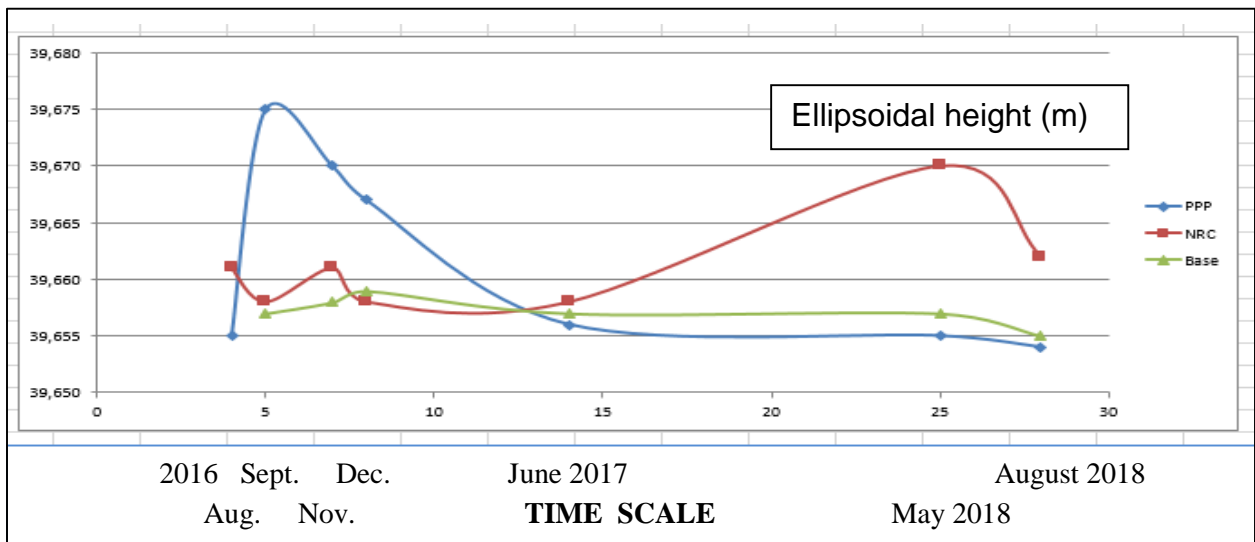


Figure 7.7: Altimetric trend estimation of MBR-8 in 2016-2017-2018 using various methods

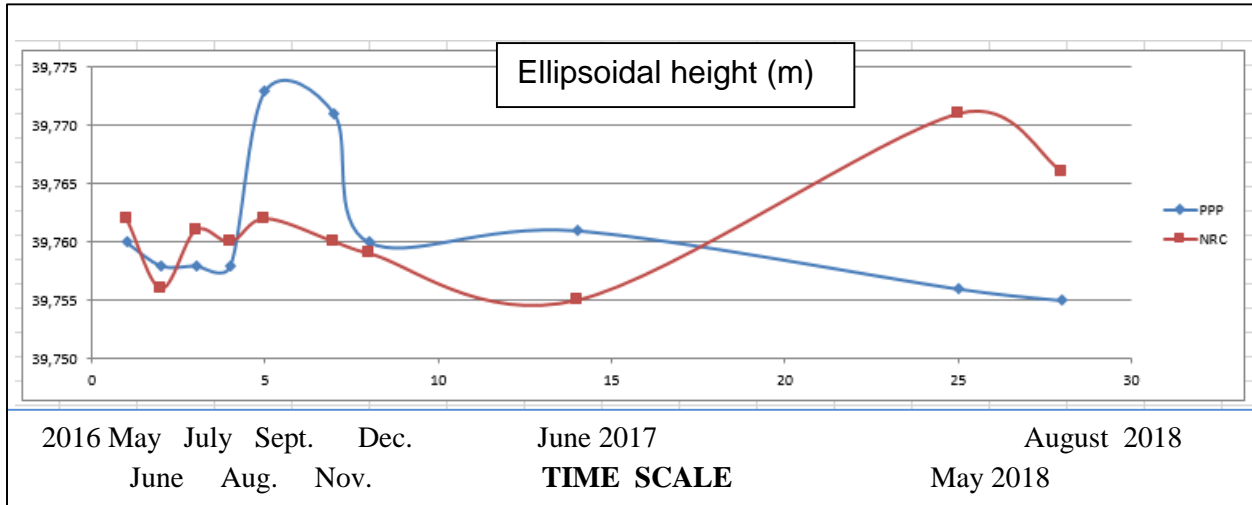


Figure 7.8: Altimetric trend estimation of "Base" in 2016-2017-2018 using various

Figures 7.9 to 7.15 illustrate the height movement of each point through the 2016-2017-2018 survey period, in relation to the Base Station. So far, this appears to provide a robust representation of vertical motion within the Mer Bleue Bog, featuring trends between the stable Base Station and the individual sites. These trends are in the order of 5-20 mm throughout the years, therefore very minimal and close to the limit of detectability previously discussed. Vertical and horizontal scales are similar for all graphs.

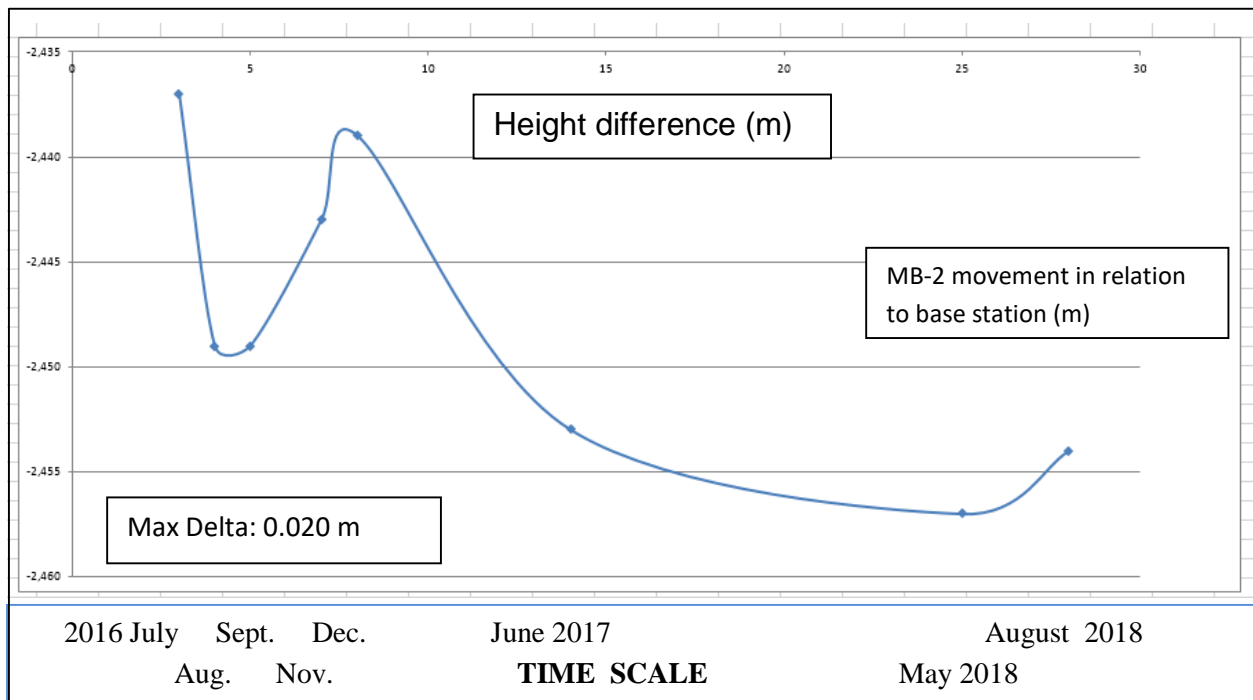


Figure 7.9: Vertical motion of MBR-2 normalized to the MBR Base Station height.

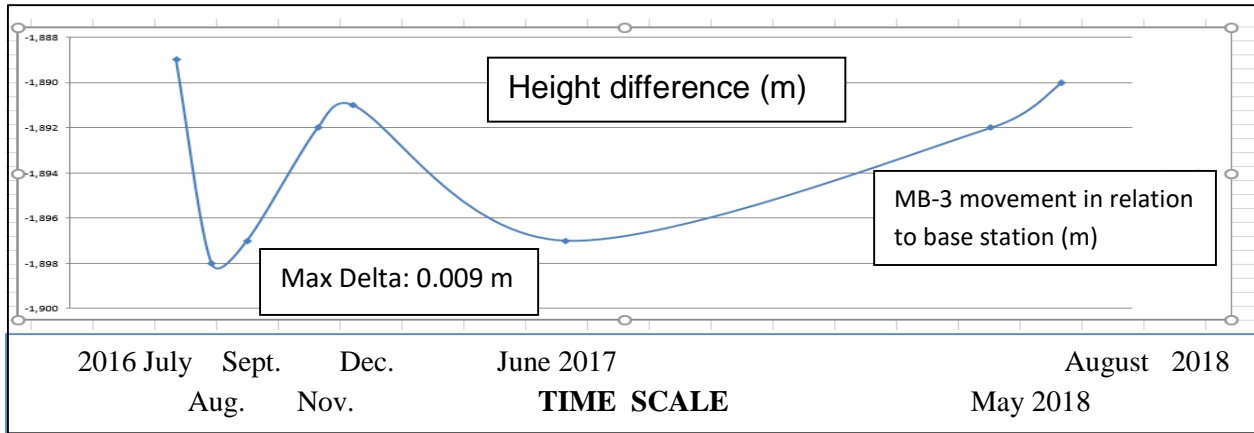


Figure 7.10: Vertical motion of MBR-3 normalized to the MBR Base Station height.

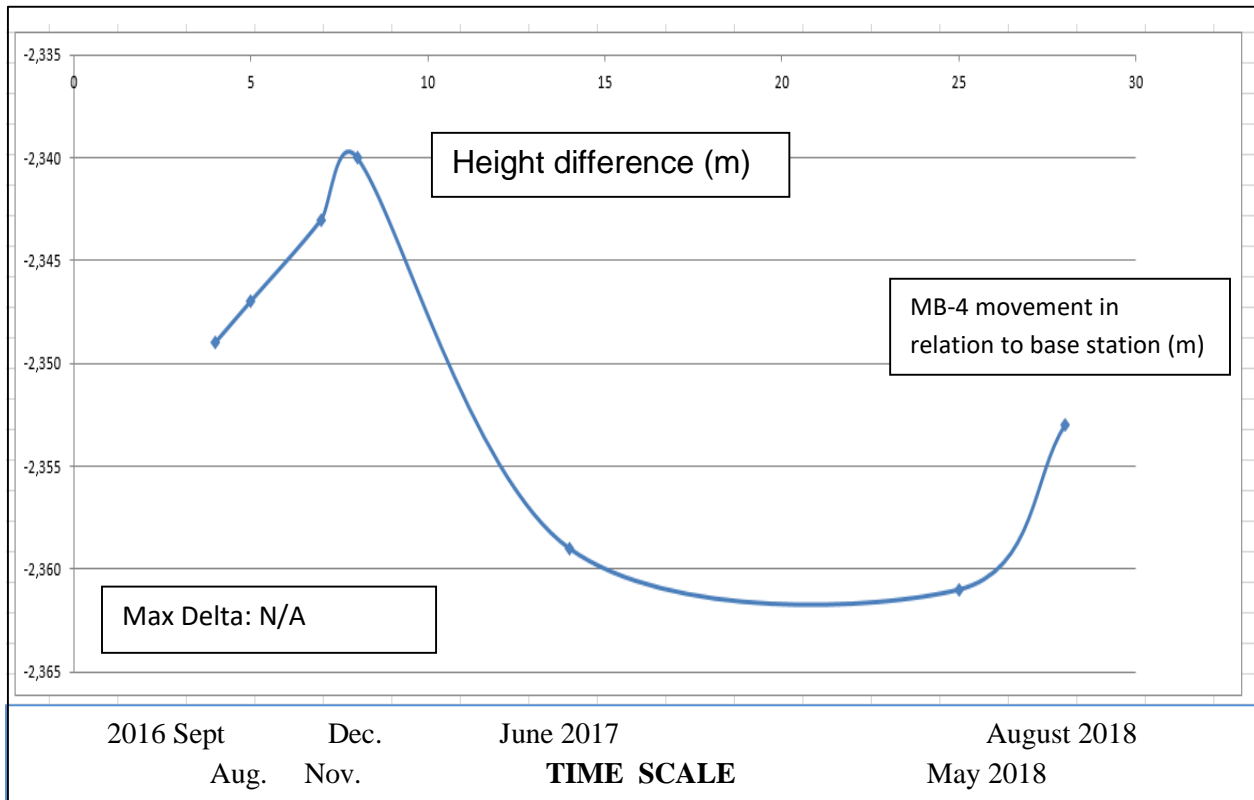


Figure 7.11: Vertical motion of MBR-4 normalized to the MBR Base Station height

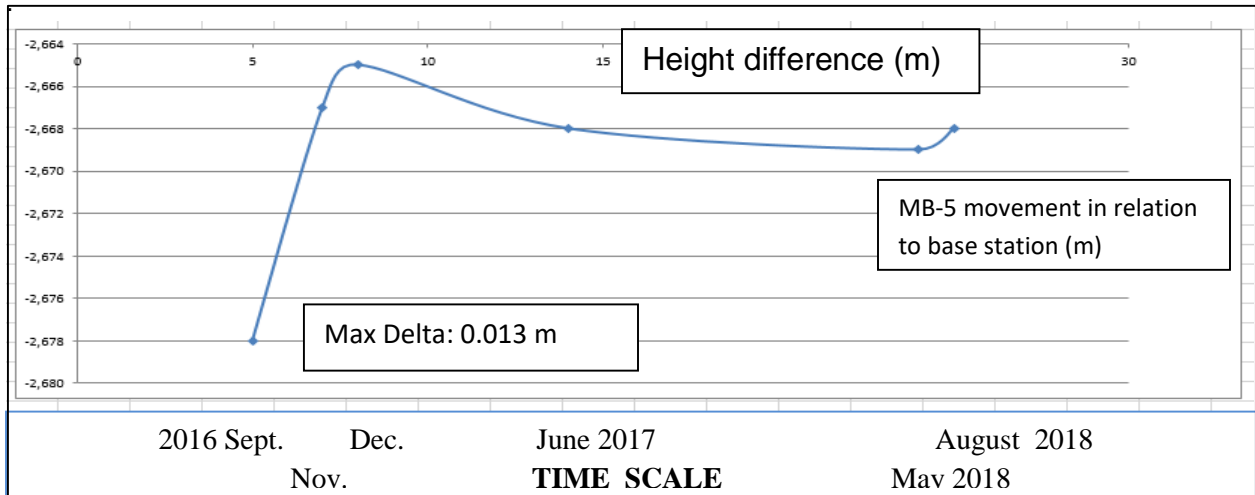


Figure 7.12: Vertical motion of MBR-5 normalized to the MBR Base Station height.

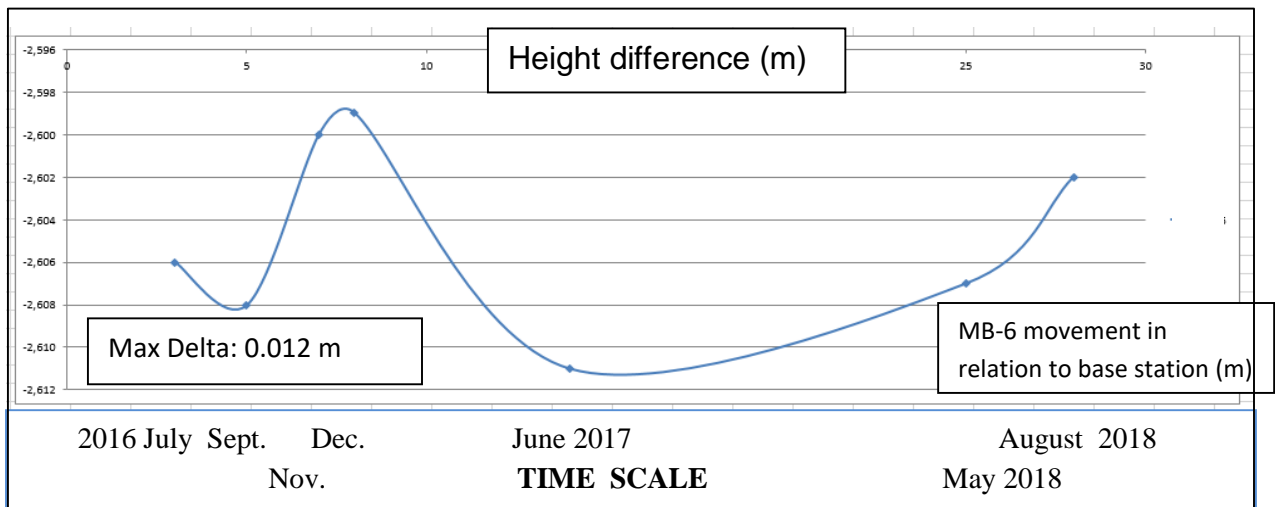


Figure 7.13: Vertical motion of MBR-6 normalized to the MBR Base Station height.

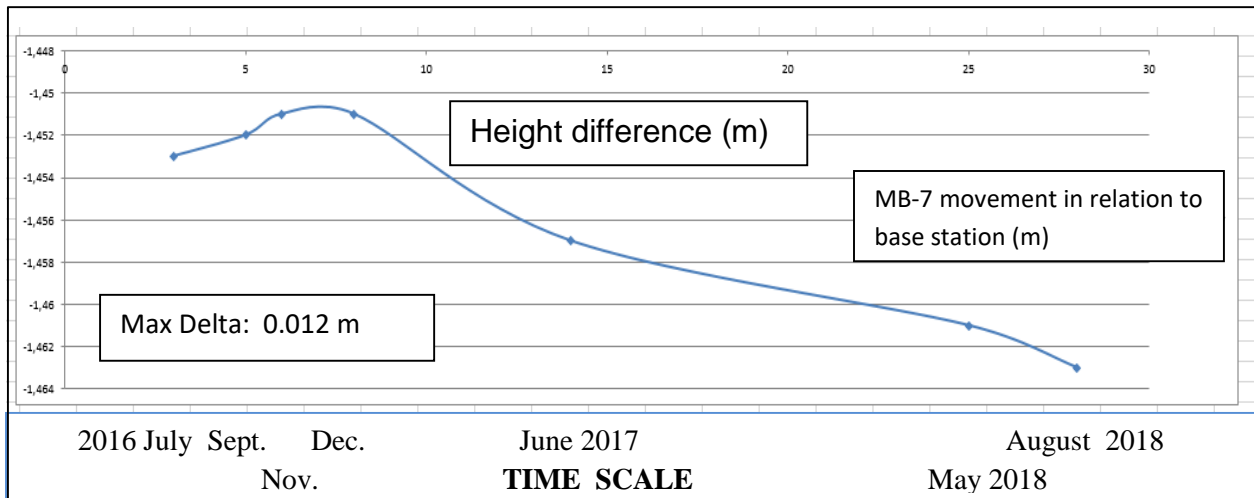


Figure 7.14: Vertical motion of MBR-7 normalized to the MBR Base Station height.

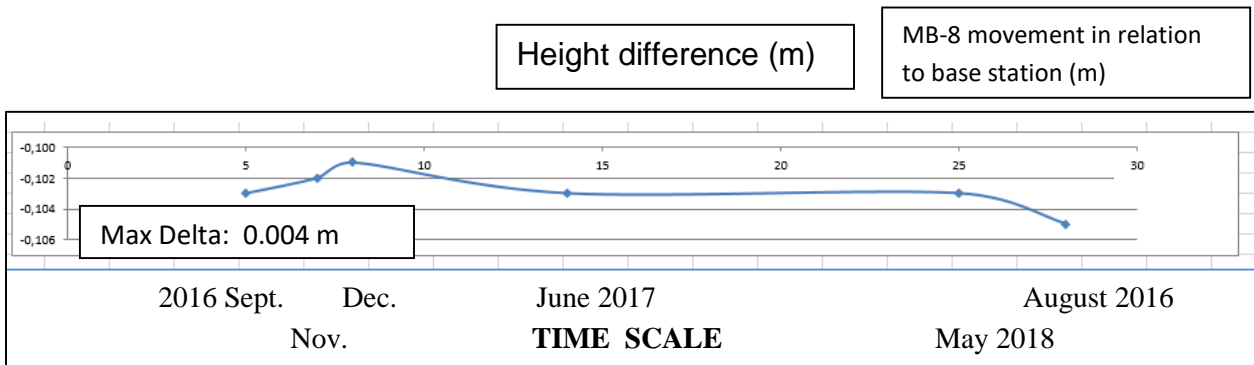


Figure 7.15: Vertical motion of MBR-8 normalized to the MBR Base Station height.

8) Conclusion and Future Considerations

Reference target sites were located with precision using dual frequency GNSS receivers running in static mode for an extended time of acquisition. These targets are well marked on the ground such that they could be used for several years for the geocoding of airborne imagery.

A permanent station was set using a ground rod in an open area located on solid ground at the fringe of the bog. This permanent rod station can continue to be used as a fine GNSS positioning method by using the short baseline differential processing technique.

For future GNSS precision surveys, improvements can be incorporated into the project Standard Operating Procedure.

- The Base Station and MBR-8 will be the primary source of information to monitor the height variation of the posts located in the bog.
- In the short baseline processing, the vertical component of the 3D vector will be used to monitor height variation. To do so, the 3 components of the Earth Centric Earth Fixed reference frame will be converted in East-West and altimetric components.
- In view of existing and future satellite mission data processing, the weather information could be collected for each survey such as: temperature, pressure, wind direction and intensity, and sky condition.

9) Related Publications

This document is one of many documents related to the use of Unmanned Aerial Vehicle imagery for snow and wetland monitoring. GNSS positioning of georeference targets is one of the elements of these initiatives. The reader will find below a list of publications related to this topic.

Prévost, C., White, H.P., 2017. Mer Bleue, Ontario, Arctic Surrogate Study Site Project – 2016 - GPS Survey Report; Geomatics Canada, Open file 36, 161 pages, doi:10.4095/304278

Prévost, C., White, H.P., 2016. Mer Bleue, Ontario, Arctic Surrogate Study Site Project – 2015 - GPS Survey Report; Geomatics Canada, Open file 29, 59 pages, doi:10.4095/299442

Prévost, C., R. Fernandes, 2016. Relevé GPS de cibles de référence au site test de Gatineau, Québec, dans le cadre du projet d'évaluation de l'épaisseur de neige par aéronef sans pilote; Géomatique Canada, Dossier public 26, 67 pages. doi:10.4095/299047

Prévost, C., Fernandes, R., and Canisius, F., 2016. Ground control point acquisition for Acadia forest, New Brunswick, during winter 2016, in support of Canada Centre for Mapping and Earth Observation snow depth from unmanned aerial vehicle activities, Geomatics Canada, Open file 27, 42 pages, doi:10.4095/299101

Prévost, C., R. Fernandes, A. Langlois, X. Gervais-Gosselin, D. Kramer, 2017. Relevé GPS de cibles de référence au site test de Quinte, Ontario, dans le cadre du projet d'évaluation de l'épaisseur de neige par aéronef sans pilote; Géomatique Canada, Dossier public GC-40, 59 pages, doi:10.4095/308409

Oakes, S., Fernandes, R.A., Canisius, F., 2016. Protocol for photographic survey of snow depth stakes in Support of CCMEQ Snow Depth from UAV Activities, CCRS Open File, in review.

Ashtech Precision Product. Z-Xtreme GPS Receiver-System Guide for Post Process Surveying. November 2000, 49 pages.
[http://sup.xenya.si/sup/info/magellan\(thalesnavigation\)/z-xtreme/Manuals/630845-01-Post-ProcessSurveying.pdf](http://sup.xenya.si/sup/info/magellan(thalesnavigation)/z-xtreme/Manuals/630845-01-Post-ProcessSurveying.pdf)

Natural Resources Canada, Precision Positioning System (PPP) Tools and Applications. <http://www.NRCan.gc.ca/earth-sciences/geomatics/geodetic-reference-systems/tools-applications/10925>

Natural resources Canada, Geodetic reference system, Canadian Active Control System (CACS). <http://www.rncan.gc.ca/sciences-terre/geomatique/systemes-reference-geodesique/donnees/10924#cacs>

Trimble NetR9 GNSS Reference Receiver User Guide , Ver. 4.15, May 2010, http://toolik.alaska.edu/gis/gps/images/gpsbase/NetR8_UserGuide.pdf

GNSS Solutions processing software., http://ashgps.com/mirror/master/GNSS%20Solutions/manuals/English/GNSSolutions_RM_F_en.pdf

8) Bibliography

- Ferland R., T. P. (2000). Recent Contribution to the ITRF and its Realization in Canada. *Towards an Integrated Global Geodetic Observing System (IGGOS)*. *International Association of Geodesy Symposia*. International Association of Geodesy Symposia (IAG SYMPOSIA).
- Government of Canada. (2016). *Environment and Natural Resources - Weather Information*. Retrieved 08 4, 2016, from https://weather.gc.ca/city/pages/on-118_metric_e.html
- Lafleur, P. M., Hember, R. A., Admiral, S. W., & Roulet, N. T. (2005). Annual and seasonal variability in evapotranspiration and water table at a shrub-covered bog in southern Ontario, Canada. *Hydrological Processes*, 19(18), 3533-3550. doi:doi: 10.1002/hyp.5842
- Natural Resources Canada. (2017). *Geodetic Reference System, Canadian Active Control System (CACS)*. Retrieved 06 21, 2017, from <http://www.nrcan.gc.ca/earth-sciences/geomatics/geodetic-reference-systems/data/10923>
- Natural Resources Canada. (2016). *Natural Resources Canada 2016-17 Report on Plans and Priorities*. Natural Resources Canada. Ottawa:
- Roulet, N., Lafleur, P., Richard, P., Moore, T., Humphreys, E., & Bubier, J. (2007). Contemporary carbon balance and late Holocene carbon accumulation in a northern peatland. *Global Change Biology*, 13(2), 397-411. doi:doi: 10.1111/j.1365-2486.2006.01292.x
- Soffer, R., White, H. P., Kalacska, M., Leblanc, G., Arroyo-Mora, P., Nazarenko, D., & Ifimov, G. (2016). *Mer Bleue Arctic Surrogate Simulation Study "MBASSS"*. IDEAS+ (Instrument Data quality Evaluation and Analysis Service) Calibration/Validation Workshop. ESRIN: ESA Earth Online. Retrieved from <https://earth.esa.int/web/sppa/meetings-workshops/expert-meetings/ideas-cal/val-workshop>

Appendix

This figure illustrates the exact position of the MBR-4 target in relation with the wood frame which holds it. These numbers will be used to re-establish the target when the inner portion of the frame will be rebuilt in summer 2019. Red spots represent red painted nails on the outer frame.

MB-4 Measurements:

