Arctic Climate Connections Activity 3 Exploring Arctic Climate Data

Part A. Understanding Albedo

Albedo is the ratio of incoming solar radiation that is reflected back into space. Albedo is expressed as a value from 0 to 1, with 1 meaning that 100% of the incoming solar radiation is bounced off the surface, and 0 meaning that all of the incoming radiation is absorbed by the surface of the Earth.

Note that albedo can be expressed either as a ratio or as a percentage. While reading about albedo, you are likely to find values expressed either way, for example, 30% or 0.30.

A surface that **reflects** most of the radiation it receives has *high albedo.*

A surface that **absorbs** most of the radiation it receives has *low albedo*.

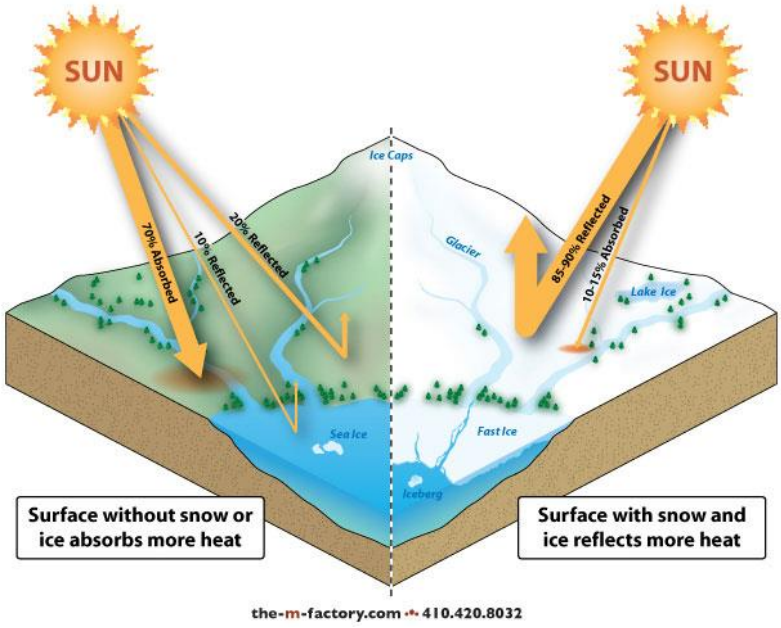


Image courtesy of the Smithsonian Institution.

The mathematical definition of albedo is the ratio of incoming to outgoing shortwave radiation.

outgoing shortwave radiation (w/m^2) ÷ incoming shortwave radiation (w/m^2) = albedo (unitless)

Incoming short-wave radiation is energy that is coming from the Sun. It is expressed in units of watts per square meter. In other words, the value tells us how many watts of energy are received per square meter of land area.

Part B. Analysis of Albedo, Snow Depth and Temperature

Next, work with three datasets from the Eureka weather station.

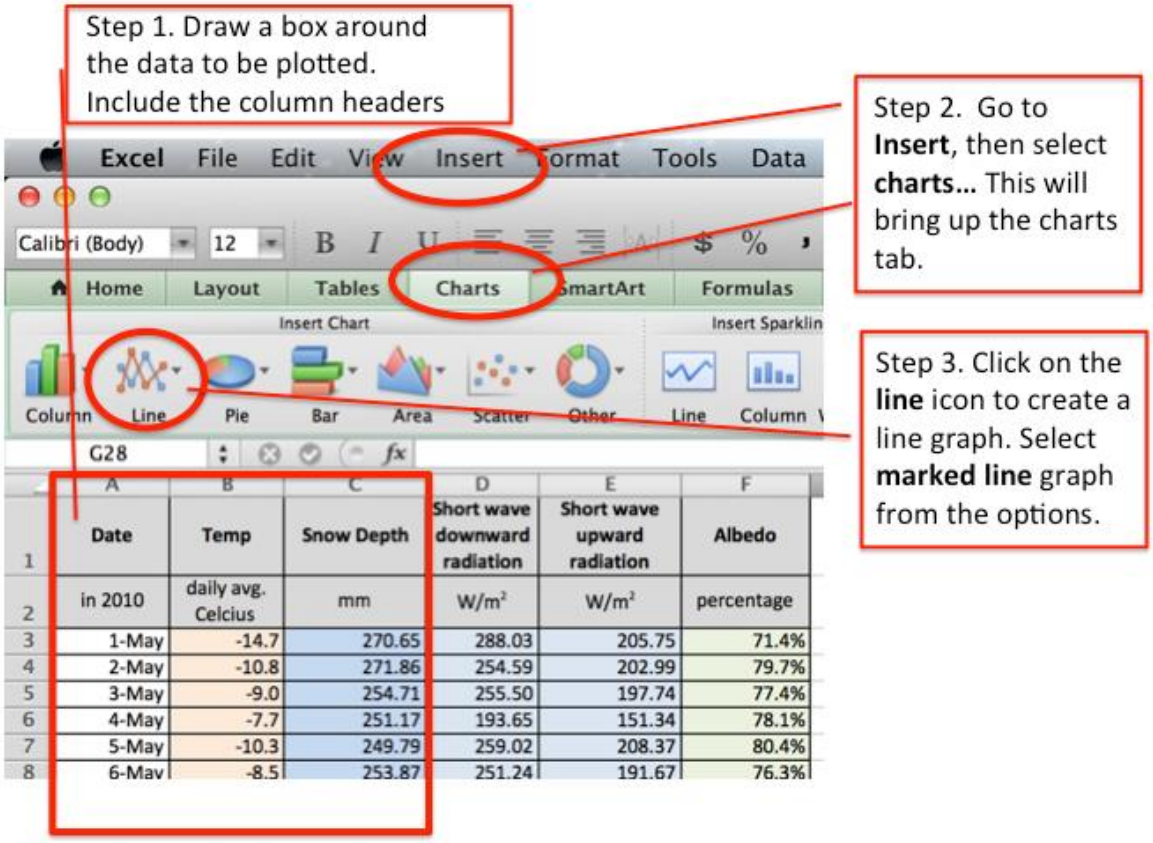
- Temperature
- Snow depth
- Albedo

Let's explore that correlation more closely. To do that, we'll want to zoom in on what's going on during the time when the snowpack is melting.

- Go to the Excel file. Save the file under your name by clicking *File > Save as…* and then adding your last name to the file name (such as Eureka_Smith.xlsx)
- Click on the tab called 'student datasets'. (The first tab contains all the same data, but remains there in case you make a mistake while working with the data.)
- That tab contains data for the entire year, but we only want to look at the spring and early summer, from May 1 through July 1.
- So you'll want to delete the rows that are before and after spring and summer.
- Keep the column headings, but delete rows from January 1 through April 30.
    - Highlight the rows, then right-click, then select 'delete.'
- Repeat this for July 2 – December 31
- Now you should just have data for May 1 through July 1.

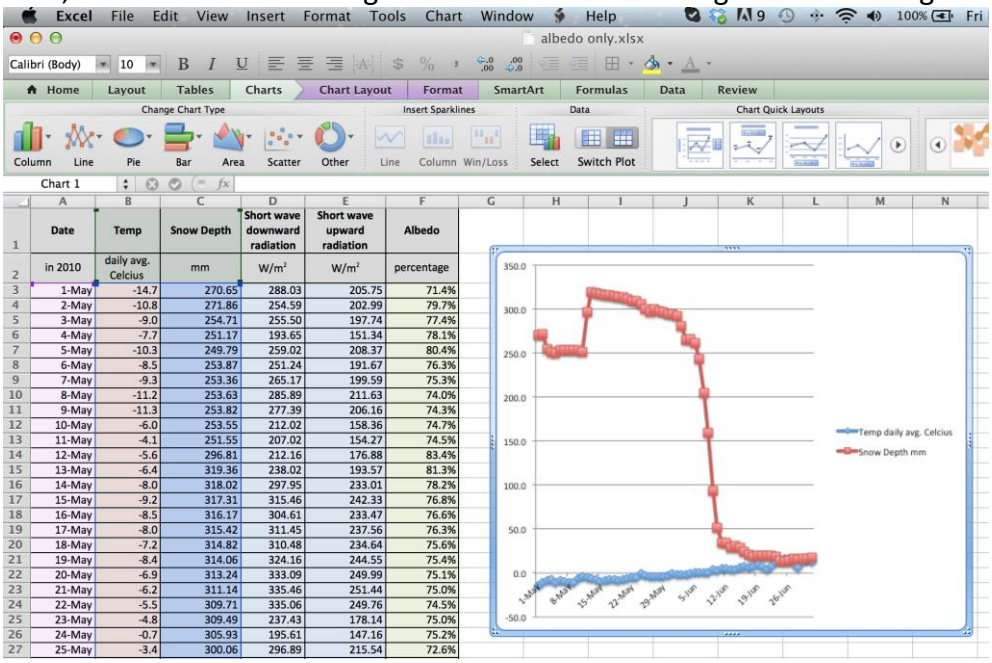
Next, create a marked line graph that plots temperature and snow depth over time.

- Starting with cell A1, drag the mouse to draw a box around columns A, B, and C, then drag your box down to surround all of the data. (It should go from A1 to C64.)
- In the uppermost menu, click on **insert** and select **chart…**
- This brings up the 'charts' tab. (Note – this may vary depending on your version of Excel.)
- From the types of charts, select **line** and then from the types of line graphs, select **marked line graph**.



	A	B	C	D	E	F
1	Date	Temp	Snow Depth	Short wave downward radiation	Short wave upward radiation	Albedo
2	in 2010	daily avg. Celcius	mm	W/m²	W/m²	percentage
3	1-May	-14.7	270.65	288.03	205.75	71.4%
4	2-May	-10.8	271.86	254.59	202.99	79.7%
5	3-May	-9.0	254.71	255.50	197.74	77.4%
6	4-May	-7.7	251.17	193.65	151.34	78.1%
7	5-May	-10.3	249.79	259.02	208.37	80.4%
8	6-May	-8.5	253.87	251.24	191.67	76.3%

A chart will appear somewhere on your screen. Drag it to a location where it does not overlap the data, and then click and drag the corners to make it larger and more legible.



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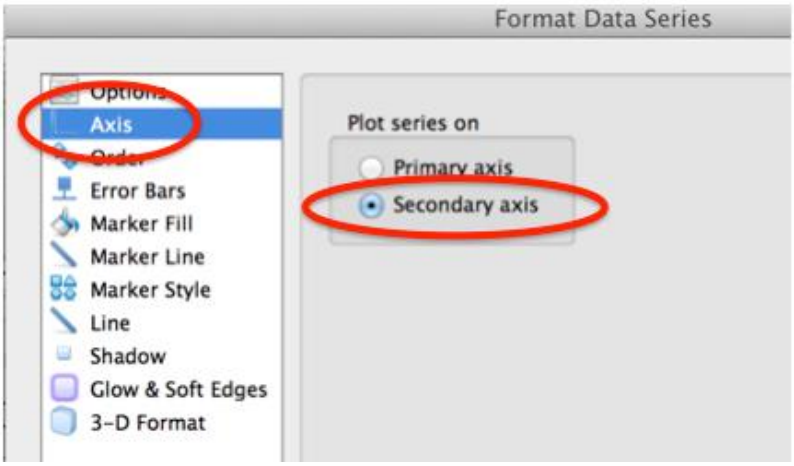
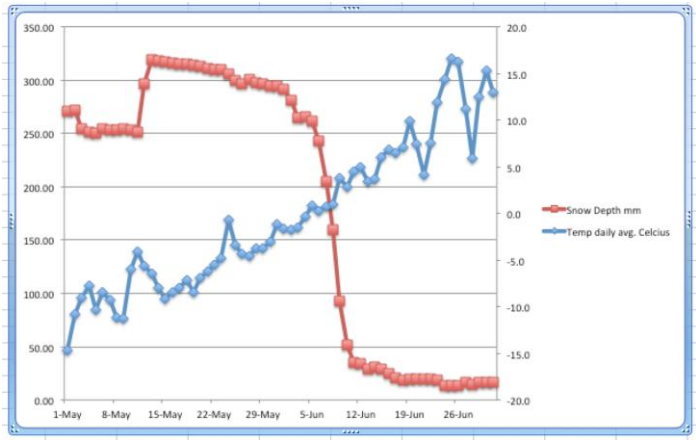
5	3-May	-9.0	254.71	255.50	197.74	77.4%
6	4-May	-7.7	251.17	193.65	151.34	78.1%
7	5-May	-10.3	249.79	259.02	208.37	80.4%
8	6-May	-8.5	253.87	251.24	191.67	76.3%
9	7-May	-9.3	253.36	265.17	199.59	75.3%
10	8-May	-11.2	253.63	285.89	211.63	74.0%
11	9-May	-11.3	253.82	277.39	206.16	74.3%
12	10-May	-6.0	253.55	212.02	158.36	74.7%
13	11-May	-4.1	251.55	207.02	154.27	74.5%
14	12-May	-5.6	296.81	212.16	176.88	83.4%
15	13-May	-6.4	319.36	238.02	193.57	81.3%
16	14-May	-8.0	318.02	297.95	233.01	78.2%
17	15-May	-9.2	317.31	315.46	242.33	76.8%
18	16-May	-8.5	316.17	304.61	233.47	76.6%
19	17-May	-8.0	315.42	311.45	237.56	76.3%
20	18-May	-7.2	314.82	310.48	234.64	75.6%
21	19-May	-8.4	314.06	324.16	244.55	75.4%
22	20-May	-6.9	313.24	333.09	249.99	75.1%
23	21-May	-6.2	311.14	335.46	251.44	75.0%
24	22-May	-5.5	309.71	335.06	249.76	74.5%
25	23-May	-4.8	309.49	237.43	178.14	75.0%
26	24-May	-0.7	305.93	195.61	147.16	75.2%
27	25-May	-3.4	300.06	296.89	215.54	72.6%

You are plotting two variables (snow depth and albedo) vs time. So there will be two y-axes, one for snow depth and one for albedo. Put snow depth on the y-axis on the left side. Put temperature on the y-axis on the right side.
To do that:

- Click the line on the graph that shows temperature.
- On the **Format** menu, click **Selected Data Series**.
- On the **Axis** tab, click **Secondary axis**.



Your graph should now look something like this:



Following the same steps as above, create another graph that plots snow depth and albedo on the same graph.

- Note – One way to make this plot is to draw a box around Columns A, B, C, and D (even though you don't want Column B). Then create a marked line graph. On the graph, click on the line that represents that column and delete that data series.
- Put snow depth on the y-axis on the left side. Put albedo on the y-axis on the right side.

Use the graphs to answer questions 9 through 15 on your worksheet.

Part C: Think Globally

Let's think about how this process is related to global climate on a larger scale. Examine the paired images below that show changes in snow and ice cover over time.
How has the albedo of this area changed over time? In turn, how does that affect further melting? What are the implications for global climate change?

Okpilak Glacier, Alaska

June 1907

Image credit:
Leffingwell, Ernest. 1907. Okpilak Glacier: From the Glacier Photograph Collection. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media.

August 2004

Image credit:
Nolan, Matt. 2004. Okpilak Glacier: From the Glacier Photograph Collection. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media.