Windstorm Simulation & Modeling Project

Airborne LIDAR Data and Digital Elevation Models in Broward County, Florida

Data Quality Report and Description of Deliverable Datasets

Prepared for:
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Executive Summary

Between December, 1999 and March, 2002, the Florida International University (FIU) International Hurricane Center (IHC) collected over 700 million airborne LIDAR elevation measurements in Broward and Palm Beach, FL as part a FEMA supported Windstorm Simulation & Modeling Project. This interim report contains a description of the datasets for this project delivered to Broward County as well as the results of an error analysis performed on the data. Several different datasets were produced from this project. These include both raw and "bare earth" data which are delivered as irregularly spaced x,y,z points and as regularly spaced digital elevation models posted at 5 foot intervals. All datasets are organized in 5000x5000 ft^2 tiles. Accuracy was assessed by comparing the bare earth DEMs with an independent dataset consisting of approximately 321 GPS control points provided by the Broward County Engineering Department. This analysis indicated a vertical root mean squared error of 0.41 ft (12 cm). This error corresponds to a vertical accuracy of ±0.80 ft (24 cm) at the 95% confidence level.

Introduction

In 2000- 2001, the International Hurricane Center (IHC) was awarded grant funding by Federal Emergency Management Division (FEMA) and the Florida Department of Community Affairs (FLDCA), for a program entitled the Windstorm Simulation and Modeling project. Four tasks under this three year project included 1) the re-evaluation of existing storm surge models including SLOSH, CMEPS and TAOS, 2) data acquisition of high-resolution elevation data via LIDAR technology for participating South Florida counties 3) computer simulation of findings for researchers and the general public and 4) development of public awareness and education programs in regards to human vulnerabilities to hurricanes and the means to mitigate the risks. This project was also supported partially from matching funds provided from participating counties including Broward, Palm Beach, and Martin Counties.

On March 8, 2001, Broward County and the IHC reached a final contract agreement about participating in this project and as part, use Airborne Laser Terrain Mapper (ALTM) technology for their evacuation zone revision project. Following this agreement initial field reconnaissance was conducted, base stations were established, and the ALTM system was used to collect detailed topographic data in Broward County in July and August 2001. Additional data gaps were re-flown in May, 2002. This data was merged with a LIDAR dataset collected during a previous contract between FIU and Broward County in 1999-2000. This report describes the estimated accuracy and deliverables of the merged FIU/IHC LIDAR data set.

LIDAR Data Acquisition

Airborne LIDAR (acronym for LIght Detection And Ranging) is an emerging remote sensing technology that can rapidly and accurately measure the elevations of ground targets. LIDAR systems direct pulses of laser light toward the ground and detect the return times of reflected or back-scattered pulses in order to determine ranges to the

reflecting surface. Since 1999, FIU and the University of Florida have jointly operated an Optech ALTM 1210 LIDAR mapping system mounted in a Cessna 337 aircraft to measure surface change and map flood hazard.

In a pilot project, FIU collected LIDAR data in regions of Broward County, east of I-95 on 4 separate days between December 1999 and March 2000 (FIU 2000, Figure 1). The survey consisted of 34 overlapping, 2000-foot-wide (600 m) swaths. In total, the project measured over 140 million irregularly spaced points. The results of this project were delivered to Broward County in the form of 2-meter resolution, bare earth and unfiltered digital elevation models. Additional details of this project are contained in the September 2000 Final Project Report.

Building on the success of the 1999-2000 project, FIU commenced a much larger data acquisition project in Broward and Palm Beach Counties as part of the Windstorm Simulation and Modeling grant. Data were collected on July 13-17 and August 6- 7, 2001 and consisted of 128 overlapping 2000-foot-wide (600 m) swaths (FIU 2001, Figure 1). Details of the acquisition parameters for this project are contained in the September 2001 Preliminary Report. An additional deployment consisting of 3 swaths was flown in May 2002 to fill in remaining data gaps.

In total, FIU collected over 700 million LIDAR measurements in Broward and Palm Beach Counties between 1999-2002. Additional LIDAR data contracted by the U.S. Army Corps of Engineers in 2000 provides coverage in western portions of populated Broward County. While this data is not included in this distribution, it is available on the Internet at http://mapsrv.evergladesplan.org/lidar/lidar.html. Together, these datasets provide high resolution topographic coverage of most of populated Broward County.

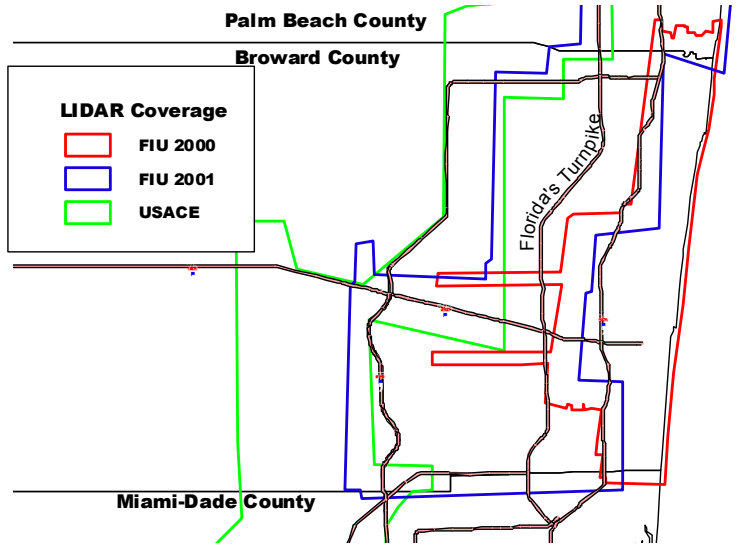

Figure 1. Index map showing coverage of LIDAR data in Broward County.

Processing

After each flight, aircraft and ground station GPS carrier phase data were differentially processed to produce a kinematic aircraft trajectory. The trajectory information was combined in the REALM software with the range, scan, and Inertial Navigation System (INS) data to produce laser return coordinates for each data swath. Swath data are output as 9 column ASCII text files containing the pulse time, the first pulse return (x,y,z coordinates and intensities) and the last pulse return.

The first and last return data were separated into different data streams. Since the first returns often correspond to features such as buildings and trees, this stream was used to produce unfiltered datasets. In contrast, since the last return can correspond to the ground return beneath the canopy in vegetated areas, this stream was used to produce the bare earth elevation data. For both data streams, horizontal coordinates were transformed to NAD83, State Plane, FL East zone feet and elevations were converted from GPS ellipsoidal heights to NAVD88 orthometric heights with the NGS GEOID99 model.

Data from overlapping swaths were checked for internal consistency, combined and subdivided into smaller and more manageable sized portions. These consisted of 5000 by 5000 ft tiles, each containing from 1 – 2 million points. The first return data for each tile was gridded using kriging interpolation with a linear variogram model and a 50 ft search radius to produce a set of 5 ft resolution, (1000x1000), DEMs. This DEM resolution was selected to be consistent with the 8 ft nominal point spacing.

The 2nd return data consists of a 3-dimensional cloud of points corresponding to laser reflections off various objects. In order to model and visualize variations in the ground surface, reflections from non-ground features such as buildings, vegetation, and vehicles must be classified and removed. Since a given DEM pixel can often contain both ground and non-ground surface reflections, terrain classification is best performed on the raw, irregularly spaced laser points rather than on gridded data. After classification, the remaining ground surface points were then gridded to produce a “bare earth” DEM for each tile.

For modeling and display purposes, a lower resolution dataset was produced by subaveraging the bare earth 5 ft pixels to 100 ft resolution. First a 21x21 focal mean filter was applied to each of the bare earth 5 ft resolution DEM tiles. Then the tiles were resampled by a factor of 20. Finally the tiles were mosaiced to form the 100 ft DEM (Figure 2).

Error Analysis

Comparison of the LIDAR data with an independent dataset of higher accuracy is necessary in order to estimate absolute uncertainties in the elevations. Verification of LIDAR data is also necessary in order to ensure against systematic errors or offsets in the data caused by instrument malfunctions or processing errors.

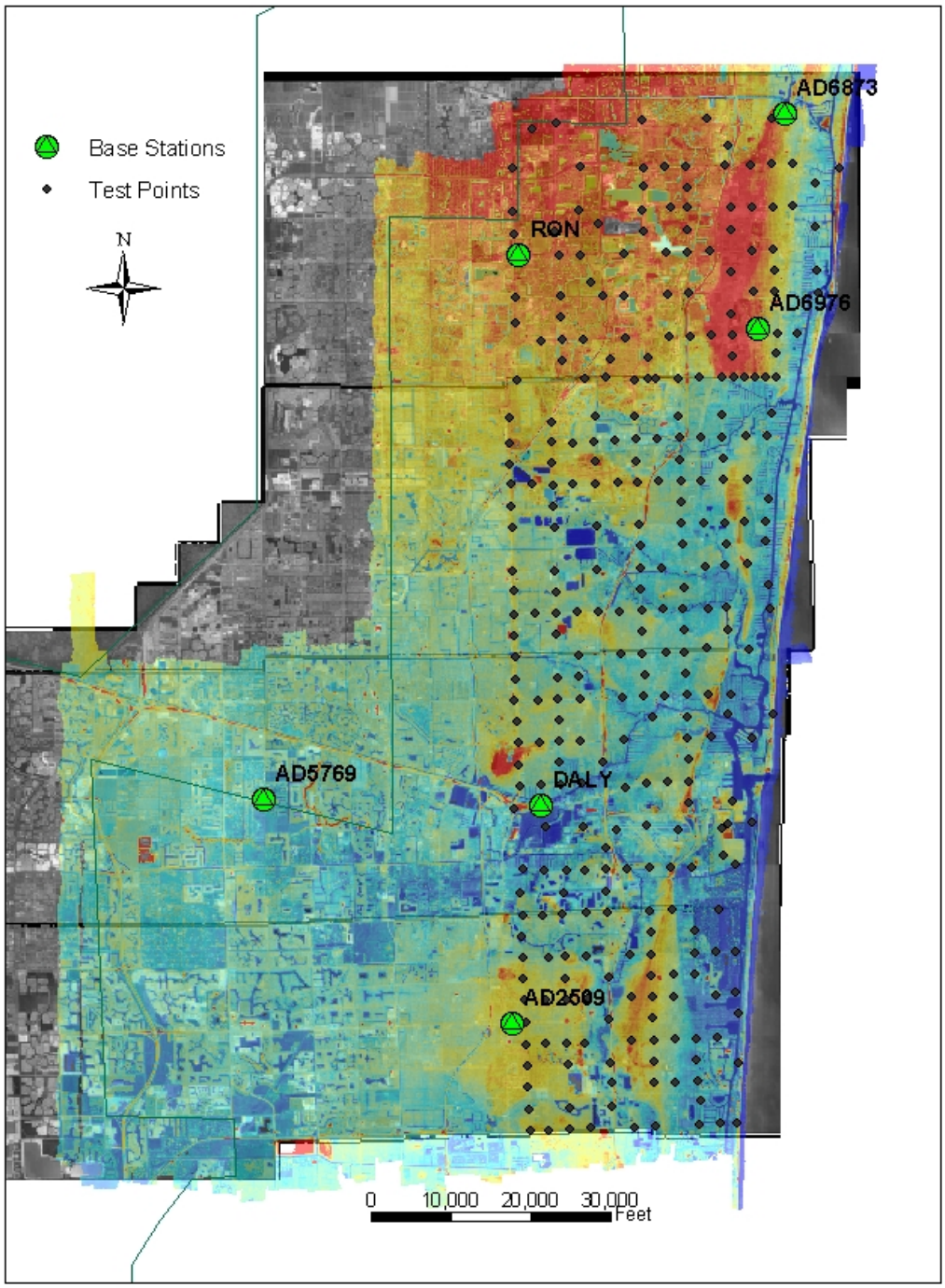

Figure 2. Map showing locations of test points used in the error analysis. Background image is a color coded 100 ft LIDAR DEM for Broward County overlaid on aerial a photograph mosaic of the County

The root mean square error (RMSE) provides a convenient means to quantitatively estimate the error in a set of measurements. The National Standard for Spatial Data Accuracy (NSSDA) defines the RMSE to be the square root of the average

of the squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy (Federal Geographic Data Committee, 1998). For a DEM, the vertical error, $RMSE_z$ is defined as

$$RMSE_z = \sqrt{\frac{\left(z_{t,i} - z_{m,i}\right)^2}{n}}$$

where $z_{t,I}$ is the elevation of the ith test point, $z_{m,I}$ is the interpolated DEM elevation at the test point, and n is the number of test points. NSSDA recommends using a minimum of 20 test points distributed over the geographic area of interest.

Accuracy is reported in measurement units at the 95% confidence level. A 95% confidence level means that 95% of the measurements will have an error of less than or equal to the reported accuracy. If the error is normally distributed with zero mean, the 95% vertical accuracy is equal to 1.96 times the $RMSE_z$.

LIDAR does not typically measure well-defined horizontal features. Therefore, testing of the horizontal accuracy of LIDAR measurements is problematic. Horizontal errors may be as much as 2 times greater than the vertical errors. Fortunately, because topographic gradients are usually low, horizontal errors are much less important than vertical errors.

The accuracy of the DEMs was tested with an independent dataset consisting of approximately 480 control points. These control points were provided by the County Surveyor for Broward County and compose the Eastern Broward County Secondary GPS Control Network. The control points usually consist of survey tacks placed in the pavement of road intersections and are spaced approximately every 0.5 mile. The Secondary GPS Control network was measured using differential GPS techniques and has vertical and horizontal accuracies of 1-2 cm.

Preliminary comparisons of the test data with the LIDAR indicated that some of the test points corresponded to anomalously high or low elevations, which skewed the error statistics. It was discovered that in all cases, these anomalous points were either buried below the height of the surrounding ground surface or were located on high features such as walls or bridges that were effectively removed by the bare earth filtering algorithm. In order to avoid these situations, the survey notes in the control point file were used to select only control points situated on road intersections and medians. This edited control point file consisted of 321 points (Figure 2).

The control point elevations were compared with the unfiltered 5 ft DEM, the bare earth 5 ft DEM and the bare earth, sub-averaged 100 ft DEM. The DEM elevations were calculated at each control point by bilinear interpolation and were compared with the control point elevations (Appendix A). Summary statistics of this analysis are shown in Table 1.

The higher errors observed for the unfiltered 5 ft DEM occur due to elevations in this dataset corresponding to reflections from vehicles or overhanging vegetation. The terrain filtering mostly removes these anomalous elevations as indicated by the lower errors for the 5 ft bare earth DEM. For this dataset, the reported RMSE is calculated as 0.41 feet (12 cm). This corresponds to a vertical accuracy of ±0.80 ft (24 cm) at the 95% confidence level. For the subaveraged 100-ft-DEM, the vertical RMSE was found to be 0.71 feet (0.22 cm). This higher error reflects both the errors in the lidar measurements and the natural variability of elevations found within each 100-foot-square DEM cell.

Table 1: Summary statistics of the difference between control point elevations and LIDAR DEMs (in Feet).

	Unfiltered 5 ft DEM	Bare Earth 5 ft DEM	Bare Earth 100 ft DEM
Mean	-0.61	-0.06	0.16
Std	1.71	0.40	0.69
RMSE	1.81	0.41	0.71

Deliverables and Formats

Several different datasets were produced from this project. These include both raw and "bare earth" data and are delivered as irregularly spaced x,y,z points and as regularly spaced digital elevation models posted at 5 ft and 100 ft intervals. Horizontal coordinates of all files are in U.S. Survey Feet, State Plane, Florida East zone, NAD83 datum. Elevations are given in NAVD88 feet. The gridded data is supplied in ESRI binary raster import format and the raw points are delivered as compressed, space delimited, ASCII, x,y,z files.

The points and the 5 ft DEM data are organized into 5000 x 5000 ft square tiles. The DEM for each tile is in ESRI binary raster floating point format and is associated with 2 files. The ".flt" files are the binary grids, and the ".hdr" files are ASCII text containing file organization and projection information. The first 2 numbers in the file names refer to the coordinates of the lower left (SW) corner of the grid. For example, if the SW corner of tile is at x,y coordinate 915000, 720000 the two files are named "915000_720000_Z.flt" and "915000_720000_Z.hdr" The DEMs may be read in ARC/INFO with the FLOATGRID command, with ArcToolbox using "Import to Raster: Floating Point Data to Grid", or in ArcView Spatial Analyst from the Import Binary raster menu.

The point data are delivered as 3-column space delimited ASCII Text. The point files are named according to the following format: XXXXXX_YYYYYY_BBB.asc. The first 2 numbers in the file name refers to the coordinates of the lower left (SW) corner of the tile. The last 3 digit number in the file name refers to a buffer width containing points outside the boundary of the time that allows each tile to be gridded without edge effects. In order to save space, the files were compressed with the public domain GNU GZIP utility and have a ".gz" extension. The executables for this program are supplied on disk 1.

The data is delivered on 16 CDROMs included with this report. Each disk has a Readme.txt file describing contents and preliminary metadata in ESRI FGDC format (.xml)

Contents

Disk 1: 100 ft DEM mosaic, and ancillary data

BrPrelimRpt2002.pdf:	This report in PDF format
BrPrelimRpt2001.pdf:	September, 2001 Interim report
BrFinalRpt2000.pdf:	Final report for Broward 2000 project
shp:	Folder containing shapefiles of tile index
grids:	Folder containing100 ft resolution subaveraged DEM mosaic
gzip:	folder containing GZIP program to uncompress point data

Disk 2: Bare earth binary grids, Vol A; 5 ft. cell size, 5000 ft. square tiles
Disk 3: Bare earth binary grids, Vol B; 5 ft. cell size, 5000 ft. square tiles
Disk 4: Bare earth binary grids, Vol C; 5 ft. cell size, 5000 ft. square tiles
Disk 5: Bare earth, compressed ASCII points, Vol A; 5000 ft. square tiles
Disk 6: Bare earth, compressed ASCII points, Vol B; 5000 ft. square tiles
Disk 7: Bare earth, compressed ASCII points, Vol C; 5000 ft. square tiles
Disk 8: Unfiltered binary grids, Vol A; 5 ft. cell size, 5000 ft. square tiles
Disk 9: Unfiltered binary grids, Vol B; 5 ft. cell size, 5000 ft. square tiles
Disk 10: Unfiltered binary grids, Vol C; 5 ft. cell size, 5000 ft. square tiles
Disk 11: Unfiltered, compressed ASCII points, Vol A; 5000 ft. square tiles
Disk 12: Unfiltered, compressed ASCII points, Vol B; 5000 ft. square tiles
Disk 13: Unfiltered, compressed ASCII points, Vol C; 5000 ft. square tiles
Disk 14: Unfiltered, compressed ASCII points, Vol D; 5000 ft. square tiles
Disk 15: Unfiltered, compressed ASCII points, Vol E; 5000 ft. square tiles
Disk 16: Unfiltered, compressed ASCII points, Vol F; 5000 ft. square tiles

Any questions about this distribution should be directed to Dean Whitman (whitmand@fiu.edu) or Quin Robertson (wrober01@fiu.edu) at the FIU International Hurricane Center: (305) 348-1607.

Appendix A:

Comparison of LIDAR DEM elevations with station elevations from the Broward County Secondary GPS Control Network. The control point file was edited to include only control points situated on road intersections and medians. This edited control point file consisted of 321 points. The control point elevations were compared with the LIDAR DEM elevations calculated at each control point by bilinear interpolation. Northings and Eastings are in US Survey Feet, State Plane Coordinate System, NAD83. Heights are in feet, NAVD88.

Station Name	Northing	Easting	Station Height	Raw 5 ft DEM	Bare 5 ft DEM	Bare 100 ft DEM
A04	717000.92	917526.55	15.19	15.51	15.33	14.46
A06	711566.45	917542.65	14.43	15.14	14.53	14.59
A07	708663.60	917679.26	15.88	15.66	15.45	14.09
A10	700828.19	917824.87	12.34	12.50	12.46	12.34
A11	697701.63	917881.54	10.81	11.95	11.82	12.11
A14	690512.32	918125.61	10.12	10.50	10.39	10.65
A16	685818.21	917041.86	12.58	12.91	12.59	11.55
A17	682576.31	917122.40	12.55	12.51	12.18	11.74
A18	680017.82	917186.19	11.23	11.47	11.12	10.42
A19	677483.53	917252.49	11.40	11.91	11.79	11.61
A20	674749.39	917324.47	9.81	10.33	10.10	9.37
A21	672004.44	917395.60	9.82	10.62	10.16	9.97
A23	666561.24	917532.03	10.48	11.09	10.95	10.52
A24	664224.09	917590.51	10.25	10.92	10.59	10.09
A25	661227.56	917665.63	9.76	10.58	10.56	10.09
A26	658532.16	917733.05	8.63	9.57	9.40	8.65
A27	655836.51	917800.69	10.30	10.32	10.13	9.26
A28	653113.88	917915.82	9.71	9.96	9.68	9.16
A29	650404.30	917761.38	7.43	8.83	8.52	8.09
A30	647788.97	918119.08	10.38	9.76	9.08	9.44
A31	645140.35	918205.21	9.91	10.66	9.99	9.38
A32	642460.93	918297.97	10.69	11.83	11.45	10.78
A33	639800.04	918387.85	9.67	9.57	9.44	8.17
A34	636898.43	917648.38	8.45	8.76	8.38	7.74
A37	629386.29	918835.52	4.38	4.98	4.34	3.52
A38	626479.02	918500.93	3.77	3.59	3.03	2.54
A39	623537.59	918848.52	8.71	7.78	7.55	7.17
A40	620851.25	918658.19	5.29	5.10	5.02	4.32
A41	618292.41	918811.85	6.04	6.35	6.17	6.50
A42	615611.27	918843.81	9.96	10.61	10.39	9.96
A43	612973.62	918957.52	9.36	10.20	9.88	9.62
A44	610217.43	919083.14	9.36	9.97	9.68	9.31
A45	607449.64	919212.69	9.22	10.22	10.06	9.68
A46	604734.51	919321.05	10.34	11.38	11.03	10.50
A47	602055.67	919429.38	8.92	9.56	9.46	9.30
A48	599381.62	919537.19	5.81	6.42	6.22	7.00
A49	596709.13	919646.55	9.54	13.26	10.02	9.66
B02	721931.98	919921.13	17.54	17.18	16.80	16.31
B12	695415.15	920962.43	13.50	13.80	13.61	11.97
B19	677443.22	919893.23	8.96	9.64	9.12	8.86
B25	661271.94	920318.44	6.41	6.66	6.41	6.83

B29	650536.47	920619.53	7.42	7.20	6.92	6.56
B31	645230.56	920855.16	8.13	7.86	7.51	7.90
B33	639904.72	921103.17	6.20	7.21	6.55	6.76
B35	634678.34	921622.46	5.86	6.19	5.56	4.45
B37	629276.78	921363.56	4.33	4.27	3.85	3.46
B39	623633.60	921254.87	6.84	6.57	5.88	5.97
B41	618398.80	921934.29	6.14	6.30	5.89	6.02
B43	613047.66	921574.24	8.97	13.31	9.20	9.15
B45	607524.61	921700.07	7.83	8.39	8.03	8.39
B49	596777.72	921997.40	9.59	10.19	9.96	9.62
C02	722620.64	922989.72	15.55	15.39	15.11	15.44
C07	709028.39	922755.00	16.50	16.60	16.41	15.60
C08	706055.25	923371.39	15.70	16.53	15.82	15.22
C10	700927.42	923483.04	11.56	11.83	11.70	11.77
C11	698340.80	923496.68	11.31	11.66	11.42	11.43
C12	695477.94	923628.67	14.62	15.08	14.80	13.47
C13	693007.02	923680.82	11.35	11.98	11.66	12.11
C16	685315.24	922318.45	9.97	10.49	10.21	9.83
C17	682722.62	922362.36	10.18	10.77	10.58	10.19
C18	680084.40	922450.64	9.81	10.56	10.43	10.30
C19	677401.40	922536.63	10.39	11.33	11.24	10.76
C20	674753.21	922618.46	7.90	10.59	7.50	6.05
C21	672104.98	922700.44	7.38	7.55	7.32	7.09
C23	666599.02	922814.83	6.61	6.94	6.56	6.32
C24	663959.20	922863.93	7.68	7.40	6.21	6.04
C25	661319.48	922892.88	8.61	8.47	8.37	8.08
C26	658658.49	922966.04	6.82	7.39	6.73	6.06
C28	653278.02	923116.08	6.99	6.64	6.64	6.41
C29	650617.48	923193.52	6.46	6.15	6.15	6.21
C30	647970.71	923254.46	6.91	6.62	6.66	6.55
C31	645314.09	923337.42	5.72	5.79	5.79	5.80
C32	642660.17	923391.31	3.79	3.40	3.40	3.27
C33	640002.27	923445.31	4.06	3.26	3.81	4.04
C37	629190.28	924209.38	5.16	5.07	4.86	4.13
C38	626392.63	923898.58	3.38	3.42	3.44	3.97
C39	623737.87	923686.62	6.59	6.47	6.40	5.81
C41	618451.79	924096.37	7.42	7.96	7.86	7.33
C42	615761.47	924140.38	7.37	7.60	7.39	7.39
C43	613122.09	924214.87	9.05	9.29	9.17	8.97
C45	607603.02	924305.42	7.24	7.57	7.31	8.02
C46	604902.43	924396.98	9.51	9.76	9.48	8.84
C48	599545.79	924572.81	5.52	6.37	6.26	6.66
C49	596860.64	924655.50	7.85	8.44	8.33	8.18
D04	717174.14	925942.77	13.13	13.30	13.00	12.64
D06	711758.73	925798.56	13.59	18.26	14.06	14.22
D08	706140.88	926032.88	13.79	20.46	15.58	14.51
D12	695575.07	926291.60	13.24	16.18	13.31	13.09
D14	690667.64	926592.15	16.79	16.69	16.65	14.86
D17	682552.48	925038.36	11.58	11.29	10.81	10.27
D19	677494.11	924991.29	7.71	7.62	7.33	7.75
D25	661450.96	925581.79	8.45	8.35	8.00	7.89
D27	656131.05	925690.87	6.70	6.92	6.88	6.50
D28	653381.64	925779.96	5.50	6.06	5.97	5.66
D29	650721.16	925866.01	6.32	6.70	6.70	6.57
D31	645394.97	925982.42	6.88	6.84	6.85	6.93
D33	640102.93	926171.68	1.73	1.96	1.79	2.80
D35	634595.20	926356.46	5.90	6.21	6.21	5.73

D37	629237.88	926492.50	6.92	7.37	7.37	7.19
D39	623853.95	926619.52	5.36	11.88	5.58	5.08
D41	618548.48	926782.18	5.55	6.49	6.31	5.70
D43	613190.87	926944.52	4.58	4.96	4.72	4.53
D45	607581.00	926502.12	6.63	7.47	7.16	7.67
D49	597008.76	927199.68	7.74	8.01	7.86	7.68
E07	710094.26	928208.00	13.24	13.32	13.15	12.33
E09	702721.11	927232.23	13.16	13.44	13.06	12.17
E10	701017.84	928783.60	12.65	14.10	13.15	12.46
E13	693137.58	929655.44	14.17	14.39	14.01	13.39
E14	690882.23	929065.66	10.83	10.87	10.32	10.34
E16	685965.63	927745.67	5.88	6.09	5.98	5.96
E17	682857.59	927698.59	6.63	7.62	7.35	6.92
E18	680252.79	927798.55	11.51	12.07	11.94	11.64
E19	677570.25	927876.34	10.19	10.46	10.33	10.14
E21	672232.00	928048.33	6.19	6.82	6.55	6.25
E23	666731.68	928099.47	5.09	5.96	5.96	5.58
E25	661545.55	928246.10	5.71	5.85	5.85	5.71
E32	642806.20	928704.26	6.84	7.13	7.13	6.09
E36	631991.03	929055.24	4.71	4.63	4.57	4.06
E37	629310.35	929126.79	8.87	9.19	9.19	8.95
E38	626630.48	929211.63	4.54	4.83	4.83	4.50
E39	623963.80	929295.93	11.21	11.77	11.76	11.46
E42	615940.20	929539.47	5.98	6.67	6.27	5.53
E44	610522.61	929580.23	8.61	9.90	8.83	7.79
E46	605131.60	929737.39	10.06	10.57	9.97	9.76
E47	602727.10	929853.07	5.22	5.82	5.12	5.62
E48	599725.56	929846.88	7.10	7.49	7.17	7.25
F08	706305.96	931363.33	14.83	14.97	14.74	13.86
F10	701097.09	931466.13	14.08	14.07	13.74	13.50
F12	695746.95	931640.16	14.12	14.73	14.21	13.92
F17	683034.00	930287.39	6.12	6.53	6.28	5.64
F19	677695.97	930724.67	8.81	9.74	9.02	8.60
F25	661602.46	930905.44	5.10	5.43	5.43	5.17
F27	656258.53	931052.36	6.46	6.61	6.01	6.40
F29	650857.24	931255.30	3.94	4.11	4.11	4.19
F31	645479.63	931343.49	4.82	5.19	5.08	5.05
F33	639463.63	931527.78	5.56	5.15	5.15	5.51
F35	634232.99	930374.34	2.54	3.59	3.51	3.44
F37	629430.75	931814.51	16.01	17.05	16.85	15.26
F41	618744.64	932148.29	5.33	5.26	5.17	5.09
F43	613324.93	932310.33	9.22	9.91	9.69	9.37
F45	607889.72	932413.38	10.17	10.61	10.22	10.40
F49	597145.87	932710.66	5.65	6.15	6.02	5.90
G02	723005.00	933712.31	14.78	14.89	14.10	14.25
G04	716908.16	933802.03	14.76	14.47	13.99	13.48
G05	714648.36	933837.79	14.02	13.87	13.30	12.73
G06	711654.85	933727.42	12.90	13.64	12.81	12.57
G07	709146.53	933915.57	14.09	13.94	13.46	12.80
G13	693244.18	934336.91	12.49	12.98	12.33	12.27
G14	690663.10	934395.61	11.19	11.66	11.37	10.74
G15	690557.59	932720.46	13.23	13.16	12.97	12.64
G16	686073.44	932772.35	10.18	10.65	10.44	9.69
G17	683121.35	932950.46	7.67	7.78	7.61	7.50
G18	680368.46	932922.28	7.24	7.32	6.95	7.81
G19	677800.19	933101.45	11.09	12.57	11.18	10.79
G21	672390.40	933310.36	9.09	9.39	8.63	8.44

G22	669725.40	933413.49	3.96	4.44	4.47	4.20
G23	666949.80	933407.61	4.66	7.71	4.83	5.47
G24	664349.43	933504.07	4.42	4.93	4.92	4.60
G25	661685.95	933580.27	5.90	5.51	6.25	6.07
G26	659021.11	933666.42	5.80	5.90	5.74	5.90
G27	656354.09	933739.89	5.33	5.92	5.21	5.30
G28	653684.44	933931.81	5.17	8.07	5.46	5.53
G29	650953.98	933923.66	4.16	5.10	5.10	4.95
G30	648330.85	935001.95	4.32	4.31	4.42	4.70
G33	640199.45	934164.53	6.69	6.99	6.99	6.16
G35	634902.85	934304.26	3.46	3.91	3.91	4.40
G37	629614.90	934503.79	5.41	5.51	5.00	5.42
G39	624190.61	934650.05	6.05	5.90	5.95	5.20
G40	621428.88	934734.70	8.38	8.82	8.82	8.46
G41	618751.27	934818.67	11.32	11.47	11.46	11.24
G42	616081.85	934867.52	11.62	11.69	11.41	11.16
G43	613415.46	934925.84	9.82	11.20	10.70	10.67
G44	610712.22	935000.20	10.30	10.35	10.35	9.83
G45	608010.77	935068.66	7.52	8.57	8.39	8.01
G46	605325.31	935105.92	8.02	8.23	7.80	7.76
G47	602643.74	935201.51	8.48	8.86	8.37	8.54
G49	597271.17	935358.20	4.29	4.37	4.37	4.42
H04	717170.51	936408.00	14.22	13.74	13.66	12.78
H06	712064.80	937255.52	13.53	13.43	13.17	13.26
H08	706449.05	936697.18	13.51	14.74	14.26	13.47
H10	701237.09	936821.90	13.93	14.08	13.82	13.23
H12	695894.00	936954.55	10.30	10.40	10.40	10.01
H15	690679.18	935285.81	11.23	11.47	10.99	8.53
H17	683246.31	935614.35	8.95	8.79	8.79	7.72
H19	677860.31	935791.38	6.08	6.14	5.94	5.95
H23	667086.61	936165.62	3.45	10.69	4.01	4.22
H25	661954.69	936227.91	4.70	4.75	4.75	4.68
H27	656408.61	936613.76	5.34	5.64	5.42	5.91
H29	651033.04	936501.28	6.56	6.73	6.46	5.56
H33	640296.55	936872.43	7.09	6.62	6.69	6.49
H35	634233.73	938127.95	1.51	1.61	1.35	1.69
H37	629565.43	937173.26	10.27	10.71	10.71	10.44
H39	624308.15	937346.64	9.43	9.13	9.17	8.80
H42	616163.36	937505.45	7.47	9.72	7.46	6.80
H43	613502.74	937533.32	6.47	5.79	5.82	5.75
H45	608122.49	937699.84	6.56	6.43	6.43	5.91
H47	602759.59	937852.00	4.56	4.67	4.67	4.20
I04	717216.02	939158.23	12.59	12.81	12.81	13.13
I05	714567.30	939218.38	11.95	13.31	13.30	13.06
I06	712108.69	939268.15	13.88	13.71	13.68	13.19
I07	709377.69	939330.10	14.06	13.99	13.93	13.48
I08	706537.42	939373.20	13.00	13.57	13.16	12.90
I10	701306.57	939508.38	17.53	17.46	17.47	15.28
I12	695962.01	939625.06	11.63	12.05	11.67	11.22
I15	690755.81	938069.35	10.96	10.99	10.32	8.90
I16	685892.50	938208.04	6.25	6.56	5.95	5.90
I17	683260.80	938299.60	6.59	6.08	5.69	5.17
I18	680594.34	938402.08	7.33	12.90	6.67	7.38
I19	677921.13	938471.21	4.74	4.96	4.96	4.98
I20	675249.63	938528.78	5.76	6.16	5.89	5.40
I21	672578.65	938588.20	5.32	5.34	5.27	4.78
I22	669929.76	938679.99	4.10	5.19	4.29	4.65

I24	664576.95	938877.95	5.34	8.64	5.33	5.65
I25	661858.70	938771.59	3.54	4.41	3.68	3.94
I26	659214.14	938998.84	3.44	3.32	3.41	4.06
I27	656471.46	938960.57	6.17	20.17	6.07	5.70
I28	653849.03	939152.74	4.75	4.99	4.94	4.71
I29	651140.76	939236.37	4.56	4.93	4.55	4.16
I30	648439.80	939313.26	5.92	5.52	5.47	4.89
I31	645758.22	939376.64	5.08	5.12	4.82	4.37
I32	643052.87	939460.76	7.47	7.33	7.11	6.85
I33	640346.96	939545.30	8.39	8.48	8.48	8.04
I34	637652.01	939470.70	12.20	12.64	12.19	11.91
I37	629577.26	939908.43	0.49	3.08	1.23	3.03
I40	621620.67	940143.37	3.41	3.66	3.66	3.66
I41	618906.89	940238.88	4.27	4.69	4.69	4.09
I42	616252.79	940200.70	4.76	4.74	4.74	4.08
I45	608236.34	940332.78	2.48	2.49	2.49	2.74
I46	605532.71	940428.85	1.09	0.96	0.96	1.51
I47	602827.51	940512.72	2.97	3.10	2.84	3.04
I48	600370.86	940885.93	3.62	3.43	3.42	3.59
I49	597464.92	940765.35	2.92	3.37	3.37	3.34
J02	723119.72	941710.26	12.36	12.46	12.32	11.98
J08	706599.62	942051.78	17.57	17.81	17.64	16.64
J12	696042.32	942290.54	14.58	14.72	14.91	15.02
J15	690876.78	940754.22	9.35	9.35	9.20	9.07
J17	683284.28	940983.37	4.75	5.24	5.13	4.98
J19	677951.71	941007.28	5.28	5.25	5.23	4.28
J21	672612.59	941290.34	4.04	4.42	4.41	4.47
J23	667252.22	941605.14	3.62	4.14	4.14	4.32
J25	661938.29	941856.52	3.25	4.15	3.37	3.75
J27	656999.65	941685.31	5.52	6.32	5.34	5.69
J29	651213.73	941878.17	7.72	7.78	7.78	7.82
J31	645878.48	942252.54	1.68	1.21	1.58	1.89
J35	634440.70	943650.44	8.27	8.07	8.07	7.37
J36	631066.86	943777.80	7.59	7.66	7.67	6.99
J39	624383.79	943232.28	1.93	1.97	2.00	1.35
J41	619008.01	942907.32	4.01	4.27	4.27	2.74
J43	613662.13	942775.30	2.01	2.40	2.22	2.89
J45	608327.62	942986.18	1.96	2.12	2.24	2.74
J49	597560.55	943331.78	3.88	4.15	4.15	4.59
K03	719884.79	944426.23	12.16	12.92	11.94	11.65
K04	717316.35	943958.57	18.66	19.15	18.38	17.37
K06	712185.80	944681.63	18.56	18.68	18.68	19.33
K07	709345.07	944693.70	20.81	20.68	20.68	20.92
K09	704054.45	944798.28	20.45	34.16	20.70	21.01
K11	698777.71	944647.66	20.00	19.78	19.65	19.81
K12	696121.56	944955.99	16.99	17.16	17.16	17.46
K13	693487.15	945019.78	17.40	18.74	18.39	18.09
K14	690851.87	945085.37	12.90	13.05	12.33	11.81
K15	690826.18	943626.69	9.27	10.39	10.24	9.66
K16	686082.89	943574.45	5.70	5.65	5.58	5.44
K17	683375.86	943662.51	5.09	5.38	5.24	5.03
K18	680664.28	943762.91	5.43	16.94	5.60	5.22
K19	678067.75	943781.37	6.85	7.32	6.62	6.65
K21	672609.61	943926.01	4.13	4.14	4.14	4.55
K22	670070.84	944088.73	4.48	5.24	5.26	5.07
K23	667382.95	944019.00	6.30	6.45	6.19	4.67
K25	662031.49	944255.12	6.06	5.90	6.00	6.42

K26	659196.19	944272.79	6.16	6.23	6.06	6.16
K29	651291.41	944728.38	2.25	2.28	2.28	2.84
K30	648698.04	944393.31	3.32	3.68	3.37	3.49
K34	637833.09	944884.28	6.00	6.32	6.60	6.71
K35	635111.96	944376.86	6.11	6.31	6.08	5.91
K37	629923.27	945281.78	10.11	10.12	10.10	7.66
K41	619093.24	945329.95	4.29	3.87	3.85	2.72
K43	613915.16	945276.29	3.90	3.76	3.76	2.78
K44	611288.23	945662.68	0.25	0.34	0.32	0.80
K46	605104.32	945724.87	3.05	2.95	2.91	2.48
K49	597654.48	945462.54	2.60	2.25	2.49	3.05
L04	717441.12	947090.53	16.89	16.72	16.45	16.11
L06	712068.83	947310.57	15.63	15.69	15.30	15.54
L08	706725.72	947397.24	15.34	15.40	15.36	14.48
L10	701532.06	947528.26	11.50	11.65	11.65	12.10
L14	690900.40	947746.60	15.73	15.93	15.92	15.38
L15	690876.12	946416.04	14.09	14.25	14.10	13.47
L17	683547.42	946604.30	7.15	12.56	7.36	7.53
L19	678170.95	946742.39	6.05	6.05	6.08	6.40
L21	672789.82	946481.12	7.22	7.18	7.19	7.50
L23	667475.27	946812.01	8.84	8.73	8.73	8.28
L27	656788.77	947016.81	5.66	5.74	5.75	5.06
L31	645731.01	947305.65	5.83	5.52	5.52	5.61
L35	635200.11	947444.50	2.77	2.85	2.85	1.77
M02	723226.03	949724.56	14.34	12.87	13.96	14.39
M04	717513.61	949841.27	12.87	12.87	12.91	12.53
M06	712146.88	949956.87	10.45	10.19	10.69	10.50
M08	706810.22	950068.29	11.24	21.38	11.37	10.81
M09	704205.27	950134.37	9.36	10.72	9.52	9.48
M10	701604.70	950209.30	9.51	9.68	9.64	10.09
M12	696289.06	950649.48	8.77	8.78	8.79	8.67
M13	693878.41	950441.39	7.82	7.73	7.70	8.03
M14	690947.46	950396.99	8.16	8.03	7.98	7.17
M15	690923.91	949018.94	11.51	11.84	11.57	11.11
M16	686295.48	949727.25	3.24	3.23	3.21	3.89
M17	683616.09	949253.47	3.20	3.40	3.38	3.91
M20	675692.92	949363.70	4.85	4.76	4.69	4.21
M21	672803.58	948975.19	3.38	4.07	3.99	4.27
M22	670298.77	949140.86	3.36	3.90	3.88	3.86
M24	664860.77	949502.34	2.40	3.01	2.72	3.93
M25	661959.37	949577.76	1.16	1.34	1.31	1.42
M30	648750.71	949943.92	9.87	9.63	9.62	9.62
N02	723253.87	952363.14	10.22	10.73	10.41	10.34
N04	717582.24	952459.30	8.35	8.06	8.06	7.84
N06	712207.76	952517.73	7.45	14.00	7.39	7.90
N12	696329.83	952957.47	4.06	4.14	4.14	4.17
O05	715034.20	955243.84	3.18	3.10	3.13	3.49
O07	709738.52	955358.76	4.93	4.78	4.61	5.70
O09	704261.85	955518.17	3.34	3.32	3.32	4.13
O10	701385.79	955650.25	2.62	2.64	2.56	3.39
P04	717087.75	958273.05	12.47	12.33	12.38	12.90