

3rd ACRE Workshop

Wednesday, November 3 - Friday, November 5, 2010

Baltimore, USA

Rajmund Przybylak, Joanna Jankowska,

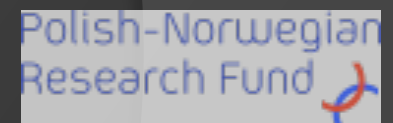
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ATMOSPHERIC PRESSURE CHANGES IN THE ARCTIC FROM HISTORICAL TIMES TO THE PRESENT



INTRODUCTION

Polar Regions:

- play a very important role in the formation of the Earth's climates,
- are the most sensitive to the climate changes,
- and therefore are perfect case studies for the detection of such changes.
- knowledge about the Arctic climate and its variability is still limited.

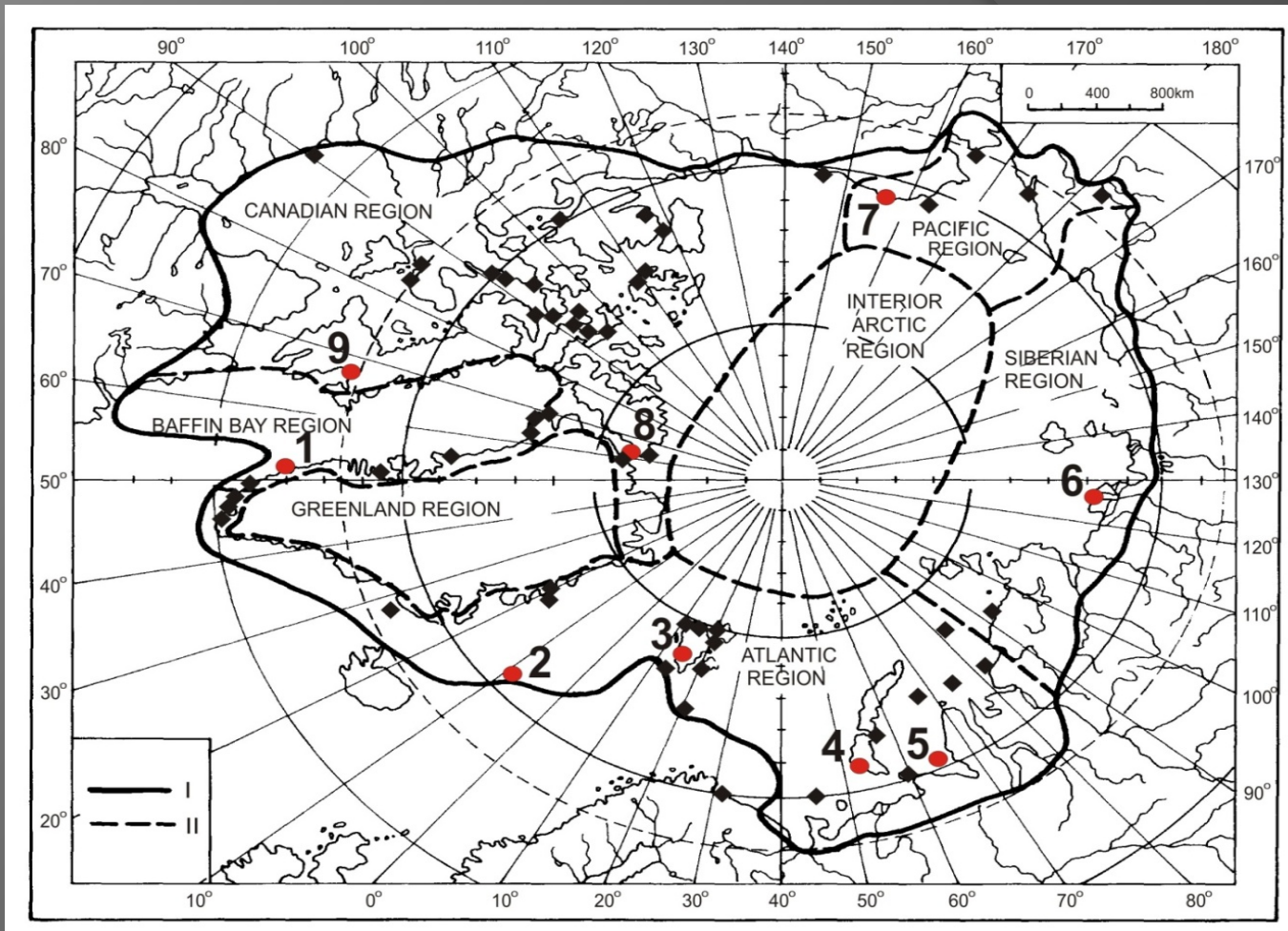
INTRODUCTION

Little is known about air pressure changes in the 19th and the beginning of the 20th centuries. Only very limited number of papers presents some analysis of atmospheric pressure in the Arctic in the studied period:

- Polyakov et al. 2003 – Arctic 1875-2000
- Przybylak and Panfil 2004 – station Sagastyr 1882-1884
- Wood and Overland 2006 - IPY-1 1882/83
- Vízi 2008 – American Arctic in the 19th century – PhD Thesis
- Przybylak and Jankowska 2009 - Eurasian Arctic from 1841 to 1920
- Przybylak and Wyszzyński 2009 - IPY-1 1882/83

DATA AND METHODS

- The instrumental records of atmospheric pressure in the Arctic are brief and geographically sparse, and are limited mainly to the 20th century.
- Any climatic data (including pressure data) for the pre-instrumental period – and in particular for the 19th century – are very important for an evaluation of climatic variation and change in the Arctic (including atmospheric circulation).
- **88** atmospheric pressure series of mean monthly values have been collected for the area of Arctic and Subarctic for the period **1801-1920**.
- mean long-term (1961-1990) air pressure values have been collected or calculated (using interpolation method) for all historical sites, for 3 Canadian stations 1971-2000 period has been used.
- monthly air pressure differences between historical and present series have been calculated and then areally averaged (for selected regions and for the entire Arctic) for 20-years periods and for the whole studied period.

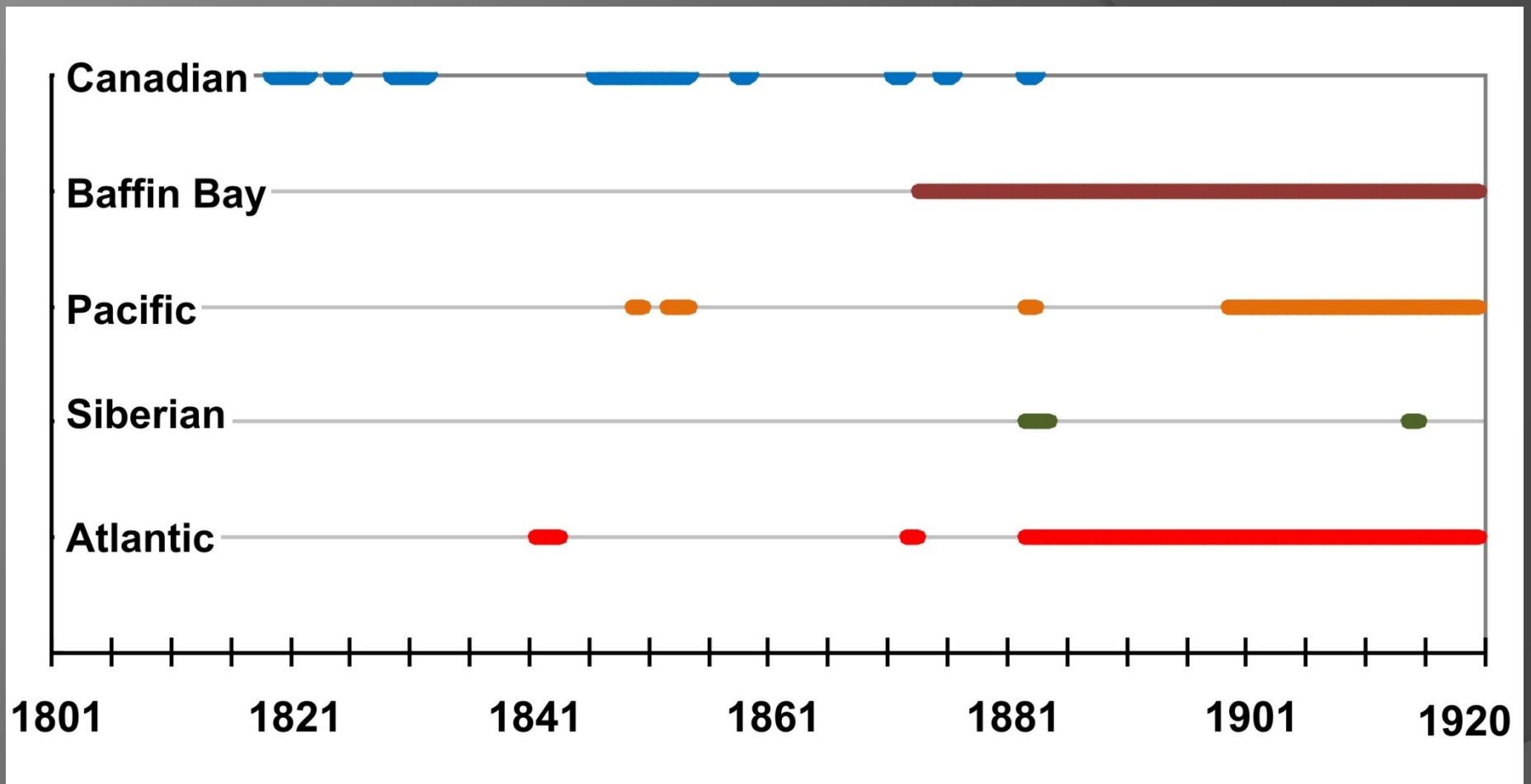


The real Arctic and its climatic regions (adapted from Treshnikov, 1985).

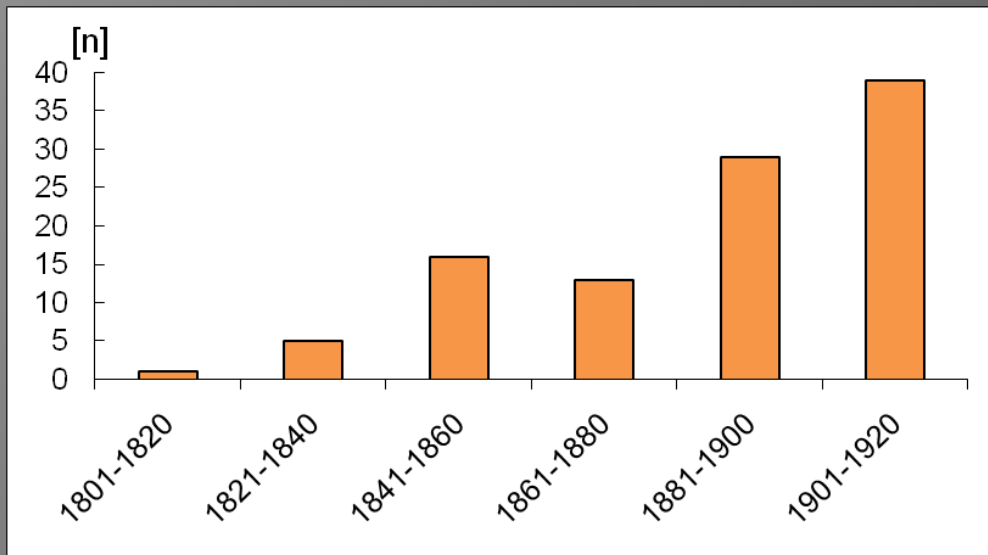
I – boundary of the Arctic, II – boundaries between climatic regions.

Location of measurement points operating in the Arctic from 1801 to 1920.

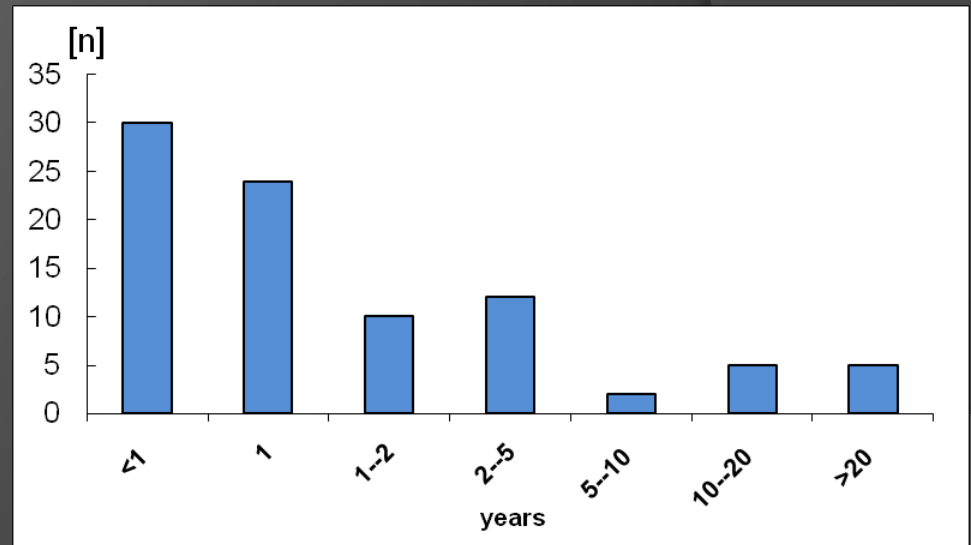
First IPY stations: 1 – Godthåb, 2 – Jan Mayen, 3 – Kapp Thordsen, 4 – Malye Karmakuly, 5 – Kara Sea, 6 – Sagastyr, 7- Point Barrow, 8 – Lady Franklin Bay, 9 – Kingua Fjord



Air pressure data coverage in the Arctic for the period 1801-1920



Number of atmospheric pressure series (n) in the 20-year periods in the Arctic from 1801 to 1920



Number of atmospheric pressure series (n) with different periods of observations in the Arctic from 1801 to 1920

Sources of the historical air pressure data

No.	Location	φ	λ	Period	Resolution of data
1	Cap Wild - Eclipse	75°39'N	91°26'E	1914.09- 1915.08	fixed hours
2	Malye Karmakuly	72°23'N	52°36'E	1882.09-1883.08	hourly

No.	Comparable station	φ	λ	Period	Sources of historical data
1	Mys Sterlegova	75°42'N	88°90'E	1961-90	Observations faites per le Dr. I. Trzemesky a bord du Vaisseau "Eclipse" eu 1914-1915, Pietrograd, 1917
2	Malye Karmakuly	72°23'N	52°44'E	1961-90	Lenz R. (red), 1886, Beobachtungen der Russischen der Polarstatio auf Novaya Semlija, Expedition der Kaiserl. Russischen Geographischen Gesellschaft, 2 vols. In 1

Corrections introduced to original barometer readings

corrections	0°C	gravity (ϕ 45° + A)		sea level
IPY-1 1882/83 ¹	+	-		-
Greenland stations (DMI) ²	+	1873 - 1892*	-	-
		1893 - present	+	
Atlantic, Siberian, Canadian sectors	+?	u		u

A - altitude

+ - introduced

- - not introduced

u - generally unknown

¹ according to the decision of the 4th International Polar Conference in Vienna, April 17-24 1884; calculated values of the gravity corrections have been placed above the tables with original barometric observations published in the IPY-1 reports

² DMI – Danske Meteorologiske Institut (Danish Meteorological Institute)

*- from 1885 onward values of the gravity corrections have been known and they were placed above tables with barometric observations published in the DMI meteorological yearbooks

Gravity correction

Possible source of errors
in process of comparison of historical
data to the present climatology !!!

According to equation:

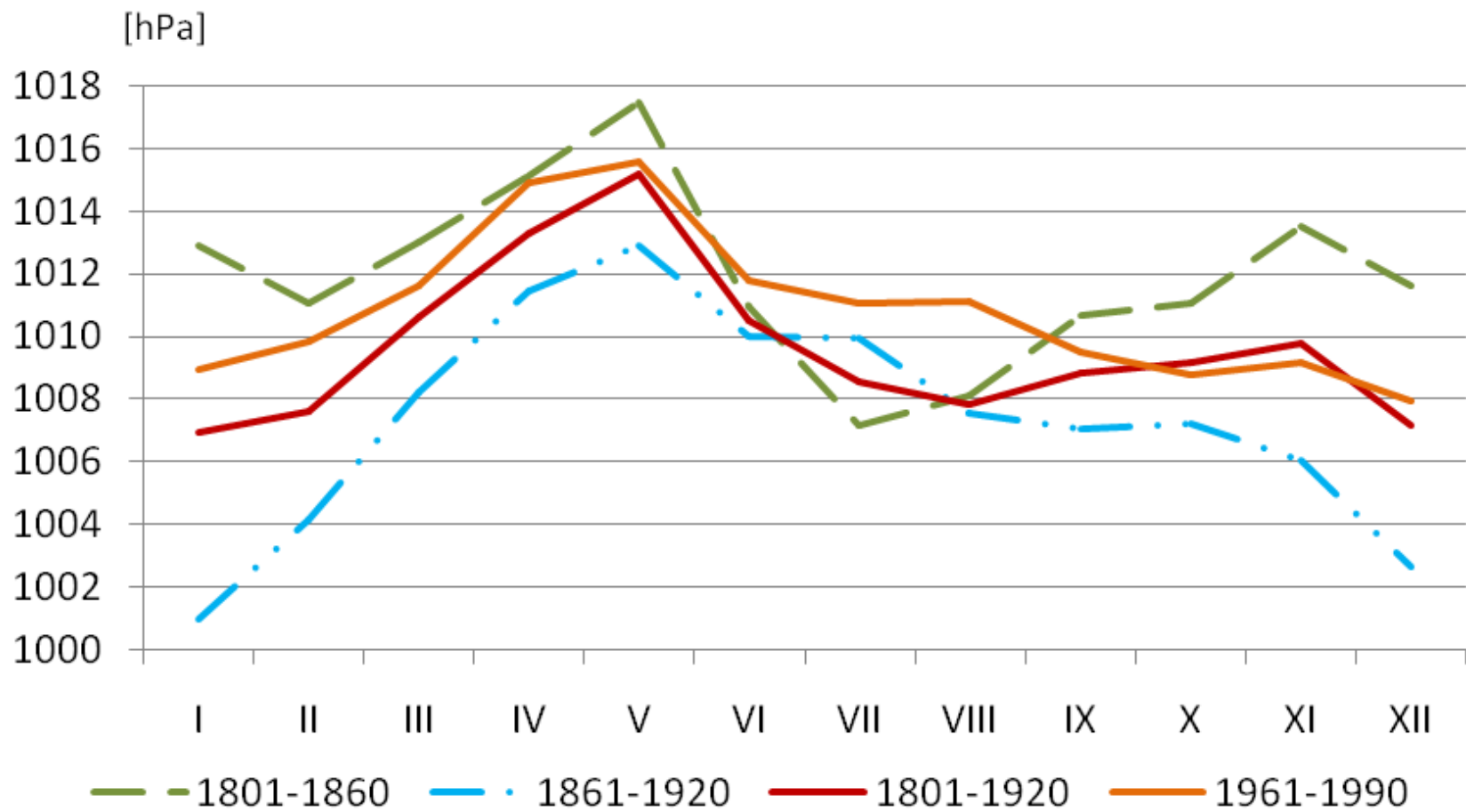
$$\text{correction} = -p(0.00259 \cos^2 \varphi + 0.000\,000\,196 A)$$

where: p - atmospheric pressure
 φ - latitude of observation
 A - altitude

*(Ekholm 1890, Kapp Thordsen IPY-1 report,
according to the decision of the 4th International Polar Conference in Vienna, April 17-24 1884)*

correction		(hPa)								
		980	985	990	995	1000	1005	1010	1015	1020
φ (°)	90	2.54	2.55	2.56	2.58	2.59	2.60	2.62	2.63	2.64
	85	2.50	2.51	2.53	2.54	2.55	2.56	2.58	2.59	2.60
	80	2.39	2.40	2.41	2.42	2.43	2.45	2.46	2.47	2.48
	75	2.20	2.21	2.22	2.23	2.24	2.25	2.27	2.28	2.29
	70	1.94	1.95	1.96	1.97	1.98	1.99	2.00	2.01	2.02
	65	1.63	1.64	1.65	1.66	1.66	1.67	1.68	1.69	1.70
	60	1.27	1.28	1.28	1.29	1.30	1.30	1.31	1.31	1.32

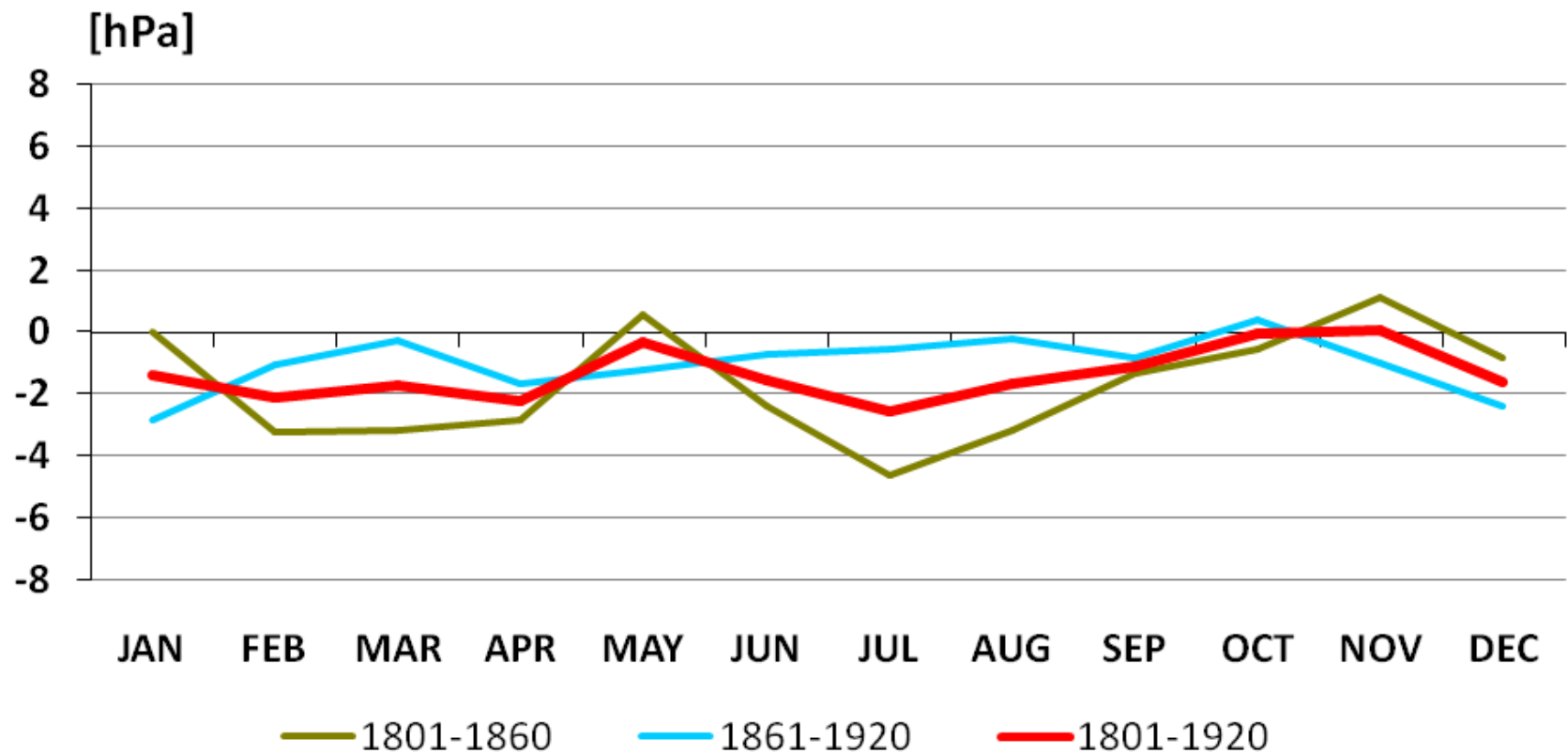
RESULTS



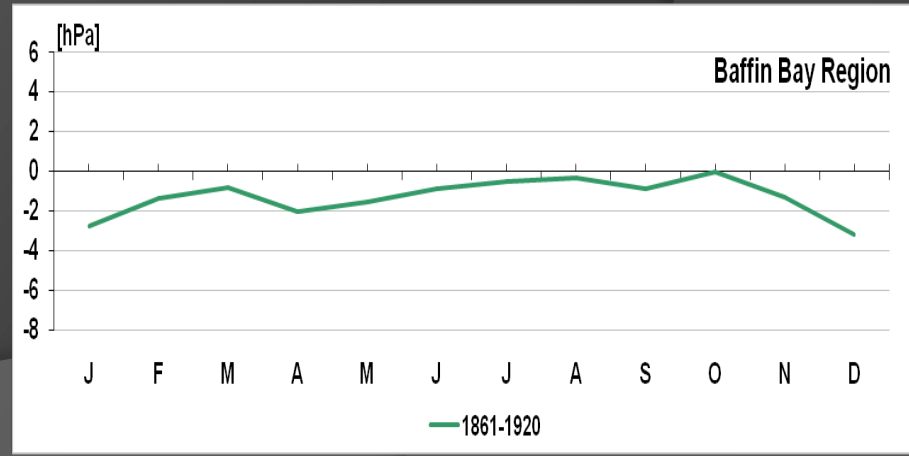
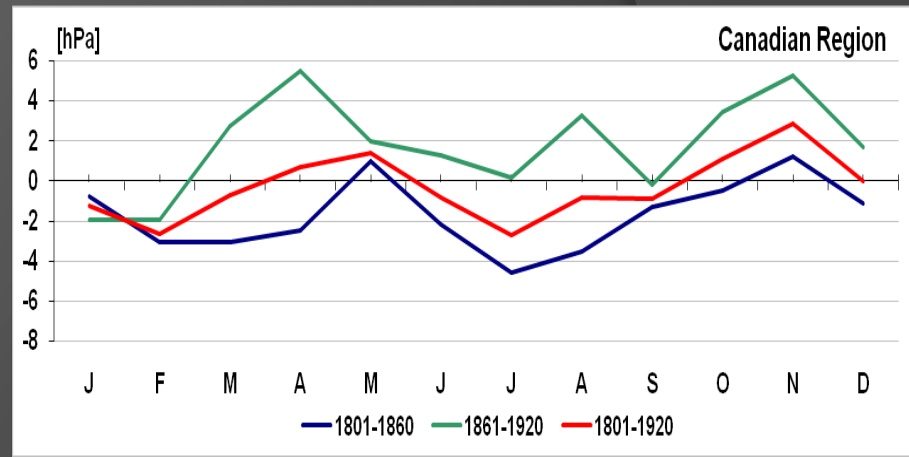
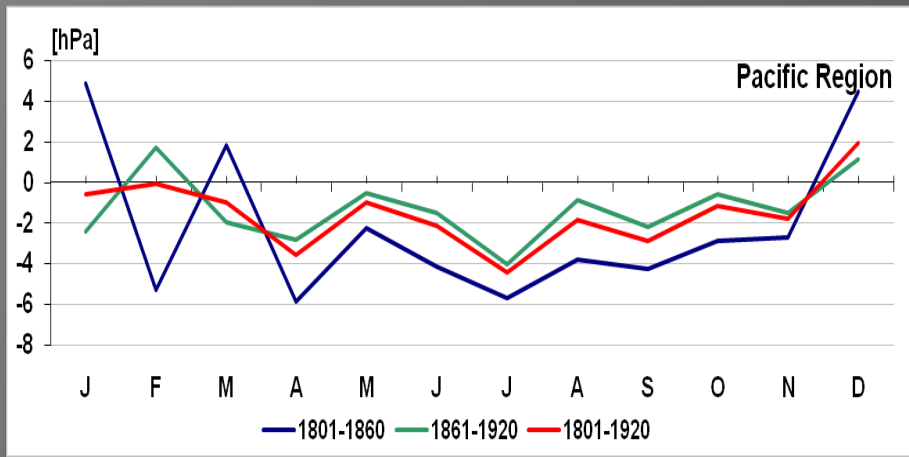
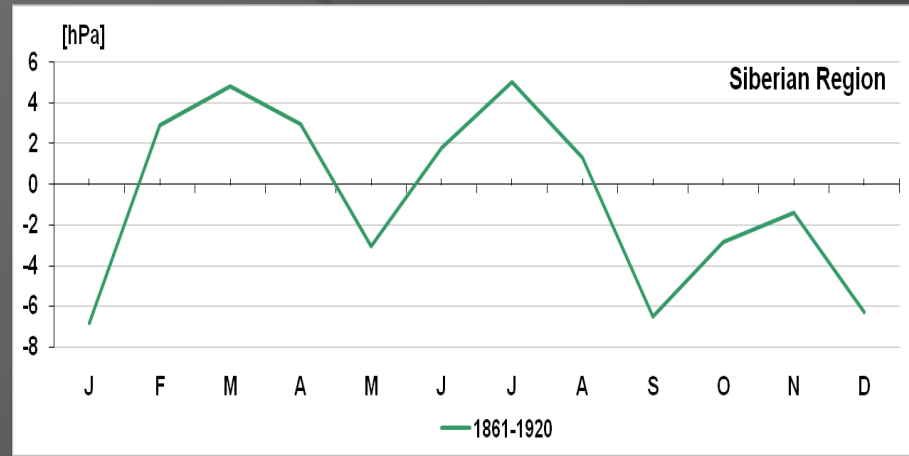
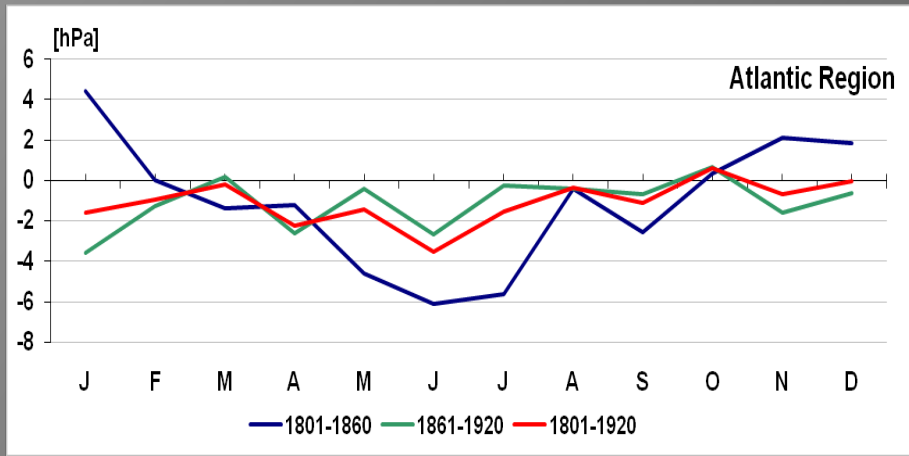
Annual courses of areally averaged atmospheric pressure in the Arctic in selected early instrumental and modern periods.

Average air pressure differences (hPa) between mean monthly (JAN, FEB, MAR, etc.), seasonal (DJF, MAM, etc.) and annual (YEAR) values from the historical and modern (1961–1990/1971–2000) periods for the climatic regions and the whole Arctic.

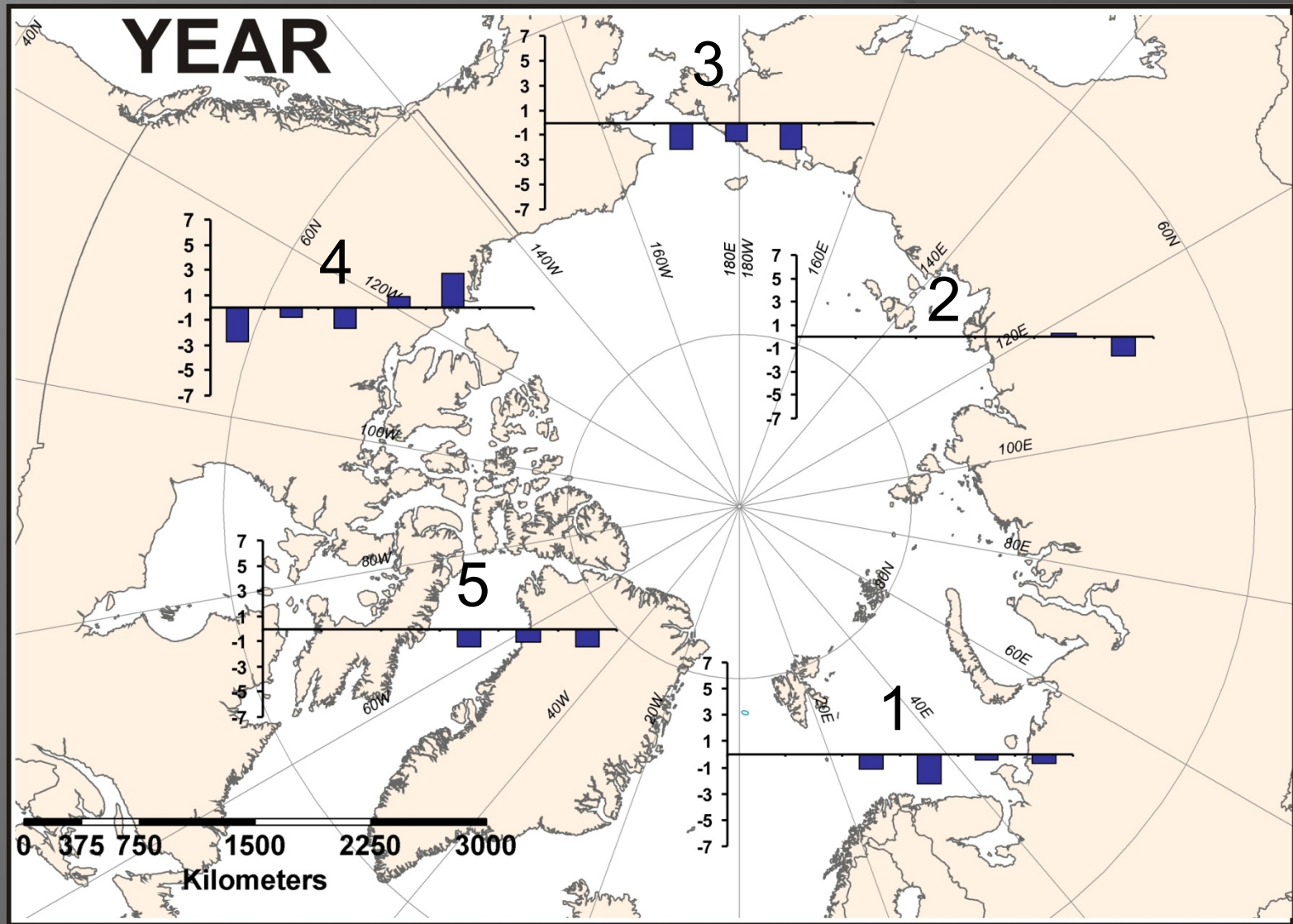
Period	Regions*	J	F	M	A	M	J	J	A	S	O	N	D	DJF	MAM	JJA	SON	YEAR
1801 - 1820	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	5,1	-6,8	-7,9	-4,3	1,4	-4,0	-7,2	-4,0	0,3	-3,1	0,3	-2,2	-1,3	-3,6	-5,1	-0,8	-2,7
1821 - 1840	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-2,8	-1,8	-2,3	-3,8	0,8	0,7	-1,5	-0,9	-1,2	1,9	2,1	-0,7	-1,8	-1,8	-0,6	0,9	-0,8
1841 - 1860	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	4,4	0,0	-1,4	-1,2	-4,6	-6,1	-5,6	-0,4	-2,6	0,3	2,1	1,8	2,1	-2,4	-4,0	0,0	-1,1
1861 - 1880	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-2,2	-1,1	0,7	-0,5	-0,5	-3,8	-5,3	-4,6	-3,1	-0,3	1,0	0,4	-1,0	-0,1	-4,5	-0,8	-1,6
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-6,7	-4,0	-1,5	-4,5	0,7	-9,6	-1,0	-1,5	0,0	0,0	0,3	1,2	-3,2	-1,7	-4,0	0,1	-2,2
1901 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-8,6	9,0	-2,5	-5,5	-0,5	-3,8	-11	0,0	0,0	2,8	-2,0	3,6	1,3	-2,8	-4,9	0,3	-1,5
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-4,8	1,6	4,0	8,1	-0,1	0,5	-3,1	1,1	-2,9	2,4	7,4	-4,5	-2,5	4,0	-0,5	2,3	0,8
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-4,7	-3,4	-1,0	-2,0	-2,7	-1,1	-1,0	-1,6	0,6	1,1	1,2	-2,8	-3,6	-1,9	-1,2	1,0	-1,5
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-5,0	-2,7	-0,7	-1,4	-2,0	-2,0	-1,5	-1,2	0,3	1,1	1,7	-2,5	-3,4	-1,4	-1,6	1,0	-1,3
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-0,3	1,9	3,1	-2,3	-1,3	0,6	-0,7	-0,5	-2,0	2,4	-3,2	-2,5	-0,3	-0,1	-0,2	-0,9	-0,4
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-3,0	2,1	4,3	5,0	-0,5	-2,4	2,3	-0,1	-3,6	-1,4	-0,3	1,3	0,1	2,9	-0,1	-1,8	0,3
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-1,1	-2,8	-1,6	-2,3	-1,7	-1,9	-1,1	-2,1	-3,0	-4,0	-3,2	-1,0	-1,6	-1,9	-1,7	-3,4	-2,1
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	0,9	-5,5	1,5	2,8	4,0	2,0	3,4	5,4	2,5	4,5	3,0	7,8	1,1	2,8	3,6	3,3	2,7
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-0,3	1,2	0,7	-2,7	-0,3	-1,6	-0,9	0,2	-2,2	0,8	-3,4	-3,9	-1,0	-0,8	-0,8	-1,6	-1,0
1881 - 1900	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-0,3	1,2	1,4	-2,3	-0,5	-0,9	-0,8	0,1	-2,1	1,2	-3,1	-3,1	-0,7	-0,5	-0,5	-1,4	-0,8
1901 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-3,8	-1,7	-1,1	-1,1	-0,7	1,0	0,9	0,9	-0,1	-0,3	-1,9	-0,7	-2,1	-1,0	0,9	-0,8	-0,7
1901 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-10,7	3,7	5,4	0,9	-5,6	6,0	7,7	2,7	-9,4	-4,3	-2,4	-14	-6,9	0,2	5,4	-5,4	-1,7
1901 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	2,4	-1,1	-1,7	-0,7	0,6	1,3	0,0	0,4	-1,4	-0,5	0,7	0,8	0,7	-0,6	0,5	-0,4	0,1
1801 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-3,4	-1,9	-2,3	-1,4	-1,6	0,1	0,4	0,3	-1,1	-2,0	-1,6	-3,0	-2,7	-1,8	0,3	-1,6	-1,4
1801 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-3,1	-1,7	-1,6	-1,2	-1,0	0,7	0,7	0,6	-0,7	-1,1	-1,6	-1,6	-2,1	-1,3	0,6	-1,1	-1,0
1801 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-1,6	-0,9	-0,2	-2,3	-1,4	-3,5	-1,6	-0,4	-1,1	0,6	-0,7	0,0	-0,9	-1,3	-1,8	-0,4	-1,1
1801 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-6,8	2,9	4,8	3,0	-3,0	1,8	5,0	1,3	-6,5	-2,8	-1,4	-6,3	-3,4	1,6	2,7	-3,6	-0,7
1801 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-0,6	0,0	-1,0	-3,6	-1,0	-2,2	-4,4	-1,4	-2,1	-1,2	-1,8	2,0	0,4	-1,8	-2,7	-1,7	-1,4
1801 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-1,2	-2,6	-0,7	0,7	1,4	-0,8	-2,7	-0,8	-0,9	1,1	2,8	0,0	-1,3	0,5	-1,4	1,0	-0,3
1801 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-2,8	-1,4	-0,9	-2,0	-1,6	-0,9	-0,5	-0,3	-0,9	0,0	-1,3	-3,2	-2,5	-1,5	-0,6	-0,7	-1,3
1801 - 1920	Atlantic																	
	Siberian																	
	Pacific																	
	Canadian Baffin Bay Arctic	-1,4	-2,1	-1,7	-2,2													



Air pressure differences (hPa) between mean monthly values from the historical and modern (1961–1990 or 1971–2000) periods for the whole Arctic

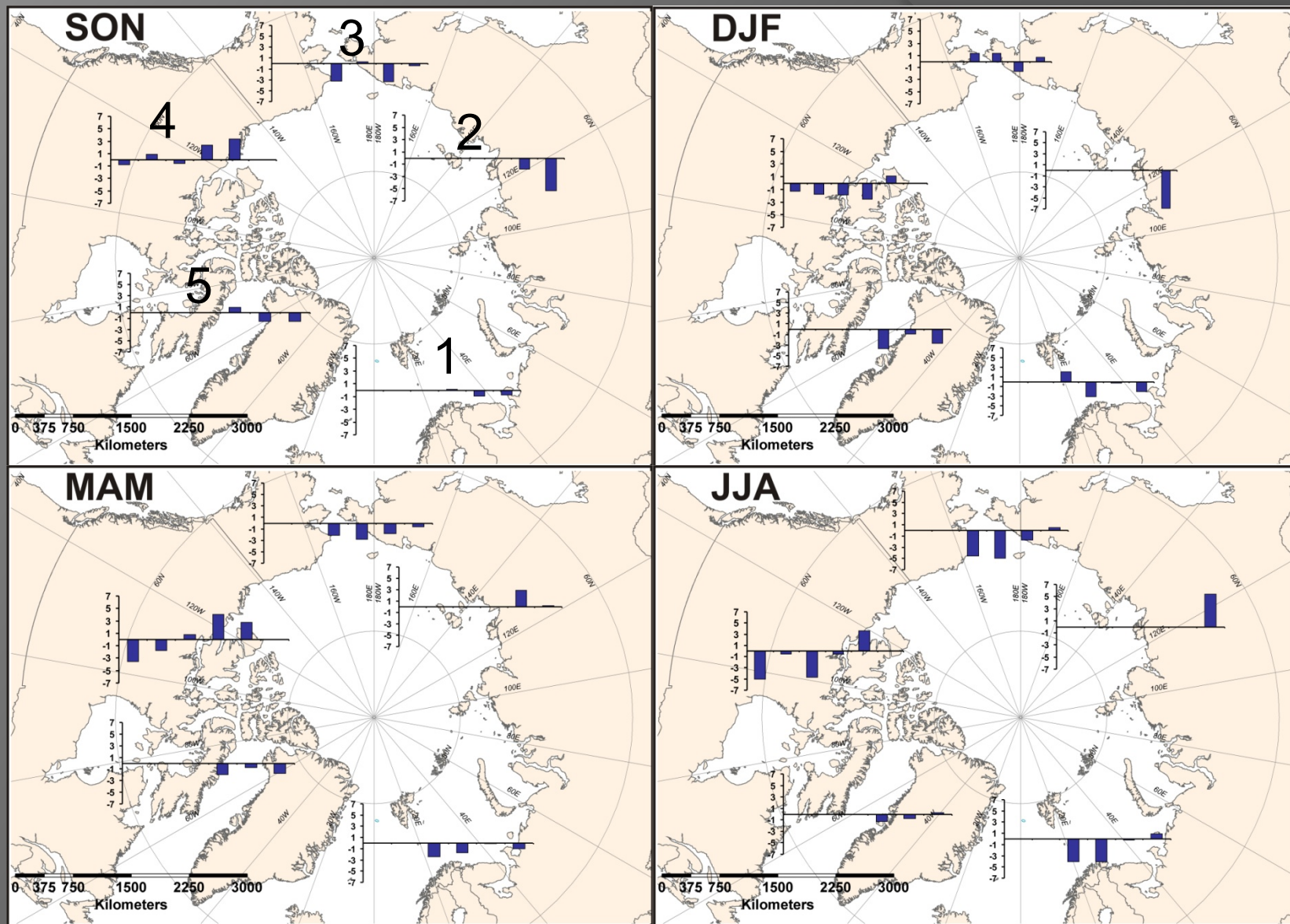


Air pressure differences (hPa) between mean monthly values from the historical and modern (1961–1990 or 1971–2000) periods for selected climatic regions



Air pressure differences (hPa) between mean annual (Year) values from the historical and modern (1961–1990 or 1971–2000) periods for selected climatic regions. From left to right the results are presented for the periods: 1801–1820, 1821–1840, etc.

1-Atlantic region, 2- Siberian region, 3 – Pacific region, 4 – Canadian region, 5 – Baffin Bay region.



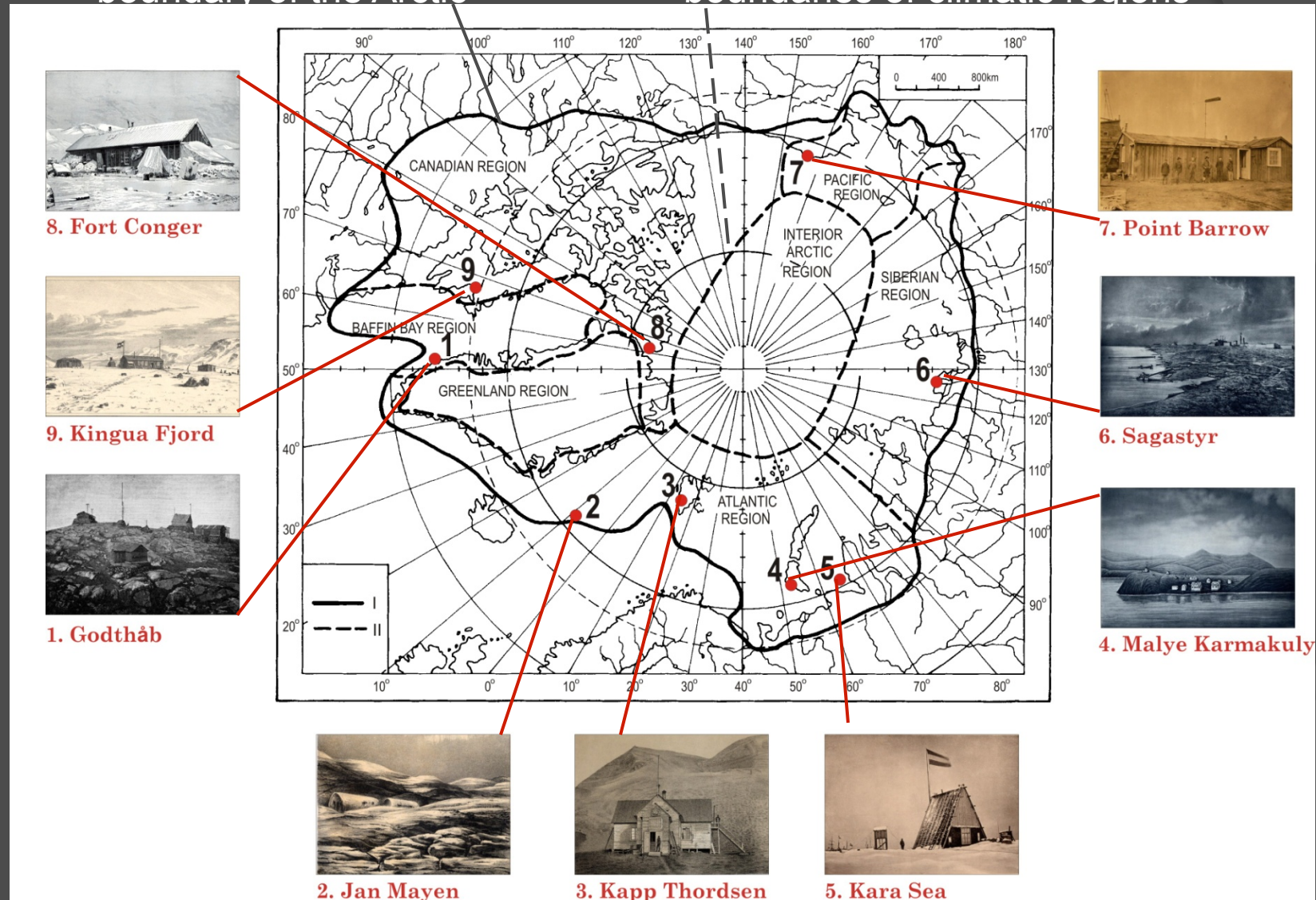
Air pressure differences (hPa) between mean seasonal (DJF, MAM etc.) values from the historical and modern (1961–1990 or 1971–2000) periods for selected climatic regions. From left to right the results are presented for the periods: 1801–1820, 1821–1840, etc.

THE FIRST
INTERNATIONAL POLAR
YEAR 1882/83

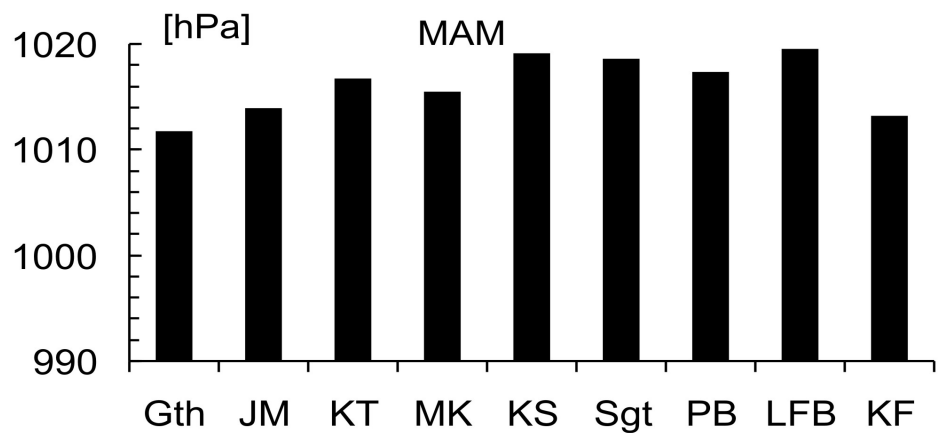
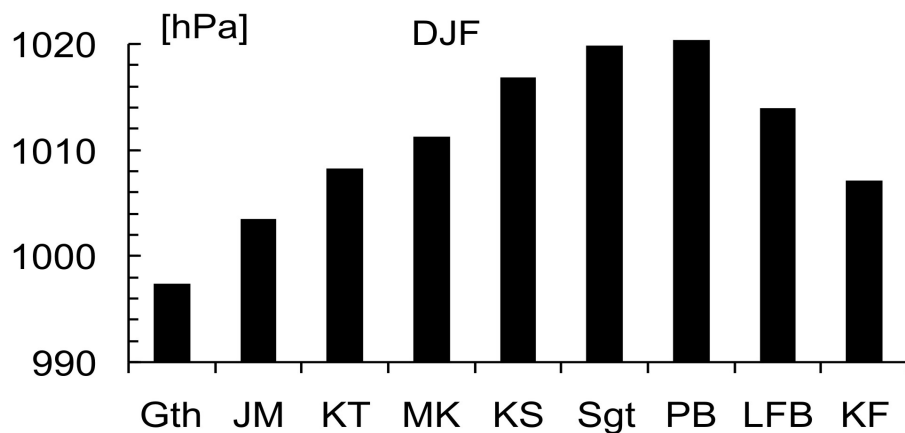
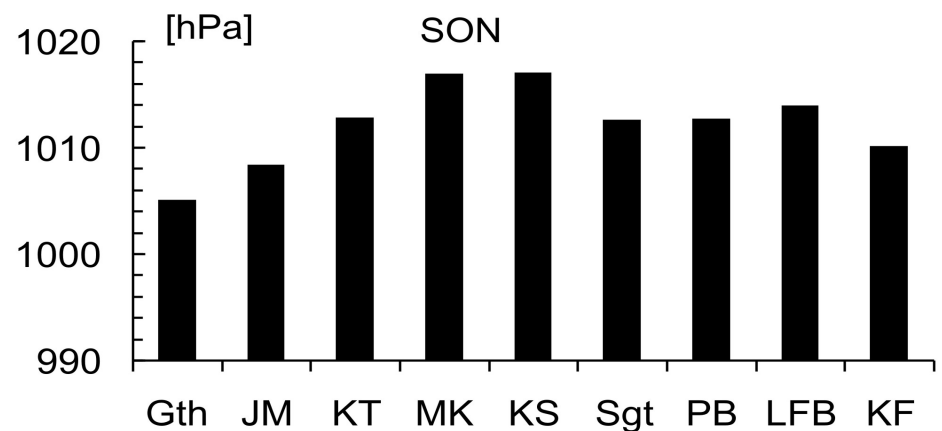
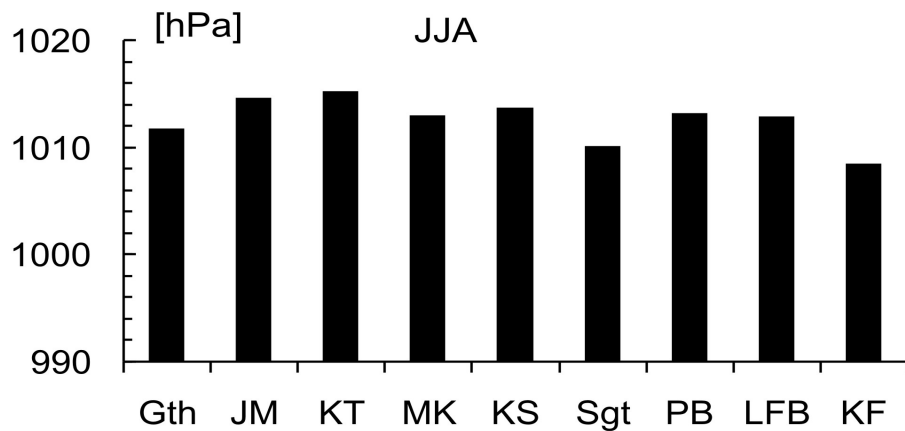
Meteorological stations in the Arctic during the First International Polar Year 1882/83

boundary of the Arctic

boundaries of climatic regions

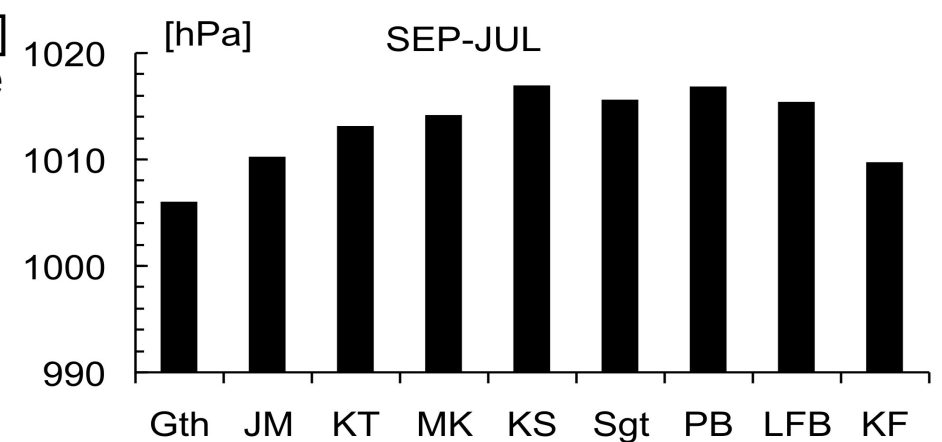


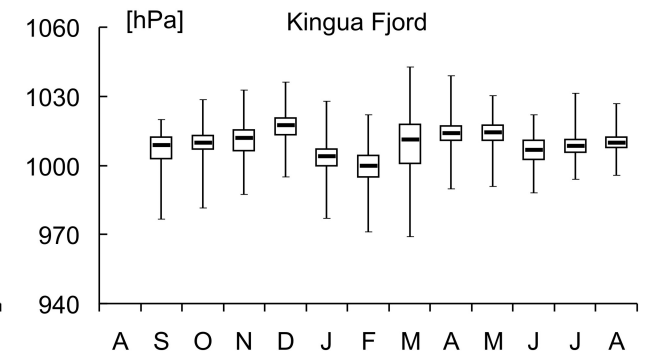
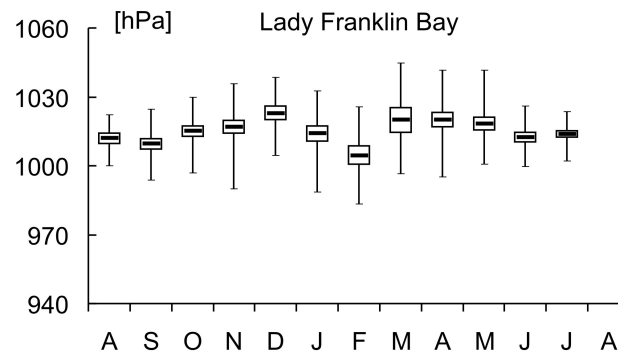
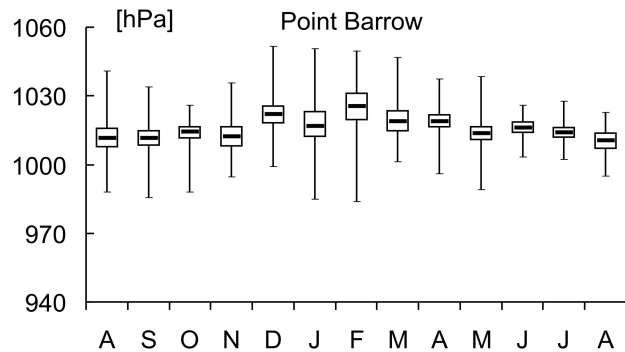
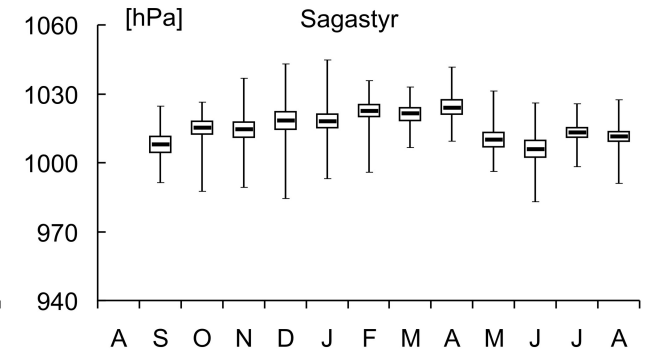
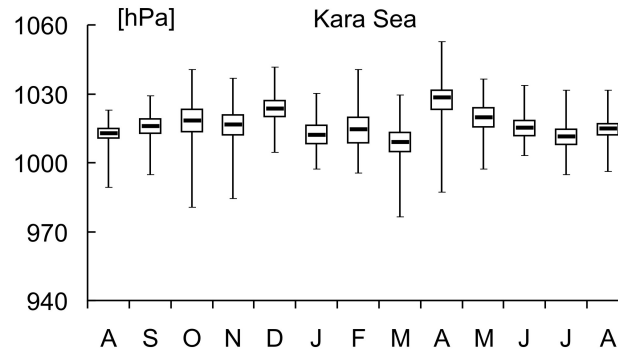
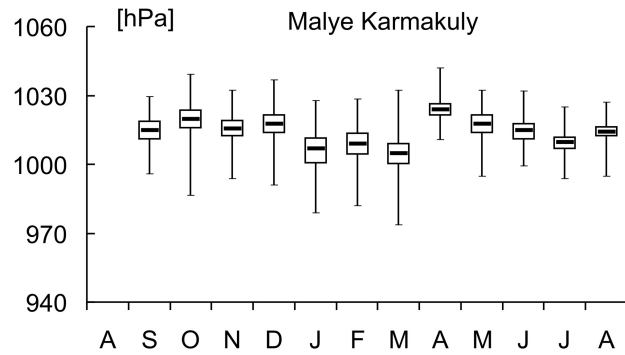
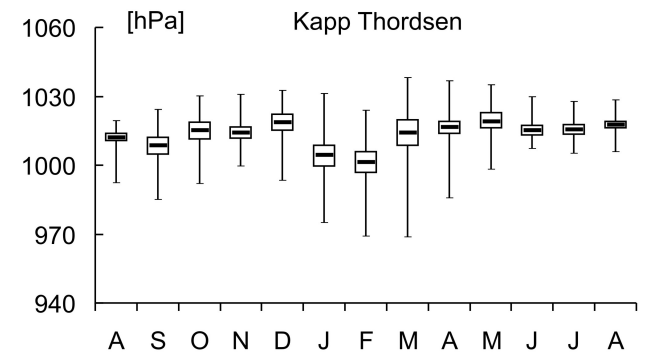
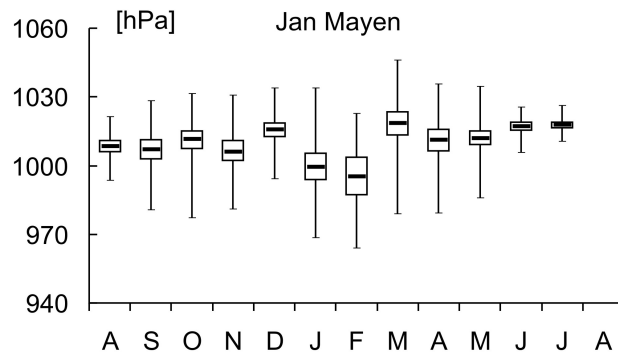
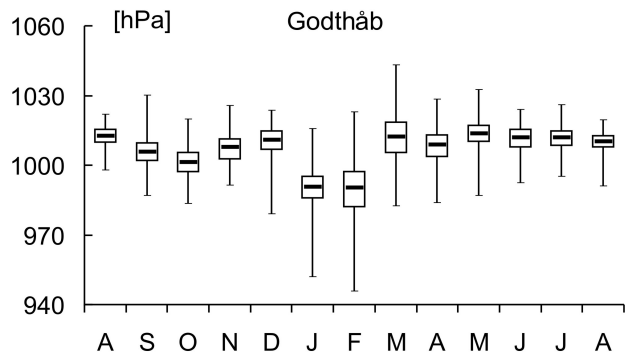
Boundaries of the Arctic and its regions after *Treshnikov, 1985.*



Seasonal means of atmospheric pressure [hPa] for nine stations working in the Arctic during the First International Polar Year 1882/83.

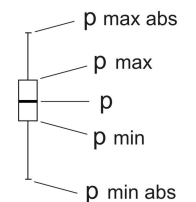
Explanations: Gth – Godthåb, JM – Jan Mayen, KT – Kapp Thordsen, MK – Malye Karmakuly, KS – Kara Sea, Sgt – Sagastyr, PB – Point Barrow, LFB – Lady Franklin Bay, KF – Kingua Fjord

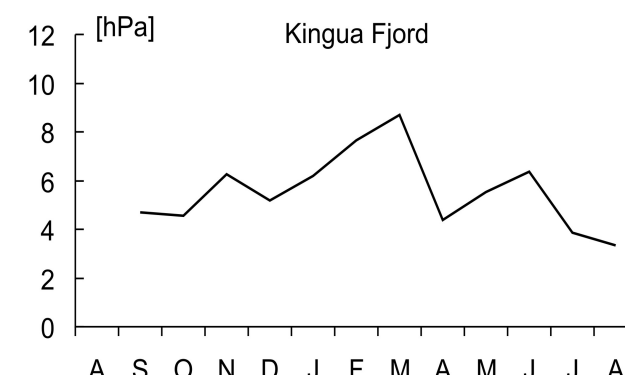
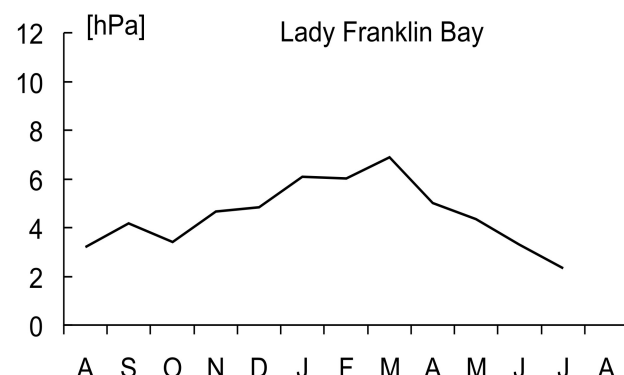
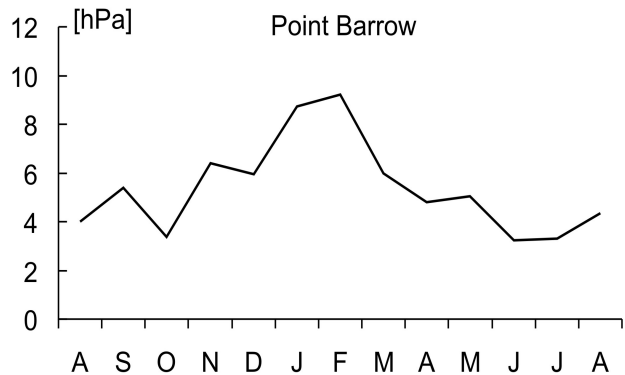
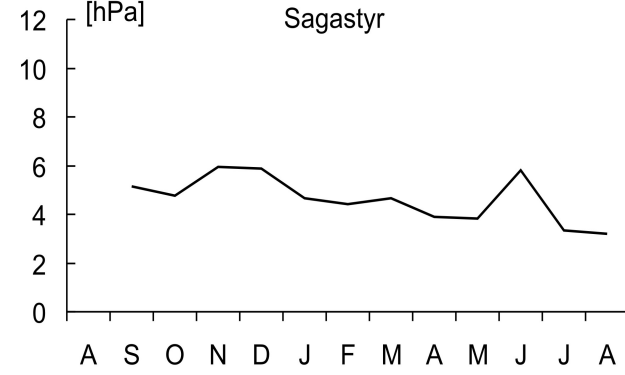
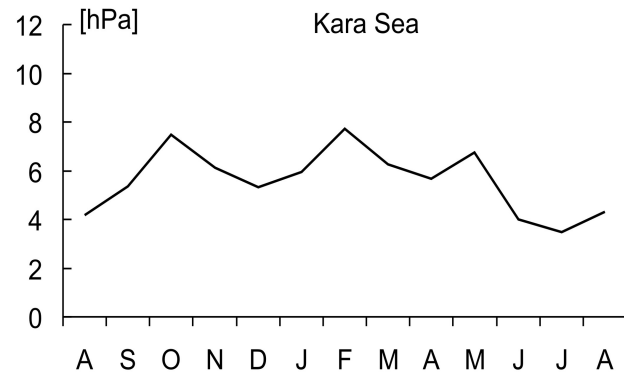
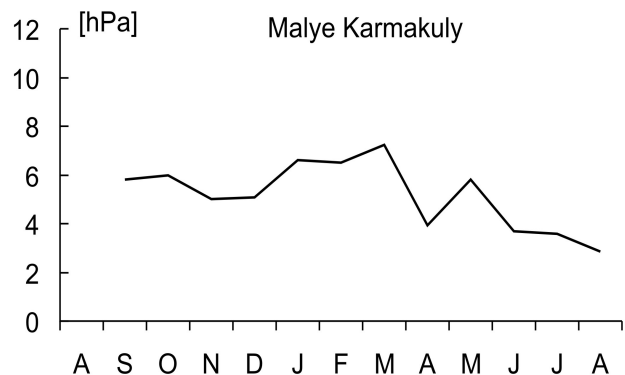
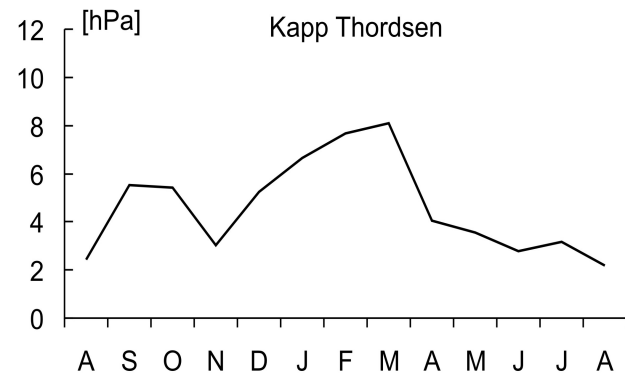
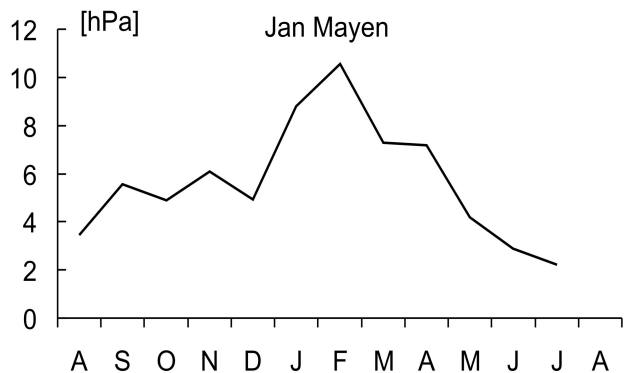
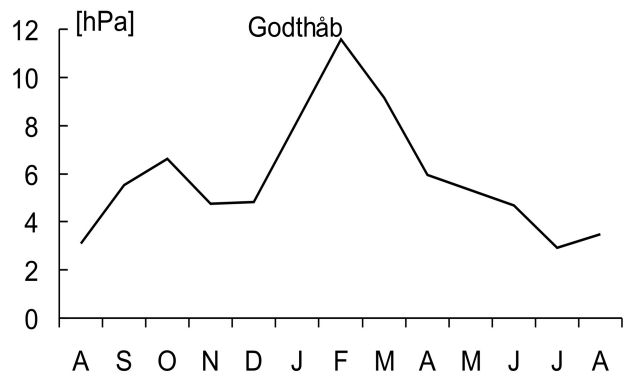




Annual courses of atmospheric pressure in the Arctic during the First International Polar Year 1882/83 according to monthly values.

Explanations: $p^{\max \text{ abs}}$, $p^{\min \text{ abs}}$ – the highest and lowest observed atmospheric pressure, p^{\max} , p^{\min} – mean monthly maximum and minimum atmospheric pressure, p – mean monthly atmospheric pressure





Mean monthly day-to-day variability of atmospheric pressure [hPa] in the Arctic during the First International Polar Year 1882/83

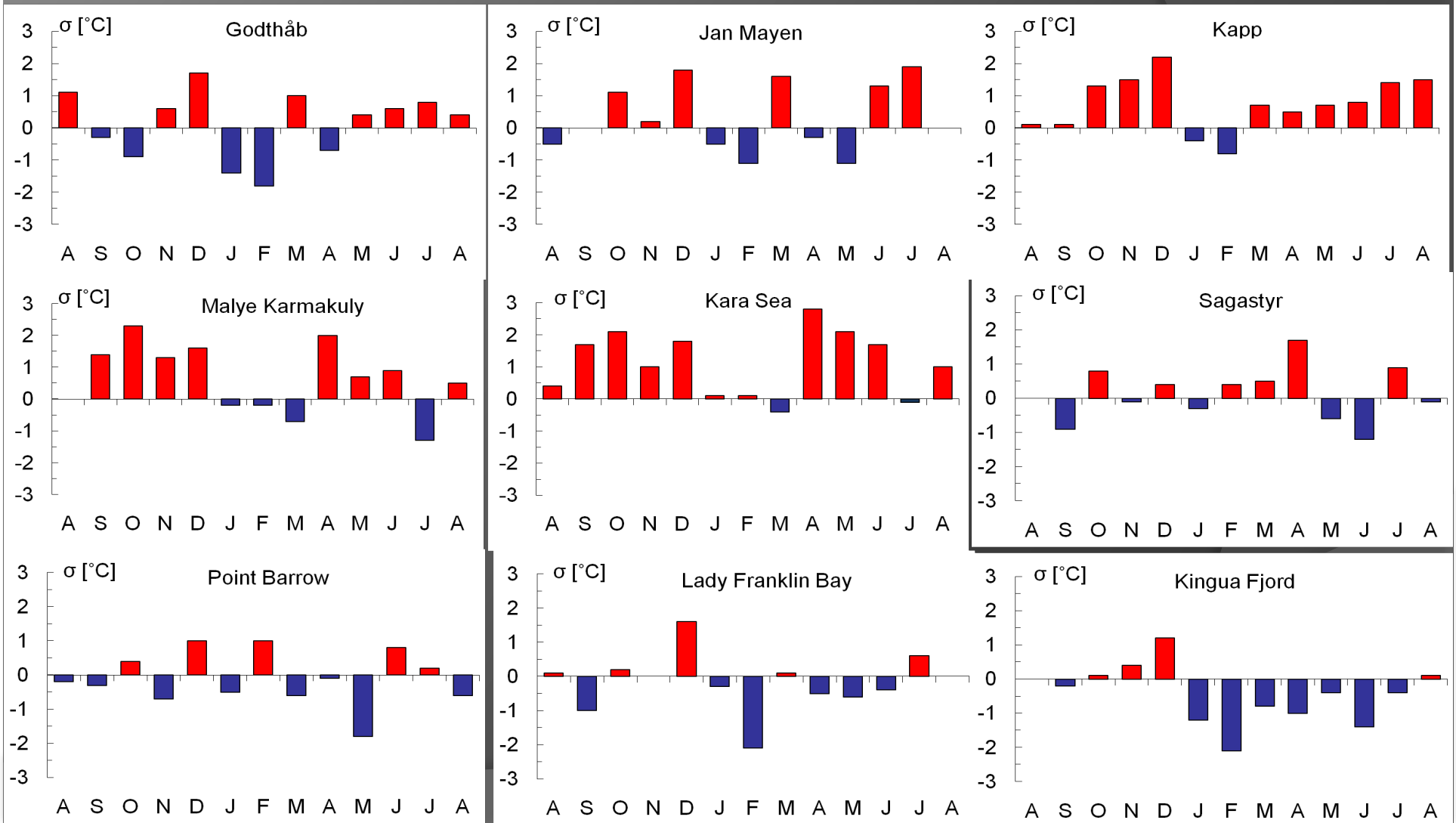
Atmospheric pressure differences (hPa) between mean monthly values from the First International Polar Year (1882/83) and modern period (1961-1990)*. Positive and 0.0 values are shown in red bold font

Station	A	S	O	N	D	J	F	M	A	M	J	J	A	JJA	SON	DJF	MAM	SEP-JUL
Godthåb	3.7	-0.8	-3.9	2.6	8.4	-9.9	-12.3	5.6	-2.9	1.1	1.8	2.3	1.4	2.3	-0.7	-4.6	1.2	-0.7
Jan Mayen	-1.8	0.0	6.2	1.2	12.4	-4.9	-10.2	12.4	-1.5	-4.2	5.0	7.5		3.5	2.5	-0.9	2.2	2.2
Kapp Thordsen	0.2	0.3	7.9	7.8	13.5	-2.6	-5.9	5.4	2.8	2.5	3.1	4.4	5.7	3.4	5.3	1.7	3.5	3.6
Malye Karmakuly		6.4	13.1	9.7	13.2	-1.2	-1.4	-5.6	10.9	2.4	2.9	-3.3	1.7	0.5	9.7	3.5	2.6	4.3
Kara Sea	1.8	7.4	10.0	7.8	14.2	0.9	0.6	-3.6	15.3	5.4	5.1	-0.3	4.0	2.7	8.4	5.3	5.7	5.7
Sagastyr		-4.1	3.6	-0.6	2.3	-2.0	2.3	3.1	8.7	-2.3	-3.9	2.6	-0.2	-0.5	-0.4	0.9	3.1	0.9
Point Barrow	-0.4	-1.1	1.7	-3.1	4.8	-2.7	5.3	-2.1	-0.3	-4.3	1.5	0.7	-1.7	0.1	-0.9	2.5	-2.2	0.0
Lady Franklin Bay	0.5	-3.5	0.7	0.0	7.6	-1.9	-12.6	0.8	-1.7	-1.5	-1.4	2.4		0.5	-1.0	-2.3	-0.8	-1.0
Kingua Fjord		-0.5	0.2	1.4	5.9	-6.0	-11.8	-4.4	-4.0	-1.3	-4.4	-1.1	0.5	-1.7	0.4	-4.0	-3.2	-2.4
Arctic 1882/83	0.7	0.4	4.4	3.0	9.1	-3.4	-5.1	1.3	3.0	-0.3	1.1	1.7	1.6	1.3	2.6	0.2	1.4	1.4

* – for comparison, data from the following modern stations located nearest the historical stations have been used: G – Godthåb – Godthåb, JM – Jan Mayen – Jan Mayen, KT – Kapp Thordsen – Svalbard Lufthavn and Isfiord Radio, MK – Malye Karmakuly – Malye Karmakuly, KS – Kara Sea – Mys Kharasavey, S – Sagastyr – Sagyllah Ary i Ostrov Dunay, PB – Point Barrow – Point Barrow, LF – Lady Franklin Bay – Alert, KF – Kingua Fjord – Iqaluit A, respectively

Anomalies in atmospheric pressure between the First International Polar Year 1882/83 period and modern times 1961-90.

Anomalies presented in standard deviations from the reference mean 1961-90



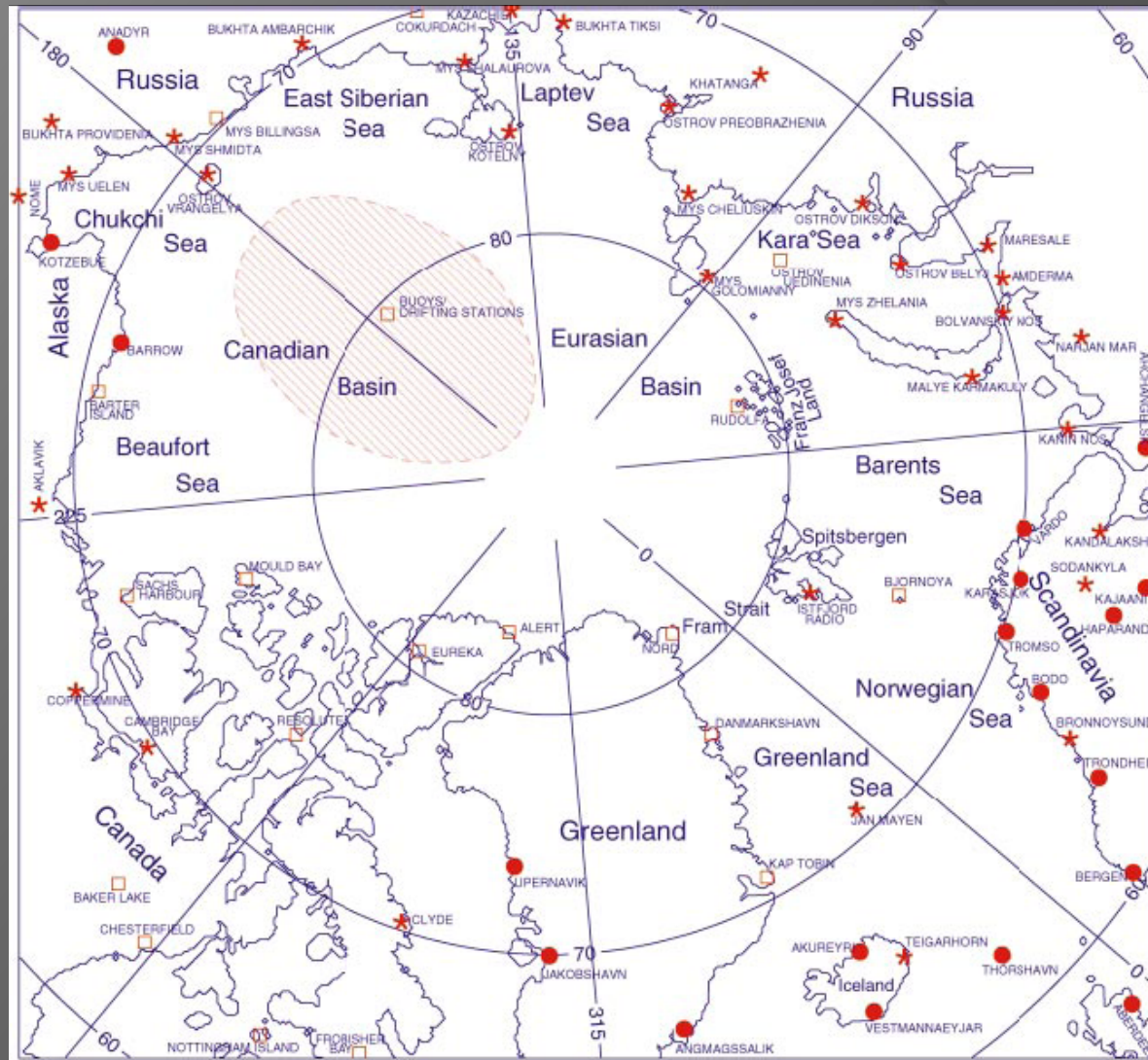
CONCLUSIONS

- 1. In the study period in the annual course maximum values of air pressure were noted in spring, while the lowest ones occurred in winter,
- 2. Areally averaged seasonal (except autumn) values of atmospheric pressure in the historical period were lower than today (1961-1990) by 1-2 hPa,
- 3. During the First International Polar Year in majority of stations the lowest mean values of monthly atmospheric pressure were observed in January and February. On the other hand in December the atmospheric pressure was markedly higher than in above mentioned months,

CONCLUSIONS

- 4. Areally averaged seasonal and annual values of atmospheric pressure in the First IPY were higher than today (1961-1990) by 1-2 hPa (except winter, only by 0.2 hPa),
- 5. Mean monthly day-to-day variability of atmospheric pressure in the Arctic during the First IPY were highest in winter and lowest in summer (except Sagastyr station).

Thank you very much
for your attention



The locations of SAT and SLP observations. Red circles show stations with $L \geq 100$ yr of observations, red stars represent stations with $65 \leq L < 100$ yr, and red squares indicate stations with $L < 65$ yr. The red cross-hatched oval denotes the region represented by data from the NP manned stations and IABP drifting buoys (Polyakov 2003)

Anomalies of mean annual values of atmospheric pressure in the latitude band 62°N-90°N (Polyakov et al. 2003)

