ACCURACY ASSESSMENT OF LIDAR

LiDAR Operations & Applications: Lab3

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Overview

This lab has will be working through a formal accuracy assessment according to the ASPRS Vertical Accuracy Reporting for LiDAR Data guidelines. While LiDAR data can be examined to have a remarkably high accuracy. It is imperative that one is be able to measure and present statistics expressing just how factual a specific survey was.

There are three major sections to completeing this lab. The process for completeing this lab is the Geoid Adjustment, which is comprised of one major process creating a geoid separation model. The second process in completing this lab is the External Data , which is comprised of viewing GeoTIFFs, loadind points drawing points and user-defined file formats. Thus leaves us with the final process that will complete this lab and that is the Accuracy Assessment protion, this process is comprised of actually performing the accuracy assessment, reviewing the known points and also computing the accuracy metrics. More detial about these processes can be found under the procedures heading of this report.

Seeing that LiDAR, airborne LiDAR to be more specific, has vertical accruacies in the order of fifteen centimeters, which is quite a common thing to use in carrier-phase Global Positioning System (GPS) rather than GPS code well collecting check point sets. Thus in addition, considering dozens or even hundreds of points are generally appropriate to adequately assess the survey area, thus meaning Real-Time Kinematic (RTK) GPS is regularly used to collect such data, RTK GPS is capable of two to five centimeter accuracy.

The image, that can be seen to the right, is an index map showing where the area of interest is located. This study are is located with the Annaplos Valley, the town of Middleton to be more specific.

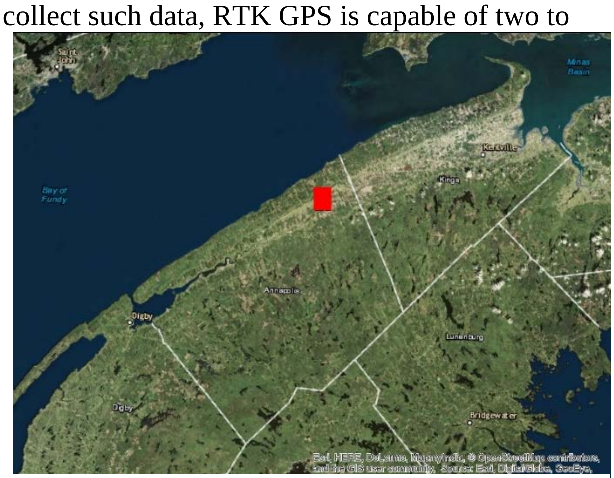

Figure 1: Index Map

Procedures

Found within this section of the report one can find the processes that are required to complete this Accuracy Assessment of LiDAR lab.

Geoid Adjustment

The first portion of this lab that needs to be completed is the Geoid Adjustment; this section of the lab is a multi-step process that calls for the following for steps to be completed. Create a reference point file, Use the GPS-H tool to create ellipsoid to geoid separation values, and finally apply the ellipsoid/geoid correction within TerraScan.

Create Reference Points

The first step in this multi-step process is to create reference points. First, you must load all of your LiDAR points (.las files) through the TerraScan window, with the software reading only every one hundredth point. Once this step has been completed, you can then export the model using the Export lattice model tool (this tool can be found under the output menu) that is found within the TerraScan window. Within this window, make sure that the grid spacing is set to five hundred meters; fit view is set to three pixels; file format is set to Xyz text, and finally make sure that outside points is set to skip.

Transforming Elevations using GPS-H

The second process that needs to be completed is transforming the elevations using the GPS-H software. These elevations are referenced to the ellipsoid NAD83 CSRS98 and can be converted to the CGVD28 datum, orthometric heights, by using a Canadian Height Transformation 2.0 model (HT 2.0). **Natural Resources Canada offers this tool as a free download; this tool can be used to perform the conversion. Please note you may have to download this software, if it is not already downloaded onto your system. Therefore, here is the link to do so**. http://www.nrcan.gc.ca/earth-sciences/geomatics/geodetic-reference-systems/tools-applications/10925#gpsh

Once you have opened the tool, make sure that the HT2_0[CGVD28 Height Transformation] is selected as the Geoid model that you wish to use. The next make sure the NAD83(CSRS) is selected as the Reference Frame. Then select UTM, and type in 20 as your zone for this lab, this is found under the projection drop down menu. Then select west as the positive longitude. The next thing is to define your lattice point format; this is done by selecting edit under the dropdown menu found next to the input button. A window titled My Format pops up the inputs for this window are as follows, name your format XYZ, for the delimiters make sure that space is selected, for the input section make sure the Easting, Northing, and input height is checked and finally make sure that easting, northing, and geoid height is selecting for the output. Once you have all of the above sections completed, you can click the save button (found in the upper right hand corner).

The next steps are to select your format from the drop down menu found next to the input button, and then you need to click the input button and find your lattice file. Once you have your lattice opened then you can save your transformation file out.

Applying the Geoid Model

Once your geoid model has been created, you can open the Adjust to geoid tool; this tool can be found under the tools tab in the main TerraScan window. When this window pops up select all blocks as the process and then points from file as the Dz model, by doing this another window will pop up and you select the model that you created in the previous section.

External Data

Using the Raster Manager tool (found under the File menu) this tool will allow you to “attach” an external GeoTIFF. This is done by opening the raster manager, then click on “attach” (which can be found under the File menu), then once you have you image selected make sure all eight views are selected in the attachment settings, and make sure that “Place Interactively” is Unchecked. Once you have this completed, you can hit okay and your image will appear in your DGN.

Accuracy Assessment

The first process is to reformat the control points to a "XYZ" format. This is done by removing the Point ID column from the preceding "PXYZ" CSV and then saving the resulting files as a new CSV.

The second process done within this portion of the lab is to run the control report. This is done by opening the tool, which can be found under the tools menu of the TerraScan project window. Thus selecting the following inputs: All blocks, Known points, choose you are FVA_points_PXYZ.csv, and then select your class, 20.0 as a length, 6.0 as degrees, and 0.150 meters.

Visual Assessment Discussion

The image below is showing a portion of "downtown" Middleton. The orange classification that is seen in the image is classified as ground. The white that can be seen within this image is just some of the vegetation that can be found within Middleton. Then finally, the red classified points that can be found within this image is just a portion of the buildings that can be found in "downtown" Middleton. There may be some white points that are found to be mixed within the ground classification; this can be fixed by going in manually and reclassifying the miss-classified and classify them correctly.

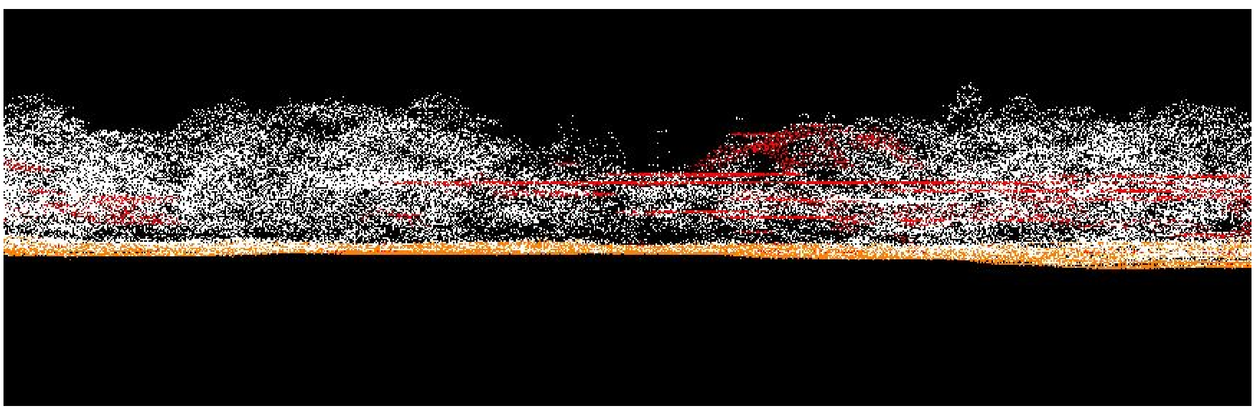

Figure 2: "Downtown" Middleton

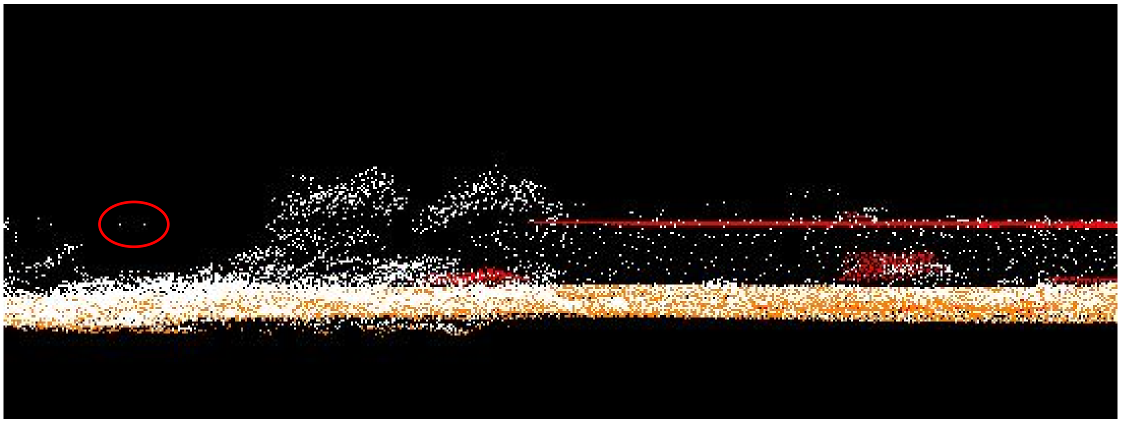

Figure 3: NSCC Middleton

The image above is looking at the backside of the Nova Scotia Community College in Middleton. As, I said above there are points that may have the wrong classification and need to be reassigned manually. A good example of this is the image above circled in red there are two points that are off on their own and need to be looked at more closely to figure out what they are.

Accuracy Stats Discussion

"The NVA and VVA for the DEM are assessed by comparing check points to the final bare-earth surface.

The minimum required thresholds for absolute and relative accuracy may be increased when any of the following items are met:

- *A demonstrable and substantial increase in cost is needed to obtain this accuracy.*
- *An alternate specification is needed to conform to previously contracted phases of a single larger overall collection effort such as for multiyear statewide collections."* (Found on page 9 of the USGS LiDAR Base Specification 2014 PDF, column 2 at the bottom just before the table)

The image to the right is that of a table that can be found on page 10 of the for mentioned PDF. This table shows the root mean squared for nonvegetated areas are equal to in NVA at the 95th percent confidence level.

Table 4. Absolute vertical accuracy for lidar-swath data, Quality Level 0–Quality Level 3.

[$RMSE_Z$, root mean square error in z; cm, centimeter; NVA, nonvegetated vertical accuracy; ≤, less than or equal to]

Quality Level (QL)	$RMSE_z$ (nonvegetated) (cm)	NVA at 95-percent confidence level (cm)
QL0	≤5.0	≤9.8
QL1	≤10.0	≤19.6
QL2	≤10.0	≤19.6
QL3	≤20.0	≤39.2

Figure 4: Table 4

This image below (Figure 5) is saying that this RMSE is equal to this number under the NVA standards. Then this image is also saying that this RMSE number is equal to this VVA number. Therefore, for example any nonvegetated classification that has an RMSE number that is greater than 5.0 centimeters then it equals a NVA at 95-percent confidence level of anything greater than 9.8 centimeters. Then take that 5.0-centimeter RMSE value and that equals a VVA at 95th percentile of anything greater than 14.7 centimeters.

Table 5. Absolute vertical accuracy for digital elevation models, Quality Level 0–Quality Level 3.

[$RMSE_Z$, root mean square error in z; cm, centimeter; NVA, nonvegetated vertical accuracy; VVA, vegetated vertical accuracy; ≤, less than or equal to]

Quality Level (QL)	$RMSE_z$ (nonvegetated) (cm)	NVA at 95-percent confidence level (cm)	VVA at 95th percentile (cm)
QL0	≤5.0	≤9.8	≤14.7
QL1	≤10.0	≤19.6	≤29.4
QL2	≤10.0	≤19.6	≤29.4
QL3	≤20.0	≤39.2	≤58.8

Figure 5: Table 5

Looking at the numbers that have been produced by completing this lab, it leads one to believe that the Middleton LiDAR does meet the USGS Base Specification requirements. The numbers that have been produced by completing this lab can be found under the Appendices portion of this lab. So, if one takes a look at all of those numbers then you can see that they are all in and around these RMSE numbers that are shown above in both tables four and five.

Data References

The LiDAR point data along with the aerial photography that was provided with this lab had been acquired together by Applied Geomatics Research Group (AGRG) on August 18th, 2010 (or Julian Day 230), which was flown over the town of Middleton, Nova Scotia. AGRG's camera system was made up of an integrated Applanix POS-AV 510, ALTM 3100 and a Rollei digital camera. The projection for the provided data is UTM 20 NAD83 CSRS98 coordinate system.

Reference

Heidemann, Hans Karl, 2014, Lidar base specification (ver. 1.2, November 2014): U.S. Geological Survey Techniques and Methods, book 11, chap. B4, 67 p. with appendixes, *http://dx.doi.org/10.3133/tm11B4.*

Appendices

D:\Chute_Lab3\reference\check\csv\CVA_points_PXYZ.csv

Number	Easting	Northing	Known Z	Laser Z	Dz	Dz(Abs)
1	336418.7	4978930	21.216	21.14	-0.076	0.076
2	337163.5	4979358	22.081	21.95	-0.131	0.131
3	337664.1	4979771	21.376	21.34	-0.036	0.036
4	335168.1	4979347	24.261	24.02	-0.241	0.241
5	335507.2	4981888	68.037	67.94	-0.097	0.097
6	336165.9	4980027	26.625	26.57	-0.055	0.055
7	335623	4978678	22.628	22.54	-0.088	0.088
8	336998.2	4979278	22.346	22.29	-0.056	0.056
9	336976	4978018	15.534	slope	*	
10	336983.6	4978015	15.393	15.31	-0.083	0.083
11	335826.2	4977993	19.962	19.89	-0.072	0.072
12	335857.4	4978005	19.51	19.34	-0.17	0.17
13	336229.7	4980126	28.391	28.29	-0.101	0.101
14	336205.8	4980108	28.021	27.84	-0.181	0.181
15	335310.6	4979675	41.578	41.59	0.012	0.012
16	334969.1	4982901	177.589	177.69	0.101	0.101
17	336219.3	4980710	30.647	30.61	-0.037	0.037
18	337136.8	4979307	21.831	21.73	-0.101	0.101
19	337521.7	4979171	19.642	19.62	-0.022	0.022
20	336844	4978001	12.361	12.29	-0.071	0.071
21	336216.6	4979995	26.404	26.43	0.026	0.026
22	336183.5	4979949	26.232	26.24	0.008	0.008
23	337638.9	4979747	21.499	21.52	0.021	0.021
24	336932.2	4978056	13.596	13.57	-0.026	0.026
25	335033.4	4982870	174.983	174.87	-0.113	0.113
26	334658.7	4981127	80.412	80.38	-0.032	0.032
27	334598.9	4981081	76.939	76.78	-0.159	0.159
28	335361.3	4981853	65.136	65.06	-0.076	0.076
29	335272.6	4982982	161.06	160.96	-0.1	0.1
30	335094.6	4979944	54.52	54.48	-0.04	0.04
31	335014.3	4982920	176.543	176.45	-0.093	0.093
32	336911.9	4978052	13.243	13.16	-0.083	0.083
33	335203	4979444	26.965	26.94	-0.025	0.025
34	335924.7	4981709	52.156	52.1	-0.056	0.056
35	336275.8	4981857	42.539	42.45	-0.089	0.089
36	335306.5	4982118	79.673	79.56	-0.113	0.113
37	334727.3	4982437	144.763	144.56	-0.203	0.203

Average dz	-0.074
Minimum dz	-0.241
Maximum dz	0.101
Average magnitude	0.083
Root mean square	0.1
Std	0.068
95% Confidence	0.076
95th Percentile	0.096

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Number	Easting	Northing	Known Z	Laser Z	Dz	Dz(Abs)
15	335310.6	4979675	41.578	41.59	0.012	0.012
16	334969.1	4982901	177.589	177.69	0.101	0.101
17	336219.3	4980710	30.647	30.61	-0.037	0.037
18	337136.8	4979307	21.831	21.73	-0.101	0.101
19	337521.7	4979171	19.642	19.62	-0.022	0.022
20	336844	4978001	12.361	12.29	-0.071	0.071
21	336216.6	4979995	26.404	26.43	0.026	0.026
22	336183.5	4979949	26.232	26.24	0.008	0.008
23	337638.9	4979747	21.499	21.52	0.021	0.021
24	336932.2	4978056	13.596	13.57	-0.026	0.026
25	335033.4	4982870	174.983	174.87	-0.113	0.113
26	334658.7	4981127	80.412	80.38	-0.032	0.032
27	334598.9	4981081	76.939	76.78	-0.159	0.159
28	335361.3	4981853	65.136	65.06	-0.076	0.076
29	335272.6	4982982	161.06	160.96	-0.1	0.1
30	335094.6	4979944	54.52	54.48	-0.04	0.04
31	335014.3	4982920	176.543	176.45	-0.093	0.093
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33	335203	4979444	26.965	26.94	-0.025	0.025
34	335924.7	4981709	52.156	52.1	-0.056	0.056
35	336275.8	4981857	42.539	42.45	-0.089	0.089
36	335306.5	4982118	79.673	79.56	-0.113	0.113
37	334727.3	4982437	144.763	144.56	-0.203	0.203

Average dz	-0.055
Minimum dz	-0.203
Maximum dz	0.101
Average magnitude	0.07
Root mean square	0.085
Std	0.066
95% Confidence	0.012
95th Percentile	0.1544

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Number	Easting	Northing	Known Z	Laser Z	Dz	Dz(Abs)
1	336418.7	4978930	21.216	21.14	-0.076	0.076
2	337163.5	4979358	22.081	21.95	-0.131	0.131
3	337664.1	4979771	21.376	21.34	-0.036	0.036
4	335168.1	4979347	24.261	24.02	-0.241	0.241
5	335507.2	4981888	68.037	67.94	-0.097	0.097
6	336165.9	4980027	26.625	26.57	-0.055	0.055
7	335623	4978678	22.628	22.54	-0.088	0.088
8	336998.2	4979278	22.346	22.29	-0.056	0.056
9	336976	4978018	15.534	slope	*	
10	336983.6	4978015	15.393	15.31	-0.083	0.083
11	335826.2	4977993	19.962	19.89	-0.072	0.072
12	335857.4	4978005	19.51	19.34	-0.17	0.17
13	336229.7	4980126	28.391	28.29	-0.101	0.101
14	336205.8	4980108	28.021	27.84	-0.181	0.181

Average dz	-0.107
Minimum dz	-0.241
Maximum dz	-0.036
Average Magnitude	0.107
RMS	0.121
Std deviation	0.059
95% Confidence	0.076
95th Percentile	0.205

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Number	Easting	Northing	Known Z	Laser Z	Dz	Dz(Abs)
38	336995.9	4979305	22.209	22.13	-0.079	0.079
39	336147.5	4979997	26.505	26.25	-0.255	0.255
40	335294.4	4979720	42.594	42.61	0.016	0.016
41	335505.7	4981878	67.383	67.47	0.087	0.087
42	336182.6	4980572	34.987	slope	*	
43	336931.7	4978010	9.193	slope	*	
44	335183.7	4979353	23.181	23.46	0.279	0.279
45	337655.2	4979785	20.768	slope	*	

Average dz	0.01
Minimum dz	-0.255
Maximum dz	0.279
Average magnitude	0.143
Root mean square	0.177
Std	0.198
95% Confidence	0.079
95th Percentile	0.2742

All XYZ points

335990.2485	4983016.62	0
334990.2485	4983016.62	0
334990.2485	4984016.62	0
335990.2485	4984016.62	0
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336990.2485	4983016.62	0
335990.2485	4983016.62	0
335990.2485	4984016.62	0
336990.2485	4984016.62	0
336490.2485	4983516.62	0
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335990.2485	4982016.62	0
334990.2485	4982016.62	0
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335990.2485	4983016.62	0

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336990.2485	4979016.62	0
336490.2485	4978516.62	0
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336990.2485	4978016.62	0
336990.2485	4979016.62	0
337990.2485	4979016.62	0
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336490.2485	4976516.62	0
337990.2485	4976016.62	0
336990.2485	4976016.62	0
336990.2485	4977016.62	0
337990.2485	4977016.62	0
337490.2485	4976516.62	0
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334969.096	4982901.117	177.589
336219.323	4980709.599	30.647
337136.756	4979307.046	21.831
337521.746	4979171.47	19.642
336843.985	4978000.78	12.361
336216.563	4979995.006	26.404
336183.528	4979948.51	26.232
337638.883	4979747.119	21.499
336932.201	4978055.701	13.596
335033.419	4982870.087	174.983
334658.681	4981126.821	80.412
334598.906	4981080.521	76.939
335361.335	4981853.194	65.136
335272.631	4982982.445	161.06
335094.551	4979944.049	54.52
335014.26	4982919.741	176.543
336911.903	4978052.072	13.243
335203.002	4979443.546	26.965
335924.724	4981709.12	52.156
336275.802	4981857.266	42.539
335306.475	4982118.002	79.673
334727.349	4982437.208	144.763
336418.731	4978930.448	21.216
337163.47	4979358.336	22.081
337664.052	4979770.56	21.376

335168.139	4979347.218	24.261
335507.244	4981888.383	68.037
336165.857	4980027.103	26.625
335622.96	4978678.158	22.628
336998.238	4979278.387	22.346
336975.965	4978018.464	15.534
336983.644	4978014.959	15.393
335826.237	4977993.01	19.962
335857.359	4978005.021	19.51
336229.742	4980126.072	28.391
336205.82	4980107.994	28.021
335310.629	4979675.416	41.578
334969.096	4982901.117	177.589
336219.323	4980709.599	30.647
337136.756	4979307.046	21.831
337521.746	4979171.47	19.642
336843.985	4978000.78	12.361
336216.563	4979995.006	26.404
336183.528	4979948.51	26.232
337638.883	4979747.119	21.499
336932.201	4978055.701	13.596
335033.419	4982870.087	174.983
334658.681	4981126.821	80.412
334598.906	4981080.521	76.939
335361.335	4981853.194	65.136
335272.631	4982982.445	161.06
335094.551	4979944.049	54.52
335014.26	4982919.741	176.543
336911.903	4978052.072	13.243
335203.002	4979443.546	26.965
335924.724	4981709.12	52.156
336275.802	4981857.266	42.539
335306.475	4982118.002	79.673
334727.349	4982437.208	144.763
336995.898	4979305.149	22.209
336147.541	4979996.988	26.505
335294.424	4979719.911	42.594
335505.742	4981878.177	67.383
336182.604	4980572.097	34.987
336931.745	4978010.222	9.193
335183.655	4979352.718	23.181
337655.151	4979785.151	20.768
336995.898	4979305.149	22.209
336147.541	4979996.988	26.505

335294.424	4979719.911	42.594
335505.742	4981878.177	67.383
336182.604	4980572.097	34.987
336931.745	4978010.222	9.193
335183.655	4979352.718	23.181
337655.151	4979785.151	20.768
336418.731	4978930.448	21.216
337163.47	4979358.336	22.081
337664.052	4979770.56	21.376
335168.139	4979347.218	24.261
335507.244	4981888.383	68.037
336165.857	4980027.103	26.625
335622.96	4978678.158	22.628
336998.238	4979278.387	22.346
336975.965	4978018.464	15.534
336983.644	4978014.959	15.393
335826.237	4977993.01	19.962
335857.359	4978005.021	19.51
336229.742	4980126.072	28.391
336205.82	4980107.994	28.021
336995.898	4979305.149	22.209
336147.541	4979996.988	26.505
335294.424	4979719.911	42.594
335505.742	4981878.177	67.383
336182.604	4980572.097	34.987
336931.745	4978010.222	9.193
335183.655	4979352.718	23.181
337655.151	4979785.151	20.768
336418.731	4978930.448	21.216
337163.47	4979358.336	22.081
337664.052	4979770.56	21.376
335168.139	4979347.218	24.261
335507.244	4981888.383	68.037
336165.857	4980027.103	26.625
335622.96	4978678.158	22.628
336998.238	4979278.387	22.346
336975.965	4978018.464	15.534
336983.644	4978014.959	15.393
335826.237	4977993.01	19.962
335857.359	4978005.021	19.51
336229.742	4980126.072	28.391
336205.82	4980107.994	28.021
335310.629	4979675.416	41.578
334969.096	4982901.117	177.589

336219.323	4980709.599	30.647
337136.756	4979307.046	21.831
337521.746	4979171.47	19.642
336843.985	4978000.78	12.361
336216.563	4979995.006	26.404
336183.528	4979948.51	26.232
337638.883	4979747.119	21.499
336932.201	4978055.701	13.596
335033.419	4982870.087	174.983
334658.681	4981126.821	80.412
334598.906	4981080.521	76.939
335361.335	4981853.194	65.136
335272.631	4982982.445	161.06
335094.551	4979944.049	54.52
335014.26	4982919.741	176.543
336911.903	4978052.072	13.243
335203.002	4979443.546	26.965
335924.724	4981709.12	52.156
336275.802	4981857.266	42.539
335306.475	4982118.002	79.673
334727.349	4982437.208	144.763