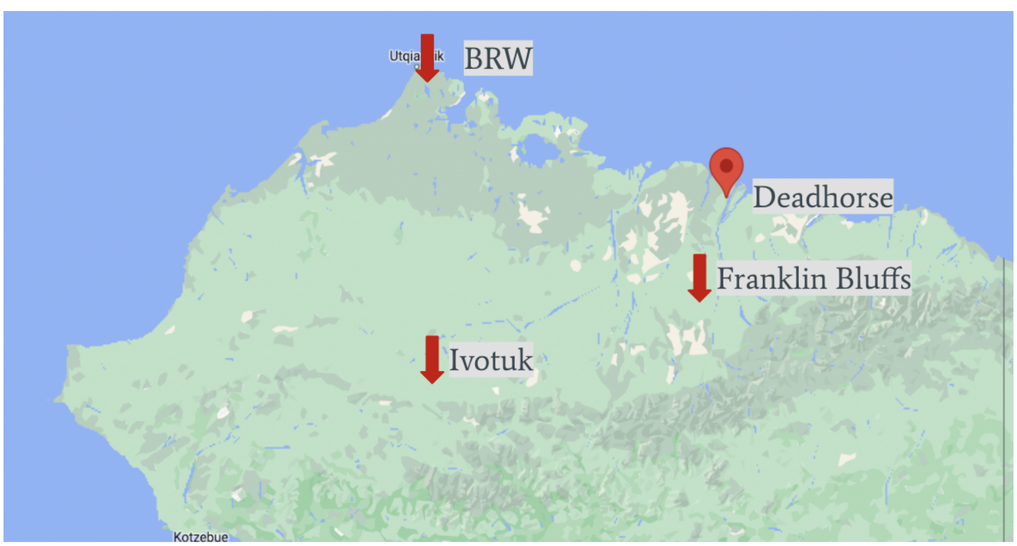
1. Introduction:

In the near past, arctic peatlands have served as an important net sink for carbon by sequestering it every summer through primary productivity and then trapping it when organic matter and soil freezes over in the winter. However climate scientists suspect that warming polar temperatures due to anthropogenic climate change will lead to increased soil respiration and therefore CO2 emissions from arctic peatlands. Studying the effects of a changing climate on these carbon-rich peatlands is critical to understanding the accumulation of CO2 in the atmosphere.

The summer of 2022, I was tasked with visualizing soil temperature of arctic peatlands in the Alaskan North Slope (Figure 1a). in the interest of confirming its resonance with North American Regional Analysis (NARR) soil temperature data , a reanalysis product, which is used to determine Net Ecosystem Exchange (NEE) in the Alaskan North Slope. This temperature is incorporated into the Tundra Vegetation Photosynthesis and Respiration Model (Polar-TVPRM) which produces a NEE estimate for regional carbon flux.

I focused on soil temperatures at Ivotuk, Deadhorse, Franklin Bluffs, and Utqiagvik (BRW for all intents and purposes in this paper). Because shallow soil temperatures of less than 1 meter were found to be the most influential for calculating regional carbon flux[1], this project focused on measurements taken under .4 meters of depth.

Site Domain (a)



[1] Luke Schiferl Paper (unpublished)

Critical features we looked for in our observations included the zero curtain period, increasing summer temperatures, a lengthening of summer, and winter temperature increase. It is critical that NARR modeled temperature reflect the pattern of these features in the Alaskan North Slope.

2. Materials & Methods:

Soil Temperature Observations

For our initial orienting observations, we used a borehole record of summer soil temperature prepared by the University of Alaska FairBanks for the Alaska Department of Transportation and Public Facilities from 1984-2001.[2]

Daily shallow peatland soil temperature measurements from about 2007-2018 were also pulled from the Geophysical Institute at the University of Alaska FairBanks. We used only observations taken with a thermistor array MRC temperature probe.

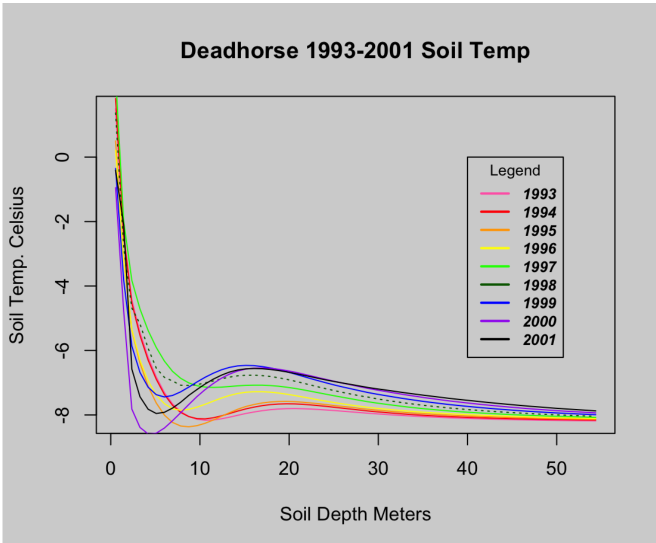
Preliminary Orienting

To gain an understanding of soil temperature trends with respect to depth, I first visualized Deadhorse Summer temperatures from 1993-2001 over 50 meters depth. Every year had a respective measurement for all depths and was individually graphed with a different color on an x axis of depth and y axis of temperature(Figure 2a). We also visualized Deadhorse soil temperature on an x axis of year and a y axis of temperature to show the change in temperature of shallower soils (Figure 2b).

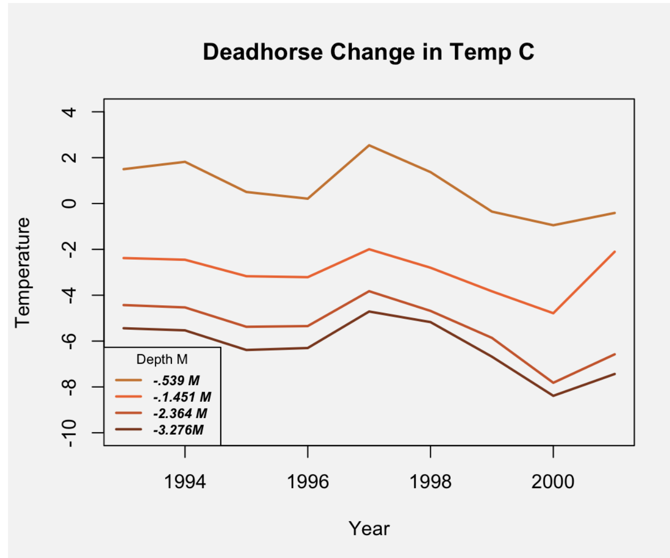
These visualizations validated that Deadhorse peatland temperatures are increasing in depths over 10 meters in this time interval . The variability demonstrated in shallower depths at this site indicates a high sensitivity to changing atmospheric conditions and meteorology which can affect the sign of temperature change over time, since factors such as precipitation can enable surface soil to be more or less sensitive to air temperature changes.

[2] https://arcticdata.io/catalog/view/doi:10.5065/D6ZG6QCB

Deadhorse (a)



Deadhorse (b)



Changes in Monthly Mean Soil Temperature

In order to isolate certain seasonal changes over time, we decided to visualize the change in every month's mean temperature from about 2006-2018.

To do this, we separated our observations from every site by 0.1 meter depth intervals. We grouped the data according to the month they were recorded and took the mean of all measurements recorded in that month. This produced 4 data frames per site that contained the mean soil temperature for every month in every year from 2006-2018.

Implementing NARR Comparisons

NARR only produced a renanalyzed temperature for .1 meter and .4 meters. Real observations from .1-.2 meters were used to compare to NARR .1 meter values, and real observations from .3-.4 meters were used to compare to NARR .4 meter values.

3. **Results:**

Critical seasonal changes

The observed soil temperatures in all focused sites demonstrate an increase in late winter temperatures, February to April, from about 2007-2018 and across all depths 0-.4 meters. A trend of decreasing summer temperatures in Deadhorse, Ivotuk (Moss), and Franklin Bluffs was also salient across all depths, while BRW seemed to remain steady throughout the time interval visualized. Figures 3a, 3b, 3c, and 3d demonstrate this trend for up to .1 meter.

The darkest orange depicted across these plots represents November, the month that serves as a proxy for determining changes in the fall freezeback zero curtain period. November soil temperatures are seen to be lasting increasingly well into November for Deadhorse and Franklin Buffs, especially for depths 0-.2 M.

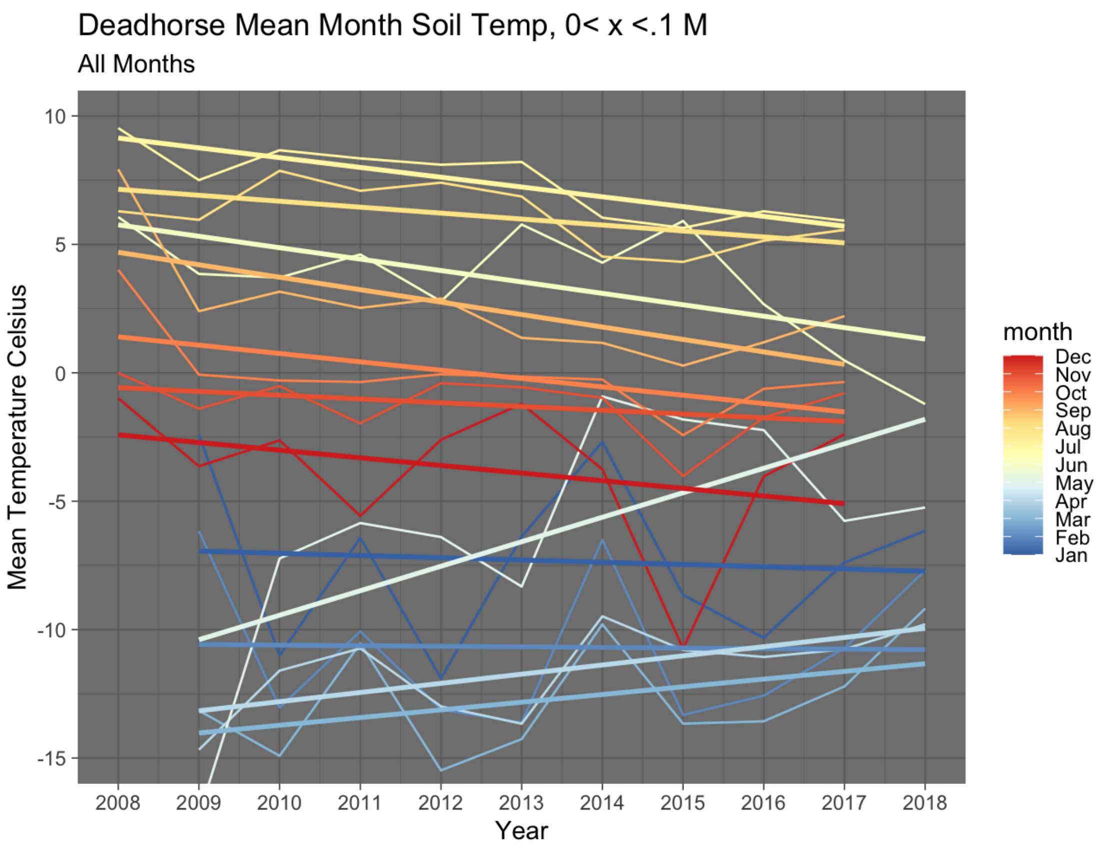


Figure 3a

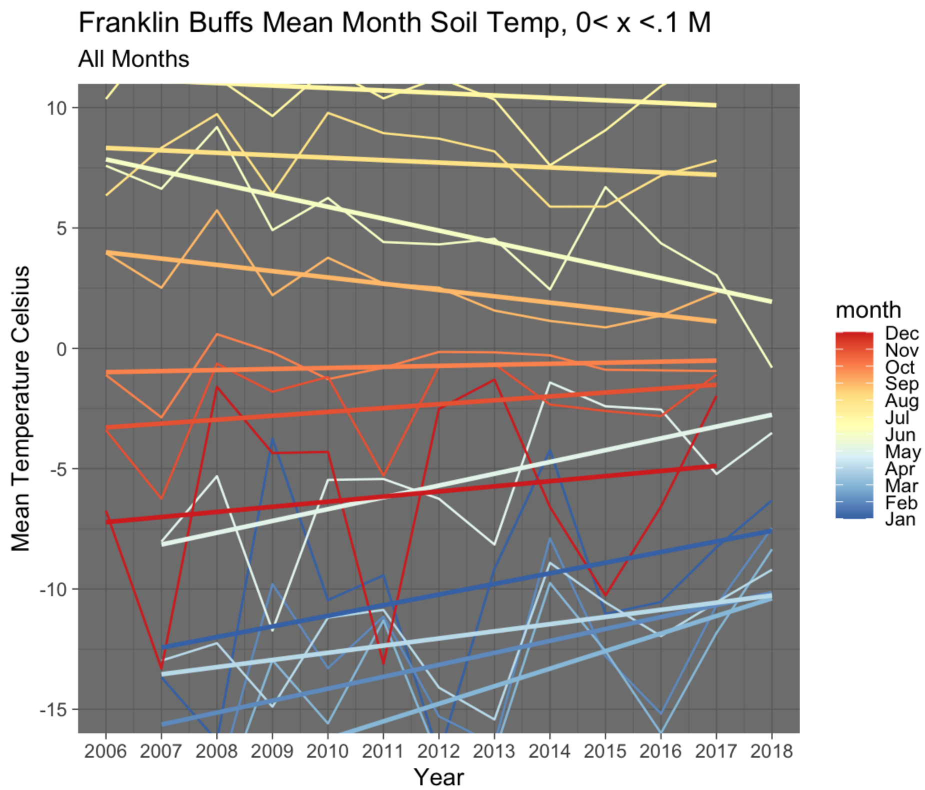


Figure 3b

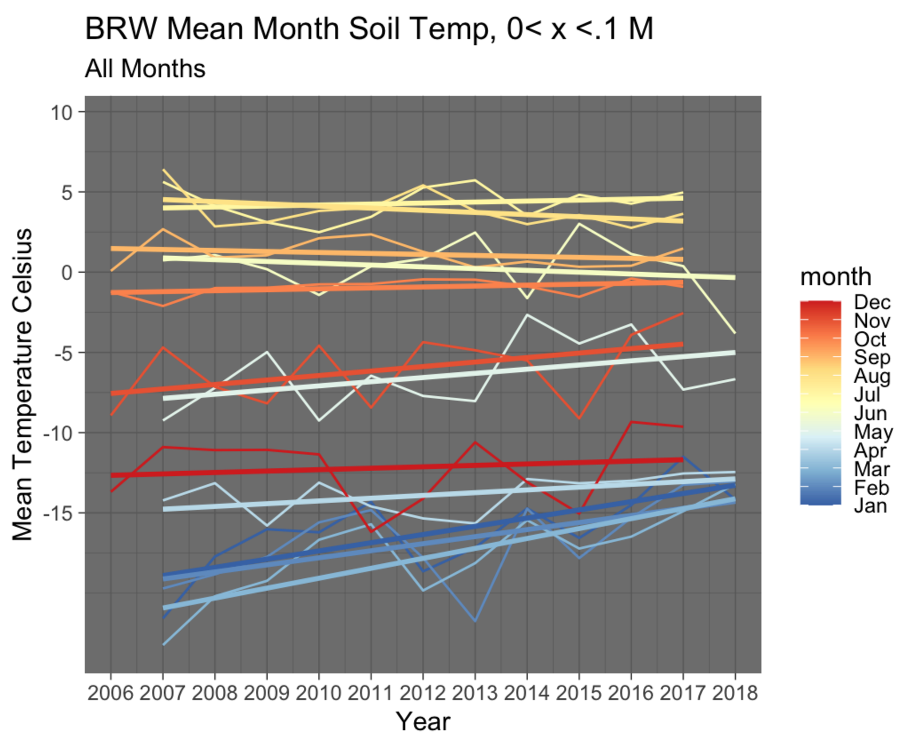


figure 3c

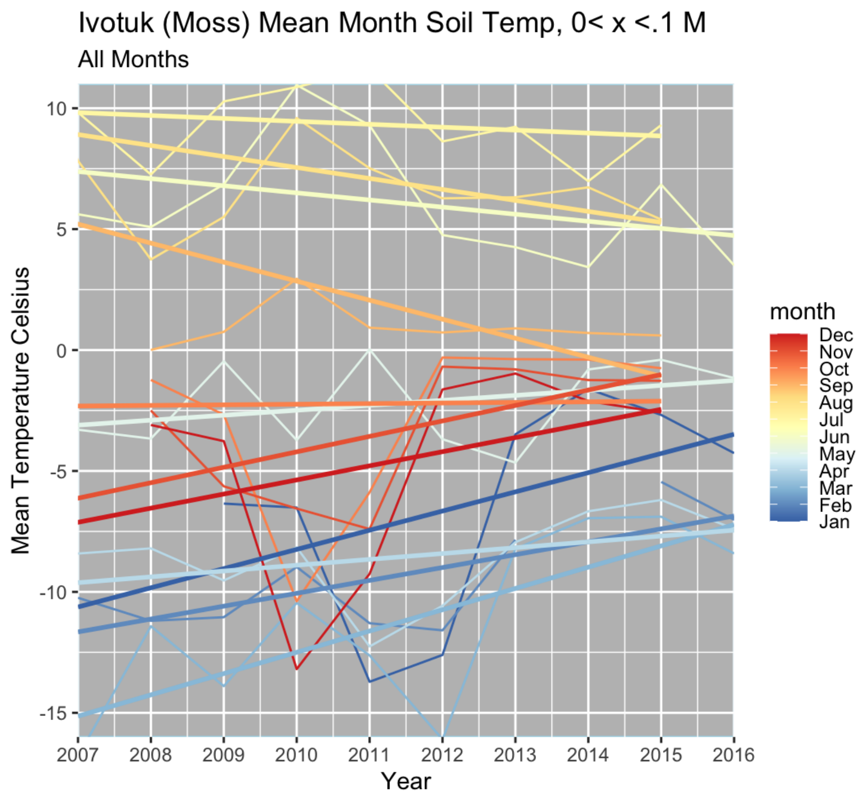
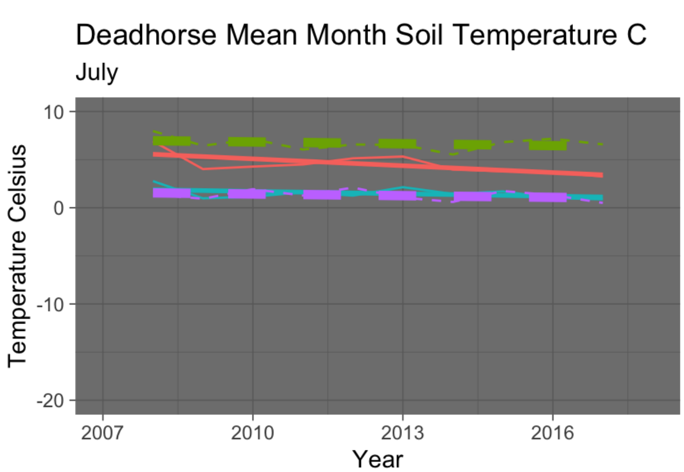


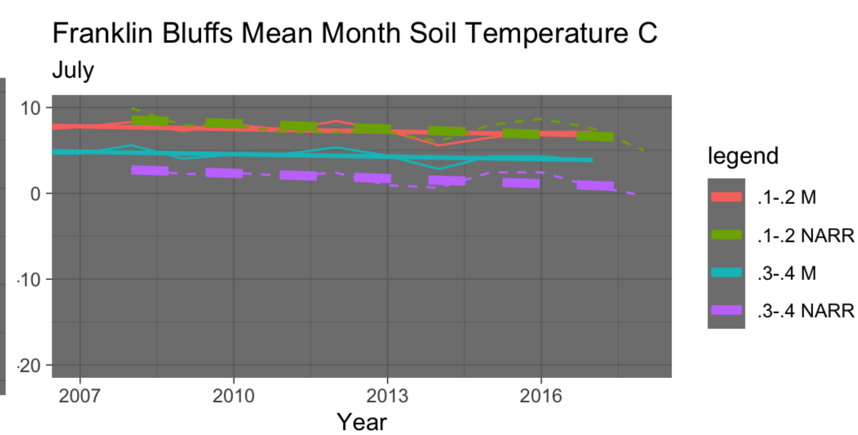
Figure 3d

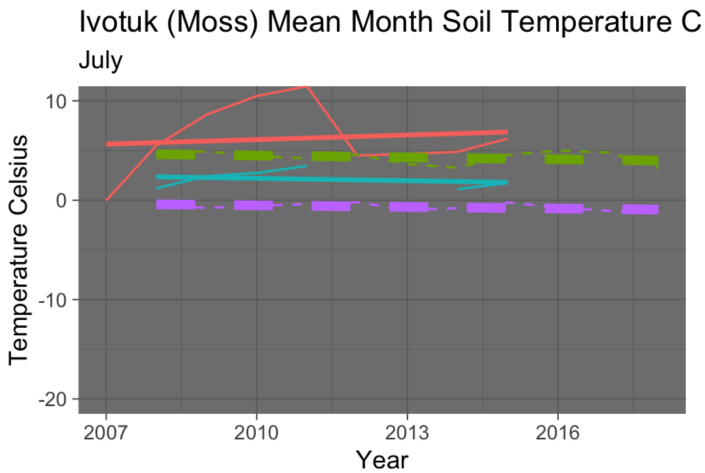
The features demonstrated in every month over time were compared with that of the reanalysis NARR soil temperature used for Polar-TVPRM. In this paper, we use July to represent patterns observed in summer (Figures 3e, 3f, 3g, 3h), February to represent those in late winter (Figures 3i, 3j, 3k, 3l), and November to represent changes in the zero-curtain period for all sites (Figures 3m, 3n, 3o, 3p).

Figure 3e

Figure 3f







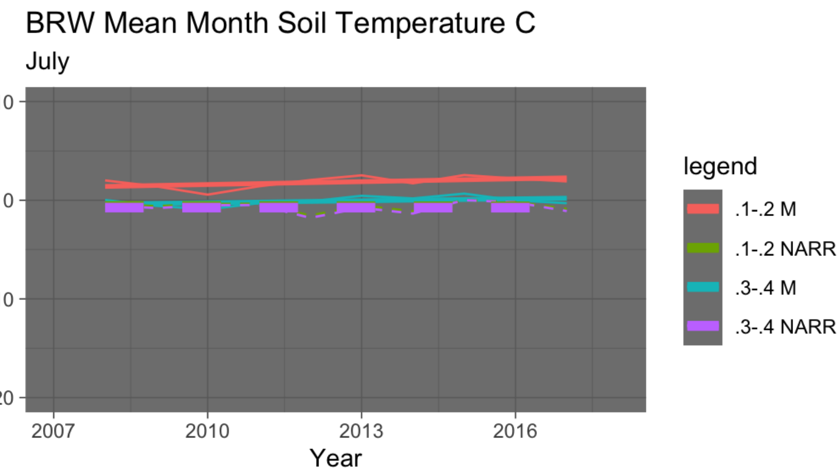
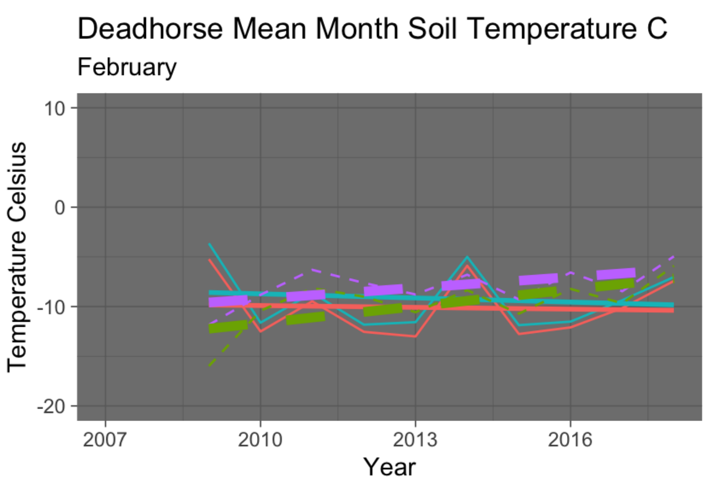


Figure 3g

Figure 3h

The above figures of July indicate that NARR is rarely more than about 5 degrees celsius away from the true observed temperature at the four sites. For this month, NARR more accurately depicts soil temperature at the deeper level than than the surface. It also correctly illustrates how arctic peatlands at this time of the year exhibit colder soil temperatures near the surface of the soil column.



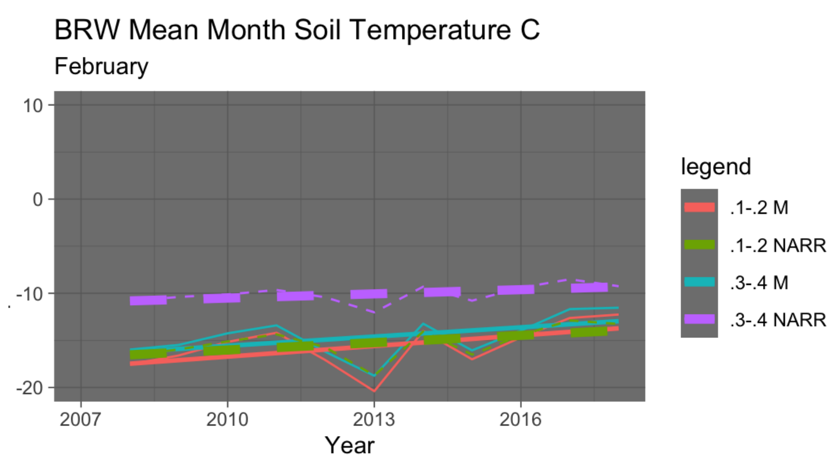
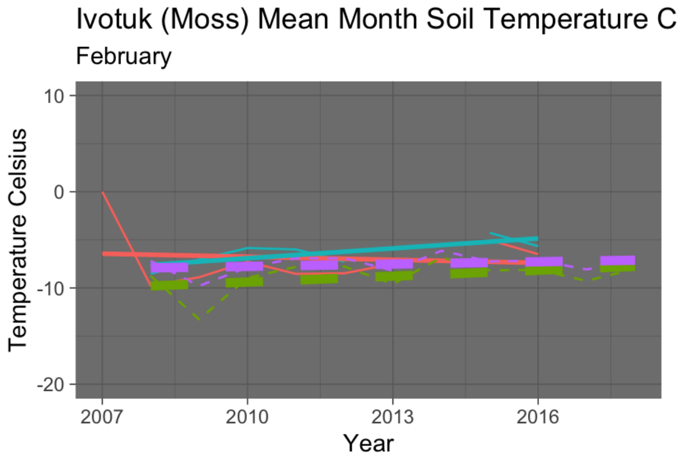


Figure 3i

Figure 3j



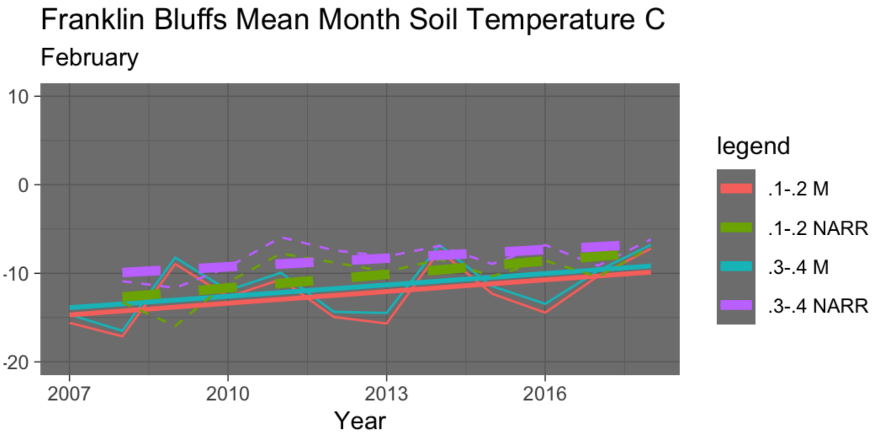
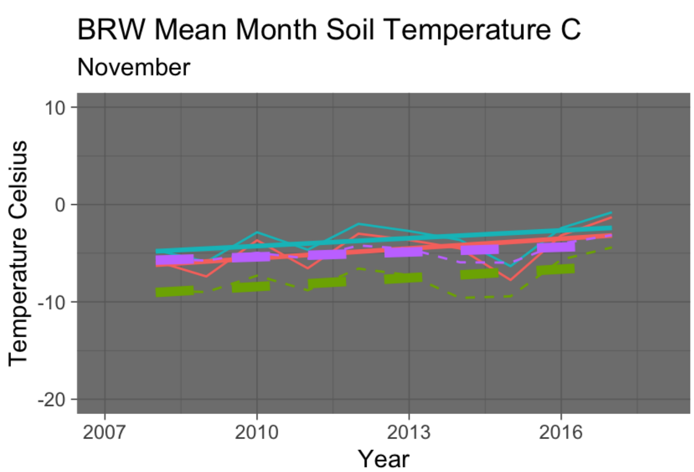


Figure 3k

Figure 3l

Among the February figures, NARR seems to fail to demonstrate the slight decrease in February temperatures at Deadhorse, however, at this site late winter temperatures begin to demonstrate increase in March. March at Deadhorse more closely resembles February at the rest of these sites, where there is an evident increase in temperatures. NARR calculates a degree of change (slope) in mean February temperatures rather accurately at BRW, Ivotuk (moss), and Franklin Bluffs. At BRW, the deeper soil temperatures visualized seem to have a warm bias, and the same is observed for both depth levels in Franklin Bluffs.



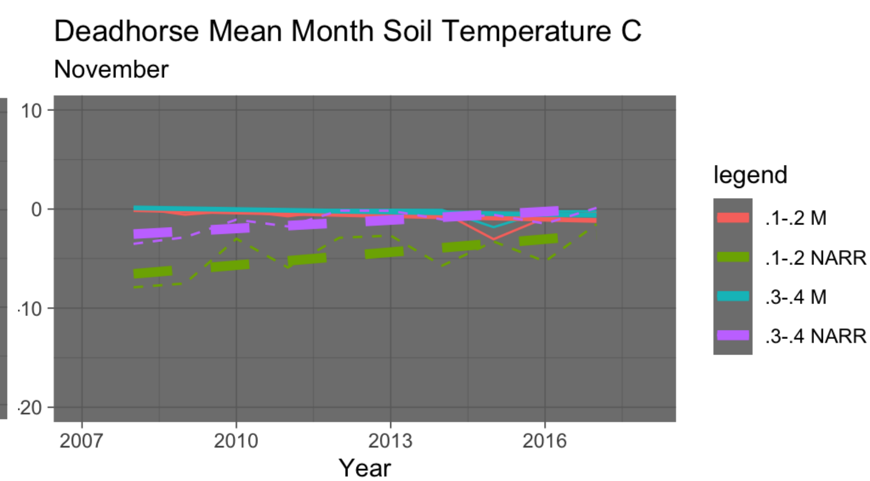


Figure 3m

Figure 3n

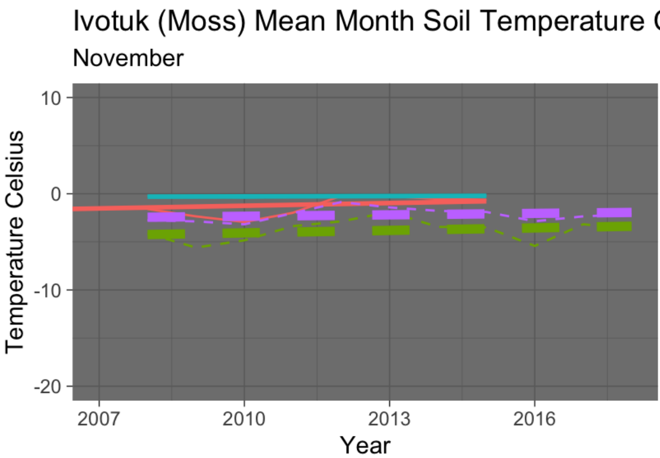


Figure 3o

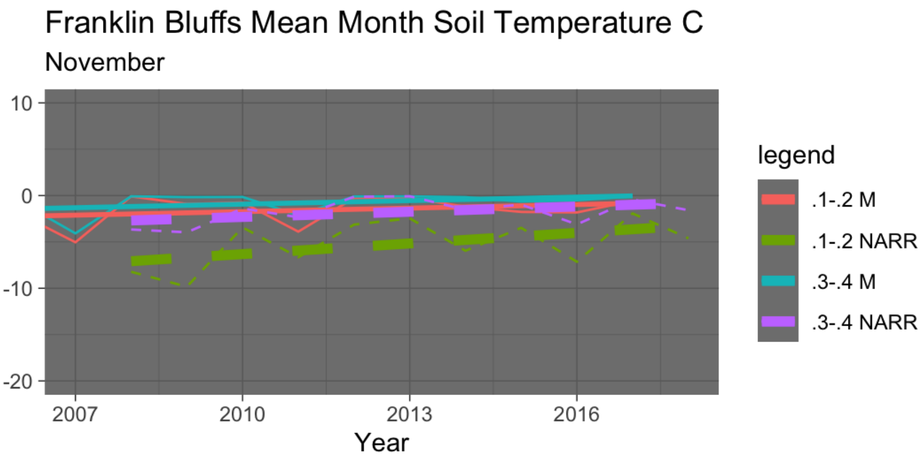


Figure 3p

In figures 3m, 30, and 3p, NARR rather accurately demonstrates an almost equal degree of increase in the soil temperature. Among all four sites there seems to be a cold bias in the NARR of no more than 5 degrees celsius. This may be due to the fact that NARR is exactly renanalyzed for .1 and .4 meters, while the observations include temperatures from .1-.2 meters and .3-.4 meters.

Discussion:

Overall, NARR renanalyzed soil temperatures for the Alaskan North Slope make a rough, but close estimate of the trends in changes that seasons exhibit from 2007-2018.

In the interest of accurately accounting for the zero curtain period, we visualized changes in November in both NARR and our observations. Because we compared .3-.4 meter observed mean temperatures in this month to just .4 meter reanalyzed soil temperatures from NARR, we expected our observed trends to be some degree colder than NARR if NARR was completely accurate for its products of .4 meters. Even though this was the case, NARR still had a very evident cold bias for the month of November. This means that Polar-TVPRM's estimates of carbon flux to the atmosphere during the non-growing season could be significantly lower than true fluctuations. If this cold bias is eliminated, our model could indicate that the Alaskan North Slope is a net source of atmospheric carbon.

Such a consistent bias was not found for summer temperatures or late winter temperatures. However, NARR does seem to underestimate the abnormal cold 2015 temperatures for Deadhorse. Another consideration is the time interval visualized for our observations is very short, and NARR is most likely accounting for trends seen closer to the present.

To improve NARR's accuracy for past temperatures, more sites need to be analyzed along a longer timescale. This could confirm the presence and the degree of the biases aforementioned and give us a better understanding of regional polar carbon flux.