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The recent temperature anomalies on western Spitsbergen and its relation to atmospheric circulation

AWAKE-2 workshop
Sopot 3-4 December 2015

Aim of the study

- Analyse changes in the seasonal frequency of atmospheric circulation types for Spitsbergen
- Study the monthly and seasonal changes in air temperature for specific atmospheric circulation types for different stations
- Relation to oceanic circulation and sea ice cover
- Study the enhanced local warming at the stations Svalbard Airport and Hornsund and link to the points above

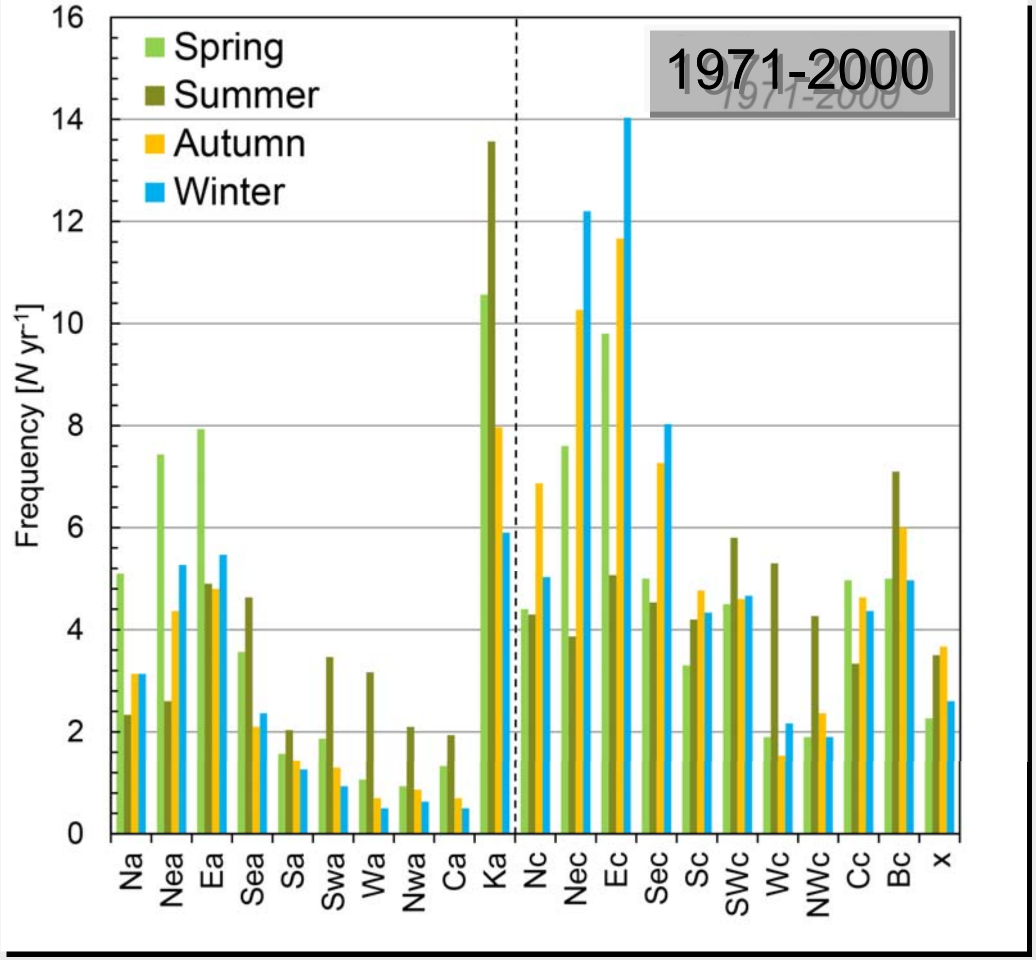
Data

- Daily air tempertaure composite series
  - 1971-2000
  - 2001-2015
- Stations
  - Hornsund
  - Isfjord Radio
  - Barentsburg
  - Svalbard Airport
  - Ny-Ålesund
- Analysed on seasonal and monthly basis
- Circulation types - based on dataset by by Tadeusz Niedźwiedź

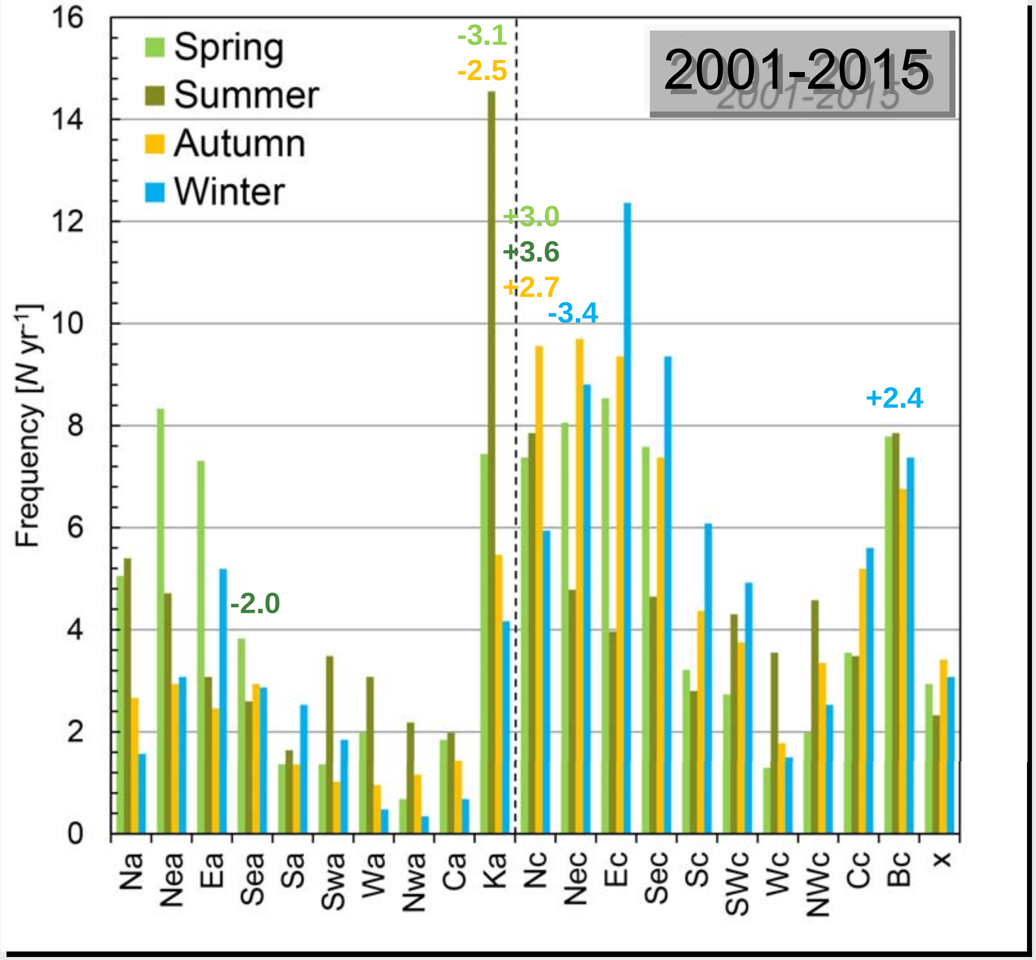
Cirulation types

- Daily classification, representative for Spitsbergen
- Based on DWD Analyse Archive
- 1950 – present
- A calendar of 20 mesoscale weather types
- Direction of geostropic wind at sea level
- Cyclonic (**c**) & anticylonic (**a**) circulation
- 8 directions (**N, NE, E, SE, S, SW, W, NW**) e.g: **Na** denote anticyclonic air advection from North
- 4 weather types characterized either by lack of advection or by very variable air flow towards Spitsbergen:
  - **Ca** - central anticylonic, centre over or very near Spistbergen
  - **Ka** - anticylonic wedge, ridge
  - **Cc** – centre of cyclone above or very near Spistbergen
  - **Bc** – cyclonic trough
- **x** - unclassified

Seasonal frequency of circulation types for Spitsbergen

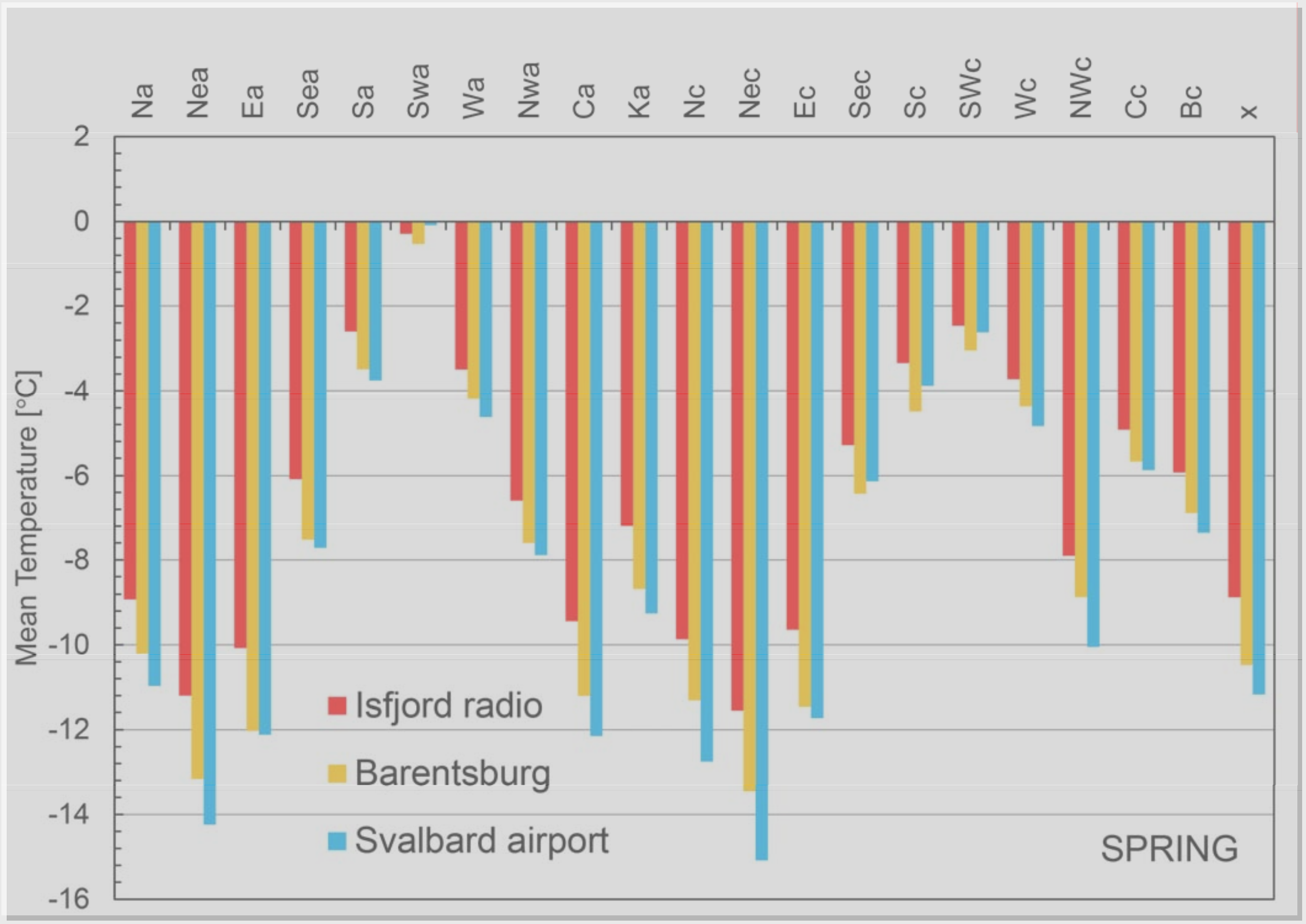


Seasonal frequency of circulation types for Spitsbergen



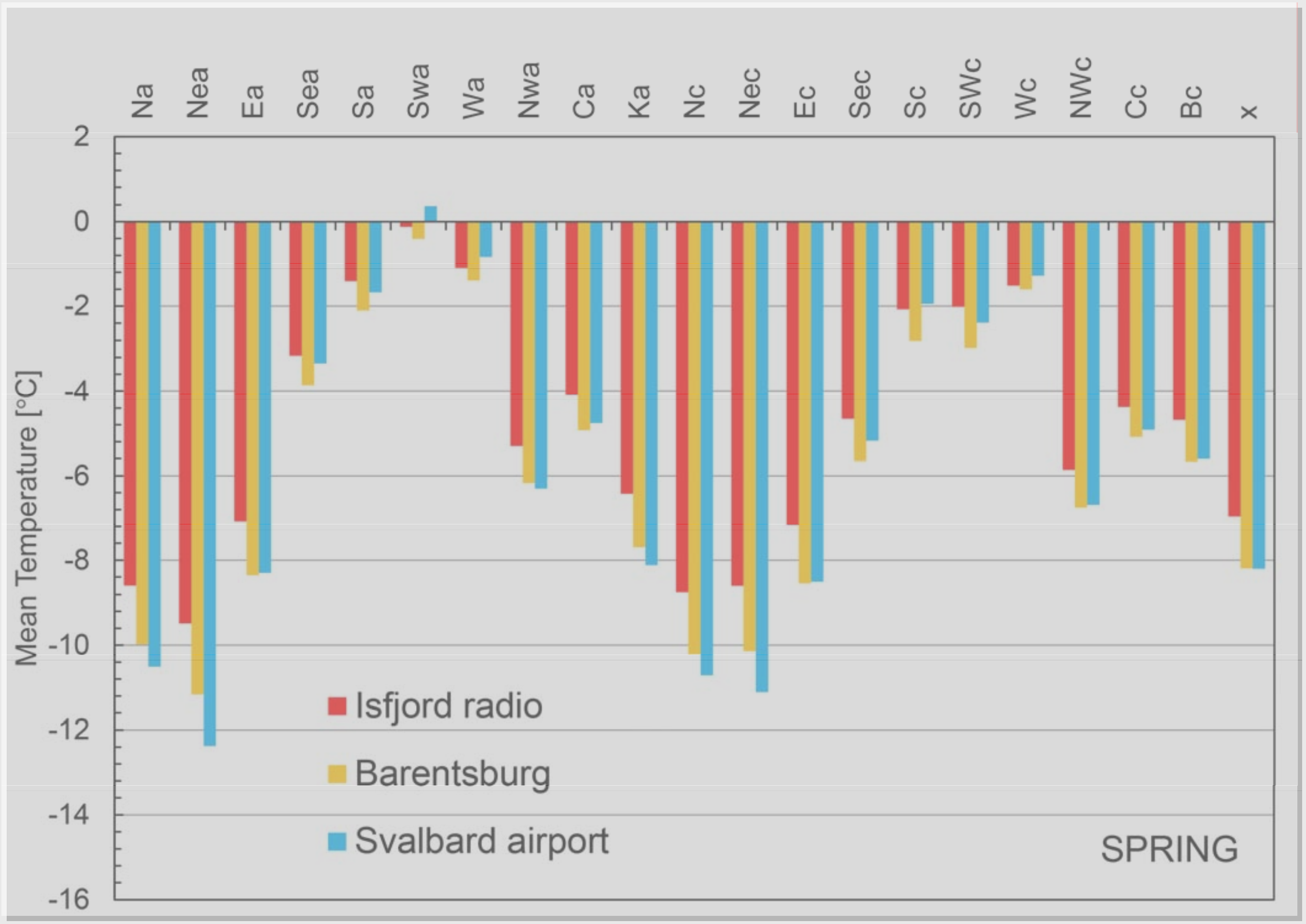
Influence of atmospheric circulation on mean air temperature

Spring, 1971-2000



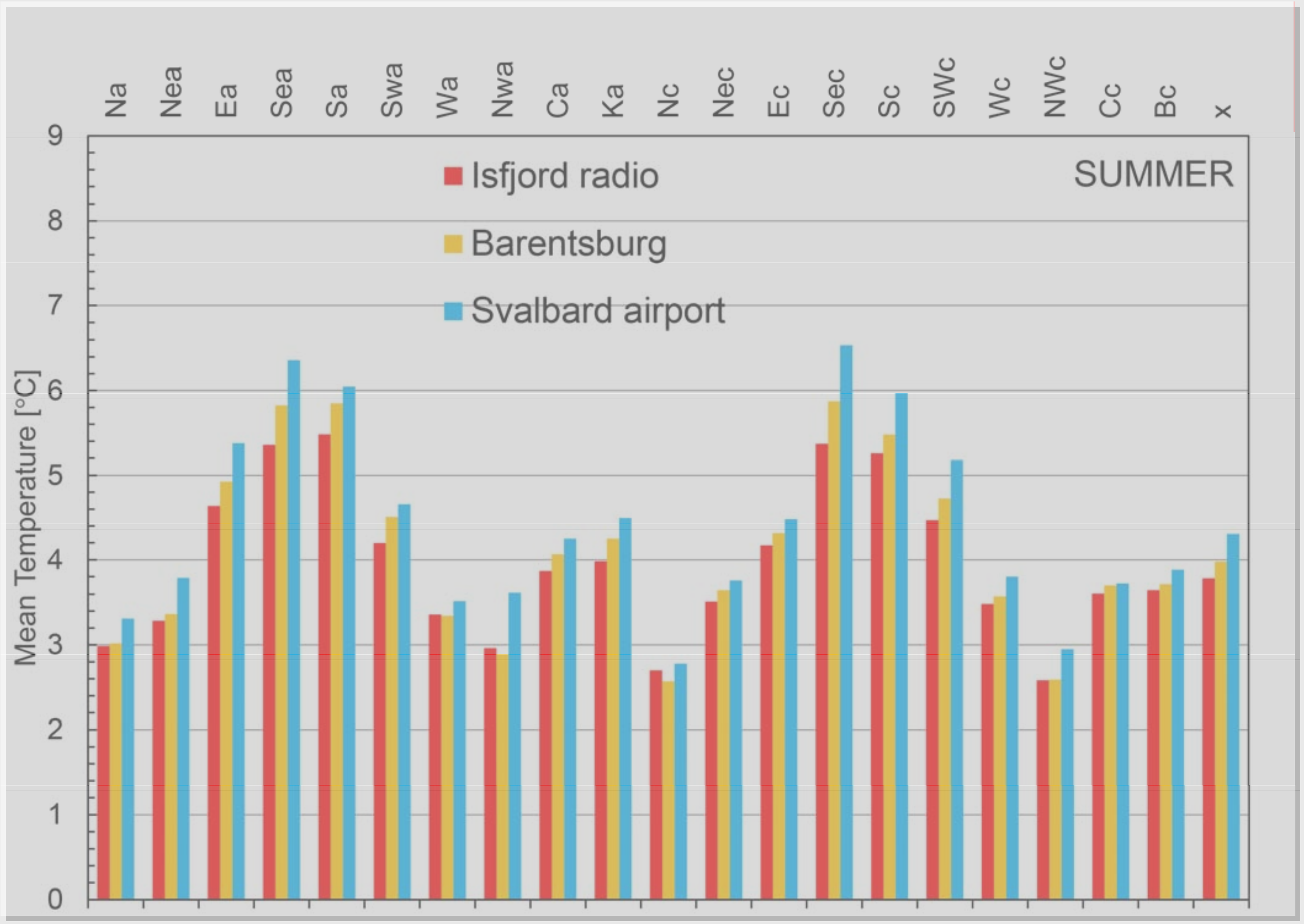
Influence of atmospheric circulation on mean air temperature

Spring, 2001-2015



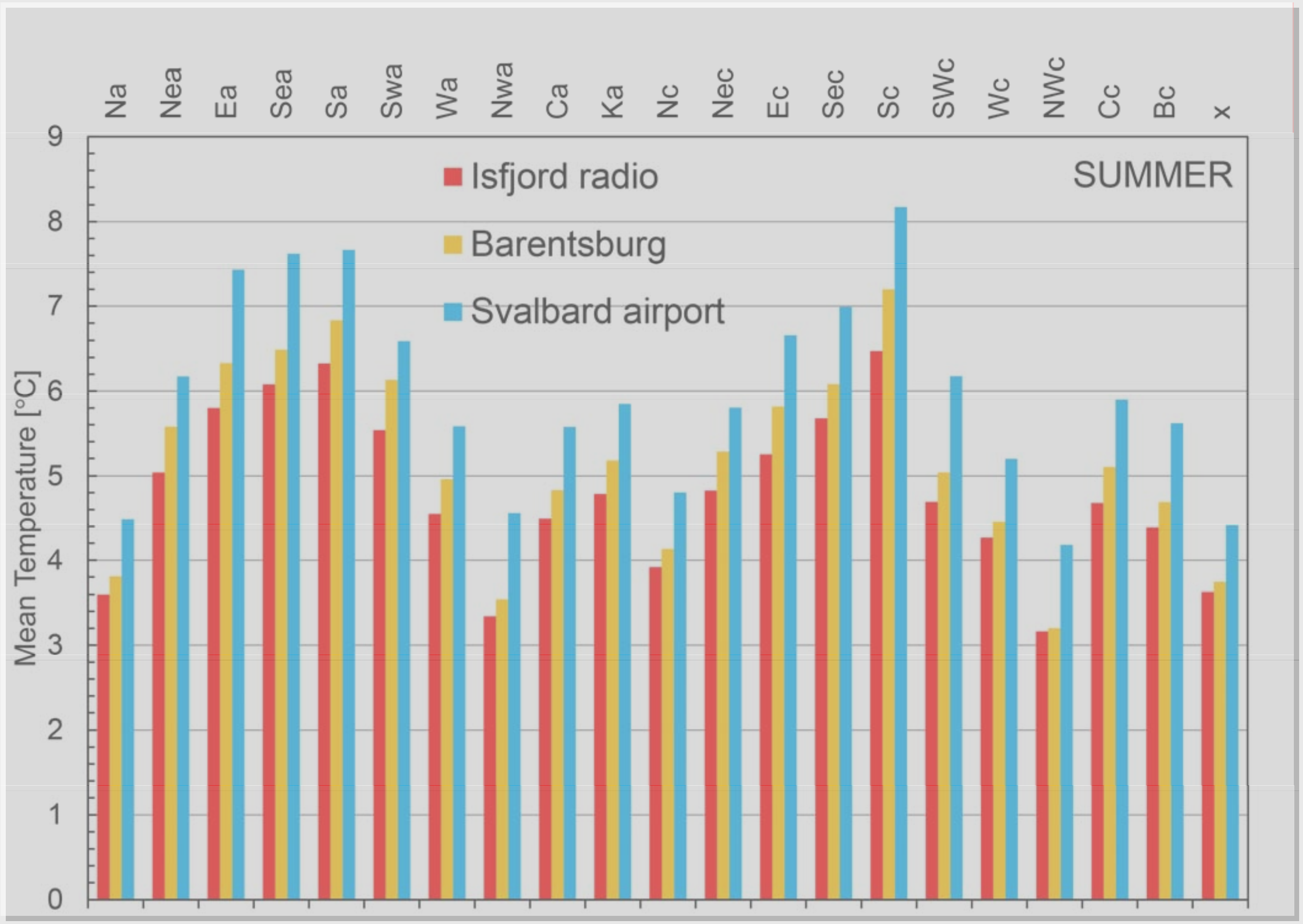
Influence of atmospheric circulation on mean air temperature

Summer, 1971-2000



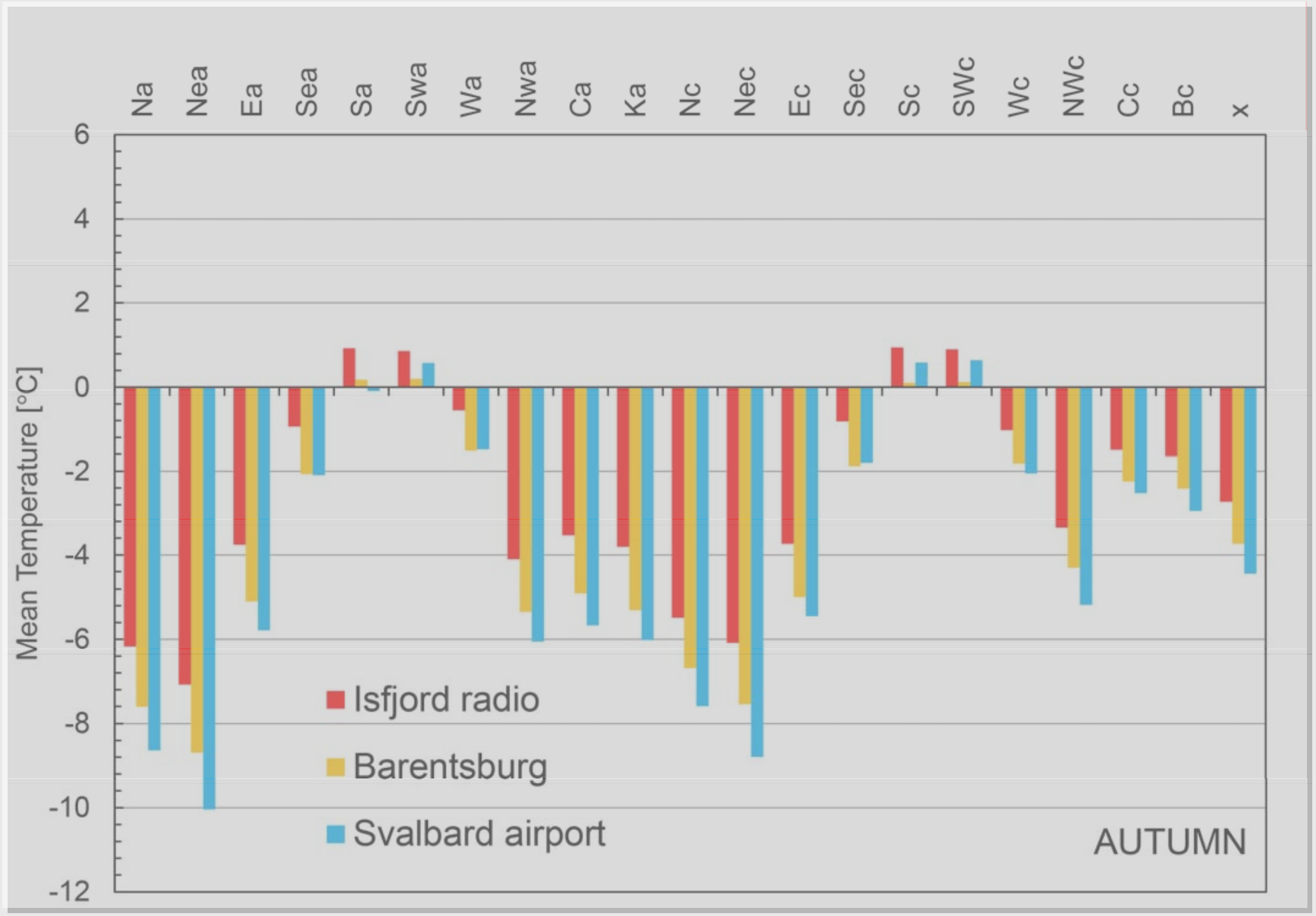
Influence of atmospheric circulation on mean air temperature

Summer, 2001-2015



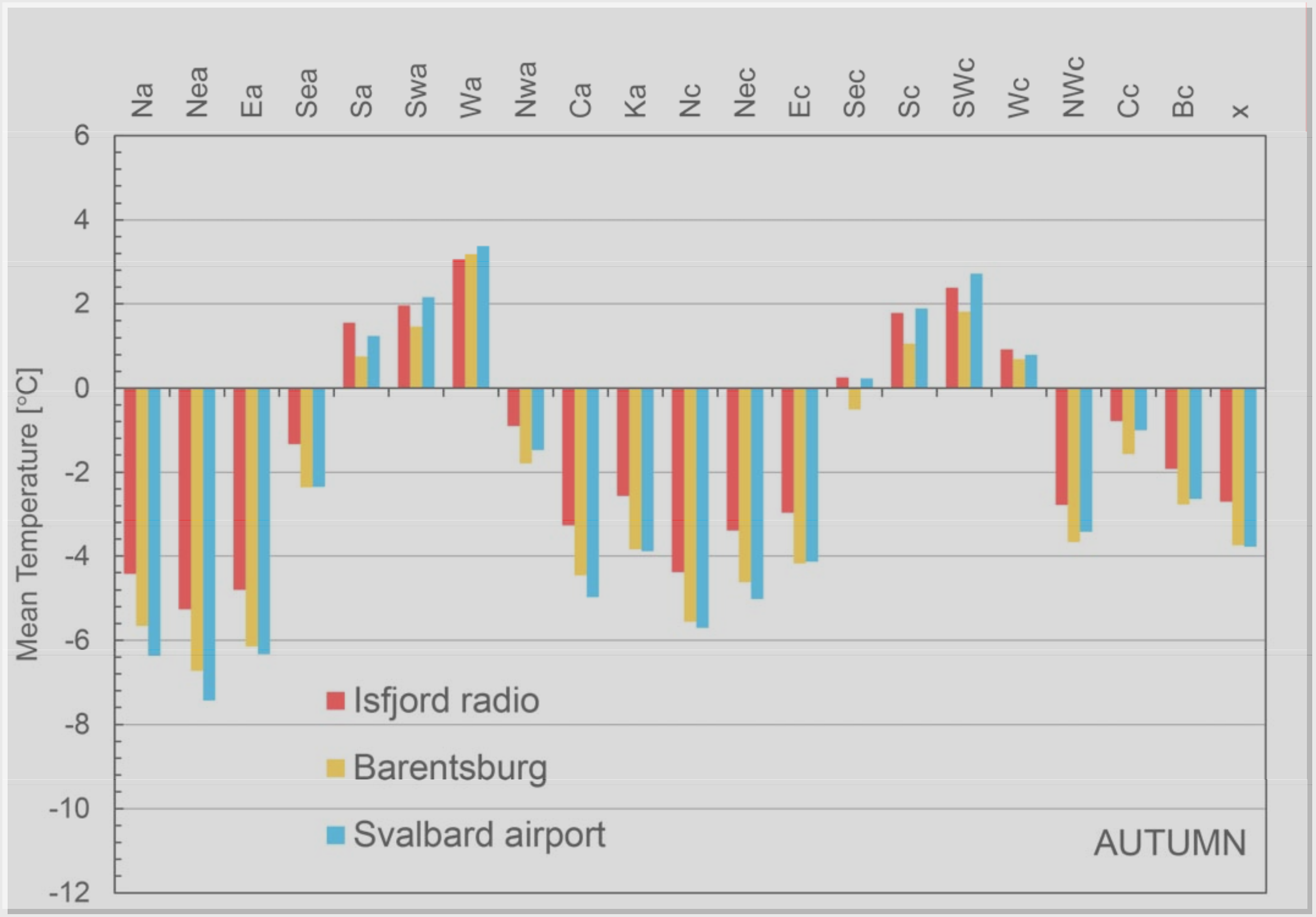
Influence of atmospheric circulation on mean air temperature

Autumn, 1971-2000



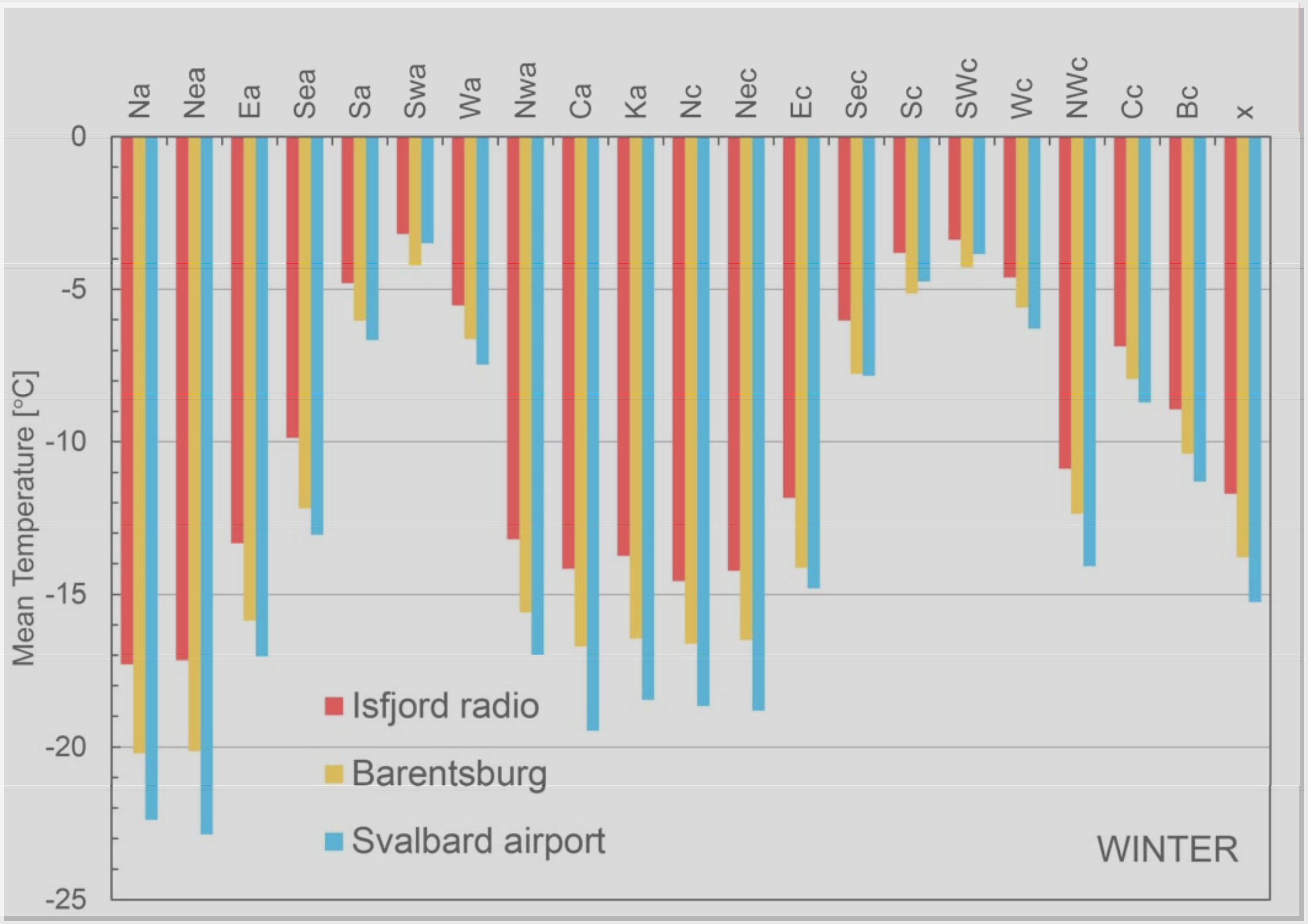
Influence of atmospheric circulation on mean air temperature

Autumn, 2001-2015



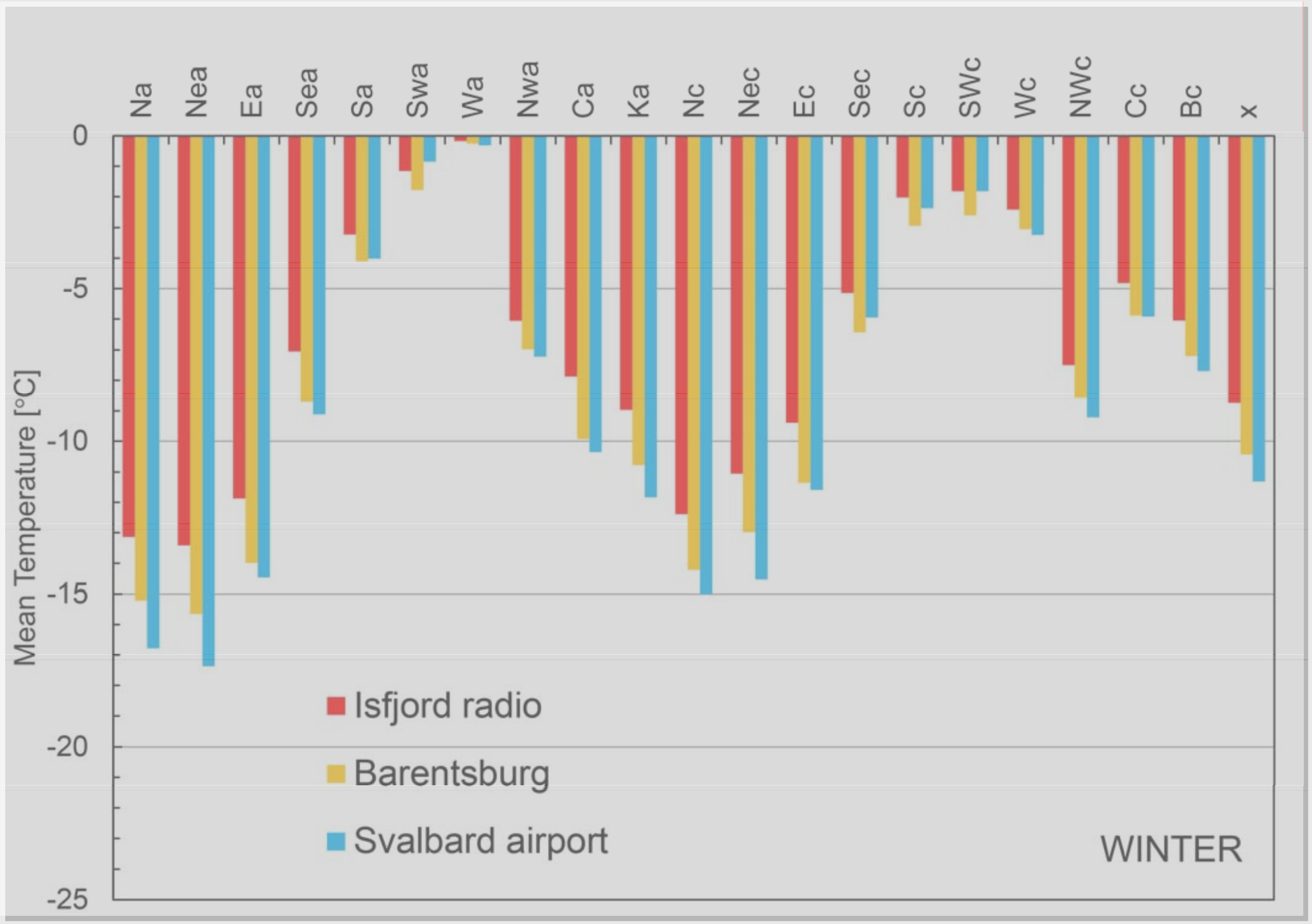
Influence of atmospheric circulation on mean air temperature

Winter, 1971-2000

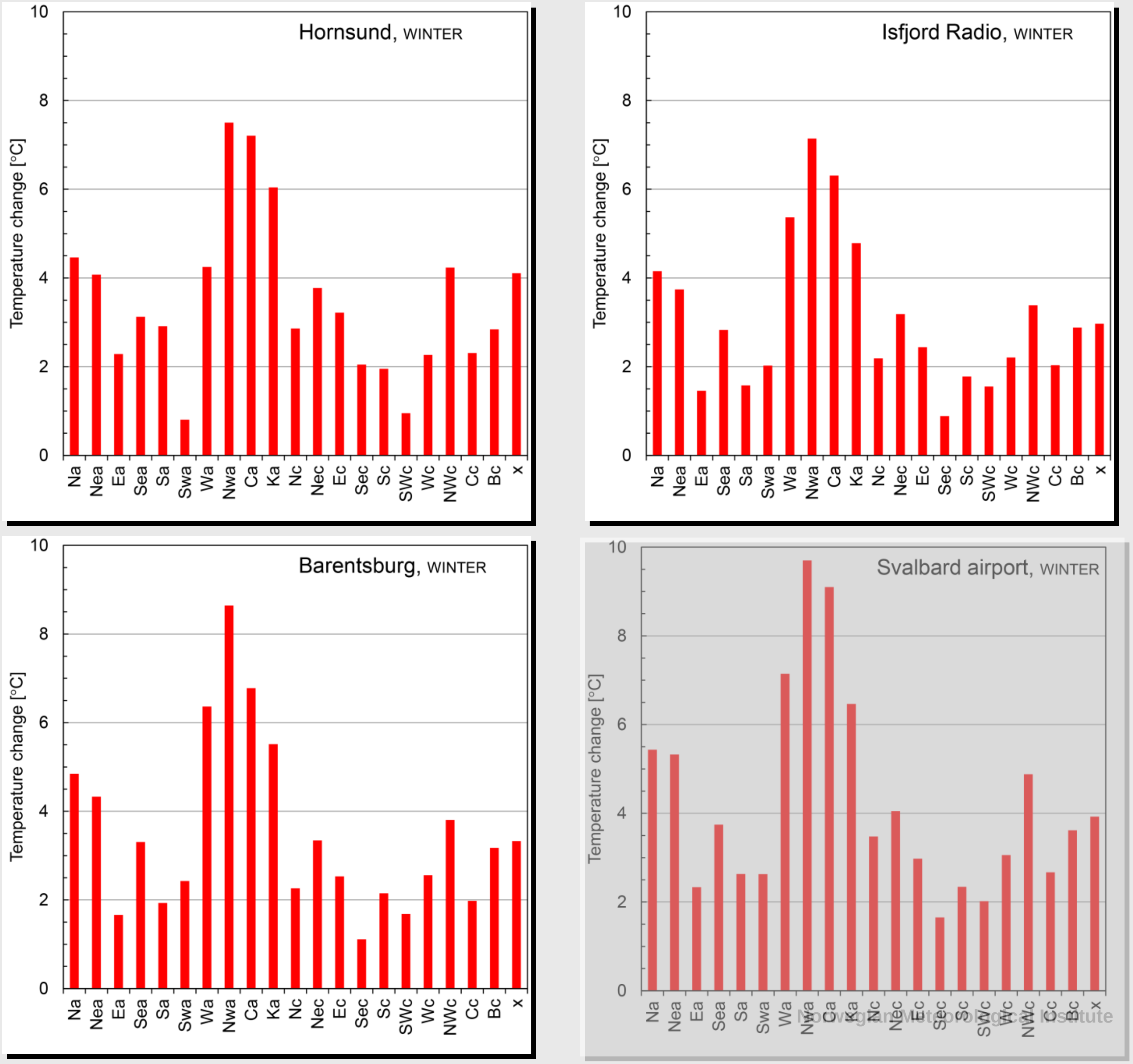


Influence of atmospheric circulation on mean air temperature

Winter, 2001-2015



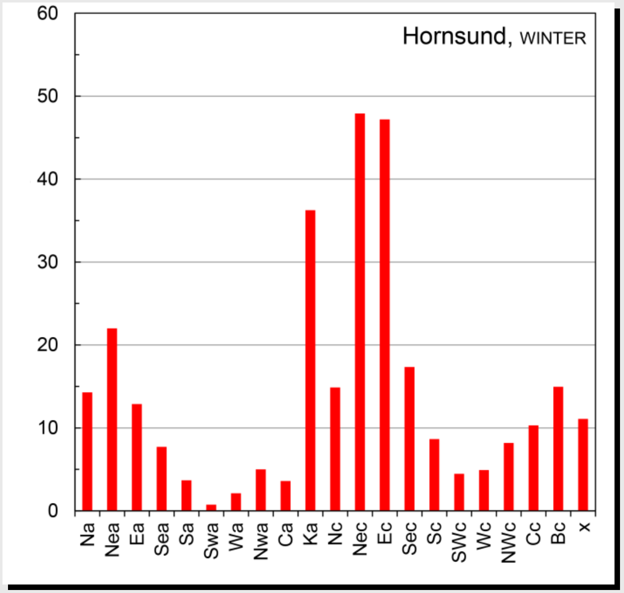
Temperature change between 1971-2000 and 2001-2015
Winter

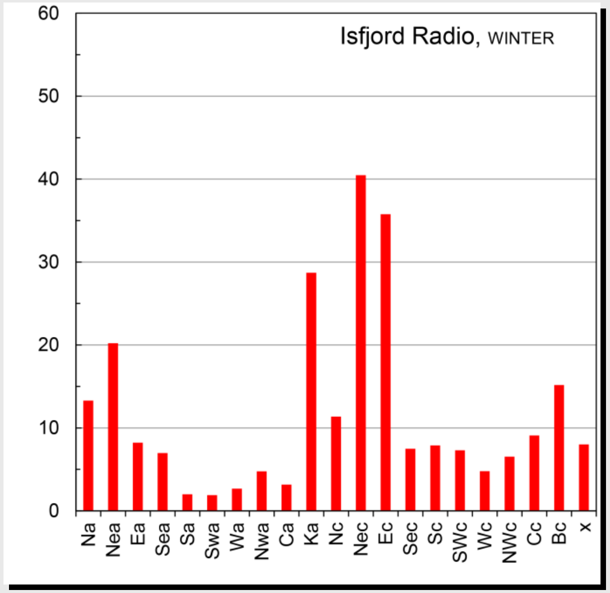


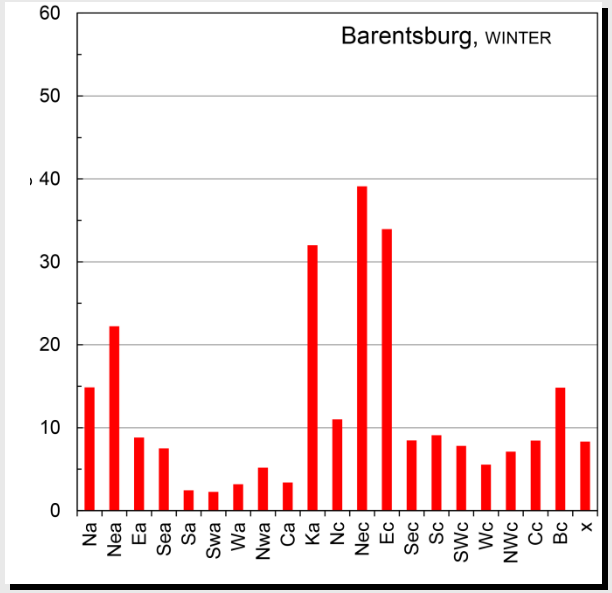
Greatest contribution to the recent warming

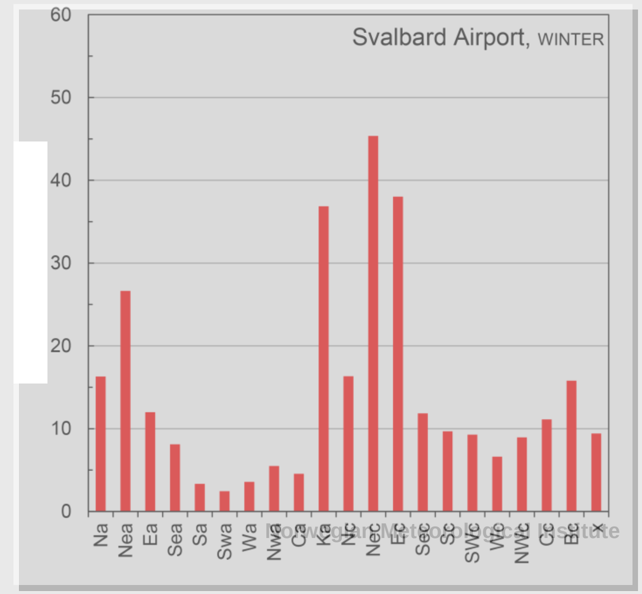
Change in mean air temperature multiplied by change in frequency

Winter





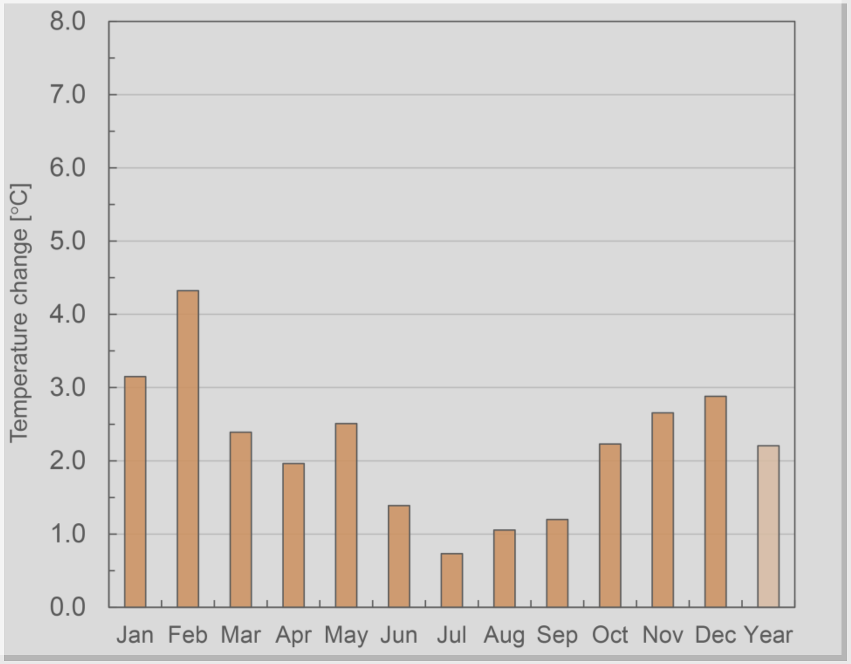




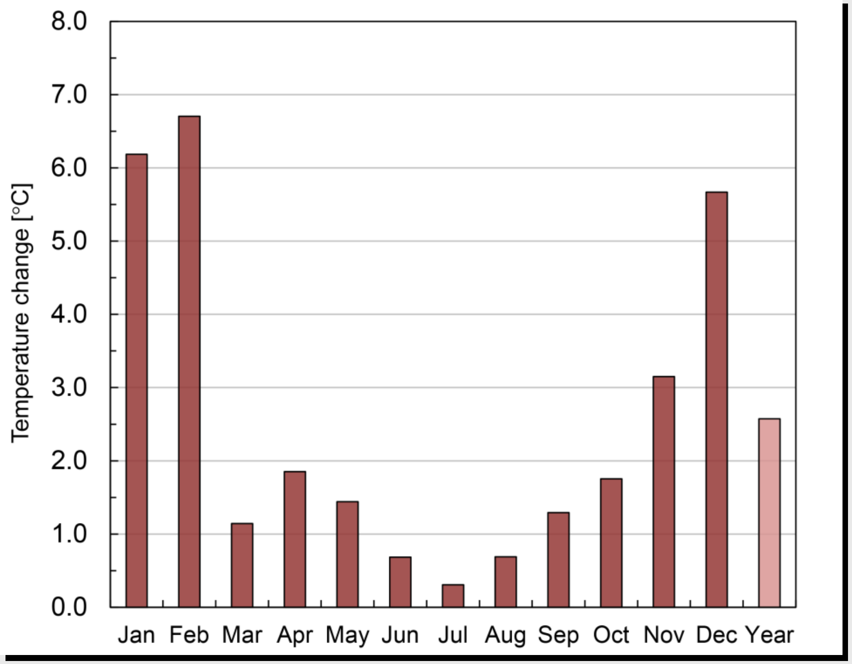
Monthly temperature change for situations contributing most to the recent temperature anomalies

Hornsund

N-NE cyclonic situations

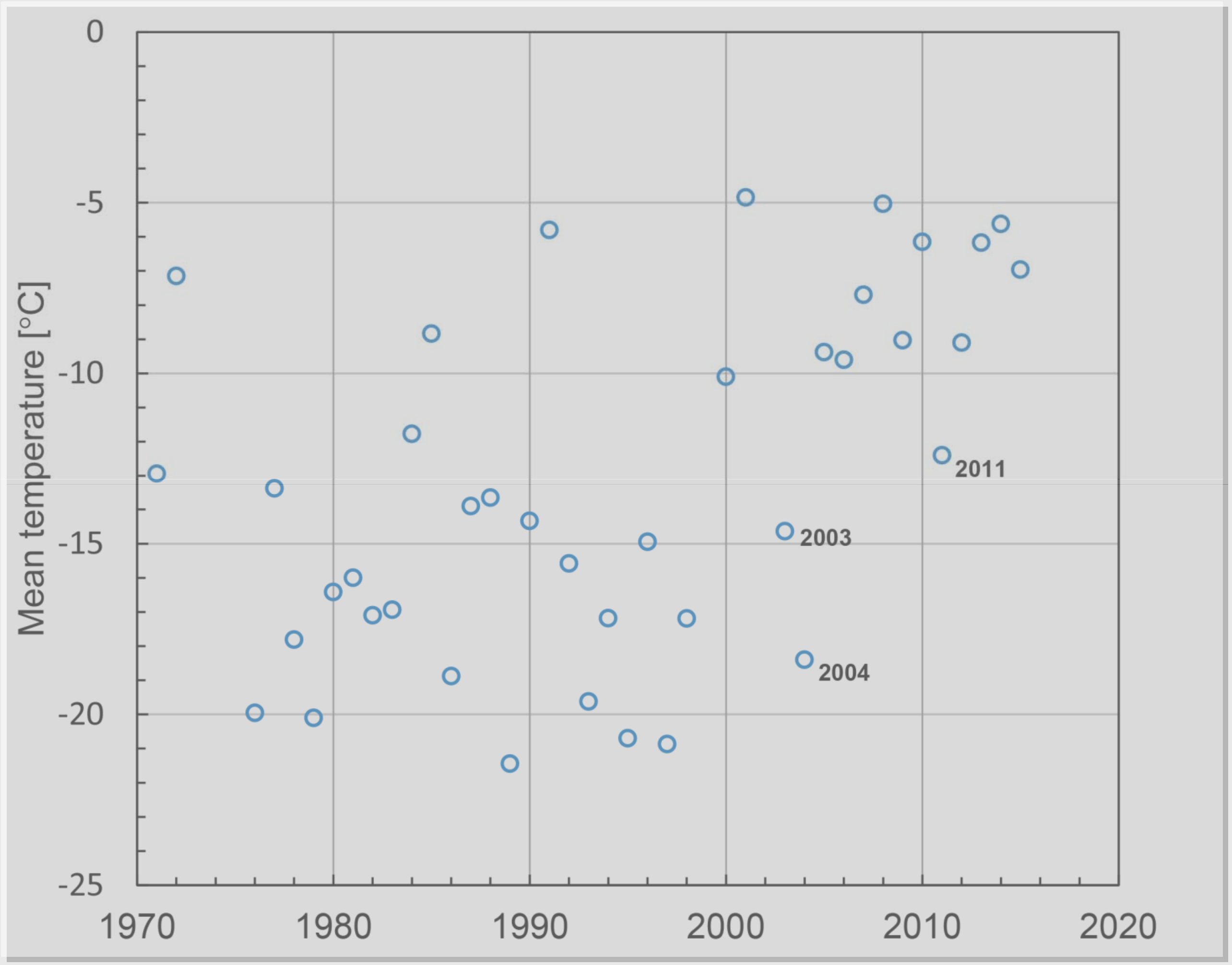


Central anticylonic/anticylonic ridge

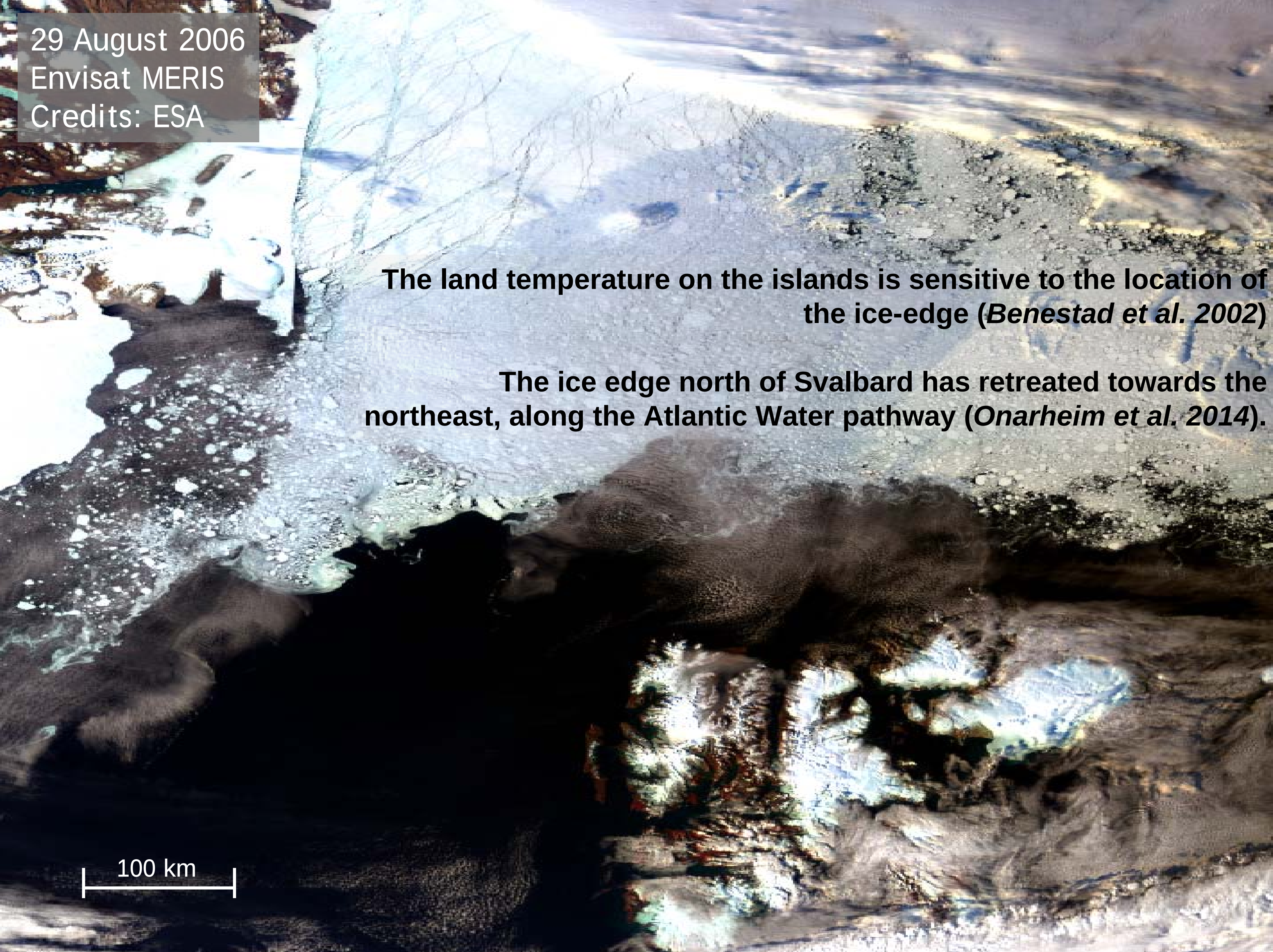


Mean temperature during situations in winter with central anticylonic/anticylonic ridge

Hornsund



A significant recent reduction of fast ice coverage in Isfjorden and Hornsund, with a distinct shift to fewer days of fast ice coverage in 2006 (*Muckenhuber et al. in review*)


29 August 2006
Envisat MERIS
Credits: ESA
The land temperature on the islands is sensitive to the location of the ice-edge (*Benestad et al. 2002*)
The ice edge north of Svalbard has retreated towards the northeast, along the Atlantic Water pathway (*Onarheim et al. 2014*).
100 km

Summary

- For all circulation patterns in all seasons there has been a substantial warming in western Spitsbergen from the period 1971-2000 compared to 2001-15.
- During winter the greatest contribution to the recent warming is associated with situations of cyclonic air advection from Northeast-East and during situations with anticylonic ridge
- The greatest temperature change have occurred during the winter months Dec-Feb, especially during anticylonic ridge situations, suggesting a more local influence which may be related to the observed reduction of sea ice and the intrusion of Atlantic Water in Isfjorden and Hornsund.
- Still open questions regarding to what extent the atmospheric warming is driven by larger open water area due to extra oceanic heat brought into the Svalbard region and west-Spitsbergen fjords, causing sea ice loss and more heat transferred to the atmosphere.

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Influence of sea ice cover in Isfjorden

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www.the-cryosphere-discuss.net/9/4043/2015/
doi:10.5194/tcd-9-4043-2015

The Cryosphere
Discussions
Open Access

Sea ice cover in Isfjorden and Hornsund 2000–2014 by using remote sensing

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9, 4043–4066, 2015

Sea ice cover in Isfjorden and Hornsund 2000–2014 by using remote sensing

S. Muckenhuber et al.

Sea ice Svalbard

Tellus SERIES A DYNAMIC METEOROLOGY AND OCEANOGRAPHY
PUBLISHED BY THE INTERNATIONAL METEOROLOGICAL INSTITUTE IN STOCKHOLM

Loss of sea ice during winter north of Svalbard

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(Manuscript received 29 January 2014; in final form 6 May 2014)

ABSTRACT

Sea ice loss in the Arctic Ocean has up to now been strongest during summer. In contrast, the sea ice concentration north of Svalbard has experienced a larger decline during winter since 1979. The trend in winter ice area loss is close to 10% per decade, and concurrent with a 0.3°C per decade warming of the Atlantic Water entering the Arctic Ocean in this region. Simultaneously, there has been a 2°C per decade warming of winter mean surface air temperature north of Svalbard, which is 20–45% higher than observations on the west coast. Generally, the ice edge north of Svalbard has retreated towards the northeast, along the Atlantic Water pathway. By making reasonable assumptions about the Atlantic Water volume and associated heat transport, we show that the extra oceanic heat brought into the region is likely to have caused the sea ice loss. The reduced sea ice cover leads to more oceanic heat transferred to the atmosphere, suggesting that part of the atmospheric warming is driven by larger open water area. In contrast to significant trends in sea ice concentration, Atlantic Water temperature and air temperature, there is no significant temporal trend in the local winds. Thus, winds have not caused the long-term warming or sea ice loss. However, the dominant winds transport sea ice from the Arctic Ocean into the region north of Svalbard, and the local wind has influence on the year-to-year variability of the ice concentration, which correlates with surface air temperatures, ocean temperatures, as well as the local wind.

Keywords: *Sea ice, Atlantic Water, Svalbard, heat transport, air–ice–sea interactions*

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RMetS
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Extreme daily precipitation events at Spitsbergen, an Arctic Island

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ABSTRACT: Daily station records and output from the MERRA atmospheric reanalysis for the period 1979 onwards are used to examine extreme daily precipitation events at Ny Ålesund and three other sites located on Spitsbergen. Spitsbergen, lying between 77°N and 80°N, is the largest island of the Svalbard Archipelago. The region is frequently influenced by extratropical cyclones associated with the North Atlantic cyclone track and (in winter) regional baroclinicity due to proximity to the sea ice margin. Despite the stronger cyclone activity in winter, extreme precipitation events at Ny Ålesund, defined as those in the top 1% of the statistical distribution, can occur year round. On the basis of a composite analysis, extreme events tend to occur when the region is influenced by a trough of low sea level pressure extending from the southwest, southerly winds in the troposphere, positive anomalies in precipitable water, and pronounced upward motion (negative omega) at 500 hPa. This is linked to positive anomalies in 500 hPa heights over the Barents Sea and negative anomalies over Greenland. While individual extreme events do not share all of these characteristics, strong southerly flow and positive anomalies in precipitable water provide a near common thread. Reflecting local topography, extremes at Ny Ålesund are typically not well represented at other stations on the island, but there are notable exceptions. Some of the largest precipitation events can be associated with features resembling 'atmospheric rivers', seen as narrow corridors of pronounced positive anomalies in precipitable water extending thousands of kilometres south into the subtropical Atlantic. There is no systematic pattern of temporal trends in the frequency or magnitude of extremes.

KEY WORDS Spitsbergen; precipitation; extremes; climatology; atmospheric rivers

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Warmer and wetter winters: characteristics and implications of an extreme weather event in the High Arctic

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Abstract
One predicted consequence of global warming is an increased frequency of extreme weather events, such as heat waves, droughts, or heavy rainfalls. In parts of the Arctic, extreme warm spells and heavy rain-on-snow (ROS) events in winter are already more frequent. How these weather events impact snow-pack and permafrost characteristics is rarely documented empirically, and the implications for wildlife and society are hence far from understood. Here we characterize and document the effects of an extreme warm spell and ROS event that occurred in High Arctic Svalbard in January–February 2012, during the polar night. In this normally cold semi-desert environment, we recorded above-zero temperatures (up to 7 °C) across the entire archipelago and record-breaking precipitation, with up to 98 mm rainfall in one day (return period of >500 years prior to this event) and 272 mm over the two-week long warm spell. These precipitation amounts are equivalent to 25 and 70% respectively of the mean annual total precipitation. The extreme event caused significant increase in permafrost temperatures down to at least 5 m depth, induced slush avalanches with resultant damage to infrastructure, and left a significant ground-ice cover (~5–20 cm thick basal ice). The ground-ice not only affected inhabitants by closing roads and airports as well as reducing mobility and thereby tourism income, but it also led to high starvation-induced mortality in all monitored populations of the wild reindeer by blocking access to the winter food source. Based on empirical-statistical downscaling of global climate models run under the moderate RCP4.5 emission scenario, we predict strong future warming with average mid-winter temperatures even approaching 0 °C, suggesting increased frequency of ROS. This will have far-reaching implications for Arctic ecosystems and societies through the changes in snow-pack and permafrost properties.

Norwegian Meteorological Institute

METreport

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Climate

Varmere og våtere svalbardvintre: konsekvenser for natur og samfunn

Sluttrapport til Svalbards miljøvernfond prosjekt 13/74

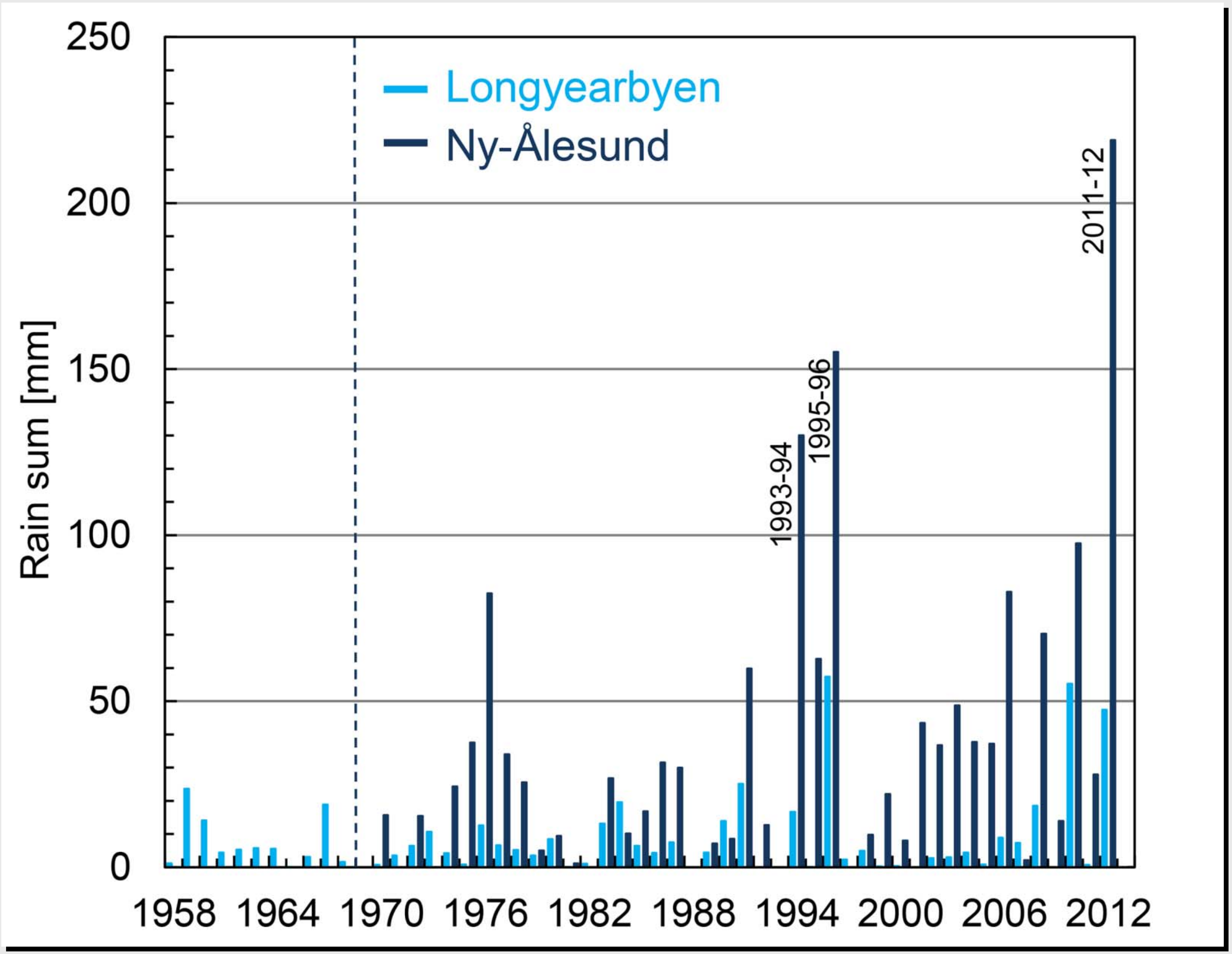
Brage B. Hansen (NTNU), Ketil Isaksen, Leif E. Loe (NMBU), Jan E. Haugen, Rasmus Benestad, Jos Milner (Univ. Aberdeen), René van der Wal (Univ. Aberdeen), Øystein Varpe (Akvaplan-niva/UNIS)

Foto: Ø. Varpe

SVALBARDS MILJØVERNFOND
NTNU Norwegian University of Science and Technology
cbd
UNIS
Akvaplan-niva
NMBU
UNIVERSITY OF ABERDEEN

Total amount of winter rain on Svalbard

Longyearbyen and Ny-Ålesund (November-April) 1957-2014



Hansen et al. 2014 & Hansen et al. 2015

Circulation types (anticyclonic)

anticyclonic situations (1-10, Code Type Description):

· 1 Na - North (direction of air masses advection, geostrophic wind),

· 2 NEa - North-East

· 3 Ea - East

· 4 SEa - South-East

· 5 Sa - South

· 6 SWa - South-West

· 7 Wa - West

· 8 NW - North-West

· 9 Ca - central anticyclone situation (high center)

·10 Ka - anticyclonic wedge or ridge of high pressure

·

Circulation types (cyclonic)

cyclonic situations (11-20):

·11 Nc - North

·12 NEc - North-East

·13 Ec - East

·14 SEc - South-East

·15 Sc - South

·16 SWc - South-West

·17 Wc - West

·18 NWc - North-West

·19 Cc - central cyclonic, centre of low

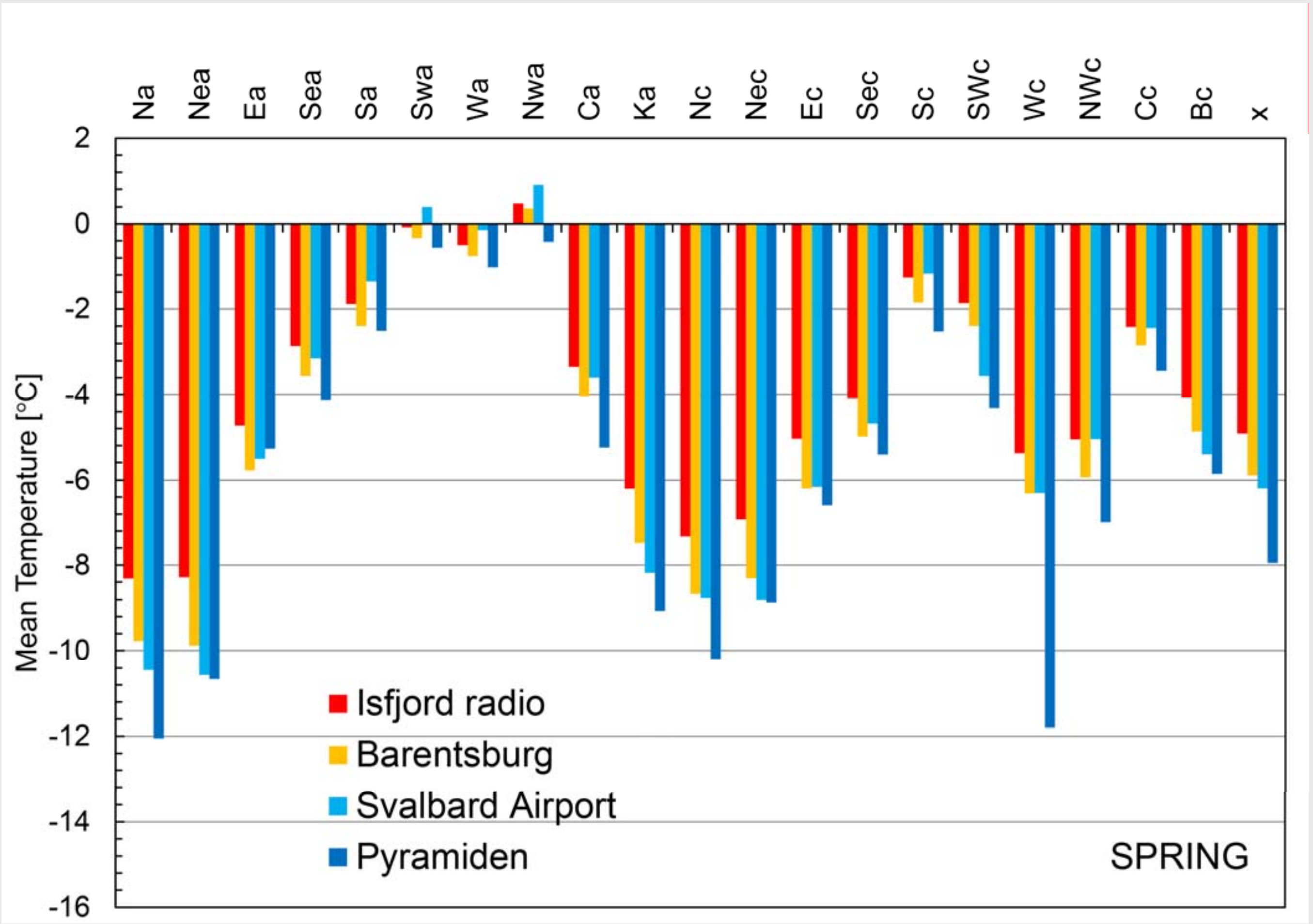
·20 Bc - through of low pressure (different directions of air flow and frontal system in the axis of through)

·21 x - unclassified situations or pressure col.

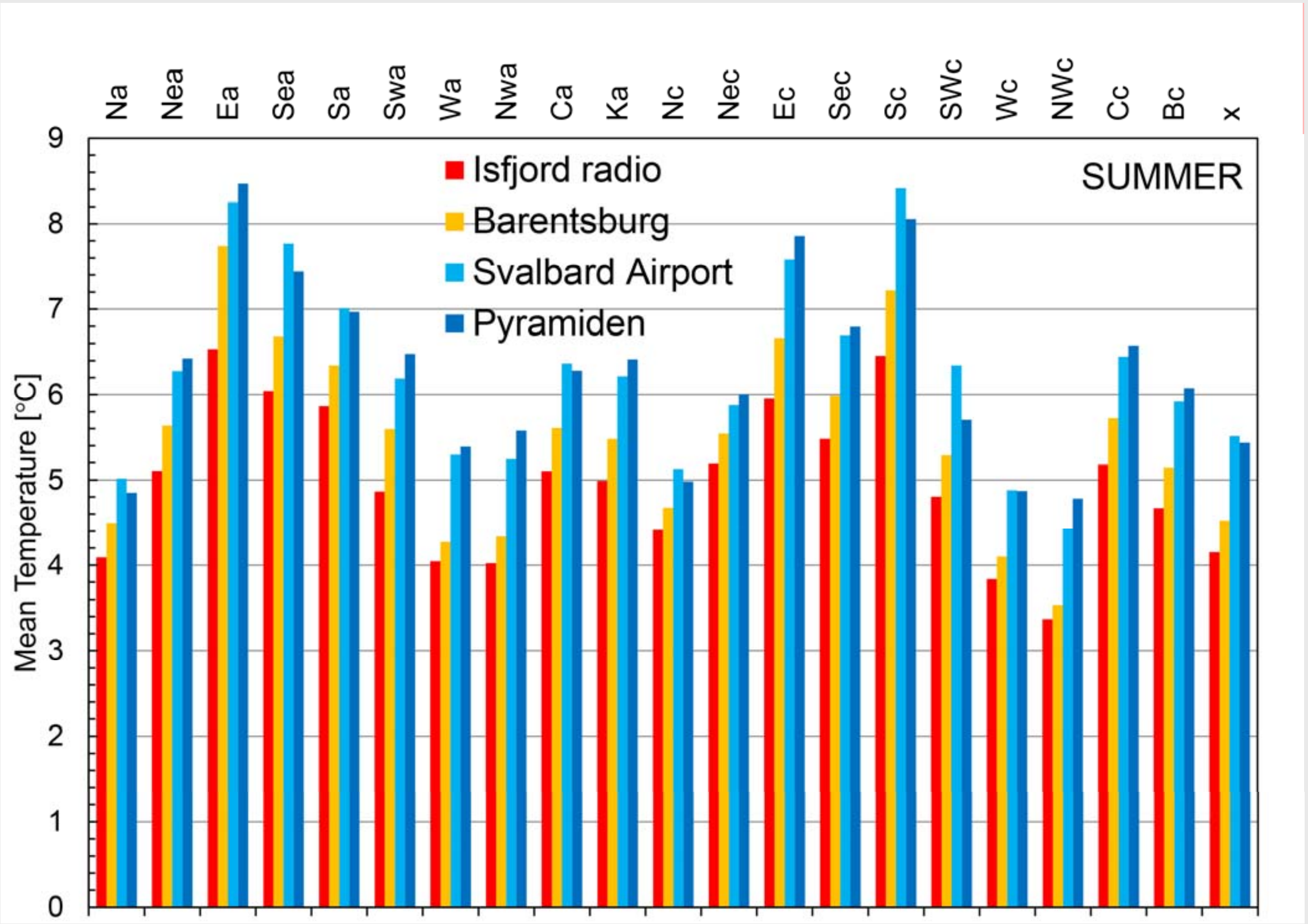
Barentsburg, 1971-2000

	Winter	Mean T	Cases	**Summer**	Mean T	Cases	**Spring**	Mean T	Cases	**Autumn**	Mean T	Cases
1	Na	-20.2	92	Na	3.0	69	Na	-10.2	69	Na	-7.6	94
2	Nea	-20.1	154	Nea	3.4	77	Nea	-13.2	77	Nea	-8.7	128
3	Ea	-15.9	159	Ea	4.9	144	Ea	-12.0	144	Ea	-5.1	138
4	Sea	-12.2	68	Sea	5.8	138	Sea	-7.5	138	Sea	-2.1	60
5	Sa	-6.0	38	Sa	5.8	61	Sa	-3.5	61	Sa	0.2	42
6	Swa	-4.2	28	Swa	4.5	104	Swa	-0.5	104	Swa	0.2	35
7	Wa	-6.6	15	Wa	3.3	93	Wa	-4.2	93	Wa	-1.5	18
8	Nwa	-15.6	18	Nwa	2.9	58	Nwa	-7.6	58	Nwa	-5.3	25
9	Ca	-16.7	15	Ca	4.1	58	Ca	-11.2	58	Ca	-4.9	21
10	Ka	-16.4	174	Ka	4.3	391	Ka	-8.7	391	Ka	-5.3	227
11	Nc	-16.6	146	Nc	2.6	122	Nc	-11.3	122	Nc	-6.7	205
12	Nec	-16.5	351	Nec	3.6	111	Nec	-13.5	111	Nec	-7.5	303
13	Ec	-14.1	402	Ec	4.3	145	Ec	-11.5	145	Ec	-5.0	344
14	Sec	-7.8	228	Sec	5.9	134	Sec	-6.4	134	Sec	-1.9	210
15	Sc	-5.1	127	Sc	5.5	124	Sc	-4.5	124	Sc	0.1	137
16	SWc	-4.3	139	SWc	4.7	167	SWc	-3.0	167	SWc	0.1	128
17	Wc	-5.6	65	Wc	3.6	155	Wc	-4.4	155	Wc	-1.8	44
18	NWc	-12.4	56	NWc	2.6	119	NWc	-8.9	119	NWc	-4.3	70
19	Cc	-7.9	128	Cc	3.7	99	Cc	-5.7	99	Cc	-2.2	136
20	Bc	-10.4	140	Bc	3.7	197	Bc	-6.9	197	Bc	-2.4	168
21	x	-13.8	75	x	4.0	102	x	-10.5	102	x	-3.7	106

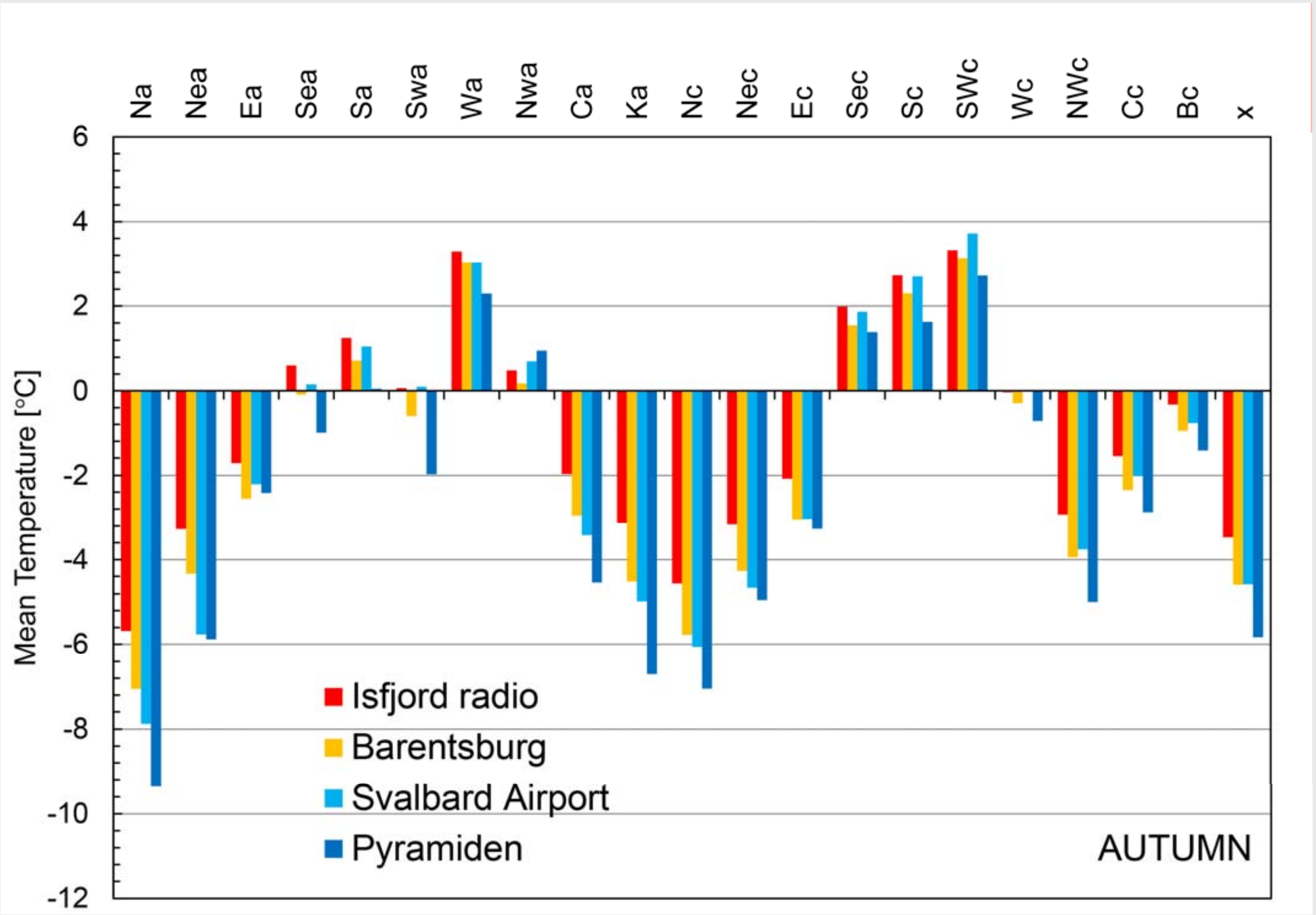
Spring, 2011-2015



Summer, 2011-2015



Autumn, 2011-2015



Winter, 2011-2015