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# Atmospheric pressure and anemological conditions in south-western Greenland in the second half of the 18th century

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## Abstract

Anemological and atmospheric pressure conditions were analysed based on two series (1767/68 and 1784–92) of meteorological observations from Nuuk, the capital of Greenland, located on the south-western coast. The first series is the oldest available long-term series of instrumental measurements for this region. Meteorological observations were conducted using instructions and instruments provided by the Palatinate Meteorological Society. The materials used in this work come from European archives: Moravian Archives in Herrnhut (Germany) and Det Kgl. Bibliotek in Copenhagen (Denmark).

Wind speed had been visually assessed by Moravian observers in a several-degree intensity scale, which was compared to the Beaufort scale and, finally, recalculated to the presently used units ($ms^{-1}$). Atmospheric pressure measurements had been taken using a mercury barometer with Paris inch scales, whereas air temperature had been measured with thermometers in Fahrenheit/Réaumur scales; these were recalculated to hPa and Celsius degrees, respectively. The frequency of occurrence of atmospheric pressure values for different intervals was examined, as were the magnitudes of day-to-day changes that affect the human body. Each year during the historical period, episodes occurred when atmospheric pressure exceeded 1020 hPa. Day-to-day changes were typically below 8 hPa, but changes exceeding 12 hPa occurred in almost every month. Analyses of the frequency of wind from each of eight directions during the year and for the seasons revealed an exceptionally low frequency of wind from the SE direction (3 to 12%) and that the highest frequency was for winds from the NE (19 to 37%).

Observations of atmospheric pressure and wind made in the 18th century were compared with those of the modern period (1991–2020). Atmospheric pressure in the historical period was 5.9 hPa lower than the contemporary period, while the average wind speed for both periods was 6.1 $m \cdot s^{-1}$.

**Keywords:** Greenland, historical climatology, Moravian Brethren, atmospheric pressure, wind direction, wind speed.

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


## 1. Introduction

As is well known, average air temperature values are rising all over the Earth. This process, called global warming, is currently most visible in the Arctic regions, where changes are occurring as much as several times faster than in other regions of our planet (Walsh et al., 2011; Jeffries et al., 2013; Przybylak and Wyszyński, 2020; IPCC, 2021; Przybylak et al., 2024; Chmist et al., 2025; Singh et al., 2025). To understand these changes, in terms of both thermal conditions and other meteorological elements, it is necessary to thoroughly analyse the climate in this region using the oldest available data though to present-day data. If a sufficiently long series of measurements covering the pre-industrial period can be obtained, it will be possible to estimate the extent to which currently observed climate changes are the result of natural changes and what role humans play in this process (Przybylak et al., 2024). A better understanding of the climatic conditions in the Arctic requires knowledge of the prevailing climatic conditions of the past, (as described in, e.g., Przybylak, 2000; Przybylak and Vizi, 2005; Vinther et al., 2006; Demarée and Ogilvie, 2008, 2021; Przybylak et al., 2010, 2013, 2016, 2022, 2024; Nordli et al., 2014, 2020; Przybylak and Wyszyński, 2017; Araźny et al., 2019; Demarée et al., 2020; Chmist et al., 2025; Singh et al., 2025).

The oldest meteorological data found so far in the Arctic come from Greenland – specifically, from the settlement of Nuuk (now the island's capital) in the south-west of the island. These data are taken from records of weather observations conducted by the Moravian missionaries using meteorological instruments. The missionaries had set up a religious mission in this area. The first records of air pressure and wind measurements that survived had a duration of almost one year (Sep 1767 to July 1768). After a long break, the next available series of such observations covers the period 1784–92.

The thermal conditions in Nuuk for this period have already been described by Przybylak et al. (2024). Thus, the main goal of this work is to focus on less-studied meteorological variables for the south-western coast of Greenland in the second half of the 18th century – namely, atmospheric pressure and anemological conditions – and to compare them with the contemporary period (1991–2020).

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


## 2. Area, data and methods

### 2.1. Area

The coastline of south-western Greenland is densely indented with fjords. At the tip of one small (~70-km-long) peninsula is present-day Nuuk (64°10′N 51°45′W). The city is located about 20 km from the open ocean and about 120 km from the compact mass of the Greenland ice sheet (Fig. 1). The Moravian missionaries established their mission in the area that is now within the city of Nuuk, formerly also known as Neu-Herrnhut, Godthaab, Godthab or Godthåb (for more details see Przybylak et al., 2024; Araźny et al., 2025).

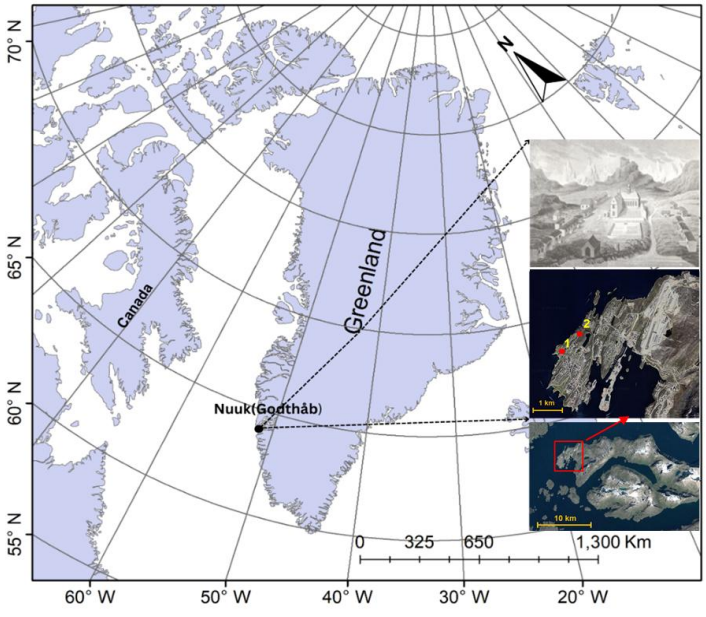



**Fig. 1.** Location of the study area
Explanation: 1 – Nuuk, historical; 2 – Nuuk, present-day; Upper photo – Nuuk (Neu-Herrnhut)
Source: authors' own work, based on Google Earth ([2024], https://www.google.pl/earth/). Map data for the location of sites: © Google Earth; images © 2023 Maxar Technologies, © 2023 Airbus, and © 2023 Asiaq

According to the Köppen–Geiger climate classification (Kottek et al., 2006), the climate in this part of the island is polar tundra (ET). In the contemporary period (1991–2020), the average annual air temperature is -1.0 °C. The warmest month is July (7.0 °C) and the coldest is February (-8.3 °C). Atmospheric pressure is at an annual average of 1006.9 hPa and ranges from 998.4 hPa in January to 1013.8 hPa in May. The average wind speed during the year is 6.0 $m \cdot s^{-1}$. The highest speeds are recorded in January (7.1 $m \cdot s^{-1}$) and the lowest in July (4.9 $m \cdot s^{-1}$). For most of the year, winds are northerly and north-easterly (Cappelen and Drost Jensen, 2021).

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


## 2.2. Sources and data

The climatic conditions in SW Greenland were characterised using data for diaries containing records of meteorological measurements taken during the historical period. These materials were prepared by the Moravian missionaries, who were conducting missions at that time, including in Arctic areas. The aforementioned materials are kept in European archives: 1) Moravian Archives in Herrnhut (Germany); 2) Det Kgl. Bibliotek in Copenhagen (Denmark). The records present two periods: 1) September 1767 – July 1768; 2) September 1784 – June 1792. This second period consisted of four shorter series: September 1784 – June 1785, October 1786 – June 1787, November – December 1788, January 1790 – June 1792 (hereinafter, all series are often referred to collectively as those of the "historical period").

During the first historical sub-period (1767/68), observations were made twice a day: at 7 a.m. and 2 p.m. The parameters measured at that time were: air temperature (°F), atmospheric pressure (Paris inch and Paris line) and wind direction (eight directions, N, NE, E, etc.…) and force (6-degree scale, 1–6). For this series, atmospheric pressure measurements began only on October 26, whereas the air temperature series contains a break from October 4 to 25. In the second sub-period (1784–92), observations were made three times a day: at 7 a.m., 2 p.m. and 9 p.m. local time (LT). The measurements taken included: air temperature (°R), atmospheric pressure (Paris inches and Paris lines) and wind direction and wind force (this last having been measured on a scale of 1–4 that differs from that used during the first period). During the second period, there are no data on wind force for September 1784 – June 1785, so the analyses herein ultimately cover the 1767/68 period and the years 1786–92. All data used for this purpose have been published in the repository (https://doi.org/10.18150/XGCONO).

The work also uses contemporary data to compare against prevailing conditions in the historical period. These data come from the Danish Meteorological Institute (DMI) (Cappelen and Drost Jensen, 2021) and are available on their website (https://www.dmi.dk/publikationer/). The range of the data used covers the period from January 1991 to December 2020, with a few gaps. The analyses were based on meteorological observations made at 7 a.m., 2 p.m. and 9 p.m. local time (LT) and included variables such as air temperature (°C), atmospheric pressure (hPa), wind speed ($ms^{-1}$) and direction.

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


## 2.3. Methods

Atmospheric pressure conditions were studied using a series of available meteorological observations for Nuuk (1767/68; 1784–92). Measurements were taken using barometers with a scale in Paris inches and Paris lines. The results were converted to mmHg and then to hPa. Corrections were applied to the resulting data, allowing for comparison of historical and contemporary data. A gravity correction (Pφcorr) was applied, and the pressure was converted to sea-level altitude (SLP) using the formulas provided in Cappelan (2009). For more details, see Przybylek et al. (2013).

A barometer with temperatures from November 1788 to June 1792 is also available in Nuuk. These measurements allowed the correction of atmospheric pressure to a temperature value of 0 °C. For this purpose, the Kämtz formula provided in Können et al. (2003) was applied. For more details, see Przybylek et al. (2013). The obtained correction values averaged for individual months (Table S1), were used to correct the remaining atmospheric pressure data at Nuuk.

Wind speed and direction measurements were used to analyse anemological conditions in Nuuk. Furthermore, wind directions were compared against air temperature and atmospheric pressure. The data used in this work were previously subjected to quality control and conversion from historical units to those used today. Temperature was converted from °F to °C and atmospheric pressure from Paris inches and Paris lines to hPa. Wind speed was converted from numerical scales of 1–6 and 0–4 to $m \cdot s^{-1}$ (speed at a height of 10 m above ground level) based on the conversion procedure proposed in the works of Chmist et al. (2025) and Araźny et al. (2025).

Based on the available data, an analysis of wind speed in the historical period was made, examining the course of daily and monthly averages and of extreme values, and the results were compared against contemporary measurements. Observed wind directions were compared against contemporary measurements, with the analyses covering individual months, entire seasons and multi-year periods. The article also presents how observed wind direction correlates with air temperature and with atmospheric pressure.

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


# 3. Results

## 3.1. Atmospheric pressure conditions

The atmospheric pressure data for the sub-period 1784 to 1792 at Nuuk reveal significant seasonal and interannual variations. The highest single observed atmospheric pressures (P max abs) generally occurred during the winter and spring months, with values often exceeding 1025 hPa (Table 1). Conversely, the lowest pressures were recorded during autumn and early winter, with values dropping below 975 hPa. The mean monthly maximum (P max) and minimum (P min) pressure values also showed their greatest fluctuations in winter and spring months. For instance, in April 1791, the mean maximum pressure (P max) was 1004.2 hPa, and the mean minimum pressure (P min) was 995.9 hPa. The mean monthly atmospheric pressure (P) during the year varied within a relatively narrow range, usually oscillating around 1000 hPa. For example, in 1791, it ranged from 1001.9 hPa in December to 1003.8 hPa in April. The winter months were characterised by greater variability compared to the more stable summer months (Table S2).

**Table 1.** Annual (Sep-Aug), seasonal (SON, DJF, …, etc.) and monthly mean (P), maximum (P max) and minimum (P min) values, and highest (P max abs) and lowest (P min abs) observed atmospheric pressure values (hPa) at Nuuk in historical sub-period 1784–92

| Station | Value | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | SON | DJF | MAM | JJA | Sep-Aug |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nuuk | P max abs | 1011.7 | 1026.4 | 1028.0 | 1027.1 | 1025.8 | 1032.1 | 1028.7 | 1036.0 | 1032.5 | 1023.0 | 1014.1 | 1012.5 | 1028.0 | 1032.1 | 1036.0 | 1023.0 | 1036.0 |
| | P max | 999.3 | 1001.1 | 1013.7 | 1002.0 | 1007.8 | 1011.7 | 1010.3 | 1010.8 | 1014.5 | 1005.8 | 1001.1 | 1002.6 | 1004.1 | 1004.3 | 1009.6 | 1005.8 | 1005.9 |
| | P | 997.6 | 997.0 | 1004.3 | 998.8 | 997.9 | 998.6 | 1001.7 | 1006.6 | 1006.8 | 1003.5 | 999.7 | 1001.9 | 999.6 | 999.8 | 1005.0 | 1002.9 | 1001.5 |
| | P min | 994.3 | 994.4 | 1000.0 | 996.0 | 989.0 | 989.6 | 997.1 | 999.8 | 1003.5 | 1001.1 | 998.4 | 1001.3 | 998.1 | 994.2 | 1003.6 | 1001.2 | 999.3 |
| | P min abs | 982.6 | 971.7 | 978.4 | 968.1 | 947.0 | 965.6 | 969.7 | 982.0 | 982.5 | 980.9 | 981.7 | 982.0 | 971.7 | 947.0 | 969,7 | 980.9 | 947.0 |
| | 1SD | 1.6 | 1.8 | 5.3 | 2.4 | 6.6 | 7.3 | 4.1 | 4.0 | 3.8 | 1.3 | 1.2 | 0.5 | 1.5 | 4.0 | 1.4 | 1.9 | 1.6 |

Explanations: SD – standard deviation

During the multi-year sub-period 1784 to 1792, the highest absolute pressure (P max abs) reached 1036.2 hPa on 6 April 1791 at 7 a.m., while the lowest absolute pressure (P min abs) was 961.2 hPa on 22 January 1790 at 2 p.m. Mean monthly pressure (P) values fluctuated around 1002.9 hPa throughout the sub-period, with the highest values generally occurring in spring and winter and the lowest in late autumn and early winter. The standard deviation values further highlight that the winter and spring seasons underwent the highest pressure fluctuations (Table 1).

The frequency distribution of Nuuk's average daily atmospheric pressure values reveals distinct seasonal and interannual variations – during both the historical period (1767/68; 1784–92) and the contemporary period (1991–2020) (Fig. 2). The classification follows predefined

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025

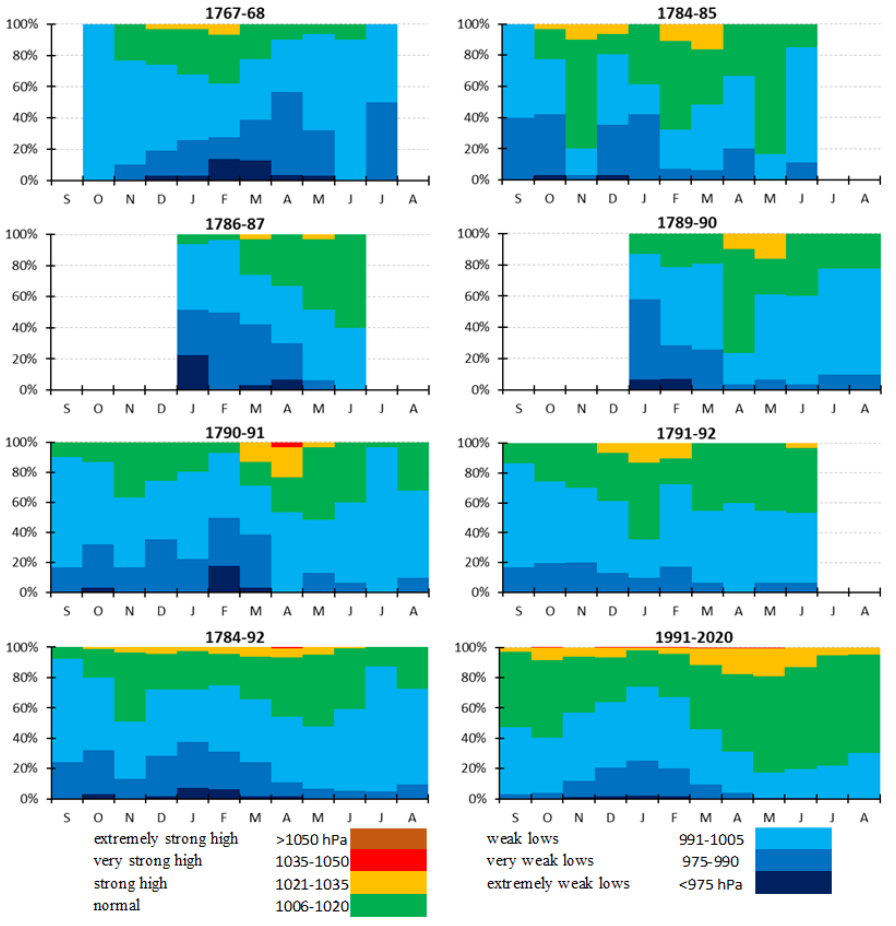




**Fig. 2.** Frequency classes of average daily atmospheric pressure values for Nuuk (according to daily averages) for the historical period (according to the thresholds). Graph for individual months, seasons and years, cumulated to 100%

pressure thresholds. Across all years, weak low-pressure conditions (991–1005 hPa) and normal pressure conditions (1006–1020 hPa) dominated, particularly during autumn and winter. In contrast, strong high-pressure events (≥1021 hPa) were more frequent in spring and summer, with occasional occurrences of very strong highs (>1035 hPa), as seen in 1790–91. Notably, 1790–91 displayed increased variability, with a small fraction of extremely strong highs and extremely weak lows appearing. The seasonal progression highlights a pattern consistent with large-scale atmospheric circulation in the Arctic, with low-pressure systems being more prominent in winter, whereas high-pressure systems stabilise in summer. Contrasting the full historical span (1767/68; 1784–92) with the contemporary one (1991–2020) hints at a possible gradual change. The latest figures reflect an upsurge in normal pressure situations across the

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


year and a steadier display of strong high-pressure systems, mainly in the spring and summer months. At the same time, weaker low-pressure systems (especially very weak lows) seem to occur less frequently in the contemporary period.

The day-to-day variations in atmospheric pressure in Nuuk for the historical period and for the contemporary period are categorised according to specific pressure thresholds in Fig. 3. Compared to the historical period, the modern era shows a tendency towards a higher frequency of days characterised by weak and moderate day-to-day pressure variations. Conversely, days

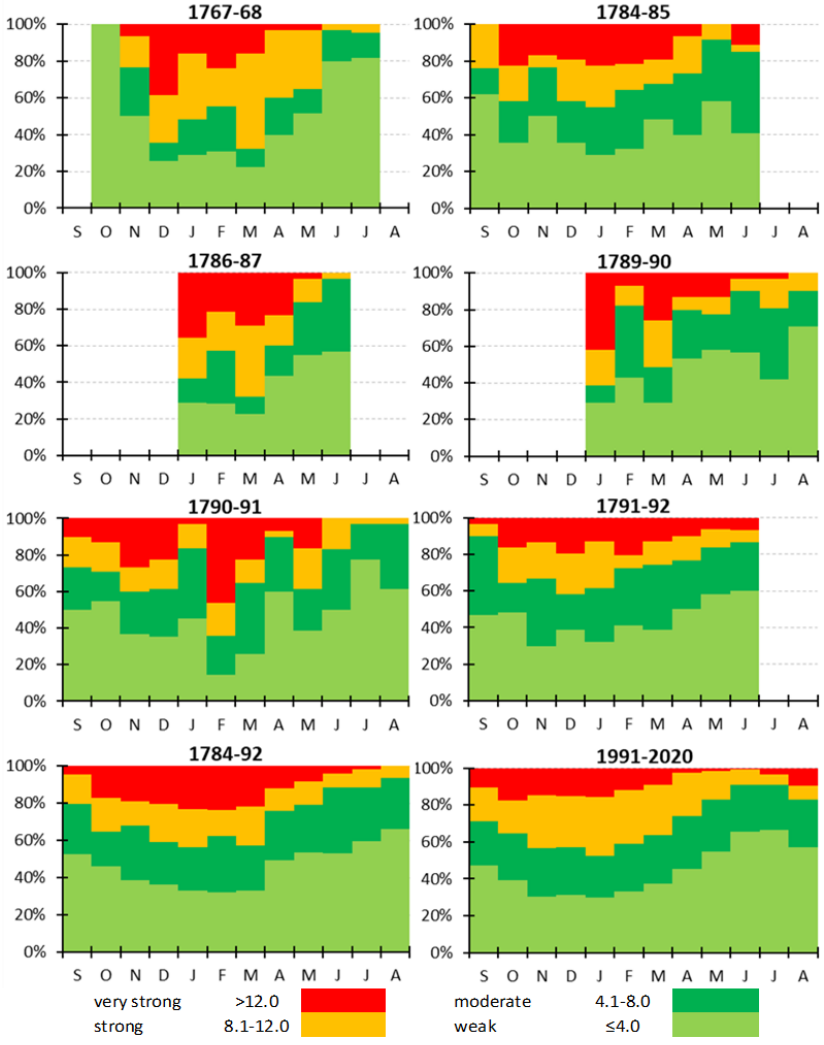



**Fig. 3.** Day-to-day variation in atmospheric pressure for the historical period Nuuk (according to daily averages). Graph for individual months, seasons and years, cumulated to 100%

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


exhibiting strong and very strong day-to-day pressure variations appear to be less frequent in the 1991–2020 period compared to some parts of the historical record. This means that, in the contemporary period, there has been a lower frequency of the human sensation of changes in atmospheric pressure relative to the historical period (Fig. 3).

In the annual cycle of average daily atmospheric pressure values (Fig. 4), during the historical period (1767/68; 1784–92), the daily mean atmospheric pressure in Nuuk typically ranged from approximately 985 hPa to 1015 hPa. Lower pressure values were more frequent during the autumn and winter months, indicating of a more significant influence of cyclonic activity, while higher pressure values were more common in late winter and spring, suggesting periods of greater atmospheric stability. The use of an 11-day moving average to "smooth" the historical series made for an easier comparison against the contemporary period. The years 1991–2020 clearly show higher average daily atmospheric pressure throughout the year. The typical range of daily averages for the contemporary period is between 1000 hPa and 1020 hPa, which represents a noticeable increase in pressure. While a seasonal cycle of lower pressures in autumn and winter and higher pressures in warmer months persists, it occurs at these elevated pressure levels.

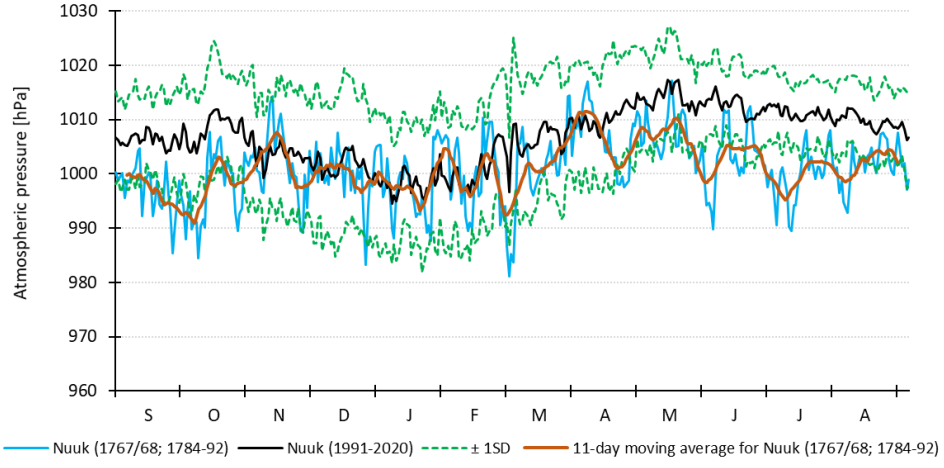



**Fig. 4.** Annual course of daily means of atmospheric pressure and 11-day moving average at Nuuk in the historical (1767/68; 1784–92) and contemporary (1991–2020) periods, along with the standard deviation

Explanations: SD – standard deviation (± 1SD)

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


## 3.2. Anemological conditions

### 3.2.1. Wind speed

The multi-year average monthly wind speeds at Nuuk station during the historical period (1767/68; 1786–92) ranged from 4.8 $m \cdot s^{-1}$ in August to 7.3 $m \cdot s^{-1}$ in September. During the years analysed, almost every month (except August) had a wind classified as the fastest (30.5 $m \cdot s^{-1}$). In the case of seasonal values, the highest average speeds occurred in autumn. The highest average of daily maximums occurred in winter, while the lowest average of daily minimums was recorded in summer (Table 2).

**Table 2.** Annual (Sep–Aug), seasonal (SON, DJF, …, etc.) and monthly mean (V), maximum (V max) and minimum (V min) values, and highest (V max abs) and lowest (V min abs) observed wind speed values ($ms^{-1}$) at Nuuk in the historical period (1767/68; 1786–92)

| Station | Value | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | SON | DJF | MAM | JJA | Sep-Aug | Jan-Jun |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nuuk | V max abs | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 18.9 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 |
| | V max | 9.3 | 7.6 | 10.0 | 9.8 | 8.4 | 9.2 | 8.4 | 7.8 | 9.5 | 8.2 | 7.9 | 7.5 | 9.0 | 9.1 | 8.5 | 7.8 | 9.8 | 8.6 |
| | V | 7.3 | 5.5 | 7.0 | 6.7 | 5.9 | 6.4 | 5.7 | 5.6 | 6.9 | 5.7 | 5.8 | 4.8 | 6.6 | 6.4 | 6.1 | 5.4 | 6.1 | 6.1 |
| | V min | 5.1 | 3.3 | 4.2 | 3.8 | 3.5 | 3.4 | 3.2 | 3.5 | 4.3 | 3.4 | 3.8 | 1.8 | 4.2 | 3.6 | 3.7 | 3.0 | 3.5 | 3.6 |
| | V min abs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 1SD | 1.3 | 1.7 | 1.0 | 0.6 | 1.5 | 1.9 | 1.3 | 1.1 | 2.6 | 1.8 | 0.7 | 0.3 | 1.3 | 1.3 | 1.7 | 0.9 | 1.3 | 1.7 |

Explanations: SD – standard deviation

In the historical period, complete data for the entire measurement year (Sep–Aug) were available in only one instance (1790/91). Therefore, we decided to focus analysis based on the average of the six months for which data were most frequently available (Jan–Jun) (Table S3). In this way, individual years can also be compared against each other. Based on the designated half-year, the period of highest wind speeds occurred in 1787 (7.0 $m \cdot s^{-1}$), while the lowest speeds occurred in 1792 (5.4 $m \cdot s^{-1}$) (Table S3). A comparison of average monthly wind speeds shows a similarity in values between the historical and contemporary periods, and their differences do not exceed 2.0 $m \cdot s^{-1}$ (Fig. 5). In the years 1991–2020, average monthly wind speed values ranged from 4.8 $m \cdot s^{-1}$ in July to 7.1 $m \cdot s^{-1}$ in January. For both periods, the annual mean values are 6.1 $m \cdot s^{-1}$ (Table 2, Table S4).

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025

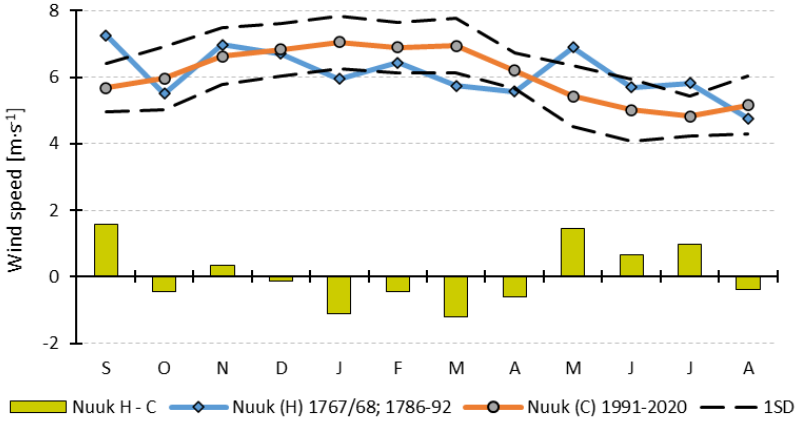




**Fig. 5.** Annual course of monthly means of wind speed at Nuuk in the historical (H) (1767/68; 1786–92) and the contemporary (C) (1991–2020) periods, with standard deviation
Explanations: bars – differences in monthly mean values between stations from the historical and contemporary periods, SD – standard deviation

The annual cycle of daily average wind speed values at Nuuk in the historical period is largely similar to that of the contemporary period (Fig. 6). In the contemporary period, the course is more even, which is attributable to the length of the measurement series (30 years). Wind speeds in this period oscillate from 4.0 to 8.4 $m \cdot s^{-1}$. In the case of the historical period, the data have a much larger range (1.0 to 16.0 $m \cdot s^{-1}$), but the vast majority fall within ±2 standard deviations, and the speeds rarely exceed the range of 2.0 to 10.0 $m \cdot s^{-1}$ (Fig. 6).

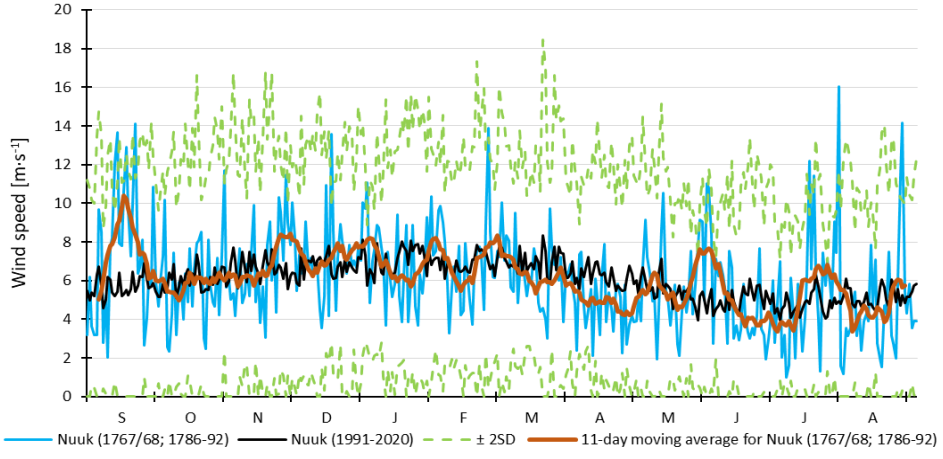



**Fig. 6.** Annual cycle of daily means of wind speed and 11-day moving average at Nuuk in the historical (1767/68; 1786–92) and contemporary (1991–2020) periods
Explanations: SD – standard deviation (±2SD)

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


### 3.2.2. Wind direction

Analysing the wind directions in the historical and contemporary periods, eight-way wind roses were made to show their frequencies (Fig. 7). In the years 1767/68; 1784–92, the most common wind direction was north-easterly (21% of cases), followed by northerly and easterly (16% and 15% of cases, respectively). In total, the wind from the N-NE-E sector accounted for 52% of all measurements. Another distinctive direction was southerly, which accounted for 16% of measurements. Calm accounted for 10% of observations. In comparison, in the years 1991–2020, the most common winds were northerlies (23% of cases), while winds from the NW-N-NE sector constituted 54% of all records. Similarly to the historical period, wind from the south had a significant share, accounting for 21% of measurements. However, calm was recorded in only 1% of cases in the contemporary period (Fig. 7, Table S5).

From a seasonal perspective, in the historical period, winds from the northerly to easterly directions (N-NE-E) were the most frequent in autumn, winter, and spring, constituting, respectively, 63%, 63%, and 57% of all winds. In summer, the frequency of these directions was significantly weaker, but still constituted 37% of measurements. During summer there was a greater prevalence of southerlies to westerlies (S-SW-W), reaching 39% of cases. In the other three seasons, these accounted for 21%, 19% and 27%, respectively. In the contemporary period, the dominant sectors from which the wind blew were the northerly to easterly (N-NE-E) and the northerly sectors (NW-N-NE). From autumn to spring, the northerly sector constituted from 58% to 60% of all measurements. As in the historical period, summer differed from the other seasons, with southerly to westerly (S-SW-W) directions dominating, but with a greater frequency of 56% (Fig. 7, Table S5).

The frequency of wind directions in the historical period can be analysed on a monthly basis (Table S6). The most frequently observed wind direction was north-easterly (21.1% of cases). This direction dominated in five months, from September to February (excluding December, in favour of the southerly direction, which also dominated in June and August). The second most frequently occurring wind direction was the wind from the north, which from March to May and in July was the direction most frequently observed (Table S6). Anemological conditions at the analysed station are largely dependent on the orography of the area. The wind here blows mainly along the coast (which runs N/NE–S), which is consistent with the conclusions drawn by Vizi (2008), who described, among others, anemological conditions in northern Canada.

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025

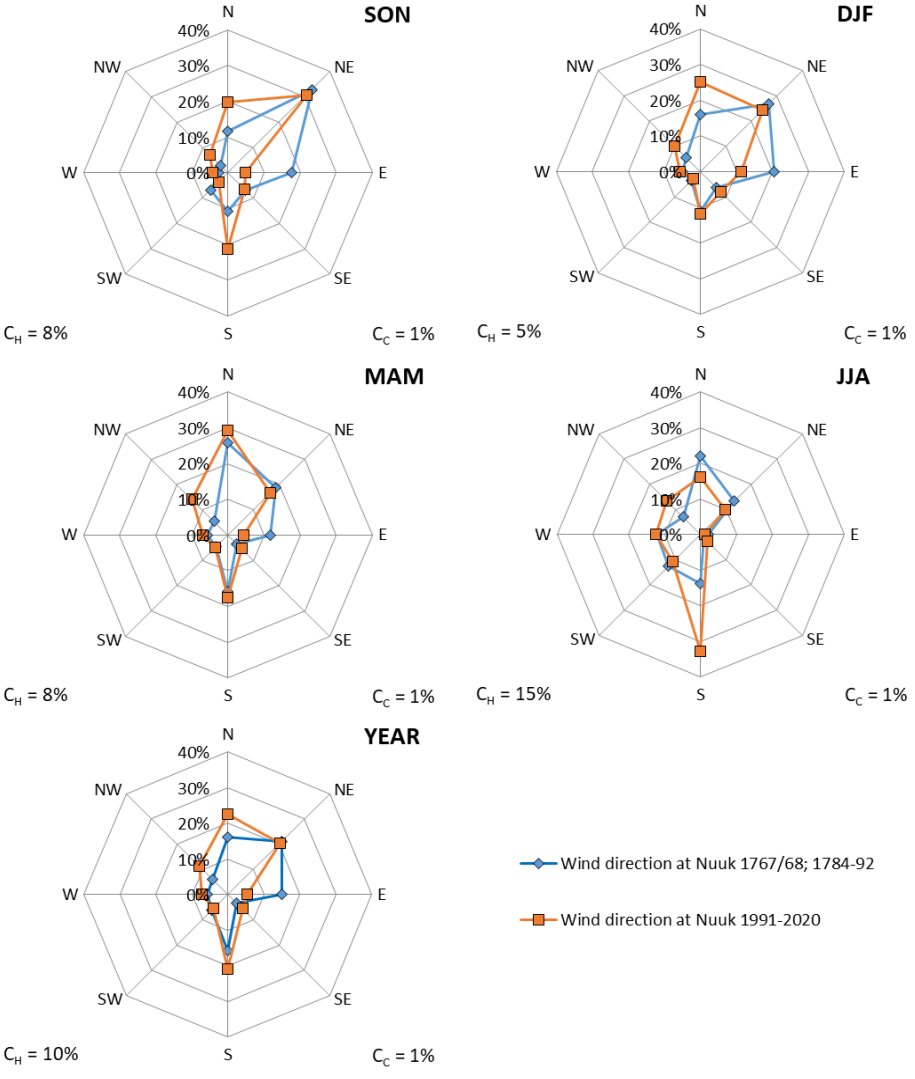



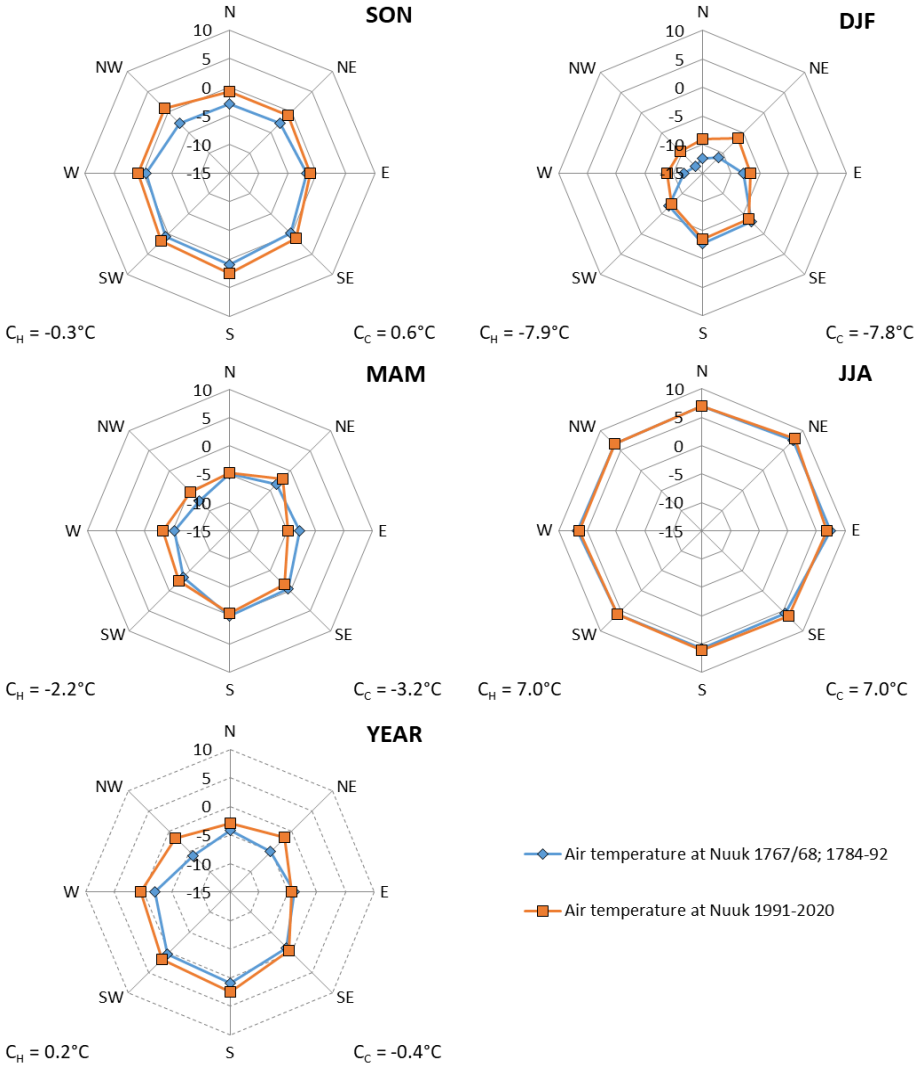

**Fig. 7.** Seasonal (SON, DJF, …, etc.) and annual (YEAR) frequencies (in %) of wind directions and calms (C) at Nuuk in historical (1767/68; 1784–92) and contemporary (1991–2020) periods

### 3.2.3. Wind direction vs. air temperature

Using air temperature measurements taken during anemological observations, we were able to determine the relationship between air temperature differences and wind direction. For this purpose, as in previous analyses, eight-way wind roses were used (Fig. 8). The mean annual air temperature at the Nuuk station during the historical period (1767/68; 1784–92) was -2.3 °C. The lowest air temperature values were associated with winds from the north and north-east (NW-N-NE-E), during which, air temperatures ranged on average from -3.9 °C to -6.0 °C. The

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


294 highest temperatures were recorded during southerly and south-westerly (S-SW) winds, being
295 1.0 °C and 0.3 °C, respectively. In the contemporary period (1991–2020), the mean annual air
296 temperature was higher and reached -0.8 °C. The lowest temperatures occurred during winds
297 from similar directions as in the historical period (NW-N-NE-E), though air temperature ranged
298 from -1.6 °C to -4.4 °C. The highest temperatures were measured (as in the historical period)
299 during southerly and south-westerly winds (2.5 °C and 1.6 °C, respectively) (Fig. 8, Table S7).




300
301 **Fig. 8.** Seasonal (SON, DJF, …, etc.) and annual (YEAR) average values of air temperature (in °C)
302 according to different directions at Nuuk in historical (1767/68; 1784–92) and contemporary (1991–
303 2020) periods

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


Considering this pattern from a seasonal perspective (in the historical period), the lowest air temperatures in the autumn, winter and spring seasons were associated with winds from the north and north-east. The highest temperatures in these seasons were recorded during winds from the south and south-east (and, in autumn, additionally from the south-west). In summer, this pattern reverses, with winds from the northern sector bringing the highest temperatures, while winds from the southern sector bring the lowest. In the summer season, the change in air temperature depending on wind direction is not significant, averaging up to 2 °C. The greatest differences are observed in the winter season, when, depending on wind direction, temperatures vary by up to 10 °C (Fig. 8, Table S7).

Comparing the seasons from the historical period to the three-decade contemporary period 1991–2020, the relationship between wind direction and air temperature is the same. From autumn to spring, average air temperatures are lowest during winds from the west through the north to the east, while the warmest are observed during southerly winds. As in the historical period, the summer air temperature is lowest during winds from the south and highest during winds from the north-east (Fig. 8, Table S7).

### 3.2.4. Wind direction vs. atmospheric pressure

Thanks to the meteorological observations conducted in Nuuk in the 18th century (1767/68; 1784–92), it is possible to correlate wind direction with prevailing atmospheric pressure (Fig. 9). The mean atmospheric pressure during the historical period was 1000.0 hPa. The lowest values (995.2 hPa) were achieved during south-easterlies (SE). The highest values occurred during calm (C) (1002.3 hPa), and slightly lower values were associated with south-westerly (SW) and northerly (N) winds (Fig. 9, Table S8). In the contemporary period (1991–2020), the lowest atmospheric pressure was associated with easterly (E) winds, whereas the highest values were associated with south-westerly and southerly (SW-S) winds. The average atmospheric pressure was 7.0 hPa lower in the historical period than in the reference period. This may be due to imprecise instrumentation, but it should not affect the accuracy of the relationships described above.

Looking at the relationship between atmospheric pressure and wind direction during the historical period, south-easterly (SE) winds were associated with some of the lowest barometric readings in all seasons except summer. The situation was similar for westerly (W) winds, but only in autumn and spring. For the highest atmospheric pressure values, the situation was more complex – the highest atmospheric pressure values were associated with a different wind direction (Fig. 9, Table S8).

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025

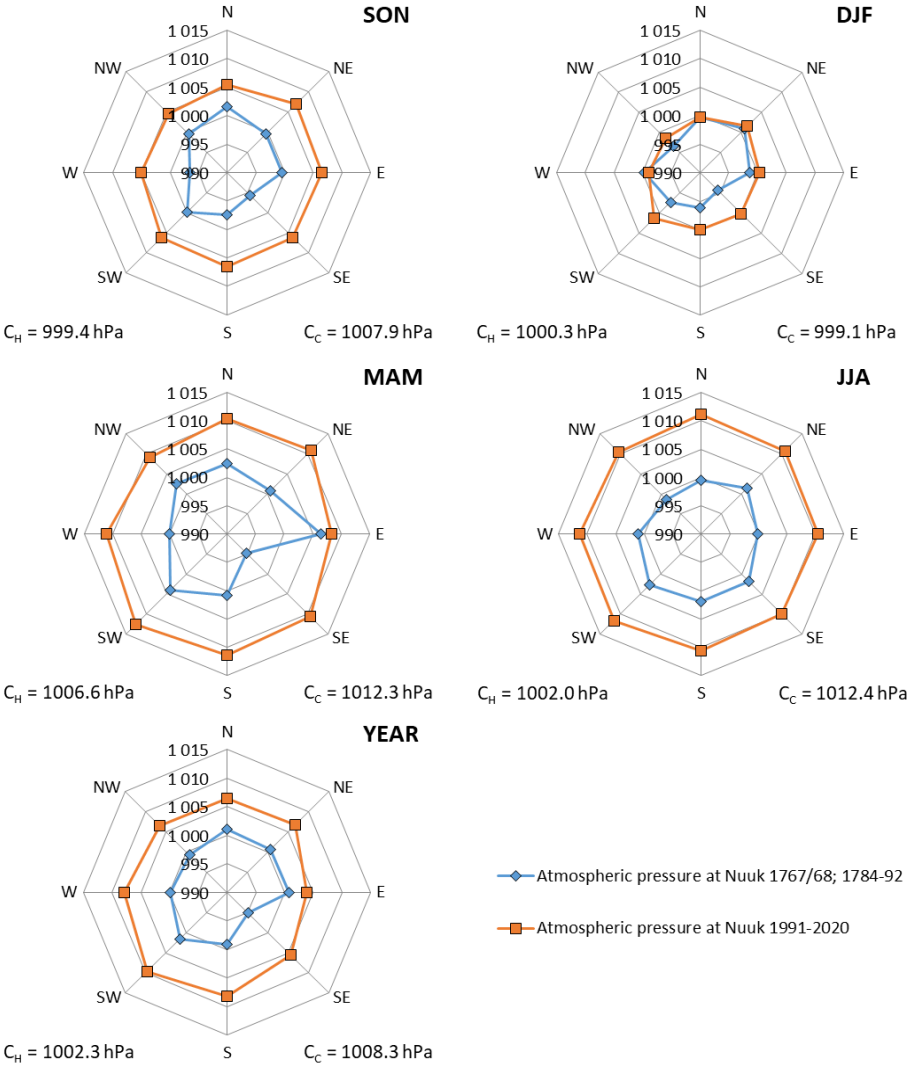




**Fig. 9.** Seasonal (SON, DJF, …, etc.) and annual (YEAR) average values of air pressure (in hPa) according to wind direction at Nuuk in historical (1767/68; 1784–92) and contemporary (1991–2020) periods

During the contemporary period, some of the lowest atmospheric pressure values occurred during north-westerly (NW) wind. It is noteworthy that this is the only relationship that did not change even during the summer season. South-westerly (SW) winds often occur in conjunction with the highest values, but this relationship does not occur during the autumn season. For the remaining wind directions, atmospheric pressure is (somewhat similarly to the historical period) characterised by values that are so divergent that it is difficult to identify a specific relationship (Fig. 9, Table S8).

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


## 4. Discussion

Long-term series of measurements of atmospheric conditions are necessary to determine the climate prevailing in a given place. The further back in time we go, the harder it is to obtain such data; it is especially difficult to find measurements made using meteorological instruments and to find observations made in places that are difficult to access or not very friendly to humans. These impediments all relate to the Arctic area in the second half of the 18th century. The Arctic has only had good coverage with meteorological stations since the mid-20th century (Przybylak, 2000), and its climate can definitely be described as making human settlement difficult. Such data would allow for a detailed analysis of the climate of this region, as well as more precise reanalyses. For this reason, the main goal of the present work was to describe the climatic conditions prevailing in the historical period (1767/68; 1784–92) on the south-western coast of Greenland (the city of Nuuk). Because the air temperature results have already been published (Przybylak et al., 2024), this article focuses on the course of atmospheric pressure values and anemological conditions. The data used are extremely valuable because they are the oldest available instrumental measurements in this region of the world. However, for this very reason, the absence of other works describing climatic conditions in a similar time and space makes comparison of the results difficult.

In the Arctic (defined as the area north of the 62nd parallel in the Northern Hemisphere), a statistically insignificant decrease in atmospheric pressure was observed between 1880 and 2000 (Polyakov et al., 2003; Przybylak, 2007). However, this decrease is not permanent, given that, during this 120-year period, there was a period of increasing pressure (1920–60) followed by a significant decrease between 1960 and 2000, primarily due to changes in the winter season. Other studies confirm this trend (Walsh et al., 1996; Cullather and Lynch, 2003).

Along with the decrease in atmospheric pressure, cyclonic activity began to increase proportionally, resulting in more frequent occurrences of both cyclones and anticyclones (Serreze et al., 1993, 1997). Turner et al. (2007) also noted changes in the strength of nearby major pressure centres. In the second half of the 20th century, there was a noticeable decrease in mean atmospheric pressure within the Icelandic and Aleutian lows, while there was an increase in the Siberian High. The results of the research by Panagiotopoulos (2005) contradict this thesis; they indicate that, in the first half of the 20th century, there was indeed an increase in atmospheric pressure in the Siberian High, but that, since the 1970s, there has been a sharp decline in the value.

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


Atmospheric pressure around Greenland appears to increase with increasing latitude, although this increase is uneven, with higher values recorded on its eastern coast. Pressure in the southern part of the island reaches comparable values to neighbouring areas at this latitude, while in the northern part these values are higher (Putnins, 1970; Wang and Iokeda, 2000; Cassou, 2004).

The daily variation in atmospheric pressure typically reaches its maximum in winter and its minimum in summer (Putnins 1970). This is confirmed by a study published by Petersen (1935), in which he analysed atmospheric pressure at Angmagssalik, among other places. The winter maximum was 10 hPa, and the summer minimum was 3.7–4.3 hPa. In the case of Nuuk described in this article, which is located slightly further south of Angmagssalik but on the opposite side of the island, the greatest mean daily variability of atmospheric pressure occurred from December to March. During this period, on average, approximately 20% of the day-to-day variations exceeded 12.0 hPa. The lowest differences were recorded in July and August, when in most cases they were below 4.0 hPa, which is consistent with the above studies.

Wind in Greenland is strongly dependent on terrain. In general, air in the troposphere moves from west to east over the island, which is the result of the global energy balance determined by the inflow of solar radiation being greater at lower latitudes. However, topography plays a decisive role closer to the ground surface. Wind is often channelled into the flow in fjords, where katabatic flow from the interior of the island dominates (due to the extensive ice sheet in the centre), whereas over the sea, winds flow parallel to the coast, blowing clockwise (Putnins, 1970; Cappelen, 2021; Koch, 2023). In summer, winds often blow from the sea along the fjord toward the inland centre, whereas in winter, they blow in the opposite direction. Despite Nuuk being located at the mouth of the fjord, this relationship is still evident. The station located on the south-western coast, both in the historical and contemporary periods, witnesses winds predominantly from the north-east sector (N-NE-E) in winter, whereas in summer, winds from the south intensify. South-easterly and westerly directions play only a marginal role throughout the year. Putnins provides an example comparing two stations on the south coast. The sheltered town of Ivigtut (now Ivittut) is characterised by frequent atmospheric calms (which translates into a bigger air temperature amplitude), almost half the wind speed, and significantly fewer fog days, as compared to the exposed location of the nearby Nanortalik. Further examples supporting the thesis of the strong role of topography on the local climate around specific stations are observations conducted at the Danmarkshavn, Nord and Brønlund Fjord stations (Putnins, 1970).

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


Putnins (1970) also analysed wind direction for Greenland. Thus, we learn that, from October to April, easterly or north-easterly winds predominated. In the remaining months (except May), south-westerly winds dominated, although atmospheric calms were also common. In the combined period 1767/68 and 1784–92 and in 1991–2020 alike, outside the summer season, the wind also most often blew from the north and north-east. The summer season, however, was characterised by winds from the south and south-west, although in the historical period, summer winds were also frequently observed from the north and north-east. Calm periods were almost non-existent in the contemporary period, but in the historical period, they most frequently occurred in the summer season, accounting for 15% of all observations. The probable reason for these differences is the low accuracy of wind force estimates in the historical period.

In Greenland, coastal and central inland weather conditions generally differ, unless a very strong high-pressure system is present over the island (Baumann, 1933). In 1936, Loewe wrote about the unfavourable weather conditions that frequently occur in the centre of the island. As atmospheric pressure dropped in the regions around Greenland, a strong katabatic wind from the centre of the island toward the coast was observed. It is clearly visible on the steep slopes of the sheet (Loewe, 1935). It reaches its highest speeds in November and February. However, in summer, the contrast between the interior of the ice sheet and the zone bordering the mainland is smallest, resulting in a weakening of wind speeds.

Putnins (1970) also notes that extremely strong winds are not uncommon in the coastal zone, where wind speeds reaching several dozen $m \cdot s^{-1}$ are recorded. The example of Nuuk, analysed in this article, seems to confirm this. During the historical period, wind speeds exceeding 30 $m \cdot s^{-1}$ were repeatedly observed. However, observational data in coastal regions are not easy to analyse due to the specific variability of climatic conditions depending on the station location. Measurement points located close together but in areas that differ orographically can exhibit greater differences in measurements than those located farther apart but in areas that are similar in terrain (Petersen, 1935).

Møller and J. Helgason (2021) described the meteorological conditions in the years 2007–16 in the four largest cities of Greenland's south-western coast. They showed that, in the southern part of the island, the climate is warmer and more humid, whereas further north, the relative air humidity, precipitation and air temperature decrease, especially in winter. Moreover, Nuuk, compared to the other three large cities (which are located relatively close to each other and, like Nuuk, on the coast) has higher wind speeds, with monthly average values ranging from less than 5 $m \cdot s^{-1}$ in the summer months to more than 6 or even 6.5 $m \cdot s^{-1}$ from November

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


to April. These values are very close to the average from the longer series used in this article (1991–2020); however they differ slightly from the historical period (1767/68; 1786–92), when the recorded wind speed was similar in winter but when values in June and July were almost 1 $m \cdot s^{-1}$ higher.

A study by Putnins (1970) also provides insight into anemological conditions prevailing in the mid-20th century (1931–56). At Nuuk (formerly known as Godthaab), monthly mean wind speeds range from 2.1–2.2 $m \cdot s^{-1}$ in the summer months to 3.0–3.3 $m \cdot s^{-1}$ in the winter months, with an annual mean of 2.7 $m \cdot s^{-1}$. These values are significantly lower than those presented in this study and others describing conditions in both the recent and the more distant past.

Anemological conditions in the Arctic, including Godthåb station (now the city of Nuuk) dating back to the 19th century and deriving from the 1st International Polar Year 1882/83 were analysed by Wyszyński (2011). These data cover the period from August 1882 to August 1883. This is almost 100 years after the period described in this work, and the average monthly wind speed ranged from 5.8 $m \cdot s^{-1}$ in August to 10.7 $m \cdot s^{-1}$ in February, with an annual average of 8.0 $m \cdot s^{-1}$. In the case of the annual average, this speed is almost 2 $m \cdot s^{-1}$ greater than the values for the years 1767/68; 1786-92. However, it should be borne in mind that the work of Wyszyński (2011) only analysed one year, which is less representative than using data from several years, which, as we know, averages the obtained results. Differences between periods can also be seen in the case of wind directions. In the year 1882/83, only one direction was dominant in the individual months. From April to September, the most frequently observed wind was southerly and south-easterly, whereas from October to January, it was north-easterly. In the combined period 1767/68; 1784–92 in this work, the frequencies of wind from individual directions in the autumn and winter months are similar to those of 100 years later. However, in the warm season, there is often no dominant direction, and the wind blows equally from the north and south.

Araźny et al. (2025) also provide wind speeds describing the bioclimatic conditions prevailing in Nuuk in 1767/68 and 1790–92. The values in that paper are not comparable to those presented in this paper, because they come only from measurements around noon and were reduced to a speed at height of 1.2 m above ground level, which is about 66% of the value from 10 m above ground level.

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


## 5. Conclusions

The main conclusions from this study can be presented as follows:

- In both the historical and contemporary periods, the lowest atmospheric pressure values were recorded in January and February. The highest values occurred from March to May, and in the contemporary period, they also occurred in June.
- In both historical and modern periods, day-to-day changes in atmospheric pressure have been weak or moderate. Very strong changes dominated during the autumn and winter seasons. In the summer season, they almost never occurred in the historical period, whereas in the contemporary period this minimum shifted to the transition from spring to summer.
- The multi-year average monthly wind speed values in the historical and contemporary periods have similar values, and the annual average for both data series reached 6.1 $m \cdot s^{-1}$.
- In the historical period, the most frequent wind directions at the Nuuk station were N-NE-E, whereas in the contemporary period they were NW-N-NE. These were the dominant directions almost all year round, except for summer, when (in both periods) the wind from the south showed increased activity.
- In both the historical and contemporary periods, the wind from the north-west and north (W-NW-N-NW) was associated with lower air temperatures than were winds from other directions. The exception was the summer season, when the wind from the north (NW-N-NE) brought with it (slight) warming.
- Barometer measurements indicate a much lower atmospheric pressure prevailing in the historical period. However, this may be the result of the device's incorrect calibration. In this work, however, the relationship between wind direction and atmospheric pressure difference is of greater importance, which is still possible. In the historical period, the lowest atmospheric pressure values corresponded to winds from the north-west and south-east (NW and SE). In the contemporary period, the lowest pressure values were observed for easterly directions (NE-E-SE).

This work significantly addresses the gaps in the historical data series currently available for Greenland for the 18th century. Further work on historical data is necessary due to their uniqueness and potential to enhance our understanding of current climate changes.

https://doi.org/10.5194/egusphere-2025-5657
Preprint. Discussion started: 4 December 2025


## Statements and Declarations:

### Data availability

Datasets for this research were derived from the following public domain resources:

1. Repository for Open Data (RepOD), Nicolaus Copernicus University Centre for Climate Change Research collection, Chmist et al. (2025), https://doi.org/10.18150/XGCONO
2. Danish Meteorological Institute (DMI), https://www.dmi.dk/publikationer/

### Authors' contribution

**Konrad Chmist**: Conceptualisation, Methodology, Investigation, Data curation, Formal analysis, Software, Visualisation, Interpretation of results, Writing – original draft, review and editing. G**arima Singh**: Conceptualisation, Methodology, Investigation, Data curation, Formal analysis, Software, Visualisation, Interpretation of results, Writing – original draft. **Andrzej Araźny**: Conceptualisation, Methodology, Investigation, Data collection and selection, Formal analysis, Validation – original draft and review, Supervision, Interpretation of results. **Rajmund Przybylak**: Conceptualisation, Data collection and selection, Validation – original draft and review, Funding acquisition, Project administration. **Przemysław Wyszyński**: Conceptualisation, Data collection and selection, Open data repository curation, Validation – original draft and review.

### Competing interests

The authors declare that they have no conflict of interest.

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https://doi.org/10.5194/egusphere-2025-5657
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