Second Session of the Pan-Arctic Regional Climate Outlook Forum (PARCOF-2), virtual forum, October 2018

Consensus Statement for the Arctic Winter 2018-2019 Season Outlook

Climate change in the Arctic is affecting the entire Earth system. Indigenous Peoples and communities, Northerners, industry and wildlife are experiencing significant and direct impacts. For example, temperature increases have led to significant reductions of sea ice, thawing permafrost and coastal erosion. To meet Arctic adaptation and decision-making needs, substantial progress has been made towards the establishment of an Arctic Regional Climate Centre Network (ArcRCC-Network). The ArcRCC-Network is based on the World Meteorological Organization (WMO) RCC concept with active contributions from all the Arctic Council member countries. The Pan-Arctic Regional Climate Outlook Forum (PARCOF) is a flagship activity of the ArcRCC-Network, following the well-known Regional Climate Outlook Forum (RCOF) concept supported by WMO and its partners around the world.

The virtual PARCOF-2 meeting was held online on October 30, 2018, with representatives and scientists from most of the Arctic Council Member States. Representatives from Arctic Indigenous groups, Permanent Participants of the Arctic Council and shipping companies, who attended the first PARCOF in Ottawa, May 2018, also participated. This consensus statement includes a seasonal summary and forecast verification of the 2018 summer season, and outlook for the first half of the 2018/2019 winter season. The statement was adopted by the participants at the end of the PARCOF-2 meeting.

Summary

The temperature and precipitation outlooks cover the period November 2018 to January 2019 and to March 2019 for sea-ice. Overall the Winter 2018-19 outlook shows a significantly warmer climate than normal with implications for precipitation and sea ice.

Temperature: The June to August 2018 average surface air temperature anomalies were above average for most of the Arctic domain, with the exception of parts of the Canadian Arctic and central Greenland, which experienced colder than normal temperatures. Above normal temperatures are expected over the Arctic in winter 2018/19.

Precipitation: Precipitation between June and August 2018 was slightly below average over the Arctic region. For November 2018 to January 2019 we expect above normal

precipitation over the Arctic, with an exception of Scandinavia, eastern Russia, Alaska and eastern Canadian Archipelago.

Sea ice: The summer 2018 minimum sea ice extent was the 6th lowest on record, tied with 2008, since 1979. There were large regional differences observed in sea ice conditions between the Canadian and Eurasian Arctic during summer 2018. Above normal ice extent in the eastern Beaufort Sea and throughout the North West Passage had a major impact on the 2018 shipping season resulting in the North West Passage remaining blocked for ice free navigation. We expect earlier than normal Fall freeze-up in Hudson Bay, Baffin Bay and the Beaufort Sea, and later than normal freeze-up across most of the eastern Arctic from the Barents to Chukchi Seas. For the 2019 March ice extent, we expect below normal ice extent in the Bering Sea and below to near normal ice extent in the Barents Sea and Sea of Okhotsk.

Temperature

Summary of Summer 2018: The June, July, and August (JJA) 2018 average surface air temperature in the Arctic domain north of 65°N ranged between the highest (eastern Siberia) to the 17th highest (Canadian Arctic) warmest summer in 69 years, since the start of the record in 1949. The JJA 925 mb air temperature anomalies (Figure 1) show average or above average temperatures for most of the Arctic domain, with the exception of parts of the Canadian Arctic and central Greenland, where temperatures were below normal.

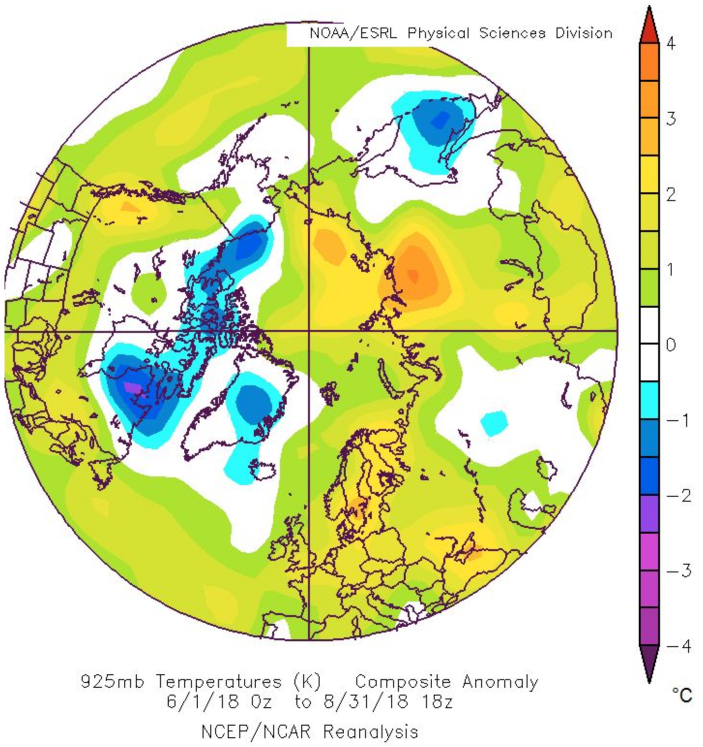

Figure 1: June, July, August 2018 925 mb temperature anomaly based on the 1981-2010 reference period from NCEP/NCAR Reanalysis. The 925 mb temperature anomaly is representative of surface conditions

Data from NCEP/NCAR reanalysis was also used to rank the 2-m surface temperatures since 1949. Between May and September 2018, most of Scandinavia, northern Siberia, the Arctic Ocean, the Chukchi and Beaufort Seas, as well as the North Pole, experienced their warmest year since 1949, while parts of the eastern Canadian Arctic and southern Greenland experienced their coldest temperatures since 1949.

Forecast verification for Summer 2018: To verify the seasonal forecast for temperature (Figure 2), statistical techniques are used to fill gaps when meteorological station information was not available. The interpolated result is adapted by a meteorological model in order to produce a re-analysis (Figure 3). The verification is done by subjective comparison between the forecast and re-analysis region by region. A subjective percentage score is adapted where 100% is a successful forecast for the region, and 0% is a miss.

When comparing the results between Figure 2 and 3 we see good agreement in the western Chukchi sea region, but a poor agreement is seen in the interior of Alaska. The forecast over the Canadian Arctic and Greenland did not capture the below normal temperatures experienced this summer. Very good forecast results were recorded for the North Atlantic, European Arctic and Central Russia, all having above normal temperatures in the June, July and August 2018 season. Eastern Russia also had correct forecast values over its easternmost regions while the rest of the region experienced near normal temperatures.

As a general conclusion, approximately 50% of the Arctic territory had a correct forecast, far better than a pure chance which would be a 33% (due to the three categories we are trying to forecast).

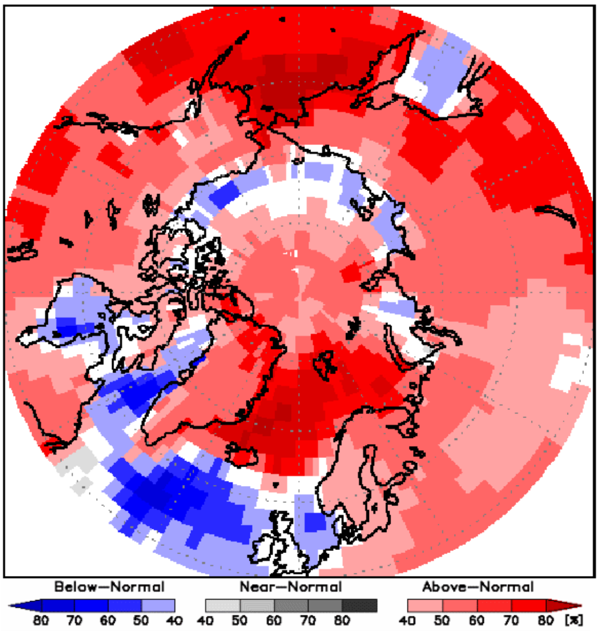

Figure 2: Surface Air Temperature Outlook for June, July and August 2018. Multi-model ensemble (MME) probability forecast of three categories (below normal, near normal, above normal) (www.wmolc.org)

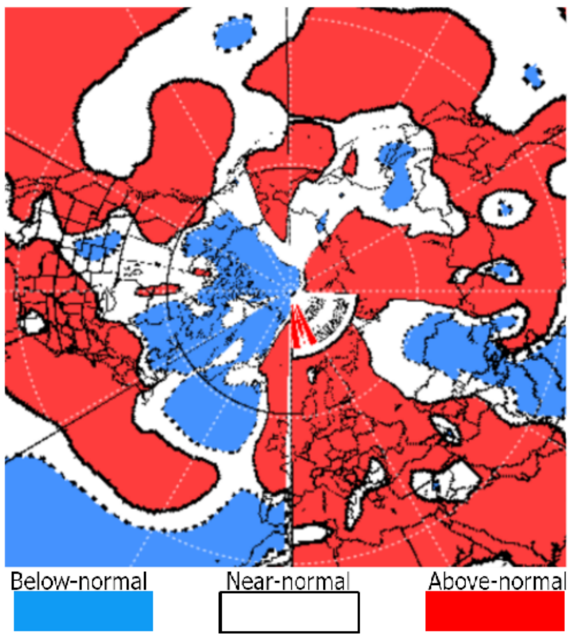

Figure 3: NCAR (National Center for Atmospheric Research) Climate Forecast System Reanalysis (CFSR) for Air Temperature, June, July and August 2018

Outlook for Winter 2018-2019: The November, December and January (NDJ) 2018-2019 period show there is probability of 50% or more that temperatures will be above normal in the Alaskan region (red areas in Figure 4). Over most of the continental Canadian Arctic, this probability is somewhat smaller, around 40% for above normal temperature.

White areas in Figure 4 represent regions where the forecast was inconclusive, shown over Greenland with an exception of the northern region where there is at least 40% chance for above normal temperatures. Over the Scandinavian region and over Iceland there is at least a 40% chance for above normal temperatures. Somewhat higher probabilities (around 60%) are expected over northern Norway and Finland. Over the entire Russian Arctic, above normal temperatures are expected for NDJ 2018-2019. Highest probabilities for this outcome are of at least 70% chance over the central and western Russian Arctic. Over the eastern Russia, there is at least a 50% chance for above normal temperatures.

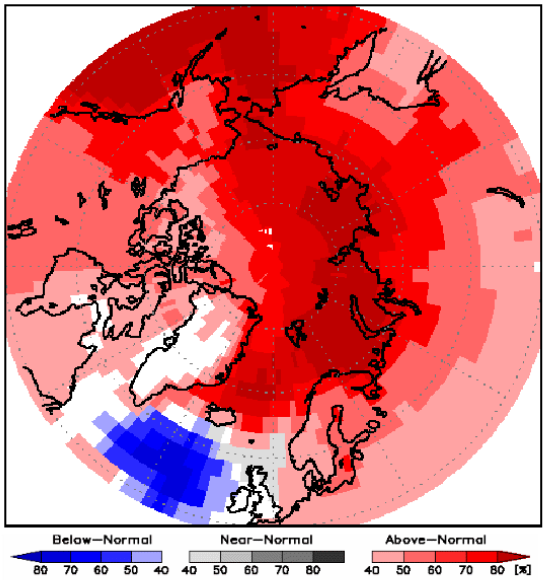

Figure 4: MME probability forecast for surface temperature for NDJ 2018/2019

Precipitation

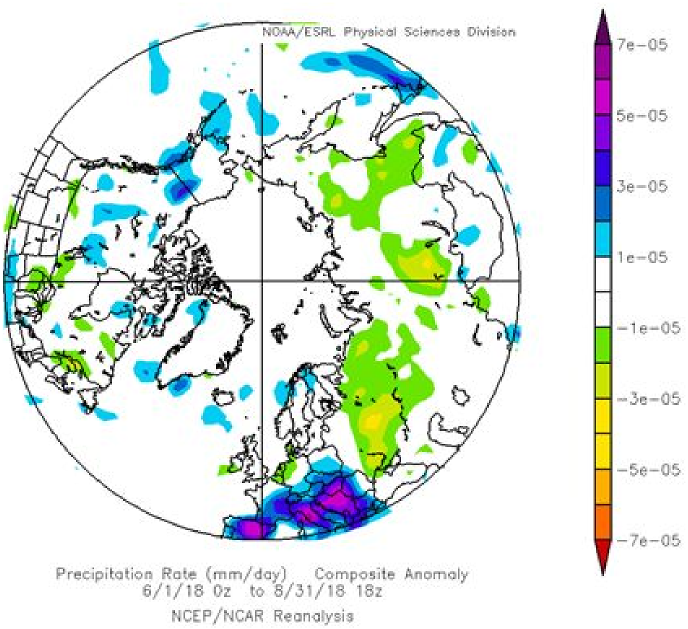

Figure 5: June, July, August 2018 precipitation anomaly based on the 1981-2010 reference period from NCEP/NCAR Reanalysis

Summary of Summer 2018: For the JJA 2018 time period, lower than average precipitation was observed over Siberia (yellow and green areas, Figure 5), while close to normal and slightly above average values were observed in the Atlantic, Northern European and Canadian Arctic regions (green areas). Taken as a whole however, the Arctic region experienced lower than average precipitation for that same time period. Data from NCEP/NCAR reanalysis was also used to rank precipitation since 1949. The Chukchi Sea region and northwestern Siberia saw their driest summer in the 69 year record.

Forecast verification for Summer 2018:

Over the southern region of Alaska, the forecast was in agreement with the reanalysis both showing above normal precipitation values (Figures 6 and 7). Northern Alaskan regions were however missed by the forecast. Over Greenland, the North Atlantic and Central Russia, the forecast was inconclusive (regions given in white colour) and therefore, we can not evaluate the forecast over this region. The forecast for above normal precipitation in Eastern Russia was not in agreement with the reanalysis, showing below normal precipitation values. Only small regions in the southeastern Russia had above normal precipitation values, in agreement with the reanalysis.

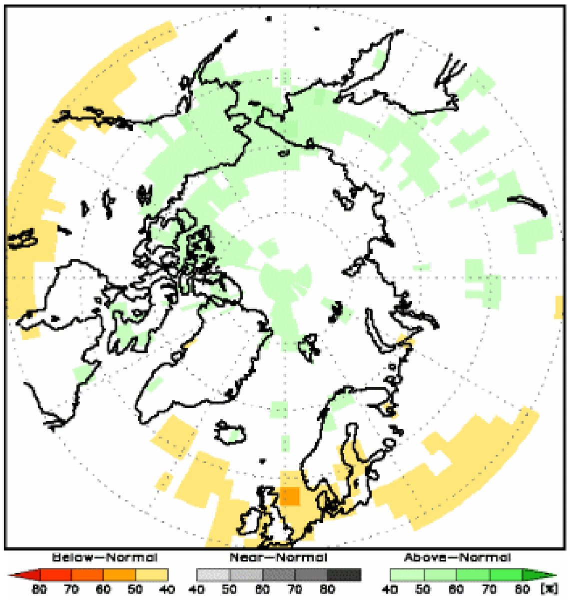

Figure 6: MME probability forecast for precipitation for JJA 2018

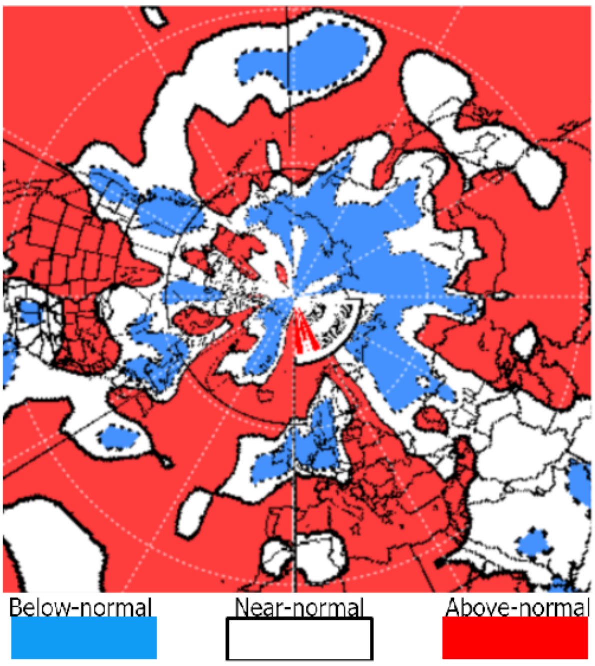

Figure 7: NCAR Climate Forecast System Reanalysis (CFSR) for Precipitation, JJA 2018

In general, precipitation forecast showed mostly to be inconclusive over the Arctic. In regions where the models predicted above or below normal precipitation chances, we had a very good forecast. As with temperature forecasts, approximately 50% of the territory had a good percent correct score for precipitation in the JJA18 season.

Outlook for Winter 2018-2019: The green areas show the probability of above normal precipitation. There is a probability of 40% or more for above normal precipitation over the entire Canadian and Russian Arctic with some exceptions over the eastern Russia, Baffin Island and Hudson Bay, where the model was inconclusive (Figure 8). Over Scandinavia, Iceland, Greenland and over most of the Alaskan region the model was again inconclusive. In the northern Atlantic region, there is at least 40% chance for below normal precipitation (orange areas), likely linked to high probabilities for below normal temperatures over this region.

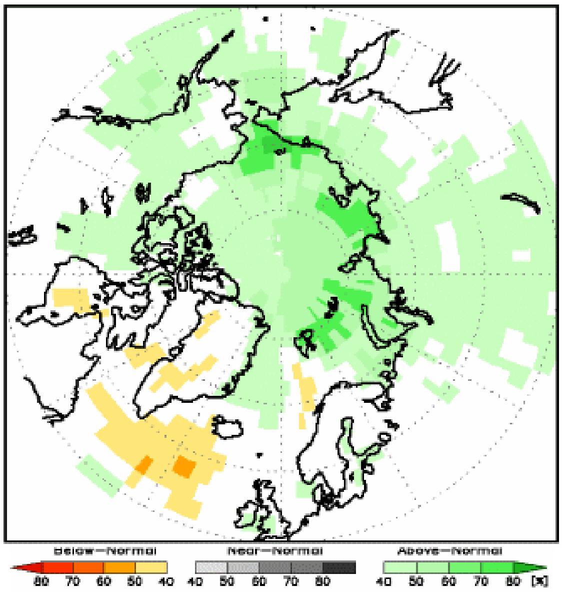

Figure 8: MME probability forecast for precipitation for NDJ 2018/2019

Sea Ice

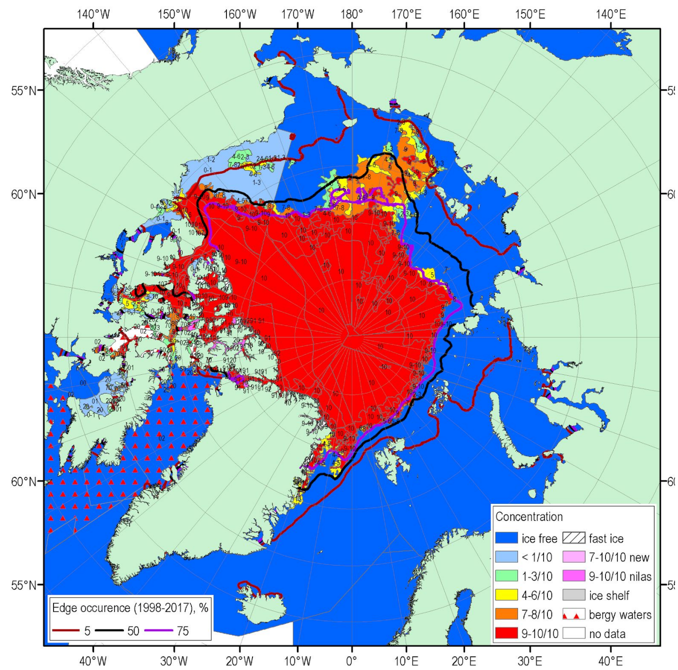

Figure 9: Blended Arctic ice chart (AARI, CIS, NIC) for 17-20 September 2018 and ice edge occurrences for 16-20 September for 1998–2017

Summary for Summer 2018 : The summer 2018 minimum sea-ice extent was reached on September 16, 2018, making 2018 the 6th minimum sea-ice extent in the 39 year record which started in 1979 (Figure 9). Estimates of the sea ice volume, based on numerical reanalysis (HYCOM-CICE, PIOMAS), show a similar 6th minimum sea-ice extent in row since 1979 and higher ice thicknesses in comparison to 2017. A precursor for higher sea ice thicknesses in the Central Arctic could be due to the higher precipitation amounts observed prior to the sea-ice melt season (April).

High spatial variability in sea ice conditions between the Canadian and Eurasian Arctic was observed during the entire 2018 summer period. Sea ice extent for the Canadian Arctic was higher than the last decade's median extent, with the Northwest Passage remaining blocked for ice free navigation. Simultaneously, parts of the Eurasian Arctic (southeastern Barents, Kara, and Eastern Siberian Seas) showed close to the 1998-2017 median ice coverage until the middle of July, with further extreme low sea ice extent in the most parts of this region until the end of September. Until the end of October 2018, persistent strong westerly winds (North Atlantic Oscillation index - NAO>0) continued to generate a positive surface air temperature anomaly over the Eastern and Central Arctic (with the exception of theCanadian archipelago and the Hudson Bay regions), slowing the sea ice formation process in those areas.

Forecast verification for Summer 2018: The outlook for the 2018 Spring break-up and regional September sea ice extent verified reasonably well. A later than normal break-up in the Baffin Bay and Hudson Bay regions were predicted correctly. Below normal ice extent in the Chukchi and Greenland Seas, as well as below to near normal ice extent in the Kara and Barents seas were predicted correctly. Below normal ice extent observed in the Laptev Sea was not predicted as well as the observed above normal ice extent in the Canadian Arctic Archipelago. Locally, above normal ice extent the eastern Beaufort Sea and throughout the North West Passage was not predicted and had a major impact on shipping during the 2018 season.

Outlook for Winter 2018-2019: This outlook concerns the timing of freeze-up at fall, and the maximum sea ice extent in March. The classification for specified regions is defined as earlier than/below normal, near normal and later than/above normal. These categories are defined in relation to average conditions during the preceding nine years 2009-2017. Figures 10 and 11 show the model predictions for Fall freeze-up as both the actual date (Figure 10a) and as an anomaly (Figure 10b). The March ice extent (Figure 11, green line) is shown along with the 2009-2017 average March ice extent (Figure 11, yellow line). There are also three uncertainty categories; 'low confidence', 'moderate confidence' and 'high confidence'. This is derived from the model skill in each region (not shown).

Fall Freeze-up

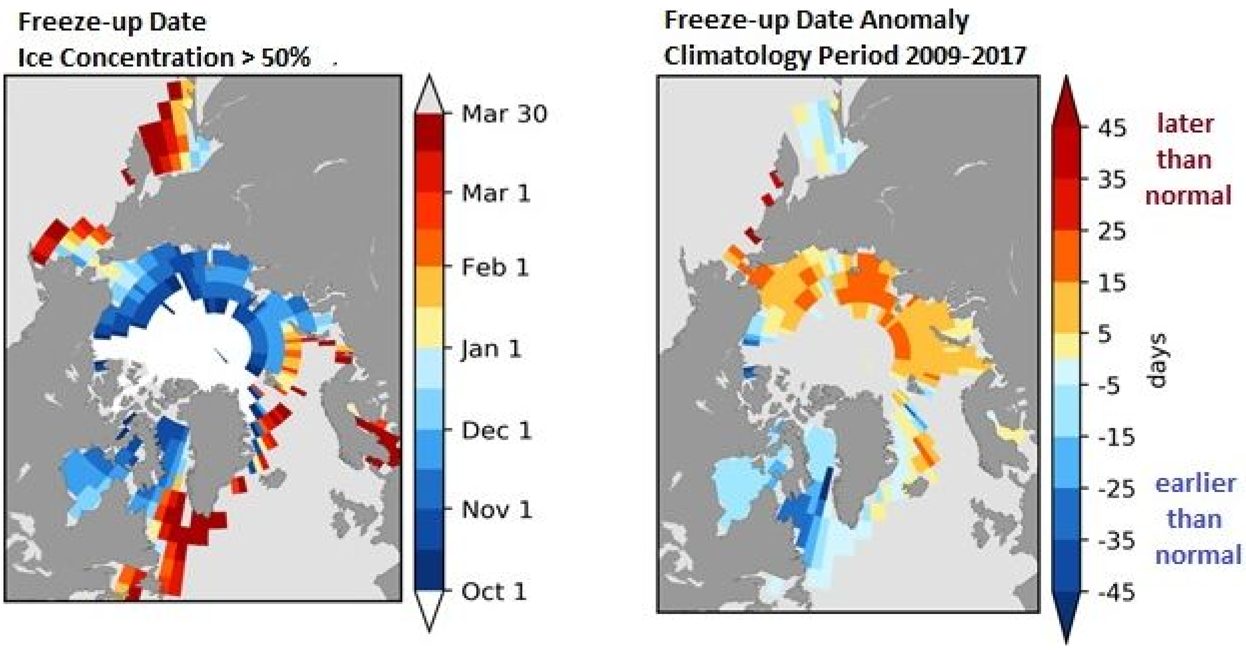

Figure 10: Forecast for the 2018 Fall freeze-up (a) actual freeze-up date and (b) anomaly (difference from normal) based on the 2009-2017 period. The freeze-up date is first day when the ice concentration exceeds 50%

Region	Fall freeze-up	Confidence
Hudson Bay/Baffin Bay/Labrador Sea	**earlier than normal**	[moderate to high confidence]
Gulf of St. Lawrence	**near normal**	[low confidence]
Greenland Sea	**near normal**	[moderate confidence]
Barents Sea	**later than normal**	[moderate confidence]
Kara/Laptev/East Siberian Seas	**later than normal**	[moderate to high confidence]
Chukchi Sea	**later than normal**	[high confidence]
Beaufort Sea	**earlier than normal**	[high confidence]
Sea of Okhotsk	**near normal**	[low confidence]
Bering Sea	**later than normal**	[low confidence]

Table 1: 2018 Outlook for fall freeze up by region

March 2019 Sea Ice Extent:

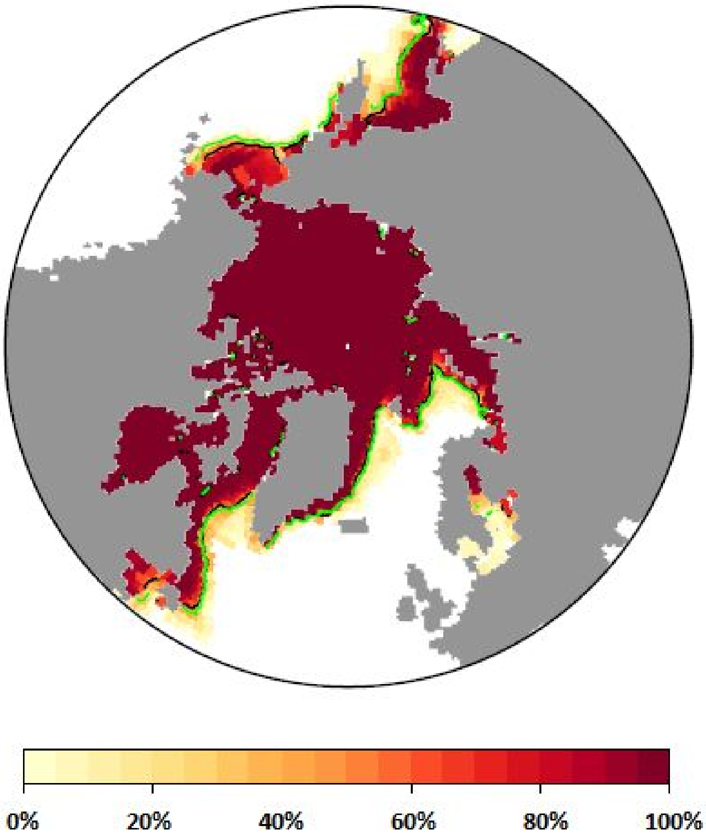

Figure 11: March 2019 probability of sea ice at concentrations greater than 15% from CanSIPS (ECCC). Ensemble mean ice extent from CanSIPS (black) and observed mean ice extent 1998-2017 (green)

Region	Sea-ice extent	Confidence
Greenland Sea	**near normal**	[low confidence]
Gulf of St. Lawrence	**below normal**	[low confidence]
Bering Sea	**below normal**	[moderate confidence]
Barents Sea	**below to near normal**	[moderate confidence]
Sea of Okhotsk	**below to near normal**	[moderate confidence]
Labrador Sea	**below to near normal**	[low confidence]

Table 2: Outlook for winter 2018-2019 Sea ice extent by region

Background and Contributors

This Arctic seasonal climate outlook was prepared for the second session of the Pan-Arctic Regional Climate Outlook Forum (PARCOF-2). Contents and graphics were prepared in partnership with the Russian, United States, Canadian, Norwegian, Danish, Finnish, Swedish, and Icelandic meteorological agencies and contributions of the Expert Team on

Sea Ice, an expert team of the Joint WMO/IOC Technical Commission on Oceanography and Marine Meteorology, the Global Cryosphere Watch and the International Ice Charting Working Group.

The temperature and precipitation forecasts are based on a multi-model ensemble (MME) approach using computer-generated climate predictions from a number of WMO designated GPC-LRFs. The multi-model ensemble approach is a methodology reputed as providing the most reliable objective forecasts on average. The sea ice outlook presented here is based on model forecasts from a modified experimental version of the Canadian Seasonal to Inter-annual Prediction System (CanSIPS). A multi-model ensemble for sea ice from the GPC-LRFs centres that will form the basis for future ArcRCC Outlooks and Consensus Statements is under development. The factors that contribute to predictability at the seasonal time scale in the Arctic are: the ocean (e.g. sea ice and temperature anomalies), the atmospheric internal modes of variability (e.g.: Arctic Oscillation in winter), and interaction between the ocean and the atmosphere.

The ArcRCC is in demonstration phase to seek designation as a WMO RCC-Network, and products are in development and are experimental. For more information, please visit www.arctic-rcc.org.

Acronyms:
AARI: Arctic and Antarctic Research Institute
ArcRCC: Arctic Regional Climate Centre
CAA: Canadian Arctic Archipelago
CanSIPS: Canadian Seasonal to Interannual Prediction System
CIS: Canadian Ice Service
ECCC: Environment and Climate Change Canada
GCW: Global Cryosphere Watch
GPC-LRF: Global Producing Centres Long-Range Forecasts
IICWG: International Ice Charting Working Group
IOC: Intergovernmental Oceanographic Commission
NIC: National Ice Center (United States)
NCEP/NCAR: National Centers for Environmental Prediction/National Center for Atmospheric Research
MME: Multi-model ensemble
NSR: Northern Sea Route
NWP: Northwest Passage
PARCOF: Pan-Arctic Regional Climate Outlook Forum
RCC: Regional Climate Centre
RCOF: Regional Climate Outlook Forum
WMO: World Meteorological Organization