# November 2018 – April 2019 Arctic Seasonal Review

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# Content of review

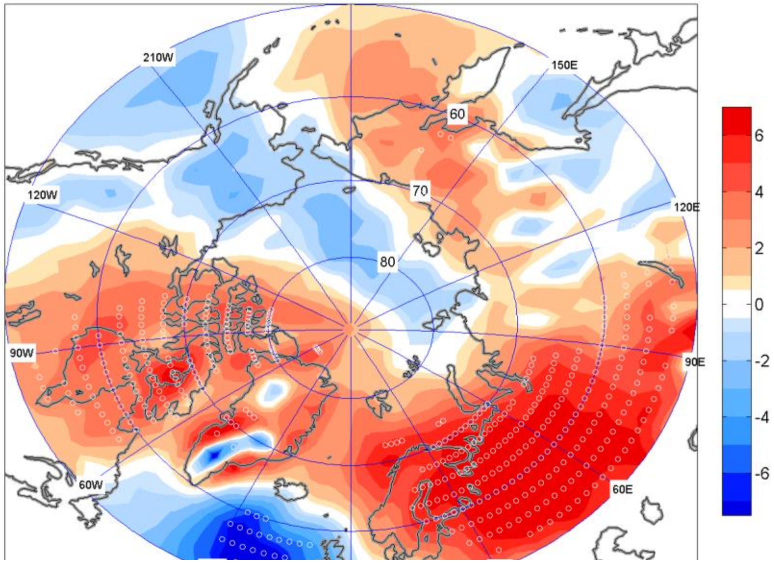
- Review for 2 periods: November, December, January 2018/2019 (NDJ) and February, March, April 2019 (FMA)
- Atmosphere variables include:
  - Atmospheric circulation (mean sea level pressure) and geopotencial height)
  - Surface air temperature
  - Precipitation
- Sea ice variables include:
  - Ice extent analysis
  - Ice conditions analysis
  - Ice thickness observations at coastal stations
  - Sea ice thickness and volume reanalysis
- Solid precipitation (snow)
- Current status
- Background slides: highlights and ranks

Atmosphere variables:

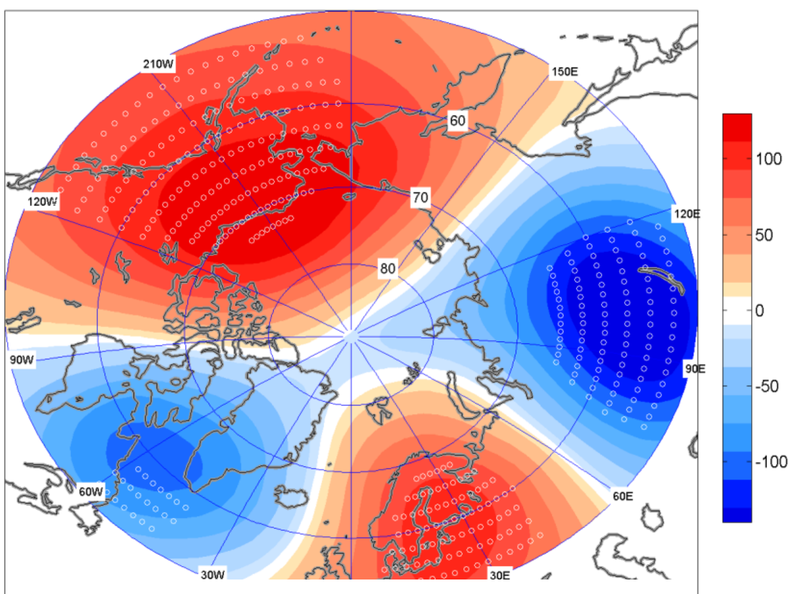
- ✓ Atmospheric circulation
- ✓ Surface air temperature
- ✓ Precipitation

Source:
[AARI, HMC Moscow, NOAA NCEP-NCAR, DMI]

# NDJ 2018/2019 atmospheric circulation




MSLP hPa anomalies (norms 1981-2010)

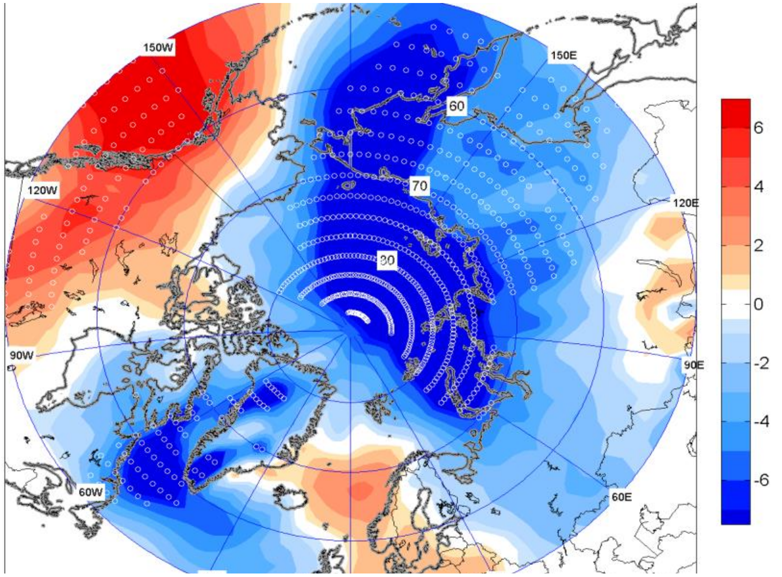



H50 anomalies (norms 1981-2010)

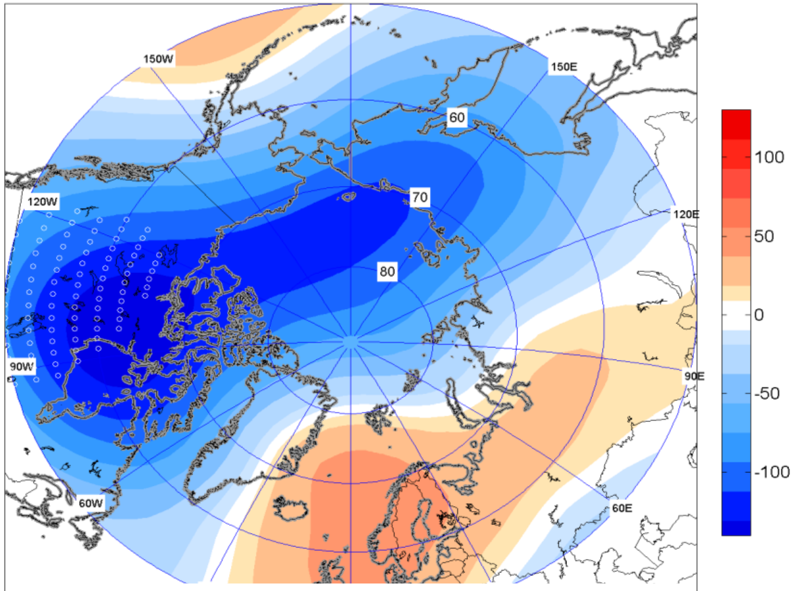
- **Based on atmosphere numerical model analysis)**
- **Positive mean sea level atmospheric pressure (MSLP) anomalies (higher pressure, marked in red) dominated over European and west Siberian region**
- **Opposite situation (lower pressure, marked in blue) observed for Atlantic and Alaska regions.**
- **That led to prevalence of meridian form of circulation (transfer of heal/cold northward along meridian) in the troposphere and bi-central polar vortex, clearly seen on the 50 hPa geopotencial height (H50)**

**[HMC Moscow]**

# FMA 2019 atmospheric circulation




MSLP hPa anomalies (norms 1981-2010)

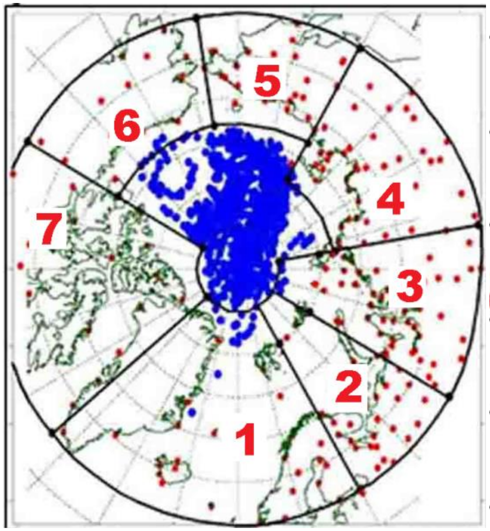



H50 anomalies (norms 1981-2010)

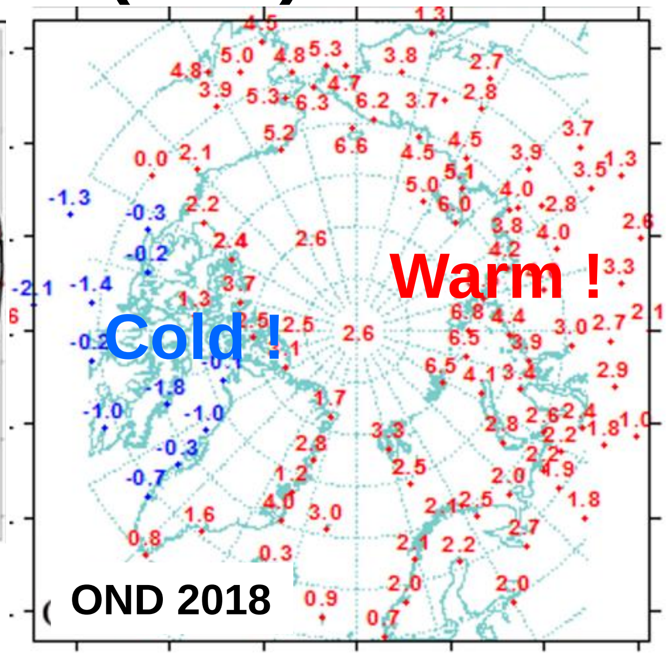
- **Very significant negative MSLP anomalies (lower pressure, marked in blue) observed in the northern Eurasia and Greenland**
- **That led to increased cyclonic activity with further increased precipitation.**
- **Single center polar vortex observed again as observed at H50 pattern**

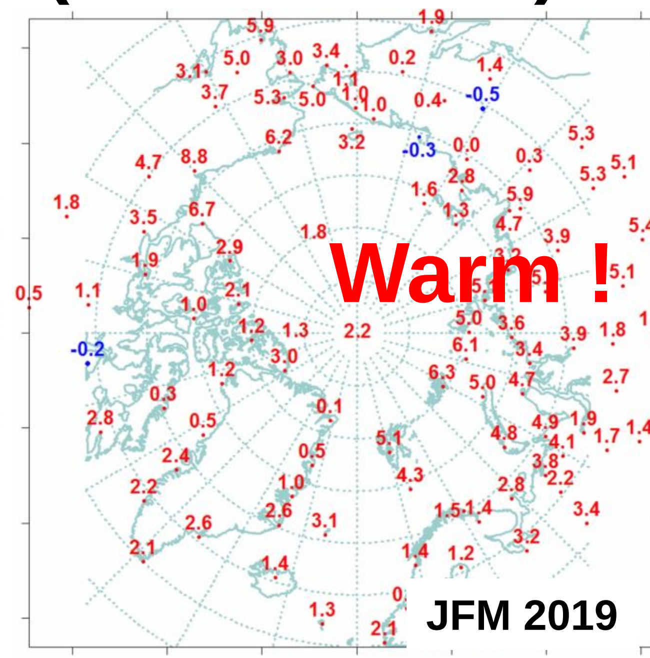
**[source: HMC Moscow]**

# OND 2018 / JFM 2019 Surface Air Temperature (SAT) anomalies (observations)




Network of meteorological stations and boundary of the regions: **1** – Atlantic; **2** – N Europe; **3** – West Siberia; **4** – East Siberia; **5** –Chukchi; **6** – Alaska; **7** – Canada




| JFM 2019 | Anomaly | Rank | The warmest year (anomaly) | The coldest year (anomaly) |
|---|---|---|---|---|
| Atlantic | 2,0 | 13 | 2014 (3,9) | 1966 (-2,4) |
| N.European | 3,2 | 16 | 1937 (6,5) | 1979 (-4,4) |
| West Siberia | 3,4 | 14 | 2012, 2016 (7,6) | 1969 (-5,6) |
| **East Siberia** | **4,1** | **2** | **2016 (4,6)** | **1966 (-4,5)** |
| Chukchi | 1,5 | 16 | 2018 (6,7) | 2002 (-2,3) |
| Alaska | 5,1 | 4 | 2018 (6,1) | 1965 (-5,6) |
| Canada | 1,8 | 13 | 2010 (5,0) | 1972 (-3,6) |

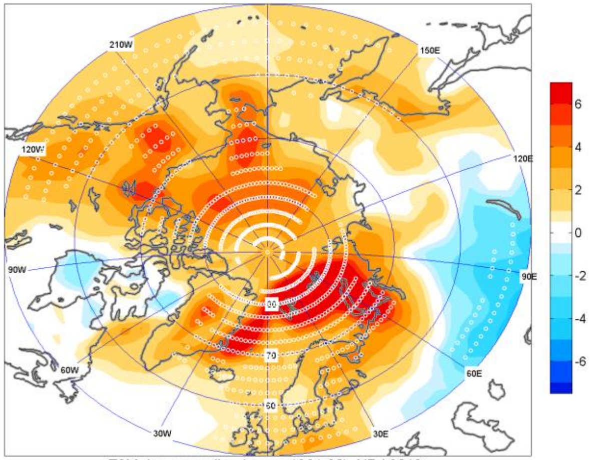
**Warmest !**

[AARI]

**reference period: 1961-1990**

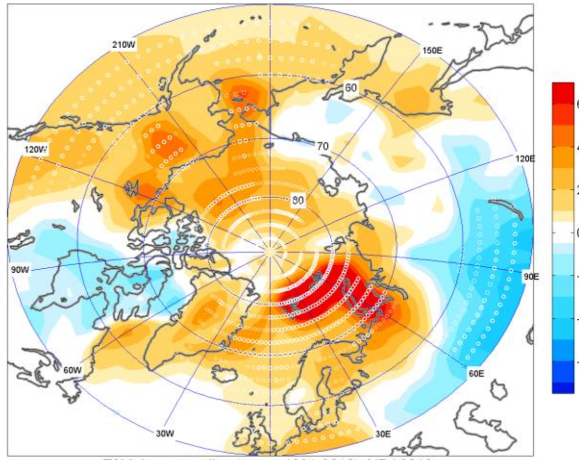
# SAT NDJ and FMA 2018/2019: anomalies and ranks

## NDJ 2018/2019




T2M deg anomalies (norms 1961-90). NDJ 2018.

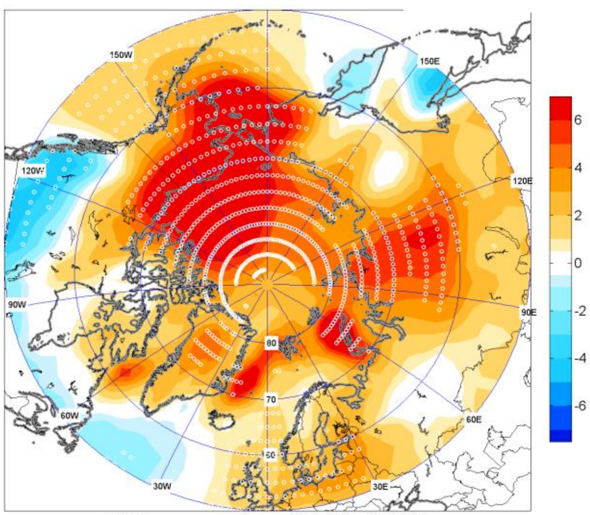
***Ref [1961-1990]***




T2M deg anomalies (norms 1981-2010). NDJ 2018.

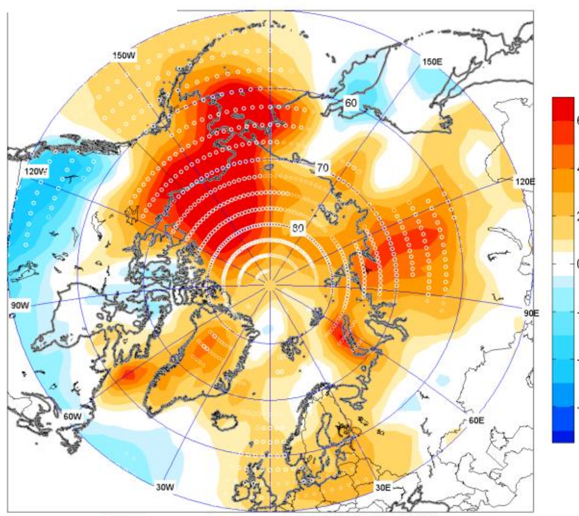
***Ref [1981-2010]***

## FMA 2018/2019




T2M deg anomalies (norms 1961-90). FMA 2019.

***Ref [1961-1990]***




T2M deg anomalies (norms 1981-2010). FMA 2019.

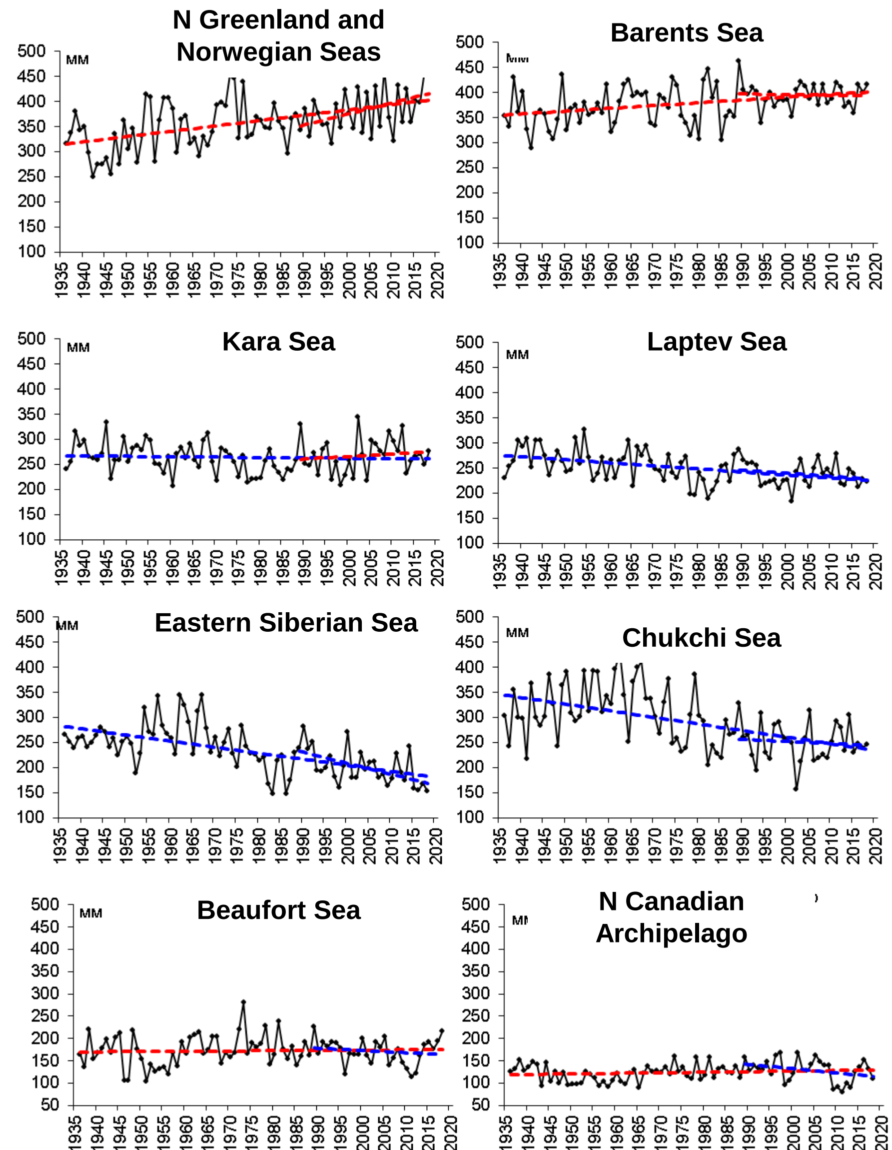
***Ref [1981-2010]***

- NDJ 2018/2019 temperature in the Arctic domain north of 65°N in majority above average.
- 10 warmest over parts of Alaska, Greenland, and the European Arctic
- Contrary, 3rd coldest (a portion of the southern Canadian Arctic) in 70 years

- FMA 2019 temperature in the majority, above average
- Alaska, NW Canada, central Siberia, and the Beaufort, Chukchi and Bering Seas saw their warmest spring
- Contrary, temperature over eastern Canadian Arctic close to normal

# Precipitation trends for ND 2018 - JFM 2019

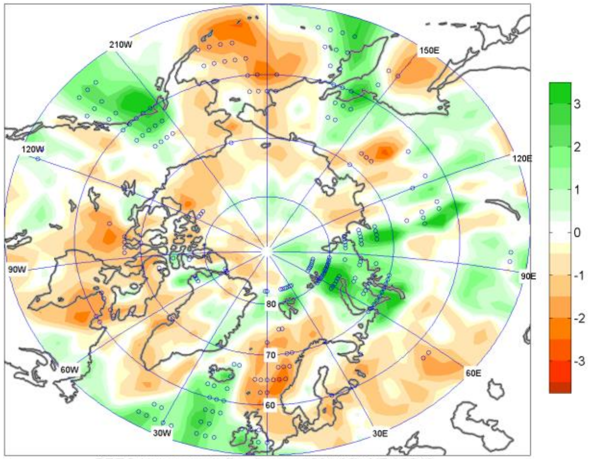
- Analysis based on observations by the Arctic seas
- Significant general positive trends – wetter conditions – for the Nordic seas
- General negative trends – drier conditions - for Siberian shelf seas
- No general significant trends for Alaska and Canadian Arctic regions




**Reference period: 1961-1990**

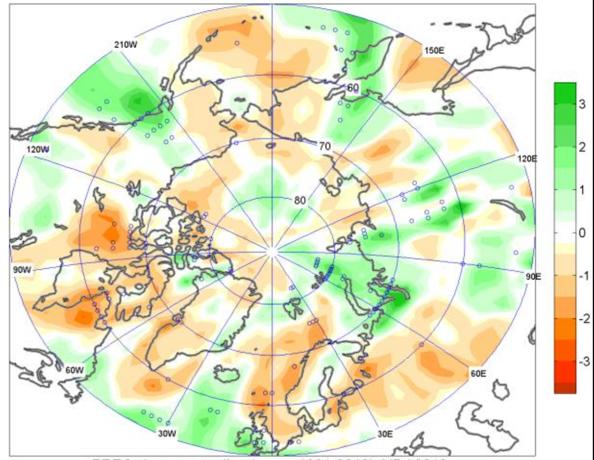
# Precipitation NDJ and FMA 2018/2019: anomalies and ranks

## NDJ 2018/2019



PREC sigma anomalies (norms 1961-90). NDJ 2018.

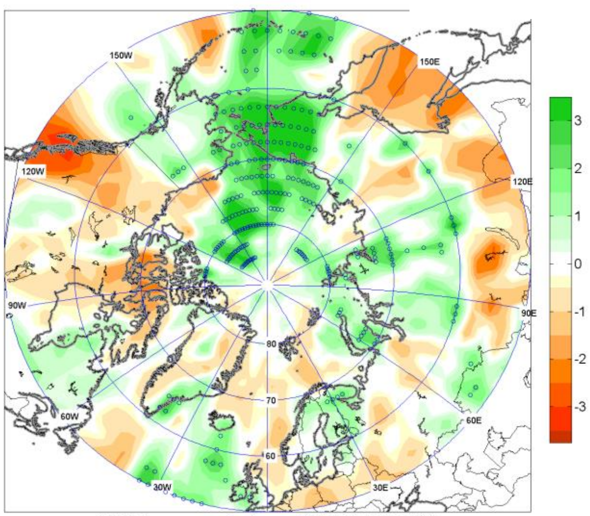
*Ref [1961-1990]*



PREC sigma anomalies (norms 1981-2010). NDJ 2018.

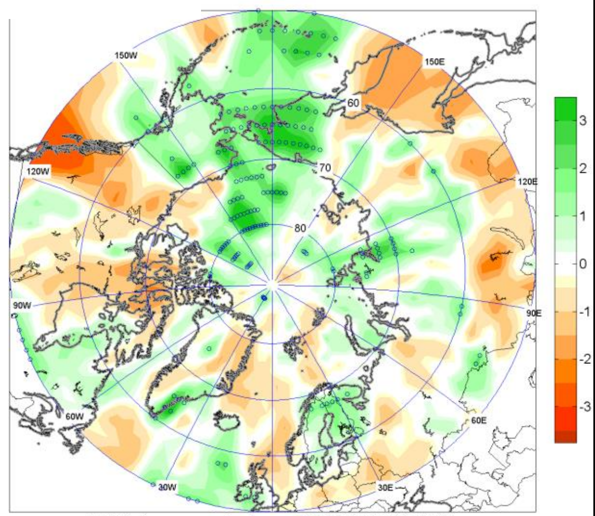
*Ref [1981-2010]*

## FMA 2018/2019



PREC sigma anomalies (norms 1961-90). FMA 2019.

*Ref [1961-1990]*



PREC sigma anomalies (norms 1981-2010). FMA 2019.

*Ref [1981-2010]*

- **For NDJ 2018/2019 Siberia saw the driest winter (NDJ) in the 70-year record.**
- **For FMA southern portion of the Canadian Arctic saw their driest spring in the 70-year record,**
- **Contrary, NE Siberia and part of the Arctic Ocean saw their wettest spring on record.**

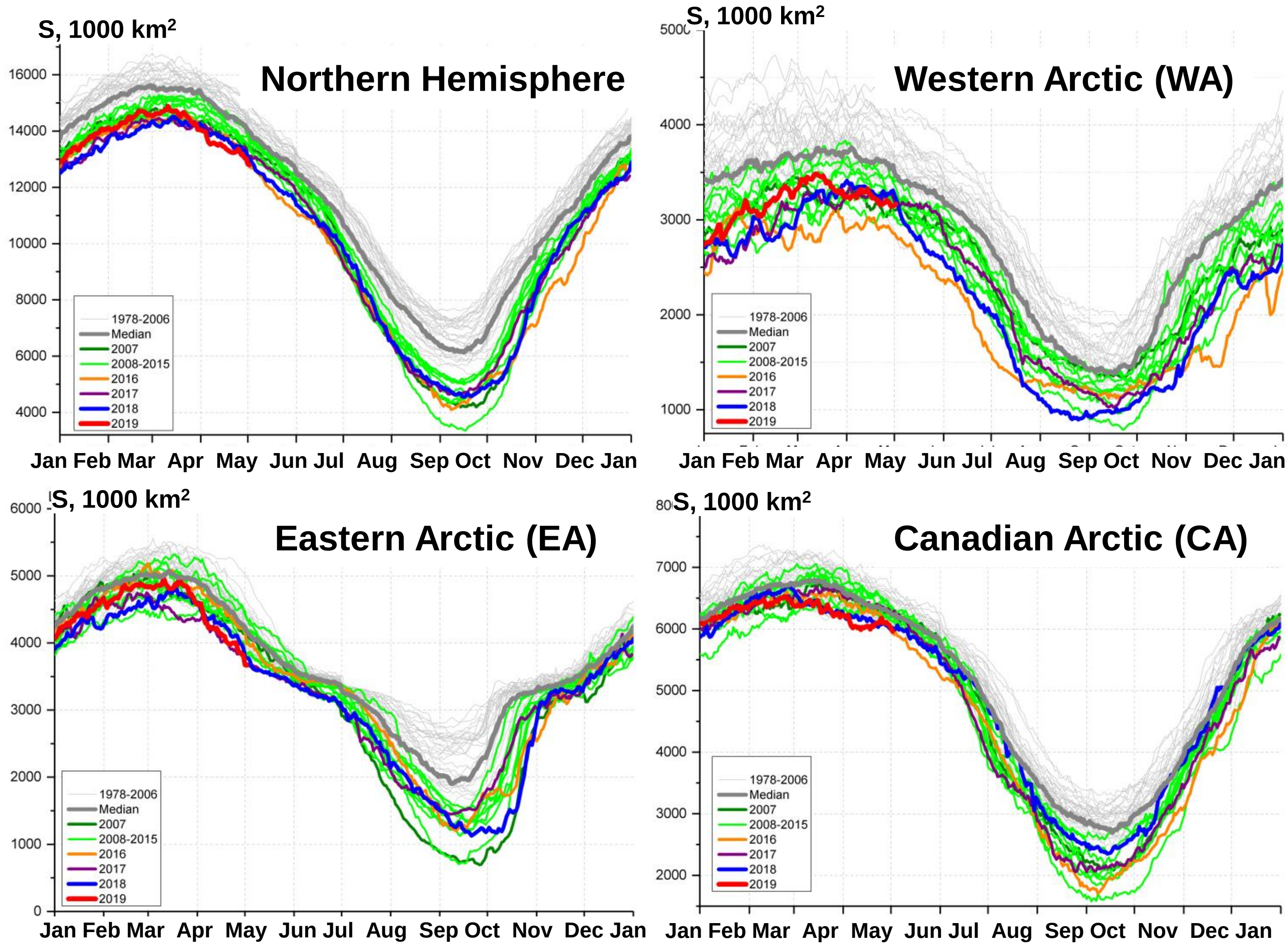
**HMC Moscow**

# Sea ice variables:

- ✓Ice extent analysis
- ✓Ice conditions analysis
- ✓Ice thickness at coastal stations
- ✓Sea ice thickness and volume for the Arctic Ocean

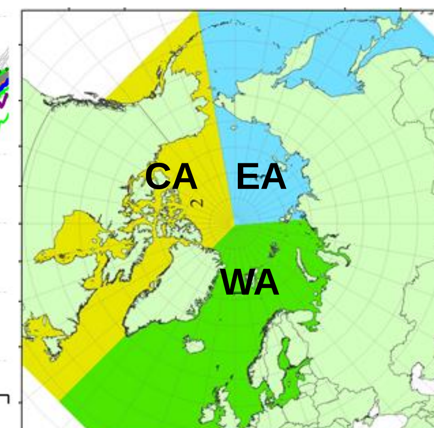
Source:
[AARI, NSIDC, CIS, US NIC, DMI] / JCOMM

# Arctic (NH) seasonal ice extent 1978…. 2019




| S, 1000 km²* | |
|---|---|
| 2017 | 14467 |
| 2018 | 14516 |
| 2015 | 14526 |
| 2016 | 14580 |
| 2011 | 14701 |
| 2006 | 14867 |
| 2019 | 14891 |
| 2007 | 14931 |
| … | … |
| 1988 | 16461 |
| 1983 | 16547 |
| 1979 | 16769 |

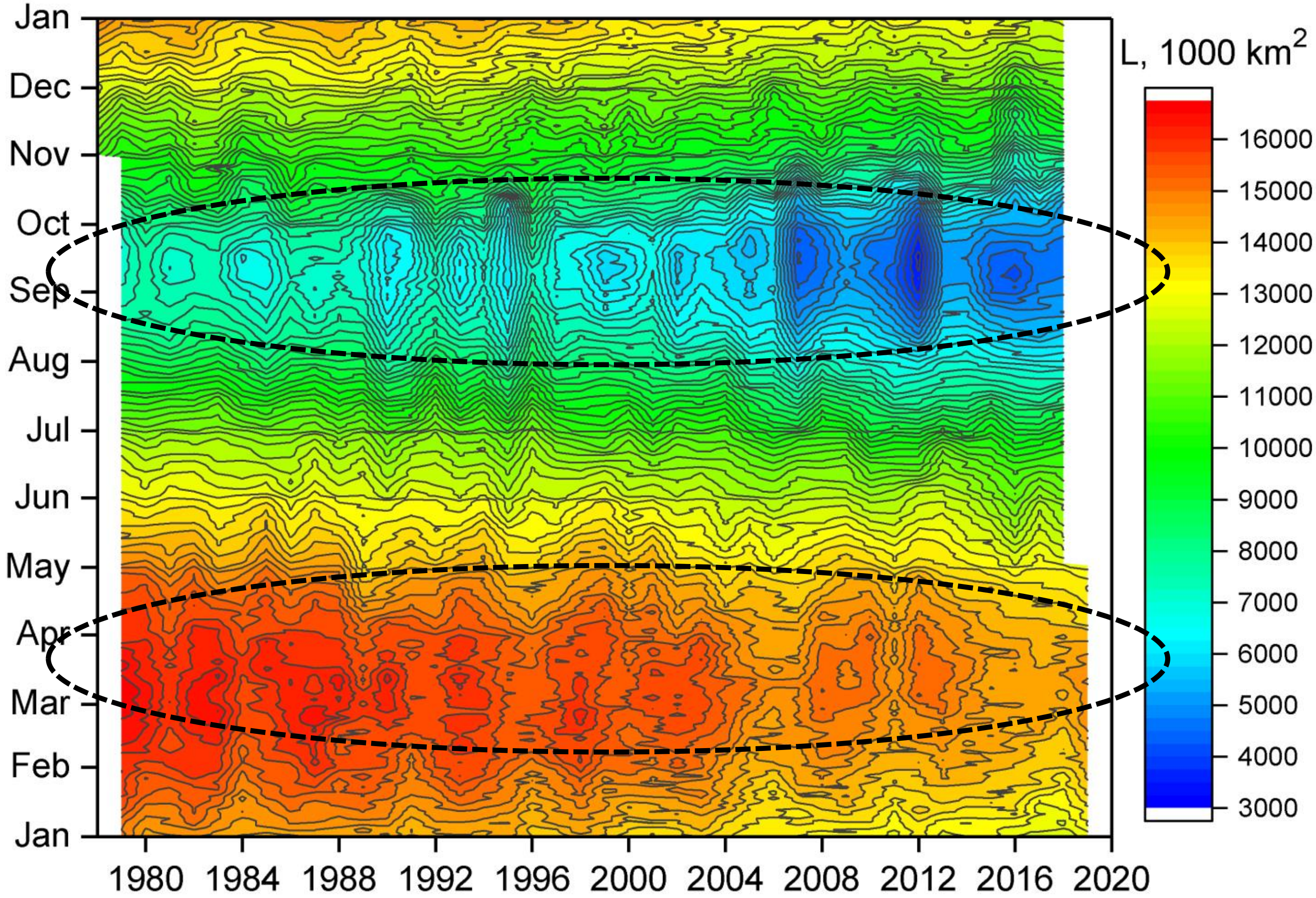
* - minimum for Sep (AARI)




- Maximum winter ice extent, 7th in row, 14,89 mln km² (14,52 in 2018) reached 11 March 2019
- Lowest on record in April due to Bering Sea

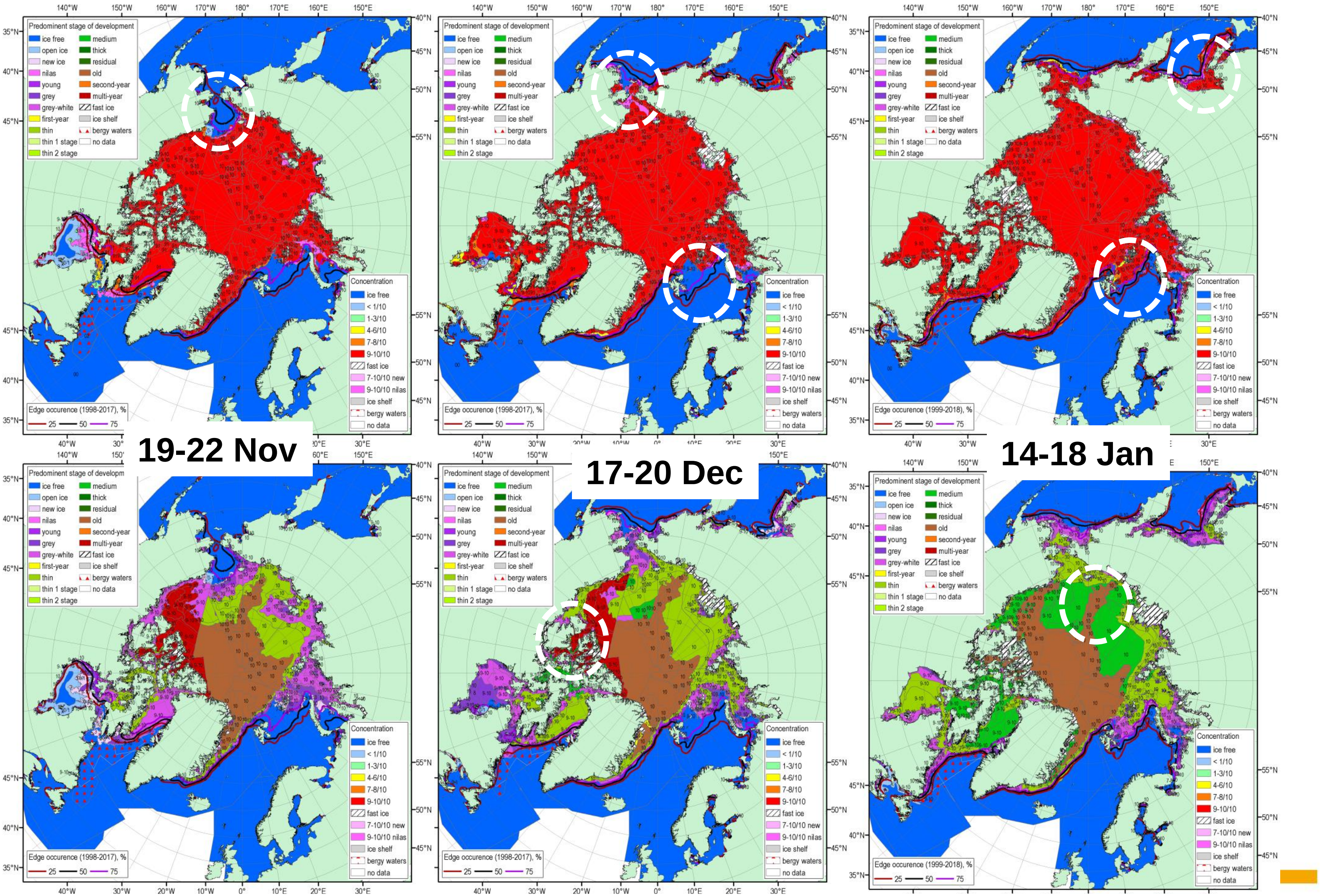
[AARI, NSIDC]

# Seasonal NH ice extent variability: 1978 - 2019



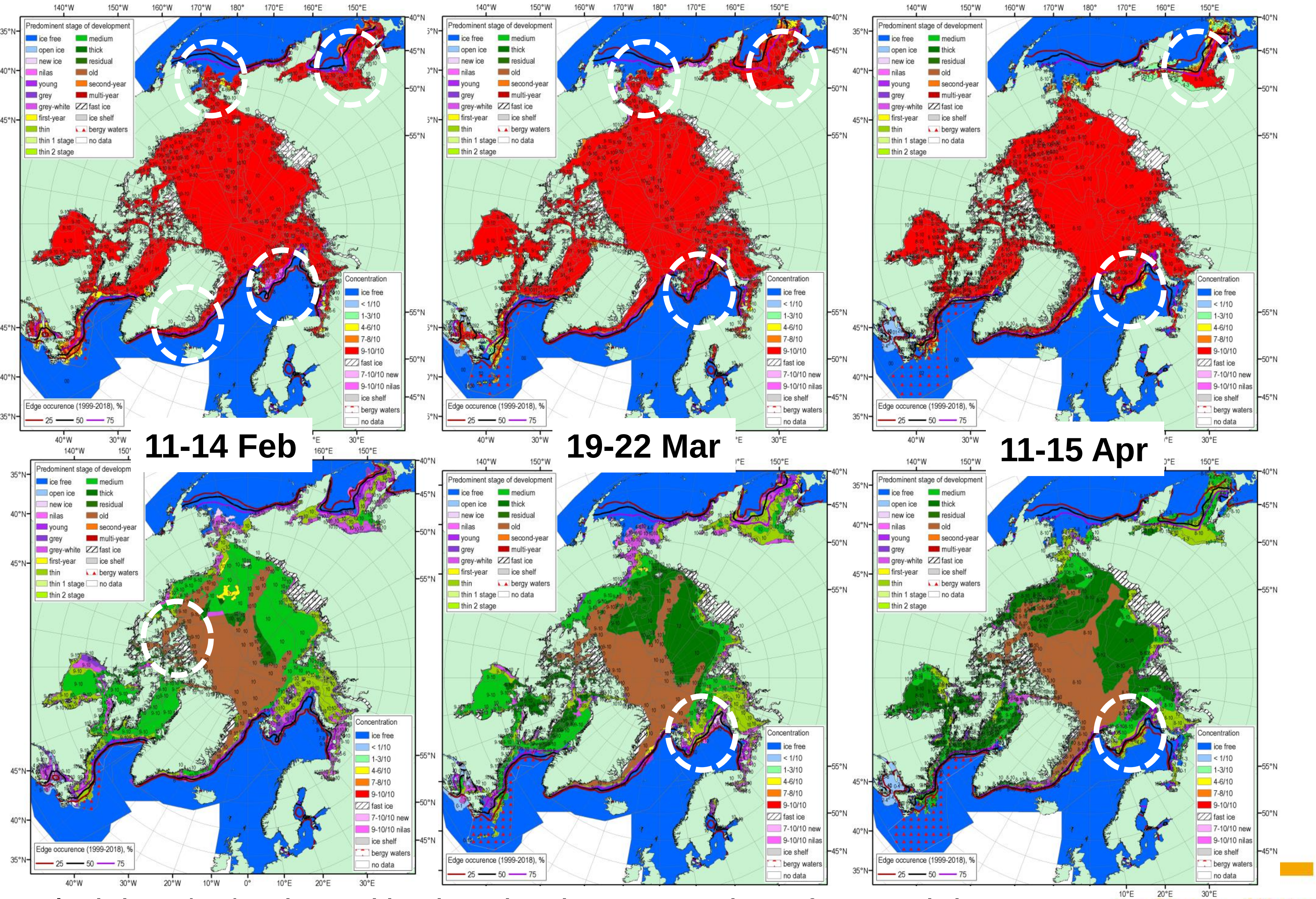

- **Year-Seasonal diagram allows to analysis seasonal variability of ice extent**
- **Both winter maximums and summer minimums continue to reduce….**
- **Though… significant interannual variability of ice extent, ice conditions actually occurs**

# NDJ 2018/2019 Arctic sea ice – concentration and age (stage of development)




**Blended AARI/CIS/NIC (JCOMM) ice charts; ice edge – nearest 5days, reference period: 1998-2017 (ND) and 1999-2018 (J)**

# FMA 2019 Arctic sea ice – concentration and age (stage of development)




Blended AARI/CIS/NIC (JCOMM) ice charts; ice edge – nearest 5 days, reference period: 1999-2018

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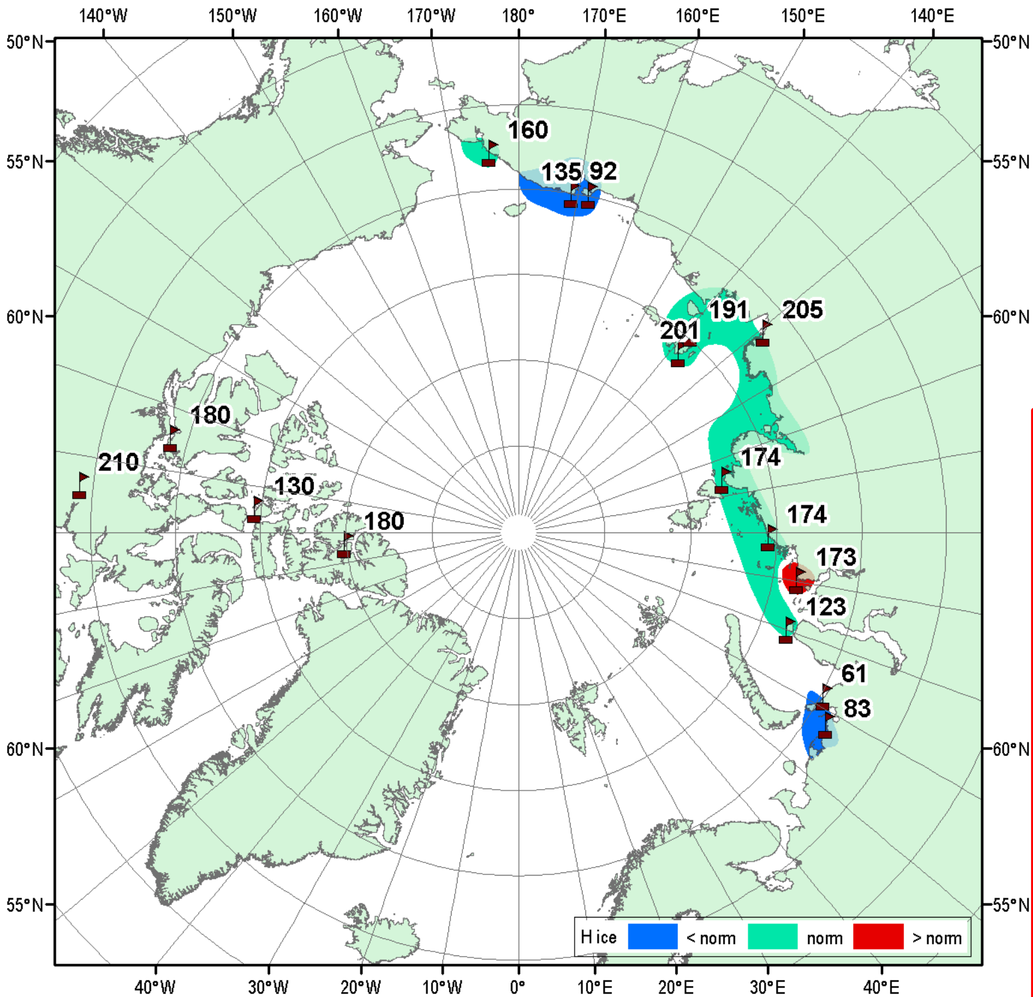
# Sea ice fast ice maximum thickness values and anomalies by end of April/Mar 2019 (stations)



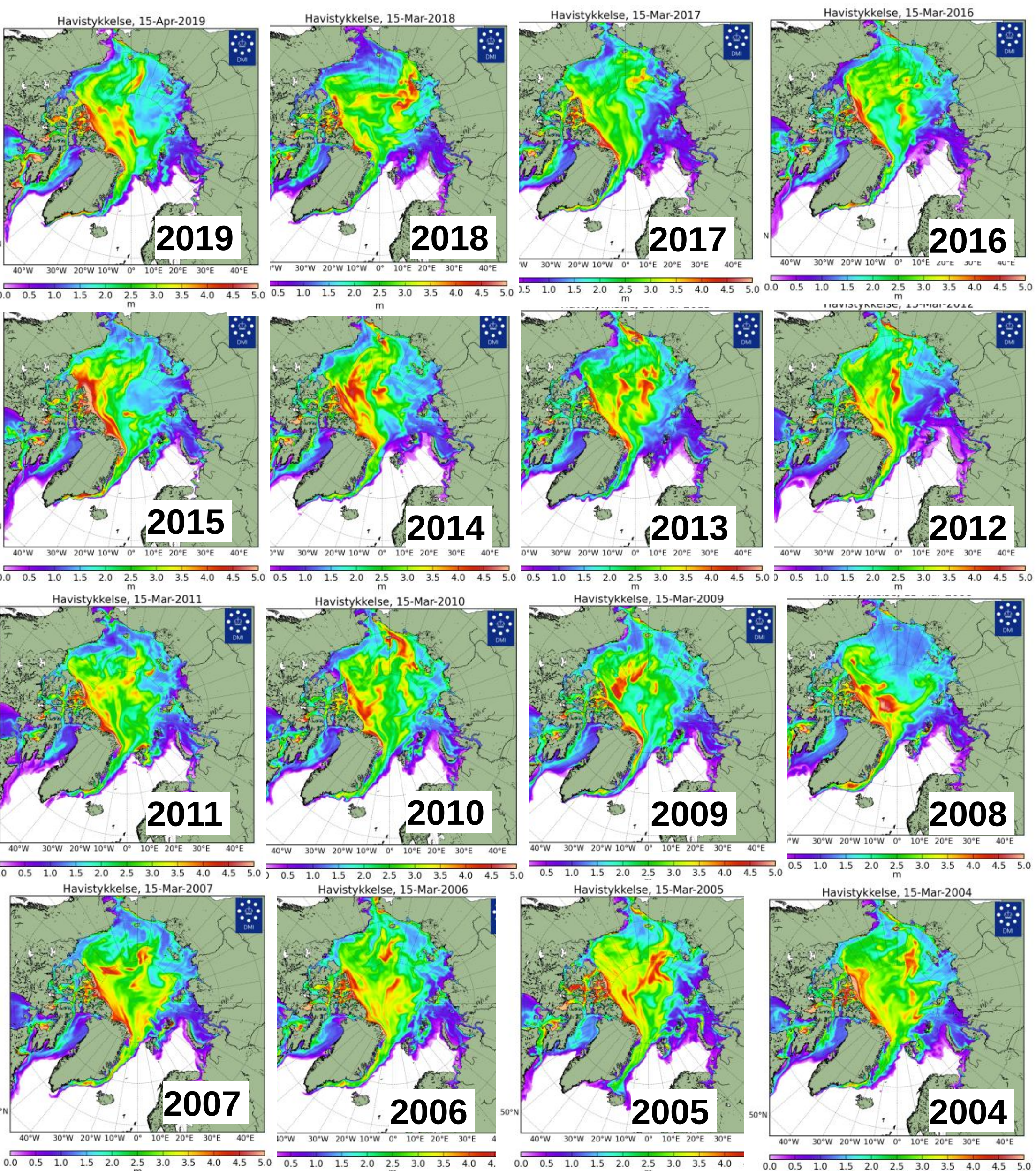

*Ref [1989-2019]*

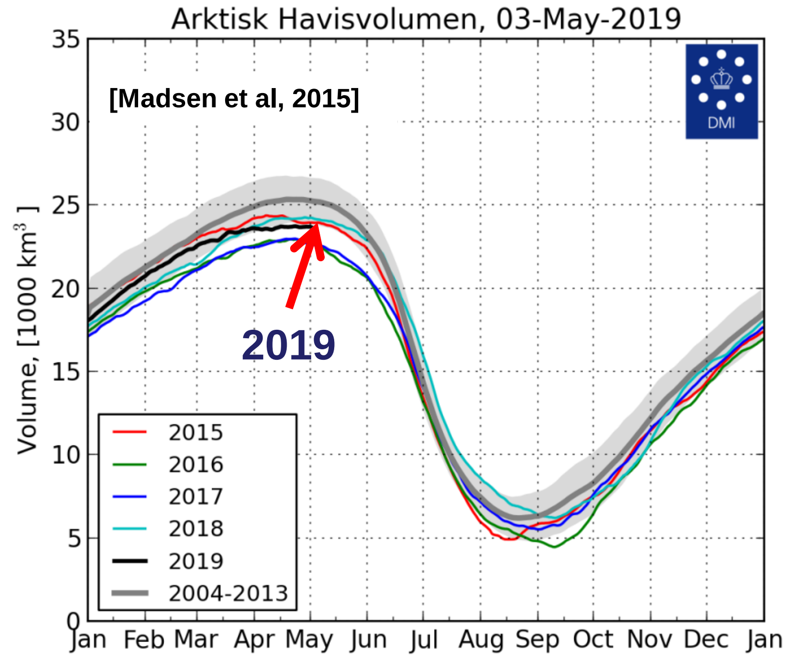
**WMO stations used:**
**Russia: 12 (Varandey, Amderma, Belyi, Dikson, Sterlegova, Cheluskin, Tiksi, Kotelnyi, Sannikova, Ayon, Valkarkay, Vankarem)**
**Canada: 5 (Eureka, Baker Lake, Cambridge Bay, Resolute, Nain NL)**

- **Observed maximum winter ice thicknesses slightly less than normal for most of the Arctic seas**
- **Thicker ice observed in Kara sea**
- **Significantly thinner observed in Chukchi Sea region.**
- **Several stations - Baker Lake, Tiksi, Kotelny, North Pole, recorded values (201…215 cm) close to physical maximum for the first year ice.**

**[AARI, CIS]**

# Sea ice thickness for 15 Mar 2004…2019 and ice volume




- **Models show Arctic ice volume greater or slightly less as in 2018 for JFMA 2019,**
- **Similar ice extent means overall ice thicknesses in winter 2019 are comparable to winter 2018**

DMI North Atlantic - Arctic Ocean model HYCOM-CICE - http://ocean.dmi.dk/models/hycom.uk.php

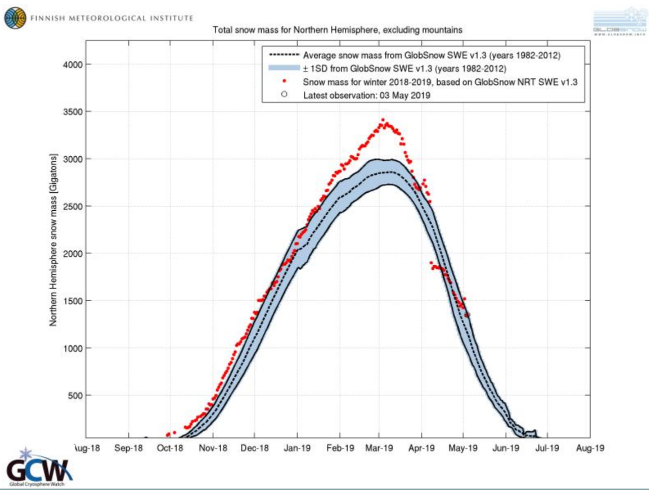
Solid precipitation (snow):

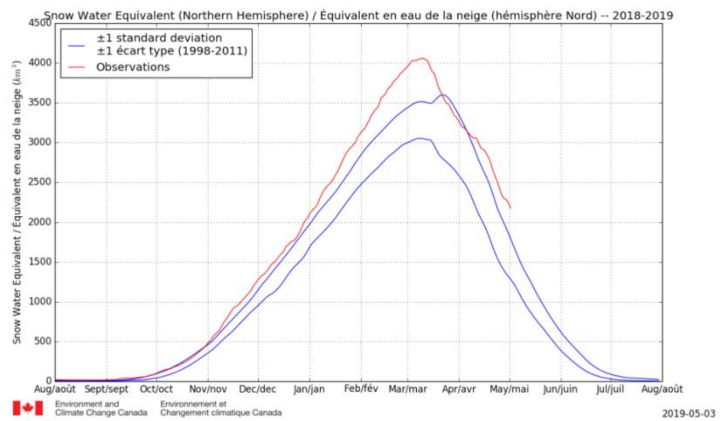
- ✓ Snow water equivalent (ocean, land)
- ✓ Snow area (land)

Source:
[FMI, ECCC] / GCW

# Terrestrial and marine snow

## Snow water equivalent (SWE) – marine + land




- Snow volume on sea ice and land (snow water equivalent) was higher than on record for the past season
- Higher than normal land snow area recorded for Canada and Alaska with lesser than normal for parts of the season for Eurasia region

## Snow area – land

**Eurasia**

| Month | Area (2019) | Mean (1981-2010 Normal) | Departure | Rank |
|---|---|---|---|---|
| 3 | 22,898 | 24,492 | -1,594 | 47/5 |
| 2 | 27,678 | 28,479 | -801 | 42/5 |
| 1 | 29,581 | 29,322 | 259 | 25/5 |

| Month | Area (2018) | Mean (1981-2010 Normal) | Departure | Rank |
|---|---|---|---|---|
| 12 | 27,594 | 27,135 | 460 | 16/53 |
| 11 | 22,053 | 20,474 | 1,580 | 13/53 |

**Canada**

| Month | Area (2019) | Mean (1981-2010 Normal) | Departure |
|---|---|---|---|
| 3 | 10,102 | 10,023 | 78 |
| 2 | 10,390 | 10,279 | 111 |
| 1 | 10,312 | 10,294 | 18 |

| Month | Area (2018) | Mean (1981-2010 Normal) | Departure | Rank |
|---|---|---|---|---|
| 12 | 10,263 | 10,096 | 167 | 12/53 |
| 11 | 9,978 | 8,663 | 1,315 | 1/53 |

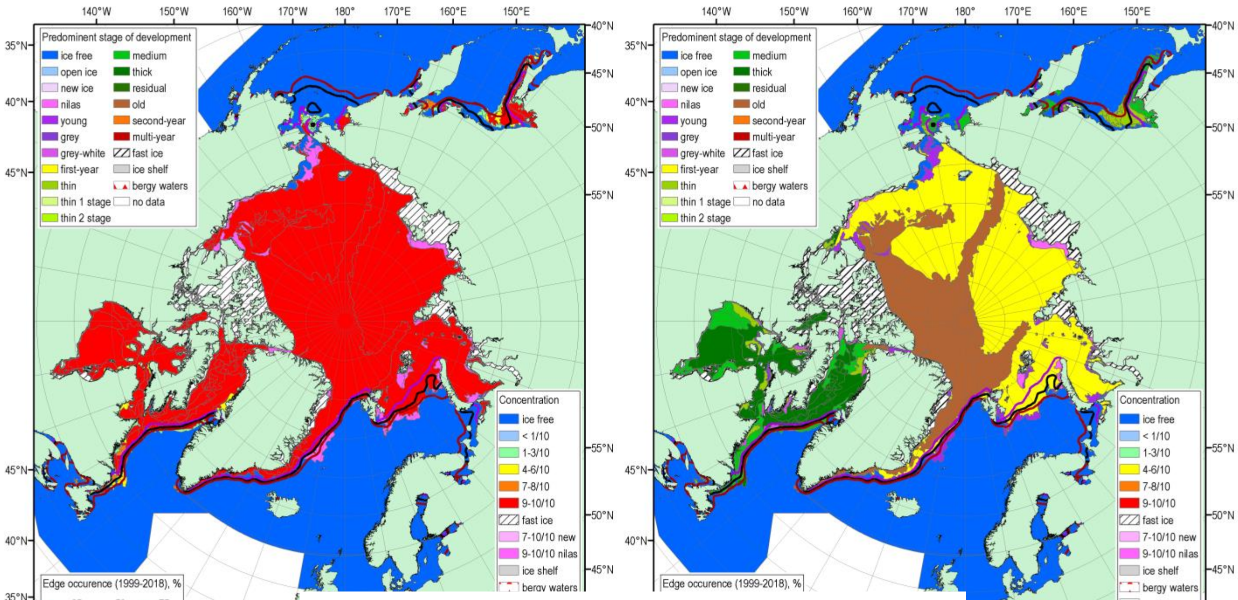
**Alaska**

| Month | Area (2019) | Mean (1981-2010 Normal) | Departure | Rank |
|---|---|---|---|---|
| 3 | 1,513 | 1,486 | 27 | 3/53 |
| 2 | 1,521 | 1,515 | 6 | 26/53 |
| 1 | 1,500 | 1,495 | 4 | 16-37/53 |

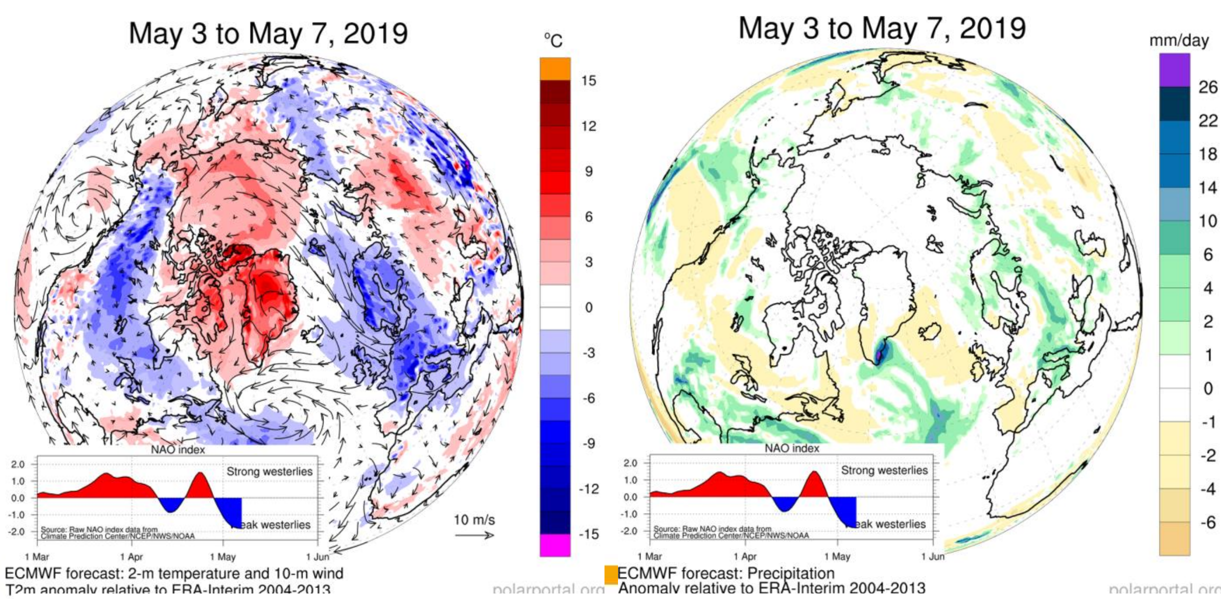
| Month | Area (2018) | Mean (1981-2010 Normal) | Departure | Rank |
|---|---|---|---|---|
| 12 | 1,500 | 1,480 | 19 | 7-23/53 |
| 11 | 1,403 | 1,406 | -3 | 33/53 |

[FMI, ECCC / GCW)]

# Current status (2 …. 7 May 2019)




**AARI/NIC ice chart for 2-7 May 2019**




**Surface air temperature (2m), precipitation anomalies and mean wind vectors (10 m) for 3-7.05.2019 (http://polarportal.dk)**

- High variability of ice conditions remains typical feature for the regional seas.
- Till the beginning of May 2019 week westerly and strong northern winds (NAO<0) in the Barents and partly in the Kara Seas regions continue to preserve negative temperature anomalies
- N Barents Sea preserves a prominent sea ice extent close to normal which will slow melting process
- Contrary Bering and adjacent Chukchi Seas have very mild ice conditions, consequently higher waves

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# Thank you! Merci! Takk! Спасибо! Tak! Tack! Kiitos! Þakka þér fyrir! Giitu !

# Background slides

# Arctic Seasonal Highlights

## Temperature & Precipitation (NDJ 2018/2019 and FMA 2019)

**Atmospheric circulation:** For NDJ positive MSLP anomalies dominated over European and west Siberian region with opposite situation in the Atlantic and Alaska regions. That led to prevalence of meridian form of circulation in the troposphere and bi-central polar vortex. For FMA very significant negative anomalies observed in the northern Eurasia and Greenland led to increased cyclonic activity with further increased precipitation.

**Surface air temperature:** The November 2018, December 2018, and January 2019 (NDJ, **winter**) average surface air temperature in the Arctic domain north of 65°N was, in the majority, **above average**. Using data from NCEP/NCAR reanalysis to rank the average surface air temperature, the NDJ period ranged from the **top 10 warmest** over parts of **Alaska**, **Greenland**, and the **European Arctic**, to the **3rd coldest** (a portion of the **southern Canadian Arctic**) winter in 70 years, since the start of the record in 1949. Over the February, March, and April (FMA, **spring**) 2019 period, average surface air temperature in the Arctic domain north of 65°N was, in the majority, **above average**. Particularly, **Alaska**, **northwestern Canada**, **central Siberia**, and the **Beaufort, Chukchi and Bering Seas** saw their **warmest spring** (FMA) since the start of the record in 1949. On the other hand, average surface air temperature over **eastern Canadian Arctic** for that same time period was only the $30^{th}$-$45^{th}$ warmest, that is **near the median** for the same period.

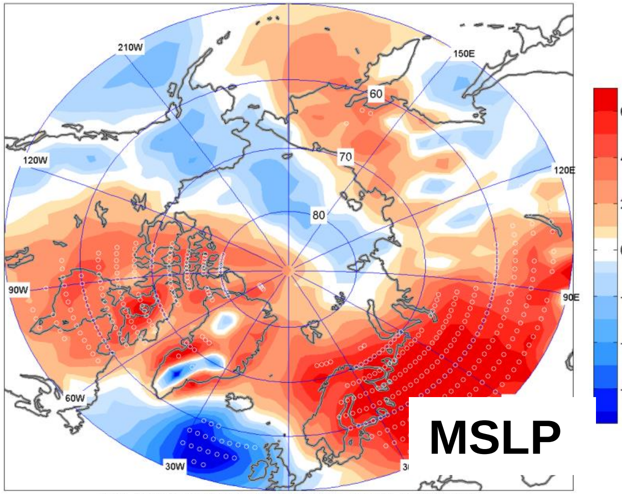
**Precipitation:** **Siberia** saw their **driest winter** (NDJ) in the 70-year record. The southern portion of the Canadian Arctic saw their driest spring (FMA) in the 70-year record, while **northeastern Siberia** and a portion of the **Arctic Ocean** saw their **wettest spring** on record.

## Arctic (NH) Sea Ice (NDJ 2018/2019 and FMA 2019)

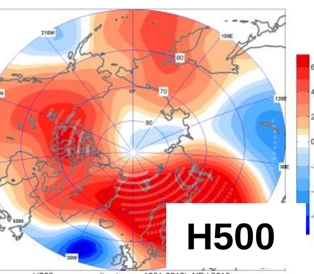
**Sea ice:** The winter **maximum sea ice extent** (14.89 mln km$^2$), reached on 11/03**, was the 7$^{th}$ minimum in row since 1979** (2018 – 2$^{nd}$), with the maximum winter sea ice extent observed in 1979 (16.77 mln km$^2$). Estimates of the sea ice volume, based on numerical reanalysis (HYCOM-CICE, PIOMAS), show slightly higher or similar to 2018 values and significantly higher than in 2016-2017. Observed at coastal stations **maximum winter ice thicknesses** was slightly **less than normal** for most of the Arctic seas with some positive anomalies observed in Kara sea and significant negative anomalies in Chukchi Sea region. At several stations Baker Lake, Tiksi, Kotelny, North Pole) recorded vales (201…215 cm) were close to physical maximum for the first year ice.

**High variability of ice conditions** was recorded during the observed period for some of the regional seas. The thermal and wind patterns during winter 2018-2019 led to **extreme low ice extent** in **Bering Sea** with close to normal ice extent in the adjacent Sea of Okhotsk. Predominance of northerly winds in the **Barents Sea** region since Jan 2019 led to **close to normal ice extent** in the northern part of this area which is opposite both to autumn 2018 as well as last decade situation.

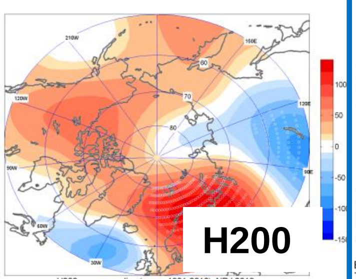
# NDJ 2018/2019 atmospheric circulation (reanalysis)



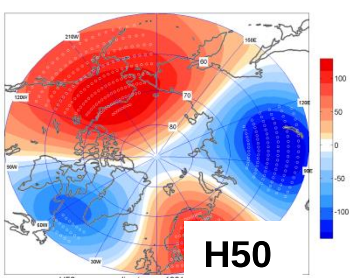
MSLP hPa anomalies (norms 1981-2010). NDJ 2018.



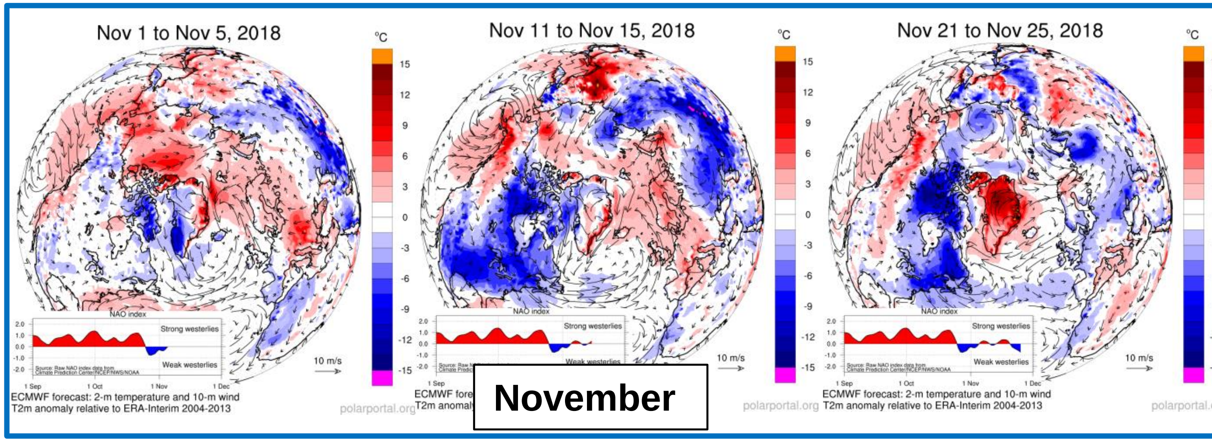
H500 gpm anomalies (norms 1981-2010). NDJ 2018.

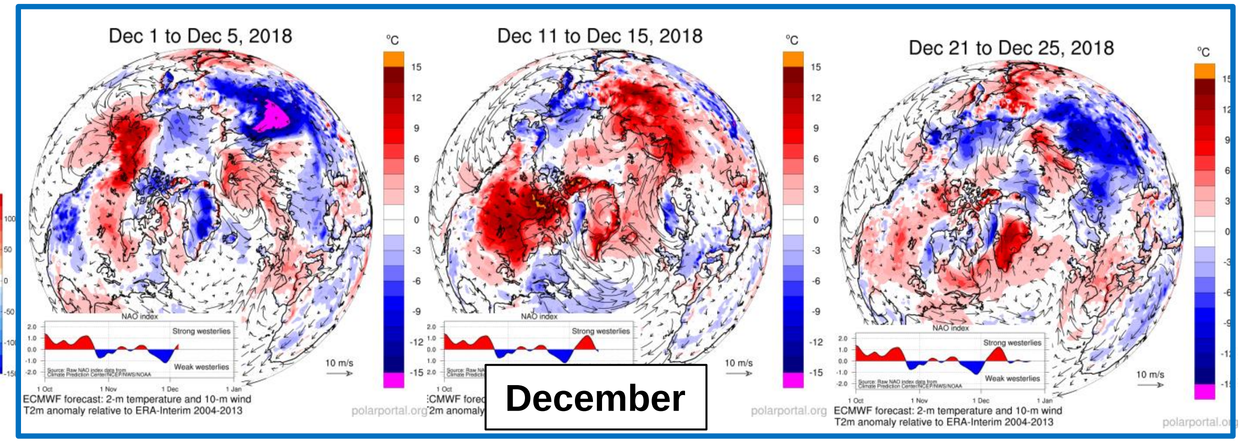


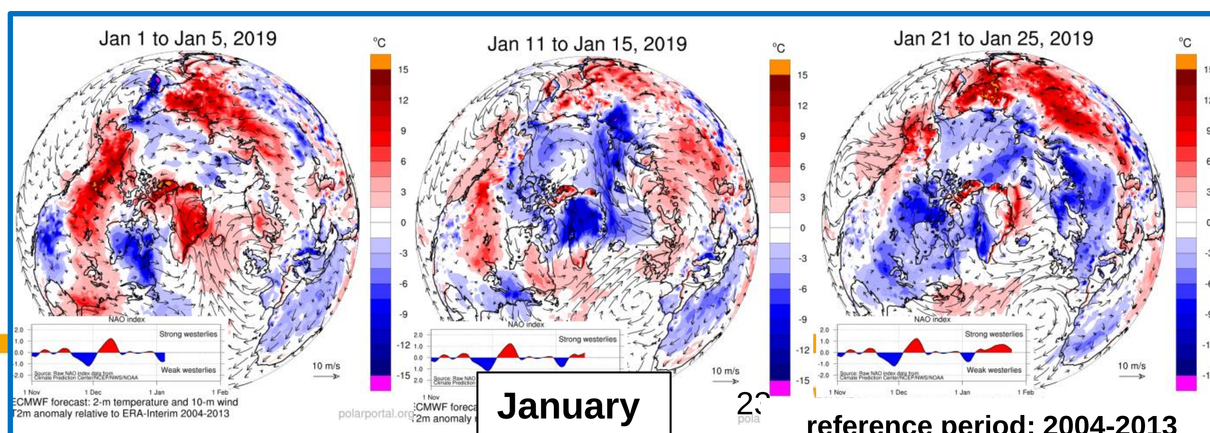
H200 gpm anomalies (norms 1981-2010). NDJ 2018.



H50 gpm anomalies (norms 1981



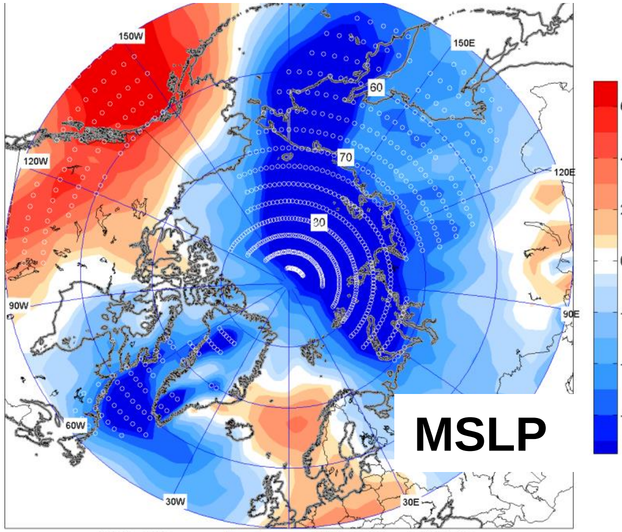



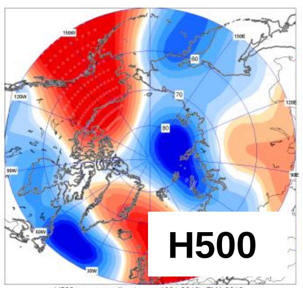

reference period: 2004-2013

[HMC Moscow, DMI]

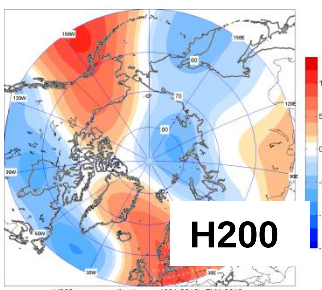
# FMA 2019 atmospheric circulation (reanalysis)



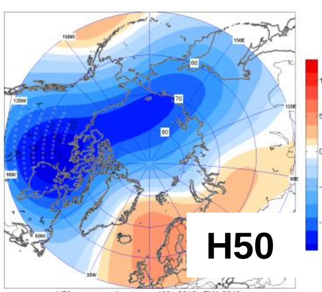

MSLP hPa anomalies (norms 1981-2010). FMA 2019.



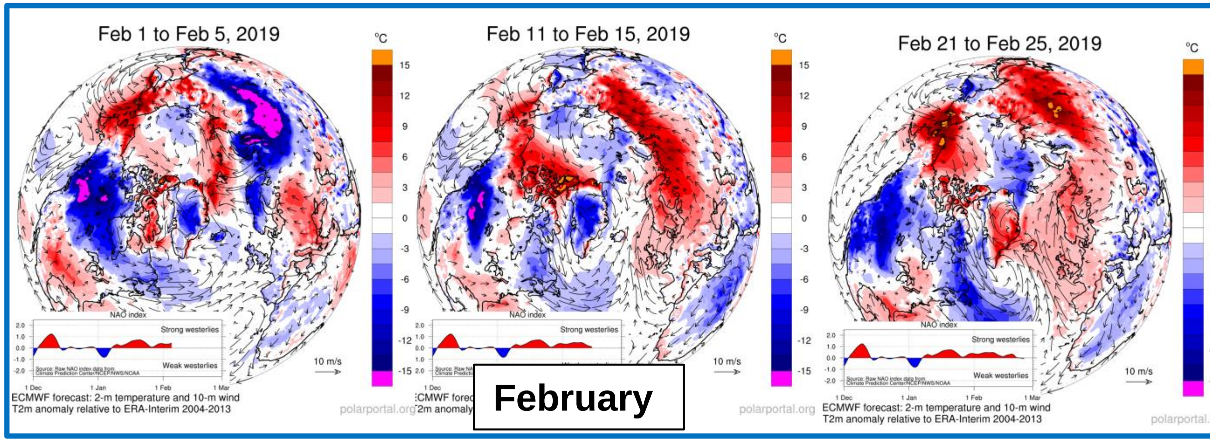

H500 gpm anomalies (norms 1981-2010). FMA 2019.

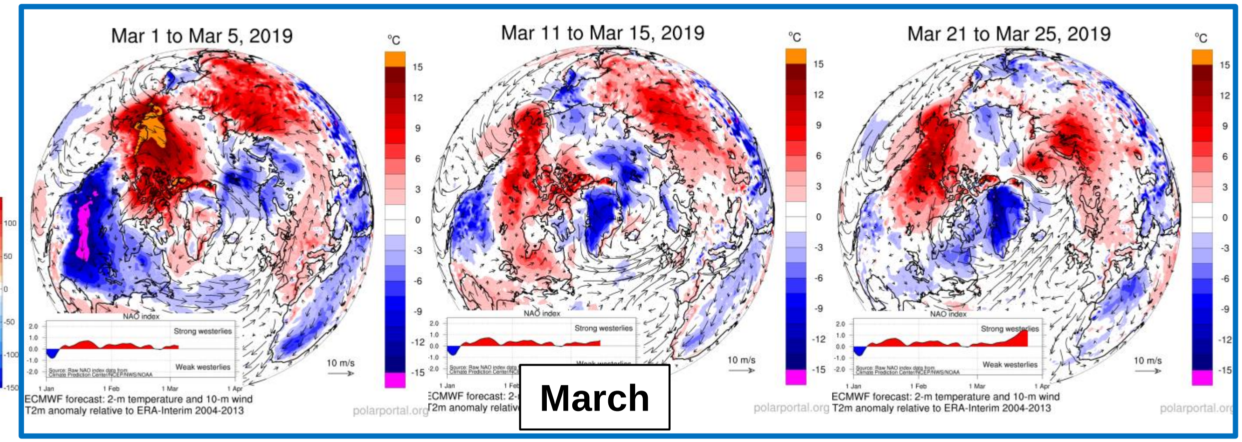


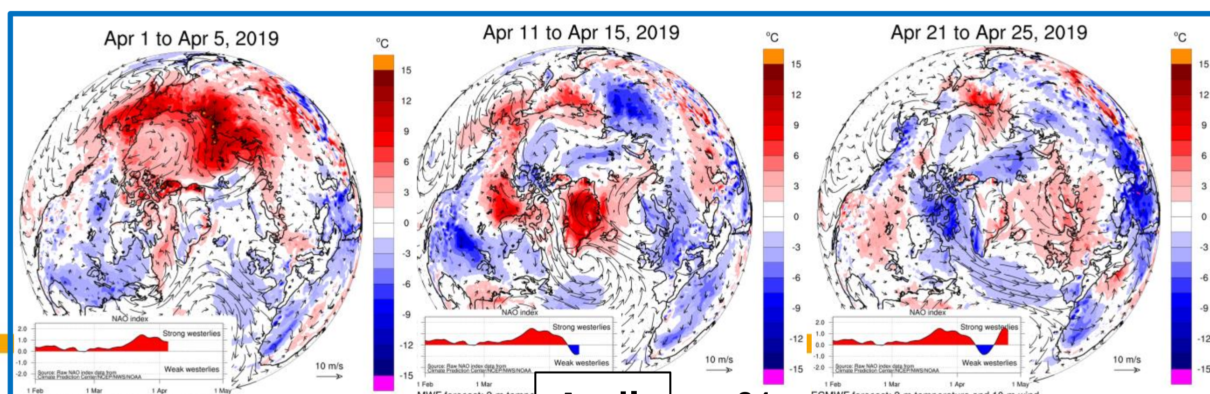

H200 gpm anomalies (norms 1981-2010). FMA 2019.




H50 gpm anomalies (norms 1981-2010). FMA 2019.



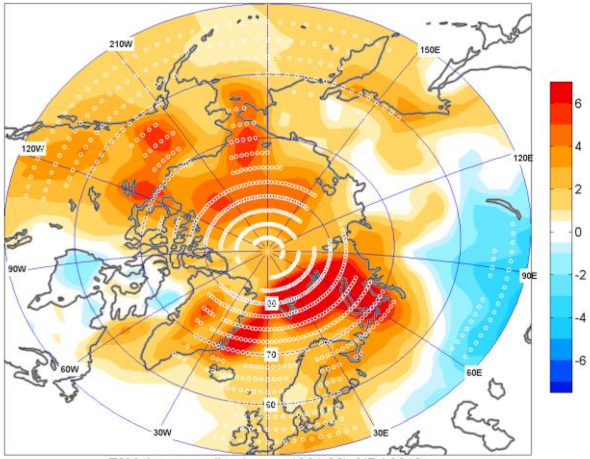




[HMC Moscow, DMI]

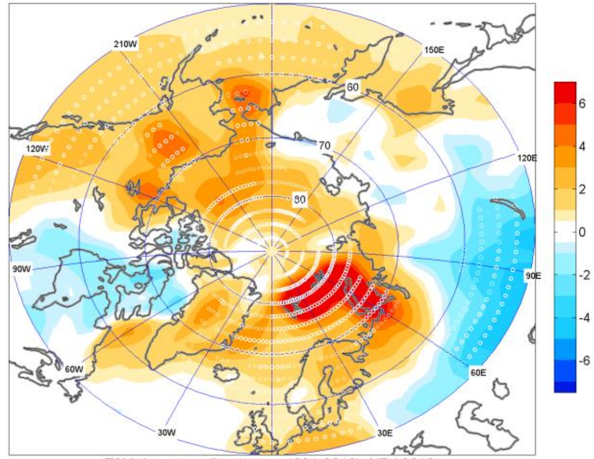
reference period: 2004-2013

# SAT NDJ and FMA 2018/2019: anomalies and ranks (reanalysis)

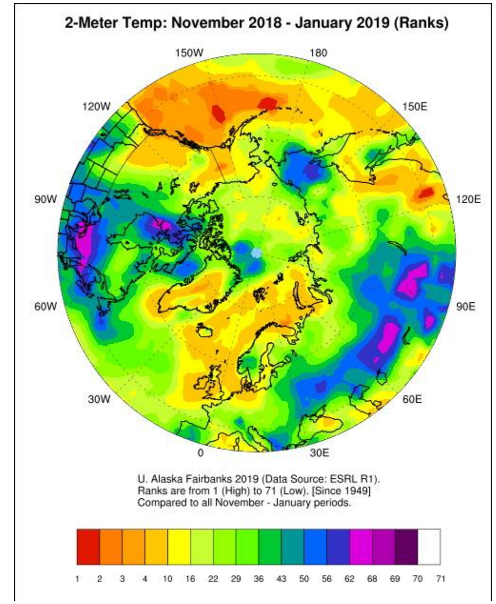
## NDJ 2018/2019


T2M deg anomalies (norms 1961-90). NDJ 2018.

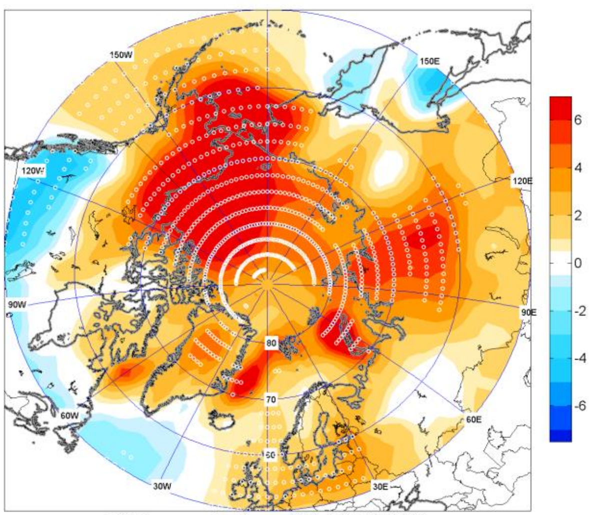
*Ref [1961-1990]*


T2M deg anomalies (norms 1981-2010). NDJ 2018.

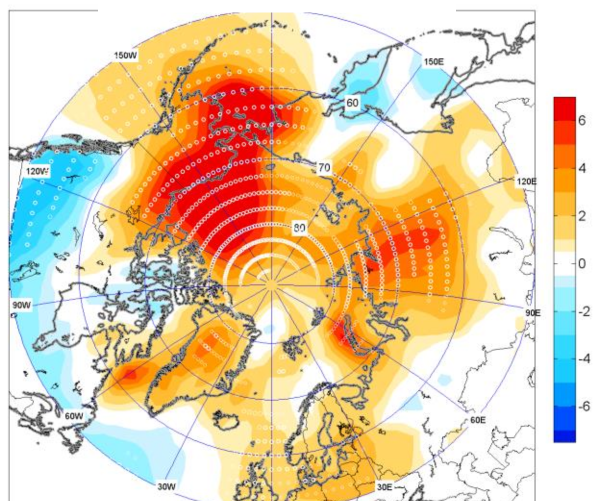
*Ref [1981-2010]*



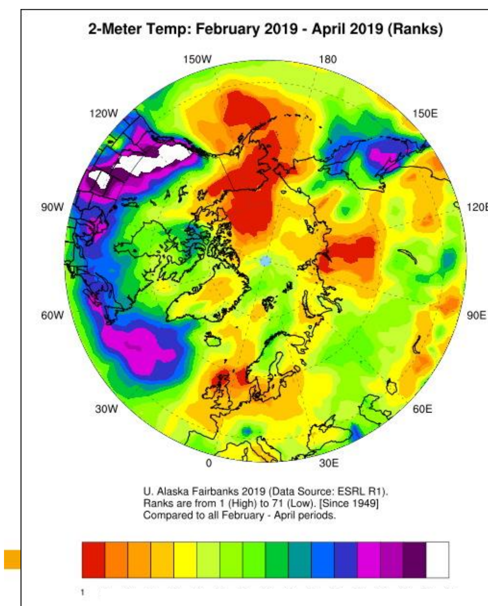

## FMA 2018/2019


T2M deg anomalies (norms 1961-90). FMA 2019.

*Ref [1961-1990]*


T2M deg anomalies (norms 1981-2010). FMA 2019.

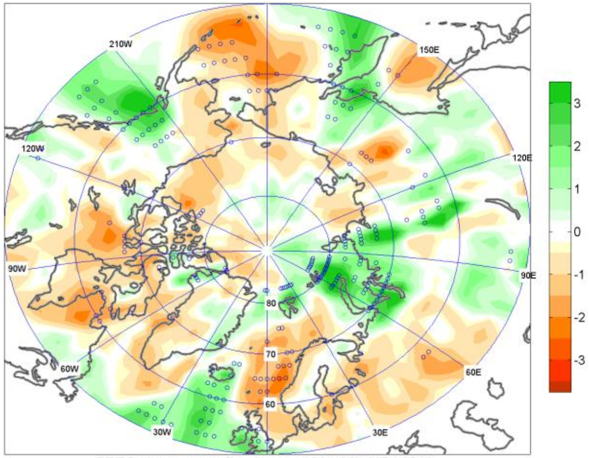
*Ref [1981-2010]*




**[HMC Moscow, NOAAI]**

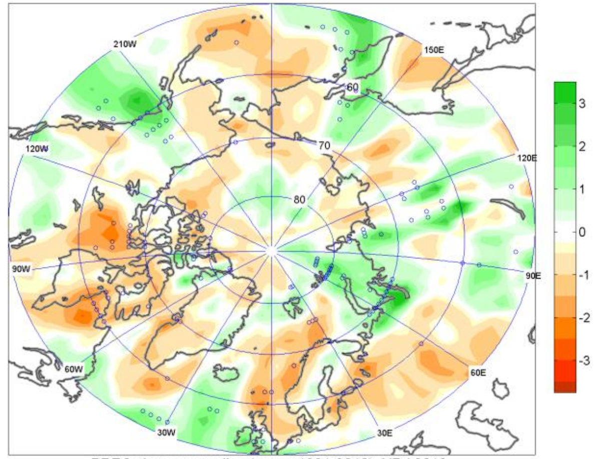
# Precipitation NDJ and FMA 2018/2019: anomalies and ranks (reanalysis)

## NDJ 2018/2019




PREC sigma anomalies (norms 1961-90). NDJ 2018.

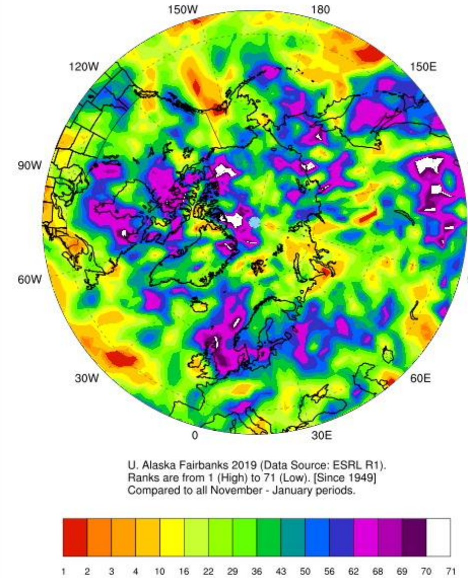
*Ref [1961-1990]*



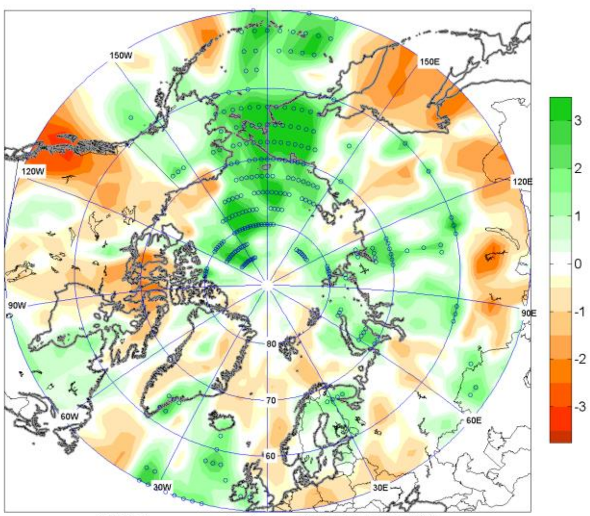

PREC sigma anomalies (norms 1981-2010). NDJ 2018.

*Ref [1981-2010]*

Precipitation Rate: November 2018 - January 2019 (Ranks)

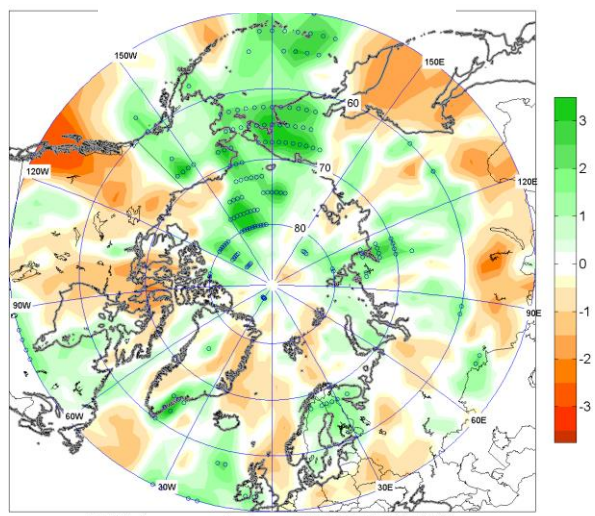



## FMA 2018/2019




PREC sigma anomalies (norms 1961-90). FMA 2019.

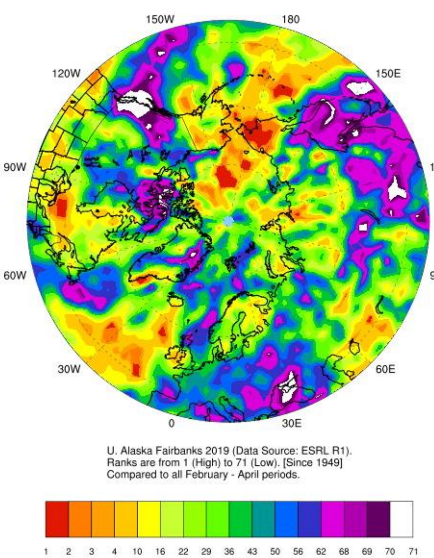
*Ref [1961-1990]*




PREC sigma anomalies (norms 1981-2010). FMA 2019.

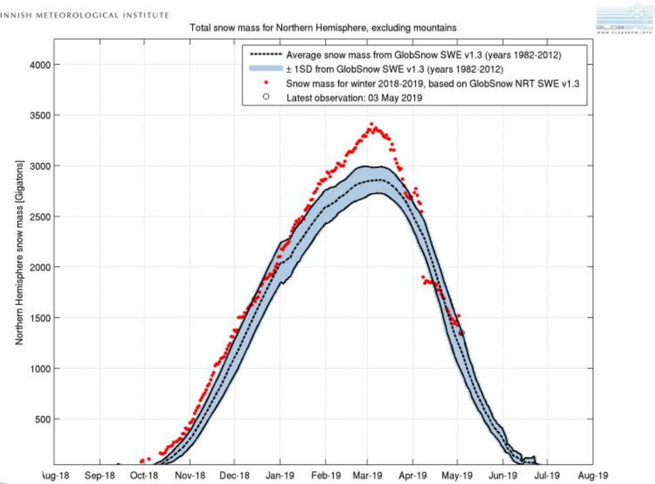
*Ref [1981-2010]*

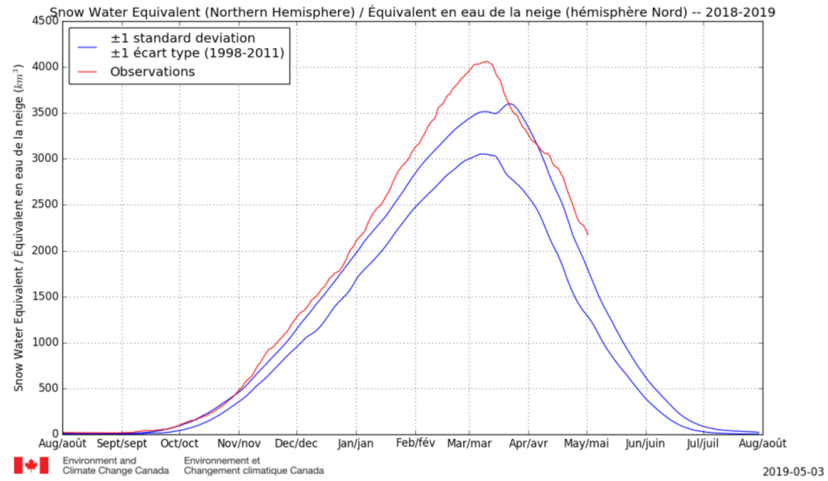
Precipitation Rate: February 2019 - April 2019 (Ranks)



# Terrestrial and marine snow

## Snow water equivalent (SWE)




**The snow water equivalent product (SWE) is based on the combination of satellite-based microwave radiometer and ground-based weather station data**

## Snow area

**The areal snow extent product is based on satellite-based optical data. It includes daily, weekly and monthly snow extent products excluding glaciers, Greenland, Antarctica and snow on ice (lakes/seas/oceans).**

### Canada

| *2019* | | *1981-2010 Normal* | | | *Period of Record from 11-1966* | |
|---|---|---|---|---|---|---|
| Month | Area | Mean | Departure | Rank | Maximum (Year) | Minimum (Year) |
| 3 | 10,102 | 10,023 | 78 | 30/53 | 10,368 (1982) | 9,486 (1981) |
| 2 | 10,390 | 10,279 | 111 | 7/53 | 10,424 (2013) | 10,015 (1981) |
| 1 | 10,312 | 10,294 | 18 | 28/53 | 10,424 (1982) | 10,060 (1981) |

| *2018* | | *1981-2010 Normal* | | | *Period of Record from 11-1966* | |
|---|---|---|---|---|---|---|
| Month | Area | Mean | Departure | Rank | Maximum (Year) | Minimum (Year) |
| 12 | 10,263 | 10,096 | 167 | 12/53 | 10,403 (2016) | 9,691 (1980) |
| 11 | 9,978 | 8,663 | 1,315 | 1/53 | 9,978 (2018) | 7,254 (1987) |

### Eurasia

| *2019* | | *1981-2010 Normal* | | | *Period of Record from 11-1966* | |
|---|---|---|---|---|---|---|
| Month | Area | Mean | Departure | Rank | Maximum (Year) | Minimum (Year) |
| 3 | 22,898 | 24,492 | -1,594 | 47/53 | 27,950 (1981) | 20,183 (2002) |
| 2 | 27,678 | 28,479 | -801 | 42/53 | 32,285 (1978) | 25,913 (2002) |
| 1 | 29,581 | 29,322 | 259 | 25/53 | 32,265 (2008) | 25,823 (1981) |

| *2018* | | *1981-2010 Normal* | | | *Period of Record from 11-1966* | |
|---|---|---|---|---|---|---|
| Month | Area | Mean | Departure | Rank | Maximum (Year) | Minimum (Year) |
| 12 | 27,594 | 27,135 | 460 | 16/53 | 29,699 (2002) | 22,882 (1980) |
| 11 | 22,053 | 20,474 | 1,580 | 13/53 | 24,132 (1993) | 16,796 (1979) |

### Alaska

| *2019* | | *1981-2010 Normal* | | | *Period of Record from 11-1966* | |
|---|---|---|---|---|---|---|
| Month | Area | Mean | Departure | Rank | Maximum (Year) | Minimum (Year) |
| 3 | 1,513 | 1,486 | 27 | 3/53 | 1,534 (2008) | 1,293 (1968) |
| 2 | 1,521 | 1,515 | 6 | 26/53 | 1,534 (tie) | 1,417 (1968) |
| 1 | 1,500 | 1,495 | 4 | 16-37/53 | 1,534 (tie) | 1,423 (1986) |

| *2018* | | *1981-2010 Normal* | | | *Period of Record from 11-1966* | |
|---|---|---|---|---|---|---|
| Month | Area | Mean | Departure | Rank | Maximum (Year) | Minimum (Year) |
| 12 | 1,500 | 1,480 | 19 | 7-23/53 | 1,534 (2012) | 1,330 (1967) |
| 11 | 1,403 | 1,406 | -3 | 33/53 | 1,500 (tie) | 950 (1979) |