# 11th Arctic Climate Forum Consensus Statement

## Summary of 2022-2023 Arctic Winter Season and the 2023 Arctic Summer Seasonal Climate Outlook

**CONTEXT**

The role of the ArcRCC-Network is to foster collaborative regional climate services amongst Arctic (hydro)meteorological and ice services, as to meet climate adaptation and decision making needs among societal actors across the Arctic. Arctic Climate Forums (ACFs) were established in 2018 and are convened by the Arctic Regional Climate Centre Network (ArcRCC-N) under the auspices of the World Meteorological Organization (WMO).

A main product of the ACFs are the Consensus Statements, which synthesize observations, historical trends, forecasts, and in doing so, include regional expertise. These statements include a review of the major climate features of the previous season and outlooks for the upcoming season for temperature, precipitation, sea-ice and several other experimental forecasts.

The elements of the Consensus Statements are presented and discussed at the Arctic Climate Forum (ACF) sessions, with both providers and users of climate information in the Arctic being held twice a year in May and October. The Consensus Statements are issued prior to summer thawing and sea-ice break-up (May/June) and before winter freezing and the return of sea-ice (October/November).

This Consensus Statement is an outcome of the 11th session of the ACF held online 31 May and 1 June, 2023 coordinated by the Nordic Node of the ArcRCC-Network and hosted by the Swedish Meteorological and Hydrological Institute (SMHI).

**HIGHLIGHTS**

The winter of 2022-2023 was the third consecutive La Niña winter. The average December-February temperature north of 65N was approximately -21.5℃. This is nearly the same value as each of the previous four winters, and significantly warmer than the pre-2000 average. The higher than normal temperatures resulted in the slow ice growth in most regions, with thickness values significantly lower than historical norms. In the early part of the winter, temperatures were below normal on the North American side of the Arctic and above normal on the European/Asian side. The second half of winter saw the opposite conditions.

**Temperature:** December temperatures across the Arctic were consistent with those observed since about 2000. The core of warm temperatures was on the North American side of the Arctic. January was a relatively cold month in most areas - the second coldest in the last 20 years. February was cold on the North American side, but warm on the European/Asian side of the Arctic. European Arctic Ocean regions were much colder than normal in March; however, most land areas were notably warmer than normal. Forecast models for the upcoming summer (June-August) mostly show warmer than normal conditions. Many of these models incorporate both air temperature trends and sea ice trends.

**Precipitation:** Arctic precipitation is always a challenge to assess. Winter precipitation is difficult to measure, and the observations from high quality recording stations are sparse - with no observations over water. Using reanalysis data, December-February precipitation was near average for the last 25 years. This is a value that is wetter than the prior pre-2000 historical average. Snowfall anomalies north of the Arctic Circle were not extreme in most places, except for Arctic Canada. Greenland had higher than average snowfall for nearly the entire island. Precipitation forecasts are difficult to produce for most areas and very difficult for high latitudes. There are no unusually strong signals for anomalous precipitation for the upcoming summer. We do note that El Nino summers are typically drier in the Arctic than non-El Nino summers.

**Sea-ice:** The annual sea ice minimum occurred in mid-September 2022. The value of 4.7 million square kilometers was the 10$^{th}$ lowest in the satellite era. Significant negative anomalies were noted in all regions. The maximum sea ice extent for 2022-2023 was reached in early March 2023. The value of 14.6 million square kilometers was the 5$^{th}$ lowest in the modern era. Negative ice anomalies were most notable in the Western and Eastern Nordic regions. A smaller anomaly was noted in the Chukchi and Bering Region.

## UNDERSTANDING THE CONSENSUS STATEMENT

This consensus statement includes: a seasonal summary and forecast verification for temperature, precipitation, and sea-ice for the previous 2022-2023 Arctic winter season and an outlook for the upcoming 2023 Arctic summer season. Experimental products with outlooks for snow water equivalent, sea-surface temperature and effective temperature bioclimatic index are also included in this consensus statement. Figure 1 shows the regions that capture the different geographic features and environmental factors influencing temperature and precipitation. Figure 2 shows the established shipping routes and regions used for the sea-ice products.

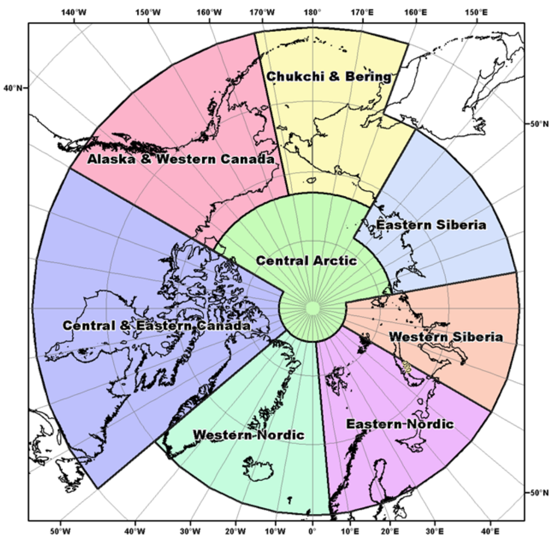



**Figure 1:** Regions used for the seasonal summary and outlook of temperature and precipitation

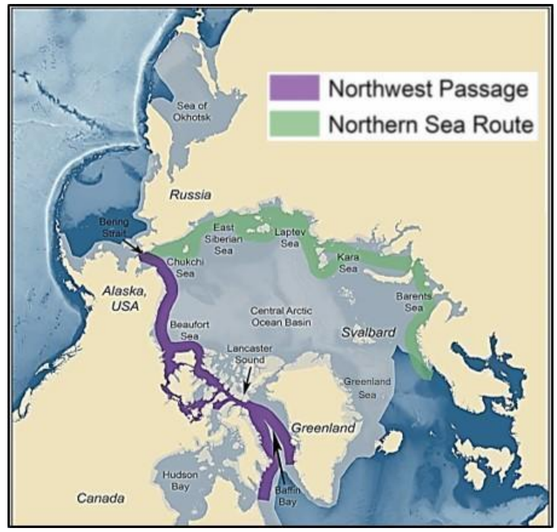



**Figure 2**: Sea-Ice Regions. Map Source: Courtesy of the U.S. National Academy of Sciences

Seasonal summaries of temperature, precipitation, and sea-ice are based on a synthesis of routine observations at polar stations and marine mobile platforms, sea ice analyses from the national Ice Services, satellite estimates of sea ice extent and thickness, WMO GCW SnowWatch data, and a set of modern reanalysis products including Copernicus climate change service (ERA5, MEMS, GloFAS-ERA5) and NCEP-NCAR reanalysis. Anomalies of the parameters are given in the majority of cases for the WMO reference period 1991-2020.

The temperature and precipitation forecasts are based on eleven WMO Global Producing Centers of Long-Range Forecasts (GPCs-LRF) models and consolidated by the WMO Lead Centre for Long-Range Forecast Multi-Model Ensemble (LC-LRFMME). In terms of models' skill (i.e., the ability of the climate model to predict the observed seasonal climate), a multi-model ensemble (MME) approach essentially merges information from all of the individual models. This provides a forecast with higher confidence in the regions where different model outputs/results are consistent, versus a low confidence in the regions where the models show less agreement. The MME approach is a methodology well-recognized for providing the most reliable objective forecasts.

The majority of the sea-ice extent and experimental freeze-up and break-up forecasts are based on the Canadian Seasonal to Interannual Prediction System (CanSIPSv2), a MME of two climate models. The Baltic Sea forecasts are developed using outputs from the ECMWF Long-Range Forecasts, UK MetOffice, and NOAA CFSv2. A larger multi-model ensemble that will include forecasts from the following WMO GPC-LRFs is under development: ECCC/MSC (CanSIPSv2), NOAA (CFSv2), Meteo-France (System 5), UK MetOffice (GloSea5) and ECMWF

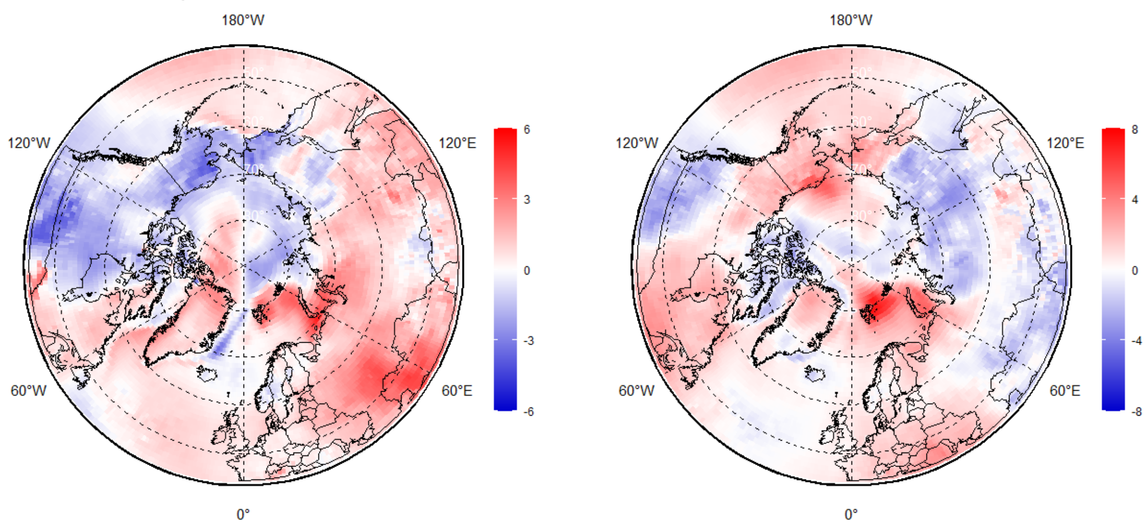
(SEAS5). When sea ice extent is at its minimum in September of each year, forecasts are available for the following peripheral seas where there is variability in the ice edge: Barents Sea, Beaufort Sea, Canadian Arctic Archipelago, Chukchi Sea, Eastern Siberian Sea, Greenland Sea, Kara Sea, and Laptev Sea. In addition to these regions, forecasts for sea ice break-up are also available for Baffin Bay, Bering Sea, East Siberian Sea, Kara Sea, Laptev Sea, Chukchi Sea, Barents Sea, Greenland Sea, Hudson Bay, and Labrador Sea.

Summer outlooks for key shipping areas are provided by the Arctic and Antarctic Research Institute (AARI), Alaska Sea Ice Program, and Canadian and Finnish ice services, and are based on statistical techniques and forecaster expertise.

## TEMPERATURE

### *Temperature Summary for November 2022 - April 2023*

At the start of the winter 2022-2023 (November-December), surface air temperature showed prominent positive anomalies in the Western Nordic (4th consecutive winter) and Chukchi & Bering (10th consecutive winter) and negative anomalies in Alaska, Central & Eastern Canada and the Western Nordic. These anomalies were in reference to the 3rd WMO reference period 1991-2020, with the ranks for 1950-2022 observation period. During mid-winter (January-February 2023), strong positive anomalies were observed over Alaska & Western Canada, Central and Eastern Canada, the Eastern Nordic, and Western Siberia with negative anomalies observed over the Western Nordic region and Eastern Siberia. By the end of the winter in March – April 2023, both negative and positive anomalies were observed over Alaska and Western Canada and the Western Nordic. Negative anomalies were observed over the Eastern Nordic regions, and positive anomalies over Western Siberia.




**NDJ 2022-2023 SAT Anomalies** **FMA 2023 SAT Anomalies**

**Figure 3:** NDJ 2022-2023 and FMA Surface Air Temperature (SAT) anomalies (ref. 1991-2020). Data source: AARI. Maps produced by the AARI. Data source: CCCS ERA5

Due to a lack of in situ surface marine observations, conclusions for the Central Arctic were based on reanalysis, including partly colder conditions in November 2022, but warmer in December 2022, and predominantly colder during February – April 2023. For the whole land-based Arctic, extremely warm conditions were observed in January 2023 and less extreme in February 2023, with preliminary ranks 1st (from 1950), though large regional and inner-season variations and changes in anomaly sign did occur. Centennial long analysis showed that extreme negative anomalies (compared to the 1991-2020 period) in general occurred in the mid 20th century. Positive anomalies, comparable to those seen in the current decade, occurred in the 1910-1920s (Note that this was not consistent for all Arctic subregions). Positive trends are seen in 1940s-1950s, however the quantitative estimates depend on the WMO reference period chosen, station density, and the subset of the stations chosen for the analyzed subregion, in particular for the marine Arctic.

***Verification of late winter (FMA) 2023 Temperature Forecast***

The FMA 2023 temperature forecast was verified by subjective comparison between the forecast (Figure 4, left) and re-analysis (Figure 4, right), region by region. A reanalysis is produced using dynamical and statistical techniques to fill gaps where meteorological observations are not available.

Above normal temperatures were accurately forecasted for the Eastern Nordic and Eastern and Western Siberia. For the Chukchi and Bering, Western Nordic and the Central Arctic, above normal conditions were expected for the entire regions, but this was the case only for the southernmost part of the Chukchi and Bering and western part of Greenland and Central Arctic. The remaining areas experienced near-normal to below normal temperature conditions. For Alaska and Western Canada and Central and Eastern Canada, the forecast gave equal chances for above normal, near-normal and below normal temperature conditions over large areas. The only areas with moderate model agreement were the ocean southwest of Alaska and Northeastern Canada, where above normal temperatures were accurately forecasted.

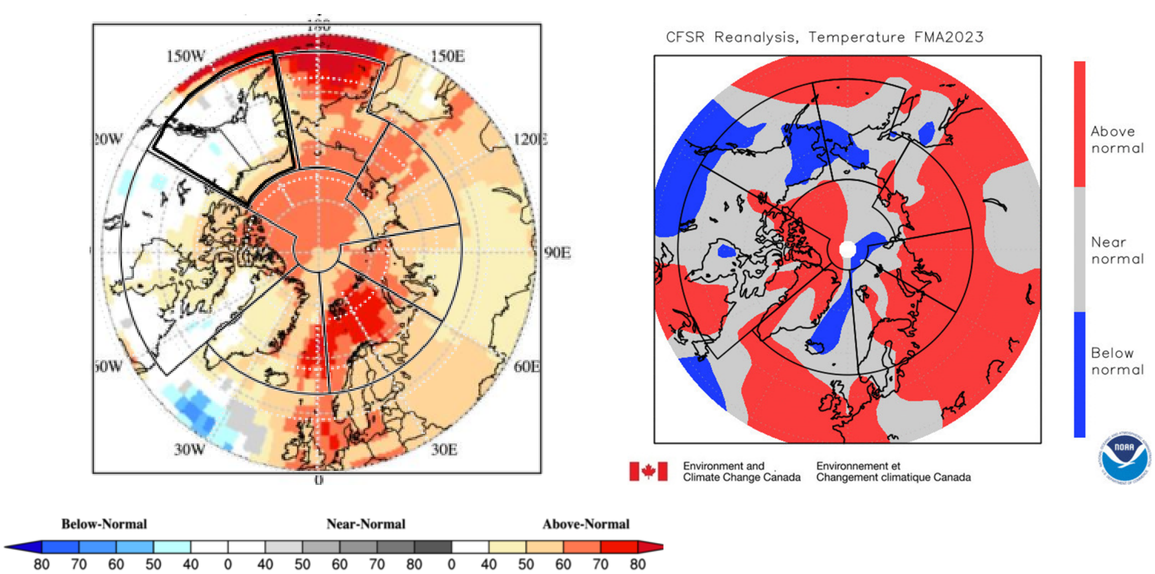



**Figure 4:** (Left) Multi-model ensemble (MME) probability forecast for surface air temperatures: February, March, and April 2023. Three categories: below normal (blue), near normal (gray), above normal (red); no agreement amongst the models is shown in white. Source: www.wmolc.org. (Right): NCAR (National Center for Atmospheric Research) Climate forecast System Reanalysis (CFSR) for air temperature for February, March, and April 2023.

***Temperature Outlook for summer 2023***

For the June-July-August 2023 (JJA 23) period, there is a probability of 40% or more that temperatures will be above normal in all regions across the Arctic. The highest probabilities for an above normal summer (60-70% or more) are in the eastern Canadian Arctic, western Nordic region and over eastern parts of Alaska and western Canada. However, 60-70% of the models agree on lower than normal temperatures in the Greenland Sea which differs from the rest of the Western Nordic region and from previous years.

For the eastern Nordic region, the MME forecast is for above normal probabilities of 50% or higher, in the central and northern parts of the region, while these probabilities are somewhat higher (60% or more) in the south. Both Siberian regions (eastern and western) are expected to have above normal summer with 50% probabilities in the north and 60% or higher in the southern parts of the region. The Chukchi and Bering region has a probability of at least 50% for an above normal summer in the northern coastal parts while these probabilities exceed 60% above normal in other parts of this region.

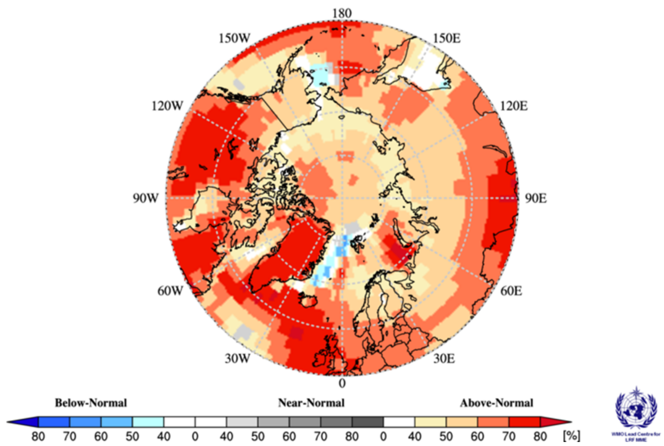



**Figure 5:** Multi model ensemble probability forecast for surface temperature for June, July, and August 2023. Red indicates warmer conditions, blue colder conditions and white, no agreement amongst the models. Source: [www.wmolc.org](http://www.wmolc.org).

**Table 1. Summer (JJA) 2023 Outlook: Regional Forecasts for Arctic Temperatures**

| **Region (see Fig.1)** | **MME Temperature Forecast Agreement** | **MME Temperature Forecast** |
|---|---|---|
| **Alaska and Western Canada** | Moderate | Above normal |
| **Central and Eastern Canada** | Moderate | Above normal |
| **Western Nordic** | Moderate-High | Above Normal; Below-Normal Greenland Seas |
| **Eastern Nordic** | Moderate | Above Normal |
| **Western Siberia** | Moderate | Above normal |
| **Eastern Siberia** | Low-Moderate | Above normal |
| **Central Arctic** | Moderate | Above normal |

## PRECIPITATION

### *Precipitation Summary for November 2022 - April 2023*

In general, during the whole season, wetter (snowy) conditions occurred in parts of the Canadian, Alaska, Bering & Chukchi regions. Drier conditions occurred in parts of the eastern and western Nordic regions and parts of Canadian and Alaska regions.

Impacts of wetter/drier and colder/warmer weather conditions were reflected in the winter/spring 2022-2023 Arctic rivers discharge. However, persistence of frozen ground restricts direct effects. There was lesser drainage than normal seen for Pechora, Ob', most of Enisey and Mackenzie Rivers through the whole season, the Yukon and partly Enisey Rivers experienced greater discharge than normal, and close to normal river discharge was estimated for the Lena and further eastward Siberian Rivers.

***Verification of late winter (FMA) 2023 Precipitation Forecast***

The FMA 2023 precipitation forecast was verified by subjective comparison between the forecast (Figure 6, left) and reanalysis (Figure 6, right), region by region. For Western and Eastern Siberia, Central Arctic and northern part of Eastern Nordic, above normal precipitation levels were accurately forecasted. For Chukchi and Bering and Alaska and Western Canada, mainly above-normal precipitation levels were expected, while this region experienced near-normal conditions. For Central and Eastern Canada and Western Nordic, the forecast gave equal chances for above-normal, near-normal and below-normal precipitation over large areas, and these regions experienced near-normal or below-normal precipitation.

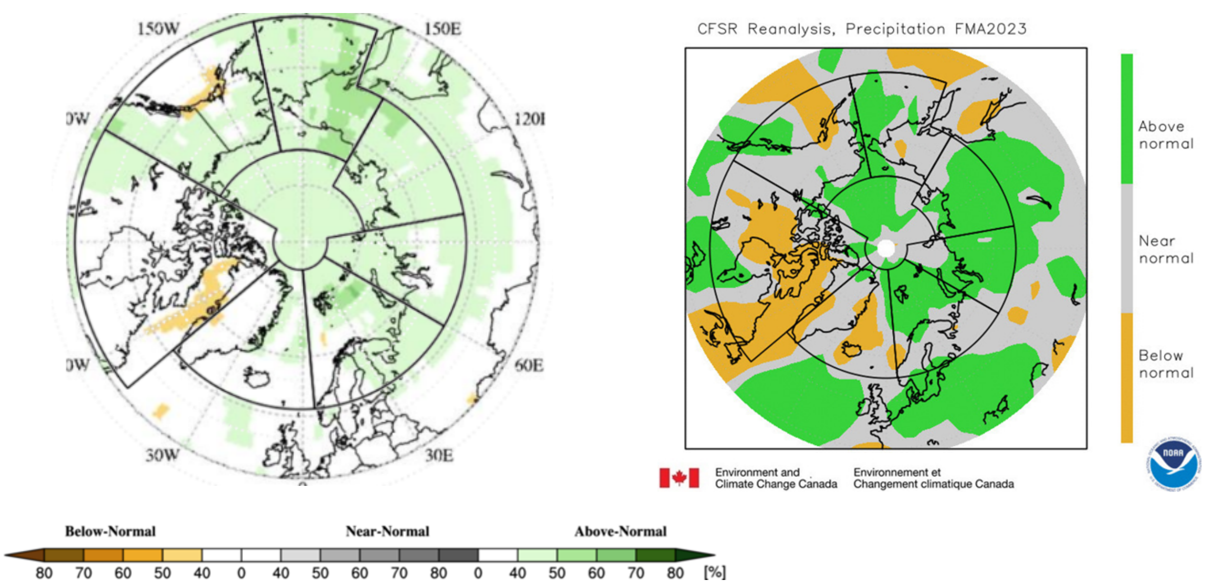



**Figure 6**: (Left) Multi-model ensemble (MME) probability forecast for precipitation: February, March, and April 2023. Three categories: below normal (brown), near normal (gray), above normal (green); no agreement amongst the models is shown in white. Source: www.wmolc.org. (Right): NCAR CFSR for precipitation for February, March, and April 2023.

***Precipitation Outlook for summer 2023***

Over the largest part of the Arctic region, MME forecast is predicting equal probability chances for precipitation this summer (white color on the Figure 7). There are some scattered regions over Alaska & Western Canada, Eastern Siberia and Chukchi and Bering regions where above normal precipitation is forecasted with at least 40% probability. Below normal precipitation is expected over Eastern Canada (Hudson Bay region) and over maritime areas of the eastern Nordic region, with at least 40% probability.

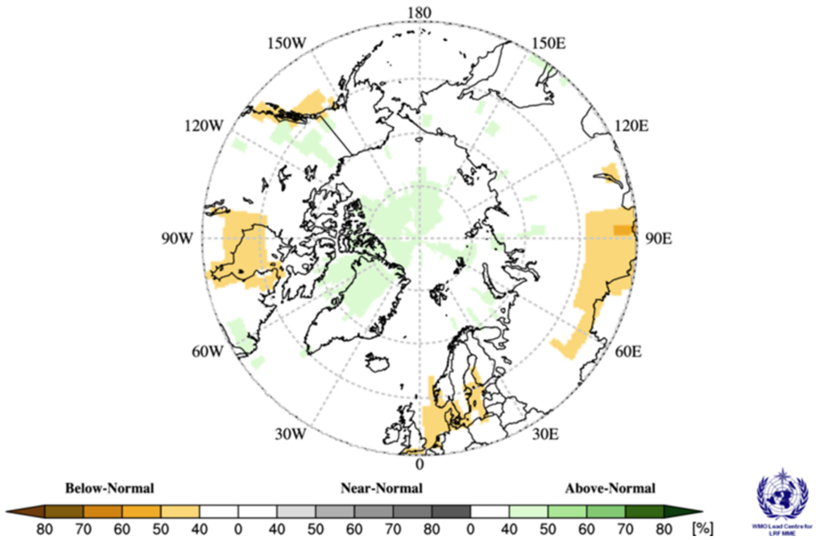



**Figure 7:** Multi model ensemble probability forecast for precipitation for June, July, and August 2022. Green indicates wetter conditions, orange drier conditions and white, no agreement amongst the models.
Source: www.wmolc.org

**Table 2. Summer (JJA) 2023 Outlook: Forecasted Arctic Precipitation by Region**

| **Region (see Fig.2)** | **MME Precipitation Forecast Agreement** | **MME Precipitation Forecast** |
|---|---|---|
| **Alaska and Western Canada** | Moderate | Near normal |
| **Central and Eastern Canada** | Low | Above normal for Nunavut northern regions and West Greenland; Below normal for Hudson Bay |
| **Western Nordic** | Moderate | No model agreement except Above normal for North East Greenland |
| **Eastern Nordic** | Moderate-High | Below normal for Southern Scandinavia and Northern North Sea - no model agreement for Svalbard, Barents Sea, Murmansk, White Sea, Northern Scandinavia |
| **Western Siberia** | Low | Above normal for North of Kara Sea,No model agreement for all other regions |
| **Eastern Siberia** | No model agreement | |
| **Central Arctic** | No model agreement | |

**SNOW WATER EQUIVALENT (Experimental Product)**
***Snow Water Equivalent Outlook for summer 2023***

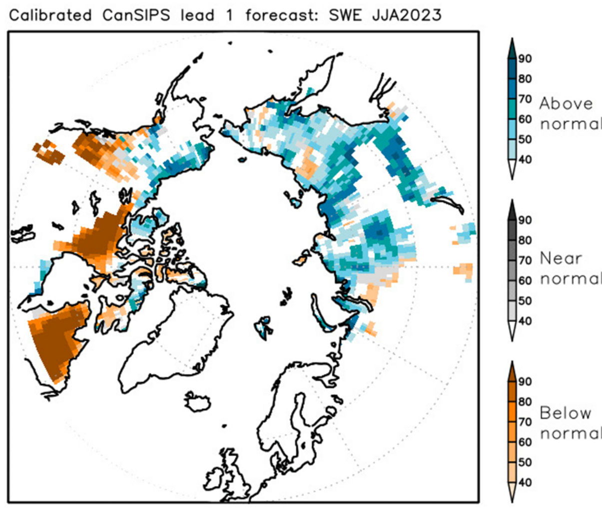



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**Figure 8:** Canadian Seasonal to Interannual Prediction system probability forecast for snow water equivalent for June, July, and August 2023.

**Table 3. Summer (JJA) 2022 Outlook: Forecasted Arctic Snow Water Equivalent (SWE) by region**

| **Region (see Fig. 2)** | **MME SWE Forecast Agreement** | **MME SWE Forecast** |
|---|---|---|
| **Alaska and Western Canada** | Moderate | Near normal for northern Alaska Yukon and Western and Eastern NWT; No model agreement for most of Alaska and Central NWT |
| **Central and Eastern Canada** | No model agreement for Nunavut - northern regions; High agreement for nunavut - southern regions | Below normal for Nunavut - southern regions |
| **Eastern Nordic** | Low | Above normal |
| **Western Siberia** | Moderate-High | Above normal for Novaya Zemlya Islands and coastal areas of Kara Sea, Near or Below normal in the South of Yamal |
| **Eastern Siberia** | Moderate-High | Below normal East of Sakha and archipelago of Severnaya Zemlya, Above normal West of Sakha region |

Snow Water Equivalent (SWE) calibrated probabilistic seasonal forecast is from the Canadian Seasonal to Interannual Prediction System (CanSIPS). Over the Alaskan and western Canada region there is a probability of 50% or more for an above average SWE in the northern coastal region. Over the southwestern parts of this domain below normal SWE is expected with at least

40% probability. Over the northern continental Canadian Arctic, the forecast is for below normal snowfall this summer (at least 50-60% probability). The Canadian Archipelago is forecast to have above normal snow over some scattered regions of Baffin and Victoria Islands. The western Siberian region is forecast to have below normal snow amounts this winter in the southeast (40% or more), while above normal SWE is forecasted over the northern, coastal regions. The eastern Siberian region also has above normal (>50%) forecasts for SWE in almost all parts of the region with the eastern portions having the highest probabilities of at least 60% and higher. The Chukchi and Bering region have above normal SWE for this summer (40-50% or more) while the MME is clear forecast signal over some central portions.

## POLAR OCEAN

### *Polar Ocean Summary for November 2022 - April 2023*

During the first part of the winter 2022-2023, higher 15m upper ocean layer Heat Content (HC) was observed in the east Bering, Svalbard, and southern Greenland waters. Lower HC was observed in the Chukchi and Okhotsk Seas, somewhat neutral over other parts of the Arctic. Calmer sea surface conditions were observed in the Barents and Greenland Seas with higher stormier conditions in the Bering and Okhotsk Seas. Later in winter the HC was mostly near the 1993-2020 average for most of the Arctic, below average for the Sea of Okhotsk and above average for parts of Svalbard and the Barents Sea. Prominent higher stormier seas were observed for the open-water Atlantic sector of the Arctic, Barents and west Bering Seas.

Numerical models show for the current winter season both neutral and positive pH anomalies (alkalization) for the Arctic Basin, Laptev, and Chukchi Seas, and negative pH for the Barents, parts of the Kara, East Siberian, and Greenland Seas with anomalies to the 1993-2020 period, which is in general similar to 2022. The latter may point to acidification processes, though needs further verification with ground-truth data.

### *Sea-Surface Temperature Outlook for summer 2023 (Experimental Product)*

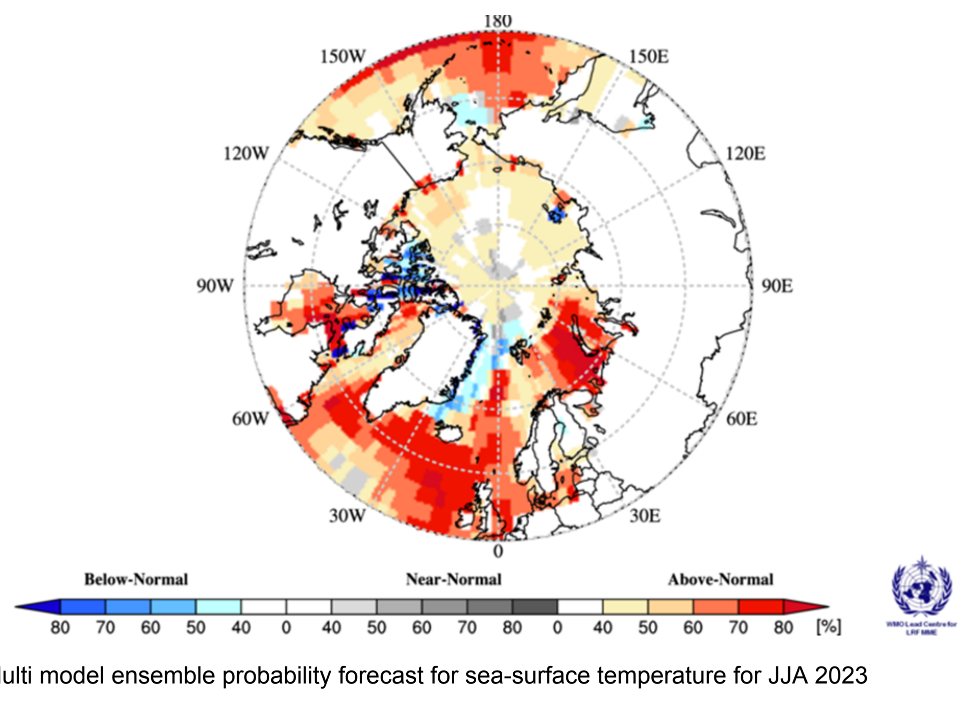



**Figure 9:** Multi model ensemble probability forecast for sea-surface temperature for JJA 2023

Over a large portion of the Arctic seas, the multi-model ensemble approach is forecasting above normal SST's. The highest probabilities for above normal SST's are forecasted for Barents and Kara Seas and Hudson Bay with probabilities of more than 70%. East Siberian, Laptev, Chukchi and Beaufort Seas have rather weak expectancies for above normal SST this summer, at least 40%. Northern parts of the Canadian archipelago and Greenland Sea have below normal SST expectancies of at least 40% probability.

## SEA ICE

### *Sea-Ice Summary for November 2022 - April 2023*

Prevailing positive ocean heat capacity (HC) anomaly during Sept-Nov 2021 for Svalbard, the Barents and Kara Sea, and parts of the Laptev Sea and Hudson Bay slowed freezing processes in these regions. In contrast, zero or negative HC anomalies in Sept-Nov 2022 in the East Siberian Sea, Chukchi, Bering, Okhotsk, and Baffin Seas provided background for close to normal freeze-up. Further into winter season, occurrence of general positive SAT anomalies over Barents and Svalbard areas in Feb-April 2023 slowed the ice growth, however negative SAT anomalies during the same period stimulated ice growth in Eurasian, Arctic, Bering and Okhotsk Seas.

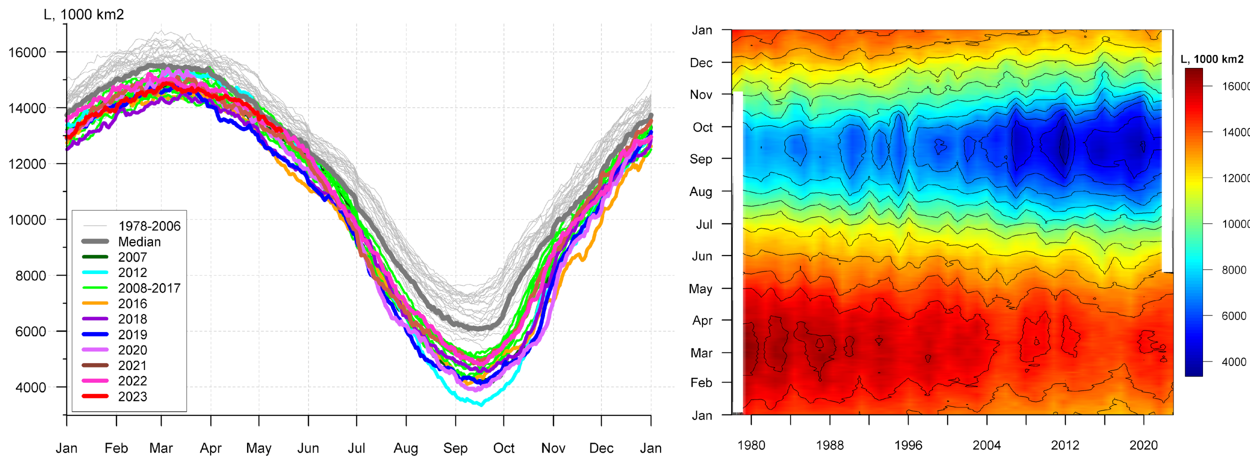



**Figure 10:** Arctic (Northern Hemisphere) daily (left) and Daily Seasonal Northern Hemisphere (right) ice extent variability for 1978- 2023. Graphics produced by the AARI. Data source: NSIDC.

Arctic sea ice reached its maximum extent for the year at 14.62 million square kilometers (5.64 million square miles) on March 6, 2023. The 2023 maximum is the 5th lowest maximum ice extent in the 45-year satellite record. With exception of the Barents Sea, a prominent area of residual ice in late summer led to decadal normal ice extent growth in the Eurasian and Canadian Arctic. Opposite to the 2021/22 winter, the Sea of Okhotsk had an ice extent close to the 45-years median and the Greenland Sea ice extent exceeding the 45-years median in late winter 2023. Seasonal patterns of daily ice extent (Figure 10 on right) allow us to retrieve additional information on intraseasonal variability of ice extent. Though both winter maximums and summer minimums continue to diminish, there are certain hints to the possibility for summer ice cover in 2023 to be greater than in 2019-2020 and close to 2021-2022.

Special features of ice conditions in the Arctic during autumn-winter 2022-2023 included the occurrence of residual ice, and further in season the second-year ice in parts of the Laptev and East Siberian Sea. Also, close to normal autumn ice growth within eastern lanes of the Northern Sea Route, close to decadal normal ice conditions in the Canadian Arctic, and close to normal ice conditions in the Sea of Okhotsk (which is opposite to 2022) were observed.

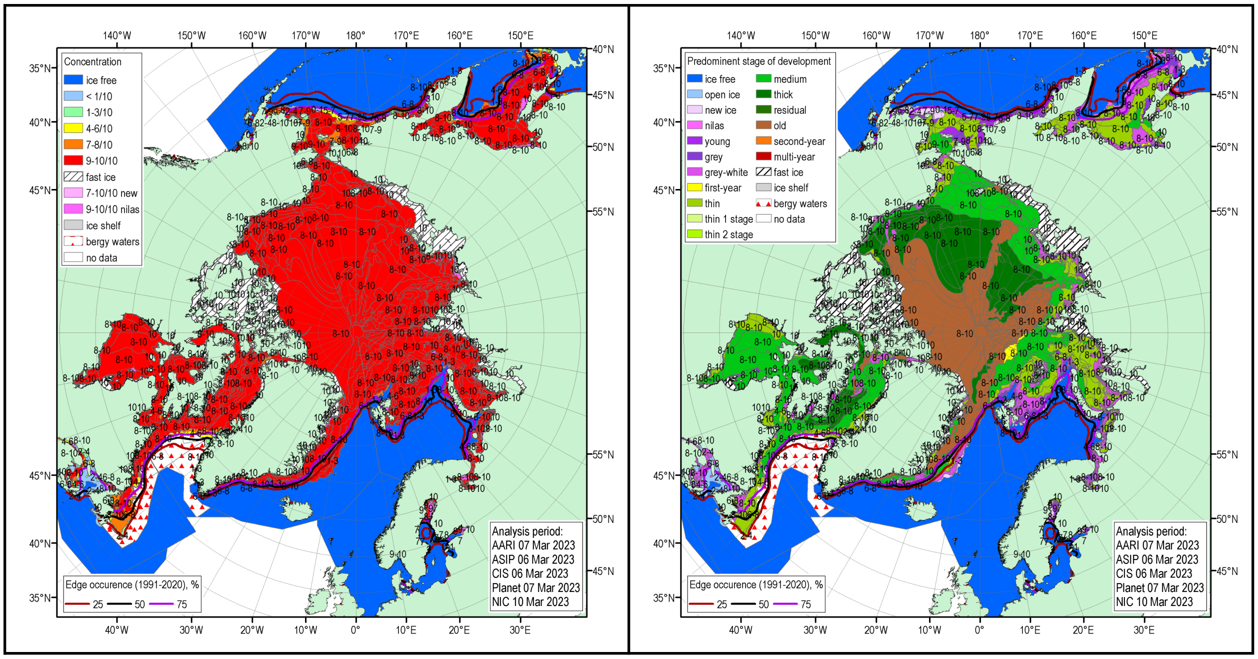



**Figure 11:** Blended Arctic sea-ice chart (AARI, ASIP, CIS, NIC, Planet) during winter 2023 ice maximum (6-10 March 2023) and sea-ice edge occurrences for 06-10 March for 1991-2020 reference period. Left: total concentration, right: predominant stage of development. Graphics produced by the AARI.

Cryosat-2 measurements showed the general Arctic Basin sea ice thickness distribution in March 2022 similar to the mean distribution 2011-2023 (see corresponding seasonal review for the graphics). The estimate of the total Arctic ice volume, based on modeling, is close to 2nd lowest for 2004-2023 after 2020 and 2021 due to sea ice thickness loss in the Canadian Arctic.

### *Verification for March 2022 Sea Ice Extent*

**Table 4. Winter 2022-2023: Regional Comparison of Observed & Forecasted Max Sea-Ice Extent**

| **Regions (see Figure 1)** | **CanSIPS Sea-Ice Forecast Confidence** | **CanSIPS Sea-Ice Forecast (2013-2021 climate normal)** | **Observed Ice Extent (2013-2021 climate normal)** | **CanSIPS Sea-Ice Forecast Accuracy** |
|---|---|---|---|---|
| **Bering Sea** | Low | Near normal | Below normal | Moderate |
| **Sea of Okhotsk** | Moderate | Near normal | Near normal | High |
| **Barents Sea** | High | Below normal | Below normal | High |
| **Greenland Sea** | High | Below normal | Above normal | Low |
| **North Baltic Sea** | High | Near normal | Near normal | High |
| **Labrador Sea** | High | Above normal | Near normal | Moderate |

The forecast for the March 2022 sea ice extent was based on output from CanSIPSv2, an MME of two climate models, and verified well for all but the Greenland Sea. Near normal ice extent was correctly forecasted for the Sea of Okhotsk and North Baltic Sea (Table 4). Below normal ice extent was correctly forecasted for the Barents Sea. The model did not forecast the above normal ice extent in the Greenland Sea.

### *Outlook for Spring Break-up 2023*

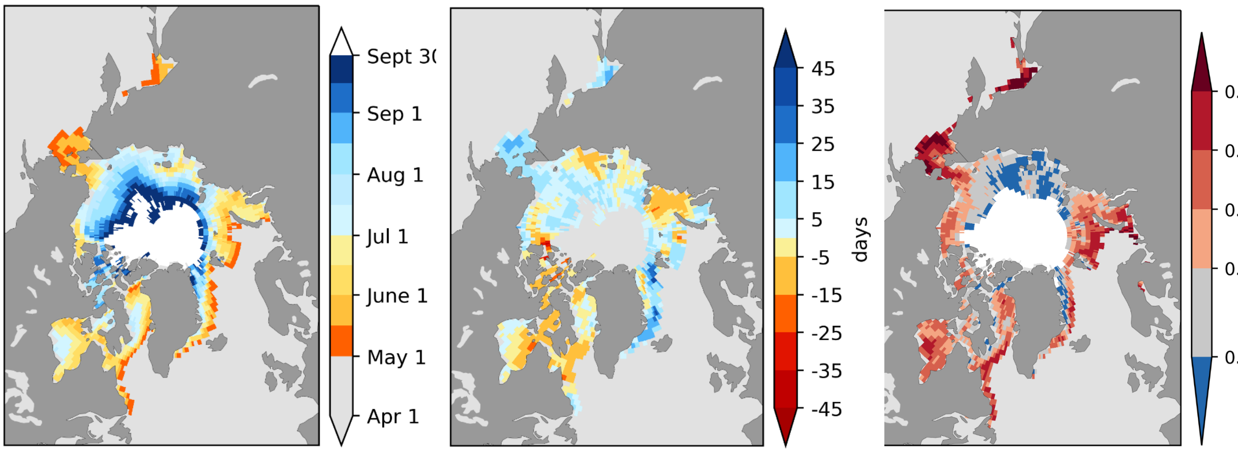



**Figure 12:** Predicted ice-free dates (for concentrations falling below 50%) Deterministic forecast from May 1, 2023. (Left) 2023 Ice-Free Date (bias corrected). (Middle) 2023 Ice-Free Date Anomaly compared to 2014-2022 average. (Right) Historical Skill 1993-2022 anomaly correlation detrended. Source: CanSIPSv2 (ECCC).

**Table 5: Spring 2023 ArcRCC Regional Outlook for Arctic Sea Ice Break-up**

| **Regions (see Figure 1)** | **CanSIPSv2 Sea-Ice Forecast Confidence** | **CanSIPSv2 Sea-Ice Break-up Forecast** |
|---|---|---|
| Barents Sea | High | Near normal |
| Greenland Sea | High | Late |
| Baffin Bay | High | Near normal |
| Hudson Bay | High | Near normal |
| Labrador Sea | High | Early |
| CAA | Low | Early |
| Beaufort Sea | High | Near normal |
| Chukchi Sea | Moderate | Near normal |
| East Siberian Sea | Low | Early |
| Bering Sea | Already Occurred | |
| Laptev Sea | Low | Early |
| Kara Sea | High | Early |

Sea ice break-up is defined as the first day in a 10-day interval where ice concentration falls below 50% in a region. Figure 12 displays the predicted ice-free dates (for concentrations falling below 50%) based on a deterministic forecast from May 1, 2023. The 2023 Ice-Free Date (bias corrected) are displayed on the left, the 2023 Ice-Free Date Anomaly compared to 2014-2022 average is in the middle, and the correlation detrended historical skill 1993-2022 anomaly is on the right. A summary of the forecast for the 2023 spring break-up for the different Arctic regions are shown in Table 5.

***Outlook for September 2023 Minimum Sea Ice Extent***

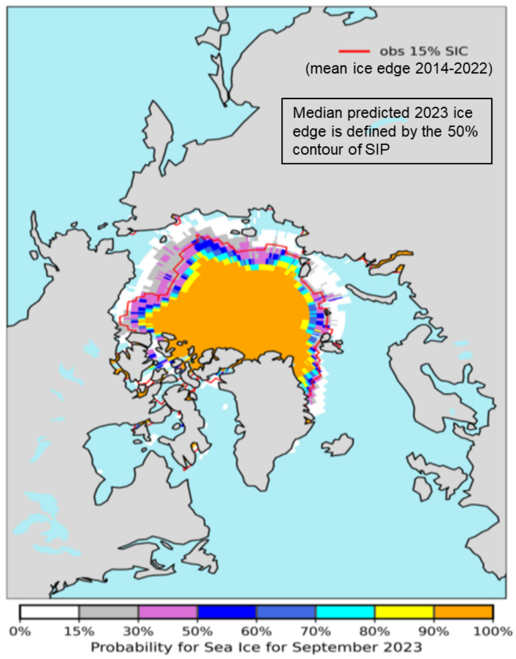



**Figure 13:** Chance of Average September 2023 sea ice concentration exceeding 15% based on the 2014-2022 average. Source: CanSIPSv2 (ECCC).

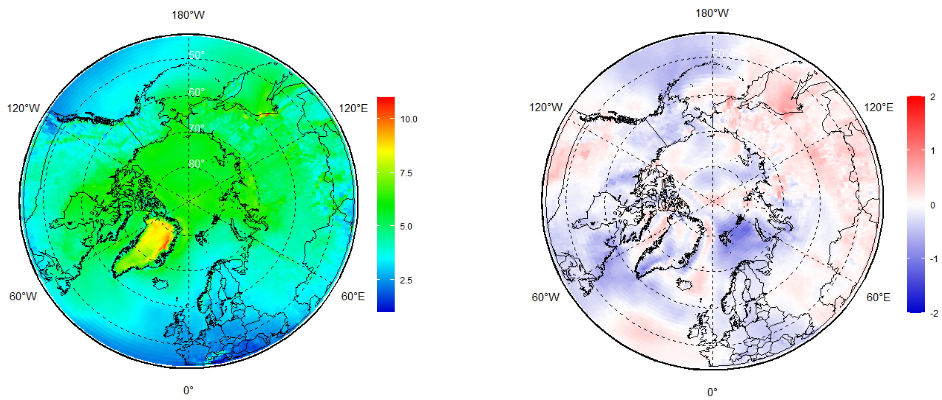
**Table 6**: **Summer 2023 Regional Outlook for Minimum Sea-Ice Extent**

| **Regions (see Figure 1)** | **CanSIPSv2 Sea-Ice Extent Forecast Confidence** | **CanSIPSv2 Sea-Ice extent Forecast** |
|---|---|---|
| **Beaufort Sea** | High | Below normal |
| **East Siberian Sea** | Moderate | Below normal |
| **Canadian Arctic Archipelago** | High | Below normal |
| **Chukchi Sea** | High | Below normal |
| **Barents Sea** | Moderate | Near normal |
| **Greenland Sea** | Moderate | Near normal |
| **Kara Sea** | Moderate | Below normal |
| **Laptev Sea** | Moderate | Below normal |

Minimum sea ice extent is achieved each year during the month of September in the northern hemisphere. Table 6 categorizes the sea ice extent forecast confidence and relative extent (i.e., near normal, below normal, above normal) with respect to a 2013-2022 climatology for the Arctic region. The chance of average September 2023 sea ice concentration exceeding 15% based on the 2014-2022 average is shown in Figure 13. The forecast for most of the Arctic is a below normal September ice extent. Near normal ice extent is forecast for the Barents and Greenland Seas.

## BIOCLIMATIC INDICES (EXPERIMENTAL PRODUCT)

### *Summary for winter 2022-2023*

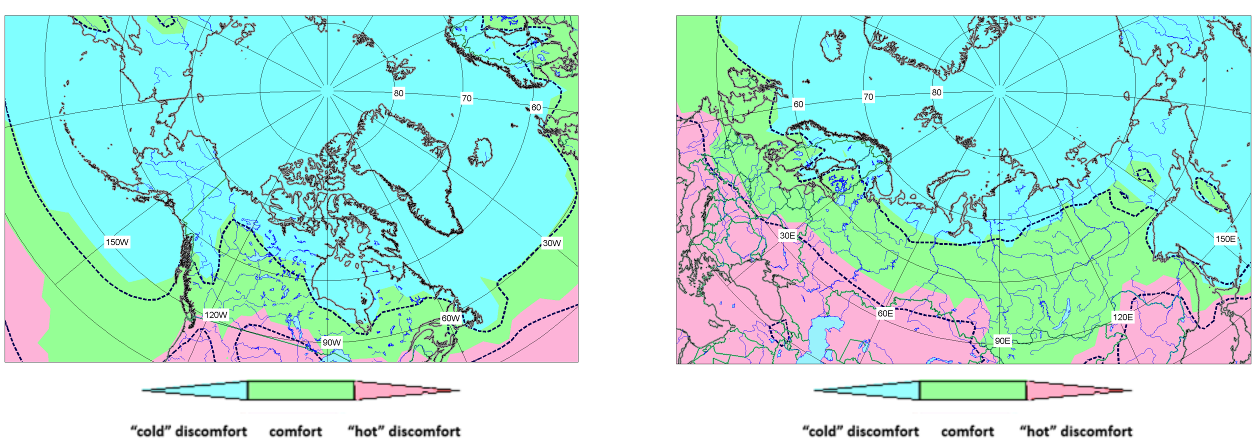



**NDJ 2022-2023 Bodman's Index** **NDJ 2022-2023 Bodman's Index Anomaly (1991-2020)**

**Figure 14**: Bioclimatic indexes in DJF 2022-2023 - Bodman's weather severity index (left) and Bodman's Index Anomaly (1991-2020) (right). Maps produced by the AARI. Data source: CCCS ERA5.

During the winter 2022-2023, milder than climatological bioclimatic weather severity can be attributed using the Bodman's index for most of the Nordic, Western Siberia, Eastern and Central Canada regions and for NDJ 2022-2023 in the Alaska region. Harsher and more severe weather can be attributed to most of Siberia, parts of the Chukchi and Bering regions, and in FMA 2023 for the Eastern Canada and Alaska regions.

### *Bioclimatic Indices Outlook for Summer 2023*




**-------- norm (1991-2020)**

**Western Hemisphere Summer 2023 Forecast** **Eastern Hemisphere Summer 2023 Forecast**

**Figure 15**: Effective temperature (ET) forecast for June - August 2023. Maps produced by the Hydrometcenter Russia. Data source: Institute of Numerical Mathematics Russian Academy of Science.

Forecast of the bioclimatic indices is provided in a form of forecasted effective temperature (ET) values for June – August 2023 (Figure 15) and is based on the experimental seasonal forecast of air temperature and humidity produced by the Institute of Numerical Mathematics, Russian Academy of Science. The same model was used to calculate hindcasts for 1991-2020 norms (dotted lines). The effective temperature index allows us to assess the degree of thermal comfort of weather conditions. Cold discomfort indicates, for example, fatigue during prolonged active outdoor activities. Hot discomfort (which is not commonly seen in the Arctic region) may be informative for hiding from the sun, and taking breaks from work outdoors.

In the Eastern Hemisphere in the summer of 2023, cold discomfort conditions are expected in most of Norway and Sweden (excluding southern parts: this is consistent with long-term averages 1991-2020). In most of the Arctic coast of Russia, bioclimatic conditions are also generally expected to be relatively in the cold discomfort range, however, the comfort zone will significantly move north relative to the norm in Western Siberia and move a little bit south in Eastern Siberia.

In the Western Hemisphere in the summer of 2023 cold discomfort conditions are expected in Alaska, the Yukon, the western and northern Northwest Territories, Nunavut, Northern Quebec, Greenland and Iceland. In the rest of the territories, conditions are expected to be comfortable, with the comfort zone (relative to 1991-2020) moving north in the center of Quebec, into Nunavut and NW of the territory. No hot discomfort conditions expected in the Arctic Zone.

**BACKGROUND AND CONTRIBUTING INSTITUTIONS**

The Arctic seasonal climate summary and outlook were prepared for ACF-11. Contents and graphics were prepared in partnership with the Canadian, Danish, Finnish, Icelandic, Norwegian, Russian, Swedish and United States (hydro)meteorological institutions, sea ice services and contributions of the WMO GCW.

The ArcRCC-Network, a collaborative arrangement with formal participation by all the eight Arctic Council member countries, is in demonstration phase to seek designation as a WMO RCC-Network, and its products and services are in development and are experimental. For more information, please visit https://arctic-rcc.org/acf-spring-2023.

ACF

Arctic Climate Forum

***Acronyms:***

AARI: Arctic and Antarctic Research Institute
ArcRCC-Network: Arctic Regional Climate Centre Network https://www.arctic-rcc.org/
ACF: Arctic Climate Forum
AMAP: Arctic Monitoring and Assessment Programme
CAA: Canadian Arctic Archipelago
CanSIPSv2: Canadian Seasonal to Inter-annual Prediction System
CAP: Common Alerting Protocol
CCl: WMO Commission for Climatology
CCCS: Copernicus climate change service
CBS: WMO Commission for Basic Systems
CIS: Canadian Ice Service
DMI: Danish Meteorological Institute
ECCC: Environment and Climate Change Canada
ECMWF: European Centre for Medium-Range Weather Forecasts
ESA: European Space Agency
FMI: Finnish Meteorological Institute
GCW: Global Cryosphere Watch
GPCs-LRF: WMO Global Producing Centres Long-Range Forecasts
GloFAS-ERA5: CCCS operational global river discharge reanalysis
GloSea5: Met Office Global Seasonal forecasting system version 5
H50, H500: Geopotential heights 50hPa, 500hPa
HYCOM-CICE: HYbrid Coordinate Ocean Model, Coupled with sea-ICE
IICWG: International Ice Charting Working Group
IMO: Icelandic Meteorological Office
IOC: Intergovernmental Oceanographic Commission
LC-LRFMME: WMO Lead Centre for Long Range Forecast Multi-Model Ensemble
MEMS: CCCS Marine environment monitoring service
MSLP: Mean sea level pressure
NAO: North Atlantic Oscillation
NIC: National Ice Center (United States)
NCAR: National Center for Atmospheric Research
NCAR CFSR: National Center for Atmospheric Research Climate Forecast System Reanalysis
NMI: Norwegian Meteorological Institute
NOAA/NWS/NCEP/CPC: National Oceanic and Atmospheric Administration/National Weather Service/National Centers for Environmental Prediction/Climate Prediction Center (United States)
NSIDC: National Snow and Ice Data Center (United States)
MME: Multi-model ensemble
NSR: Northern Sea Route
NWP: Northwest Passage
PIOMAS: Pan-Arctic Ice Ocean Modeling and Assimilation System
RCC: WMO Regional Climate Centre
RCOF: Regional Climate Outlook Forum
SAT: Surface air temperature
SST: Sea surface temperature
SMHI: Swedish Meteorological and Hydrological Institute
WMO: World Meteorological Organization