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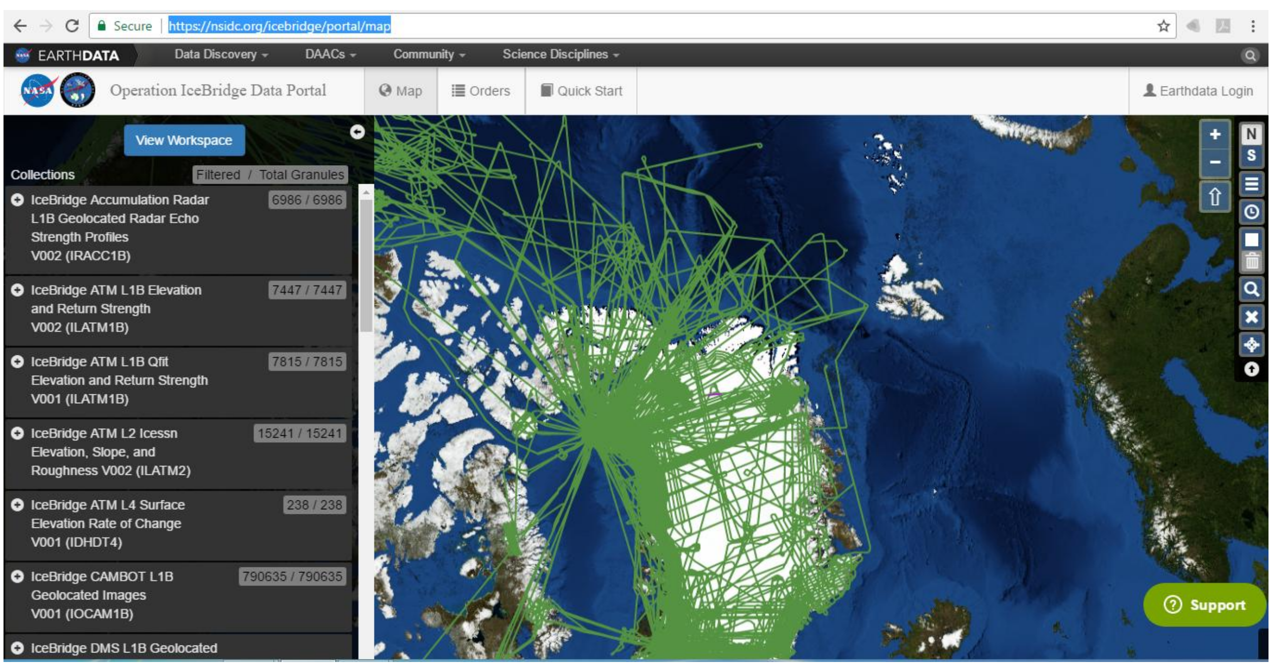
NASA Operation IceBridge Flight Segment Data Lab - Student Guide

Introduction: NASA's Operation IceBridge (OIB) uses remote sensing techniques from an airborne laboratory to take measurements on changing polar ice in the Arctic and Antarctica each year. The amount of data collected is immense, but in this study you will learn how to extract localized data from a segment of a particular science flight and explain how the data from an airborne mission fits into the 'big picture' of understanding how Earth's ice sheets are changing. Work through each part in this series of exercises carefully to learn how to use OIB data in Excel and how to attach a segment of data points to a map in Google's MyMaps application. You will need access to a computer and internet for this assignment.

Part 1: Accessing Data from National Snow and Ice Data Center (NSIDC)

1. Open the NASA Operation IceBridge data portal in your internet browser using the following URL: https://nsidc.org/icebridge/portal/map. You will see a map of the Greenland Ice Sheet covered with hundreds of green flight lines. These lines represent every science flight Operation IceBridge has completed since it began its mission in 2009.



The National Snow and Ice Data Center (NSIDC) contains collections from each year of NASA Operation IceBridge science flights in the Arctic and Antarctica and includes data from snow and ice penetrating radar, a LiDAR-based instrument known as the Airborne Topographic Mapper (ATM), and high resolution digital imagery. Each collection is listed in the Collections Menu on the left side of the screen.

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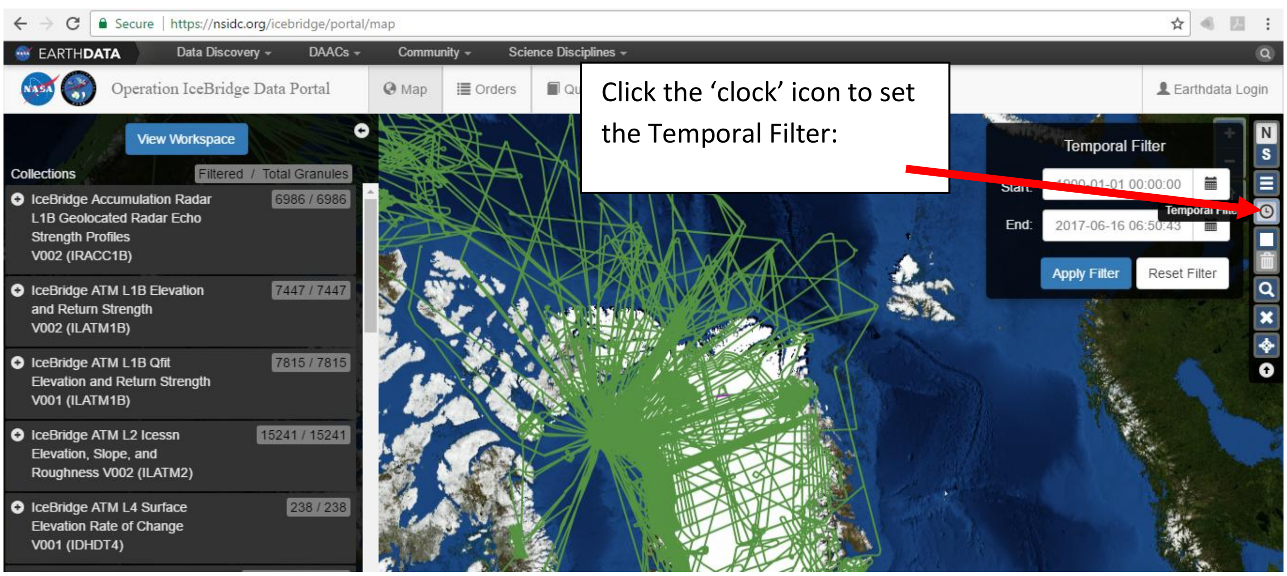
FOCUS: We will be working with data collected using the Airborne Topographic Mapper which uses Light Detection and Ranging (LiDAR) to measure the topography of the ice surface above ground level. By the end of Parts 1-3 you should be able to plot position and height coordinates from OIB ATM data on a map in the Google MyMaps application.

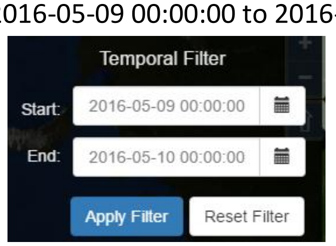
BACKGROUND: Each year a panel of scientists determines critical flight paths needed to collect important information on Earth's polar ice and to maintain a continuous record of data. One of those flights each year is known as Zachariae- 79N named for two outlet glaciers in Northeast Greenland. The base of these glaciers is below sea level and data from these glaciers is critical for scientists studying how they lose ice and interact with ocean water. In this assignment, we are going to examine data from the 2016 mission over those glaciers (each year the same flight path is flown to keep a record of changes over time).

EXTRACTING OUR DATA: Let's filter the map in our browser window to reveal only the Zachariae- 79N 2016 flight path. Follow these steps:

2. On the right side of the map in your browser, select the icon that looks like a clock (see below). This provides a temporal filter (or allows us to filter by time). You should see a window pop up with spaces to input a **start** and **end** time:



3. In 2016, the Zachariae- 79N 2016 mission was completed on May 9. Use this information to set your start and end boundaries as shown below, from midnight on May 9th to midnight on May 10th (entered in military time as 2016-05-09 00:00:00 to 2016-05-10 00:00:00):



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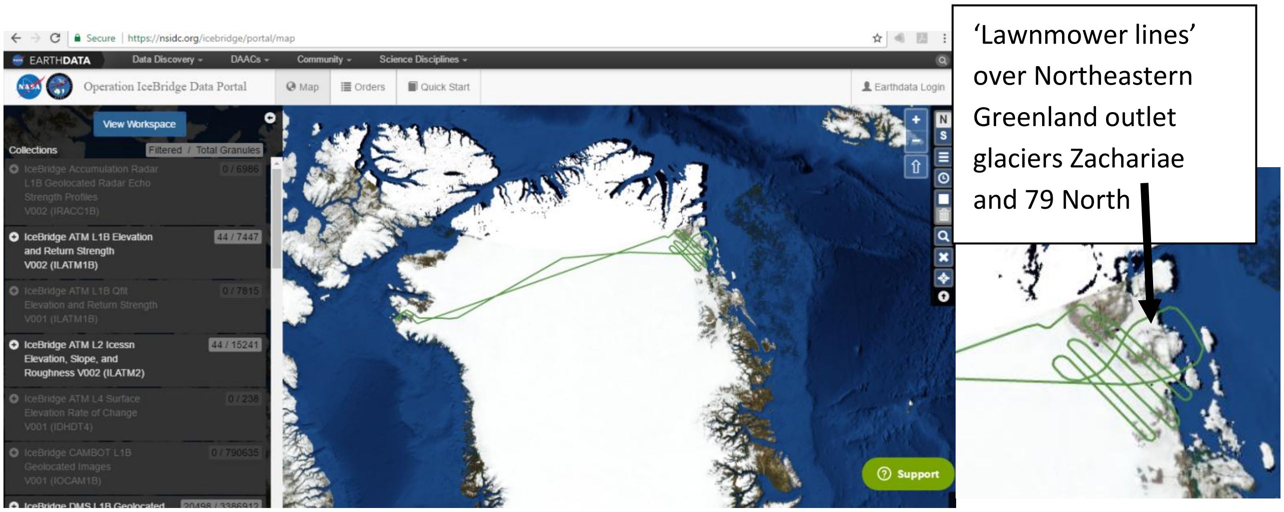
4. All of the flight lines will disappear except for the May 9, 2016 flight which collected data from West to East across the interior of Greenland and then across the outlet glaciers in the Northeast along 'lawn mower' flight segments. Your map should look like this:



5. We are going to work with data from a segment of that flight as the aircraft passed over the interior of the Greenland Ice Sheet. Below, you see some images from the aircraft (a NOAA WP-3D) taken by ATM Scientist Jim Yungel during this flight:


6. To access the data collected along the flight line chosen, take a look at the Collections Menu on the left of the browser window. Find the file set titled: IceBridge ATM L2 Icessn Elevation, Slope, and Roughness V002 (ILATM2)

7. Click the (+) sign next to that title to reveal the year of data available (2016). Click the (+) sign next to 2016 to reveal the dates of data available. Finally, click the (+) sign next to May 9 to reveal all of the data sets from the May 9th 2016 science flight as shown.

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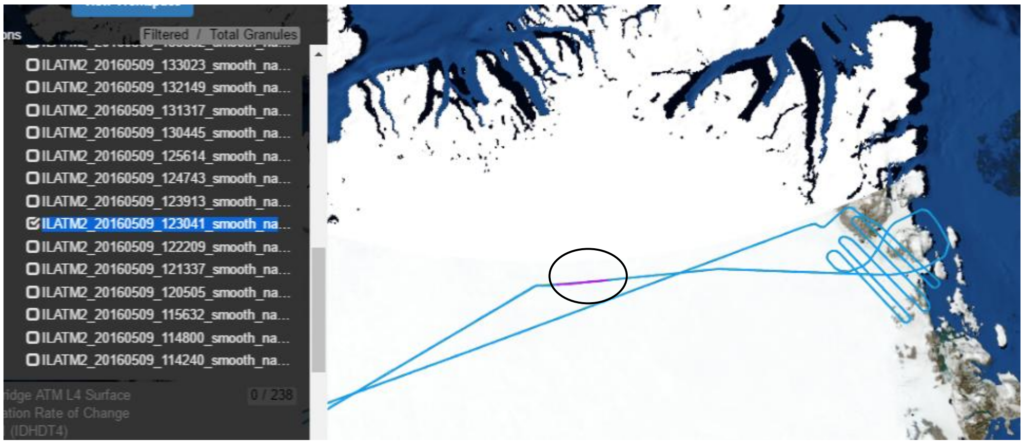
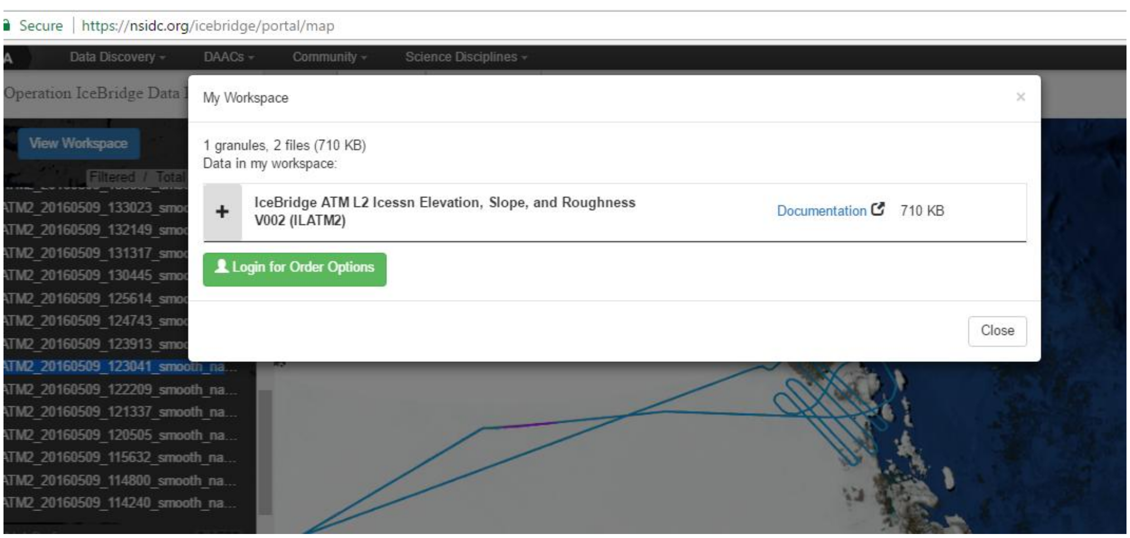
With the cursor, hover over each of the data files listed and pay attention to the flight path on your map. What do you notice about the flight line as you move your mouse over each file? We are going to select a segment from the interior of the Greenland Ice Sheet and you will see that section of the flight line change color. Follow the instructions below:

8. Find the data file on the left menu with the name ILATM2_20160509_123041_smooth_nadir3seg_50pt.csv Click the checkbox next to the file name. You should see a segment in the middle of the flight line change to purple once that box is checked:



9. Now all of the data from that segment of the flight is available in your 'Workspace.' To access and download the data you will need to Create a Log-in for the NSIDC Operation IceBridge Portal. If your teacher has provided a log in or a link to the file, you may use that instead.

10. Click the 'View Workspace' button above the data collections menu on the left side of your screen. You will see a pop-up window like the one shown below:



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If there is more than one file listed in your workspace, you may have accidentally checked another file's box. You can hover over the right side of the file name IN THE POP-UP window to click an 'x' and delete the additional files.

11. Log in to download the file or follow the prompts to create an account by clicking the green login button.

12. Once you have created an account or logged into the portal, you can download the data set either to your computer or send it to Google Drive. With the file available as an xml worksheet, it is time to dig in to the raw data and clean it up to create a visual. **<u>You are now ready to move into Part 2: Working with OIB ATM data in Excel!</u>**

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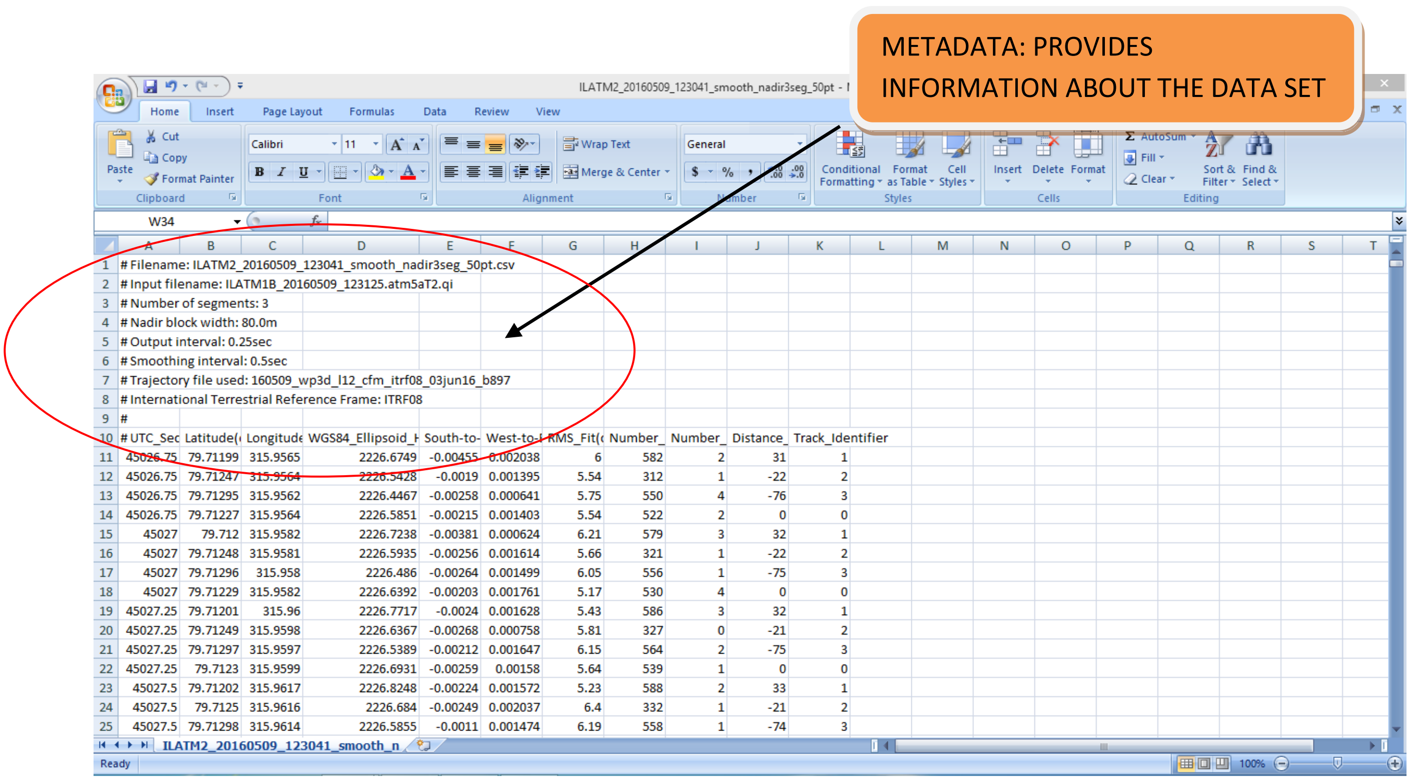
PART 2: WORKING WITH OIB ATM DATA IN EXCEL

In this section, you will learn how to extract a data from a segment of a NASA OIB science flight using Microsoft Excel.

File Preparation

1. Begin by launching Microsoft Excel on your desktop. Open the xml file you saved in Part 1 (if you sent the file to Google Drive, you will have to download the file to your computer first.
2. You should see a table that looks like this:



	A	B	C	D	E	F	G	H	I	J	K
1	# Filename: ILATM2_20160509_123041_smooth_nadir3seg_50pt.csv										
2	# Input filename: ILATM1B_20160509_123125.atm5aT2.qi										
3	# Number of segments: 3										
4	# Nadir block width: 80.0m										
5	# Output interval: 0.25sec										
6	# Smoothing interval: 0.5sec										
7	# Trajectory file used: 160509_wp3d_l12_cfm_itrf08_03jun16_b897										
8	# International Terrestrial Reference Frame: ITRF08										
9	#										
10	# UTC_Sec	Latitude(	Longitude	WGS84_Ellipsoid_H	South-to-	West-to-E	RMS_Fit(	Number_	Number_	Distance_	Track_Identifier
11	45026.75	79.71199	315.9565	2226.6749	-0.00455	0.002038	6	582	2	31	1
12	45026.75	79.71247	315.9564	2226.5428	-0.0019	0.001395	5.54	312	1	-22	2
13	45026.75	79.71295	315.9562	2226.4467	-0.00258	0.000641	5.75	550	4	-76	3
14	45026.75	79.71227	315.9564	2226.5851	-0.00215	0.001403	5.54	522	2	0	0
15	45027	79.712	315.9582	2226.7238	-0.00381	0.000624	6.21	579	3	32	1
16	45027	79.71248	315.9581	2226.5935	-0.00256	0.001614	5.66	321	1	-22	2
17	45027	79.71296	315.958	2226.486	-0.00264	0.001499	6.05	556	1	-75	3
18	45027	79.71229	315.9582	2226.6392	-0.00203	0.001761	5.17	530	4	0	0
19	45027.25	79.71201	315.96	2226.7717	-0.0024	0.001628	5.43	586	3	32	1
20	45027.25	79.71249	315.9598	2226.6367	-0.00268	0.000758	5.81	327	0	-21	2
21	45027.25	79.71297	315.9597	2226.5389	-0.00212	0.001647	6.15	564	2	-75	3
22	45027.25	79.7123	315.9599	2226.6931	-0.00259	0.00158	5.64	539	1	0	0
23	45027.5	79.71202	315.9617	2226.8248	-0.00224	0.001572	5.23	588	2	33	1
24	45027.5	79.7125	315.9616	2226.684	-0.00249	0.002037	6.4	332	1	-21	2
25	45027.5	79.71298	315.9614	2226.5855	-0.0011	0.001474	6.19	558	1	-74	3

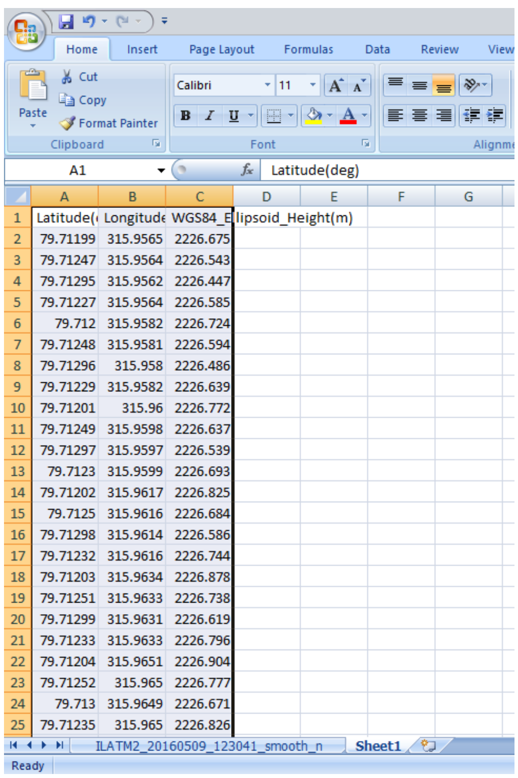
Rows 1-8 in this table provide our **metadata**, a data set that provides information about other data. Row 10 identifies the information listed in each column.

3. First, we want to determine the data we are interested in plotting. In our case, we are going to plot **position (latitude and longitude)** and **height.** In this data set, *select and highlight* the columns titled Latitude, Longitude, and Ellipsoid Height. You can use the double arrow with your mouse to stretch each column in order to see full titles and units. (***Note: the combination 'Shift+Ctrl+↓' allows you to highlight the full column instantly).** See the example on page 7.

9	#											
10	# UTC_Sec	Latitude(deg)	Longitude(deg)	WGS84_Ellipsoid_Height(m)	South-to-	West-to-E	RMS_Fit(	Number_	Number_	Distance_	Track_Identifier
11	45026.75	79.71199	315.956521	2226.6749	-0.00455	0.002038	6	582	2	31	1
12	45026.75	79.71247	315.956379	2226.5428	-0.0019	0.001395	5.54	312	1	-22	2
13	45026.75	79.712949	315.956237	2226.4467	-0.00258	0.000641	5.75	550	4	-76	3
14	45026.75	79.71227	315.956438	2226.5851	-0.00215	0.001403	5.54	522	2	0	0
15	45027	79.712002	315.958242	2226.7238	-0.00381	0.000624	6.21	579	3	32	1
16	45027	79.712481	315.958103	2226.5935	-0.00256	0.001614	5.66	321	1	-22	2
17	45027	79.712961	315.957964	2226.486	-0.00264	0.001499	6.05	556	1	-75	3
18	45027	79.712286	315.95816	2226.6392	-0.00203	0.001761	5.17	530	4	0	0
19	45027.25	79.712012	315.959965	2226.7717	-0.0024	0.001628	5.43	586	3	32	1
20	45027.25	79.712492	315.959829	2226.6367	-0.00268	0.000758	5.81	327	0	-21	2
21	45027.25	79.712972	315.959692	2226.5389	-0.00212	0.001647	6.15	564	2	-75	3
22	45027.25	79.712302	315.959883	2226.6931	-0.00259	0.00158	5.64	539	1	0	0
23	45027.5	79.712022	315.961687	2226.8248	-0.00224	0.001572	5.23	588	2	33	1
24	45027.5	79.712502	315.961553	2226.684	-0.00249	0.002037	6.4	332	1	-21	2
25	45027.5	79.712982	315.961419	2226.5855	-0.0011	0.001474	6.19	558	1	-74	3

ILATM2_20160509_123041_smooth_n

4. Copy and paste the three selected columns into a new sheet. Once everything is highlighted, **CTRL + C** will work to copy everything the selected columns. Click the tab at the bottom of the Excel workbook to add a new sheet. Click Cell A1 and use the combination **Ctrl + V** to paste your copied data columns. Your new sheet should look like the one below (be sure to include the titles for those columns):



	A	B	C	D
1	Latitude(	Longitude	WGS84_Ellipsoid_Height(m)	
2	79.71199	315.9565	2226.675	
3	79.71247	315.9564	2226.543	
4	79.71295	315.9562	2226.447	
5	79.71227	315.9564	2226.585	
6	79.712	315.9582	2226.724	
7	79.71248	315.9581	2226.594	
8	79.71296	315.958	2226.486	
9	79.71229	315.9582	2226.639	
10	79.71201	315.96	2226.772	
11	79.71249	315.9598	2226.637	
12	79.71297	315.9597	2226.539	
13	79.7123	315.9599	2226.693	
14	79.71202	315.9617	2226.825	
15	79.7125	315.9616	2226.684	
16	79.71298	315.9614	2226.586	
17	79.71232	315.9616	2226.744	
18	79.71203	315.9634	2226.878	
19	79.71251	315.9633	2226.738	
20	79.71299	315.9631	2226.619	
21	79.71233	315.9633	2226.796	
22	79.71204	315.9651	2226.904	
23	79.71252	315.965	2226.777	
24	79.713	315.9649	2226.671	
25	79.71235	315.965	2226.826	

Google MyMaps has some restrictions and we will need to make some adjustments to our data in order to meet the criteria. The first restriction involves position coordinates: Latitude and longitude values range from $0° \; to \; \pm 90°$. Notice the longitude coordinates in Column B do not meet that restriction so we will need to reformat that information.

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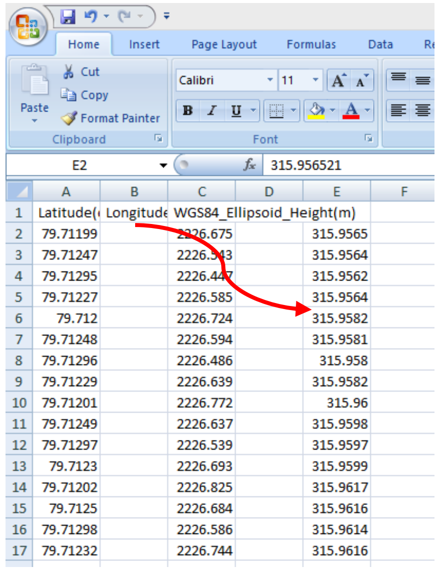
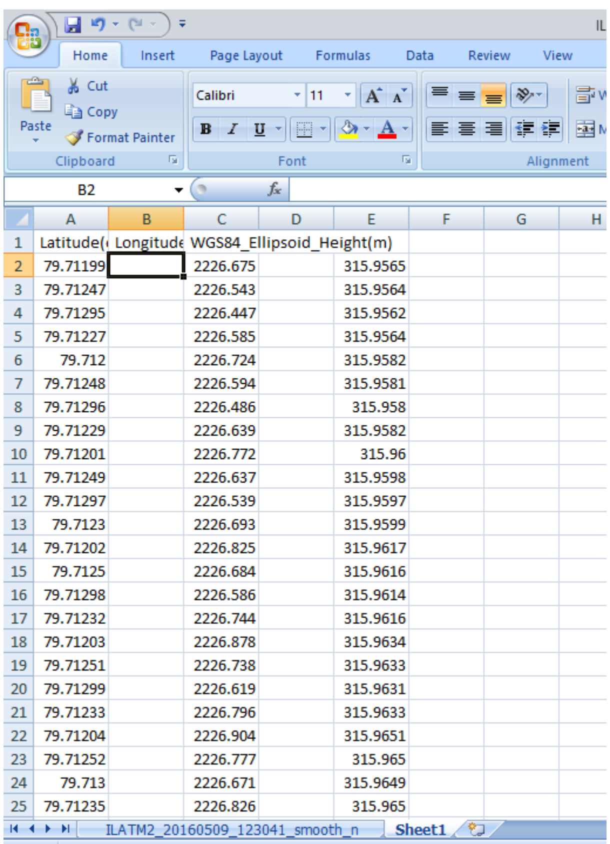
5. Select and cut (**CTRL+X+**↓) the numerical data in Column B (beginning with B2) in Sheet 1 and paste it into Column E as shown below:



	A	B	C	D	E	F
1	Latitude(	Longitude	WGS84_Ellipsoid_Height(m)			
2	79.71199		2226.675		315.9565	
3	79.71247		2226.543		315.9564	
4	79.71295		2226.447		315.9562	
5	79.71227		2226.585		315.9564	
6	79.712		2226.724		315.9582	
7	79.71248		2226.594		315.9581	
8	79.71296		2226.486		315.958	
9	79.71229		2226.639		315.9582	
10	79.71201		2226.772		315.96	
11	79.71249		2226.637		315.9598	
12	79.71297		2226.539		315.9597	
13	79.7123		2226.693		315.9599	
14	79.71202		2226.825		315.9617	
15	79.7125		2226.684		315.9616	
16	79.71298		2226.586		315.9614	
17	79.71232		2226.744		315.9616	

6. To reformat the longitude, we need to subtract 360 degrees from each longitude value to obtain its reference angle and sign. This is a fast process using Excel formulas. Begin by highlighting cell B2:



	A	B	C	D	E	F	G	H
1	Latitude(	Longitude	WGS84_Ellipsoid_Height(m)					
2	79.71199		2226.675		315.9565			
3	79.71247		2226.543		315.9564			
4	79.71295		2226.447		315.9562			
5	79.71227		2226.585		315.9564			
6	79.712		2226.724		315.9582			
7	79.71248		2226.594		315.9581			
8	79.71296		2226.486		315.958			
9	79.71229		2226.639		315.9582			
10	79.71201		2226.772		315.96			
11	79.71249		2226.637		315.9598			
12	79.71297		2226.539		315.9597			
13	79.7123		2226.693		315.9599			
14	79.71202		2226.825		315.9617			
15	79.7125		2226.684		315.9616			
16	79.71298		2226.586		315.9614			
17	79.71232		2226.744		315.9616			
18	79.71203		2226.878		315.9634			
19	79.71251		2226.738		315.9633			
20	79.71299		2226.619		315.9631			
21	79.71233		2226.796		315.9633			
22	79.71204		2226.904		315.9651			
23	79.71252		2226.777		315.965			
24	79.713		2226.671		315.9649			
25	79.71235		2226.826		315.965			

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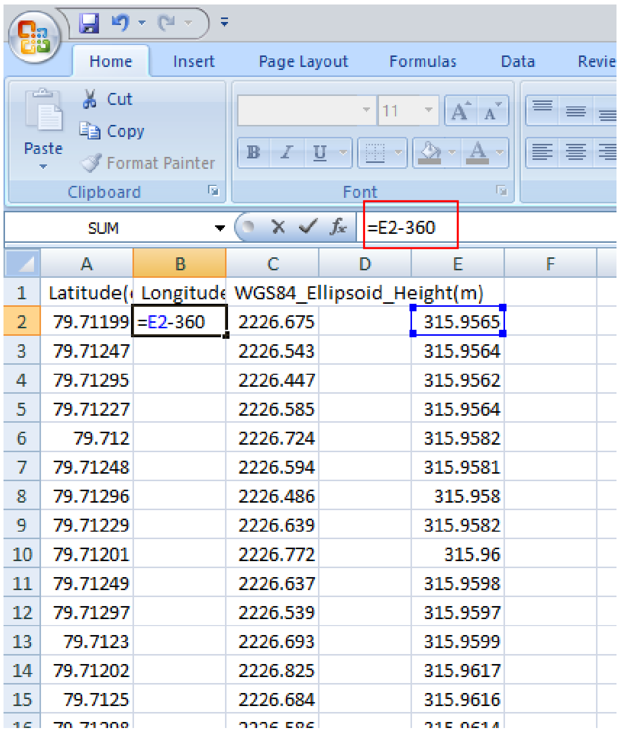
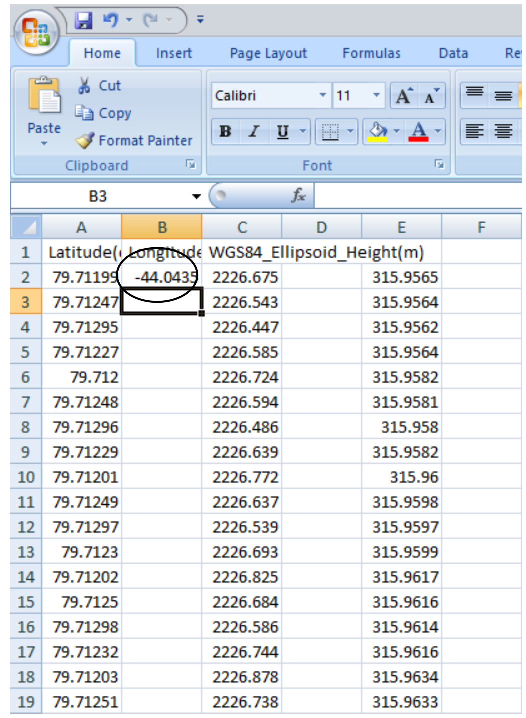
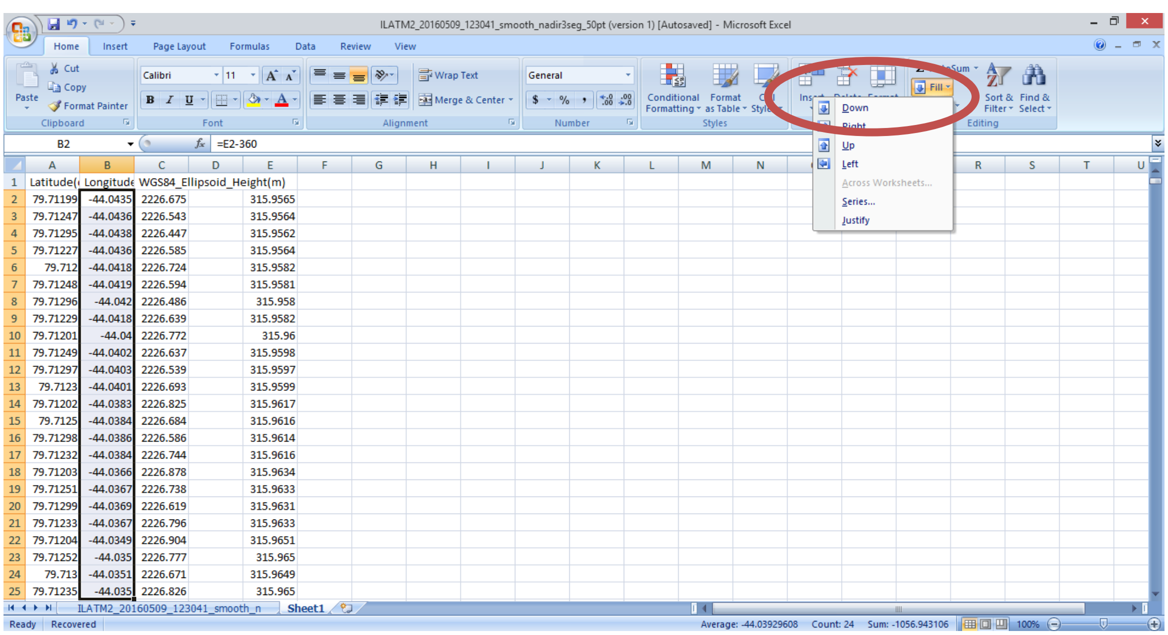
7. With B2 highlighted, and the original Longitude values listed beginning in cell E2, type the following formula exactly as shown: $= E2 - 360$. You will see it appear in the function cell in the menu bar. Hitting enter will reveal the calculated value (315.9565-360).





8. Highlight B2 and use the combination **Ctrl + Shift + ↓** on your keyboard to highlight all of the cells in column B. From the menu bar, select '**Fill**' and '**down**' in order to apply the formula in B2 to the rest of the column. Delete any cells in column B that do not have a corresponding latitude and height coordinate.



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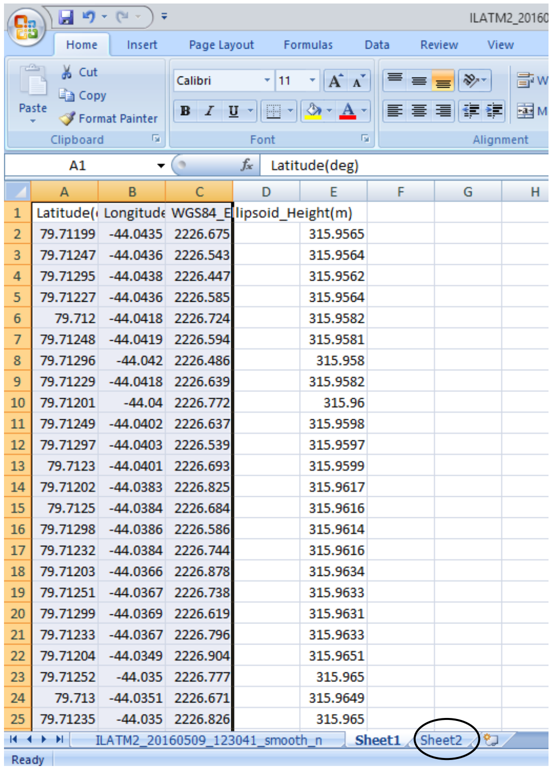
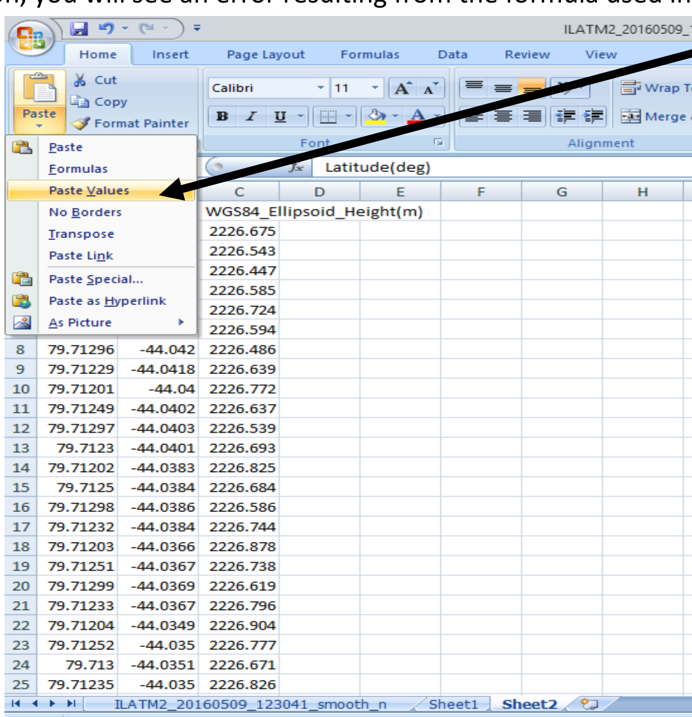
9. Highlight columns A, B ,and C. Then, use the combination **Ctrl+C** to copy your reformatted position and elevation values. Open another new sheet (Sheet 2).



	A	B	C	D	E
1	Latitude(	Longitude	WGS84_E	lipsoid_Height(m)	
2	79.71199	-44.0435	2226.675		315.9565
3	79.71247	-44.0436	2226.543		315.9564
4	79.71295	-44.0438	2226.447		315.9562
5	79.71227	-44.0436	2226.585		315.9564
6	79.712	-44.0418	2226.724		315.9582
7	79.71248	-44.0419	2226.594		315.9581
8	79.71296	-44.042	2226.486		315.958
9	79.71229	-44.0418	2226.639		315.9582
10	79.71201	-44.04	2226.772		315.96
11	79.71249	-44.0402	2226.637		315.9598
12	79.71297	-44.0403	2226.539		315.9597
13	79.7123	-44.0401	2226.693		315.9599
14	79.71202	-44.0383	2226.825		315.9617
15	79.7125	-44.0384	2226.684		315.9616
16	79.71298	-44.0386	2226.586		315.9614
17	79.71232	-44.0384	2226.744		315.9616
18	79.71203	-44.0366	2226.878		315.9634
19	79.71251	-44.0367	2226.738		315.9633
20	79.71299	-44.0369	2226.619		315.9631
21	79.71233	-44.0367	2226.796		315.9633
22	79.71204	-44.0349	2226.904		315.9651
23	79.71252	-44.035	2226.777		315.965
24	79.713	-44.0351	2226.671		315.9649
25	79.71235	-44.035	2226.826		315.965

10. From the Paste drop-down on the menu in Sheet 2, select '**Paste Values**.' If you miss that option, you will see an error resulting from the formula used in Column B on Sheet 1.



	A	B	C
1			WGS84_Ellipsoid_Height(m)
2			2226.675
3			2226.543
4			2226.447
5			2226.585
6			2226.724
7			2226.594
8	79.71296	-44.042	2226.486
9	79.71229	-44.0418	2226.639
10	79.71201	-44.04	2226.772
11	79.71249	-44.0402	2226.637
12	79.71297	-44.0403	2226.539
13	79.7123	-44.0401	2226.693
14	79.71202	-44.0383	2226.825
15	79.7125	-44.0384	2226.684
16	79.71298	-44.0386	2226.586
17	79.71232	-44.0384	2226.744
18	79.71203	-44.0366	2226.878
19	79.71251	-44.0367	2226.738
20	79.71299	-44.0369	2226.619
21	79.71233	-44.0367	2226.796
22	79.71204	-44.0349	2226.904
23	79.71252	-44.035	2226.777
24	79.713	-44.0351	2226.671
25	79.71235	-44.035	2226.826

Make sure to choose this option to avoid any errors from the formula used in Step 9 (which requires the values from column E2)!

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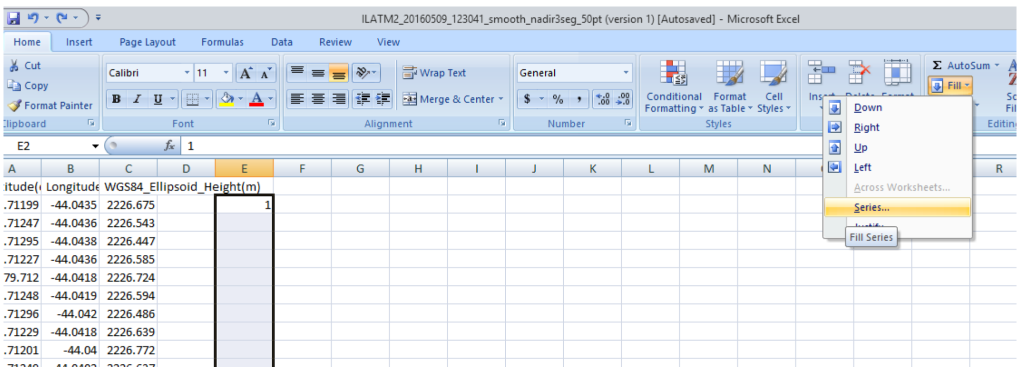
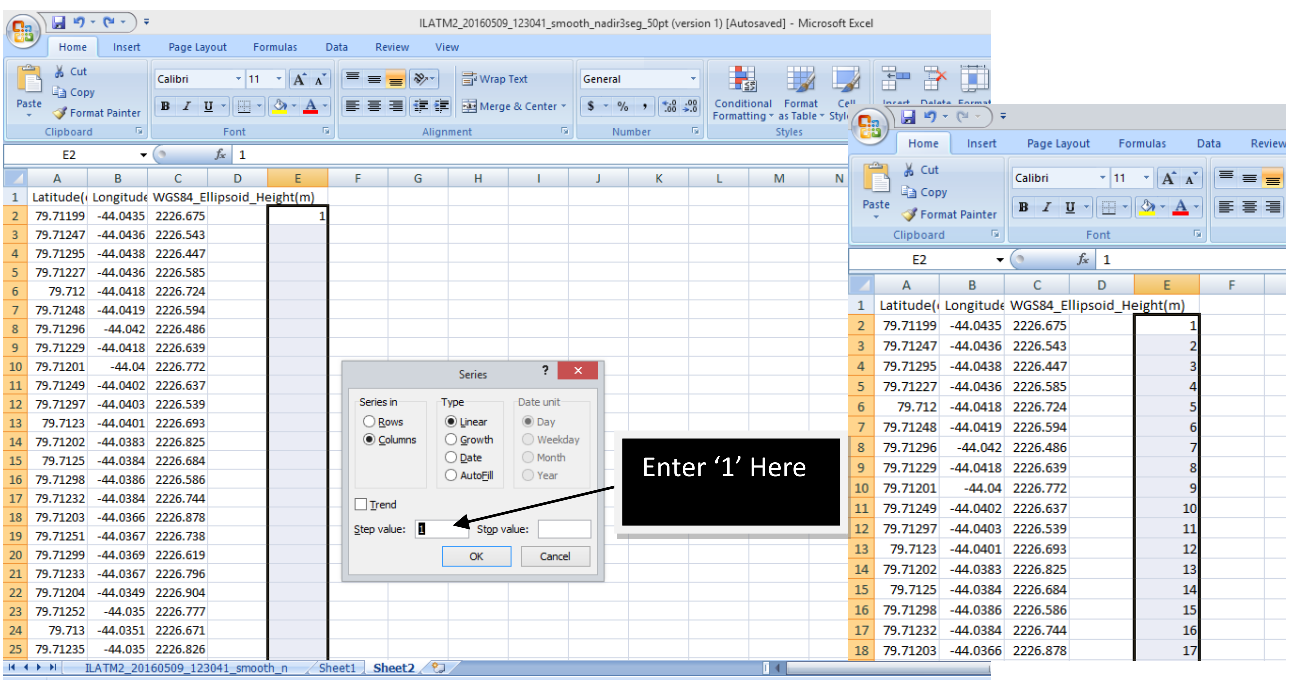
Now that we have correctly formatted position coordinates, the next step is reducing the amount of data points in order to successfully create a visual in My Maps. To do this, we will extract every 3rd data point from our data set in Sheet 2. This will reduce our set by about 6000 points but still provide enough information to plot on Google MyMaps.

11. We are going to use Columns E and F in Sheet 2 for this step. Number the rows in column E (beginning with E2) in sequential order beginning with the number 1. To do this type ‘1’ in cell E2. Then select ‘Fill’, ‘series’, and ‘linear.’ Make sure the step value under linear is set to ‘1.’ (See inset below):





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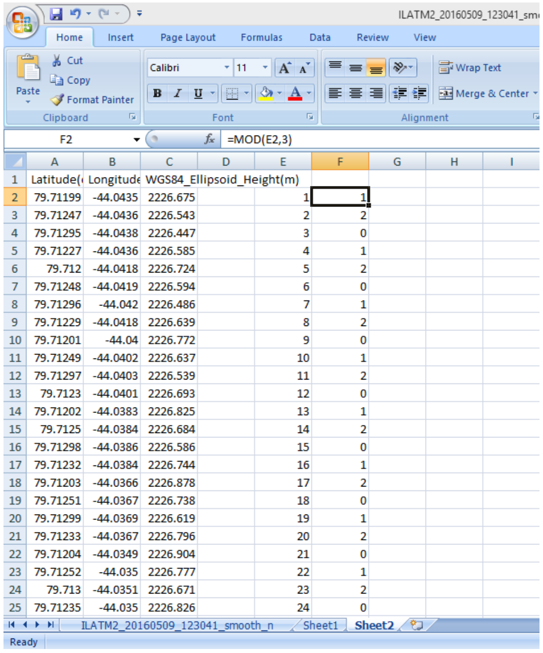
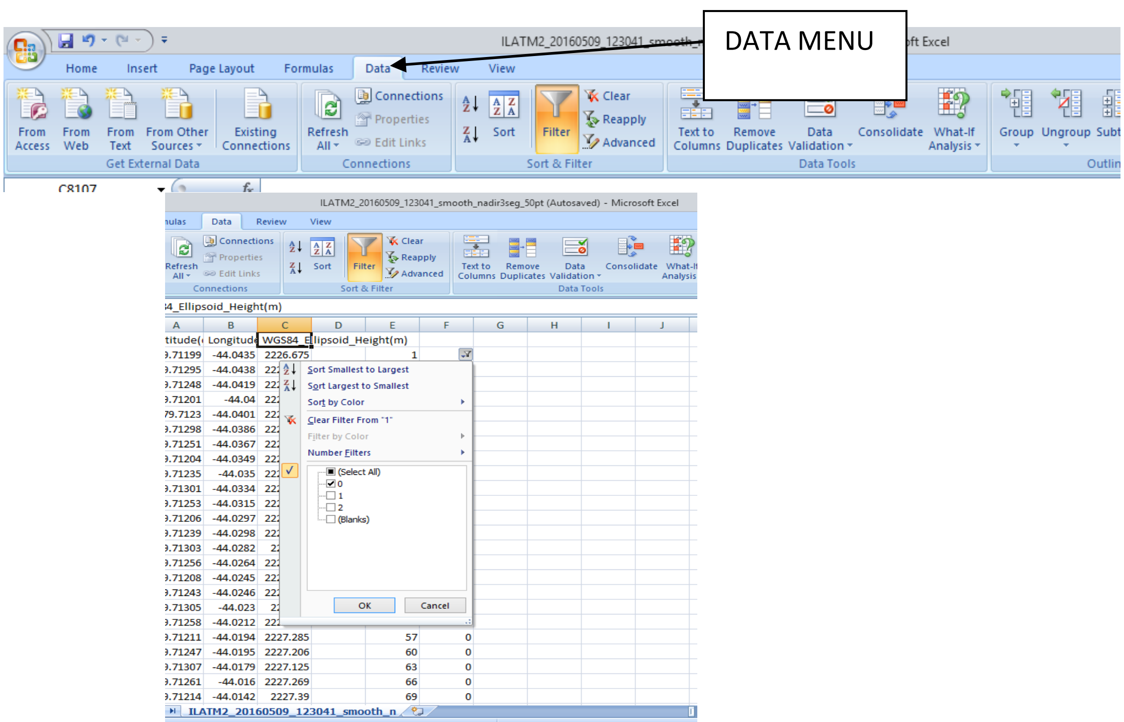
12. Now, in column F, beginning with cell F2, enter the following formula:
    =MOD(E2,3)
    Use the combination **Ctrl+Shift+↓** to highlight the entire column; select 'Fill' and 'down' to apply the formula to all of column F. Your table should like this:



13. Now we'll implement a filter to delete every third row in the sheet
    -Select all of column F using the Ctrl+Shift+↓ combination.
    -Choose 'filter' from the data menu.
    -Select Autofilter and using the drop-down menu, choose '0':



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14. Now your table will only be showing every 3rd data point from the original data set. This reduces the size of the file by several thousand points.

SAVING DATA INTO A CSV FILE (For Import into MyMaps):

15. Highlight and copy columns A, B, and C now that you have formatted and reduced the data set. Use **Ctrl + C** to copy those columns.

16. Select 'File', 'New,' and 'Blank Workbook'.

17. Paste your newly reformatted and reduced columns A, B, and C into the new workbook. Now you will save the workbook into a file format that can be important into MyMaps in Google.

18. Go to 'File,' and 'Save As': ATM_MAPFILE_NAMEDATE. In File Type, select the option for CSV file. There may be pop-up warnings explaining formatting changes in csv versus xml. Click 'OK' on each of these warnings.

Now you have a file ready to be imported as a map layer- move on to Part 3!

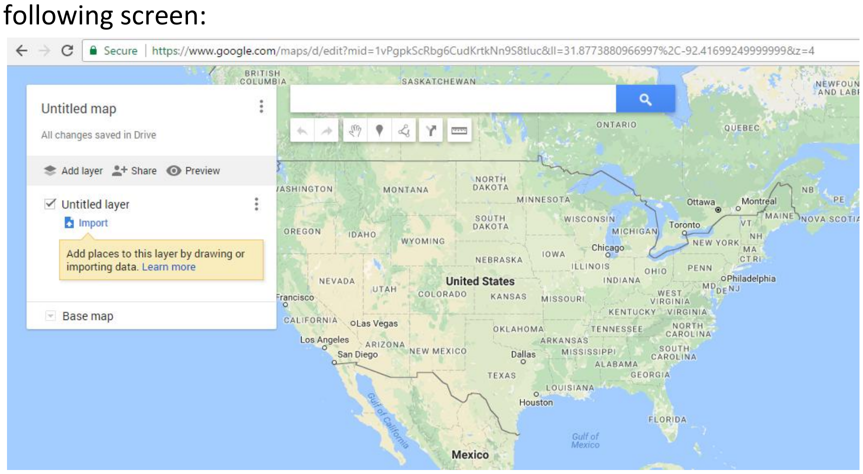
Part 3: Creating a Layer in Google MyMaps with OIB Data

1. Open your internet browser (this instruction set was created using Google Chrome).

2. In the browser window, type mymaps.google.com

3. You will be prompted to log into your Google account (if you do not have one, follow the prompts to Create a New Account before moving on).

4. Select the **+ CREATE A NEW MAP** button to (you guessed it ☺) create a new map. You'll see the following screen:



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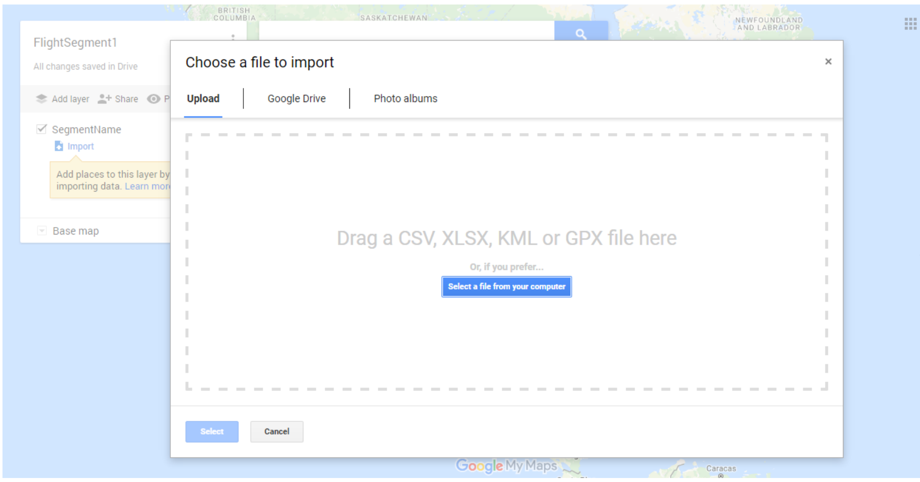
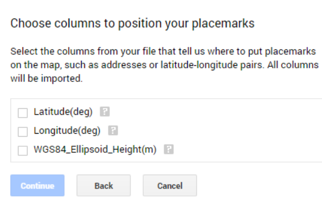
5. Click the words ‘Untitled map’ and change the name to ‘FlightSegment1’. Click the words ‘Untitled Layer’ and change the name to SegmentYourName (using your actual name)

6. Under ‘SegmentYourName,’ click Import.

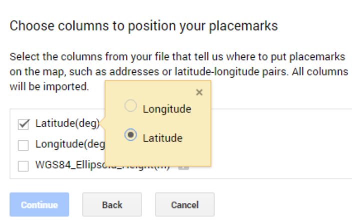
7. Choose the file you saved from Part 2 to import into your map



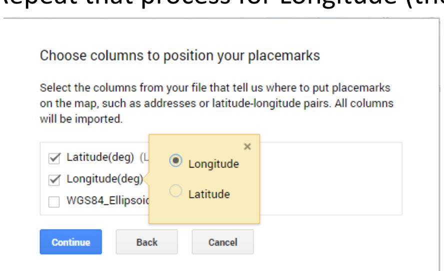
8. A pop-up window will appear to determine which columns in your csv file to use for position. If this does not appear, double check your saved file and make sure you have titles in each of your columns (Latitude, Longitude, Ellipsoid Height).



9. Click Latitude, and then select *latitude* in Google’s options:



10. Repeat that process for Longitude (then click ‘continue’):



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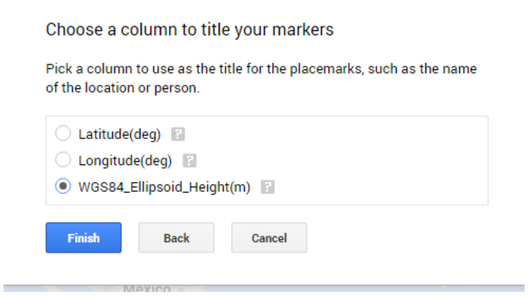
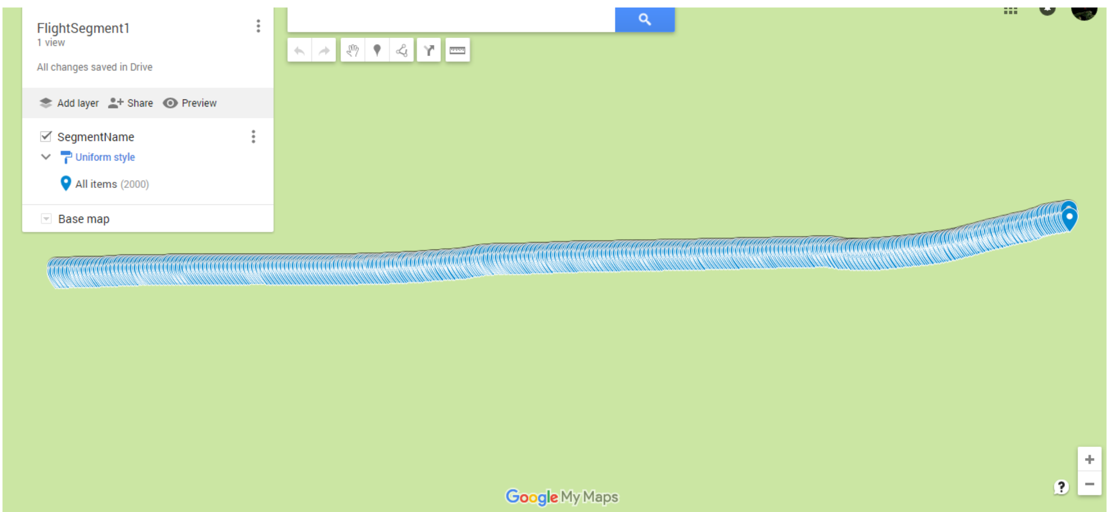
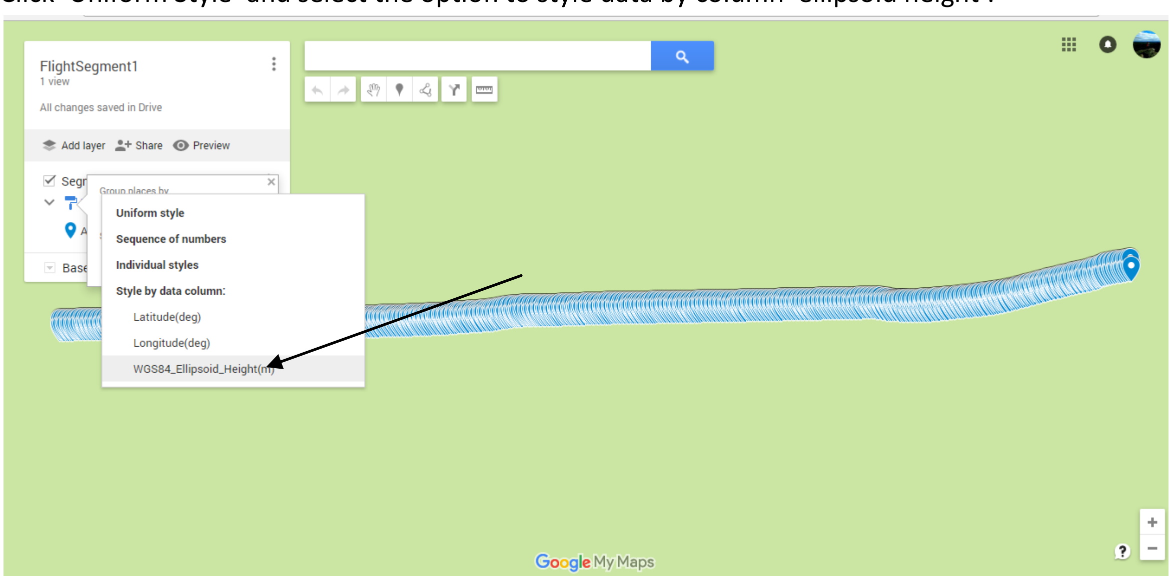
11. The next pop-up asks you to title your data markers that will appear on the map. Select the 3rd option (Ellipsoid height) and click 'Finish':



12. Your screen should look something like this:



13. Click 'Uniform Style' and select the option to style data by column 'ellipsoid height':



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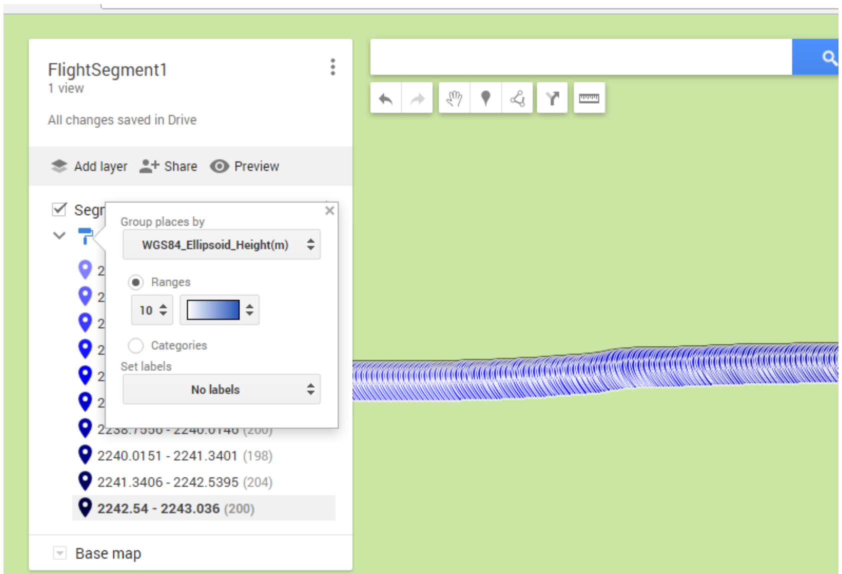
14. Select 'Range' and change the range value to 10



15. Describe based on the segment of data points on your map, how thickness or height level varies from West to East. Do you think this information is representative of the entire mission flown when this data was collected? What differences might you see if we extracted a flight segment closer to the East Coast of Greenland?

16. Change the 'Base Map' to satellite view. Zoom out until you can see the outline of the Greenland Ice Sheet. How does the flight segment you worked with today compare to the size of the entire Ice Sheet? What do you think are some advantages of using airborne missions rather than local ground-based measurements in polar ice studies? (Use examples from the exercises you completed in Parts 1-3 to support your response).

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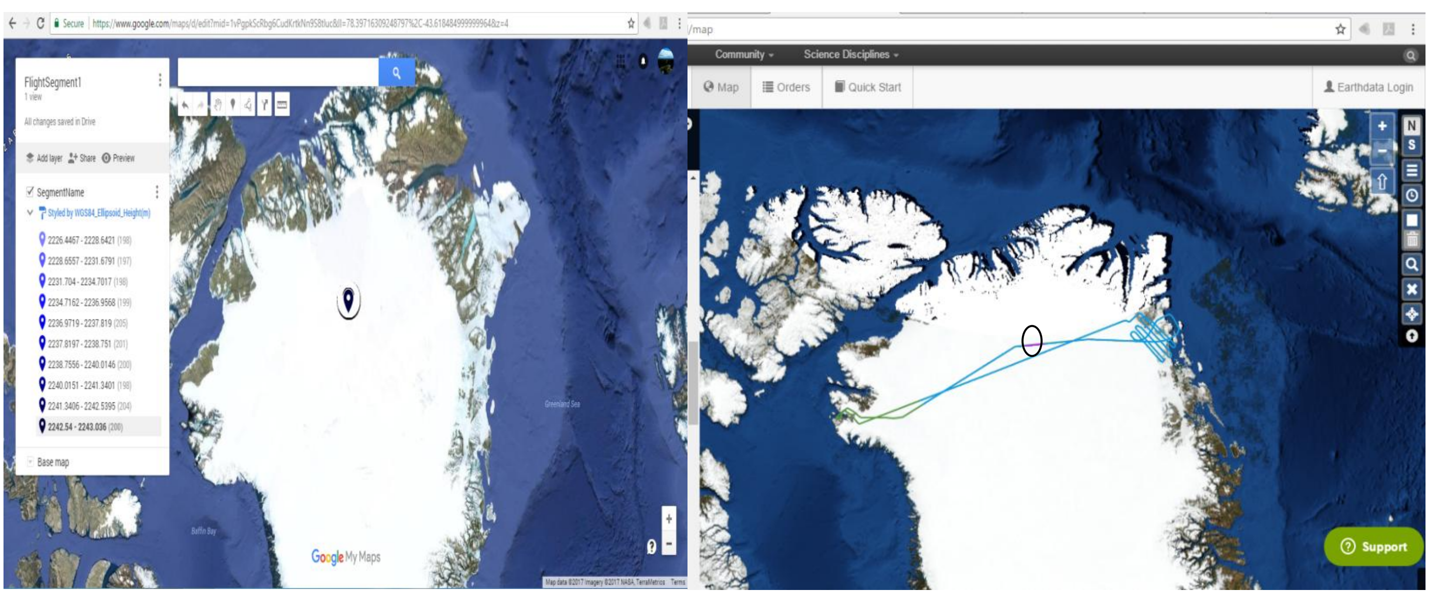
DELIVERABLES:

In a Microsoft Word Document or new Google Doc, take a screenshot of the flight path we collected data from on the NSIDC OIB portal. Mark, circle, highlight, or otherwise note the location of the segment of data we worked with on your map. *A sample is shown on the following page.* In that document, respond to the following discussion questions:

Q1.) What is the benefit of using airborne remote sensing techniques to collect data on polar ice? How might these techniques help us learn about other regions of our planet (tropics, deserts, cities, oceans, etc.). Be specific in your response and include any evidence you used to support your responses on page 16.

Q2.) If you could create your own data collection project using an airborne remote sensing campaign, what would you study? Briefly describe the timeline and geographic extent of your study including reasons for your choice.

Q3.) Ground measurements, airborne science measurements, and satellite imagery help provide a complete picture of our changing planet. In your own words, explain how these three techniques complement one another in polar ice studies. (Think: Do we need all three to understand our ice sheets fully? If we stopped one of the three, would we still gain sufficient information to support scientific models?) Cite any additional sources you use to respond to this question.



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Part 4: Team Flight Segment Profiles

Instructions: Now that you've worked through the process of extracting and mapping data from a specific science flight segment completed by NASA's Operation IceBridge, you and your team are challenged with creating a data story for a series of flight segments over outlet glaciers in Northeastern Greenland. You may choose to look for Zachariae-79N flight paths from other years in addition to the 2016 data. Watch the NSIDC Quickstart videos to learn how to search for data from a specific region in addition to using the temporal filters that we used in this activity.

1. With your team members, choose a series of flight segments covering the 'lawn mower' lines over the tidewater glaciers Zachariae and 79 N. Using the process you followed in Parts 1-3, each of you should reformat your data files into a csv file that can be imported into Google MyMaps.

2. Select a group leader to open a new map in MyMaps. That person should 'share' the map with all group members. (It works just like any Google Doc. Make sure to allow your team members to edit).

3. Each group member will title and add a new layer to that map for his or her chosen lawn mower line segment.

4. Using the MyMaps overlay you constructed as a team and the information from the NSIDC portal, create a visual representation of the tidewater glaciers in Northeastern Greenland. Be creative in your representation and use any media you'd like (PPT, YouTube, old-fashioned poster board, Prezi, etc.).