



ACF

Arctic Climate Forum

Climate monitoring and seasonal summaries: what are the products and how support forecasting and consensus statement are developed (good practice of ArcRCC-Network)

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INAUGURAL SESSION OF THE THIRD POLE CLIMATE FORUM
4 – 6 June 2024, Lijiang, Yunnan Province, China



ArcRCC-N major products

Products

1. ArcRCC Regional Climate Overview Briefings

Temperature, precipitation and sea-ice conditions and extremes for North America, Europe, Northern Eurasia, and Central Arctic Review of past season (e.g. NDJFMA 2023/2024) and outlook for the next season including the risks (e.g. JJAS 2024)

2. ArcRCC Seasonal Summary

Review of atmosphere ECVs (MSLP, temperature, precipitation), hydrology (river discharge, SWE), sea-ice (SIE, SIC, SIT, ice volume), polar ocean (heat content, pH) for the past season (e.g. ONDJFMA 2023/2024)

3. Climate Conditions and Socio-Ecological Impacts at the (Sub)Seasonal Timescale

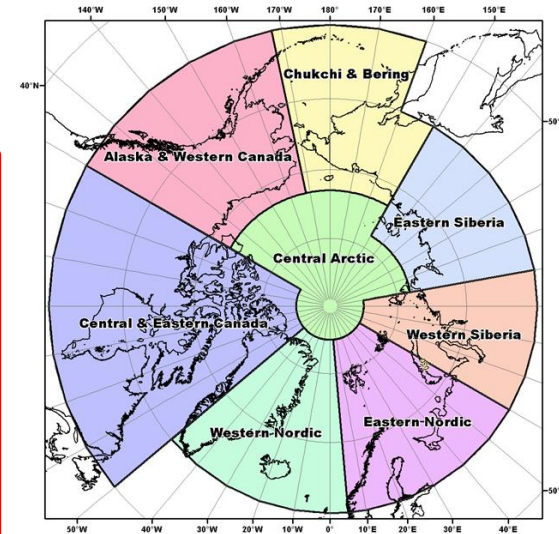
Summary of bioclimatic indexes (currently Bodman's, ET) in the Arctic for the past season (e.g. NDJFMA 2023/2024) and verification of the previous forecast and forecast for the next season (e.g. JJA 2024)

4. Outlook for atmosphere parameters

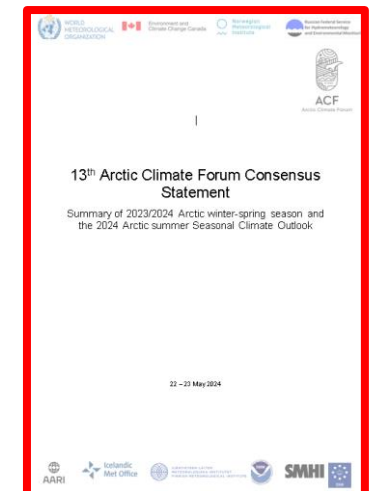
Validation of the forecast for the previous season (e.g. FMA 2024) and outlook of temperature, precipitation, and Snow/Water Equivalent (experimental) for the next season (e.g. JJA 2024) and model confidence

5. Outlook for the regional specific parameters

Validation of the forecast for the previous season (e.g. NDJFMA 2023/2024) and outlook of SIE, SIC, phenomena dates (sea ice freeze-up/break-up) for the next season (e.g. JJAS 2024) and model confidence



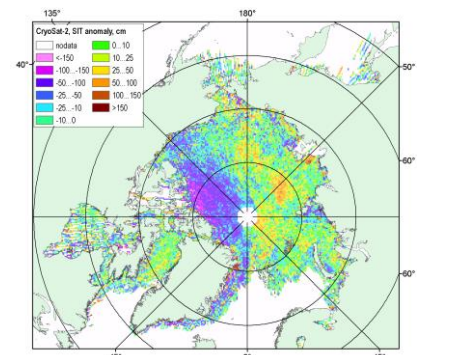
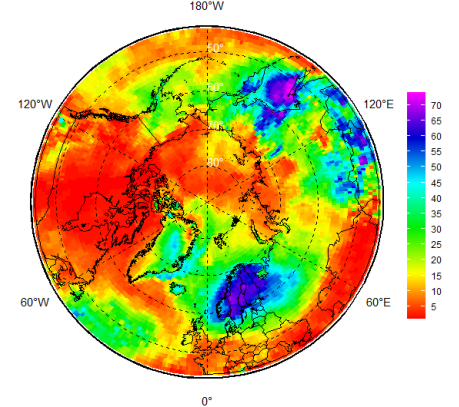
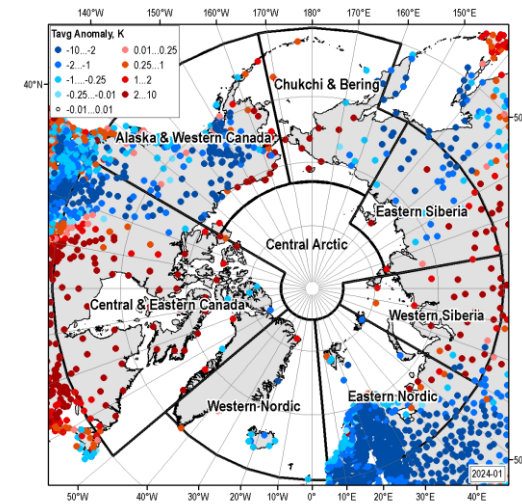
6. ACF Consensus Statement



ArcRCC-N major data sources

Data sources

1. **Regional Climate Overview Briefings** are based on a synthesis of regional NMHS observations, bulletins and relevant data sources (2) – (5)
2. **Seasonal summaries** are based on a synthesis of observations at polar stations, marine platforms, sea-ice analysis, satellite estimates, WMO GCW and modern reanalysis (CCCS ERA5, CMEMS, GloFAS-ERA5) and NCEP-NCAR reanalysis with anomalies given to the new 3rd WMO reference period 1991-2020
3. **Bioclimatic indexes** are based for validation on ERA5 reanalysis and for the forecasts on INM RAS/Hydrometcenter of Russia INM-CM5 climate model
4. **The seasonal outlooks (forecasts)** for temperature and precipitation are based on thirteen WMO Global Producing Centers of Long-Range Forecasts (GPCs-LRF) models consolidated by the WMO Lead Centre for Long Range Forecast Multi-Model Ensemble (LC-LRFMME) - the MME approach is a methodology well-recognized by the WMO to be providing the most reliable objective forecasts
5. **Sea-ice and snow water equivalent outlooks** are based primarily on the Canadian Seasonal to Inter-annual Prediction System (CanSIPsv2.1) with additional use of sea-ice forecasts from the NOAA Coupled Unified Forecast System and INM RAS/Hydrometcenter of Russia INM-CM5 climate model



(1) ArcRCC Regional Climate Overview Briefings

- ❖ Produced by the ArcRCC-N 8 regions by the NMHS within the relevant domain
- ❖ Developed using an established template: (1) map of the region, (2) seasonal summary, (3) observed extreme events, (4) seasonal outlook, and (5) potential social and environmental impacts - all sections with level of details chosen by the NMHS



Eastern Siberia

SEASONAL SUMMARY: WINTER 2023/2024

Observations above (+) and below (-) climatological normal

| | | | |
|--|---|--|--|
| Temperature Normal 1991-2020 | NDJ: +0.91°C FMA: +1.08°C | Coldest years were 1907 (NDJ) and 1989 (FMA) | Warmest years were 1924 (NDJ) and 1920 (FMA) |
| Precipitation Normal 1991-2020 | NDJ: Normal FMA: Normal | Wettest year was 1989 (125.2%) | Driest year as 1967 (78.4%) |
| Sea ice Normal 1991-2020 | Laptev Sea: near normal freeze-up Ice extent rank since 1979 | March maximum sea-ice extent: ice covered | |

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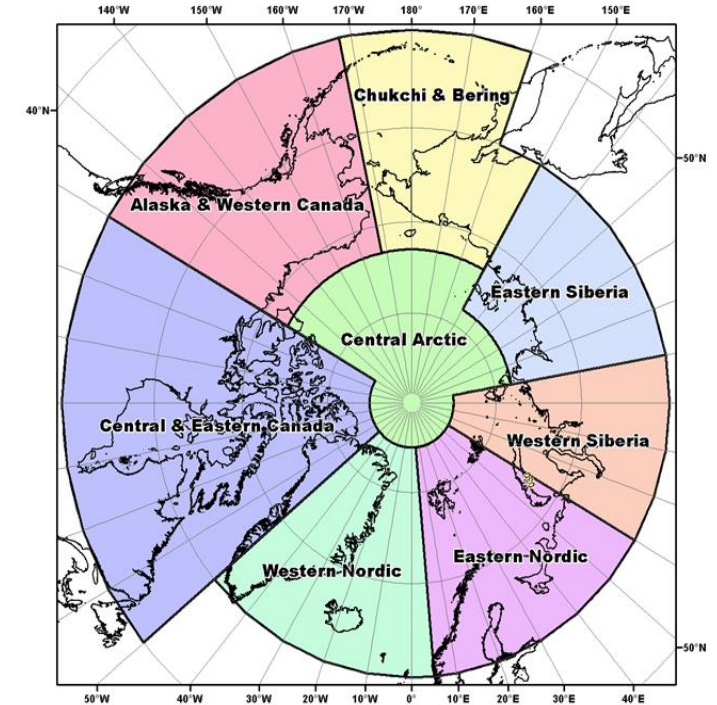
Eastern Siberia

OBSERVED EXTREME CLIMATE EVENTS WINTER 2023/2024

| Category | Location | Rarity | Impacts associated with event |
|-----------|----------------------|--|---|
| Cold wave | NE of Sakha republic | In mid-February for the first time in 30 years | New daily air temperature records (-50 - -52°C) have been set. Schools have been switched to distance learning. Cases of frostbite among the local population and electrical accidents were reported. |

Winter 2024 temperature anomalies (ERA5)

Arctic Climate Forum #13 22-23 May 2024



Eastern Siberia

SEASONAL OUTLOOK: SUMMER 2024

| Climatological variables | Forecast relative to climatological normal | Multi Model Agreement | | | |
|-------------------------------|--|-----------------------|----------|-----|----|
| | | High | Moderate | Low | No |
| Temperature | | | | | |
| Laptev Sea | | | | | |
| Continent | Warmer | | ✓ | ✓ | |
| Precipitation | | | | | |
| Laptev Sea | Uncertainty | | | | ✓ |
| Continent | | | | | ✓ |
| Sea ice | | | | | |
| Break-up | Laptev Sea | Early | ✓ | | |
| Snow Water Equivalent | | | | | |
| Continent | Below | ✓ | | | |
| Northeast coast of Laptev sea | Above | | ✓ | | |

Arctic Climate Forum #13 22-23 May 2024

Eastern Siberia

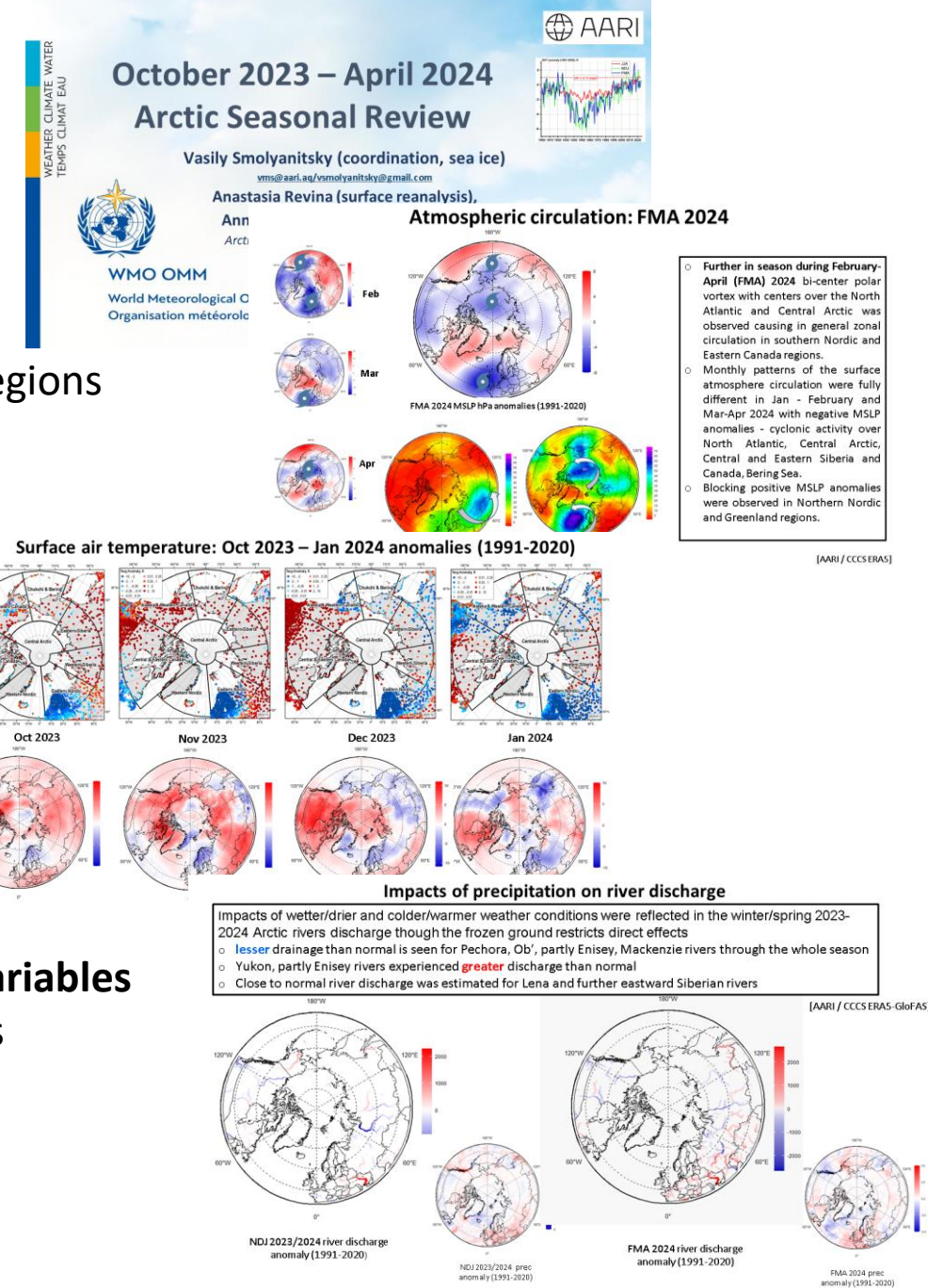
Potential societal and environmental impacts

| Economy sector/Livelihood conditions | Relevant variables from the Seasonal Outlook | Impacts associated |
|--------------------------------------|--|--|
| Forestry | Above norm T2m | An increased risk of wildfires is expected due to above-normal temperatures forecast for northern Eastern Siberia. |
| Health/Wildlife | Above norm T2m | Heat waves |
| Hydrology | Uncertainty in precipitation | Small snow reserves may affect the flood season on of main Arctic rivers (Lena, Yana, Indigirka), if there is uncertainty in precipitation - a small risk can be assumed |

Arctic Climate Forum #13 22-23 May 2024

(2) ArcRCC seasonal summaries

- ❖ Produced by the ArcRCC-N North Eurasia node (AARI)
- ❖ Atmosphere:
 - Precursors in atmospheric circulation
 - Surface air temperature and precipitation– statistics by ArcRCC-N regions
- ❖ Sea ice:
 - Precursors in atmosphere and polar ocean
 - Sea ice extent, conditions, including March'23 maximum
 - Sea ice thickness, and volume
- ❖ Polar Ocean:
 - Heat content
 - pH (acidification/alkalization)
- ❖ Land hydrology:
 - river discharge
 - snow extent
- ❖ Majority of the described parameters are the **WMO Essential Climate Variables (ECV)**. Information is based on reanalysis and surface observations and is provided:
 - for anomalies relative to the latest **3rd WMO period 1991-2020**
 - for ranks to period of observation or reanalysis **1950-2023/2024** or **1979...2024)**



(3) ArcRCC seasonal Climate Conditions and Socio-Ecological Impacts at the (Sub)Seasonal Timescale

- ❖ **Based** on bioclimatic indexes - currently Bodman's weather severity and effective temperature in the Arctic for the past season, verification of the previous forecast and forecast for the next season
- ❖ **Produced** by the ArcRCC-N North Eurasia node – AARI jointly with Hydrometcenter Russia
- ❖ Product has a **growing interest** during the last forums
- ❖ At the moment interpretation is tuned for the areas with **continental climate**, in the future impacts will be developed for other types of climate as well as other indexes will be proposed



**Bioclimatic indexes in the Arctic:
summary for October 2023– April 2024
and weather Comfort Outlook for summer 2024**

Anastasiia Revina
Arctic and Antarctic Research Institute (AARI)
Svetlana Emelina, Maria Tarasevich, Vasilisa Bragina
Hydrometeocentre of Russia

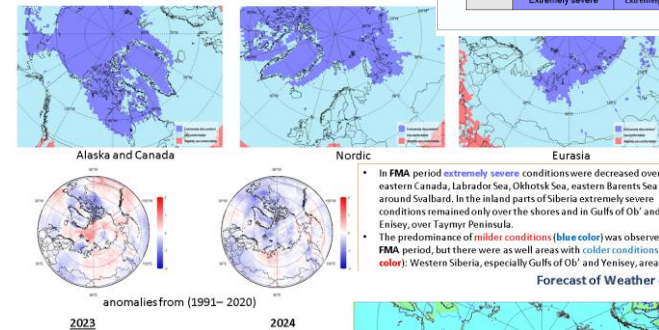
How to evaluate weather comfort on seasonal timescales?

Complex indicator that takes into account several weather factors

| Bodman's weather severity index (S) | | | |
|--|-------------------------|------------------------|--|
| [Rusanov, 1981, Issav, 2003] | | | |
| This index was developed specifically for the Arctic region, for initially difficult climatic conditions. It is widely used in biometeorological practice to assess the possibility of working outdoors. | | | |
| $S = [1 - 0.04 T] [1 + 0.272 V]$ | | | |
| <i>V</i> - wind speed (in m/s) at 10 m above ground level, <i>T</i> - air temperature (in °C) | | | |
| S | Severity of the weather | Working conditions | |
| 5-2 | Slightly less severe | Slightly uncomfortable | |
| 2 < S < 5 | Severe & very severe | Uncomfortable | |
| 5 < S | Extremely severe | Extremely discomfort | |

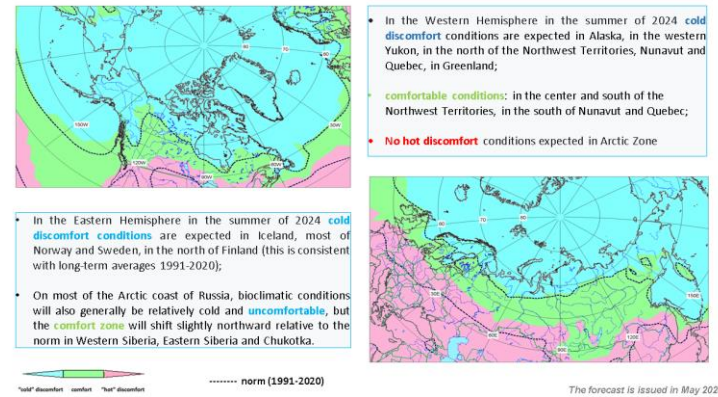
| Effective temperature index | | | |
|--|-------------------|------------------------|----------------------|
| All year | | | |
| $ET = T - 0.4(T - 10)(1 - f/100)$ | | | |
| <i>T</i> - air temperature (in °C), <i>f</i> - relative humidity | | | |
| ET | Thermal sensation | Physiological effort | Weather sensation |
| 16-20 | Very hot | Incompressible heat | Discomfort |
| 14-16 | Hot | Highly uncomfortable | Partial discomfort |
| 12-14 | Warm | Comfortable | Comfort |
| 10-12 | Slightly warm | Neutral | Partial comfort |
| 8-10 | Slightly cool | Slightly uncomfortable | Partial discomfort |
| 6-8 | Cool | Slightly uncomfortable | Partial discomfort |
| 4-6 | Fresh | Uncomfortable | Partial discomfort |
| 2-4 | Very cool | Uncomfortable | Discomfort |
| 0-2 | Extremely cool | Incompressible cold | Extreme discomfort |
| < 0 | Extremely cold | Incompressible cold | Extremely discomfort |

Bodman's index (S) of weather severity FMA (Feb, Mar, Apr)



- In FMA period **extremely severe** conditions were decreased over eastern Canada, Labrador Sea, Okhotsk Sea, eastern Barents Sea and around Svalbard. In the inland parts of Siberia extremely severe conditions remained only over the shores and in Gulfs of Ob' and Enisey, over Taymyr Peninsula.
- The predominance of **milder conditions** (blue color) was observed in FMA period, but there were as well areas with **colder conditions** (red color): Western Siberia, especially Gulfs of Ob' and Yenisey, area to

Forecast of Weather comfort level. Summer-2024



- In the Western Hemisphere in the summer of 2024 **cold discomfort** conditions are expected in Alaska, in the western Yukon, in the north of the Northwest Territories, Nunavut and Quebec, in Greenland;
 - **comfortable conditions**: in the center and south of the Northwest Territories, in the south of Nunavut and Quebec;
 - **No hot discomfort** conditions expected in Arctic Zone
-
- In the Eastern Hemisphere in the summer of 2024 **cold discomfort** conditions are expected in Iceland, most of Norway and Sweden, in the north of Finland (this is consistent with long-term averages 1991-2020);
 - On most of the Arctic coast of Russia, bioclimatic conditions will also generally be relatively cold and **uncomfortable**, but the **comfort zone** will shift slightly northward relative to the norm in Western Siberia, Eastern Siberia and Chukotka.

Legend: hot discomfort, comfort, hot discomfort, norm (1991-2020)

(4) ArcRCC Outlook for atmosphere parameters

- ❖ Includes **scientific background** of the forecast, explanation of **verification technique**, **validation** of the forecast for the previous season (e.g. FMA 2024) and **outlook** of temperature, precipitation, and Snow/Water Equivalent (experimental) for the next season (e.g. JJA 2024) and model confidence
- ❖ Along with CanSIPs v2.1, the WMO LC-LRF-MME products are extensively used

Environment and Climate Change Canada / Environnement et Changement climatique Canada

Canada

ACF - 13: Verification of the FMA 2024 season
ACF - 13: Seasonal forecast for the JJA 2024 season

Marko Markovic
Meteorological Service of Canada
Environment and Climate Change Canada

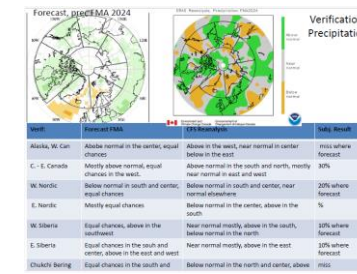
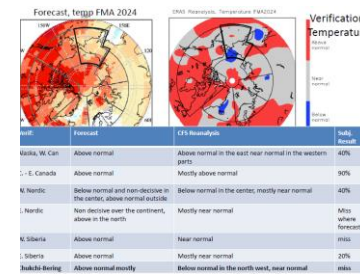
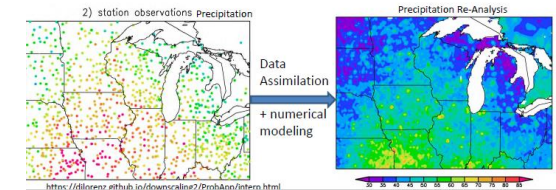
WMO ACF Arctic Climate Forum

How do we verify seasonal forecasts?

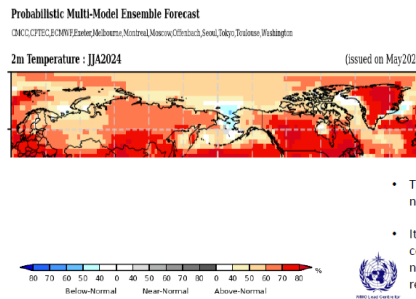
- We need observations!



- Unfortunately we can not measure temperature or precipitation on every single point over the globe.
- This is why we use statistical techniques to interpolate measured variables over the regions where we can measure. The results is called the **re-analysis**.



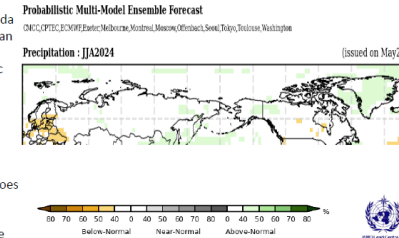
Temperature outlook over the Arctic: Jun-Jul-Aug 2024



1. Alaska W. Canada
2. Eastern Canadian Arctic
3. Western Nordic
4. Eastern Nordic
5. West Siberia
6. East Siberia
7. Chukchi and Bering

- The redder the color does not mean it is warmer.
- It means we have more confidence in the above normal forecast over that region.

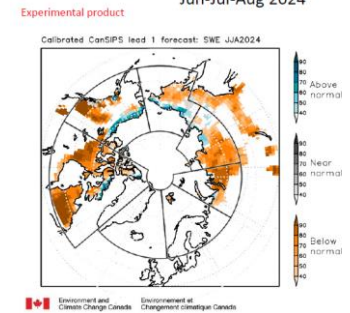
Precipitation outlook over the Arctic: Jun-Jul-Aug 2024



1. Alaska W. Canada
2. Eastern Canadian Arctic
3. Western Nordic
4. Eastern Nordic
5. West Siberia
6. East Siberia
7. Chukchi and Bering

- The greener the color does not mean it will precipitate more.
- It means we have more confidence in the above normal precipitation forecast over that region.

Snow Water Equivalent outlook over the Arctic: Jun-Jul-Aug 2024



1. Alaska W. Canada
2. Eastern Canadian Arctic
3. Western Nordic
4. Eastern Nordic
5. West Siberia
6. East Siberia
7. Chukchi and Bering

(5) ArcRCC Outlook for the regional specific parameters

- ❖ Includes validation of the forecast for the previous season and outlook for the next one for ice extent, concentration and phenomena dates (sea ice freeze-up/break-up) using deterministic and probabilistic approach as well as ice edge at summer/winter extreme
- ❖ Includes interpretation of the forecast for key shipping areas using additional information from the national ice services

13th Arctic Climate Forum May 2024



Winter 2023/24 Sea Ice Outlook Verification

and

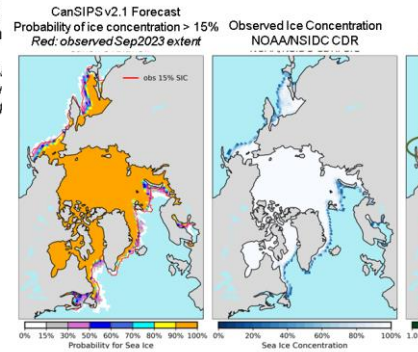
Outlook for Summer 2024

Adrienne Tivy^{1*}, Bill Merryfield¹, Arlan Dirkson¹, Gullie Michael Sigmund¹, Vasilisa Bragina (Vorobyeva)^{2,3}, M Volodin², A. S. Gritsun², Amanda Pryszney¹, Brian

¹- Environment and Climate Change Canada; ²- Marchuk Institute of Oceanography of the Russian Academy of Sciences; ³- Hydrometeorological Research Center of Russia and Atmospheric Administration (NOAA); ⁵- Moscow Institute of Physics and Mechanics



Verification of CanSIPsv2.1 probabilistic forecast for ice concentration exceeding 15% Forecast from Oct 1, 2023



Sources: Environment and Climate Change Canada

ArcRCC Winter 2024 Outlook March Sea Ice Extent Actual vs Outlook



Forecast Categories (2015-2023 normal):

- Above normal ice extent
- Near normal ice extent
- Below normal ice extent

Outlook Confidence Categories:

- low
- moderate
- high

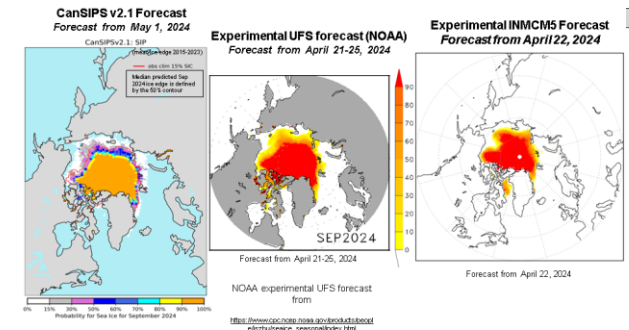
| Regions | CanSIPsv2.1 Extent Forecast Confidence | CanSIPsv2.1 Extent Forecast (2014-2022 average) | Observed Ice Extent NOAA/NSIDC CDR ¹ (2014-2022 average) | Sea Ice Forecast Accuracy |
|---------------------------|--|---|---|---------------------------|
| Barents Sea | High | Near normal | Above normal | Miss |
| Bering Sea | Moderate | Below normal | Above normal | Miss |
| Greenland Sea | High | Near normal | Above normal | Miss |
| North Baltic Sea | Moderate | Above normal | Above normal | Hit |
| Baffin Bay / Labrador Sea | High | Below normal | Below normal | Hit |
| Gulf of St. Lawrence | High | Below normal | Below normal | Hit |
| Sea of Okhotsk | Moderate | Near normal | Above normal | Miss |
| Barents Sea | High | Near normal | Above normal | Miss |

¹Regional Sea Ice | National Centers for Environmental Information (NCEI) (noaa.gov)

Verification: ArcRCC Sea-Ice Freeze-up Outlook for 2023/24

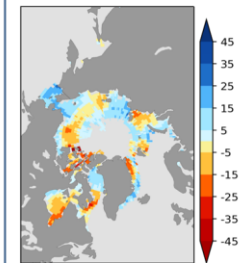
| Regions | CanSIPS Sea-Ice Forecast Confidence | CanSIPS Sea-Ice Forecast | Observed Freeze-up | CanSIPS Sea-Ice Forecast Accuracy |
|-------------------|-------------------------------------|-----------------------------|--------------------|-----------------------------------|
| Hudson Bay | Moderate | Near normal to late | Late | Hit (where there's skill) |
| Baffin Bay | Moderate | Near normal to late (south) | Late | Hit (where there's skill) |
| Labrador Sea | High | Late | Late | Hit |
| Greenland Sea (S) | High | Early | Early | Hit |
| Barents Sea | High | Early | Early | Hit |

Model Guidance for September Ice Extent: Probability of monthly mean September 2024 sea ice concentrations exceeding 15%



ArcRCC Summer 2024 Outlook Sea Ice Break-up

Deterministic break-up forecast from CanSIPsv2.1: break-up date anomaly from 2015-2023 average.



What is Normal break-up?

- the date when the ice concentration drops below 50%
- based on past 9-year reference period (2015-2023)

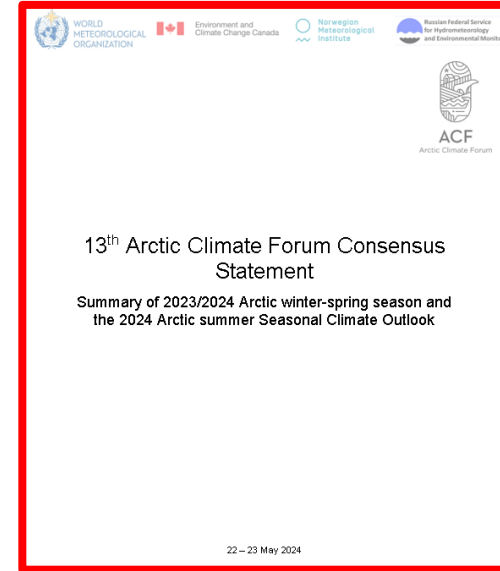
Break-up Categories:

- Red = Late break-up
- Yellow-light Blue = Near normal break-up
- Blue = Early break-up

| Regions | CanSIPsv2.1 Sea-Ice Forecast Confidence | CanSIPsv2.1 Sea Ice Break-up Forecast |
|-------------------|---|---------------------------------------|
| Barents Sea | High | Early (West), Late (East) |
| Greenland Sea | Low | Late-normal (South), Early (North) |
| Baffin Bay | High | Early (South), Late (North) |
| Hudson Bay | High | Early (East), Late (West) |
| CAA | Low | Early |
| Beaufort Sea | Moderate | Early, Late (Southeast) |
| Chukchi Sea | Moderate | Late, Early (North) |
| East Siberian Sea | Low | Late (South), Early (North) |
| Bering | High | Late |
| Laptev Sea | No skill | N/A |
| Kara Sea | Moderate | Late (east), Early (west) |
| Barents Sea | High | Early (West), Late (East) |

(6) ArcRCC Consensus Statement – major synthetic product

- ❖ Major synthetic document based and incorporating information from all previous products
- ❖ It is a joint effort by all NMHs of the ArcRCC
- ❖ Consensus statement document draft is circulated among the team
- ❖ Final version published after the Arctic Climate Forum
- ❖ Contains 13 sections:
 - ✓ Introduction to the Arctic Climate Forum CS
 - ✓ Highlights for decision making
 - ✓ Understanding the Consensus Statement
 - ✓ Temperature (summary, verification, outlook)
 - ✓ Precipitation, hydrology (summary, verification, outlook)
 - ✓ Polar Ocean (summary for Heat Content and pH)
 - ✓ Sea-ice (summary, verification, outlook)
 - ✓ Snow Water Equivalent (outlook)
 - ✓ Bioclimatic indexes (summary, verification, outlook)
 - ✓ Observed extreme events
 - ✓ Possible impacts for next season
 - ✓ Data sources and useful links
 - ✓ Background and Contributing institutions



Introduction to the Arctic Climate Forum Consensus Statement

Arctic temperatures continue to rise at rates greater than the global average. Both the annual and all season's air temperatures since early 2000s in the Arctic (northward of 50°N within the ArcRCC-N domain) have been close to the highest in the time series of observations for 1900-2024 period (figure 1) though significant interannual variations occur for all Arctic Essential Climate Variables (ECV), including the surface atmosphere, sea-ice and polar ocean ECVs. 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).

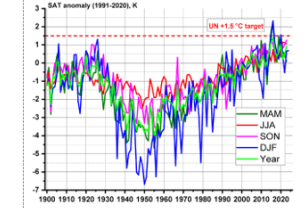


Figure 1: Annual, spring (MAM), summer (JJA), autumn (SON) and winter (DJF) average surface air temperature anomalies (K) for 1900-2020 for 1900-2020/2024 period. Graphics produced by the AARI. Data source: WMO stations within the ArcRCC-N domain (see Fig.2).

Highlights for decision making

Temperature: For the whole land Arctic extremely warmer conditions were observed in November 2023 and February – April 2024 with colder in January 2024 with preliminary ranks 2nd (for 1950-2023/2024 period) and 5-6th in row.

Precipitation: The least amount of precipitation was for the Western Nordic, parts of WCanada & Alaska regions which is close to winter 2022/2023. More abundant precipitation was observed in the Eastern Nordic, parts of Alaska and Bering and Chukchi regions.

Sea-ice: Maximum Arctic (Northern Hemisphere) winter ice extent occurred 12-14 March 2024, which is close in time to climatic date, with a value of ~15.3 10^6 km² or 15-16th in row since 1979. Prominent area of residual ice in late summer led to decadal normal.

Ongoing Impacts of Climate Change: Increase risk of coastal flooding and thawing permafrost lead to coastal erosion and losses of community infrastructure. All marine mammals with habitat on sea ice may be more difficult to harvest. Increasing interannual and intraseasonal variability lowers predictability of weather extremes.

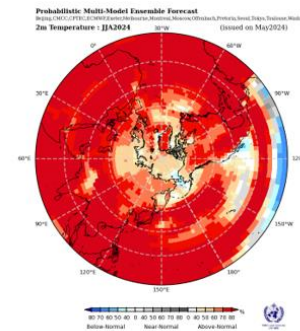


Figure 6: Multi model ensemble probability forecast for temperature for June, July, August 2024. Red indicates warmer conditions, blue colder conditions and white, no agreement amongst the models. Source: www.wmo.int.

| Arctic Region | MME Temperature Forecast Agreement | MME Temperature Forecast |
|----------------------------|--|---|
| Alaska and Western Canada | Low (eastern part), moderate to high (western part) | Above normal with exception of western part adjacent to Bering Strait and Chukchi Sea |
| Central and Eastern Canada | High (continental part), low (some marine parts) | Above normal for most of area, normal or below normal in parts of Hudson Bay and Labrador Sea |
| Western Nordic | High (Greenland, Icelandic waters, eastern part), low (parts of Greenland Sea) | Above normal (Greenland, Icelandic waters), below normal (parts of Greenland Sea) |

Observed extreme events

| Category | Location | Rarity | Impacts associated with event |
|--|------------------|---|---|
| Alaska and Western Canada | | | |
| Precipitation and temperature (winter) | Alaska | 2 nd snowiest January on record at the Juneau Intl Airport followed by melt. Nov-Dec: extreme snow fall Anchorage area (Highest Nov-Dec amount on record). | Record snow fall in a two-week period in Juneau followed by a rapid warm-up and rainfall caused local flooding issues. Weeks-long travel hazard in the Anchorage area from heavy snow fall and numerous structure collapses due to heavy snow load. |
| Temperature (spring) | Alaska | April: Extreme cold during the first week of April. | Delayed snow melt-off. Concern regarding the late-month breakup did not materialize. |
| Precipitation (winter) | Yukon | Unusually thin ice on the Yukon River at Dawson City. | The government-sponsored ice bridge across the Yukon River at Dawson City was not built this year due to warm temperatures and thin ice. |
| Precipitation (spring) | Alaska | March-April: Very heavy snow along most of the Alaska west coast. High season SWE. | Travel impacts. Subsistence impacts. |
| Flooding | Alaska and Yukon | April-May: early river breakup at most locations. Flooding significant in a few areas. Not to be confused with... | Road damage and severe erosion along the lower Kuskokwim River. |



ACF

Arctic Climate Forum

Thank you for attention!

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