

This PDF document was produced:  
2019-07-10 11:50:28

# NLS GNSS SOFAMESA

GNSS Position Solution Analysis Software of the National Land Survey of Finland  
Beta Version 0.2  
2019-07-10

## Conclusions of the Measurement Reports

Date: 2019-07-10  
Reference point: 90M9180  
Total Number of visits: 10



Author: Tuukka Mattila.  
Do not hesitate to contact via LinkedIn: <https://www.linkedin.com/in/tuukkamattila/>.

Thank you for the help: Topi Rikkinen, Marko Ollikainen, Antti Laaksonen, Hannu Koivula, Octavian Andrei, Mikael Kauhava, Timo Sallinen and Ari Huvinen.

Combination of the Measurement Reports	3
Statistics Behind the Figures	4
Combination of the Figures	6
The Number of Satellites (No Outliers Removed) . . . . .	7
The DOP Values (No Outliers Removed) . . . . .	8
The Reported HRMS and VRMS Values of the Receiver (No Outliers Removed) . . . . .	9
The Solutions (No Outliers Removed) . . . . .	10
KDE Plot for Outlier Recognition (PRECISION, INNER ACCURACY) . . . . .	11
KDE Plot for the Distribution of Errors (PRECISION, INNER ACCURACY) . . . . .	12
Gaussian Distribution Models for the Distributions of Errors (PRECISION, INNER ACCURACY) . . . . .	13
The PRECISION of the point (INNER accuracy) (m) HORIZONTAL . . . . .	14
The PRECISION of the point (INNER accuracy) (m) NORTH . . . . .	15
The PRECISION of the point (INNER accuracy) (m) EAST . . . . .	16
The PRECISION of the point (INNER accuracy) (m) VERTICAL . . . . .	17
The ACCURACY of the point (OUTER accuracy) (m) HORIZONTAL . . . . .	18
The ACCURACY of the point (OUTER accuracy) (m) NORTH . . . . .	19
The ACCURACY of the point (OUTER accuracy) (m) EAST . . . . .	20
The ACCURACY of the point (OUTER accuracy) (m) VERTICAL . . . . .	21
The Horizontal PRECISION of the point (INNER accuracy) (m) with DOP values . . . . .	22
The 3D PRECISION of the point (INNER accuracy) (m) with DOP values . . . . .	23
The Vertical PRECISION of the point (INNER accuracy) (m) with DOP values . . . . .	24
Conclusions	25

## Combination of the Measurement Reports

Please find the combined measurement results, which NLS GNSS SOFAMESA produces, on the upcoming pages.

## Statistics Behind the Figures

Parameter	METHOD1	METHOD2	METHOD3	METHOD4	METHOD5
Total Number of Measurements (No Outliers Removed)	499	498	509	498	499
Timespan (No Outliers Removed)	09:21:14 - 09:29:36	09:21:14 - 09:28:22	09:21:13 - 09:29:41	09:18:24 - 09:29:38	09:32:15 - 09:40:44
Solution Percentages (No Outliers Removed), Fixed; Float; Code Diff; Standalone; Other	99.6%; 0.0%; 0.0%; 0.4%; 0.0%	100.0%; 0.0%; 0.0%; 0.0%; 0.0%	100.0%; 0.0%; 0.0%; 0.0%; 0.0%	99.8%; 0.0%; 0.0%; 0.2%; 0.0%	100.0%; 0.0%; 0.0%; 0.0%; 0.0%
Number of All Satellites Mean (No Outliers Removed)	19.0	28.3	25.8	34.1	16.5
Number of All Satellites (No Outliers Removed), Min; Max	14; 27	26; 31	24; 26	32; 36	14; 17
Number of GPS Satellites Mean (No Outliers Removed)	11.0	9.5	10.0	11.0	10.0
Number of GLONASS Satellites Mean (No Outliers Removed)	7.9	7.0	8.0	8.0	6.5
Number of GALILEO Satellites Mean (No Outliers Removed)	0.0	7.5	7.8	7.6	0.0
Number of BEIDOU Satellites Mean (No Outliers Removed)	0.0	4.4	0.0	7.5	0.0
Mean of HDOP Values (No Outliers Removed)	0.6	0.5	0.5	0.4	0.6
Mean of VDOP Values (No Outliers Removed)	1.2	1.0	1.0	1.0	1.3
Mean of PDOP Values (No Outliers Removed)	1.3	1.2	1.1	0.9	1.4
Mean of TDOP Values (No Outliers Removed)	nan	nan	nan	nan	nan
Mean of GDOP Values (No Outliers Removed)	1.5	1.3	1.2	1.1	1.6
User-Defined Tolerance Values, North (m) and East (m); Height (m)	0.1; 0.2	0.1; 0.2	0.1; 0.2	0.1; 0.2	0.1; 0.2
Number of Measurements Above the Set Tolerance Values	2	0	0	1	0
Above Tolerance Values Percentage	0.4%	0.0%	0.0%	0.2%	0.0%
Timespan (Outliers Removed)	09:21:14 - 09:29:36	09:21:14 - 09:28:22	09:21:13 - 09:29:41	09:18:24 - 09:29:38	09:32:15 - 09:40:44
Solution Percentages (Outliers Removed), Fixed; Float; Code Diff; Standalone; Other	100.0%; 0.0%; 0.0%; 0.0%; 0.0%	100.0%; 0.0%; 0.0%; 0.0%; 0.0%	100.0%; 0.0%; 0.0%; 0.0%; 0.0%	100.0%; 0.0%; 0.0%; 0.0%; 0.0%	100.0%; 0.0%; 0.0%; 0.0%; 0.0%
Number of All Satellites Mean (Outliers Removed)	19.0	28.3	25.8	34.1	16.5
Number of All Satellites (Outliers Removed), Min; Max	14; 19	26; 31	24; 26	32; 35	14; 17
Number of GPS Satellites Mean (Outliers Removed)	11.0	9.5	10.0	11.0	10.0
Number of GLONASS Satellites Mean (Outliers Removed)	8.0	7.0	8.0	8.0	6.5
Number of GALILEO Satellites Mean (Outliers Removed)	0.0	7.5	7.8	7.6	0.0
Number of BEIDOU Satellites Mean (Outliers Removed)	0.0	4.4	0.0	7.5	0.0
Mean of HDOP Values (Outliers Removed)	0.6	0.5	0.5	0.4	0.6
Mean of VDOP Values (Outliers Removed)	1.2	1.0	1.0	1.0	1.3
Mean of PDOP Values (Outliers Removed)	1.3	1.2	1.1	0.9	1.4
Mean of TDOP Values (Outliers Removed)	nan	nan	nan	nan	nan
Mean of GDOP Values (Outliers Removed)	1.5	1.3	1.2	1.1	1.6

Parameter	METHOD1: P*	METHOD1: A**	METHOD2: P*	METHOD2: A**	METHOD3: P*	METHOD3: A**	METHOD4: P*	METHOD4: A**	METHOD5: P*	METHOD5: A**
Horizontal RMSE*** ± (m)	0.006	0.008	0.006	0.011	0.004	0.014	0.01	0.024	0.006	0.023
Vertical RMSE**** ± (m)	0.019	0.076	0.031	0.051	0.008	0.083	0.018	0.121	0.014	0.156
Horizontal 2dRMSE*** ± (m)	0.013	0.016	0.012	0.022	0.007	0.027	0.021	0.048	0.012	0.045
Vertical 2dRMSE**** ± (m)	0.037	0.153	0.062	0.102	0.017	0.166	0.036	0.242	0.028	0.312
North Coordinate Std ± (m)	0.0047		0.0043		0.0024		0.0061		0.005	
East Coordinate Std ± (m)	0.0044		0.0041		0.0026		0.0084		0.0034	
Height Std ± (m)	0.0187		0.0311		0.0084		0.0182		0.014	
North Coordinate Mean (m)	6687768.387		6687768.4		6687768.4035		6687768.4127		6687768.3756	
East Coordinate Mean (m)	394444.8174		394444.813		394444.8123		394444.8169		394444.8314	
Height Mean (m)	25.056		25.0896		25.0473		25.2498		25.2854	
North Coordinate Median (m)	6687768.387		6687768.4		6687768.403		6687768.412		6687768.376	
East Coordinate Median (m)	394444.817		394444.812		394444.812		394444.815		394444.831	
Height Median (m)	25.056		25.103		25.046		25.2513		25.288	

\* The precision of the measurements = inner accuracy.

\*\* The accuracy of the measurements = outer accuracy.

\*\*\* Horizontal RMSE is 63-68% of the measurements and it depends on the shape of the distribution. Horizontal 2dRMSE is 95-98% of the measurements and it also depends on the shape of the distribution.

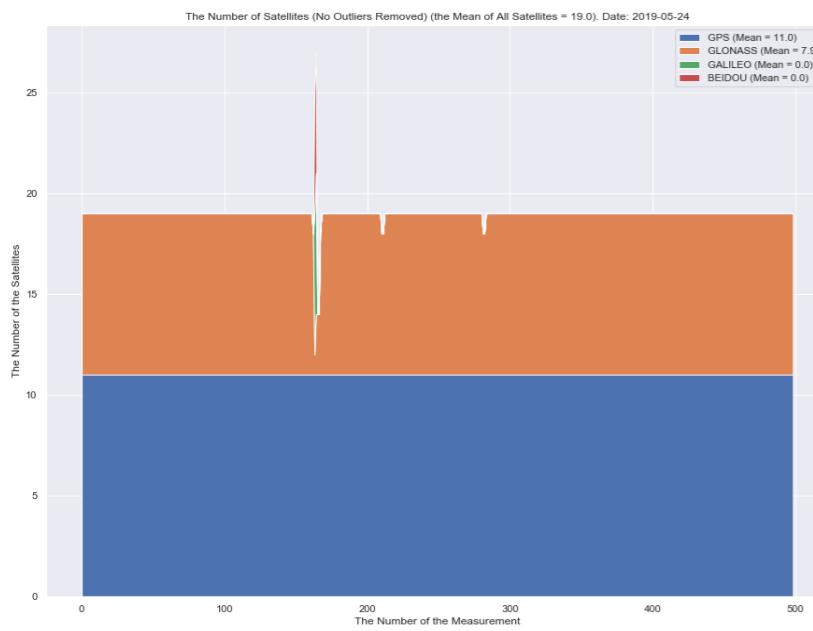
\*\*\*\* Vertical RMSE is 63-68% of the measurements and it depends on the shape of the distribution. Vertical 2dRMSE is 95-98% of the measurements and it also depends on the shape of the distribution.

## Combination of the Figures

Please find the combined figures of the measurement results, which NLS GNSS SOFAMESA produces, on the upcoming pages.

## The Number of Satellites (No Outliers Removed)

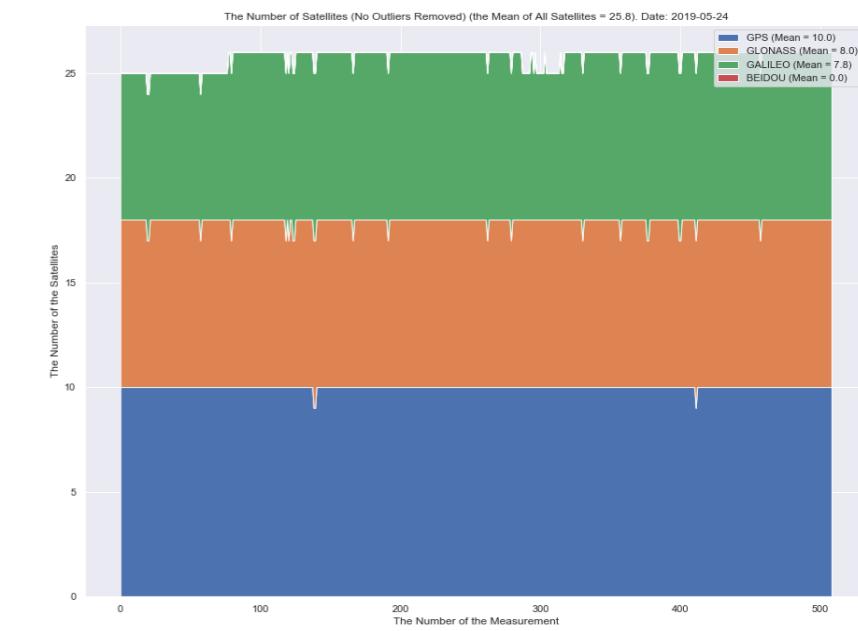
METHOD1



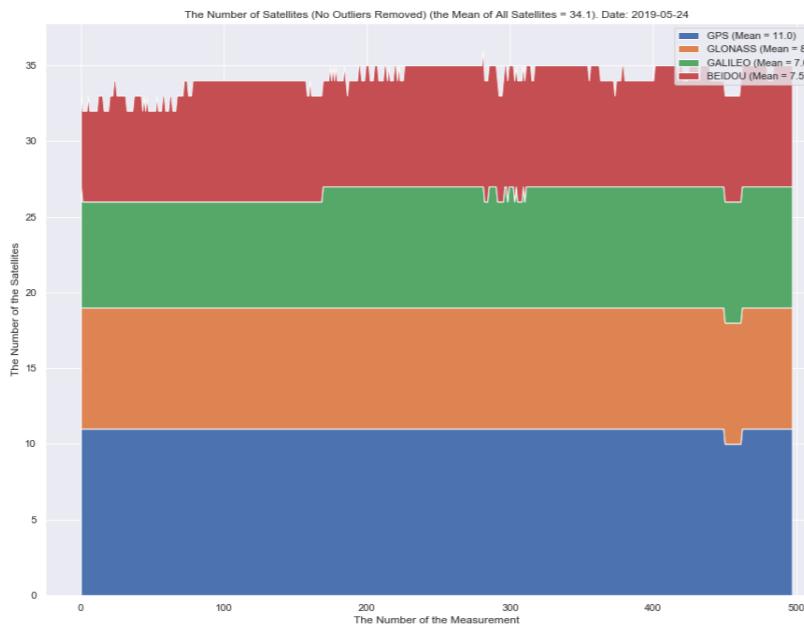
METHOD2



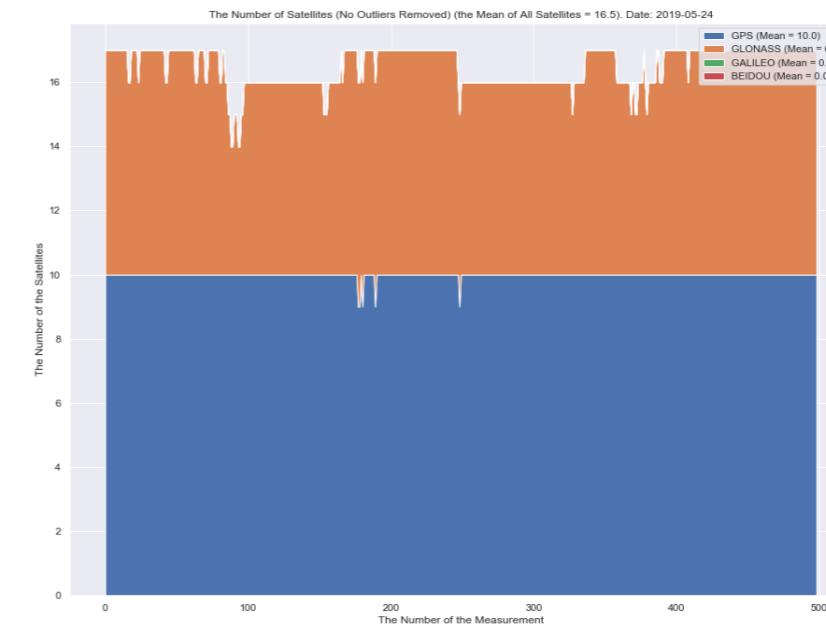
METHOD3



METHOD4

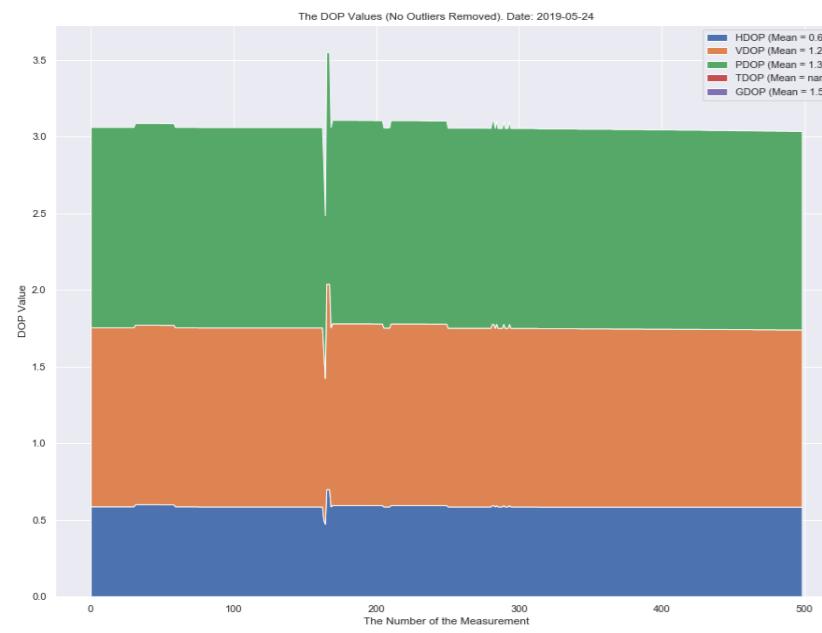


METHOD5

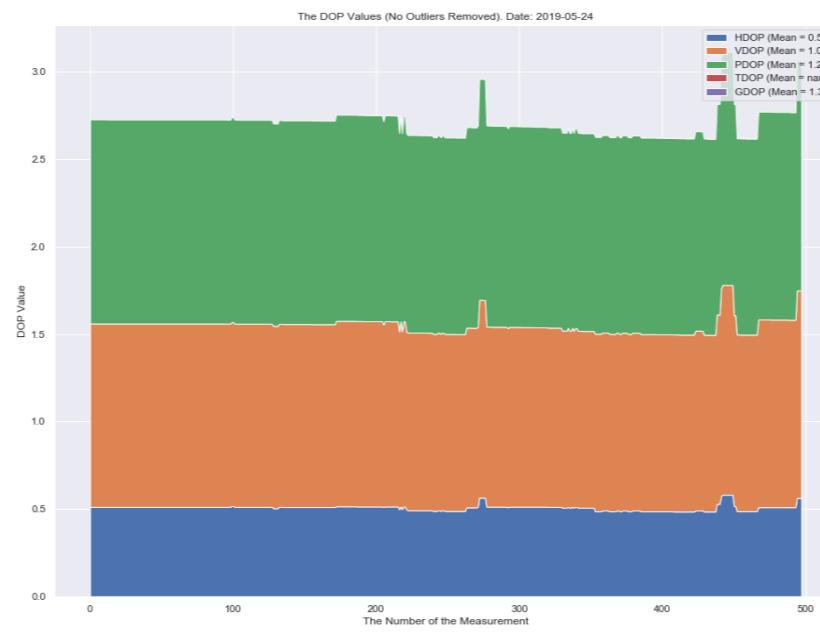


## The DOP Values (No Outliers Removed)

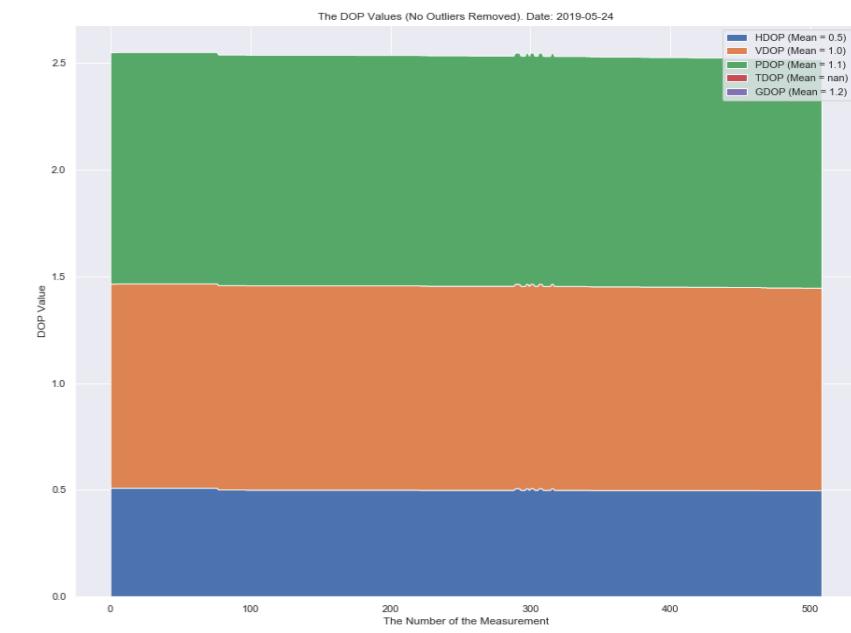
METHOD1



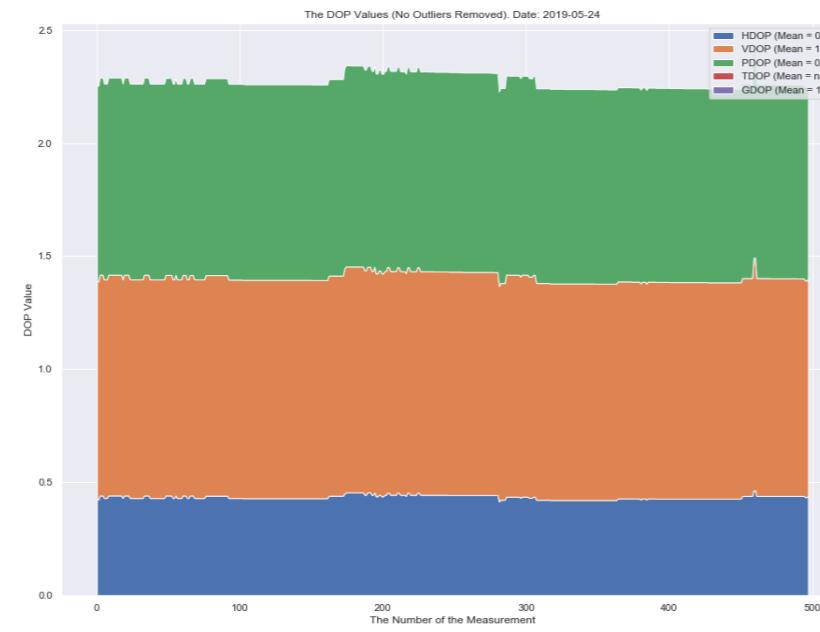
METHOD2



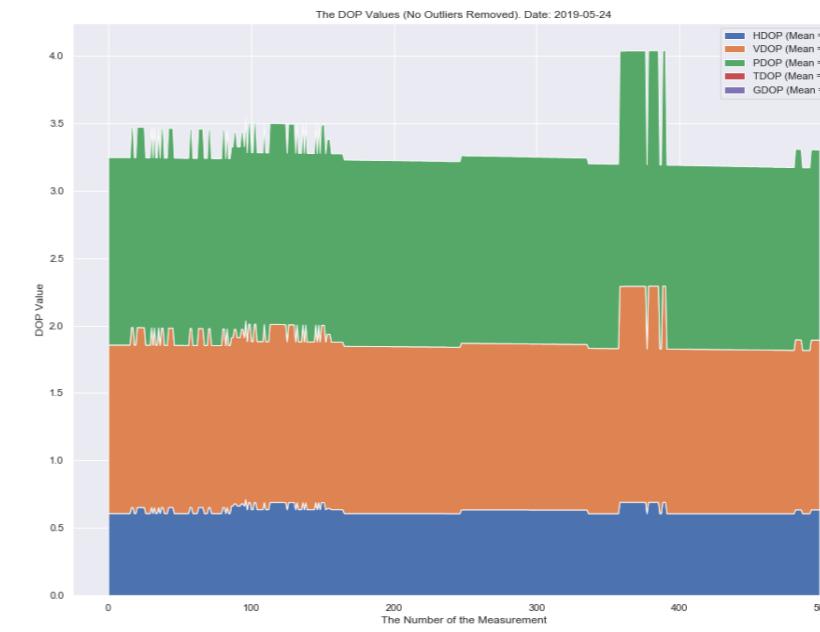
METHOD3



METHOD4

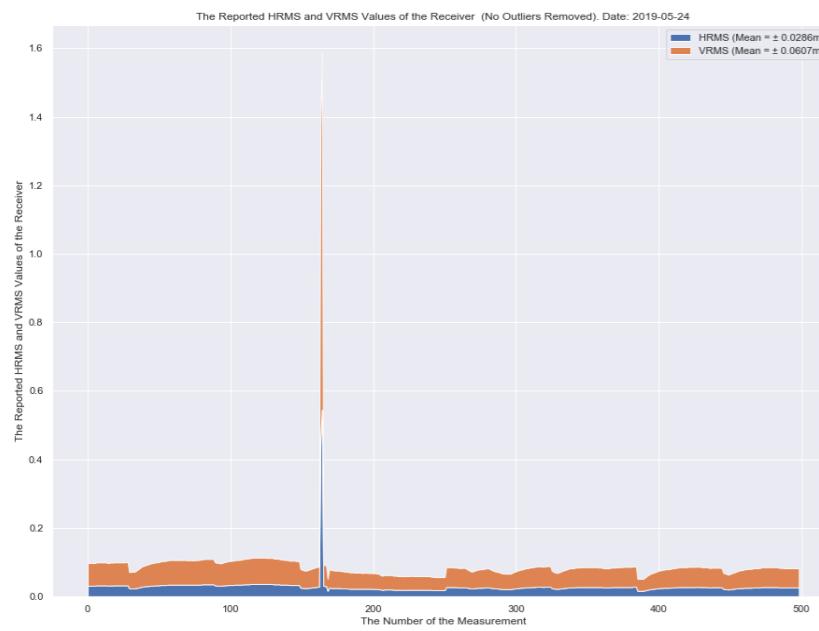


METHOD5

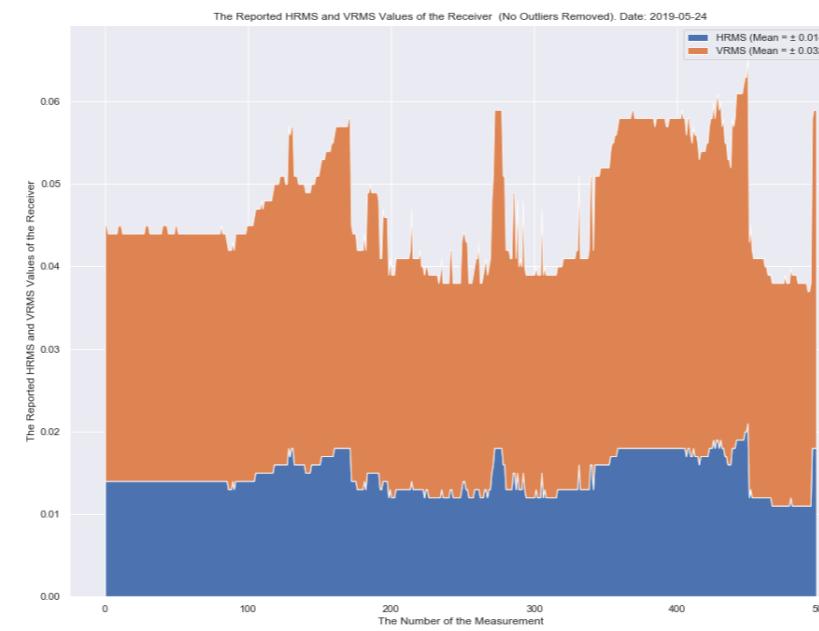


## The Reported HRMS and VRMS Values of the Receiver (No Outliers Removed)

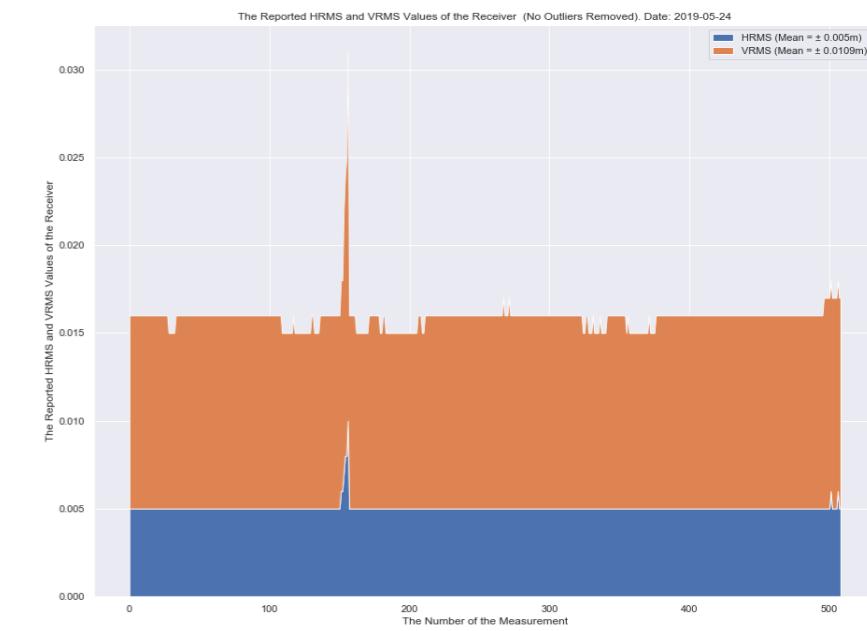
METHOD1



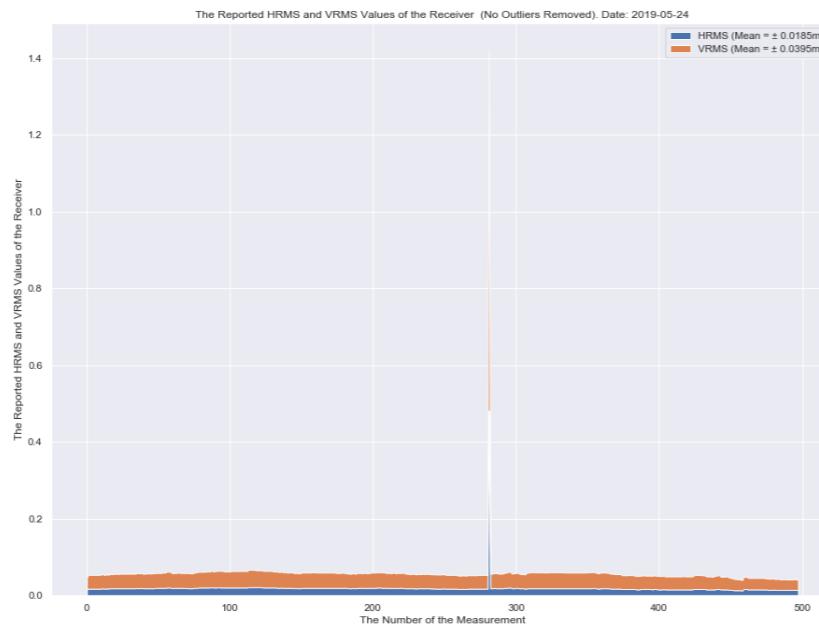
METHOD2



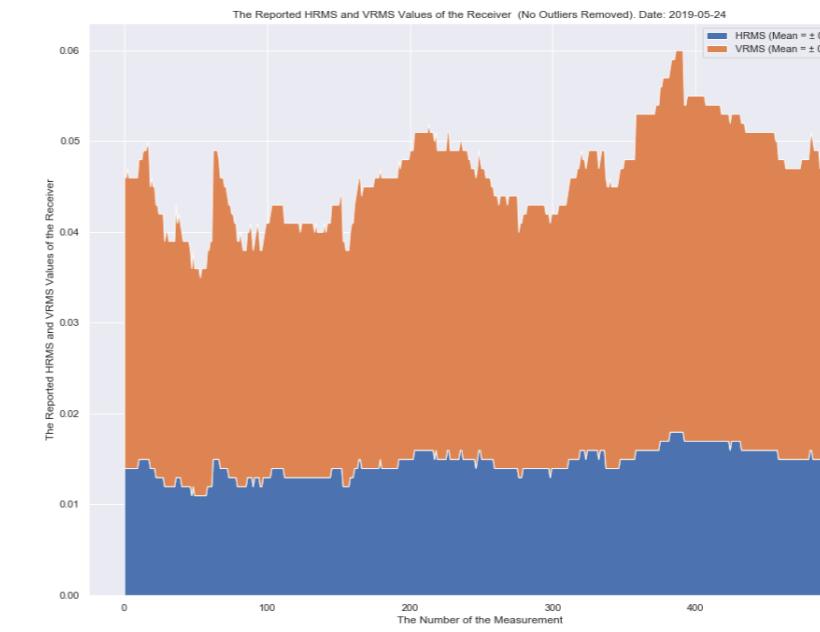
METHOD3



METHOD4

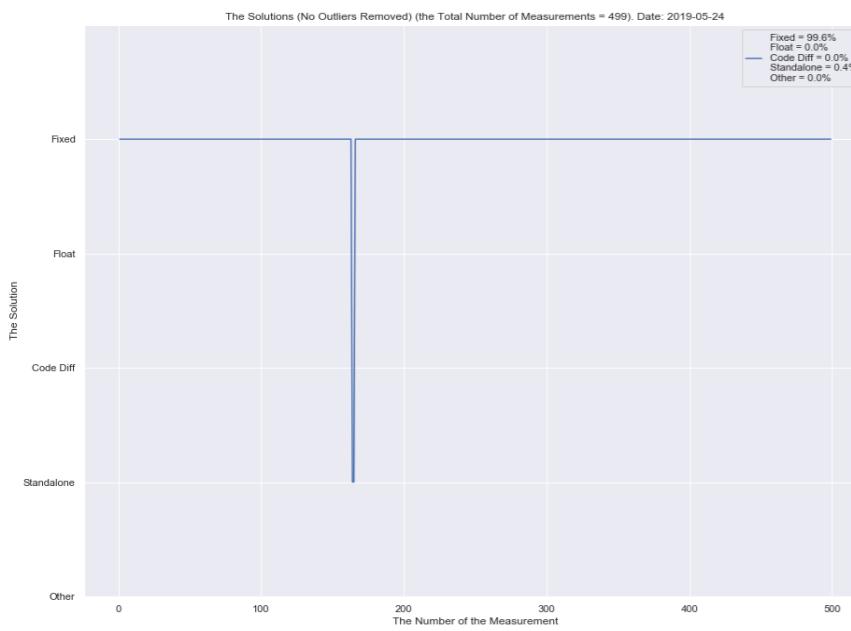


METHOD5

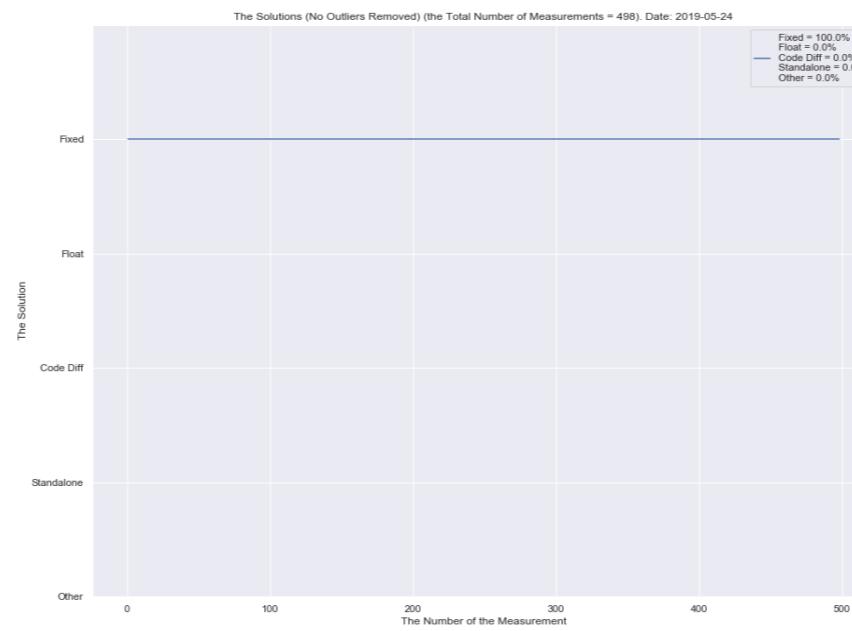


## The Solutions (No Outliers Removed)

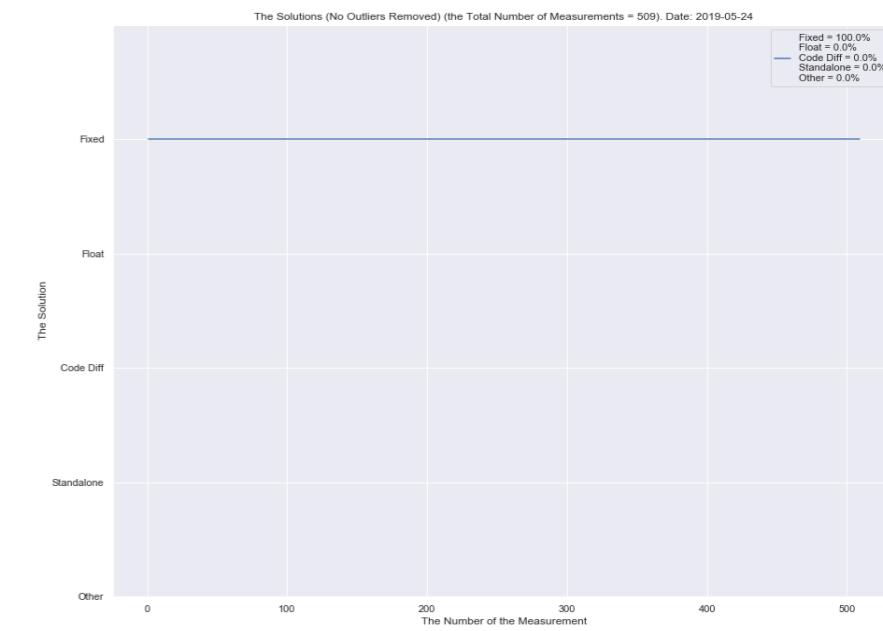
METHOD1



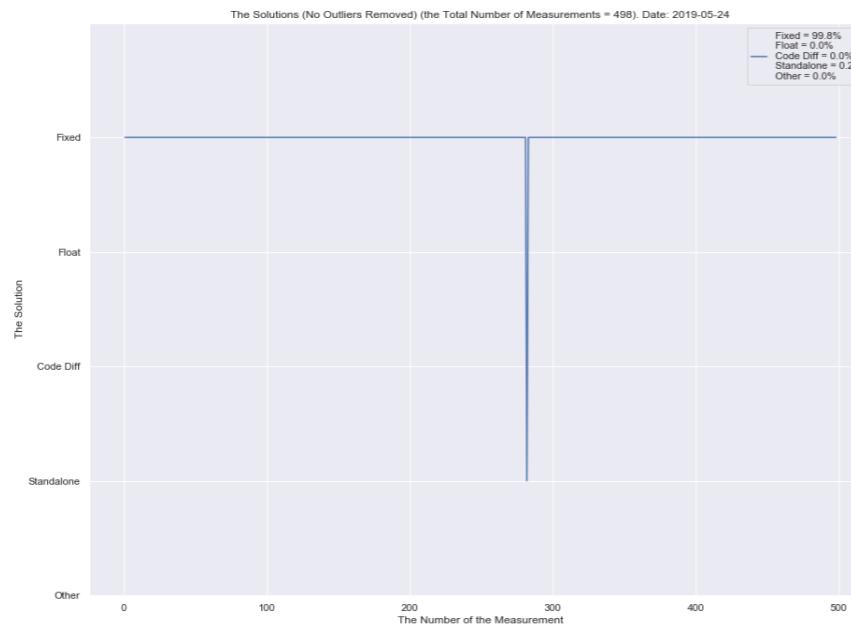
METHOD2



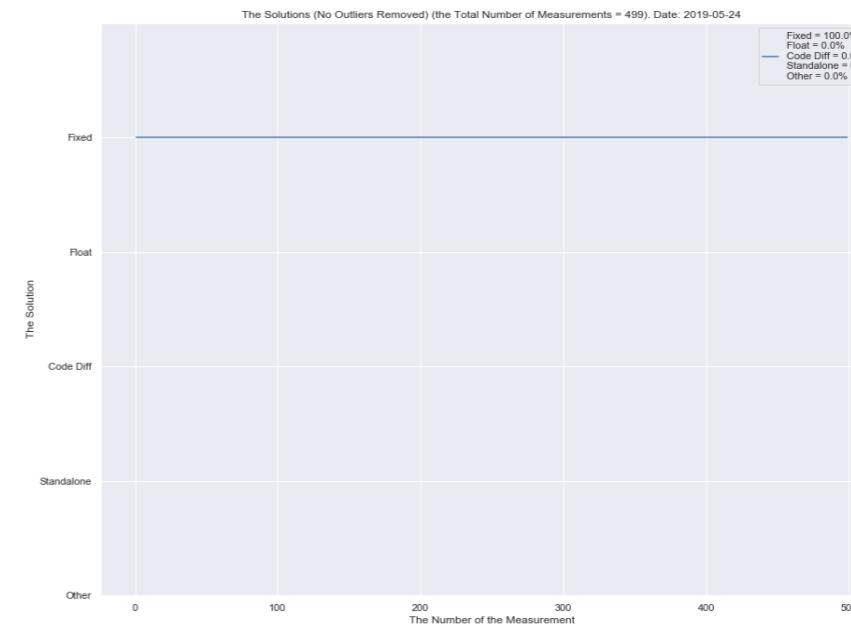
METHOD3



METHOD4

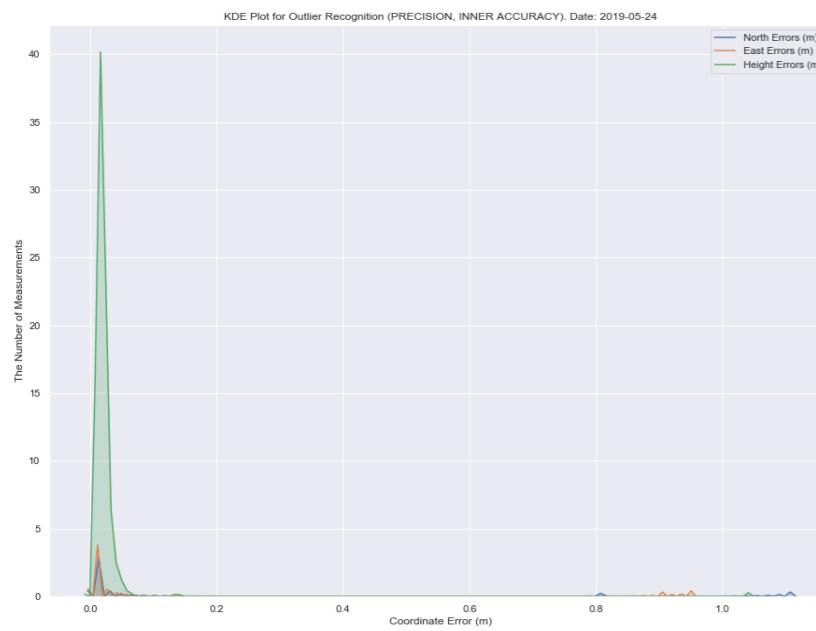


METHOD5

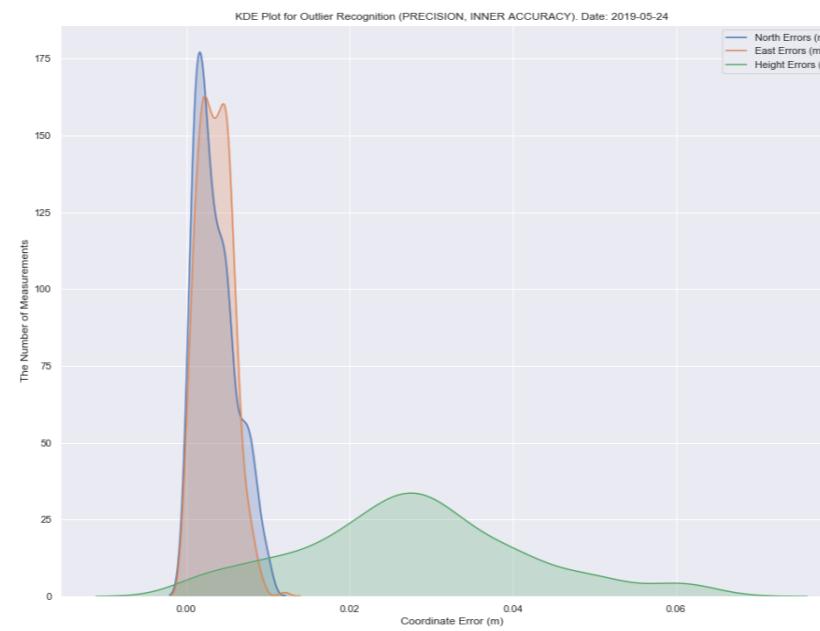


## KDE Plot for Outlier Recognition (PRECISION, INNER ACCURACY)

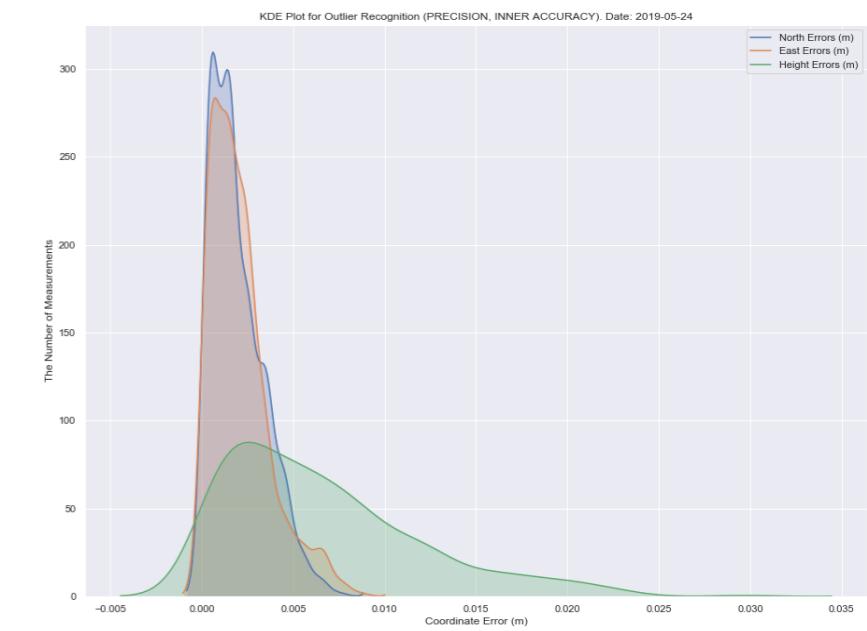
METHOD1



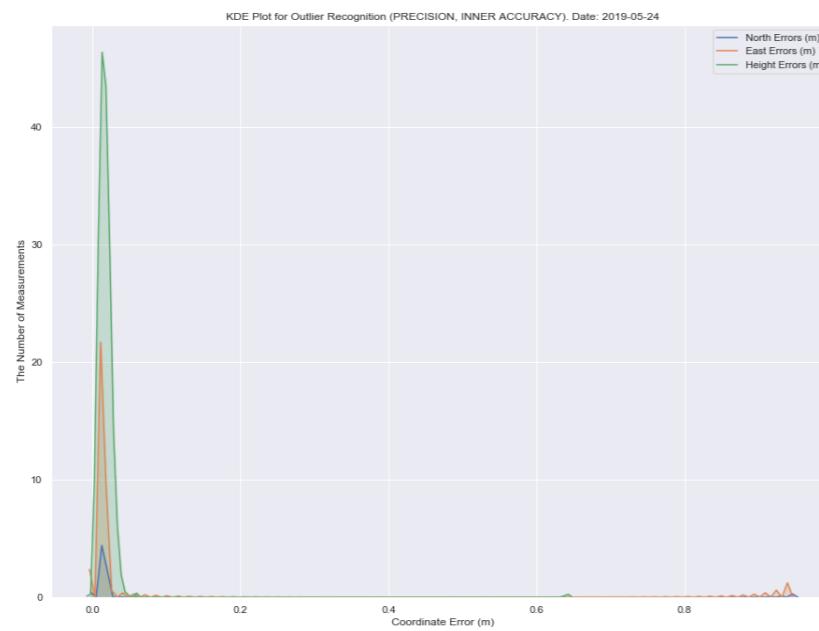
METHOD2



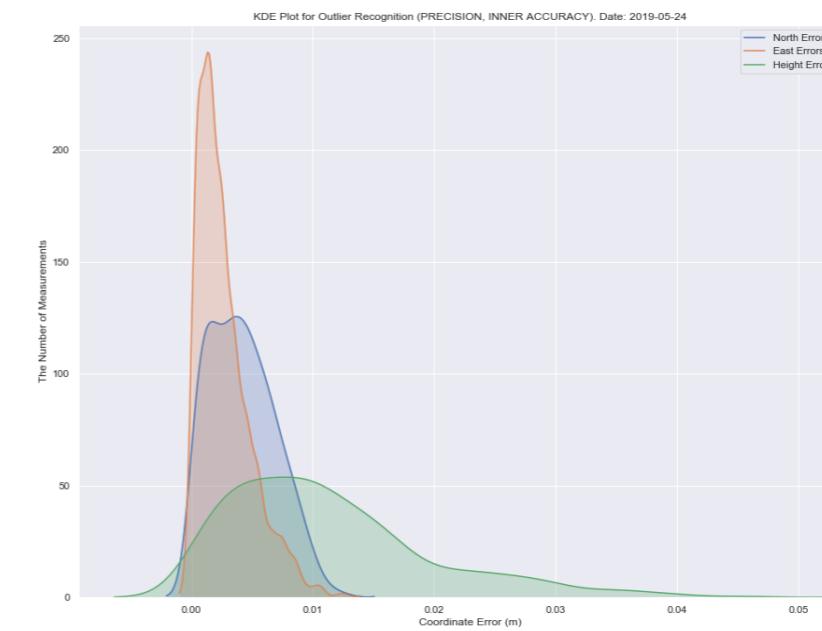
METHOD3



METHOD4

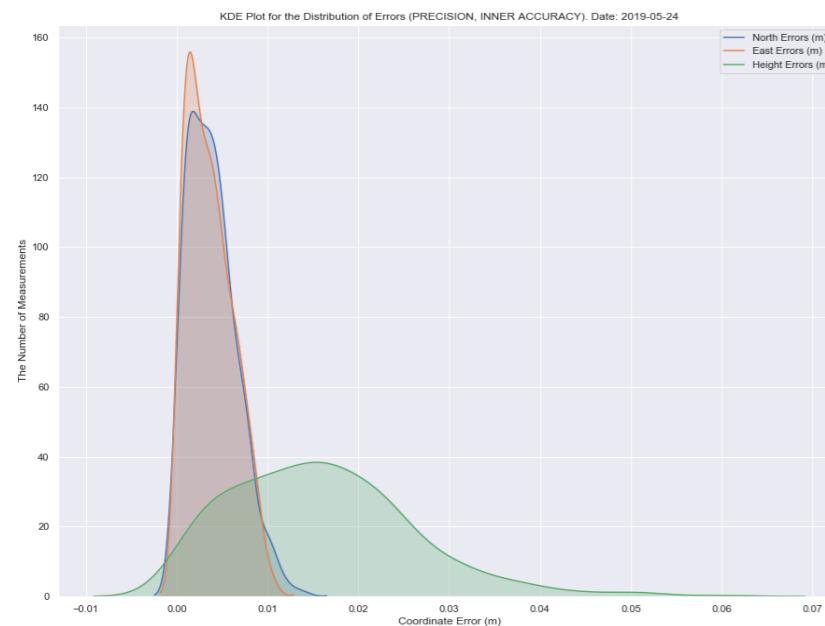


METHOD5

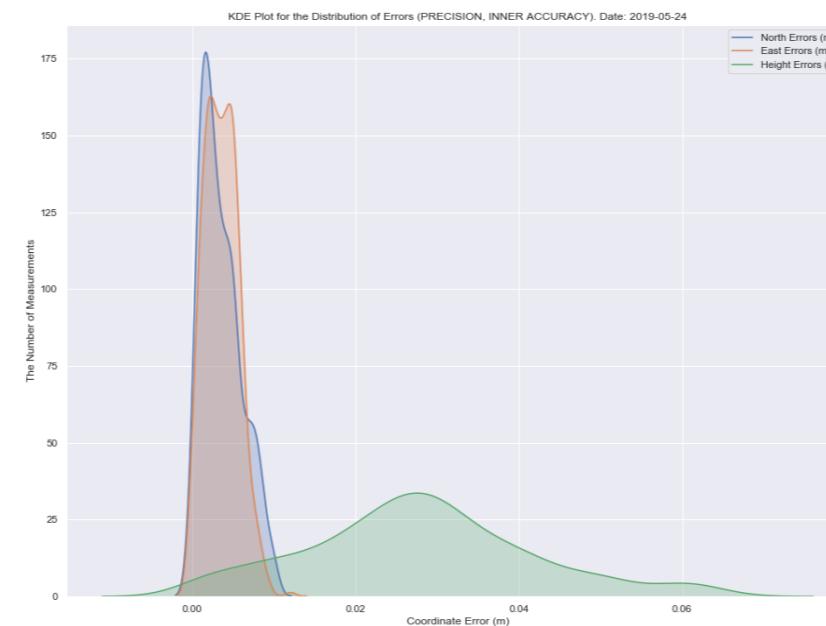


## KDE Plot for the Distribution of Errors (PRECISION, INNER ACCURACY)

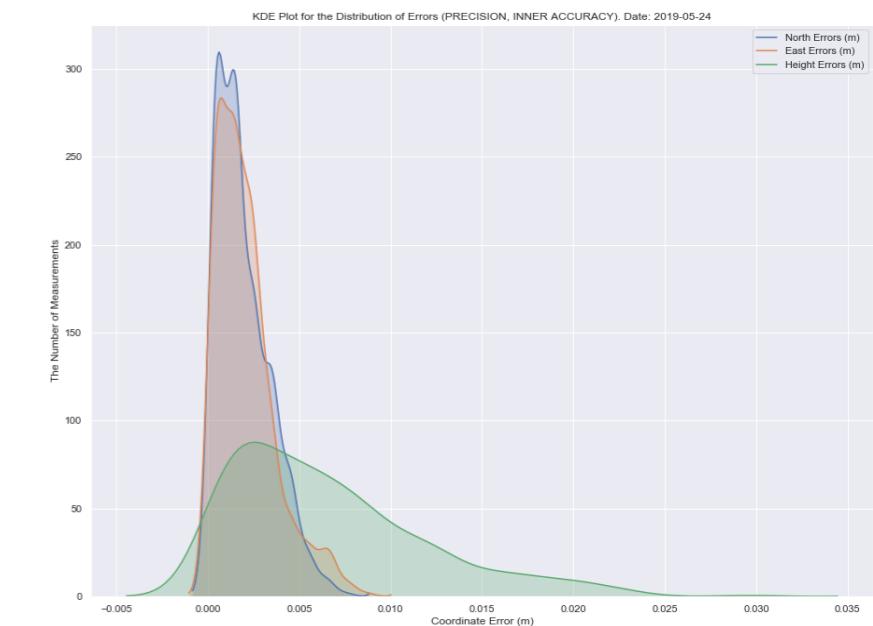
METHOD1



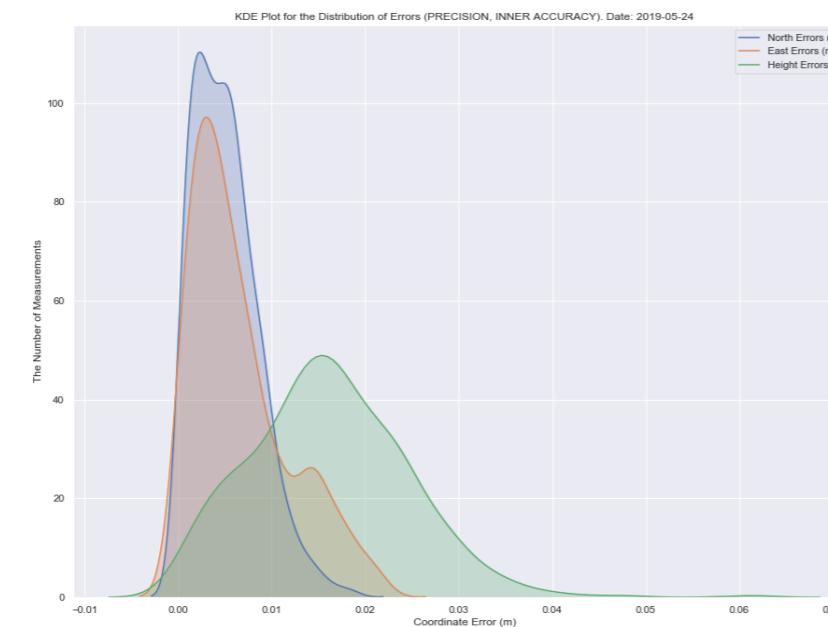
METHOD2



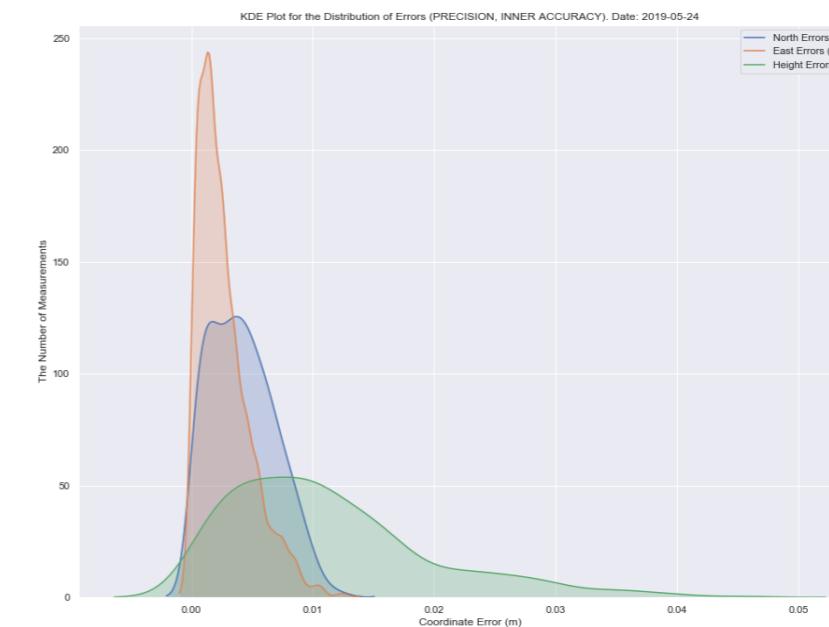
METHOD3



METHOD4

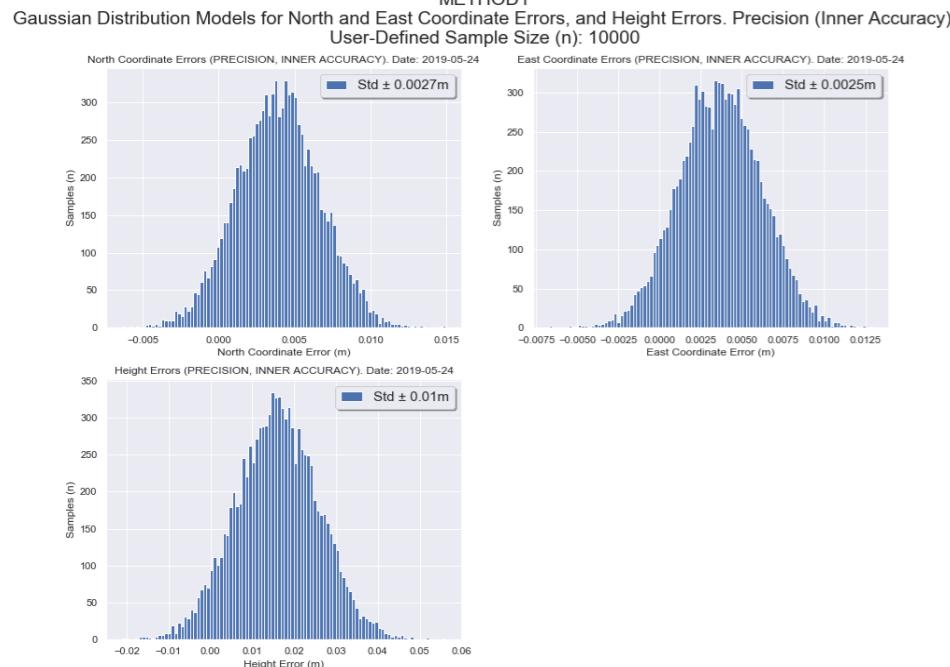


METHOD5

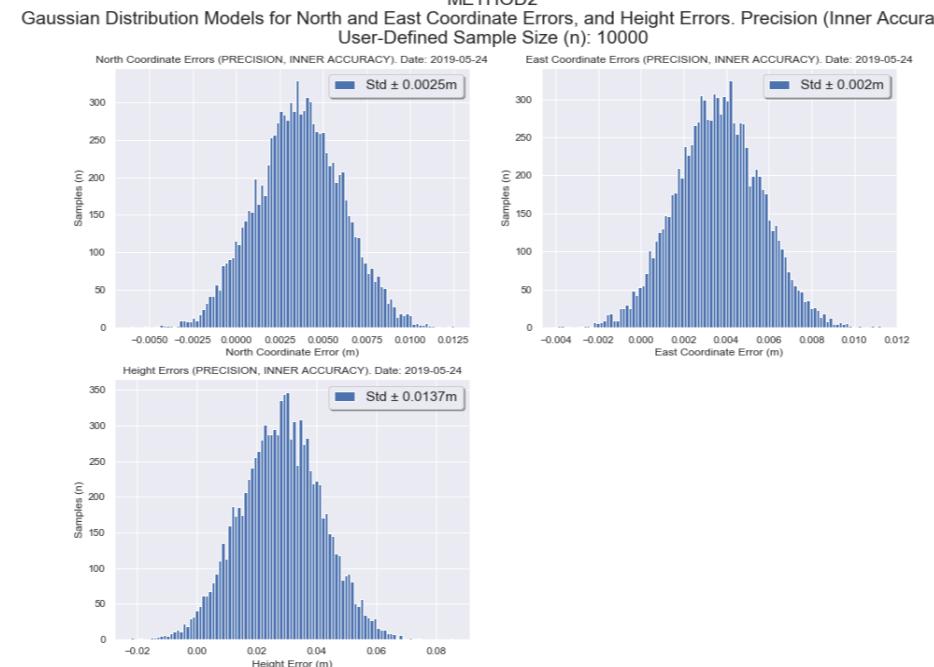


## Gaussian Distribution Models for the Distributions of Errors (PRECISION, INNER ACCURACY)

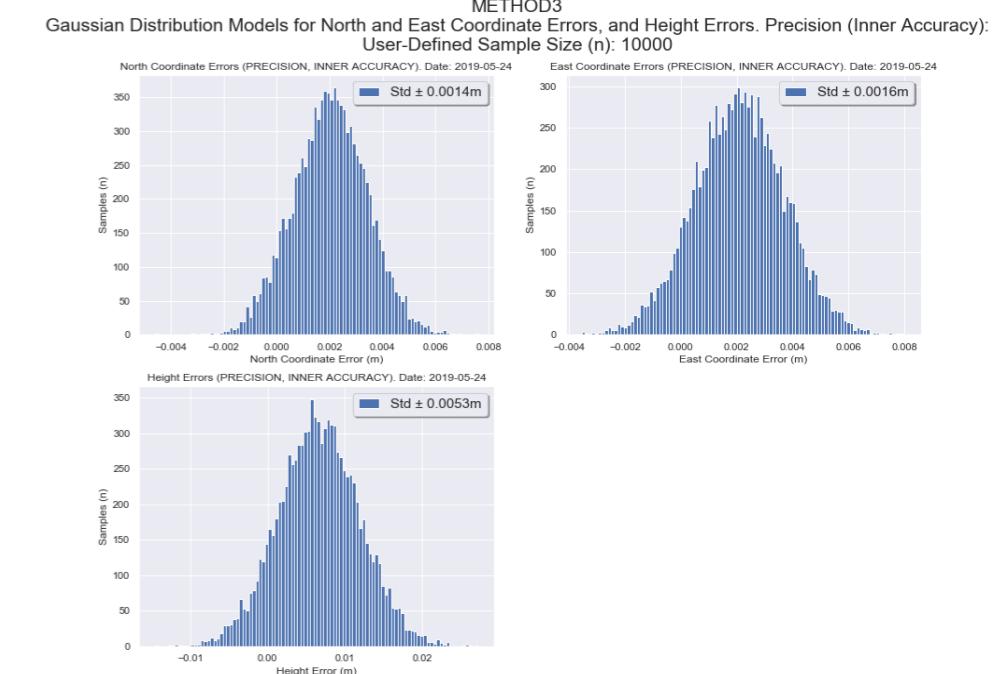
METHOD1



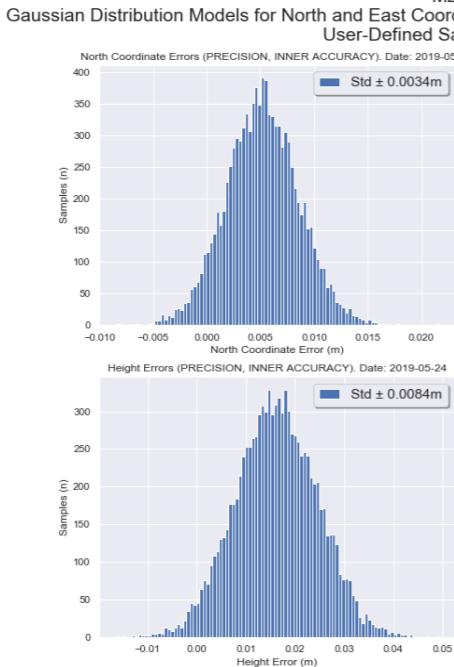
METHOD2



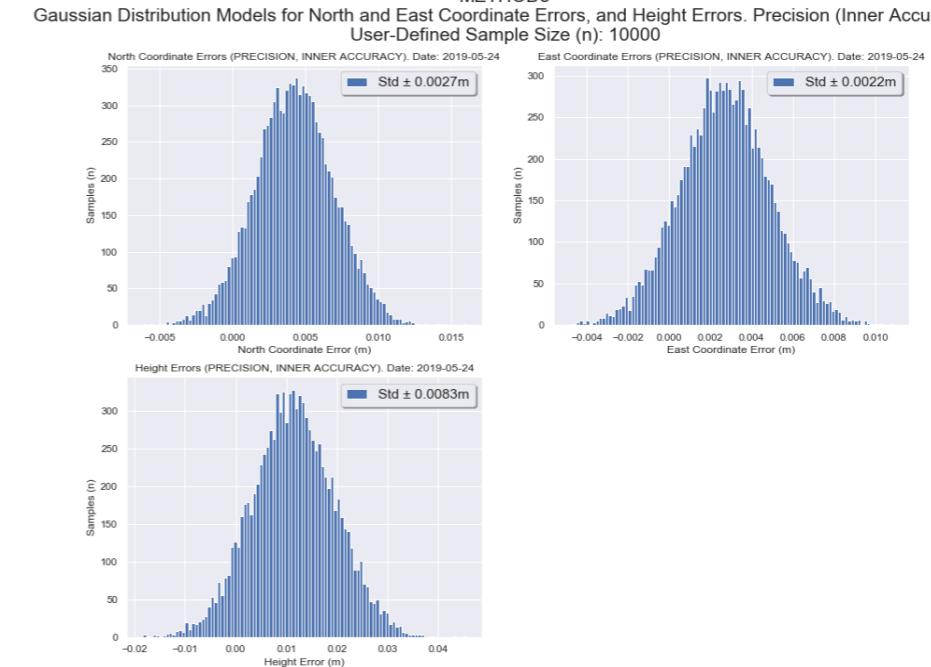
METHOD3



METHOD4

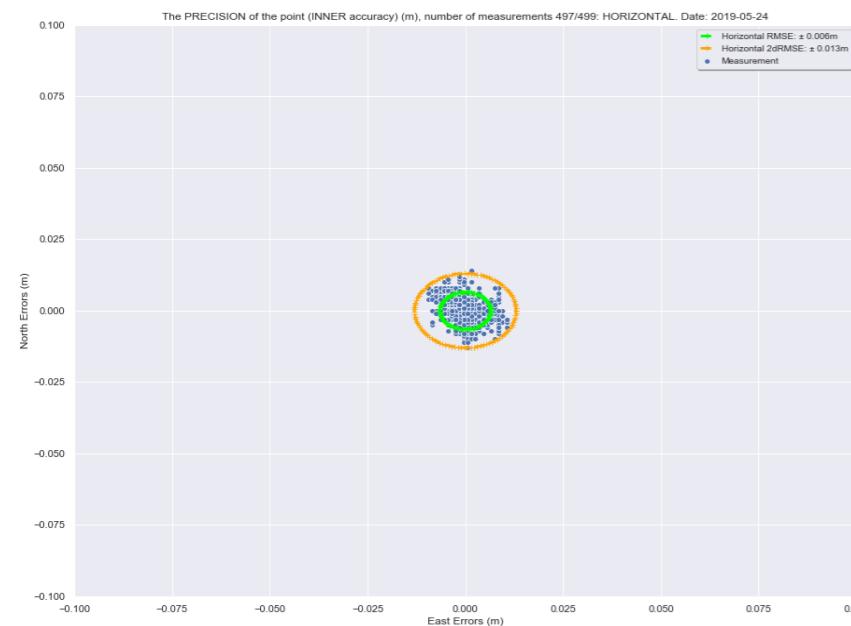


METHOD5



## The PRECISION of the point (INNER accuracy) (m) HORIZONTAL

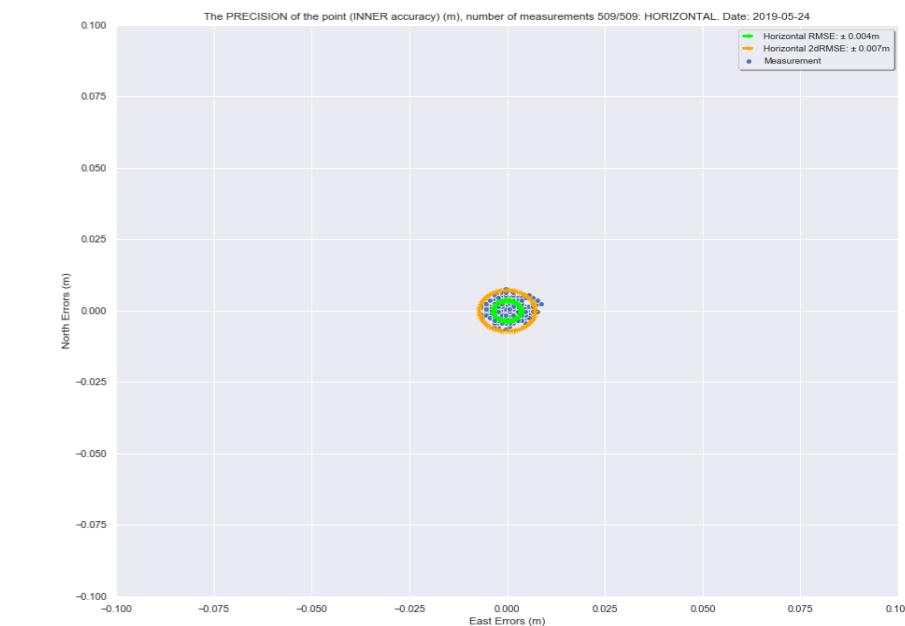
METHOD1



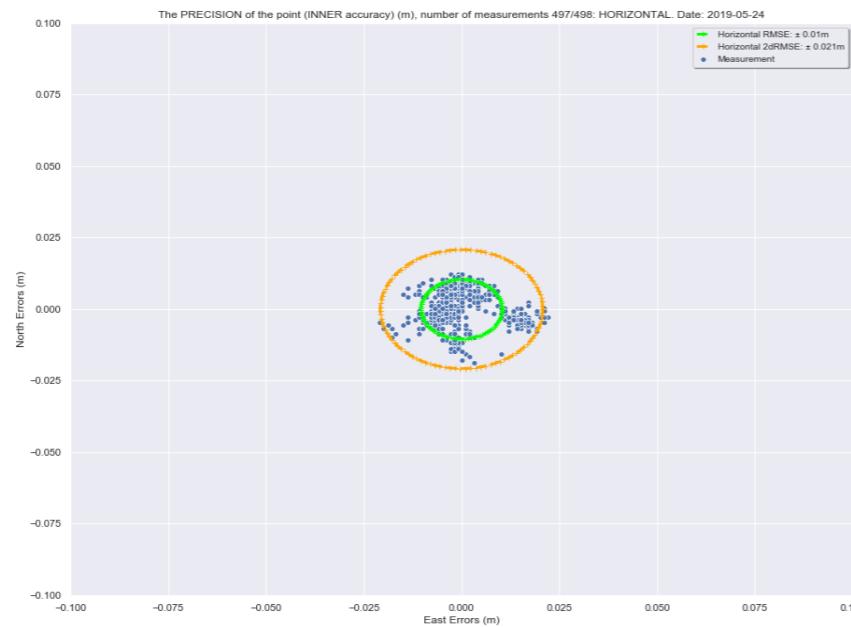
METHOD2



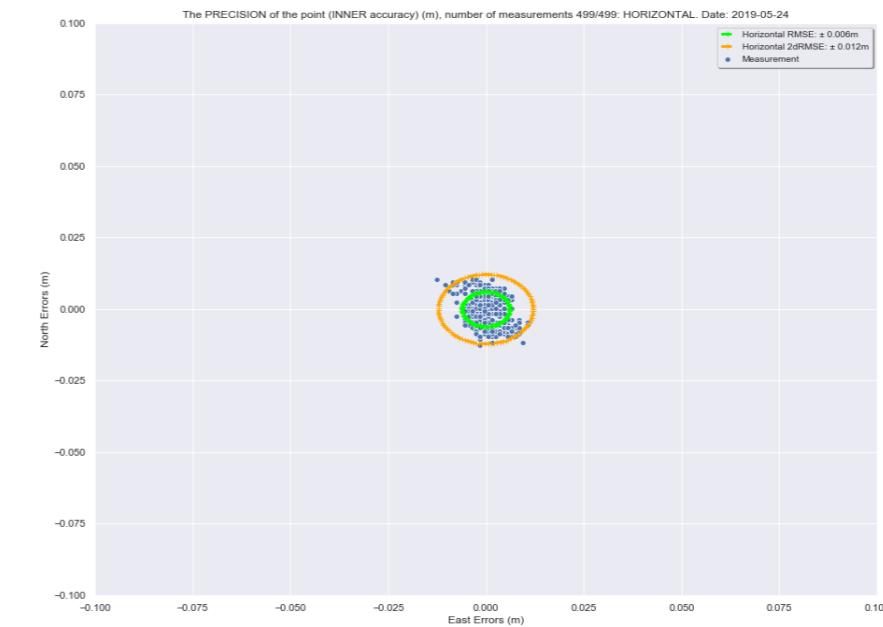
METHOD3



METHOD4

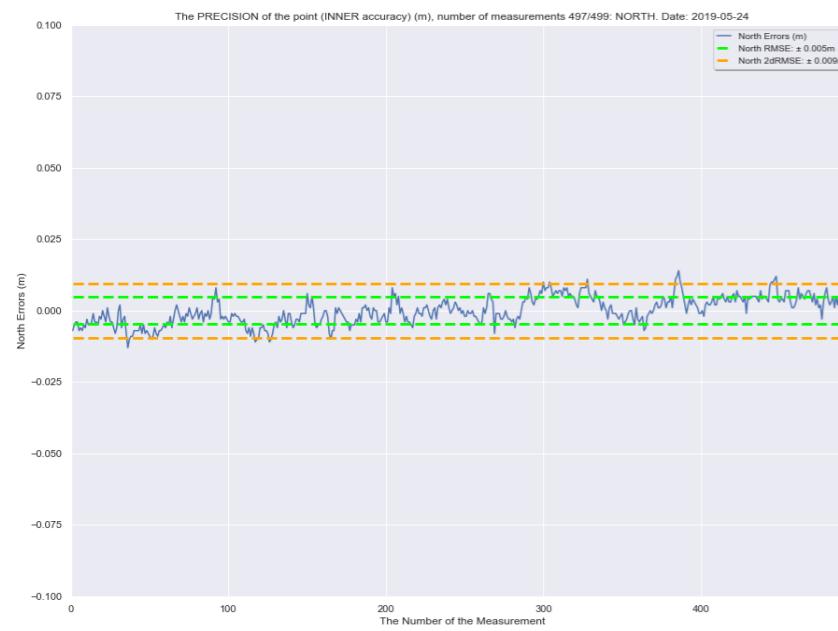


METHOD5

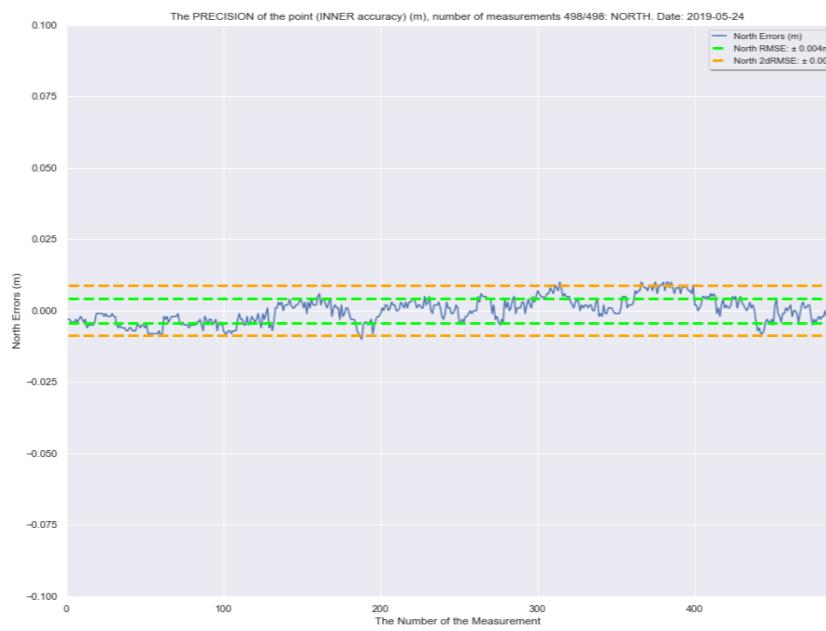


## The PRECISION of the point (INNER accuracy) (m) NORTH

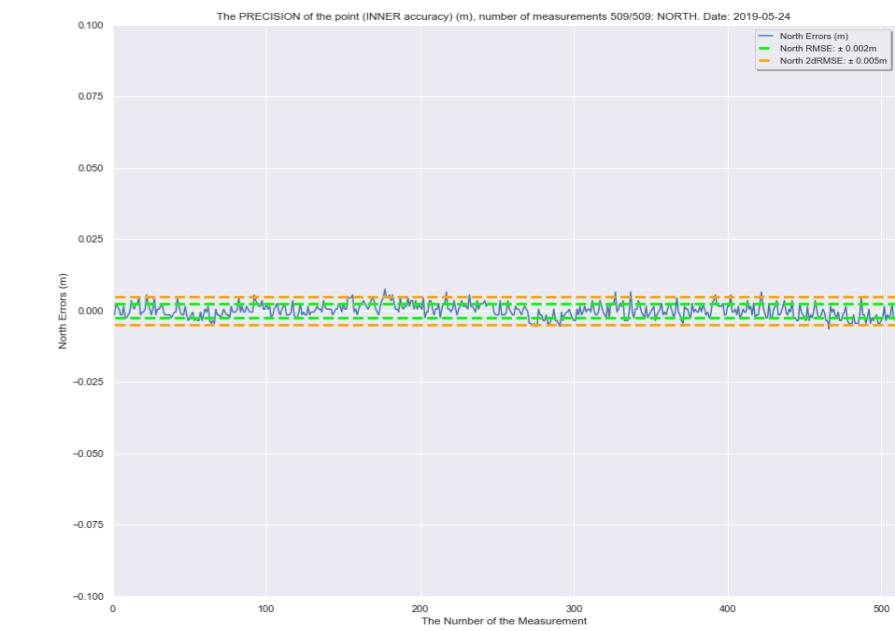
METHOD1



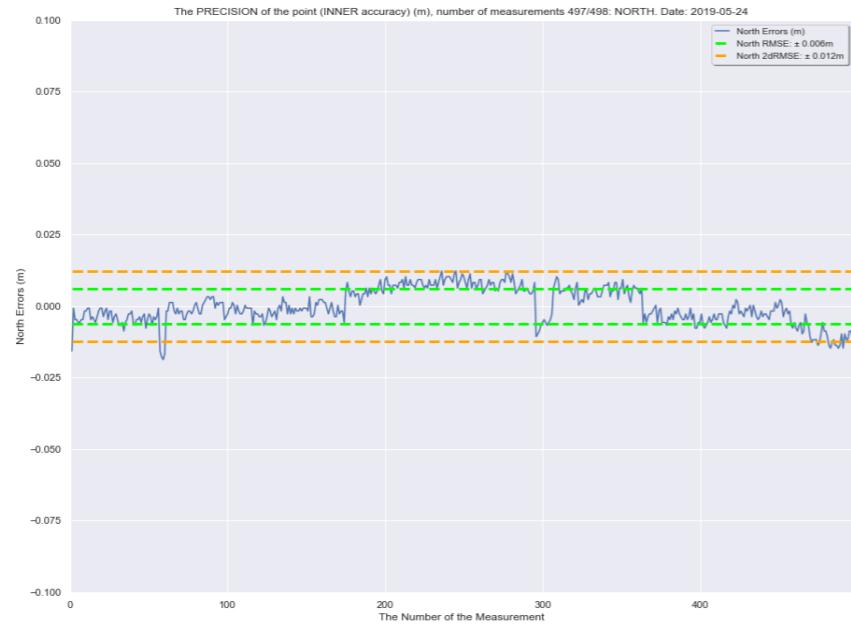
METHOD2



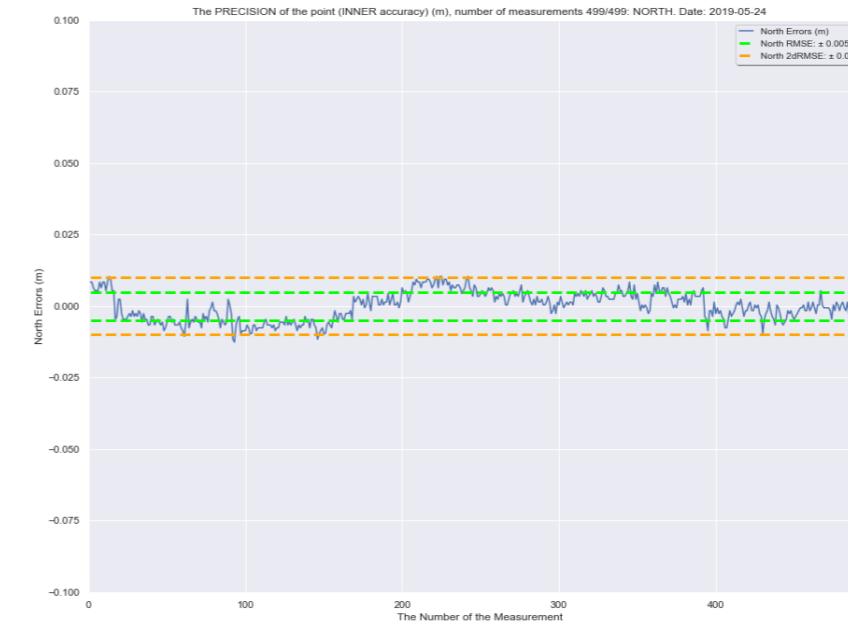
METHOD3



METHOD4

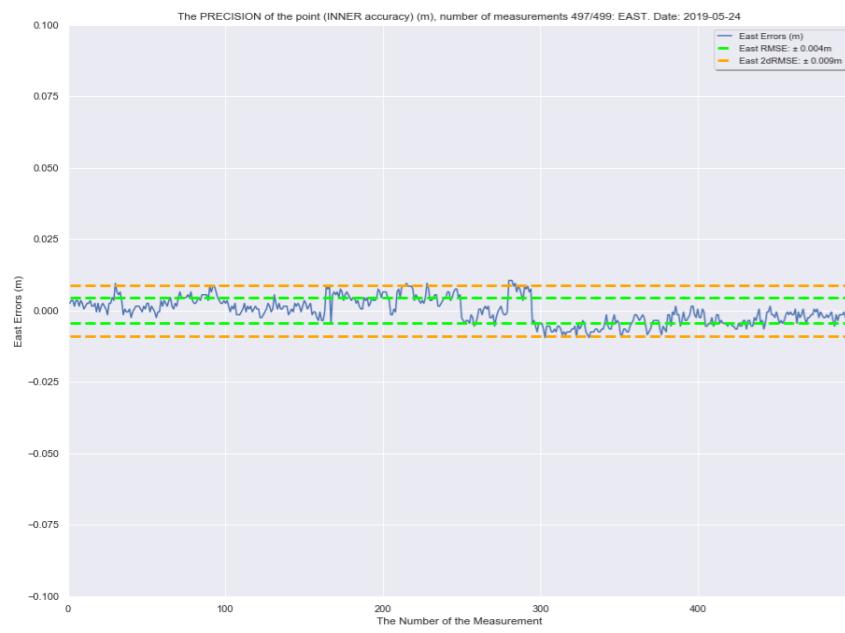


METHOD5

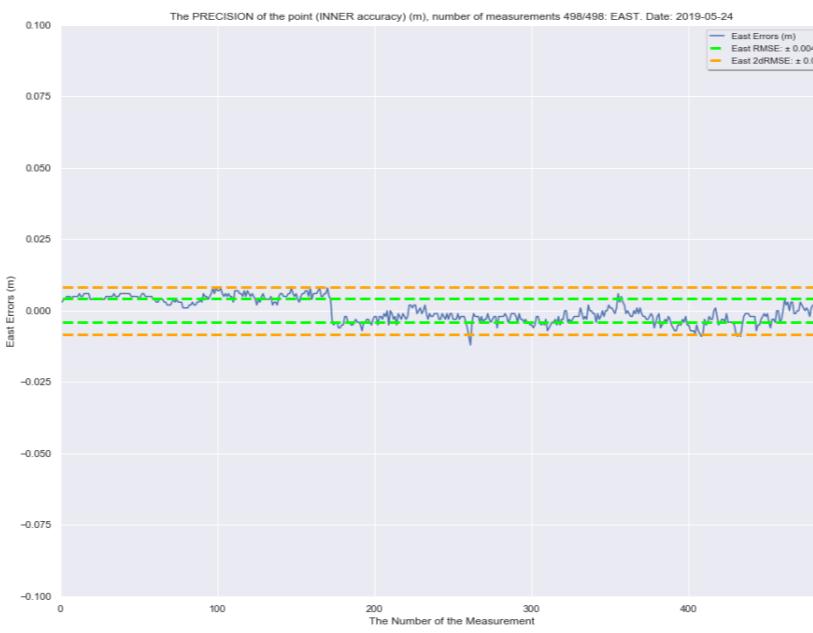


## The PRECISION of the point (INNER accuracy) (m) EAST

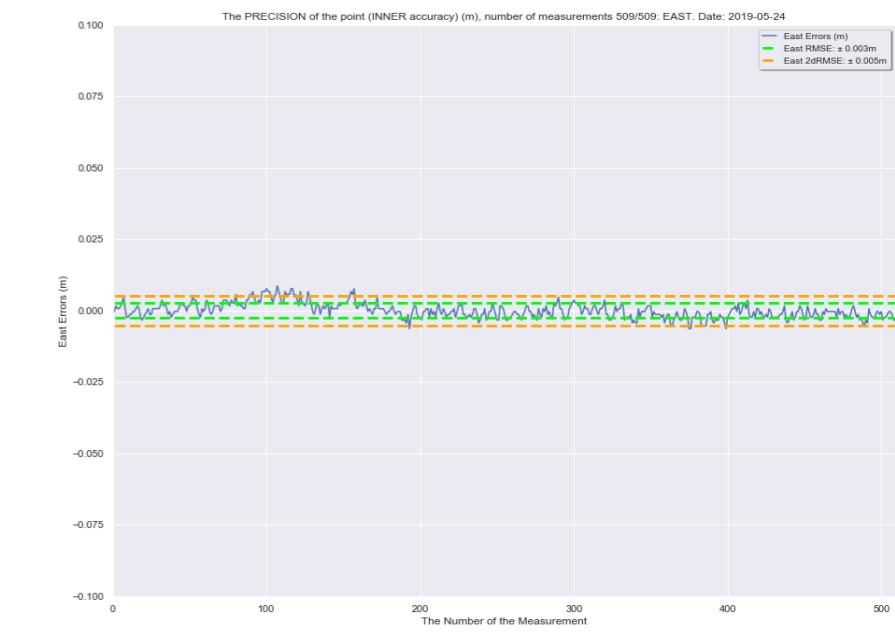
METHOD1



METHOD2



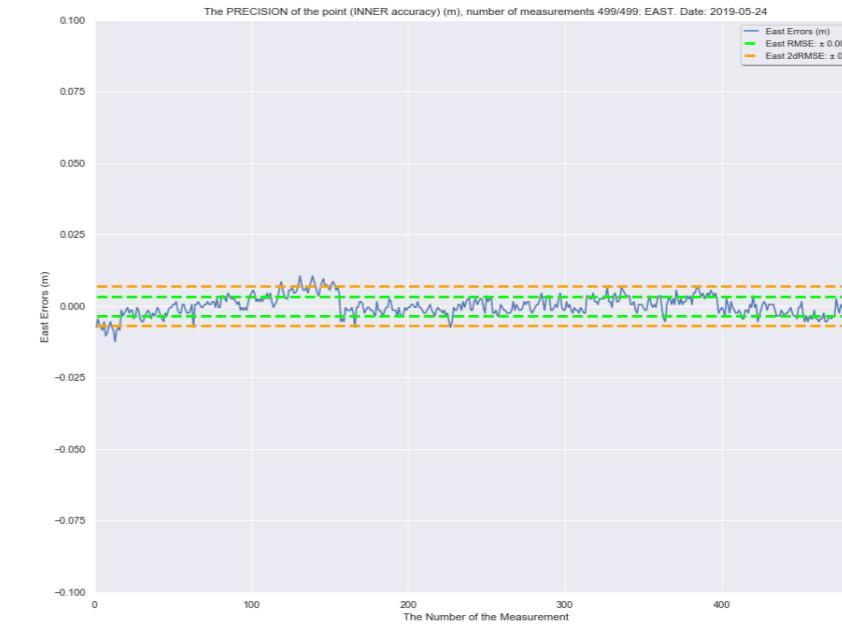
METHOD3



METHOD4

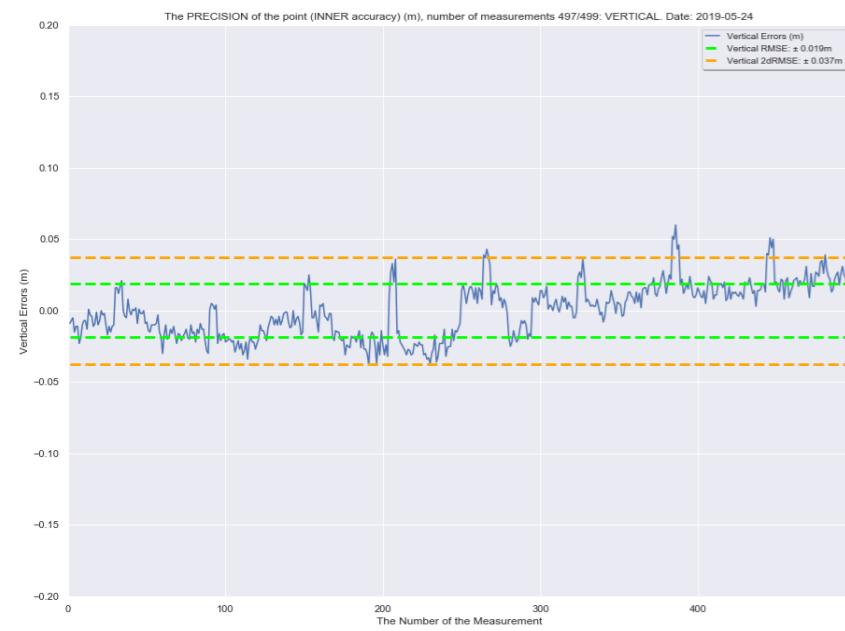


METHOD5



## The PRECISION of the point (INNER accuracy) (m) VERTICAL

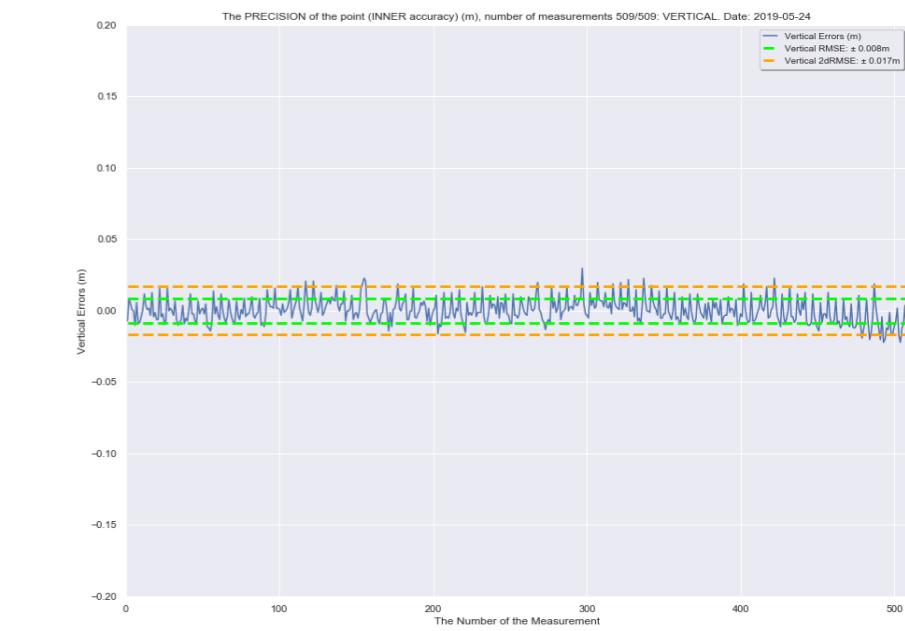
METHOD1



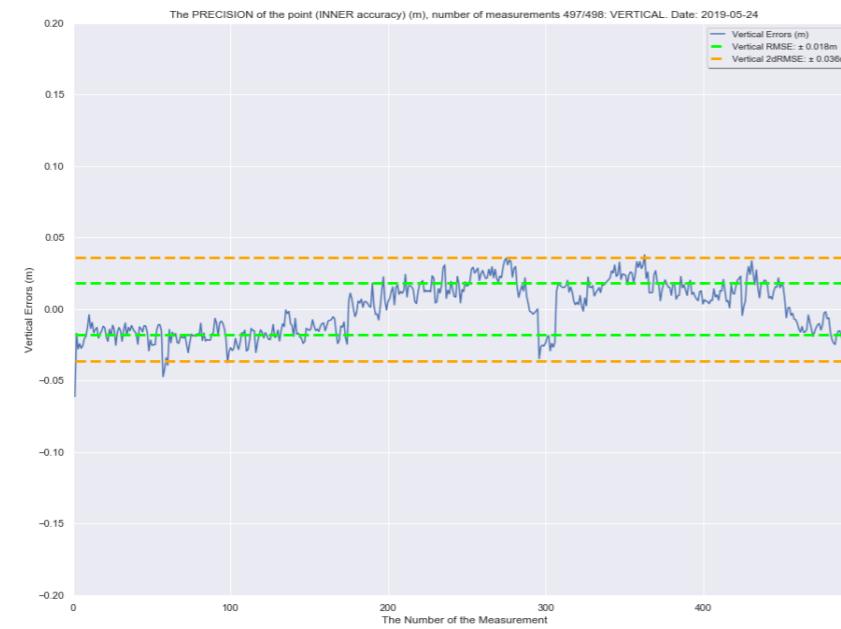
METHOD2



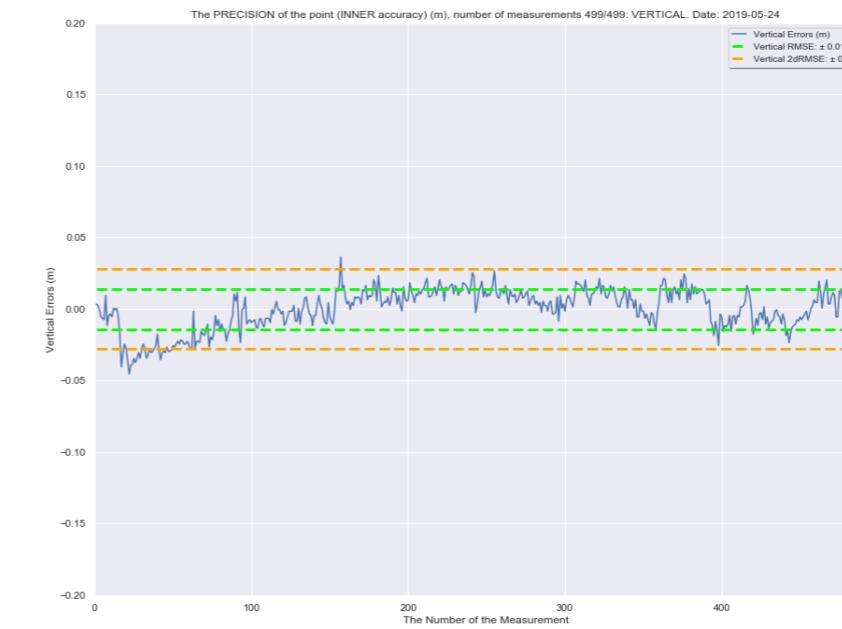
METHOD3



METHOD4



METHOD5



## The ACCURACY of the point (OUTER accuracy) (m) HORIZONTAL

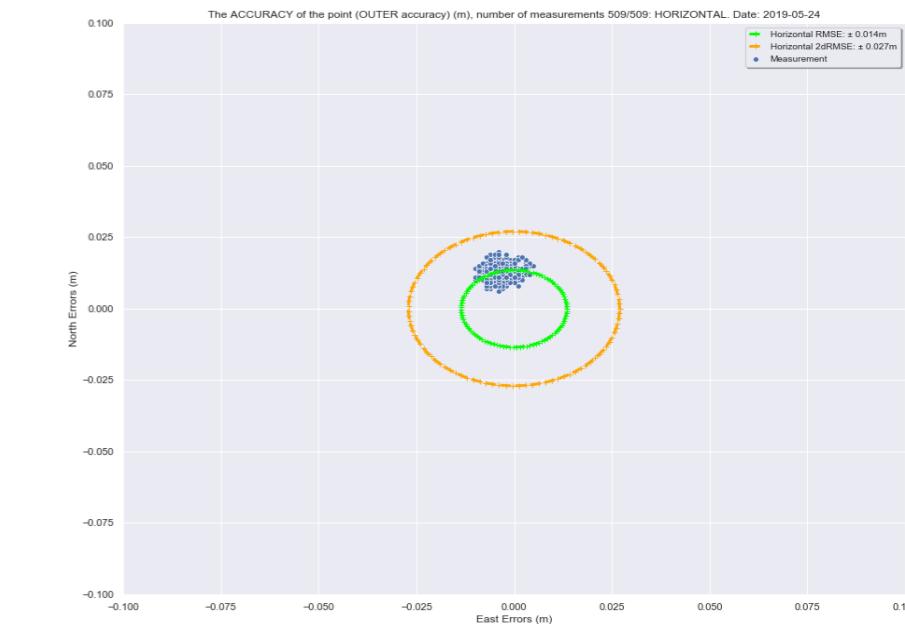
METHOD1



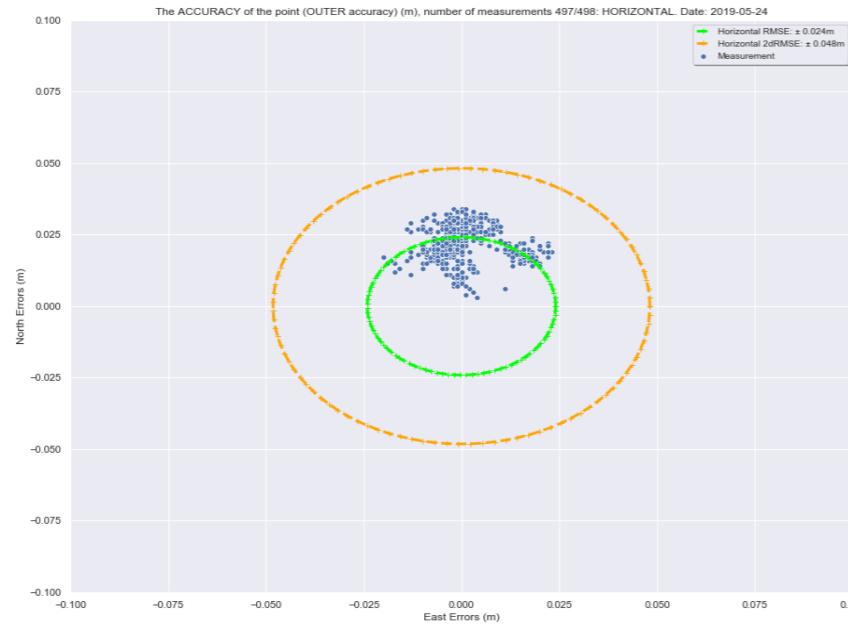
METHOD2



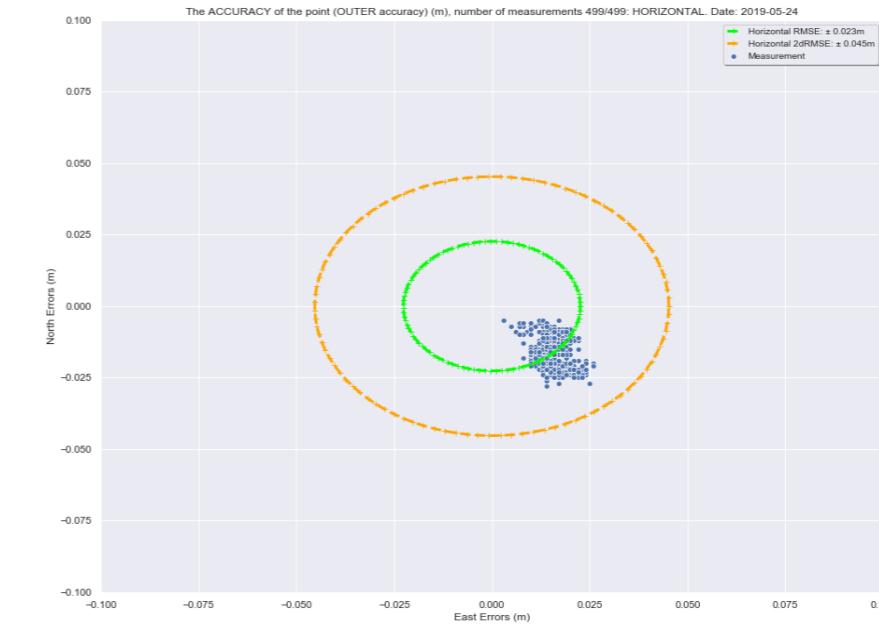
METHOD3



METHOD4

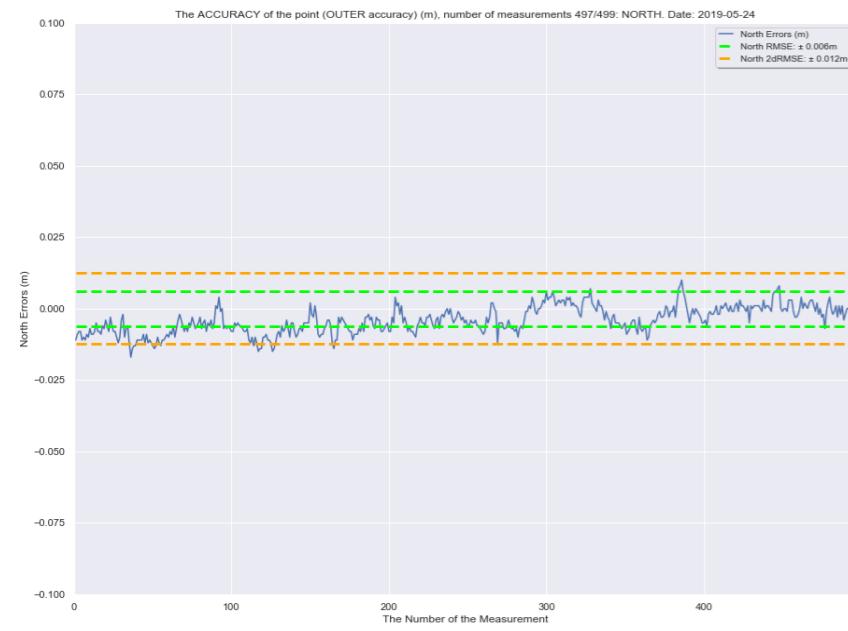


METHOD5



## The ACCURACY of the point (OUTER accuracy) (m) NORTH

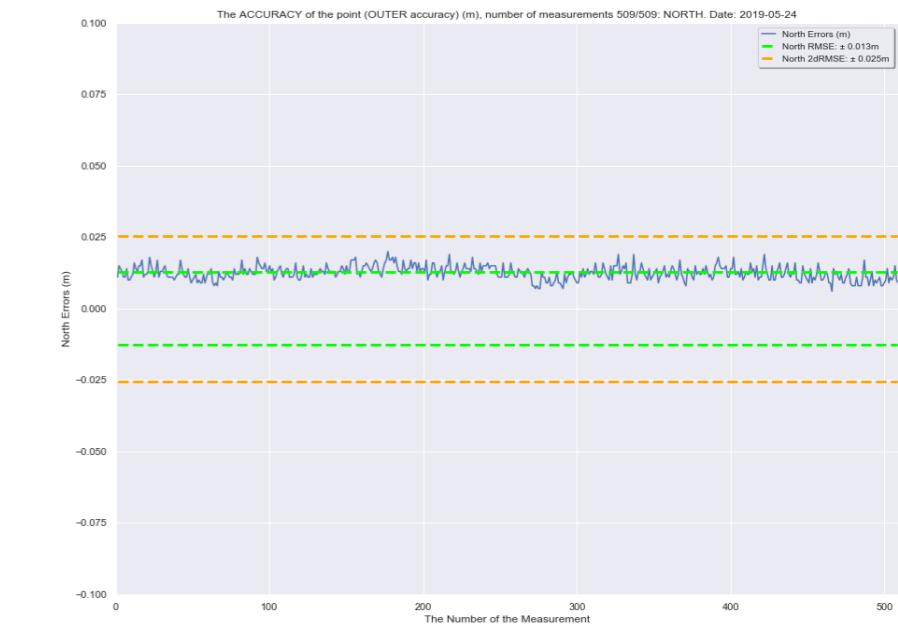
METHOD1



METHOD2



METHOD3



METHOD4

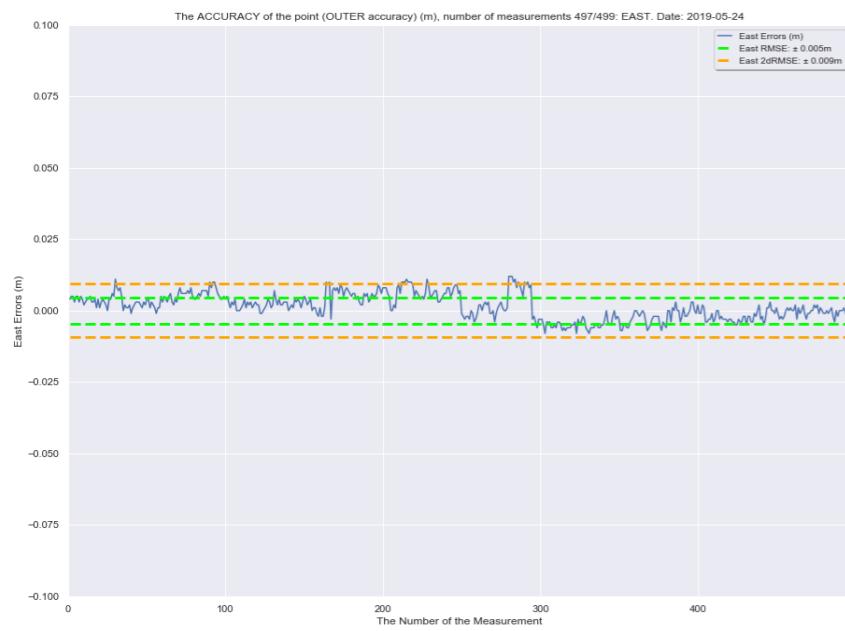


METHOD5

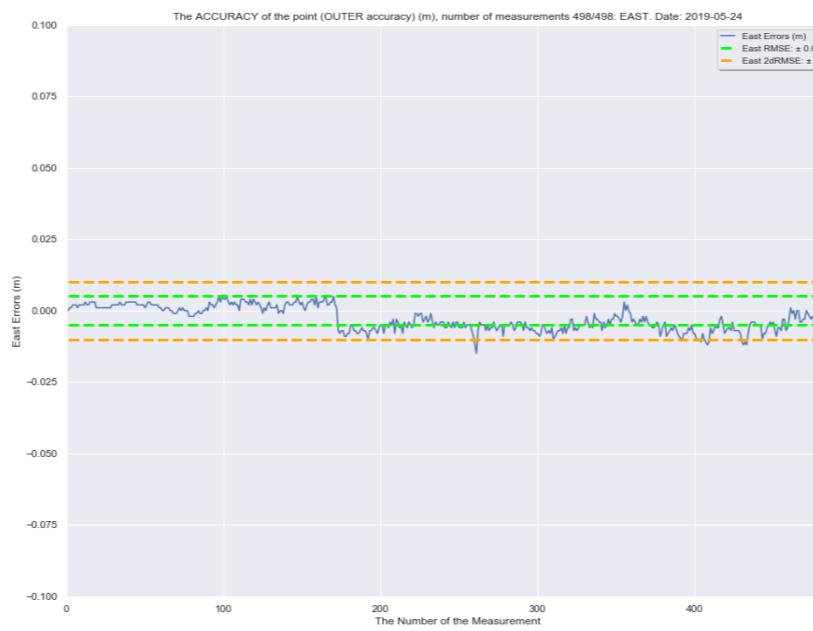


## The ACCURACY of the point (OUTER accuracy) (m) EAST

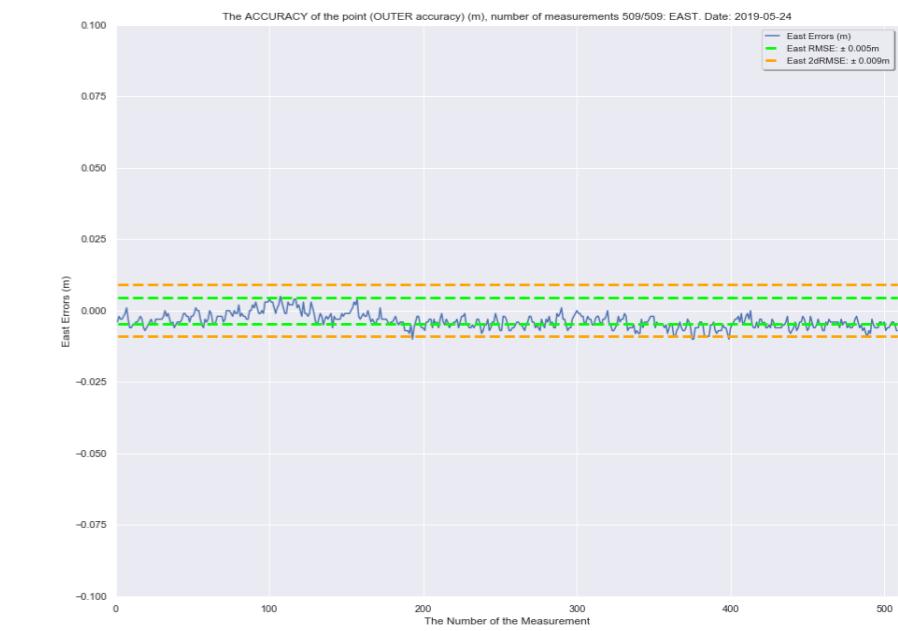
METHOD1



METHOD2



METHOD3



METHOD4



METHOD5

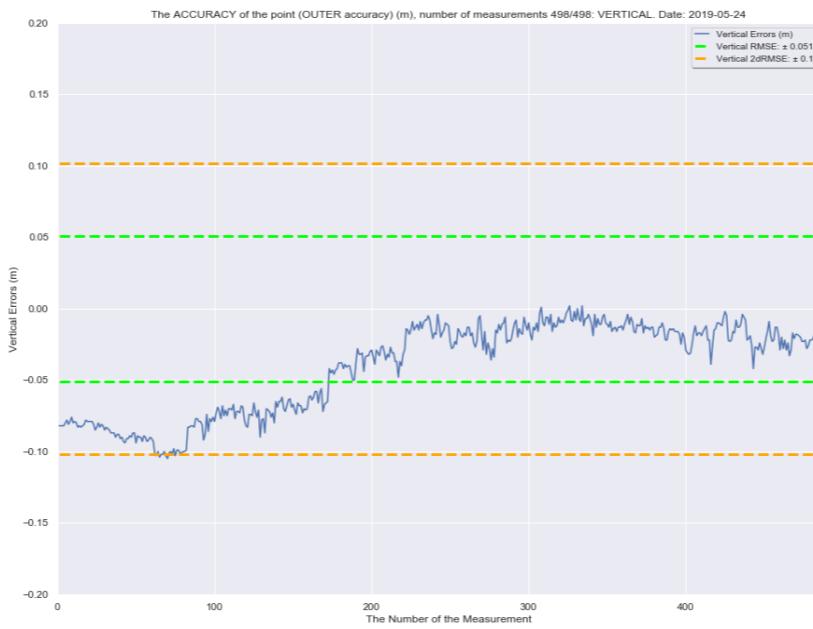


## The ACCURACY of the point (OUTER accuracy) (m) VERTICAL

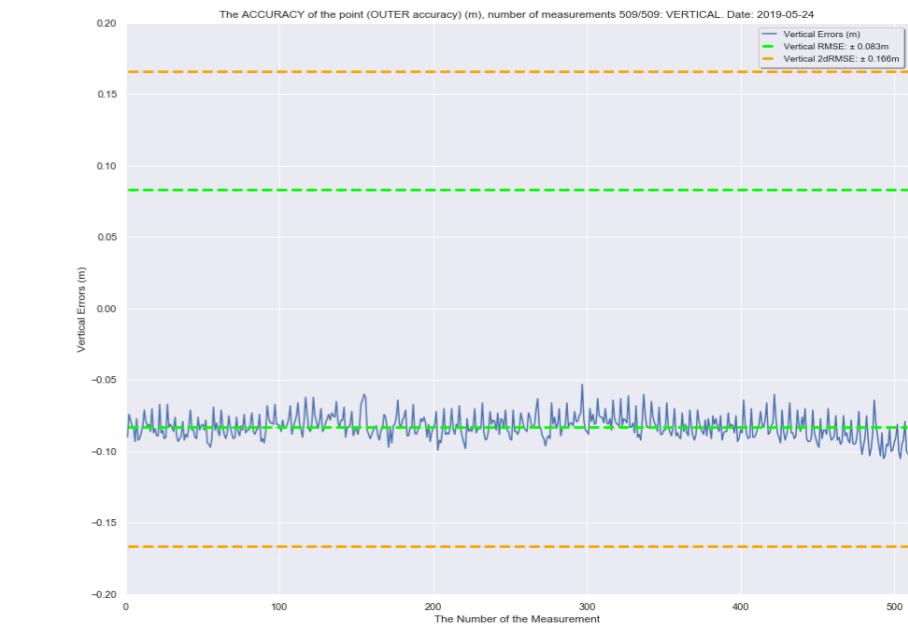
METHOD1



METHOD2



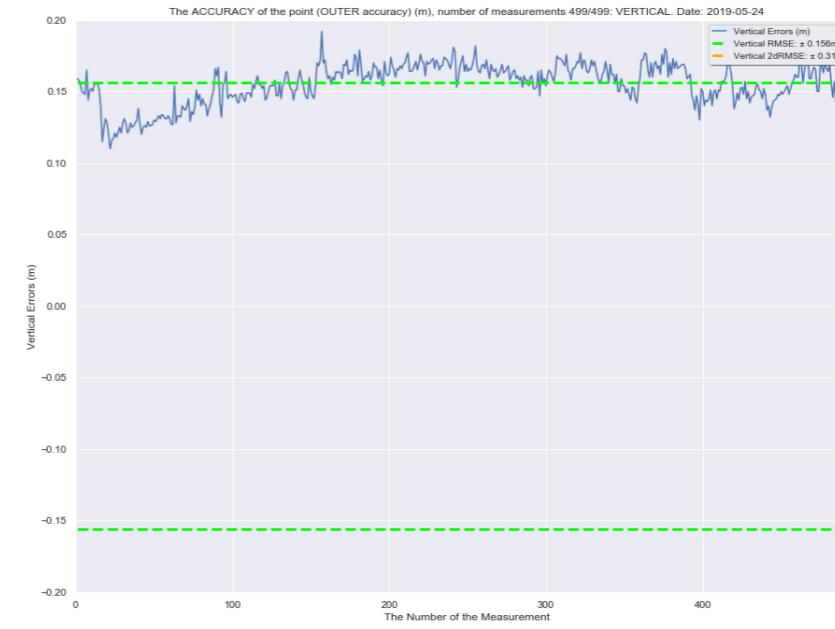
METHOD3



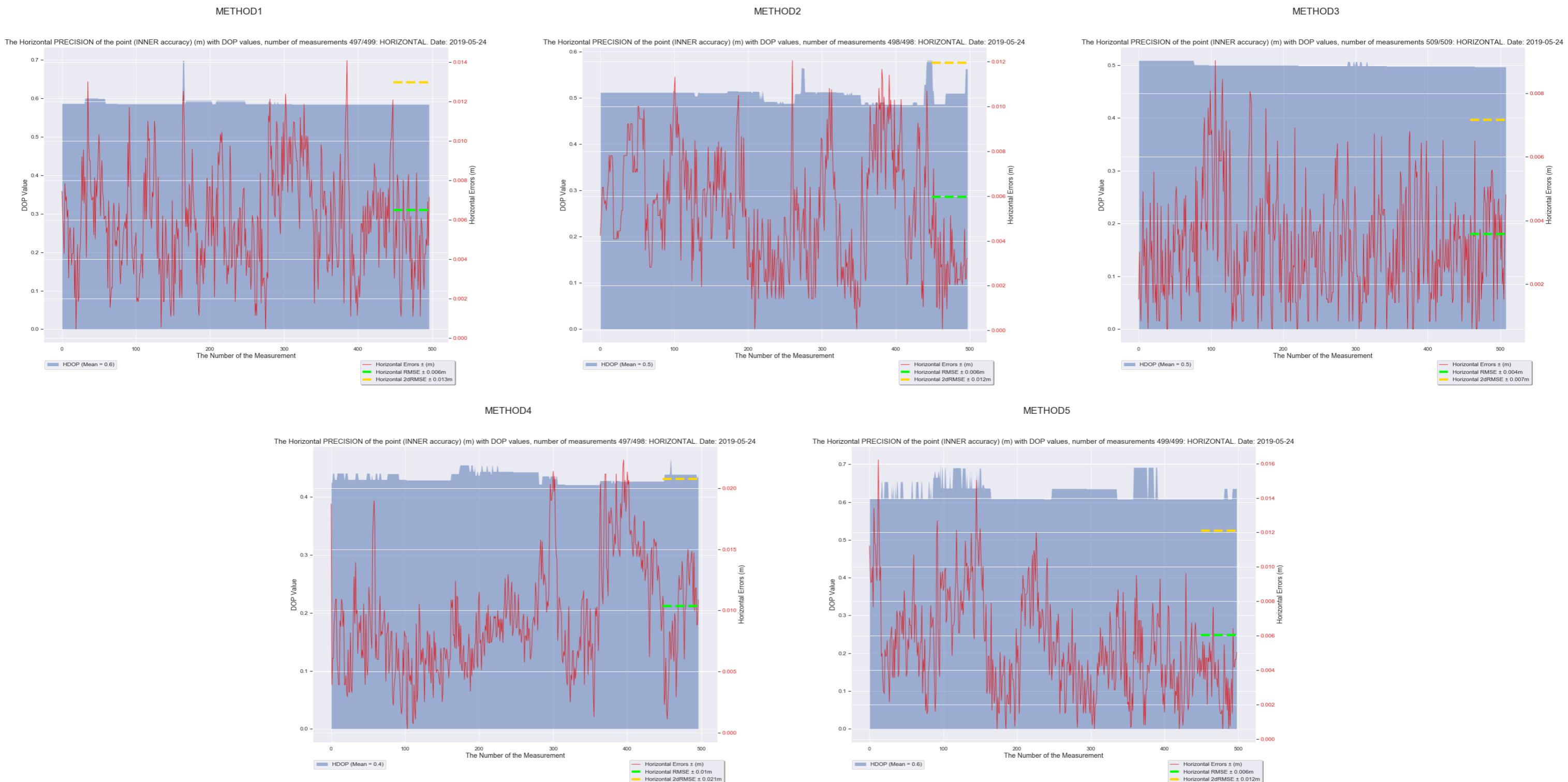
METHOD4



METHOD5

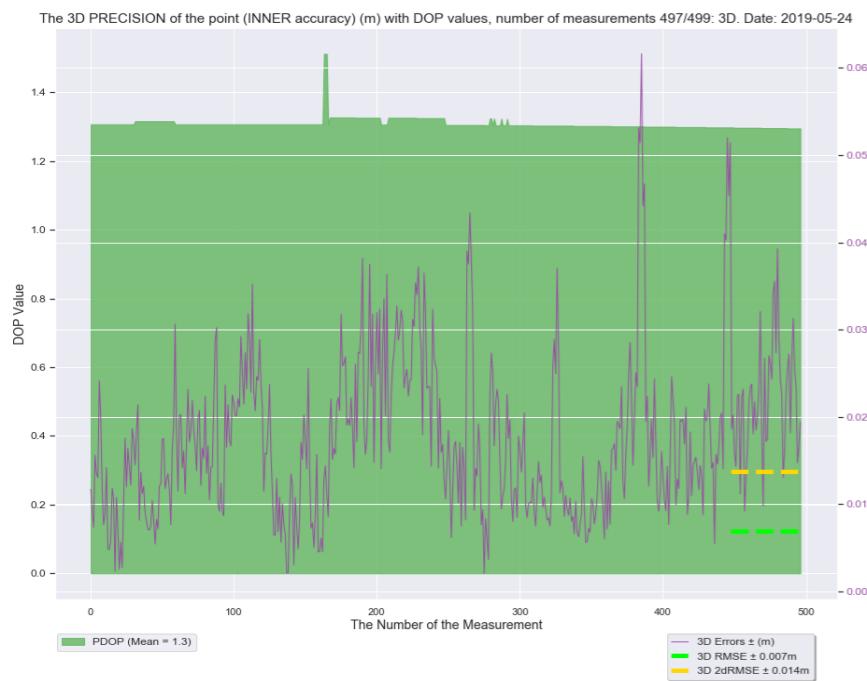


The Horizontal PRECISION of the point (INNER accuracy) (m) with DOP values

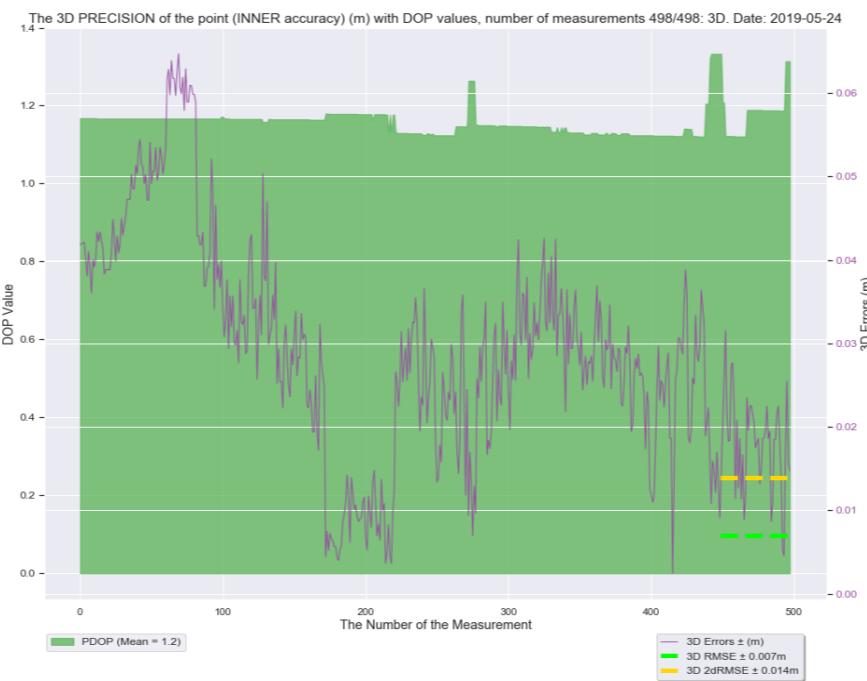


## The 3D PRECISION of the point (INNER accuracy) (m) with DOP values

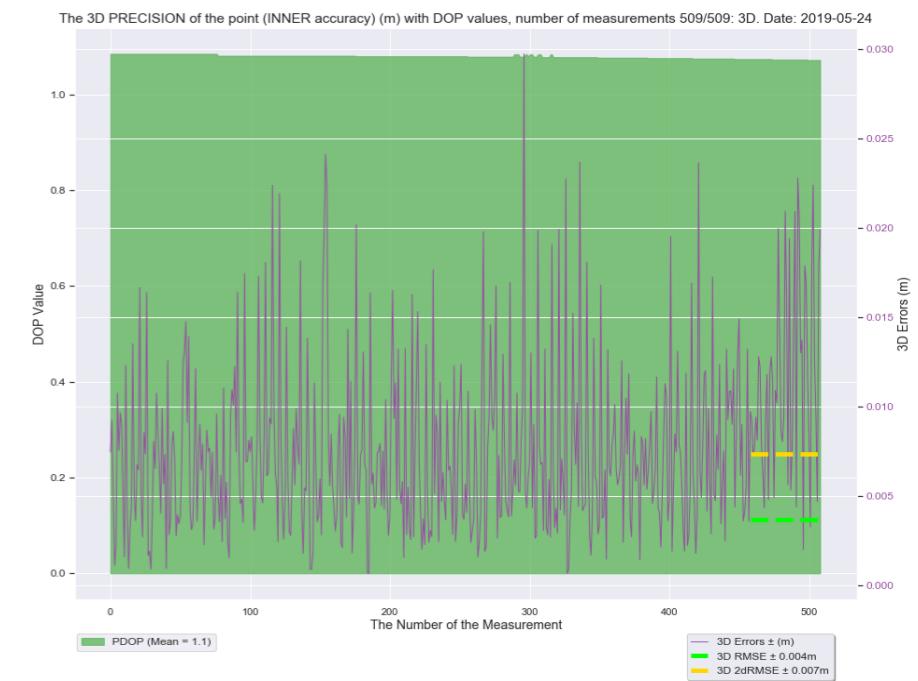
METHOD1



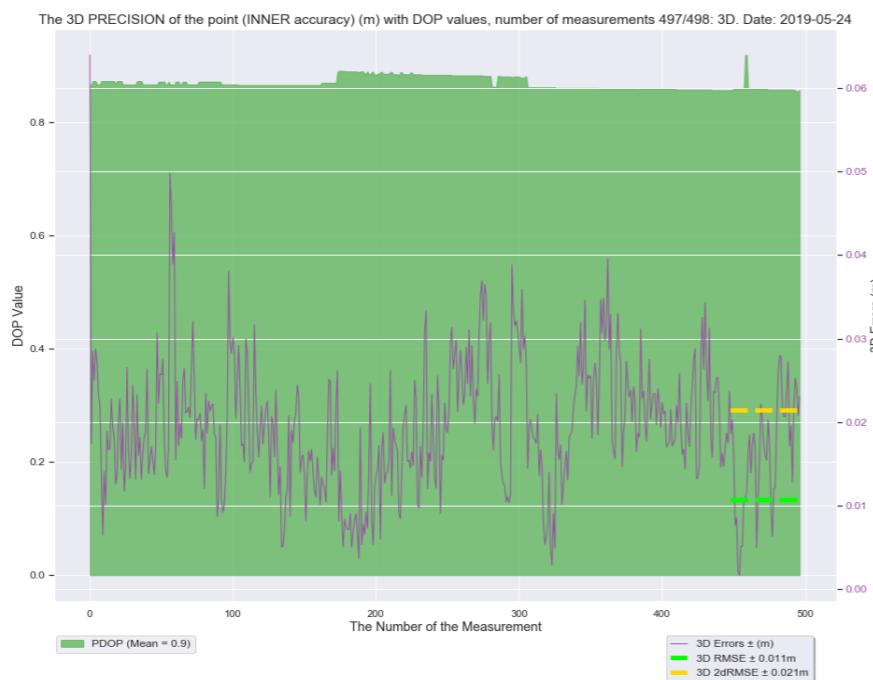
METHOD2



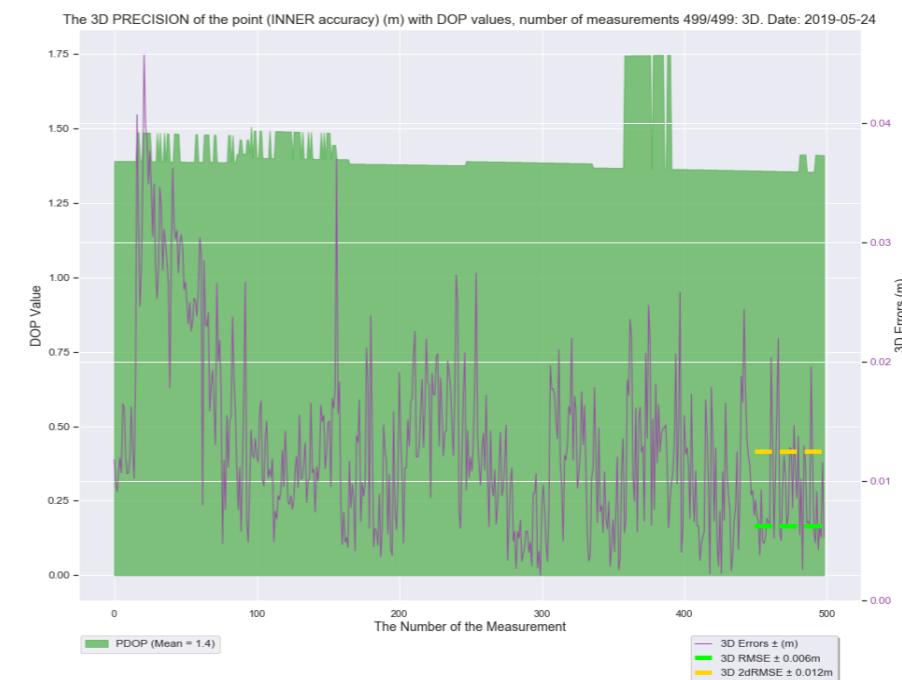
METHOD3



METHOD4

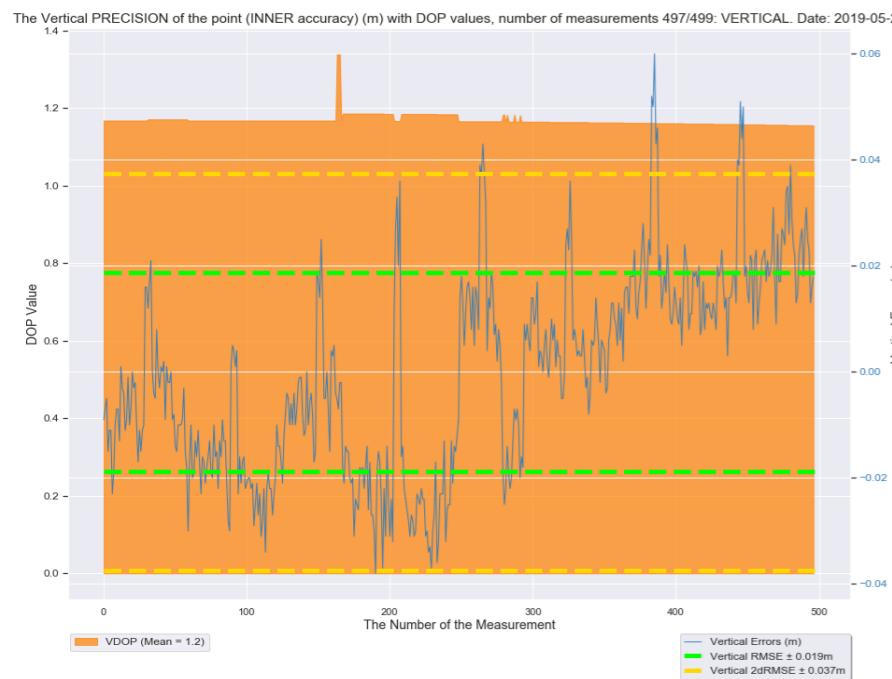


METHOD5



## The Vertical PRECISION of the point (INNER accuracy) (m) with DOP values

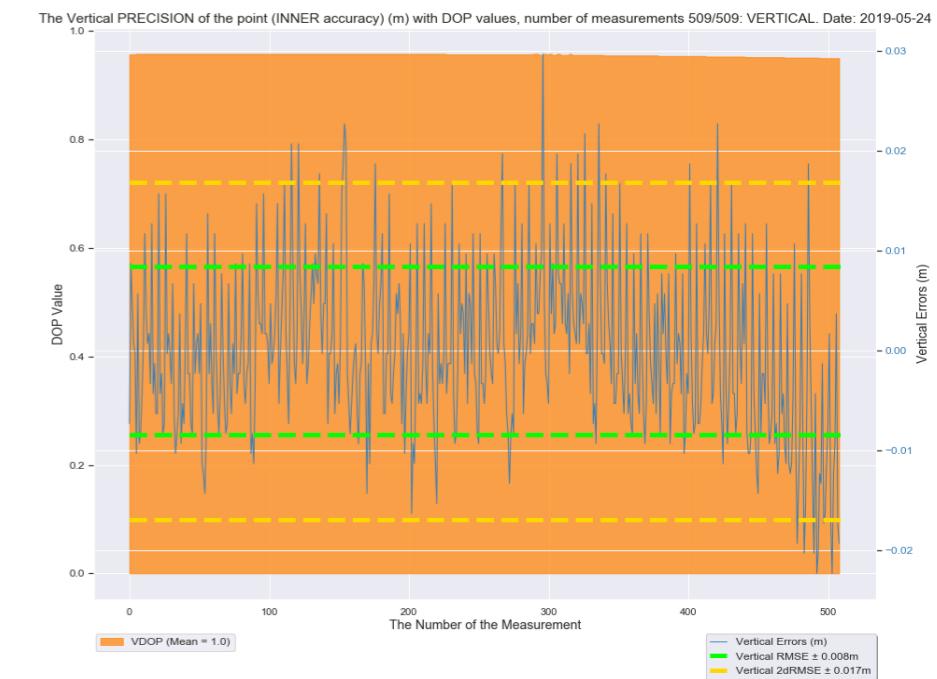
METHOD1



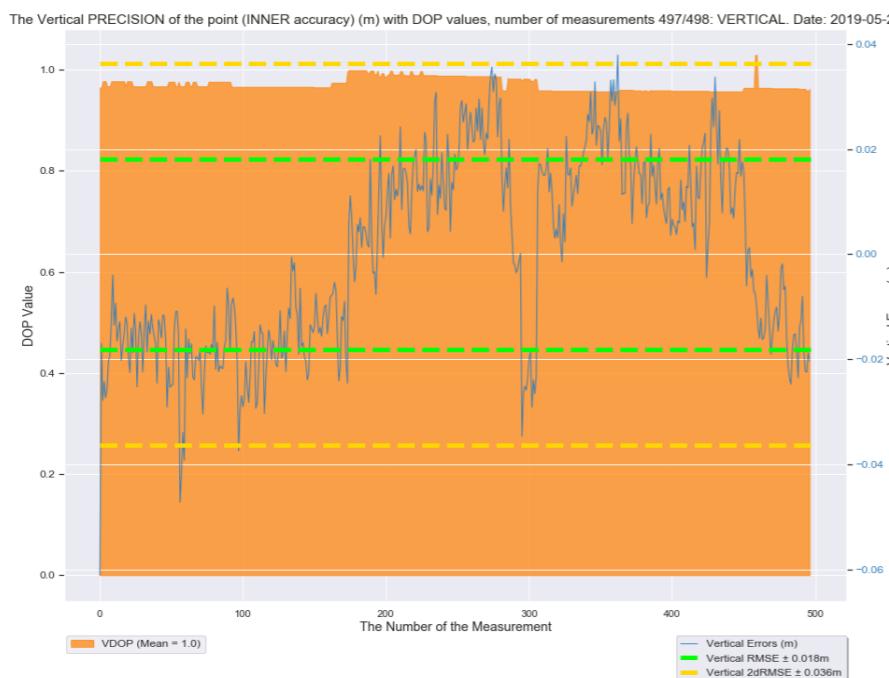
METHOD2



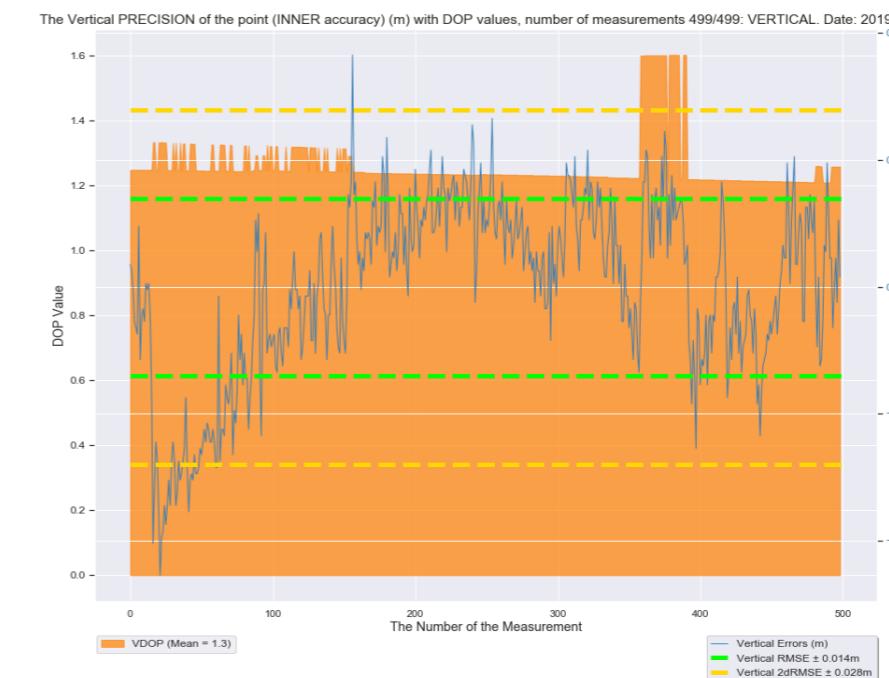
METHOD3



METHOD4



METHOD5



## Conclusions

Evaluated Parameters & Weighing Percentages Table:

Parameter*	METHOD1	METHOD2	METHOD3	METHOD4	METHOD5	Weighing %
<b>Fixed Solutions % (With Outliers)</b>	99.6	100.0	100.0	99.8	100.0	25.0
<b>Above Tolerance Values %</b>	0.4	0.0	0.0	0.2	0.0	5.0
<b>Fixed Solutions % (No Outliers)</b>	100.0	100.0	100.0	100.0	100.0	5.0
<b>Mean of PDOPs</b>	1.3	1.2	1.1	0.9	1.4	2.5
<b>Mean of GDOPs</b>	1.5	1.3	1.2	1.1	1.6	2.5
<b>Precision: Horizontal RMSE ± (m)</b>	0.006	0.006	0.004	0.01	0.006	12.5
<b>Precision: Vertical RMSE ± (m)</b>	0.019	0.031	0.008	0.018	0.014	7.5
<b>Accuracy: Horizontal RMSE ± (m)</b>	0.008	0.011	0.014	0.024	0.023	15.0
<b>Accuracy: Vertical RMSE ± (m)</b>	0.076	0.051	0.083	0.121	0.156	10.0
<b>Precision: North Coordinate Std ± (m)</b>	0.0047	0.0043	0.0024	0.0061	0.005	5.0
<b>Precision: East Coordinate Std ± (m)</b>	0.0044	0.0041	0.0026	0.0084	0.0034	5.0
<b>Precision: Height Std ± (m)</b>	0.0187	0.0311	0.0084	0.0182	0.014	5.0

\* These are the parameters, which are taken into account in the next page Grading Table, in which each of these parameters are weighted based on their importance.

Tolerance Values of Parameter Grades Table:

Parameter	5 Points*	4 Points*	3 Points*	2 Points*	1 Point*
<b>Fixed Solutions % (With Outliers)</b>	$100.0 \geq \text{value} \geq 99.9$	$99.9 > \text{value} \geq 99.0$	$99.0 > \text{value} \geq 95.0$	$95.0 > \text{value} \geq 63.0$	$63.0 > \text{value}$
<b>Above Tolerance Values %</b>	$0 \leq \text{value} \leq 0.1$	$0.1 < \text{value} \leq 1.0$	$1.0 < \text{value} \leq 5.0$	$5.0 < \text{value} \leq 37.0$	$37.0 < \text{value}$
<b>Fixed Solutions % (No Outliers)</b>	$100.0 \geq \text{value} \geq 99.9$	$99.9 > \text{value} \geq 99.0$	$99.0 > \text{value} \geq 95.0$	$95.0 > \text{value} \geq 63.0$	$63.0 > \text{value}$
<b>Mean of PDOPs</b>	$0 \leq \text{value} \leq 2.0$	$2.0 < \text{value} \leq 5.0$	$5.0 < \text{value} \leq 10.0$	$10.0 < \text{value} \leq 20.0$	$20.0 < \text{value}$
<b>Mean of GDOPs</b>	$0 \leq \text{value} \leq 2.0$	$2.0 < \text{value} \leq 5.0$	$5.0 < \text{value} \leq 10.0$	$10.0 < \text{value} \leq 20.0$	$20.0 < \text{value}$
<b>Precision: Horizontal RMSE ± (m)</b>	$0 \leq \text{value} \leq 0.03$	$0.03 < \text{value} \leq 0.05$	$0.05 < \text{value} \leq 0.075$	$0.075 < \text{value} \leq 0.1$	$0.1 < \text{value}$
<b>Precision: Vertical RMSE ± (m)</b>	$0 \leq \text{value} \leq 0.045$	$0.045 < \text{value} \leq 0.075$	$0.075 < \text{value} \leq 0.112$	$0.112 < \text{value} \leq 0.2$	$0.2 < \text{value}$
<b>Accuracy: Horizontal RMSE ± (m)</b>	$0 \leq \text{value} \leq 0.045$	$0.045 < \text{value} \leq 0.075$	$0.075 < \text{value} \leq 0.1$	$0.1 < \text{value} \leq 0.15$	$0.15 < \text{value}$
<b>Accuracy: Vertical RMSE ± (m)</b>	$0 \leq \text{value} \leq 0.067$	$0.067 < \text{value} \leq 0.112$	$0.112 < \text{value} \leq 0.168$	$0.168 < \text{value} \leq 0.3$	$0.3 < \text{value}$
<b>Precision: North Coordinate Std ± (m)</b>	$0 \leq \text{value} \leq 0.01$	$0.01 < \text{value} \leq 0.02$	$0.02 < \text{value} \leq 0.05$	$0.05 < \text{value} \leq 0.1$	$0.1 < \text{value}$
<b>Precision: East Coordinate Std ± (m)</b>	$0 \leq \text{value} \leq 0.01$	$0.01 < \text{value} \leq 0.02$	$0.02 < \text{value} \leq 0.05$	$0.05 < \text{value} \leq 0.1$	$0.1 < \text{value}$
<b>Precision: Height Std ± (m)</b>	$0 \leq \text{value} \leq 0.015$	$0.015 < \text{value} \leq 0.03$	$0.03 < \text{value} \leq 0.075$	$0.075 < \text{value} \leq 0.15$	$0.15 < \text{value}$

\* This is the amount of points, which is given, based on the parameter value. The amount of points is weighted based the weighing criteria of the first table. Please find the weighted points and ranking in the Grading Table next page.

Grading Table:

Ranking	Points In Total*	Fixed Sol. (With Outliers)	Above Tolerance	Fixed Sol.	Mean PDOPs	Mean GDOPs	P: HRMSE	P: VRMSE	A: HRMSE	A: VRMSE	P: N Std	P: E Std	P: H Std
METHOD2	4.9	1.25	0.25	0.25	0.125	0.125	0.625	0.375	0.75	0.5	0.25	0.25	0.15
METHOD3	4.9	1.25	0.25	0.25	0.125	0.125	0.625	0.375	0.75	0.4	0.25	0.25	0.25
METHOD5	4.8	1.25	0.25	0.25	0.125	0.125	0.625	0.375	0.75	0.3	0.25	0.25	0.25
METHOD1	4.55	1.0	0.2	0.25	0.125	0.125	0.625	0.375	0.75	0.4	0.25	0.25	0.2
METHOD4	4.45	1.0	0.2	0.25	0.125	0.125	0.625	0.375	0.75	0.3	0.25	0.25	0.2

\* The maximum amount of points is 5, which is the sum of the weighted points. The highest number of points reveals the winner.

This PDF document was produced:  
2019-07-10 11:50:28

# NLS GNSS SOFAMESA

GNSS Position Solution Analysis Software of the National Land Survey of Finland  
Beta Version 0.2  
2019-07-10



Author: Tuukka Mattila.  
Do not hesitate to contact via LinkedIn: <https://www.linkedin.com/in/tuukkamattila/>.

Thank you for the help: Topi Rikkinen, Marko Ollikainen, Antti Laaksonen, Hannu Koivula, Octavian Andrei, Mikael Kauhava, Timo Sallinen and Ari Huvinen.