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IS THE ARCTIC MELTING? THEORY VS. OBSERVATIONS

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ABSTRACT

The first comprehensive numerical analysis of 20 weather stations distributed within the Arctic Circle was performed using daily and monthly diurnal temperature data from the freely available global datasets accessed via KNMI Climate Explorer. The major findings were: that the Arctic Circle is the most extreme place on our planet where seasonal changes can range from +35.0°C in July and -65.0°C in February; that the total ranges of temperature at individual stations can be as 'low' as 75.0°C and as high as 100.0°C; that on average 75% of the year is spent below the melting point of water and that the youngest years cannot be distinguished from the oldest years using either their monthly or their daily historical thermometer-based data. Since the temperature of the molecules of air that are in contact with water molecules pre-determine the temperature of the water molecules and, therefore, their state (solid/liquid or gas) it must follow that on average the Arctic will be covered by ice/snow for the same proportion of time, i.e., 75% or 9 months of the year.

The same seasonal extreme variations in air temperatures are also observed in ice cover variations observed in the Arctic where the winter's ice cover can be between 14-16 million km^2, while during summer the area covered can vary between 4 and 8 million km^2. What this analysis also establishes is that the huge variations observed in daily data from every single station make the whole system a chaotic one, therefore making any future forecasting with any usable accuracy an impossible task. Based on observations, dating back to 1900, it can be concluded that it is physically impossible for the Arctic to be ice/snow free in the foreseeable future since the air temperatures were as cold in 2013 as they were in 1900.

Since ice cannot melt below 0.0°C, all these observations point towards the Arctic remaining ice-covered for the next 100 years. It must also follow that any theory predicting imminent melting of the Arctic ice cap cannot be based on thermometer-recorded data and, therefore, must be wrong and will merely be an artefact of using the term temperature where there is no true association with the calibrated thermometer, the instrument used to measure temperature in all physical, medical and engineering sciences.

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INTRODUCTION AND BACKGROUND

We know everything there is to know about physicochemical properties of one of the most important molecules on our planet, the water molecule or H_2O, since without water there would be no life on our planet. Two properties of water that are relevant to this paper are that water melts at 0.0°C and boils at 100.0°C, the two end points that were chosen by Anders Celsius as the key calibration points for thermometers since 1744 and used as a default calibration in the fields of experimental chemistry. The physical meaning of those two physicochemical properties of water can be explained as follows: At 0.0°C the kinetic energy of the molecules is sufficiently high to change the state of water from the solid to the liquid phase, while at 100.0°C the kinetic energy is sufficiently high to change the state of water from the liquid to the gas phase. All physicochemical properties of all molecules are determined by *measurements* using dedicated instruments that are manufactured and calibrated according to internationally recognised and approved standards which, in turn, allow the process of validation of results to be carried out by any scientist trained in the use of those instruments. In the case of water, we know it will always melt at 0.0°C and boil at 100.0°C at a pressure of 760.0 mm Hg irrespective where it is measured. We can also predict whether water will be in its solid or liquid state not by measuring the temperature of the water itself but by measuring the temperature of molecules that comprise air, N_2 and O_2 that are in contact with water surface. There are two extreme examples that exist on our planet since the invention of the calibrated thermometer by Fahrenheit in 1721, one where air temperatures are always above 0°C and water molecules are always in the liquid state and, at the other extreme, when the air temperatures are always below 0°C and water molecules are always in solid state. However the majority of our planet is somewhere in between those two extremes and the percentage of time that water will spend in its solid or liquid state will be directly proportional to the percentage of time that the air molecules spend above or below 0.0°C. It follows that if we want to predict whether some local or regional water mass will exist in the solid or liquid state all we need to do is to ‘learn from the past’ by analysing the relevant historical air temperature data and then using that data to predict future events. This brings us to the issue of the imminent and already started melting of the Arctic.

According to the latest UN-based Intergovernmental Panel on Climate Change, the IPCC, “The period of 1995-2005 was the warmest decade in the Arctic since at least the 17th century, with temperatures 2°C above the global 1951-1990 average.” As a consequence of this putative global warming, the Arctic is the melting and should be ice/snow-free in the very near future, giving rise to an alarming rise in the global sea levels. That is what the theory of global warming says. But since the ‘global average’ or ‘global temperature’ is a purely theoretical number that cannot be measured and has no physical meaning (Essex et al., [1], Kramm-Dlugi [2] and Butina [3]), the only way to either prove or disprove this, as with any theory, is to test it against experimental observations.

There is one important point to make here. One of the many alarms that came from the theory of global warming is that melting of the huge volume of ice formed by freezing of the Arctic Ocean would have a major effect on global sea levels and therefore cause flooding on a global scale. But the physicochemical properties of water tell us otherwise: the density of water in its liquid state is 1.0 g/cm^3 while in its solid state is 0.9 g/cm^3. So, when a given volume of water freezes, that volume is decreased by approximately 10% since ice (water in the solid state) is less dense than water (in the liquid state) and, therefore, the melting of water-based ice will not affect overall water levels. On the other hand, if snow/ice based on the land mass melts, than the resulting volume of water in its liquid state will add additional volumes of water to the nearest river or ocean, as it is regularly observed by the increased river levels across the globe during the snow melting seasons. *The defining characteristic of all scientific knowledge, including theories, is the ability to make testable predictions. A putative theory that makes no observable predictions is not a scientific theory at all*. The first systematic measurement of air temperatures using calibrated thermometers started back in early 1800s and the protocol was then, and still is today, to identify two end-points in daily temperatures, the minimum night-time temperature, Tmin, and the maximum daytime temperature, Tmax. As a consequence, one year can be described as a collection, or as a unique fingerprint, consisting of 365 Tmin and 365 Tmax readings, i.e., 730 values in total and could be described, in terms of its information content, as high resolution historical data. A very important point to make here is that *if one wants to compare temperatures recorded in 1800s with the ones measured today, one has to use the same protocol used in 1800s - that is to use the two daily readings Tmax and Tmin*.

This protocol of measuring daily Tmax/Tmin air temperatures by using fix-to-ground thermometers makes perfect scientific sense since the difference between Tmax and Tmin on the same day tells us how much heat energy was absorbed by the molecules surrounding the thermometer, i.e., the warming rate, while the difference between Tmax on one day and Tmin the next day tells us about the cooling rate. It is also important to remind the reader that all thermometer-based readings reflect the kinetic energy of the molecules that surround the thermometer, i.e., they reflect local temperatures. Therefore, the larger the geographical area of interest is, more variations in temperatures will be observed and more weather stations will need to be sampled in order to get better understanding of the local/regional temperature patterns. Let us now establish some basic facts about the Arctic Circle that will have an impact on the objectives of this paper. Geographically, the Arctic Circle is the area north of Latitude 66.6° N, it has diameter of about 5,000 km (Google Earth) with total surface area of 21,000,000 km^2. The Arctic Ocean which covers the major part of the Arctic is surrounded by the land where the weather stations are based. 20 weather stations were chosen for this paper with two selection criteria: a minimum of 50 years of data and as even a distribution around the Arctic Circle as possible. The circle was divided in 4 quadrants: G1 and G4 on the west side, being mainly parts of Canada and US, plus G2 and G3 on the East side, being mainly part of Russia (Figure 1).

DATA GENERATED BY CALIBRATED THERMOMETERS

All the data in this paper came from a freely available, public domain database via use of the KNMI Climate Explorer software (http://climexp.knmi.nl) which was linked to the GHCN, a global temperatures depository (v.3 released on 3rd March, 2014). Data from twenty weather stations were downloaded, data from each station was analysed separately and a unique code generated for each weather station according to its grid point in the four quadrants separated by longitudes 0, 90 and 180 east or west (Figure 1 and Table 1). All the data was saved in an Access-2013 database for systematic numerical analysis and comparisons:

All stations were downloaded in a monthly Tmax/Tmin format and processed as follows:

1. Tmax and Tmin individual files were aligned by year;
2. All years that had even a single missing datapoint, i.e., monthly Tmax or Tmin, were removed;
3. *The final result was that all the years had complete and comparable data; that every datapoint reported in this paper can be traced back to the original download and, therefore, that every analysis performed can be reproduced and validated by the reader.*

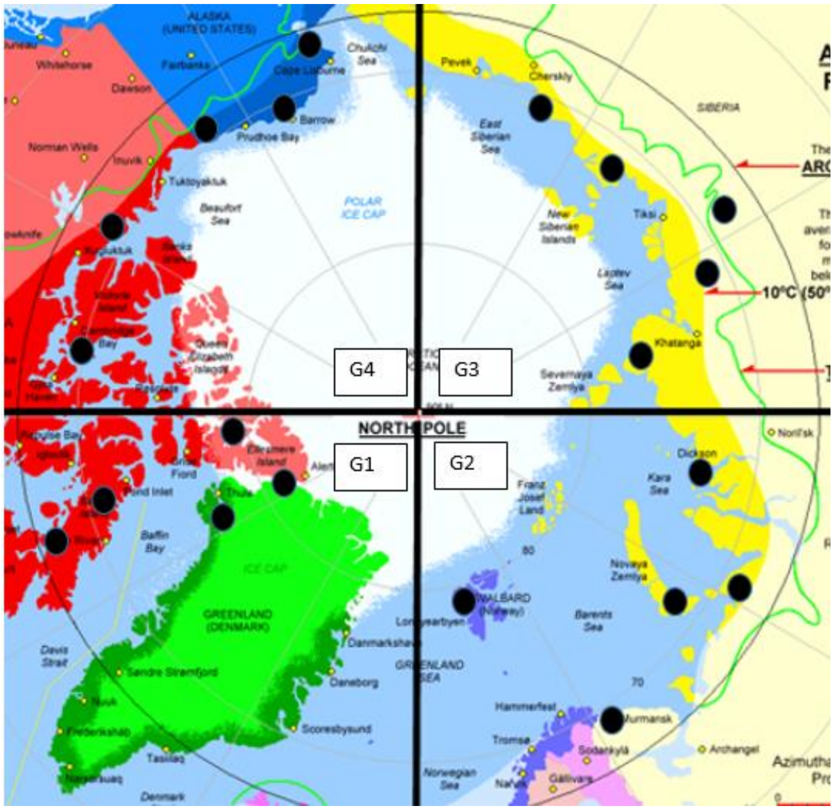
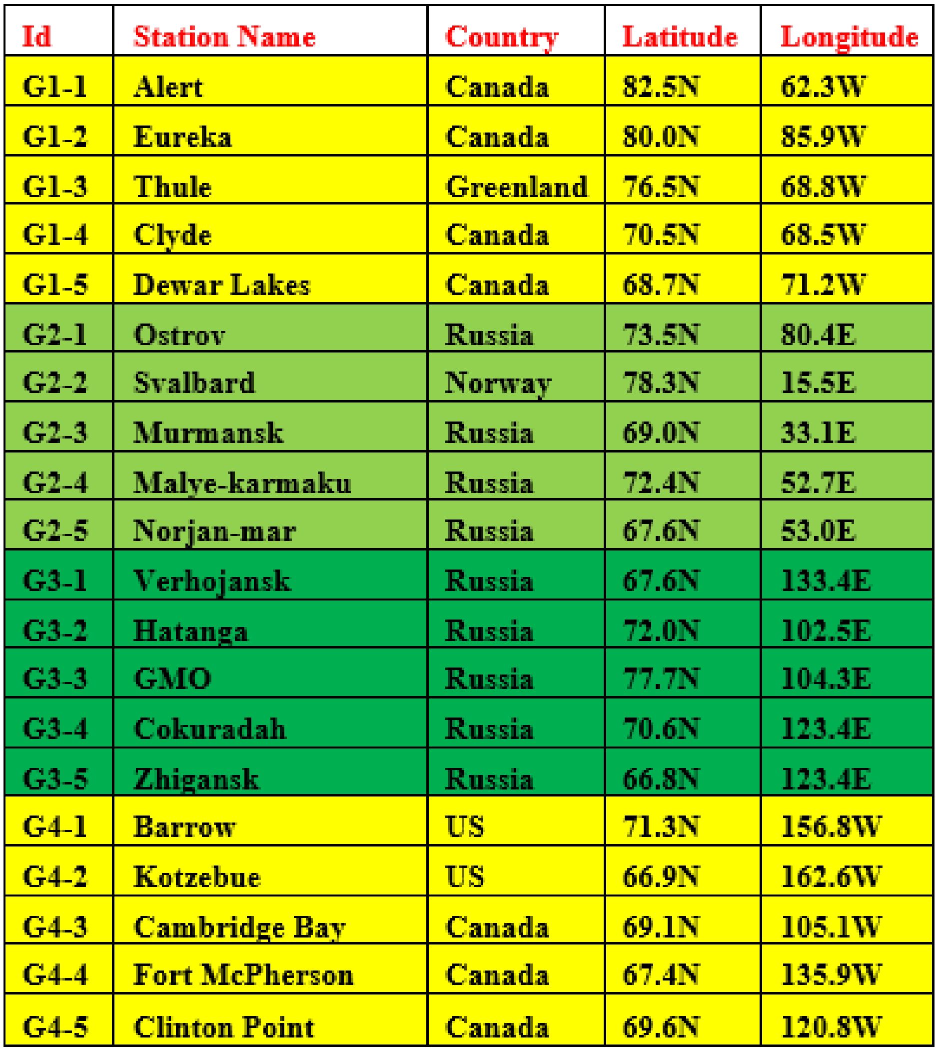


Figure 1. Map of the Arctic Circle showing the grid system used in this paper with weather stations depicted as black circles.

Since the monthly Tmax/Tmin data has been already pre-processed by the custodians of the GHCN, in this case the original daily Tmax/Tmin readings were averaged over time (month), the numerical analysis here can only give a qualitative picture of the temperature trends across the Arctic Circle. In order to quantify the loss of information or resolution by averaging original daily Tmax/Tmin observations, 4 stations were chosen (one from each quadrant with data for the greatest number of years) and individual daily Tmax/Tmin data downloaded. Those 4 stations were Barrow (G4-1) and Eureka (G1-2) on the west side, and Ostrov-Dikson (G2-1) and Hatanga (G3-2) on the East side of the Arctic Circle (see Figure 1).

Table 1. Arctic weather stations and grid points used in this paper



Id	Station Name	Country	Latitude	Longitude
G1-1	Alert	Canada	82.5N	62.3W
G1-2	Eureka	Canada	80.0N	85.9W
G1-3	Thule	Greenland	76.5N	68.8W
G1-4	Clyde	Canada	70.5N	68.5W
G1-5	Dewar Lakes	Canada	68.7N	71.2W
G2-1	Ostrov	Russia	73.5N	80.4E
G2-2	Svalbard	Norway	78.3N	15.5E
G2-3	Murmansk	Russia	69.0N	33.1E
G2-4	Malye-karmaku	Russia	72.4N	52.7E
G2-5	Norjan-mar	Russia	67.6N	53.0E
G3-1	Verhojansk	Russia	67.6N	133.4E
G3-2	Hatanga	Russia	72.0N	102.5E
G3-3	GMO	Russia	77.7N	104.3E
G3-4	Cokuradah	Russia	70.6N	123.4E
G3-5	Zhigansk	Russia	66.8N	123.4E
G4-1	Barrow	US	71.3N	156.8W
G4-2	Kotzebue	US	66.9N	162.6W
G4-3	Cambridge Bay	Canada	69.1N	105.1W
G4-4	Fort McPherson	Canada	67.4N	135.9W
G4-5	Clinton Point	Canada	69.6N	120.8W

In terms of number of datapoints to analyse, 1 year in monthly Tmax/Tmin space consists of 2 datapoints per month giving 24 datapoints per year. Therefore, 100 years of data generates 2,400 datapoints per each station. However, 1 year of daily Tmax/Tmin readings consists of 730 datapoints (365 Tmax and 365 Tmin). Therefore 100 years generates 73,000 datapoints per station. This represents a major computational task, both in hours of time spent on the analysis of a single weather station and in the problems associated with displaying the tables and graphs containing such large numbers of datapoints. All the basic computational work reported here was done in Excel 2013, while for more complex calculations a set of macros were built using Excel’s developer toolkit. Twenty stations were used in this work, all of them having monthly Tmax/Tmin datasets but only four having daily Tmax/Tmin datasets are discussed in detail here: Barrow, Ostrov-Dikson, Alert and Hatanga. Due to space restrictions, only a fraction of the total analyses performed are reported in this paper.

LOOKING FOR PATTERNS IN MONTHLY TMAX/TMIN DATASETS

We will start this section with a set of three identically-produced graphs for each of the 4 stations chosen as representatives of each quadrant by using a single criterion, namely the ones having the largest number of years of data available: Barrow, Alert, Ostrov-Dikson and Hatanga. The first graph of each set displays all the monthly Tmax/Tmin data by month, depicting the total temperature ranges for each month and allowing quick identification of the months that are mainly above or below 0°C.

The second graph of each set is a direct plot of one of the coldest months, January, and the hottest month July, over the available years. The third graph of each set was obtained by counting the number of datapoints that were above and below 0°C for each year and then dividing by two (two readings per month) to get the number of months above or below 0°C per year.

Barrow (71.3N 156.8W, 1902-2010)

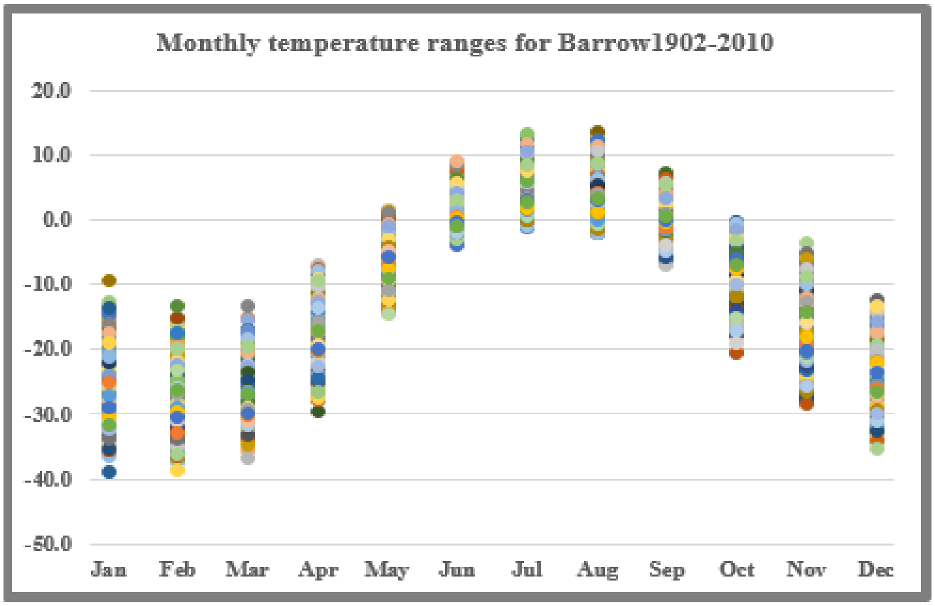


Figure 2. Monthly Tmax/Tmin ranges at Barrow between 1902 and 2010.

There are two main points of notice here: firstly, not a single month has a Tmax/Tmin range completely above 0°C and, secondly, that the overall temperature variations are between -40.0 and +15.0°C (i.e., 45.0°C in total).

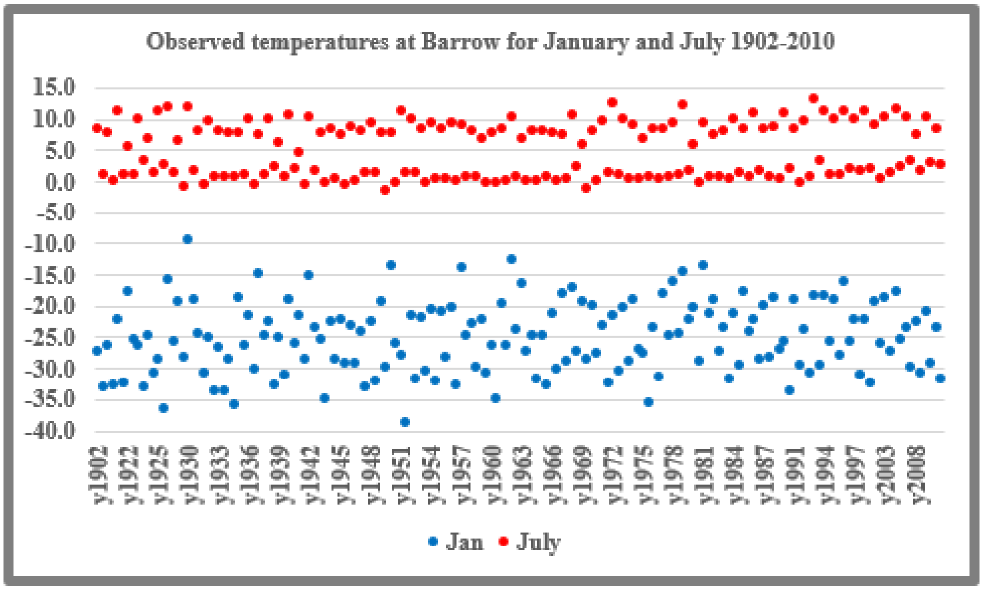


Figure 3. Observed monthly Tmax/Tmin temperatures for January and July at Barrow.

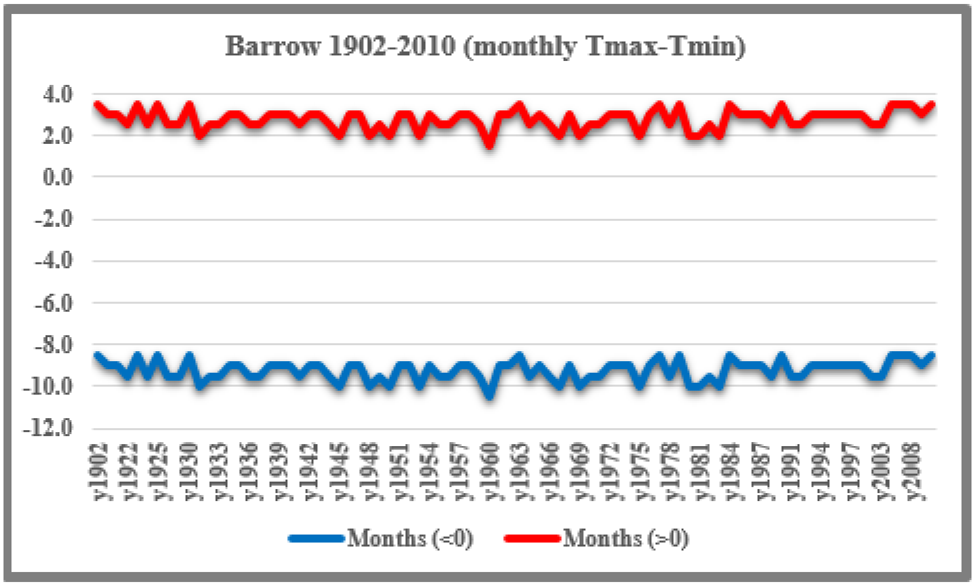


Figure 4. Annual counts of temperatures above/below zero for Barrow (in months).

There are also two main points of notice here: firstly, that the temperature patterns for January and July are chaotic in nature and, secondly, the only difference is that January's variations are twice as large as those in July, being 30.0°C and 15.0°C respectively.

As we can see from the figure above, on average, only 3 of 12 months are above 0°C which reflects temperature patterns observed across the rest of the Arctic Circle.

Only one month, July, is above 0°C with total range in temperatures of 65.0°C, between -50.0 and +15.0°C, (Figure 5).

Eureka (80N 62.3W, 1948-2012)

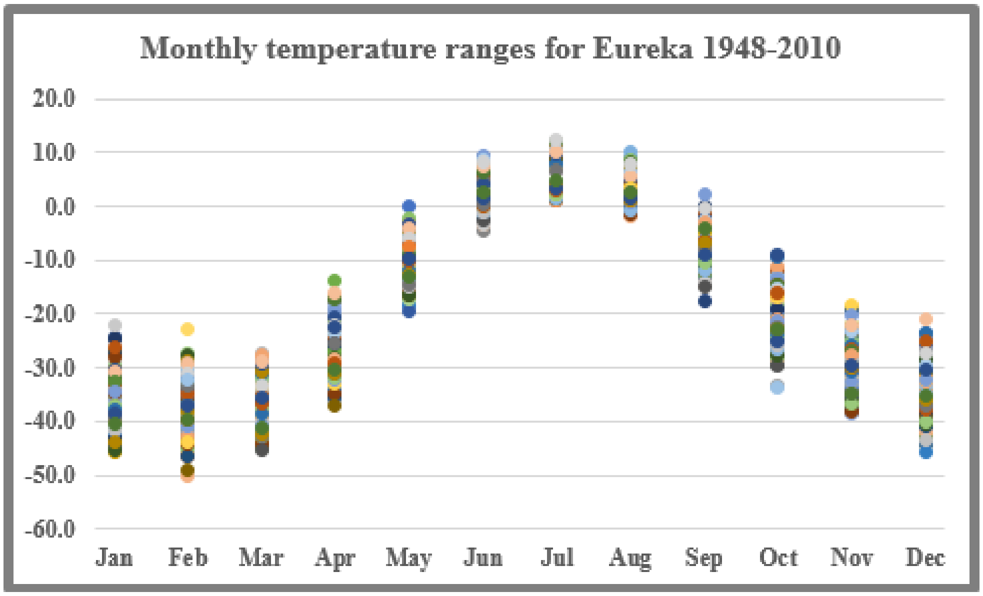


Figure 5. Monthly Tmax/Tmin temperature distributions for Eureka.

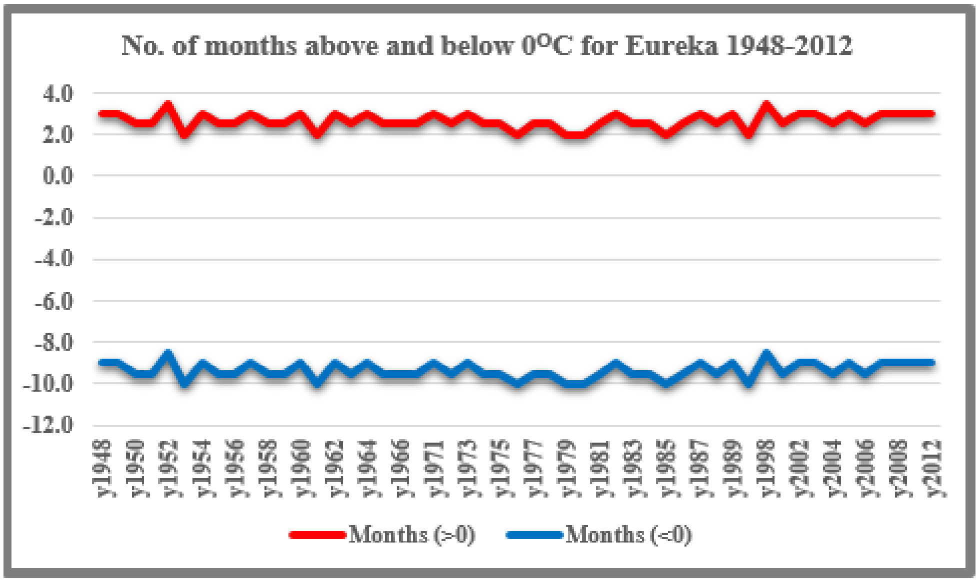


Figure 6. Annual counts of temperatures above/below zero for Eureka.

On average, only 3 of 12 months are above 0°C and 9 months are below 0°C at Eureka (Figure 6).

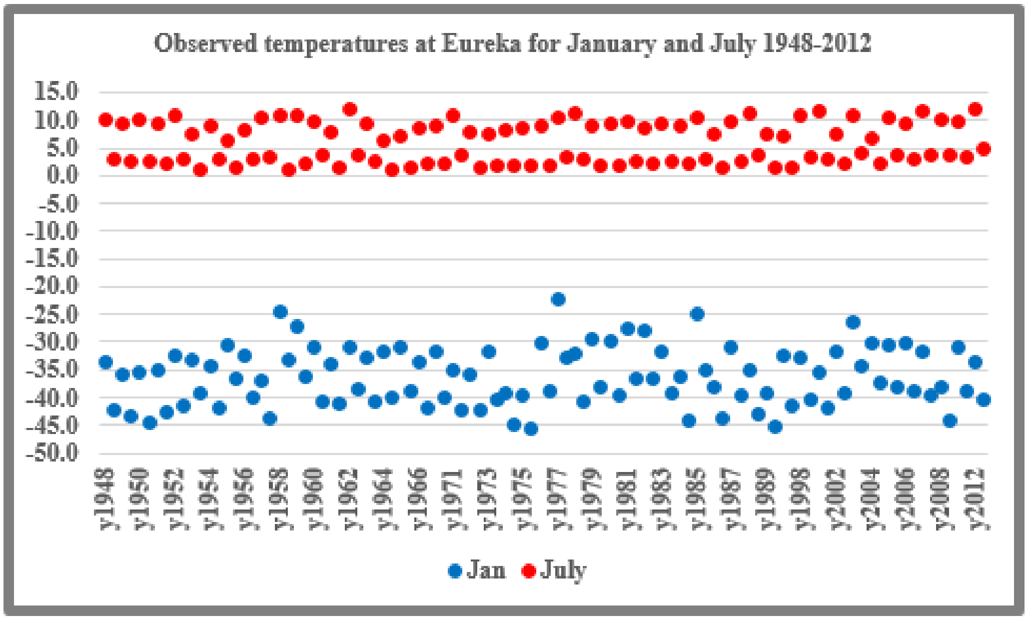


Figure 7. Observed monthly Tmax/Tmin temperatures for January and July at Eureka.

July temperatures at Eureka vary between 0.0 and 15.0°C, while January temperatures vary between -20.0 and -45.0°C. The total observed temperature range at Eureka is 60.0°C (Figure 7).

Ostrov-Dikson (73.5N 80.4E, 1936-2012)

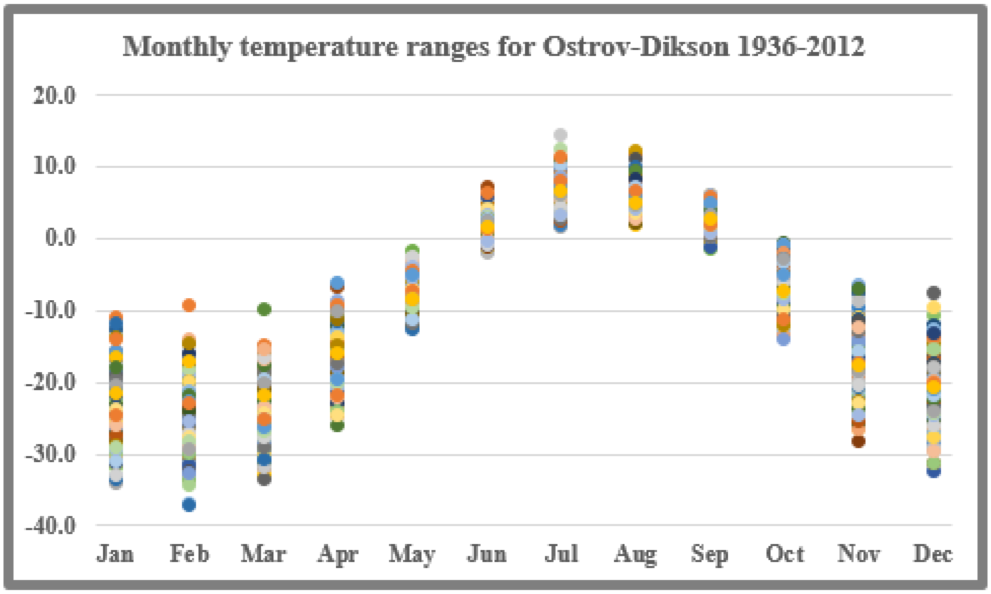


Figure 8. Monthly Tmax/Tmin temperature distributions for Ostrov-Dikson.

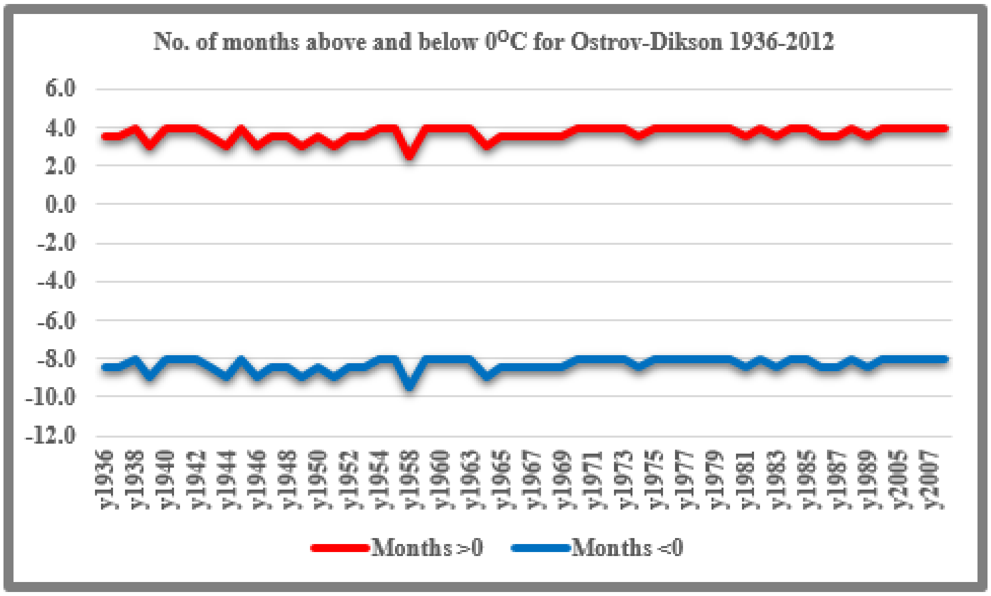


Figure 9. Annual counts of temperatures above/below zero for Ostrov-Dikson.

Two months, July and August have all their temperatures above zero with eight months all below zero with temperature ranges between -35.0 and +15.0°C (Figure 8). This seems to be a general pattern in the Arctic. On average, 3.5 months a year are above 0°C while 8.5 months below 0°C (Figure 9).

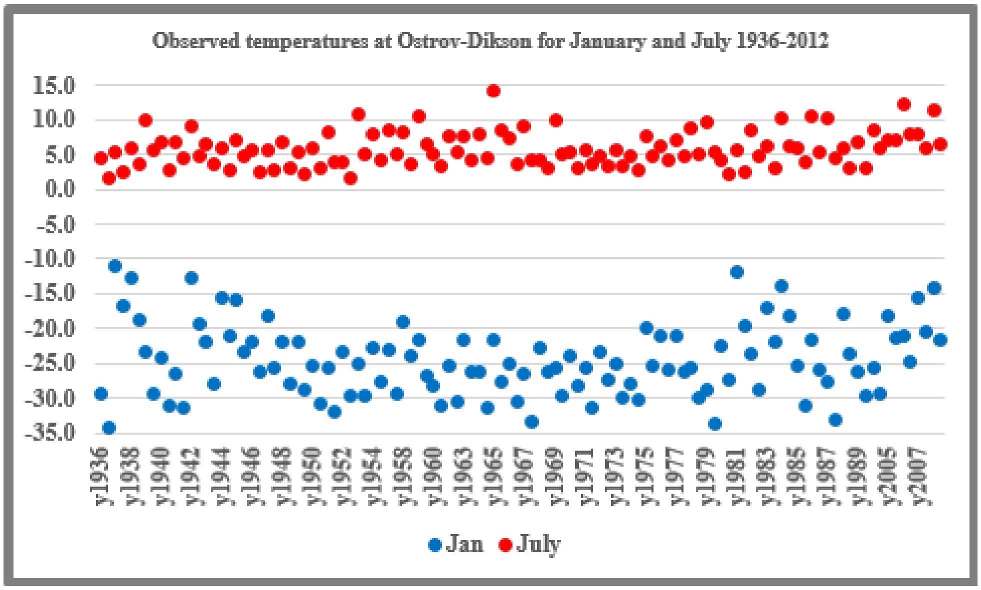


Figure 10. Observed monthly Tmax/Tmin temperatures for January and July at Ostrov-Dikson.

The total temperature range at Ostrov-Dikson is 50.0°C, between -35.0 and +15.0°C, i.e., about 10.0°C lower than those observed at Barrow and Eureka, but all have very similar overall profiles.

Hatanga (72N 102.5E, 1930-2013)

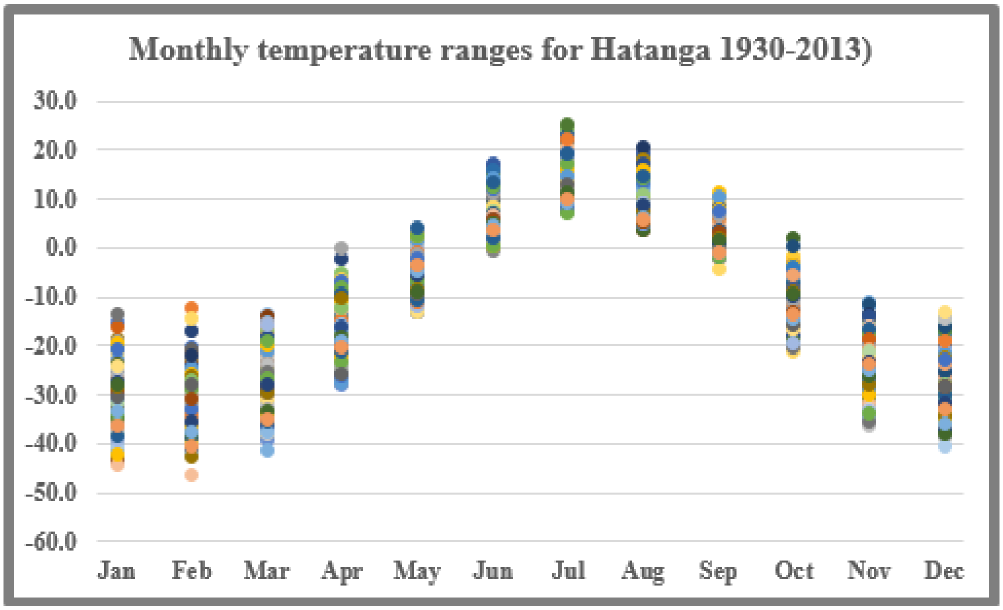


Figure 11. Monthly Tmax/Tmin temperature distributions for Hatanga.

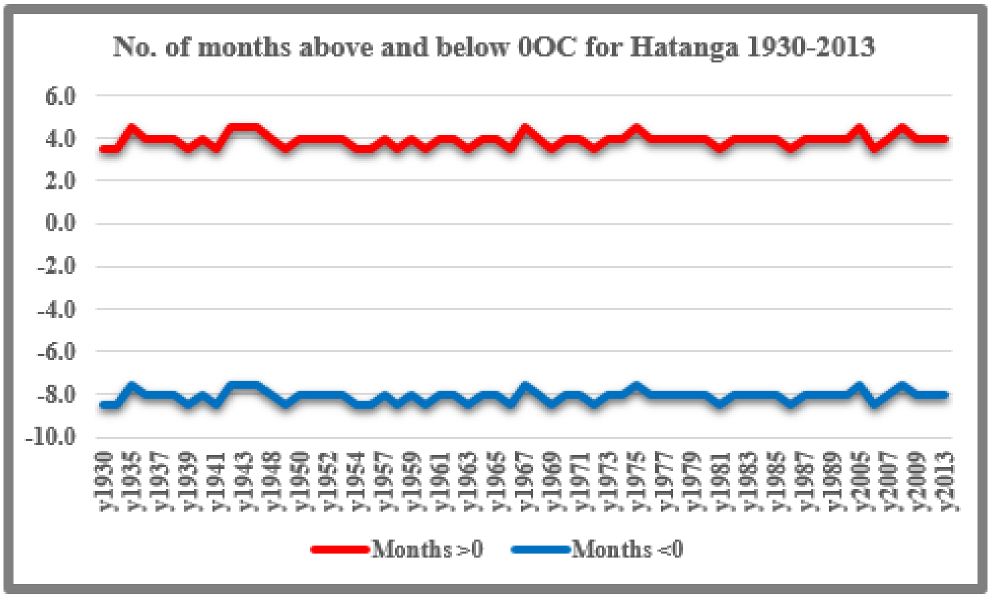


Figure 12. Annual counts of temperatures above/below zero for Hatanga.

Hatanga has 2 months (July and August) clearly above 0°C and, on average, 4 months above and 8 months below 0°C (Figures 11 and 12).

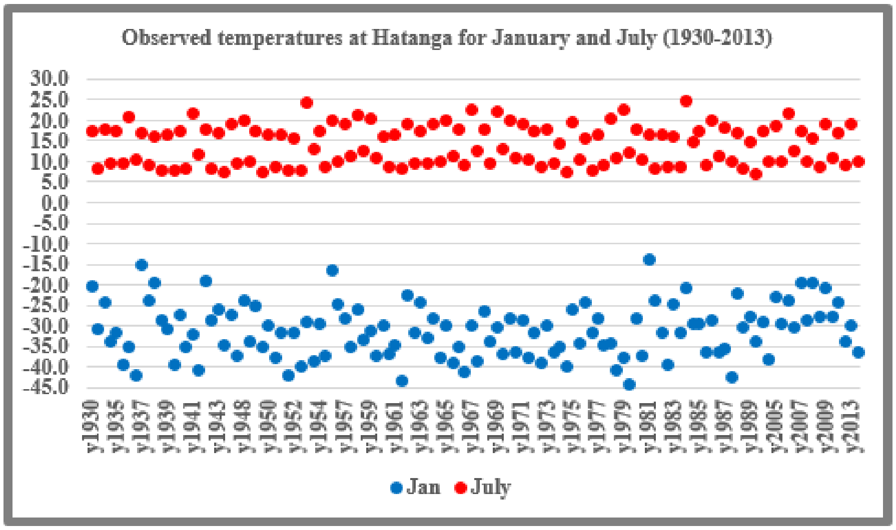


Figure 13. Observed monthly Tmax/Tmin temperatures for January and July at Hatanga.

A total temperature range at Hatanga is 70.0°C, between -45.0 and +25.0°C, the largest of the four samples weather stations examined so far.

Monthly Tmax/Tmin profiles across the rest of the Arctic Circe:

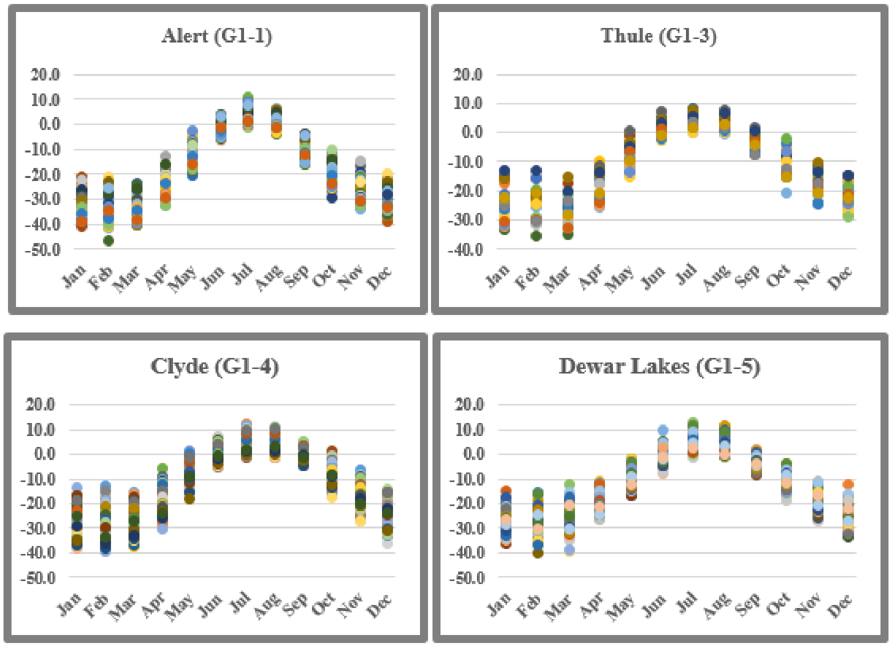


Figure 14. Monthly Tmax/Tmin temperature distributions of four weather stations from quadrant 1 (G1).

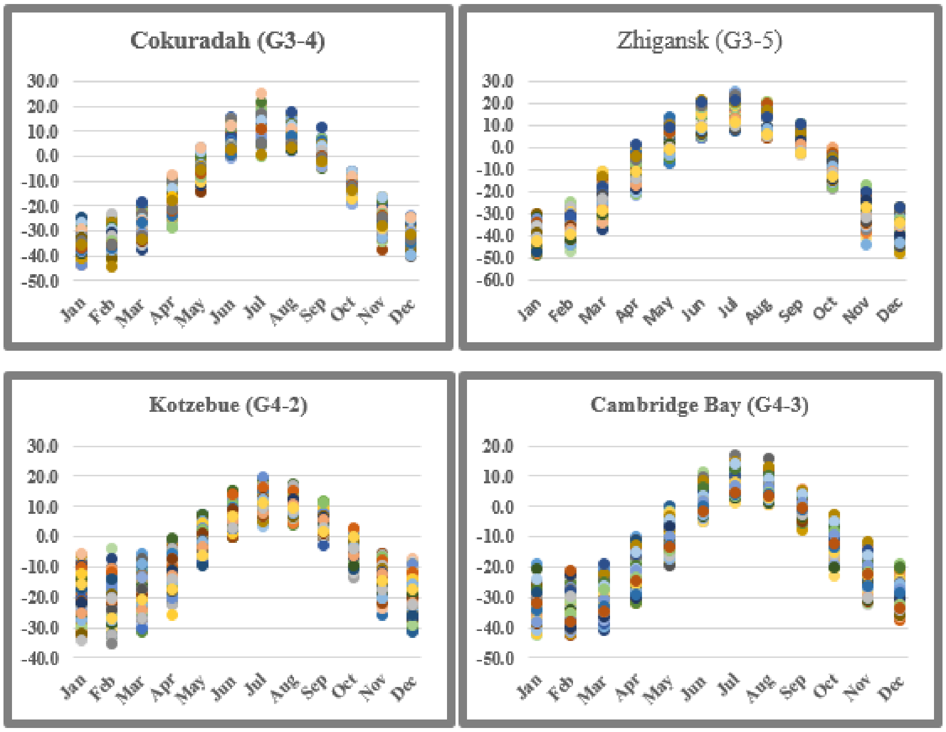


Figure 15. Monthly Tmax/Tmin temperature distributions of four weather stations from quadrants 3 and 4 (G3 and G4).

The overall pattern for each station, in terms of percentage of time spent with air temperature above or below 0°C is summarised in the graph below:

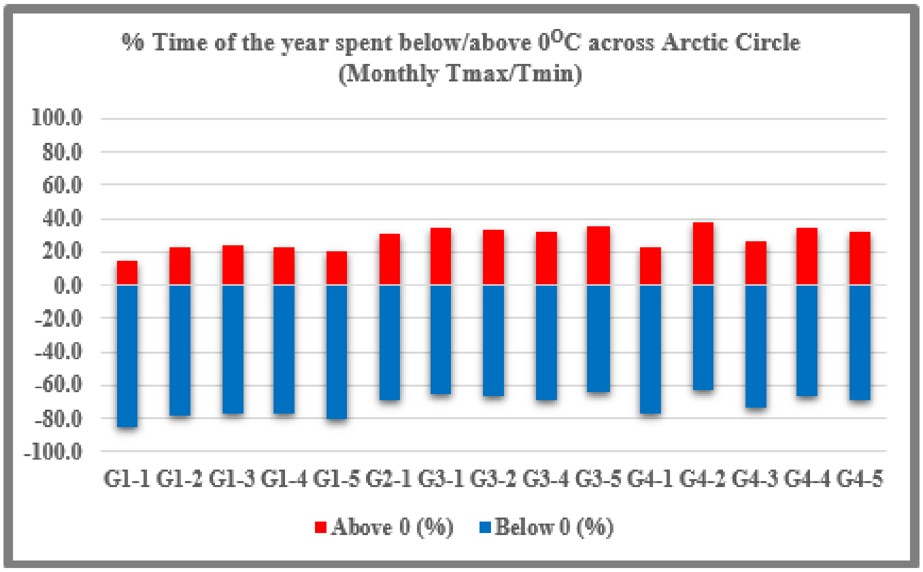


Figure 16. Summary of Arctic weather stations in terms of percentage of time spent with air temperature above/below zero.

LOOKING FOR THE PATTERNS IN DAILY TMAX/TMIN DATASETS

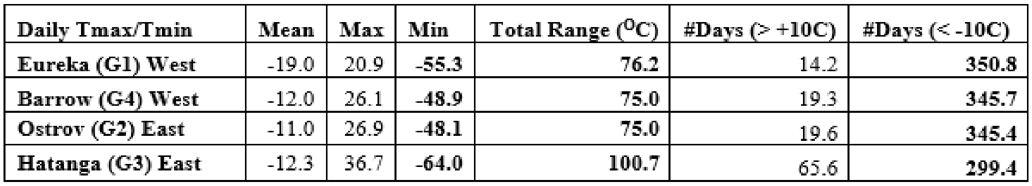
This part of the data analysis is the most important since it concerns the data at the source of thermometer readings, namely the daily Tmax/Tmin data. One year is a collection of 365 Tmax and 365 Tmin thermometer readings, giving 730 datapoints in total. Therefore, 100 years of archived data requires analysis of 73,000 datapoints for each station. One of the problems with historical data collected at one of the most extreme places on our planet, like the Arctic, where the sub-zero temperatures can be low as -65.0°C is that there are many missing datapoints. Since the main objective of this paper was to identify general trends of cooling/warming within the Arctic Circle, much statistical information can be extracted from the available daily Tmax/Tmin data without the need for detailed sorting and alignment of the original Tmax/Tmin downloads.

The table below contains the key information that we need to assess the temperature pattern across the Arctic Circle:

The key points that summarise the daily data in Table 2 are:

- The mean temperatures are below 0.0°C, between -10.0 and -20.0°C.
- The minimum temperature can be as low -64.0°C, and most importantly
- The total ranges of daily temperatures can be as large as 100.0°C

Table 2. Summary for 4 representative stations of the Arctic Circle, two from the western and 2 from the eastern quadrants



Daily Tmax/Tmin	**Mean**	**Max**	**Min**	**Total Range (^{O}C)**	**#Days (> +10C)**	**#Days (< -10C)**
Eureka (G1) West	-19.0	20.9	**-55.3**	**76.2**	14.2	**350.8**
Barrow (G4) West	-12.0	26.1	**-48.9**	**75.0**	19.3	**345.7**
Ostrov (G2) East	-11.0	26.9	**-48.1**	**75.0**	19.6	**345.4**
Hatanga (G3) East	-12.3	36.7	**-64.0**	**100.7**	65.6	**299.4**

A few words about the last two columns of Table 2 would be prudent at this point. These columns contain the number (#) of daily readings with temperatures above +10.0°C and below -10.0°C.

One of the key features of the Arctic is the huge variations between maximum and minimum observed temperatures. For a continuous melting process to occur, one would need constant heating during the daytime as well as during the night. For that reason a +/- 10.0°C cut-off around 0.0 C was used to identify the temperature ranges that will have the major effect on the rate of freezing or melting of the water molecules. The last two columns in Table 2 are plotted in the graph below for the four weather stations and are expressed in percentage terms:

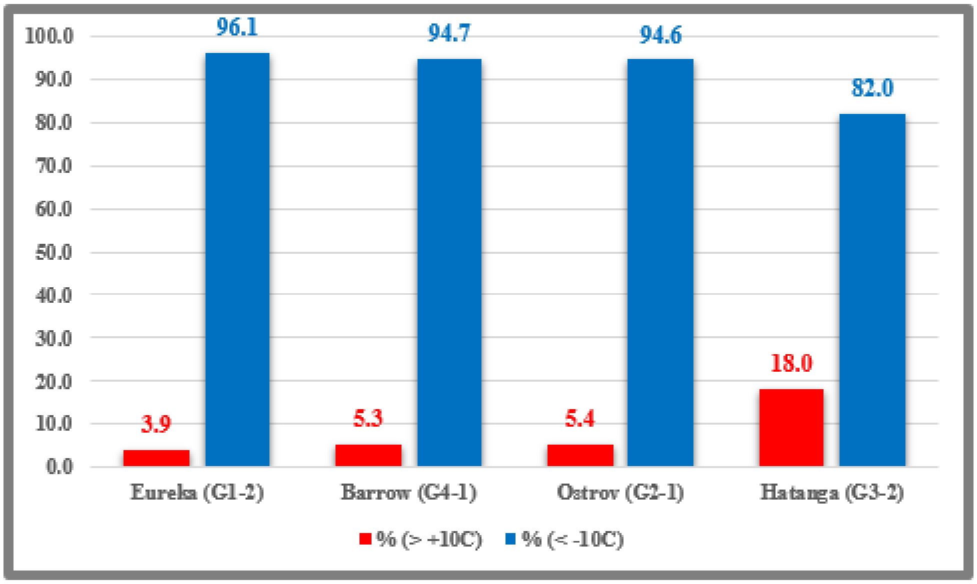


Figure 17. Percent of time that the 4 weather stations spend above +10.0°C (red) and below -10.0°C (blue).

While Table 2 and Figure 17 clearly show that on average less than 1 month, or 5% of the annual temperatures, are high enough to start the melting process, they do not tell us about the actual temperature ranges and how distant the hottest and the coldest temperatures are from the melting point of water (0.0°C). The graph below will help us to understand the sheer size of the cooling process that is ongoing across the Arctic Circle for the majority of the year:

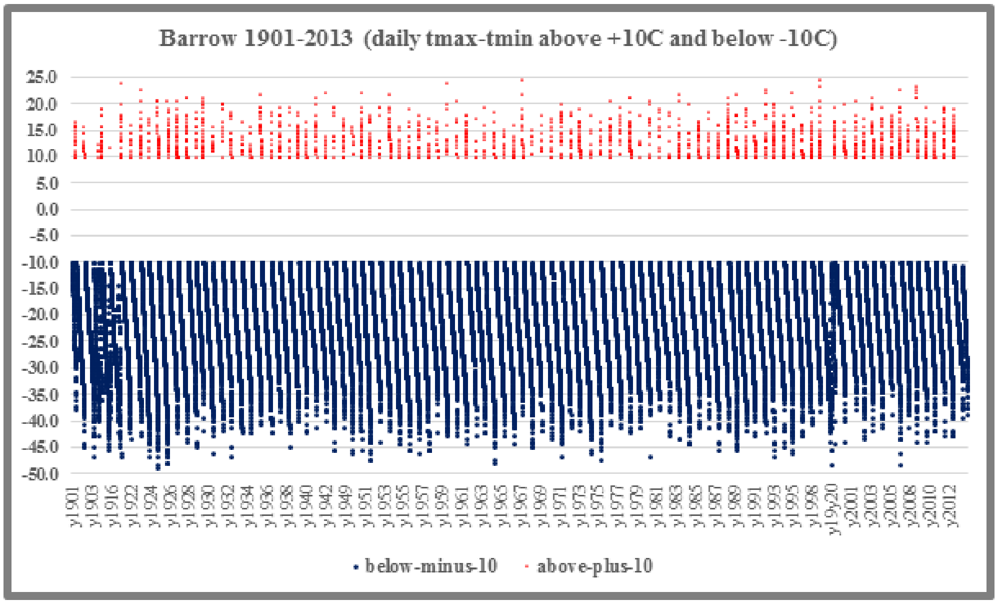


Figure 18. Direct plot of recorded temperatures above +10 and below -10 C at Barrow between 1901 and 2013.

In case of Barrow, we can see that the total range of temperature above +10.0°C is 15.0°C (between 10.0 and 25.0°C, mainly observed in July, while the total range of temperatures below -10.0°C is 40.0°C and is observed during 9 months of the year.

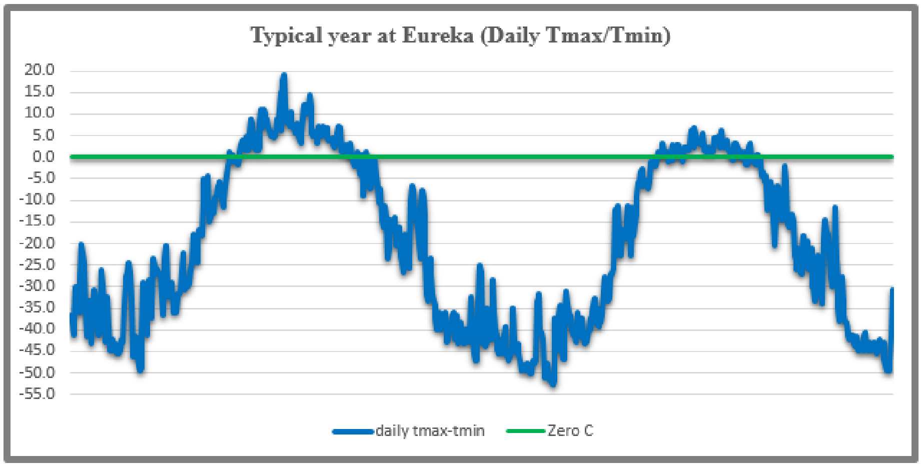


Figure 19. A typical year at Eureka with 365 Tmax datapoints followed by 365 Tmin datapoints (blue) with the green line representing melting/freezing point of water.

Figure 19 shows that even in July night-time temperatures do not reach +10.0°C at Eureka while they reach -55.0°C in the winter months. The graph below highlights what is so unique about the Arctic Circle, namely the massive variations of the surface temperatures that can occur *within* a few days, a few months or a few years:

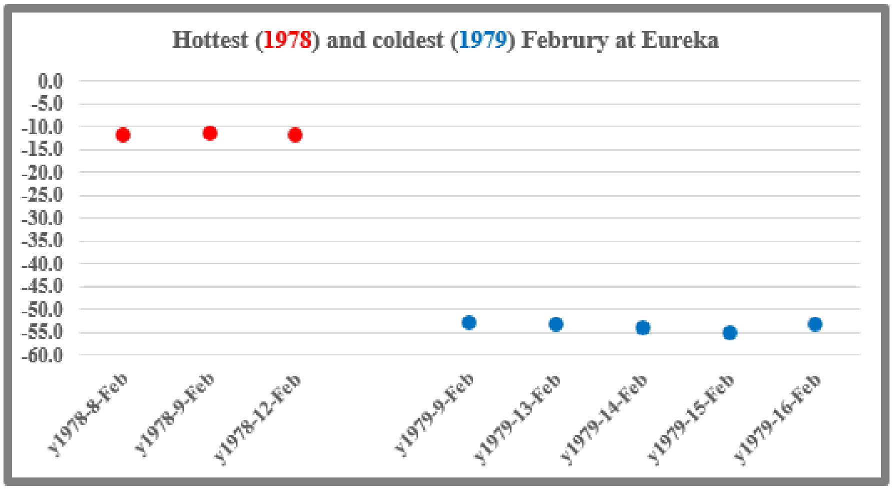


Figure 20. Three out of ten hottest (at -10.0°C) and five out of ten coldest (at -55.0°C) Februaries at Eureka occurred in two consecutive years, 1978 and 1979.

If the 10 hottest and 10 coldest Tmax/Tmin temperatures for the coldest month at Eureka (February which, by the way, is the coldest month across the Arctic Circle) are identified, it turns out that within 1 year, the 3 hottest days in February of 1978 (the 8th, 9th and 12th) were followed by the 5 coldest February days the next year (1979), the 9th, 13th, 14th, 15th and 16th. The overall switch was a massive 45.0°C. This is what makes Arctic so unpredictable, for both short term and long term weather forecasting.

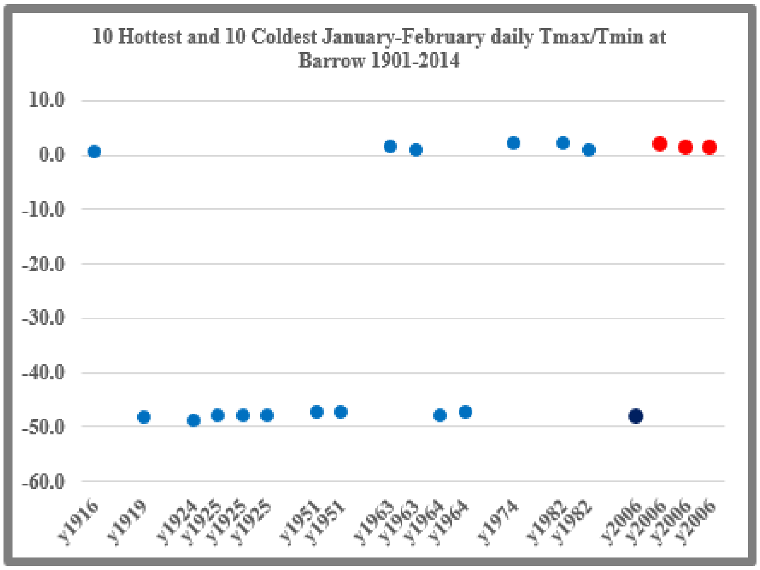


Figure 21. The ten hottest and coldest January-February daily Tmax/Tmin values recorded at Barrow.

While1963 had the two hottest Februaries at just above 0.0°C, the following year, 1964, had two of the coldest Februaries at -50.0°C, a 50.0°C degree drop in temperature. An even more drastic change was observed in 2006 when during the same month, the temperature rose from -50.0 to just above 0.0°C.

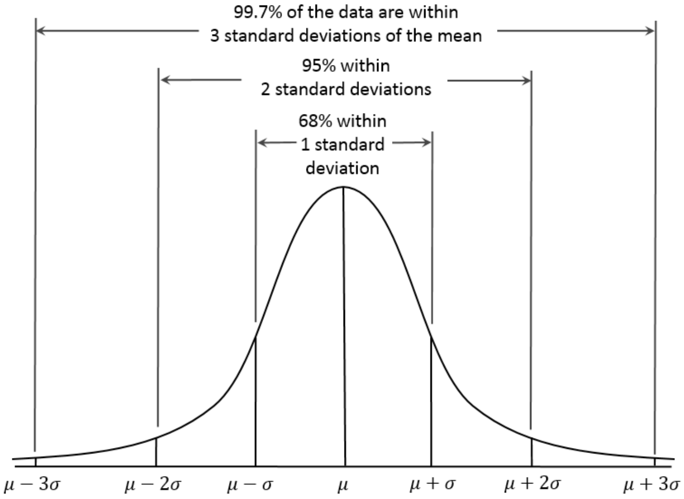


Figure 22. The normal distribution curve expressed in terms of the z-score which measures a data point's distance from the mean by the number of standard deviations above (+) or below (-) the mean.

Now, let me introduce the 68–95–99.7 rule, also known as the three-sigma rule, which states that nearly all values lie within three standard deviations of the mean in a normal distribution. Thus 68.27% of the values lie within one standard deviation of the mean, 95.45% of the values lie within two standard deviations of the mean and 99.73% of the values lie within three standard deviations of the mean (this is illustrated in Figure 22).

To calculate z-scores, one needs to subtract the mean of the dataset from the observed datapoints and divide the differences by the standard deviation. The standard interpretation of the z-scores, or distances from the mean, is that all the datapoints with z-scores *within* +/- 2.0 (also known as the 2 sigma range) are labelled as 'normal', usually consisting of 95% of the datapoints, while those *outside* the 2 sigma range (z-score >= +2.0 or <= -2.0) are labelled as 'extreme – but statistically significant', usually consisting of 2.5% of the datapoints at either end of the normal distribution curve.

z-score = (X – Mean)/Standard Deviation, or

$$z = \frac{x - \mu}{\sigma}$$

where: μ is the mean of the population and σ is the standard deviation of the population.

If we calculate the z-scores for the whole of the Barrow daily Tmax/Tmin data and identify the extreme hot and cold temperature readings we get the following distribution between 1902 and 2014:

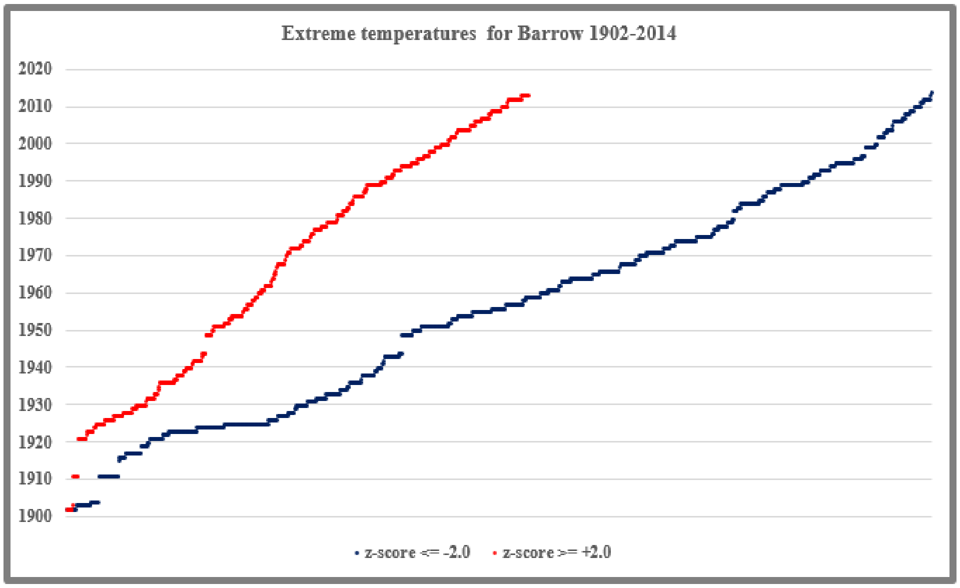


Figure 23. Years with the extreme hot temperatures (z-score >= +2.0 in red) and extreme cold temperatures (z-score <= -2.0 in blue) for Barrow between 1902 and 2014.

The most important pattern that stands out from the z-score analysis is that the observed daily temperatures of *every single decade at Barrow has experienced both,* extreme hot as well as extreme cold temperatures. In case of Barrow, there are twice as many of the extreme cold temperatures as there are extreme hot temperatures and all of them, hot or cold, are evenly distributed between 1902 and 2014 (data for 2014 available until March 2014).

DISCUSSION AND CONCLUSION

This paper had two major objectives: a) to perform a systematic numerical analysis of 20 weather stations spread across the Arctic Circle using monthly and daily Tmax/Tmin data, and b) to either prove or disprove the notion that the Arctic is melting.

The guiding principle underlying the whole analysis of the Arctic temperature data is that all thermometer data are by definition local, i.e., a thermometer detects the kinetic energy of the molecules that surround it and, therefore, it is impossible to treat the Arctic Circle as some thermally homogeneous space. Instead, it has to be treated as a large network of locally-specific temperature patterns. It is only when every single local temperature pattern moves in the same direction, i.e., either all count or none does, that definite conclusions can be made about Arctic Circle as a whole.

The results of the analysis of monthly diurnal data can be summarised as follows:

1. All the stations spend on average 3 months of the year (June, July and August) above zero and 9 months below 0°C
2. The maximum temperatures during the summer months are between 10.0 and 20.0°C while the minimum temperatures during January-March and November-December are between -30.0 and -50.0°C
3. Temperature patterns for January and July for stations representing the G1, G2, G3 and G4 quadrants: Barrow, Eureka, Ostrov-Dikson and Hatanga respectively, clearly show that it is impossible to separate the oldest from the youngest years (Figures 3, 7, 10 and 13)

In terms of differences in temperature between older years and younger years, none could be found in the monthly Tmax/Tmin data at any station within the Arctic Circle or, for that matter, anywhere else (Butina [3] and [4]).

Now we come to second part of the analysis based on the original instrument-based readings themselves, the daily Tmax/Tmin data. Let me remind the reader that a single calendar year is represented by 730 datapoints, and, therefore, that 100 years of observations will produce 73,000 datapoints which represents quite a major problem, both in terms of computing and reporting/displaying the results. While this section will be discussing the results of 4 representative stations, analyses have been done for another 10 stations in order to make sure that results obtained for those 4 stations do indeed reflect the patterns of their respective quadrant (Figure 1).

If we wanted to identify a couple of the key features that make the Arctic Circle such a unique place on our planet they would be the difference between the hottest and the coldest temperatures and the speed that those extreme temperatures can change direction from being extremely hot to extremely cold and vice versa.

The total ranges between the observed coldest and hottest readings average about 75.0°C for Eureka, Barrow and Ostrov, increasing to a massive 100.0°C for Hatanga (Table 2). The same table tells us that the first three stations average about 345 of 365 days with temperatures below -10.0°C and only 19 days at temperatures above +10.0°C, with Hatanga being one of the most variable weather stations with the minimum temperature at -64.0°C, maximum at +36.5°C!

On several occasions in this paper I have used terms like high and low resolution data, with high referring to *daily* while low was used to describe *monthly diurnal data*. The table below was designed to quantify those differences using Barrow as an example:

Table 3. Loss of resolution when averaging daily into monthly diurnal data at Barrow

Barrow	Max	Min	Total Range
Daily Tmax/Tmin	26.1	-48.9	75.0
Monthly Tmax/Tmin	12.6	-39.3	51.9
Difference	**13.5**	**-9.6**	**23.1**

The differences between the observed maximum, minimum and total range of temperatures in daily data from the corresponding monthly averages are 13.5, -9.6 and 23.1°C respectively. Table 3 highlights the problems associated with using averaging in any analysis of instrument-based data and the great danger of over-interpreting data based on averaging.

Let us now look at one more graph and one more table to highlight, yet again, this huge variability in air temperatures and also to demonstrate the chaotic nature of the Arctic's temperatures:

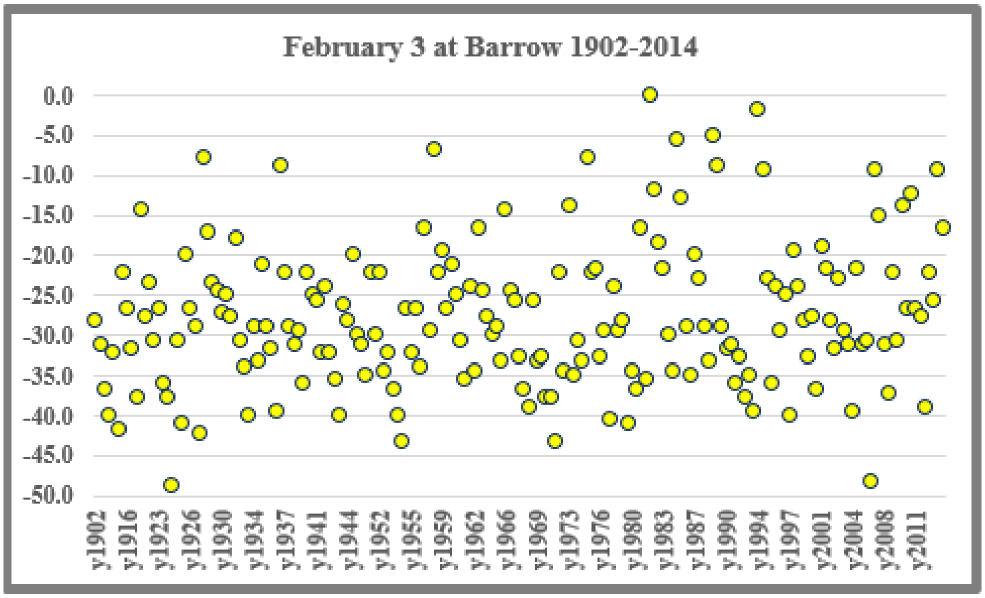


Figure 24. Variability of temperatures recorded on February 3rd at Barrow between 1902 and 2014.

Table 4. Key statistics for February 3rd at Barrow between 1902 and 2014

mean	stdev	max	min	range	max2mean	mean2min
-27.7	9.0	0.0	-48.9	-48.9	27.7	21.2

The term chaotic describes a system that we simply don't understand, one that has no patterns we can learn from and, therefore, one we can't use to predict future events. A visual inspection of Figure 24 tells us that the temperatures observed on February 3rd between 1902 and 2014 can be anywhere between -50.0 and 0.0°C and that it is impossible to find any trends between year and temperature.

Table 4 gives us the exact numbers and explains why the forecasting of future temperatures in the Arctic is, for all practical purposes, impossible. If, for example, we use the mean as the guide, the historical observations tell us that we could be wrong predicting February 3rd in 2015 by 27.7°C above the mean and by 21.1°C below the mean. *In other words, we could choose any number between -50.0 and 0.0°C to predict February 3rd in the future with each being equally likely to be correct.*

The general patterns found in *monthly* Tmax/Tmin data were confirmed by the analysis of *daily* data for the four weather stations representing each of the quadrants (Barrow, Eureka, Ostrov-Dikson and Hatanga) with a major difference being the ability to identify the exact values of extreme datapoints for those stations and, especially, the total ranges of observed temperatures (Table 2) that make the Arctic so unique.

One of the main objectives of this paper was to either prove or disprove the notion that the Arctic is melting. Every single station that was examined tells us the same thing – that air temperatures are well below the melting point of water for at least 9 months each year and, therefore, that it is impossible for Arctic to melt.

Furthermore, the coldest months of the year, like November, December, January and February reach temperatures as low as -64.0°C which means that the amount of melting in the summer month must be reversed during winter months. It must follow that we should be observing very large seasonal oscillations between ice loss in the summer and ice gain in the winter, these reflecting the extreme seasonal temperature changes. That is indeed confirmed by Figure 25 which originates from the National Snow and Ice Data Centre, at Boulder, CO, USA (www.nsidc.org).

The maximum ice cover observed in March can be as high as 16,000,000 km2, while minimum ice cover observed in October can be as low as 4,000,000 km2. The maximum ice cover is lagging behind the coldest month, February, by one month while the minimum ice cover is lagging behind the hottest month, July, by two months.

The thickness of the gain/loss *curve* at its maximum and minimum points reflects the fact that each year is a unique temperature event (Butina [3]) and, as we can see from Figure 25, that the winter ice cover can be between 14 and 16 million km^2 (a difference of 2 million km^2) while the summer ice cover can vary between 4 and 8 million km^2 (a difference of 4 million km^2). It is worth pointing out that the total ice cover in the winter is on average 2.5 times larger than that in the summer.

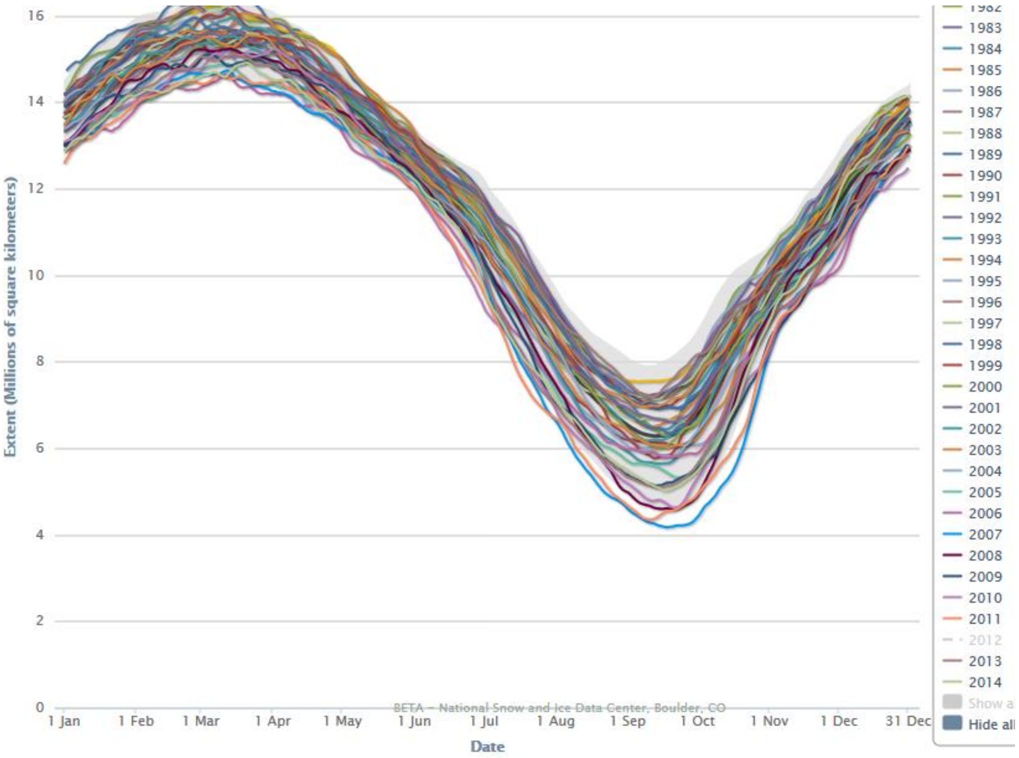


Figure 25. Monthly ice gain/loss (in millions of km^2) between 1979 and 2014 at Arctic.

So, what are the hard facts about Arctic that are based on the observations made by calibrated thermometers at 20 stations across the Arctic Circle and which conclusions can be made based on those observations?

1. Temperatures in the Arctic between 1900 and the present day are a long distance below 0.0°C for at least 9 months per year and can be as low as -64.0°C
2. It is impossible to separate the youngest from the oldest years using thermometer-based daily or monthly Tmax/Tmin data
3. The total ranges observed in daily Tmax/Tmin data can be as high as 100.0°C and as low as 75.0°C making the Arctic Circle the most variable and extreme area on our planet therefore making any accurate forecasting of future temperature patterns and trends impossible
4. The switches between the extreme hot to extreme cold temperatures are very frequent and very unpredictable and can occur within the same month, same year or between two consecutive years
5. The large *observed* ice gain/loss variations are pre-determined by the large *observed* variations in air temperatures
6. Since the air temperatures are chaotic in nature it must follow that the extent of the ice cover has to be chaotic as well and, since we cannot predict future events of a chaotic system, we cannot predict future trends of either air temperatures or ice cover patterns

Based on the facts above only one conclusion can be made in reference to the putative melting of the Arctic: historical thermometer-based data tells us that between 1900 and 2014 arctic temperatures were for 75% of the time *consistently* long distance below 0.0°C; the ice cover in the winter months is still consistently more than 14,000,000km2 and, therefore, it is physically impossible for the Arctic to be already melting and, since nothing has changed since 1900 till present day. The only sensible forecast for the future would be to expect the same extreme events to continue until thermometer-based evidence tell us otherwise.

Let me conclude this paper by answering the question asked in the first part of the title by a categorical No, *the Arctic is not melting*. As long as temperatures remain the same as they have been for the last 100 years the Arctic will remain frozen in the long winter months and partly melt during very short summer months. The answer to the second question is that the theory of global warming is completely disconnected from the observations since their definition of temperature is based on some theoretical number that has nothing to do with the temperature that is measured by calibrated thermometer and, most importantly, used as an international standard by the scientific community. Since the theory is clearly wrong about forecasting the temperature patterns in the Arctic, all other predictions made by the theory must be wrong too.

And finally but very importantly, every number, table or graph presented in this paper can be reproduced and therefore validated since the source of the data used in the analysis is in the public domain and is freely available.

ACKNOWLEDGMENTS

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