Final Project EOSC 442

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Deadline #2: Preliminary Results

1. **Revised Title:** The yearly rate of change of the permafrost active layer thickness between 2009 to 2017 at Owl River in Auyuittuq National Park, Tanquary Fiord in Quttinirpaaq National Park.
2. **Revised research question:** Is there a significant difference between the yearly rates of change of active layer thickness between Quttinirpaaq and Auyuittuq? What is the relationship between air surface temperature and active layer thickness at these locations?
3. **Revised Proposed Analysis:** Each of the locations' data will be plot against air surface temperature to investigate if there a relationship or significant correlation between air surface temperature and active layer thickness. Finally the yearly rates of change at the two locations will be compared through a a one-way ANOVA test to check for significant difference. We intend to compare our results with the "Thermal State of Permafrost and Active Layer in Central Asia during the International Polar Year." study that is described at the end of this document.
4. **Summary, Data Analysis and Graphs:**

Dataset #1: The Active Layer Thickness

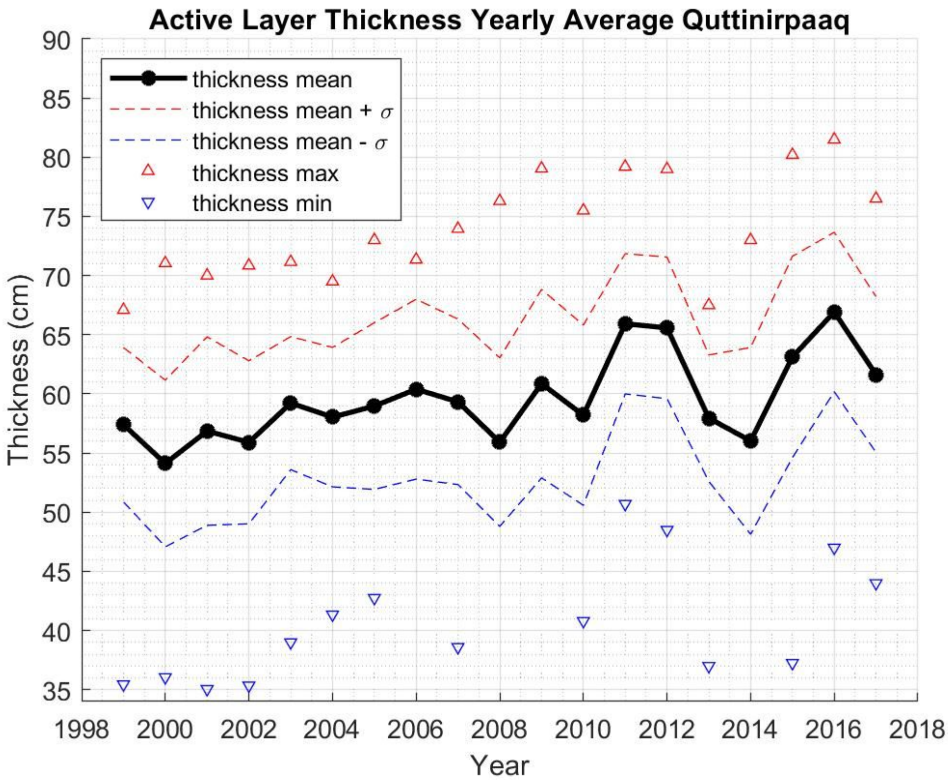
- Tried to use fopen and textscan to load data but this did not load the entire file.
- Converted file to xlsx format and used xlsread to load the data instead.
- **Goal #1:** To find the average thickness of the active layer for each year between 1999 to 2017 as measured in Quttinirpaaq.
- The data logs the active layer thickness **twice** at 100 grid points each year. So the data was read as a 1900 by 6 matrix, with column 1,2,3,4,5 & 6 as day,month,year,grid cell number, first measurement and second measurement respectively.
- From this we first created a 1900 by 2 matrix of the first measurement as column 1, and second measurement as column 2.
- This matrix was transposed into a 2 by 1900 matrix- row 1 as measurement 1 and row 2 is measurement 2. This would mean each column represented the data logged on the same day and at the same location(same grid cell that is). This was done so we could run nanmean on our transposed matrix so it could produce a row vector of column means. Nanmean on a

matrix only finds the mean of the columns, which is why transposing the matrix was required if we had to calculate average thickness measured at each location.

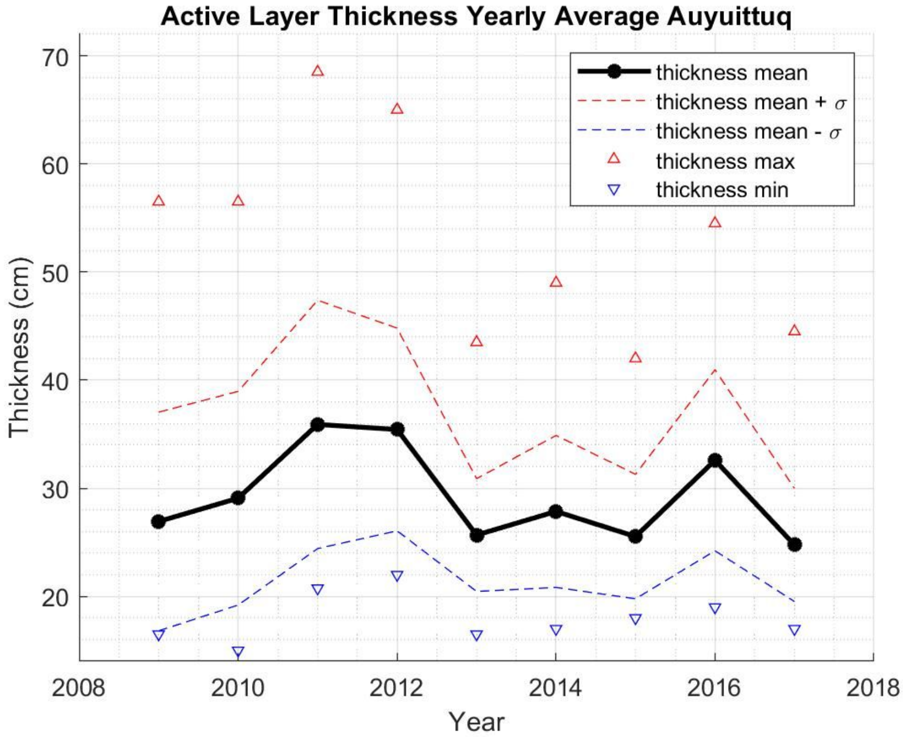
- Before we could run nanmean, the matrix was updated so that any values with -99999 are interpreted as NaN. nanmean was run on the updated matrix. A snippet of this code is shown in line 11 of the figure below.

```
7   first_thickness = quttinirpaaq_data(:,5);
8   second_thickness = quttinirpaaq_data(:,6);
9   matrix1=[first_thickness(:),second_thickness(:)];
10  matrixT= transpose(matrix1);
11  matrixT(matrixT == -99999) = NaN;
12  average_thickness = nanmean(matrixT);
```

- After this the average thickness vector has 1900 values, with 100 values (from 100 grid cells) for each year between 1999 and 2017 inclusive.
- A for loop was written to find the average thickness each year, minimum for each year, maximum for each year and the standard deviation for the year. This data let us make an initial graph of thickness versus years to see the trend in active layer thickness. The graph below shows the preliminary data of the Active Layer Thickness measured in Quttinirpaaq.



- The legend was moved to the top left so data points were not covered.
- The entire process was repeated for the data collected at Auyuittuq. The graph below was created from the data at Auyuittuq.



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- Next we will be calculating the rate of change in thickness for each data set between 2009 to 2017.

Dataset #2: Temperature

- Air temperature datasets were obtained from 'climate.weather.gc.ca'
- Both datasets contained the maximum, minimum, and average temperature per month over the course of time in the dataset
- Each of these mean temperatures were compiled and calculated per month
- Data loaded using xlsread (excel file)
- nanmean was used to obtain the average as there were some missing data in the dataset
- Legend positioned southeast to avoid covering the plot
- The data used for Quttinirpaaq National Park was obtained in Eureka (Southwest of the park)
- The data used for Auyuittuq National Park was obtained in Cape Hooper (North of the park)
- We will be analyzing the temperature data to see the impact this will have on permafrost thickness and their rate of change (The influence of air surface temperature on permafrost thickness)

Plot snippet:

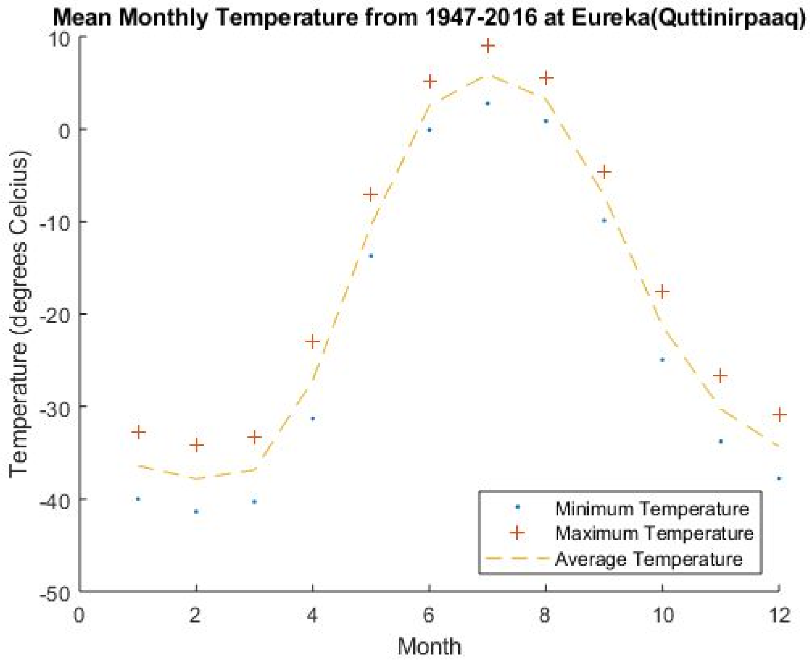
```
for month = 1:12
    meanmintemp(month)  = nanmean(Qmintemp(Qmonth == month));
    meanmaxtemp(month)= nanmean(Qmaxtemp(Qmonth == month));
    meantemp(month)= nanmean(Qmeantemp(Qmonth == month));
end

months = (1:12);
figure(1);
hold on
plot(months,meanmintemp,'.');plot(months,meanmaxtemp,'+');plot(months,meantemp,'--');
legend('Minimum Temperature','Maximum Temperature','Average
Temperature','Location','se');
title('Mean Monthly Temperature from 1947-2016 at
Eureka(Quttinirpaaq)');xlabel('Month');ylabel('Temperature (degrees Celcius)');

% table
t_month = transpose(months);
t_max = transpose(meanmaxtemp);
t_min = transpose(meanmintemp);
t_temp = transpose(meantemp);
T = table(t_month, t_min, t_temp, t_max)
```

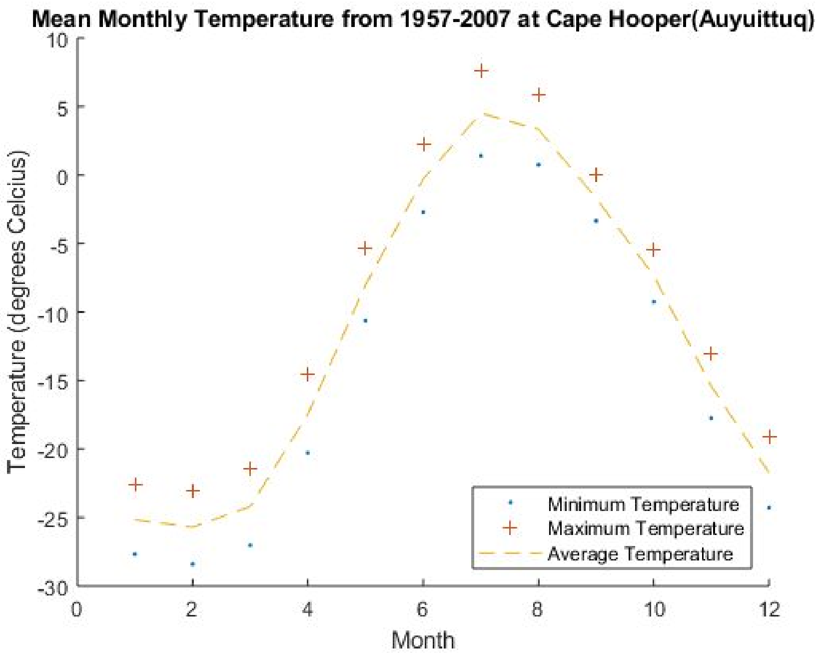
Quttinirpaaq (Eureka):

t_month	t_min	t_temp	t_max
1	-39.984	-36.394	-32.749
2	-41.348	-37.804	-34.204
3	-40.306	-36.846	-33.344
4	-31.288	-27.159	-22.99
5	-13.735	-10.413	-7.0594
6	-0.089855	2.5348	5.1246
7	2.787	5.9275	9.029
8	0.86618	3.2574	5.5985
9	-9.871	-7.2246	-4.5319
10	-24.926	-21.297	-17.607
11	-33.784	-30.265	-26.693
12	-37.764	-34.329	-30.838



Auyuttuq (Cape Hooper):

t_month	t_min	t_temp	t_max
1	-27.674	-25.174	-22.626
2	-28.405	-25.693	-23.088
3	-27.024	-24.2	-21.407
4	-20.283	-17.457	-14.583
5	-10.633	-8.025	-5.3725
6	-2.7024	-0.28049	2.219
7	1.4	4.5103	7.5744
8	0.74524	3.3286	5.8643



9	-3.3429	-1.6952	-0.021429
10	-9.26	-7.3525	-5.395
11	-17.74	-15.43	-13.07
12	-24.283	-21.732	-19.117

Comparison Study:

Zhao, Lin, Qingbai Wu, S.s. Marchenko, and N. Sharkhuu. "Thermal State of Permafrost and Active Layer in Central Asia during the International Polar Year." *Permafrost and Periglacial Processes*21, no. 2 (June 08, 2010): 198-207. doi:10.1002/ppp.688.

This study compares the permafrost temperatures and active layer thickness over 3 areas in central Asia. Data was collected in Qinghai-Tibetan Plateau, Mongolia, and the Tien-Shan Mountains over the past 30-40 years depending on the location. The data showed that the although there was an increase in the ALT in all regions over the entire periods of collection, the rates of change among the regions varied. These variations were connected to the difference in site environments and local conditions. Sites that had mean annual ground temperatures closer to 0C and ice-poor sediments had and greater increases of ALT. We can compare the specific data for annual mean ground temperatures and site sediment conditions to draw conclusions about the results of our ANOVA test between the two sites.