November 2019 – April 2020 Arctic Seasonal Review

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WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM
World Meteorological Organization
Organisation météorologique mondiale

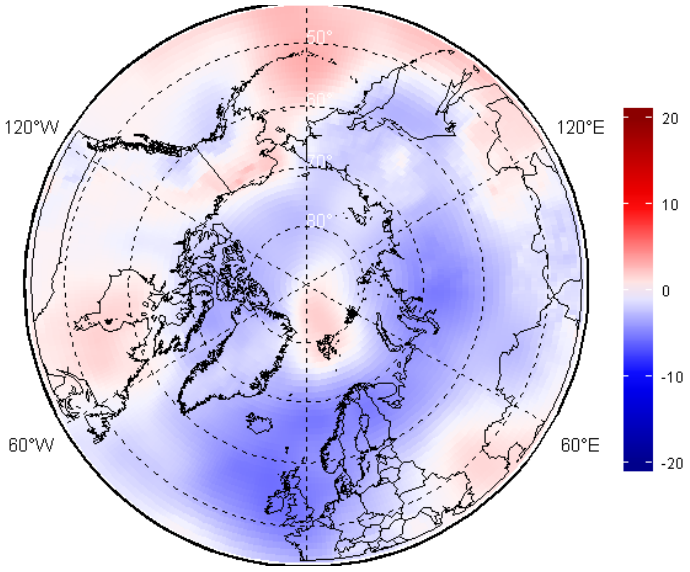
Content of review

- Review for 2 periods: NDJ 2019/2020 and FMA 2020
- Atmosphere variables include:
  - ✓ Atmospheric circulation (MSL) and geopotencial height (gp50, gp500)
  - ✓ Surface air temperature
  - ✓ Precipitation
- Sea ice variables include:
  - ✓ atmosphere and polar ocean precursors
  - ✓ Ice extent and ice conditions analysis
  - ✓ Sea ice thickness and volume reanalysis
- Polar Ocean
  - ✓ SST, waves and swell height (storminess)
  - ✓ pH (acidification/alkalization estimates)
- Solid precipitation (land snow)
- Briefs on current status (SAT, winds, Prec, sea ice, snow)

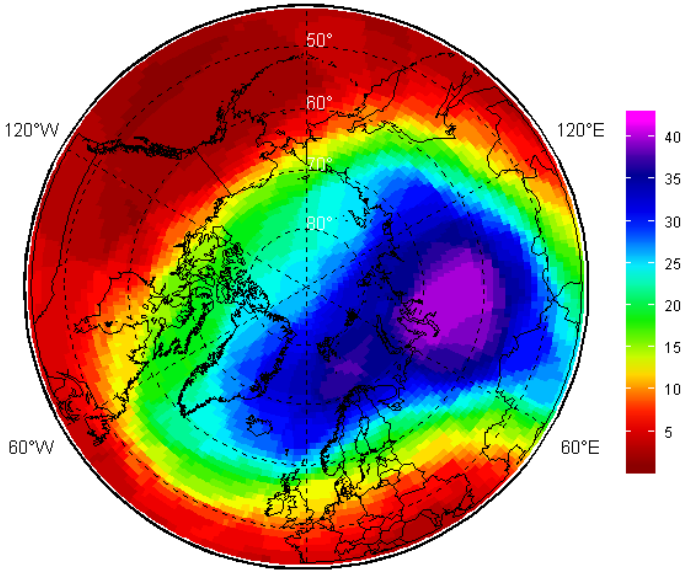
Atmosphere:

- ✓ Precursors - atmospheric circulation patterns
- ✓ Surface air temperature
- ✓ Precipitation

NDJ 2019/2020 atmospheric circulation



MSLP hPa anomalies (norms 1981-2010)



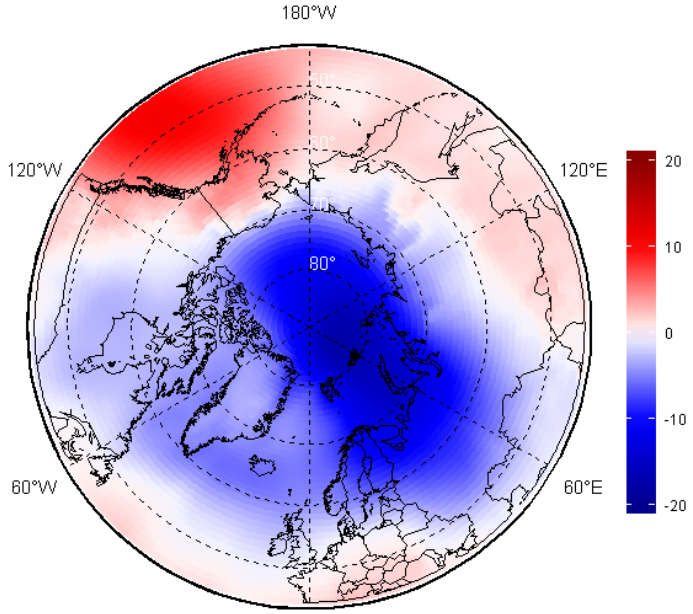
H50 ranks (1979-2020)

- Based on atmosphere numerical model (reanalysis)
- Negative mean sea level atmospheric pressure (MSLP) anomalies (lower pressure, marked in blue) dominated through the European, Siberian and Canadian archipelago regions
- Opposite situation (higher pressure, marked in red) was observed over Svalbard, Canadian and Alaska regions, Bering Sea

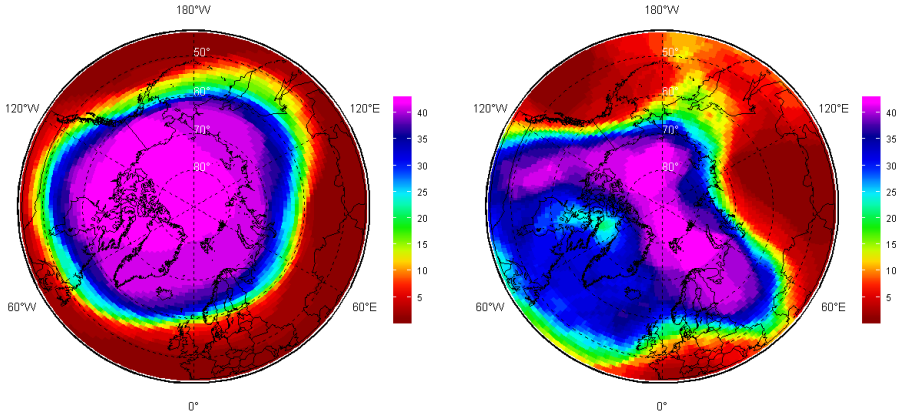
- That led to prevalence of zonal form of circulation (transfer of heal/cold west/east) in the troposphere with the center of polar vortex over western Siberia as seen on the 50 hPa geopotencial height (H50)

AARI / ERA5 reanalysis

FMA 2020 atmospheric circulation



MSLP hPa anomalies (norms 1981-2010)

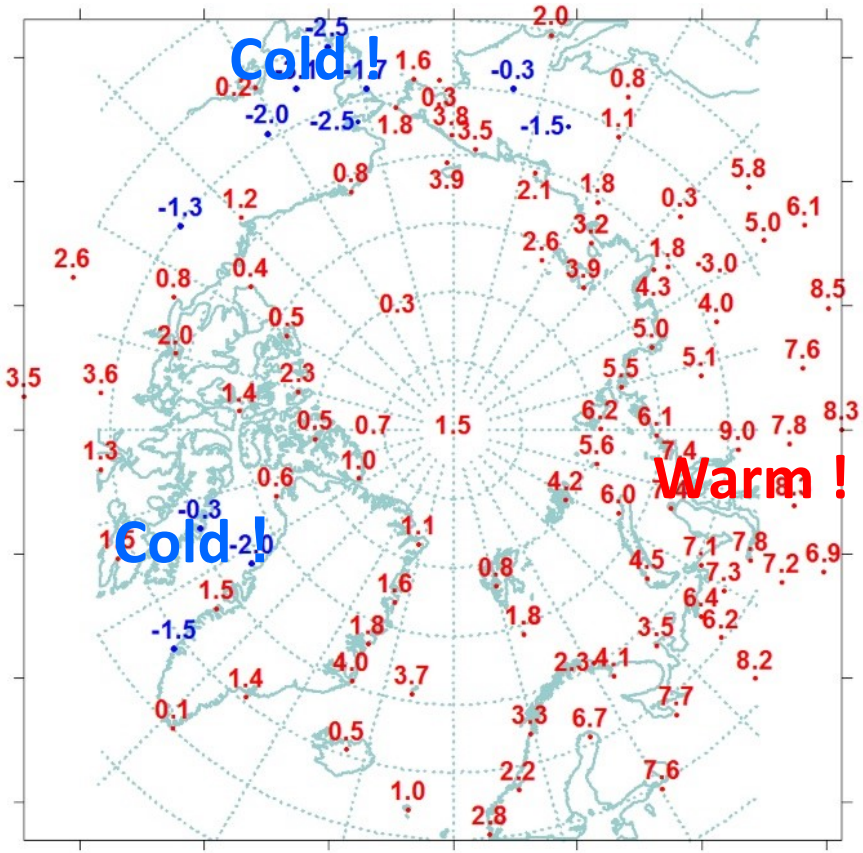


H50 (left) and H500 ranks (1979-2020)

- Much stronger negative MSLP anomalies (lower pressure, marked in blue) were observed during FMA 2020 in the European region, Western Siberia, Arctic Ocean but not in Alaska and Bering Sea
- That again led to increased cyclonic activity, more polar lows with further increased precipitation
- Polar vortex was very intense as observed at H50 pattern and caused meridian type of circulation with several 'heat waves' in Western and Eastern Siberia

[AARI / ERA5 reanalysis]

December 2019 – February 2020 SAT (T2m): anomalies and ranks (observation)



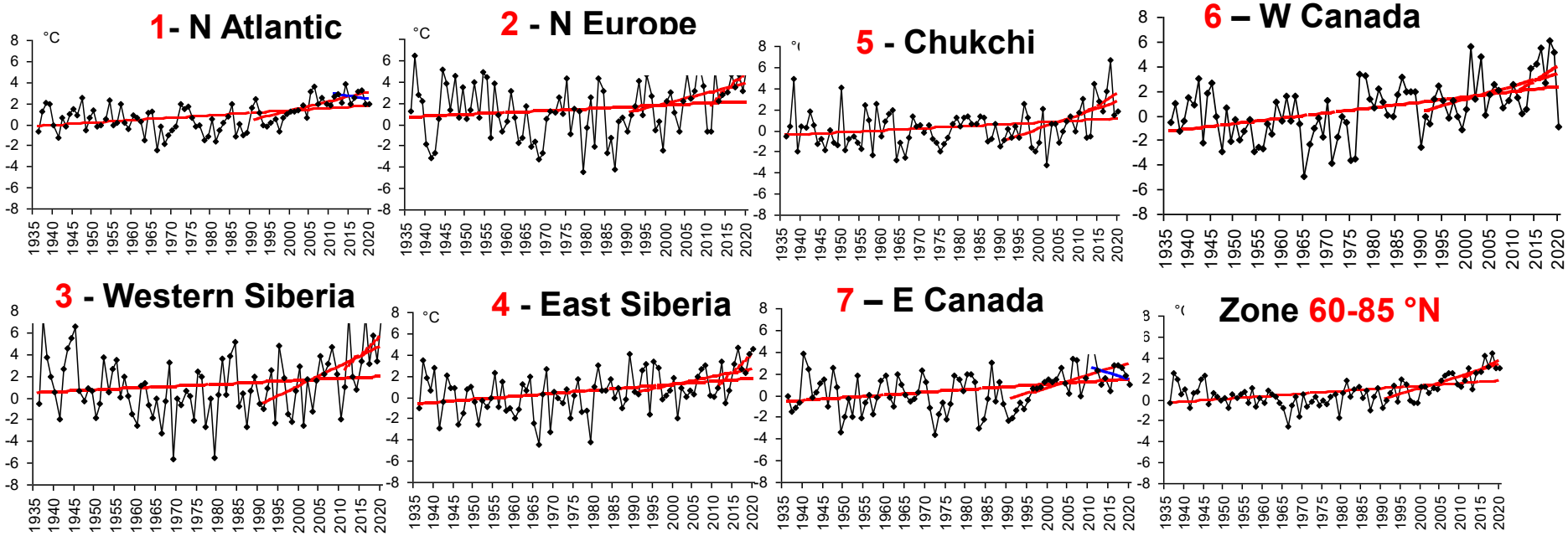
- The winter air temperature across Arctic was above normal except Alaska, Greenland, Svalbard, some parts of Canadian archipelago and Chukchi region.
- The most notable positive anomalies were present across of Western and Eastern Siberia Alaska and some parts of N Atlantic
- Very close to record high temperatures were observed in Eastern Siberia.

[AARI]

SAT anomalies by regions during winter 2019/20 (DJF) (observations)

Region	Anomaly	Rank	The warmest year (anomaly)	The coldest year (anomaly)
North Atlantic	1,9	14	2014 (3,9)	1966 (-2,4)
Barents	5,4	**3**	**1937** (6,5)	1979 (-4,4)
Western Siberia	7,2	**3**	2012, 2016 (7,6)	1969 (-5,6)
Eastern Siberia	4,6	**2**	2016 (4,6)	1966 (-4,5)
Chukchi	1,8	13	2018 (6,7)	**2002** (-2,3)
Western Canada	-0,9	42	2018 (6,1)	1965 (-5,6)
Eastern Canada	1,2	18	2010 (5,0)	1972 (-3,6)

Reference period: 1961-1990

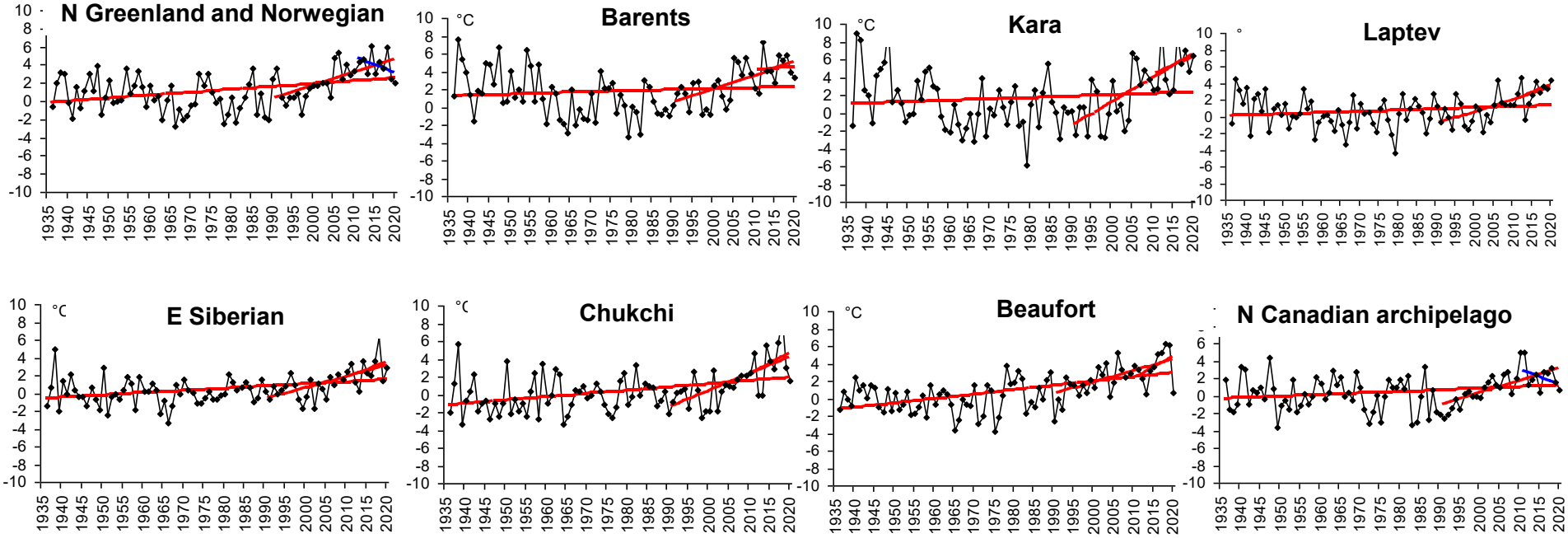


[AARI]

SAT anomalies by Arctic seas during winter 2019/20 (DJF) (observations)

Sea	Anomaly	Rank	The warmest year (anomaly)	The coldest year (anomaly)
Northern part of Greenland and Norwegian Seas	2,1	19	2014 (6,1)	1966 (-2,7)
Barents Sea	3,3	20	**1937** (7,6)	1979 (-3,4)
Kara Sea	6,5	8	1945 (9,8)	1979 (-5,9)
Laptev Sea	4,4	**3**	2012 (4,6)	1979 (-4,4)
Eastern Siberian Sea	2,9	7	2018 (6,5)	1966 (-3,3)
Chukchi Sea	1,6	19	2018 (8,8)	1939 (-3,4)
Beaufort Sea	0,7	29	2018 (6,3)	1966 (-3,1)
N part of Canadian arhipelago	1,0	18	2010 (5,0)	1949 (-3,6)

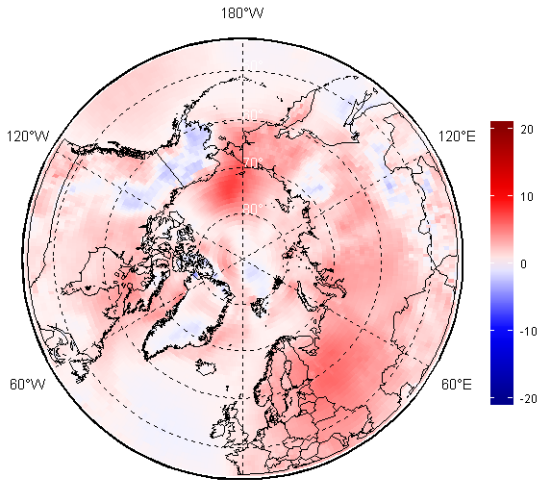
Reference period: 1961-1990



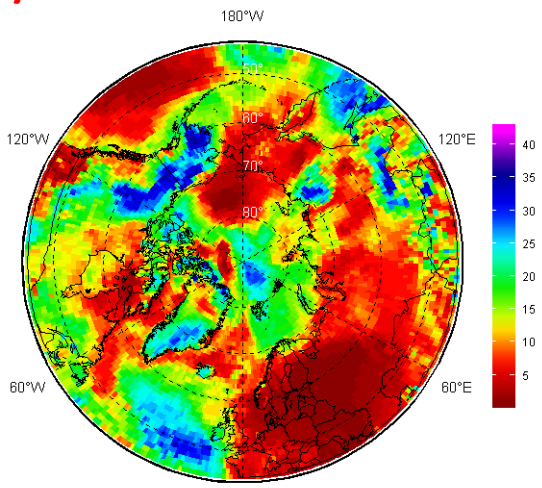
[AARI]

NDJ 2019-2020, FMA 2020 – SAT (T2m): anomalies and ranks

NDJ 2019/2020

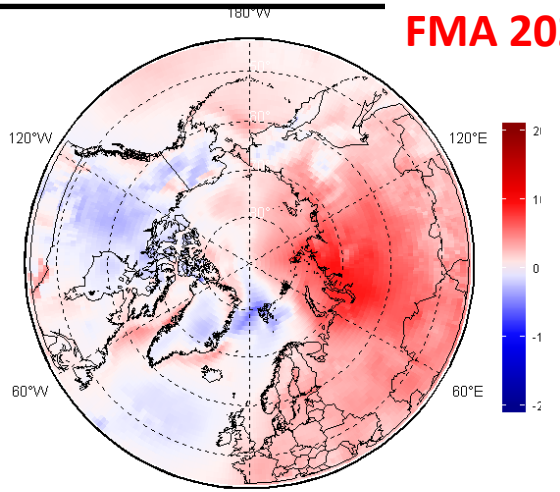


SAT anomaly, 1981-2010

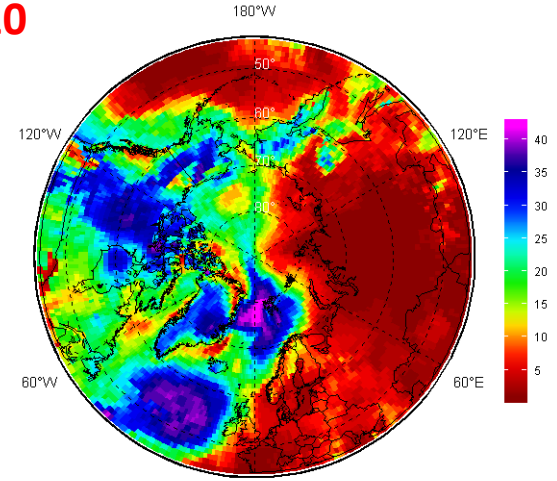


SAT rank, 1979-2020

FMA 2020



SAT anomaly, 1981-2010



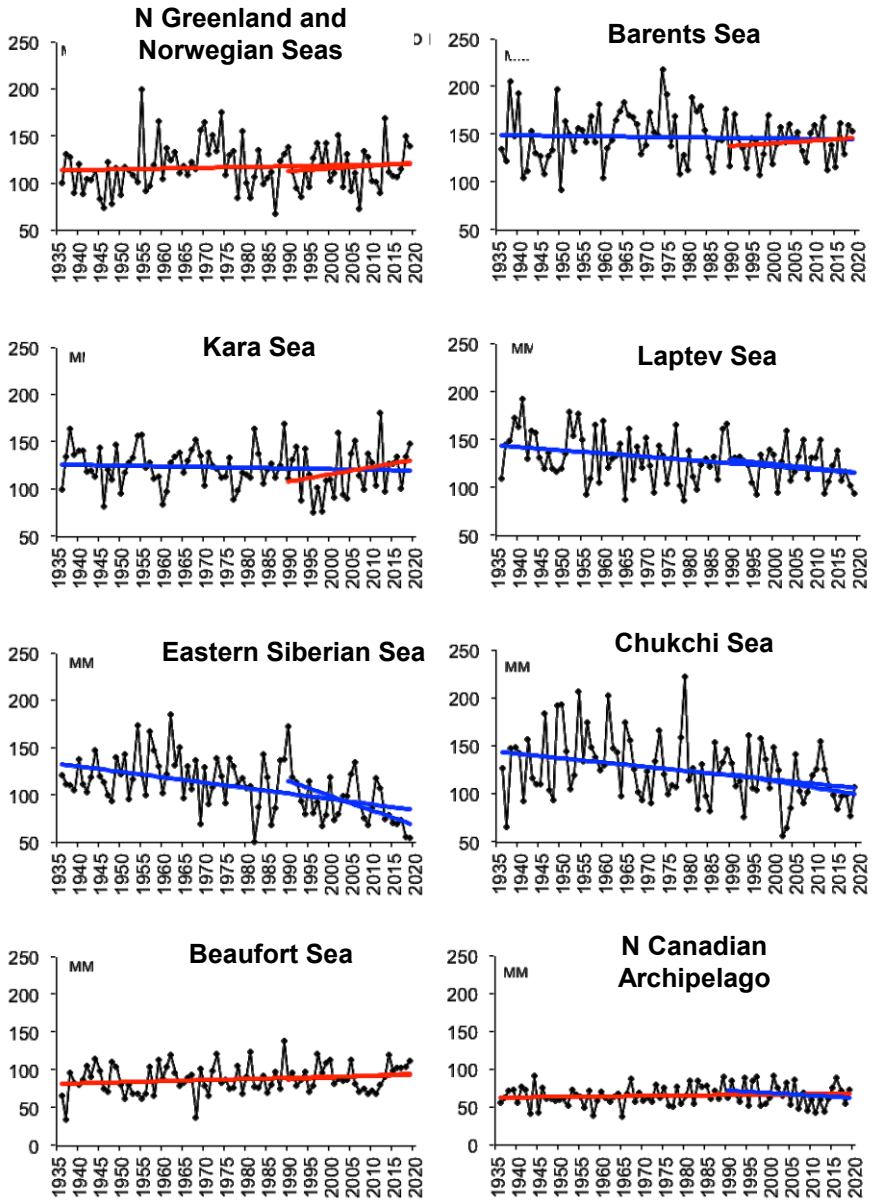
Rank, 1979-2020

- For the whole season from November 2019 – April 2010 positive close to maximum air temperature anomalies prevailed over Western and Eastern Siberia, with negative anomalies prevailing in marine Barents, Alaska and parts of Western Canada
- Atlantic and partly Chukchi areas experienced switch from positive to negative anomalies during NDJ - FMA

AARI / ERA5 reanalysis

Precipitation trends for ND 2019 - J 2020

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

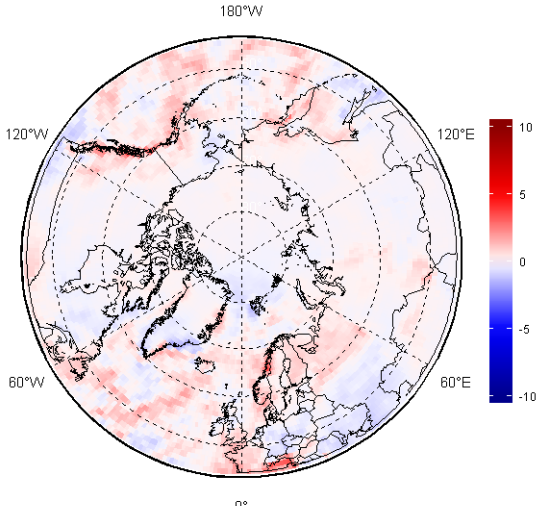


Reference period: 1961-1990

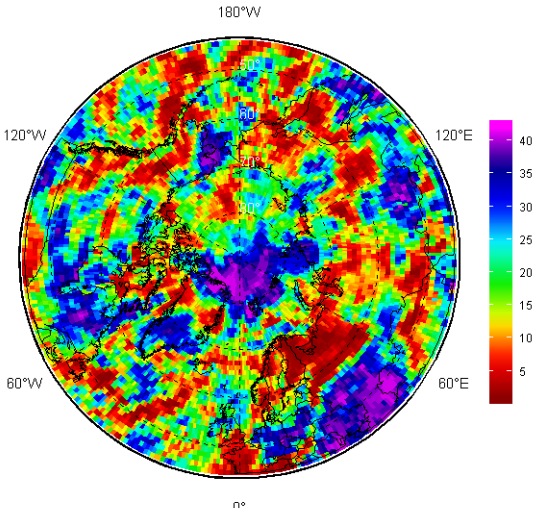
[AARI]

Precipitation (Prec) NDJ and FMA 2019/2020: anomalies and ranks

NDJ 2019/2020

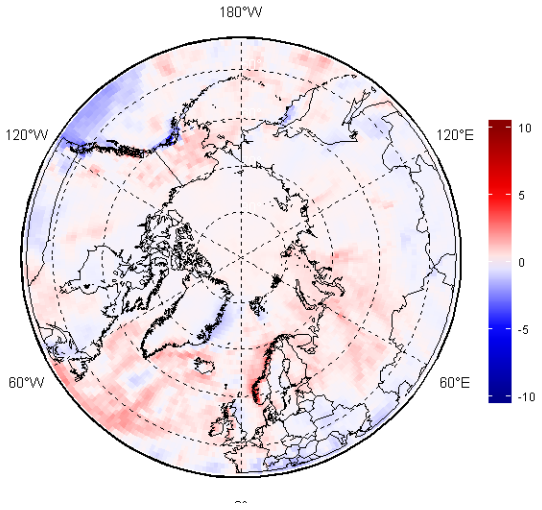


Prec Anomaly, 1981-2010

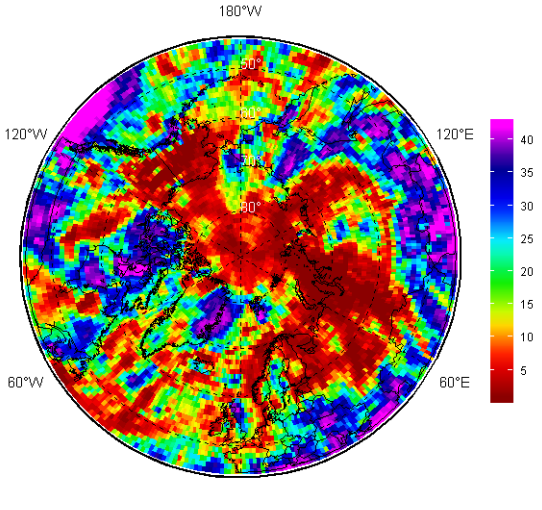


Prec Rank, 1979-2020

FMA 2020



Prec Anomaly, 1981-2010



Prec Rank, 1979-2020

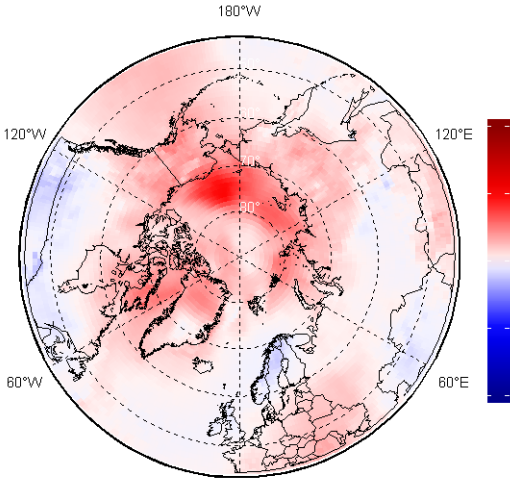
- For NDJ 2019/2020 and FMA 2020 Barents and Western Siberia regions saw very wet seasons
- Same wetter conditions observed for Alaska during FMA 2020
- Drier conditions were observed over Svalbard, parts of Greenland, Sea of Okhotsk

[AARI / ERA5 reanalysis]

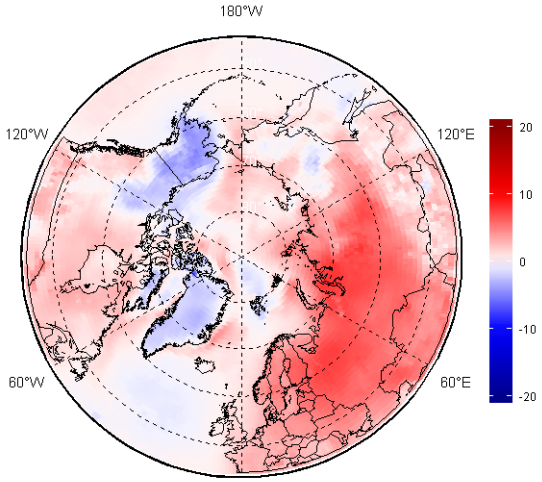
Sea ice variables:

- ✓Precursors in atmosphere and polar ocean
- ✓Ice extent and ice conditions analysis
- ✓Sea ice thickness and volume based on coastal stations and reanalysis

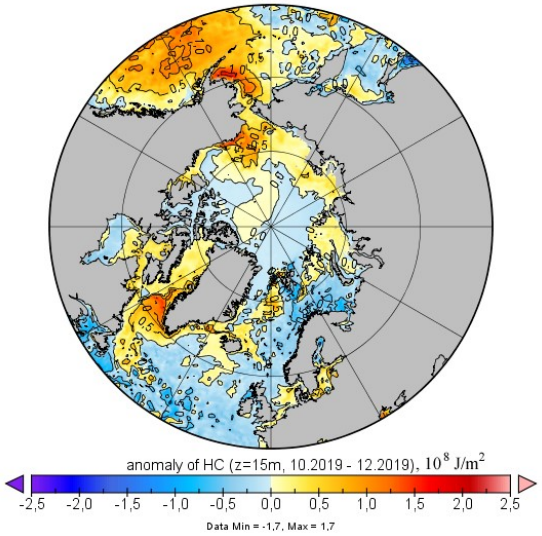
Atmosphere – polar ocean precursors for winter – spring 2019 – 2020 sea ice conditions



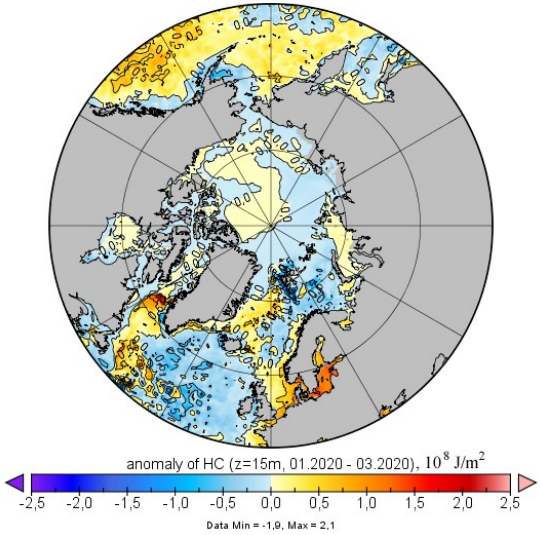
SAT SON anomaly, 1981-2010



SAT DJF anomaly, 1981-2010



Heat Capacity anomaly OND, 2000-2019

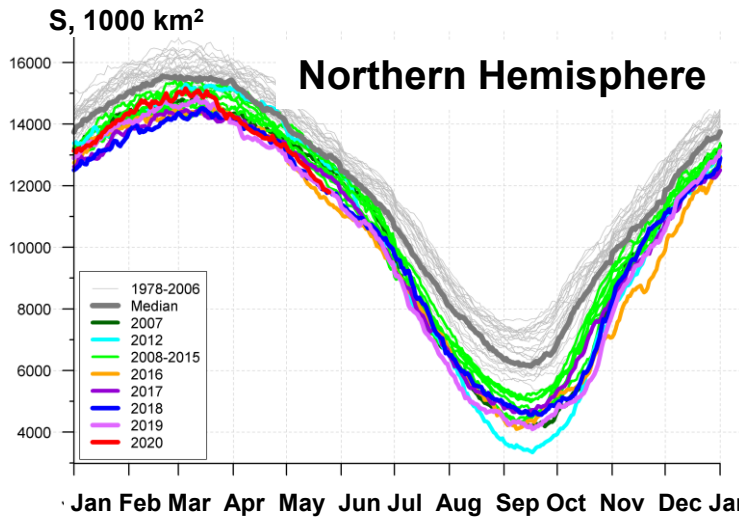


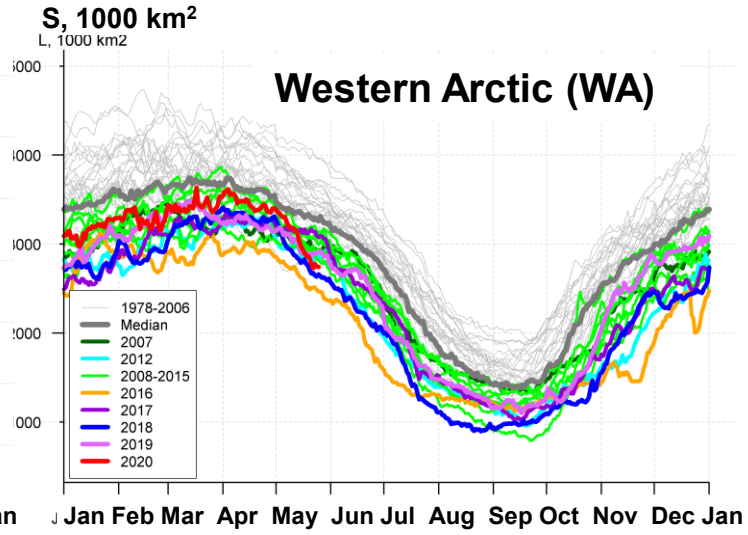
Heat Capacity anomaly JFM, 2000-2019

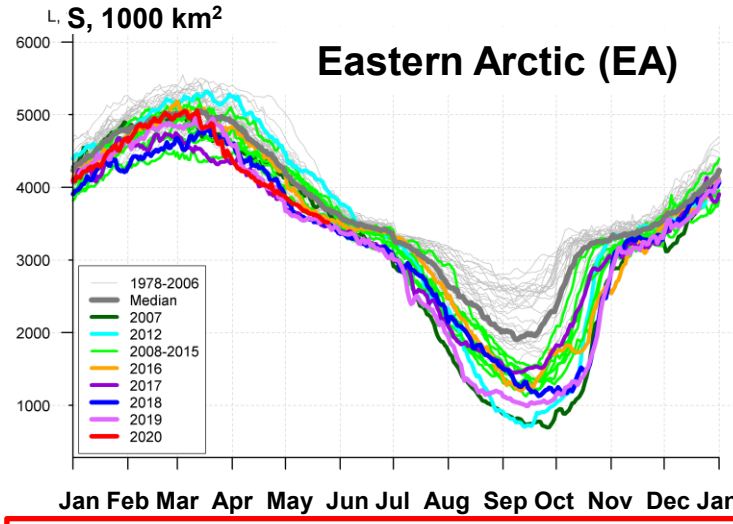
- High positive anomalies in surface air temperature (SAT) as well as prevailing positive polar ocean heat capacity (HC) in upper 15m during OND 2019 slowed in general freeze-up and sea ice growth in the Arctic
- Further in time lesser positive SAT anomalies as well as in general neutral HC anomalies during JFM stimulated ice extent growth
- Prominent negative HC anomalies lead to close to normal ice growth in the N Barents Sea and Sea of Okhotsk

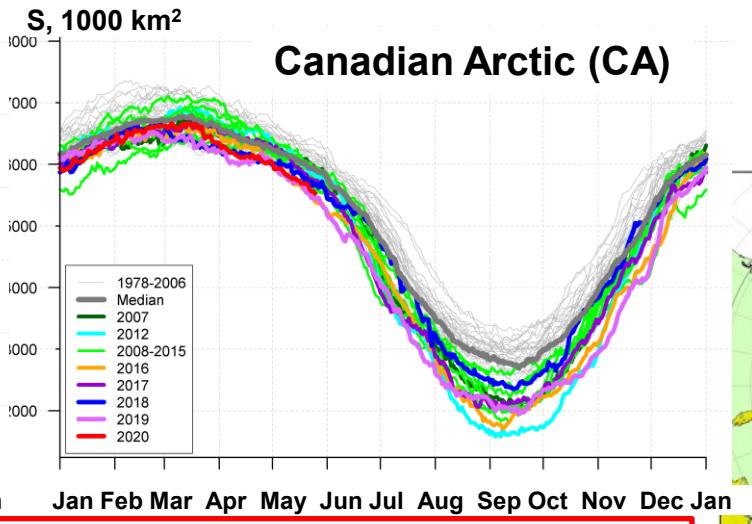
[AARI / Copernicus Climate Change Service (ERA5 & MERCATOR reanalysis)]

Arctic (NH) seasonal ice extent 1978…. 2020



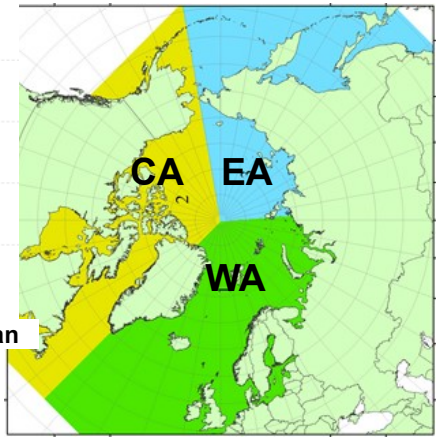






S, 1000 km²*	
2017	14467
2018	14516
2015	14526
2016	14580
2011	14701
2006	14867
2019	14891
2007	14931
2014	14972
2005	15101
2020	15159
…	…
1988	16461
1983	16547
1979	16769

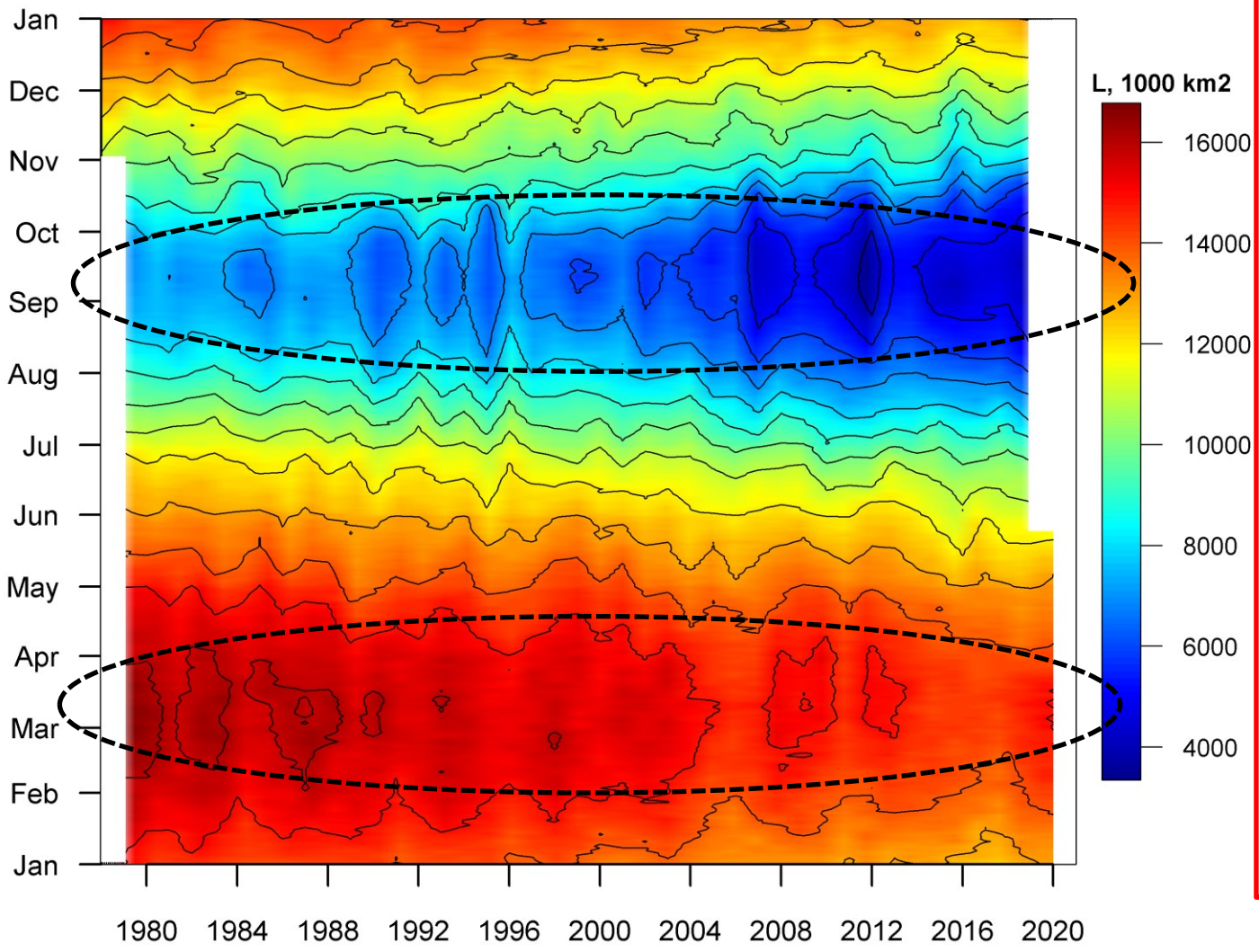
* - maximum for Mar (AARI)



- Maximum winter ice extent, 1th in row, 15,16 mln km² (14,89 in 2019) reached 4 March 2020 (11 March in 2019)
- During freezing period (ND 2019) lowest on record was observed due to extreme minimums in Bering, Chukchi Seas

[AARI, NSIDC]

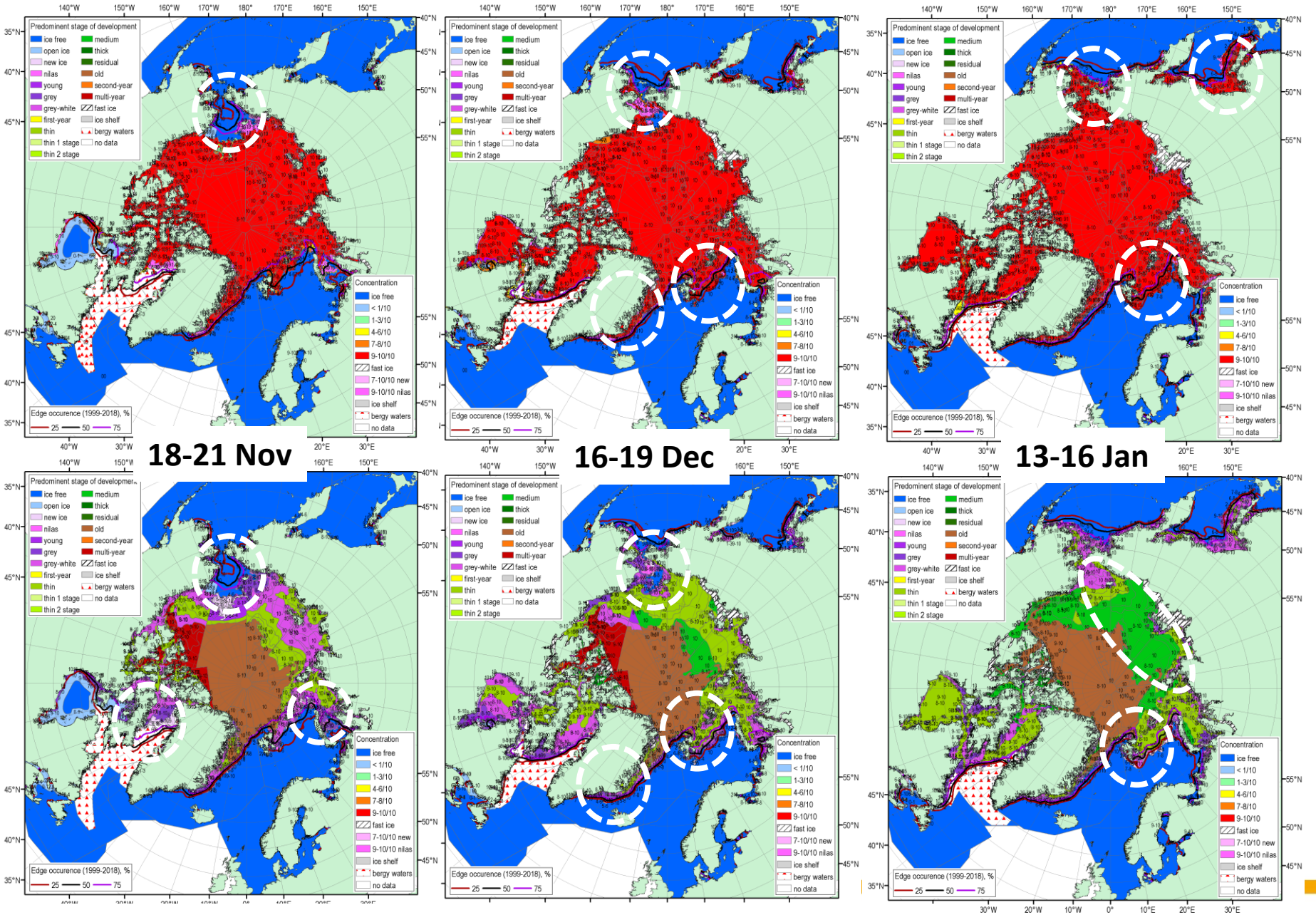
Seasonal NH ice extent variability: 1978 - 2020



- Seasonal patterns of daily ice extent allows to analysis seasonal variability of ice extent
- Both winter maximums and summer minimums continue to diminish
- Though, significant interannual variability of ice extent occurs

[AARI, NSIDC]

NDJ 2019/2020 Arctic sea ice – concentration and stage of development



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

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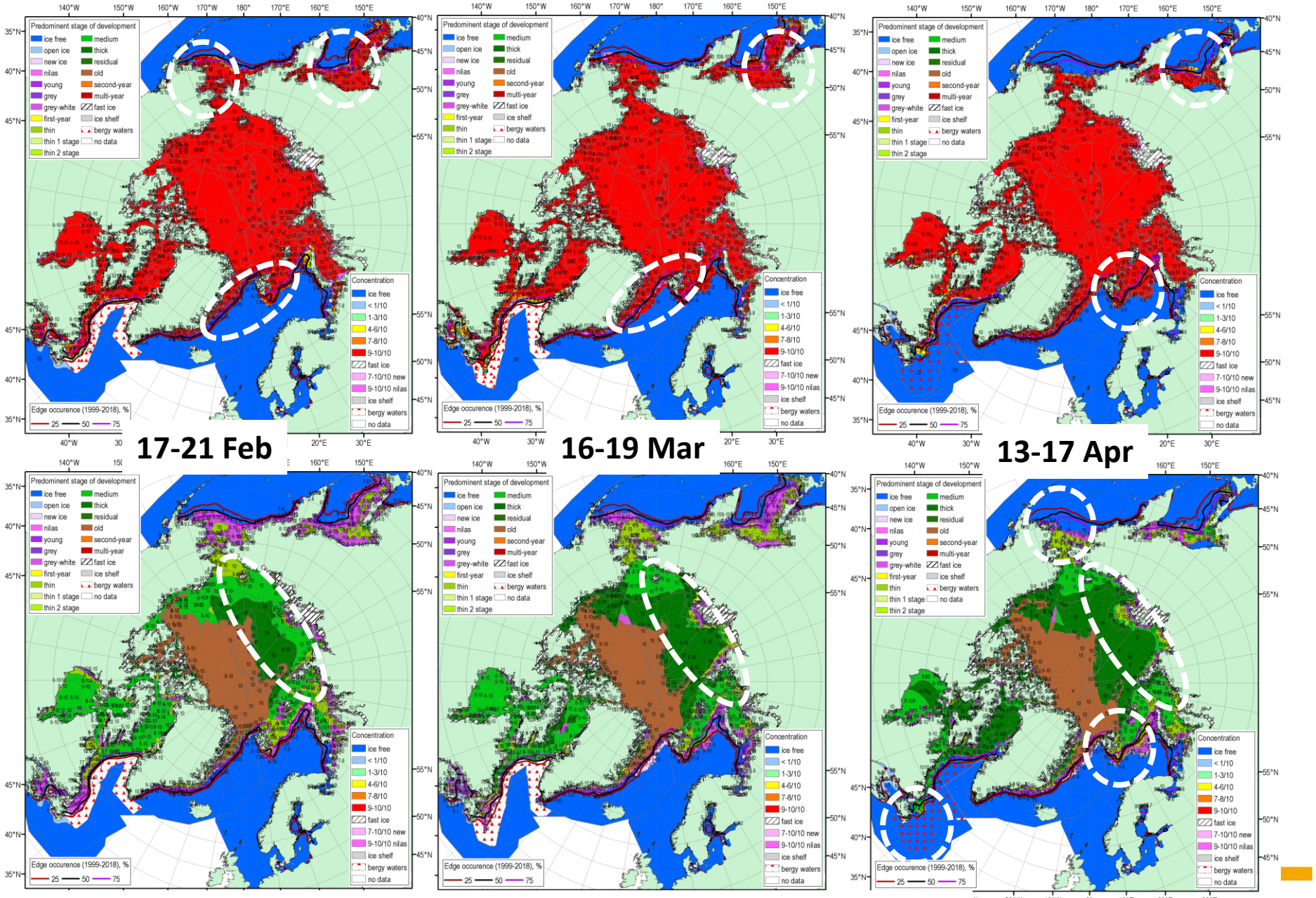
FMA 2020 Arctic sea ice – concentration and stage of development



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

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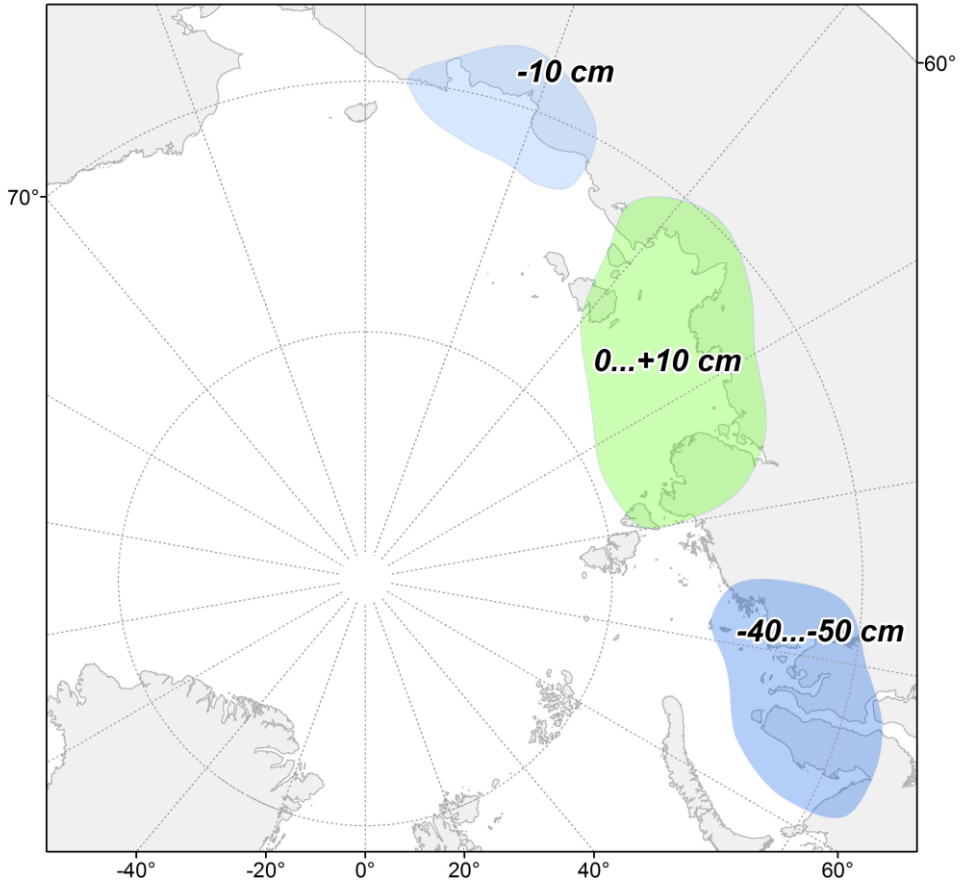
Sea ice fast ice maximum thickness values and anomalies by end of April/Mar 2019 (stations)



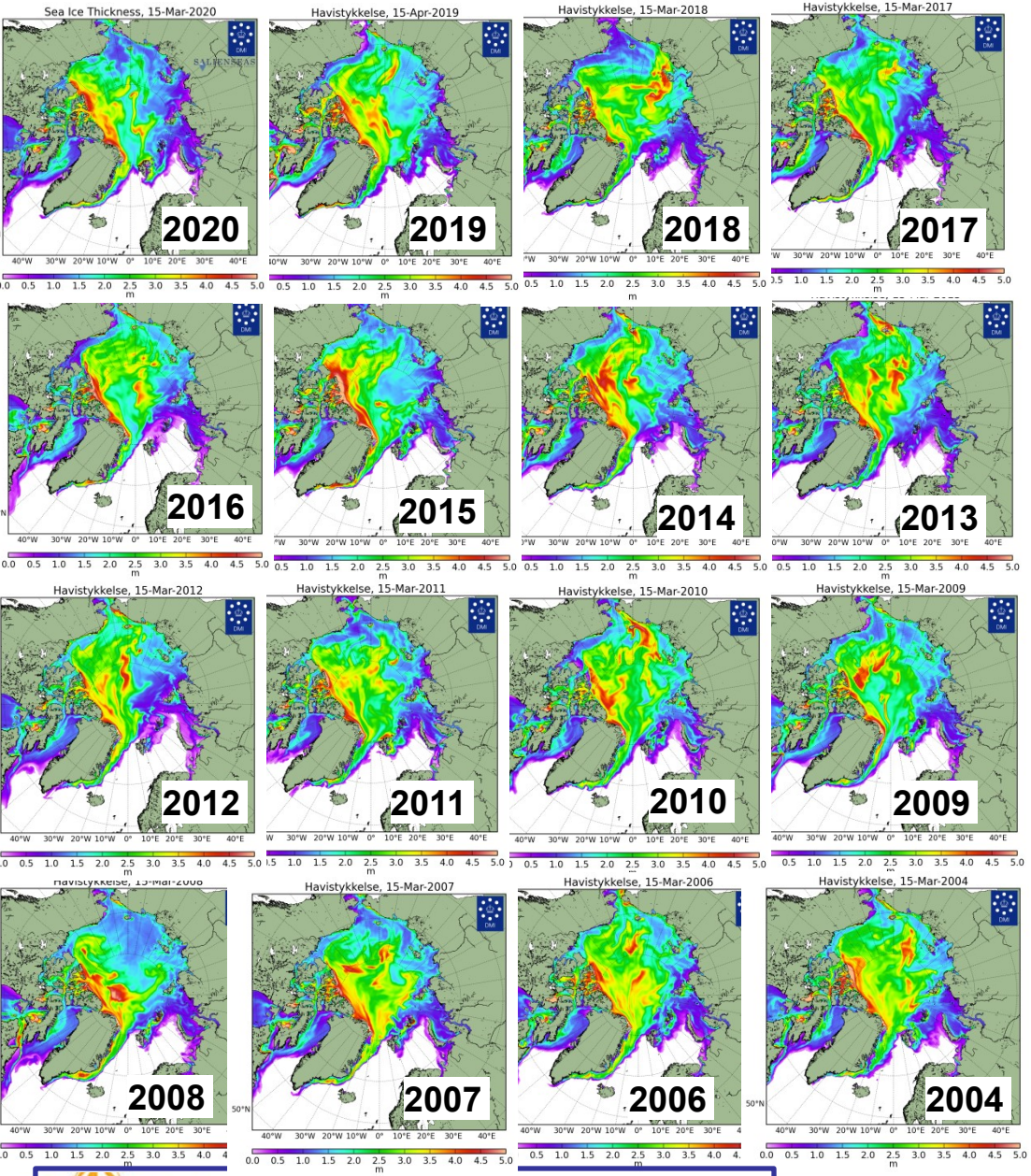
WMO stations used:
Russia: 12 (Varandey, Amderma, Belyi, Dikson, Sterlegova, Cheluskin, Tiksi, Kotelnyi, Sannikova, Ayon, Valkarkay)

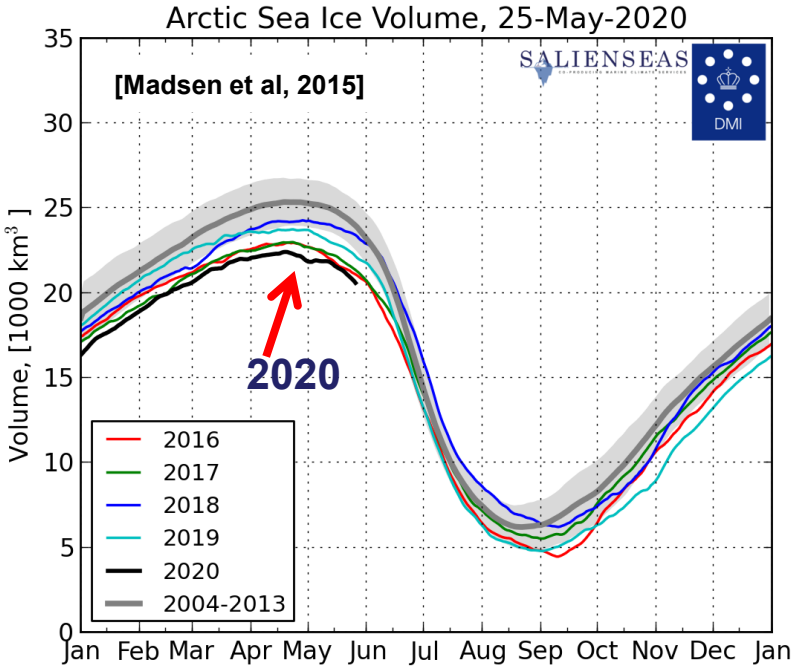
- **Observed maximum winter ice thicknesses significantly less than normal (for the last 30 years) for Kara Sea (up to -50 cm, which is opposite to 2019) and slightly less than normal for Eastern Siberian Sea**
- **Slightly thicker ice observed in Laptev Sea**

Ref [1989-2019]

[AARI]

Sea ice thickness for 15 Mar 2004…2020 and ice volume





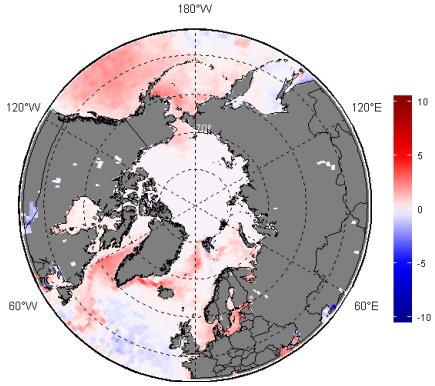
- **Models show Arctic ice volume in 2020 the lowest from Oct 2019 for 2004-2020 with 2nd in row in 2016**
- **The present ice extent slightly higher then in 2016 means sea ice thicknesses in winter / spring 2019/2020 are in general lower then in 2019**

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

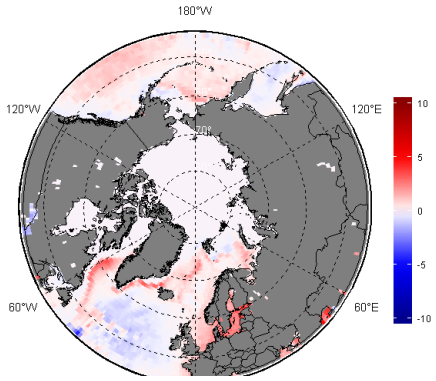
Polar Ocean:

- ✓ Sea surface temperature
- ✓ pH and acidification or alkalization of the Arctic ?
- ✓ Storms - Wave and swell height

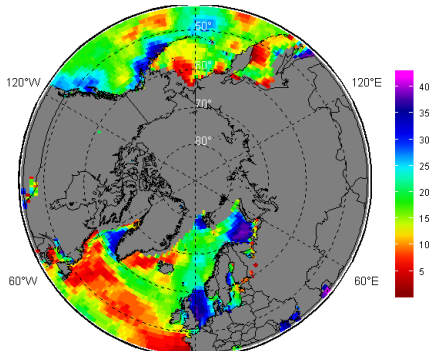
Waves and ph in the Arctic Ocean - NDJ 2019-2020, FMA 2020



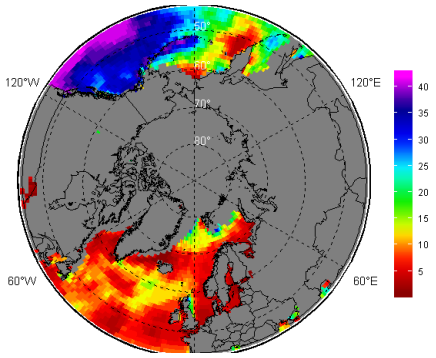
SST NDJ anomaly, 1981-2010



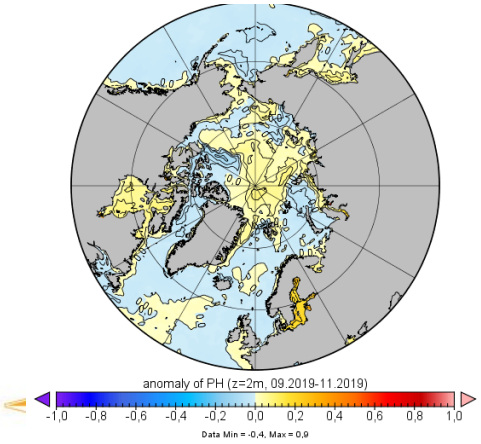
SST FMA anomaly, 1981-2010



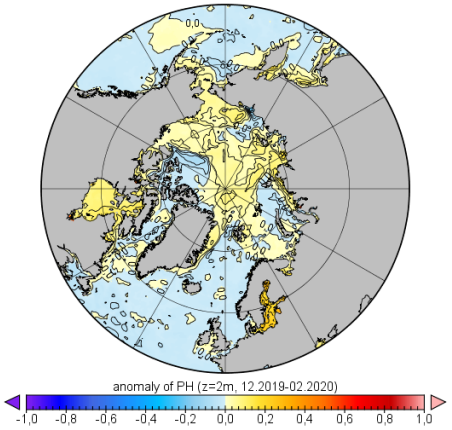
WW&S height NDJ rank, 1979-2020



WW&S height FMA rank, 1979-2020



pH anomaly 2m SON 2000-2019



pH anomaly 2m DJF 2000-2019

- Boundary seas of the Arctic Ocean were in general warmer and stormy during winter-spring 2019-2020 with exceptions Svalbard and N Greenland (colder, calmer), Sea of Okhotsk (colder)
- Numerical models show both positive (Arctic Basin, Chukchi Sea) and negative pH (Barents, Kara Sea, Canadian Arctic) anomalies to the last 20 years, that allows occurrence of both alkalization and acidification processes in the Arctic (no effect to wildlife?

AARI / Copernicus Climate Change Service
(ERA5 & MERCATOR reanalysis)

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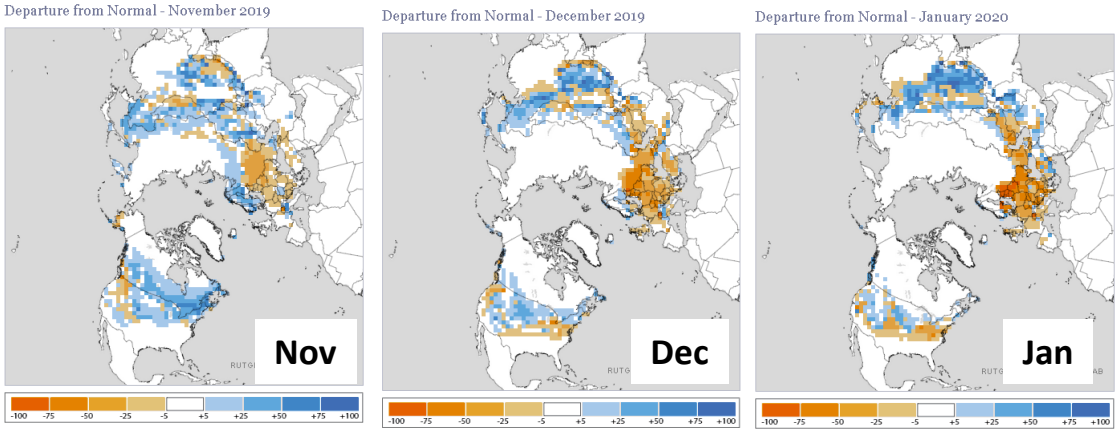
Land Snow:

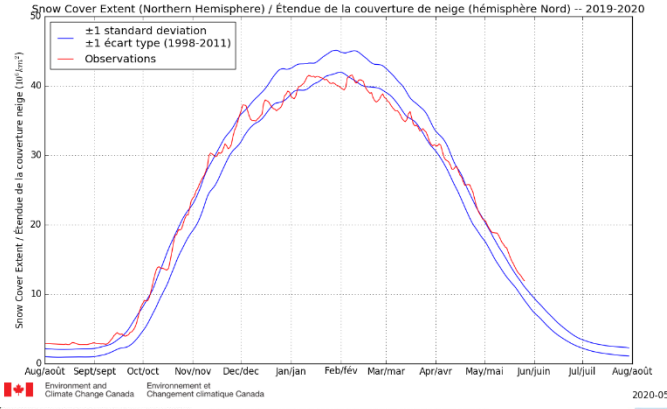
- ✓ Snow water equivalent
- ✓ Snow extent

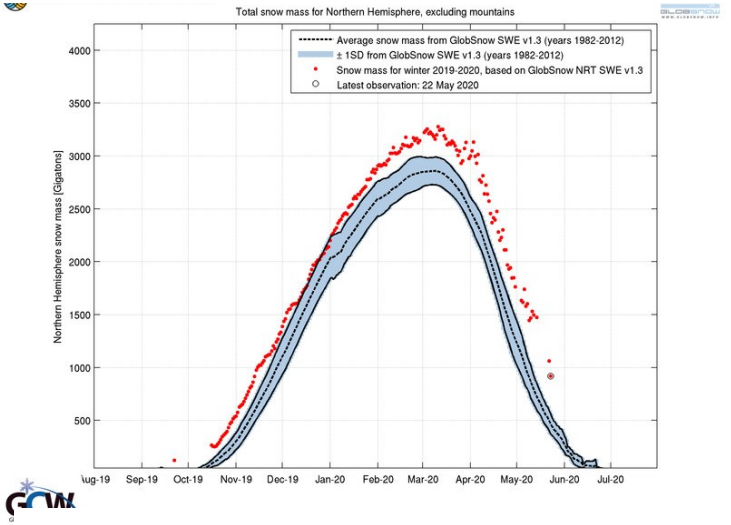
Land snow (satellite, obs)

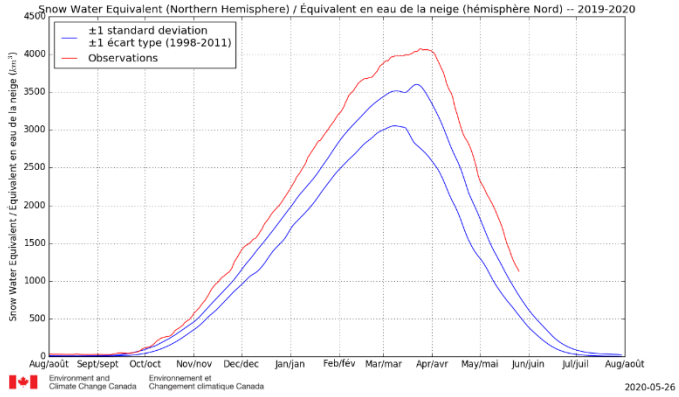
- Snow extent in winter-spring 2019/2020 was less than normal with prominent negative anomalies (no snow) in most of European sector
- Positive anomalies (more snow) were observed in Scandinavia, southern Canada
- Greater Snow Water Equivalent in 2019/2020 means higher snow height observed



Ref [1981-2010]

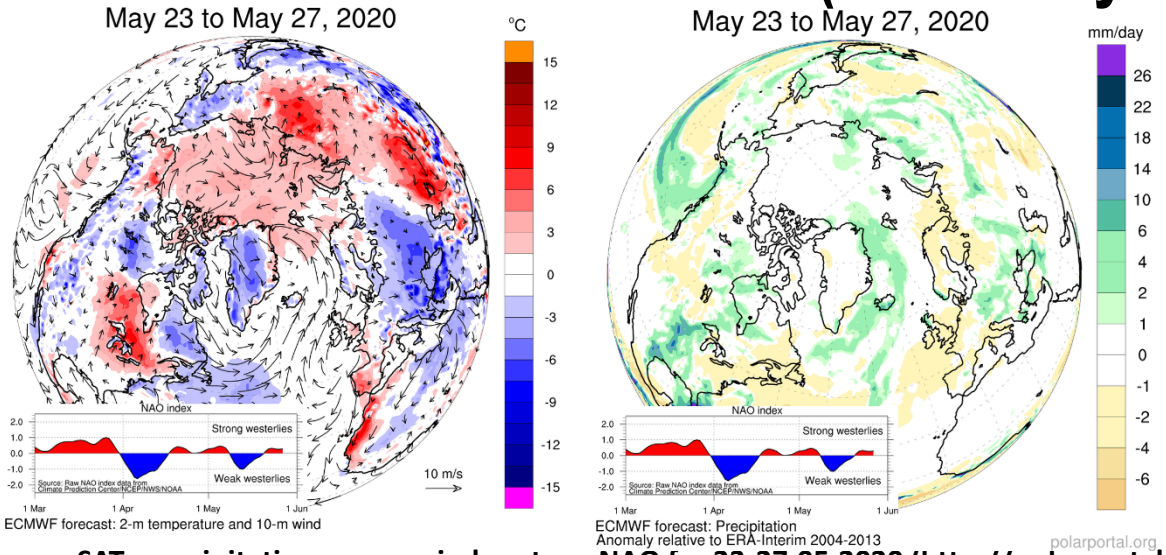




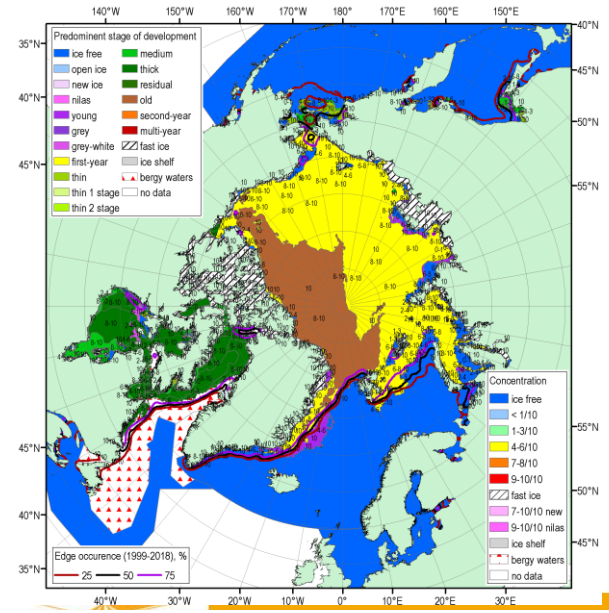


[FMI, ECCC, Rutgers Glob Snow Lab / GCW)]

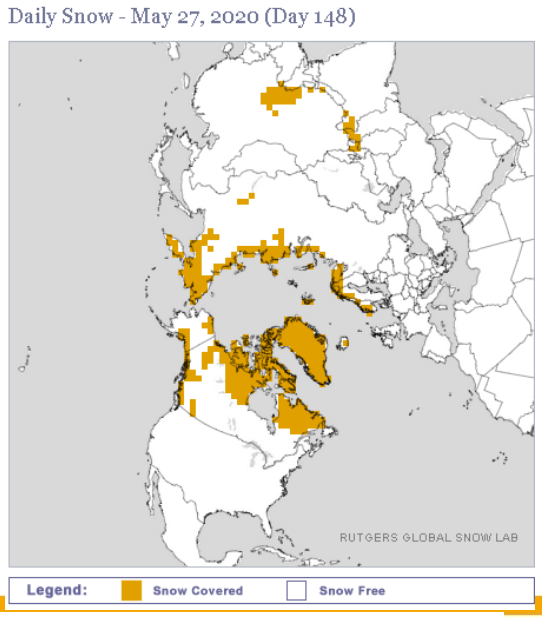
Current Conditions (21-26 May 2020)



SAT, precipitation, mean wind vectors, NAO for 23-27.05.2020 (http://polarportal.dk)



AARI/NIC ice chart for 21-26 May 2020



Snow extent for 27 May 2020, Rutgers Global snow lab

- Till now week westerly, moderate northern winds in European sector and strong southern winds over Siberia (NAO~0) led to lower SAT in European sector, prominent higher SAT over Siberia and the Arctic Ocean ('heat waves')
- Northern Scandinavia, Arctic coasts, Chukchi peninsula are still under snow
- NE part of Barents Sea, Kara, W Laptev Seas, Chukchi Sea are under intense ice melt which is extreme
- However general pattern of TransArctic drift keeps ice conditions in Greenland Sea and Svalbard waters near normal

World Meteorological Organization

Weather • Climate • Water

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

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 30th-45th warmest, that is **near the median** for the same period.

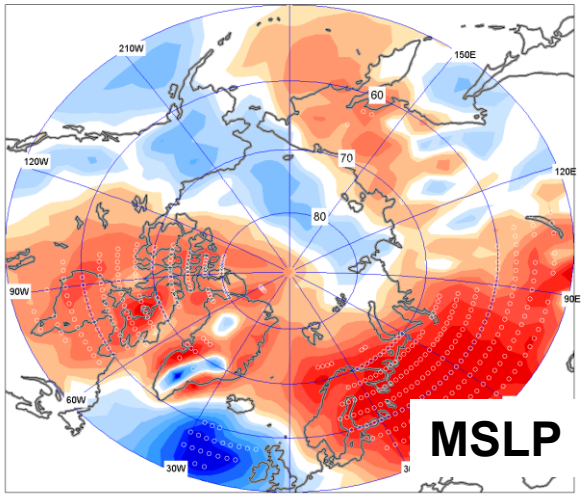
Precipitation: **Siberia** saw their **driest winter** (NDJ) in the 70-year record. The southern portion of the Canadian Arctic saw their driest spring (FMA) in the 70-year record, while **northeastern Siberia** and a portion of the **Arctic Ocean** saw their **wettest spring** on record.

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

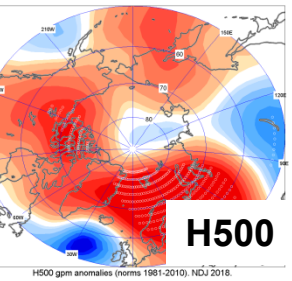
Sea ice: The winter **maximum sea ice extent** (14.89 mln km^2), reached on 11/03**, was the 7th minimum in row since 1979** (2018 – 2nd), with the maximum winter sea ice extent observed in 1979 (16.77 mln km^2). Estimates of the sea ice volume, based on numerical reanalysis (HYCOM-CICE, PIOMAS), show 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.

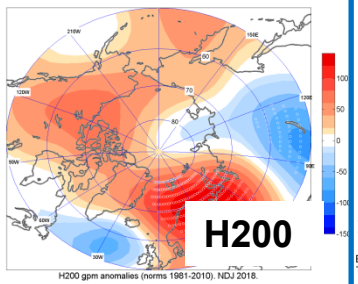
NDJ 2018/2019 atmospheric circulation (reanalysis)



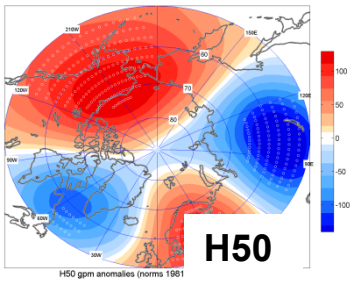
MSLP hPa anomalies (norms 1981-2010). NDJ 2018.



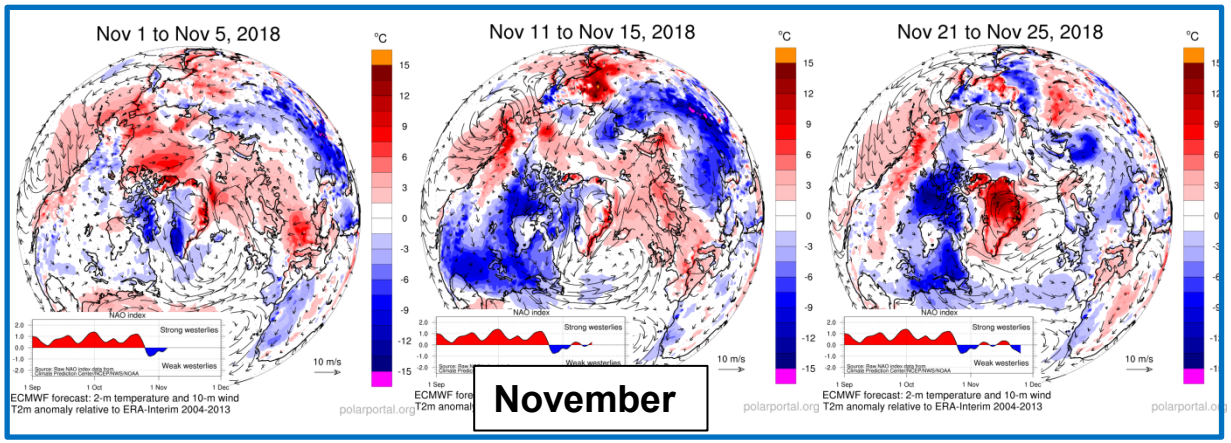
H500 gpm anomalies (norms 1981-2010). NDJ 2018.

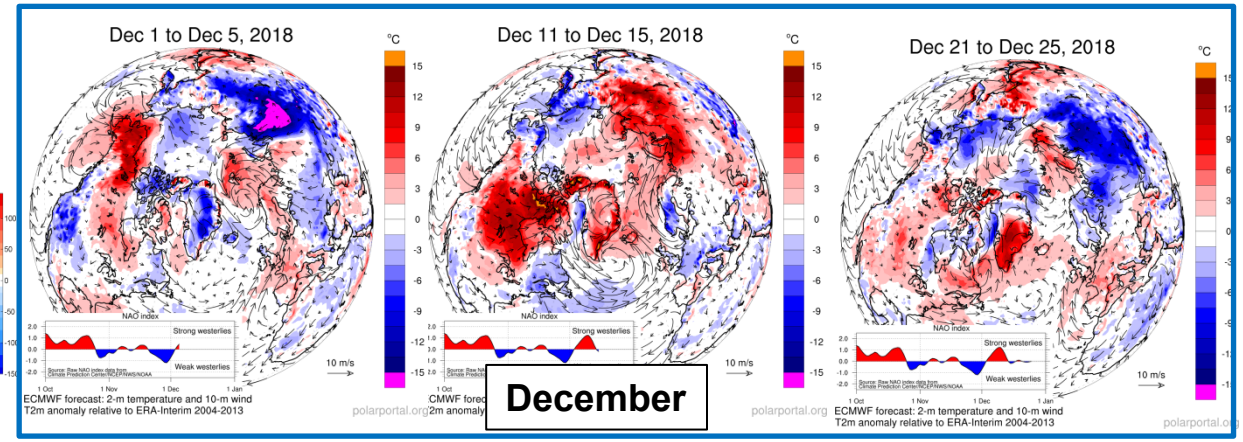


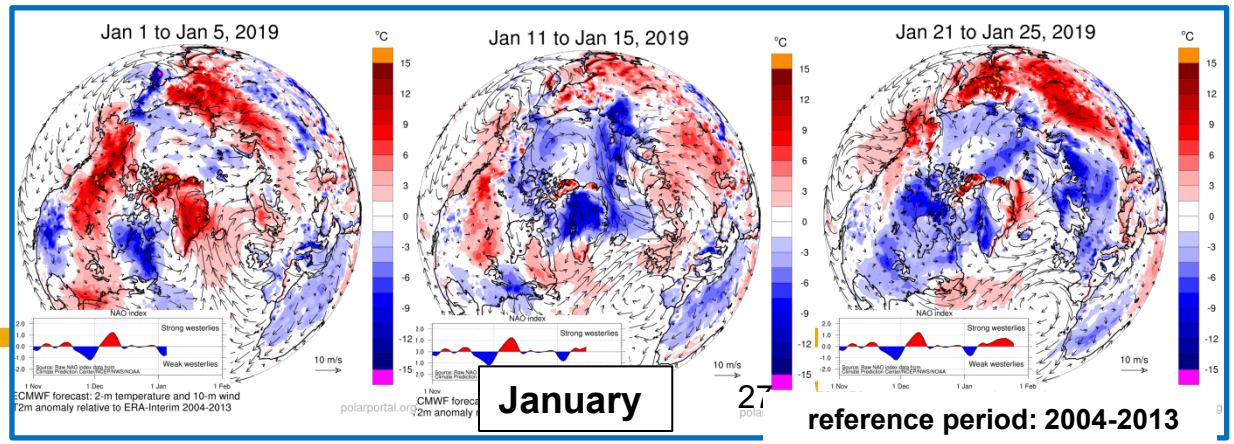
H200 gpm anomalies (norms 1981-2010). NDJ 2018.



H50 gpm anomalies (norms 1981



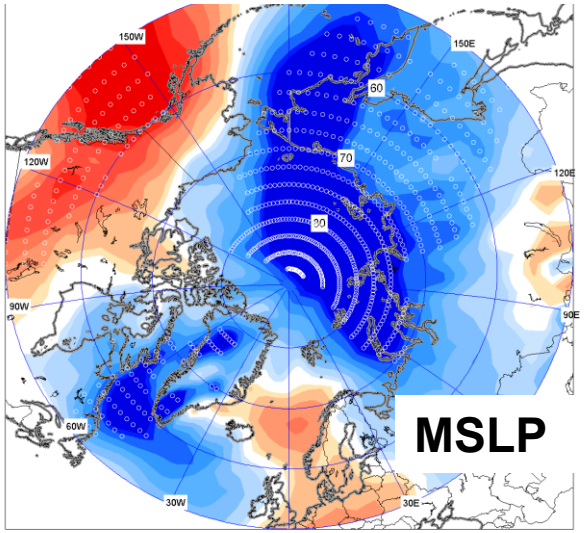




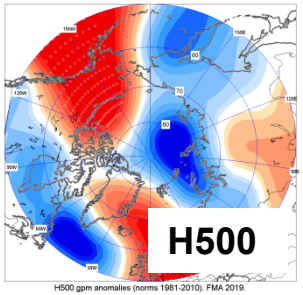
[HMC Moscow, DMI]

reference period: 2004-2013

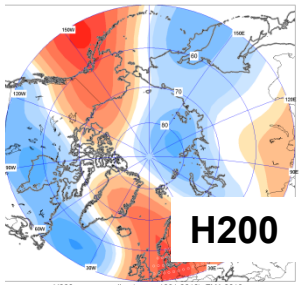
FMA 2019 atmospheric circulation (reanalysis)



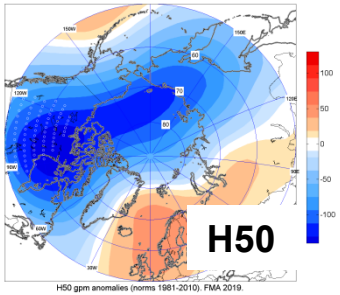
MSLP hPa anomalies (norms 1981-2010). FMA 2019.



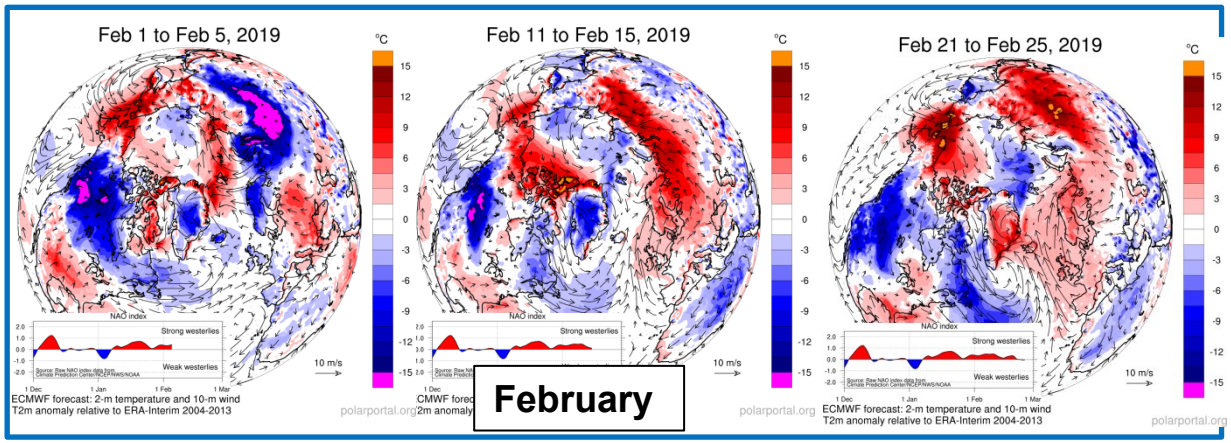
H500 gpm anomalies (norms 1981-2010). FMA 2019.

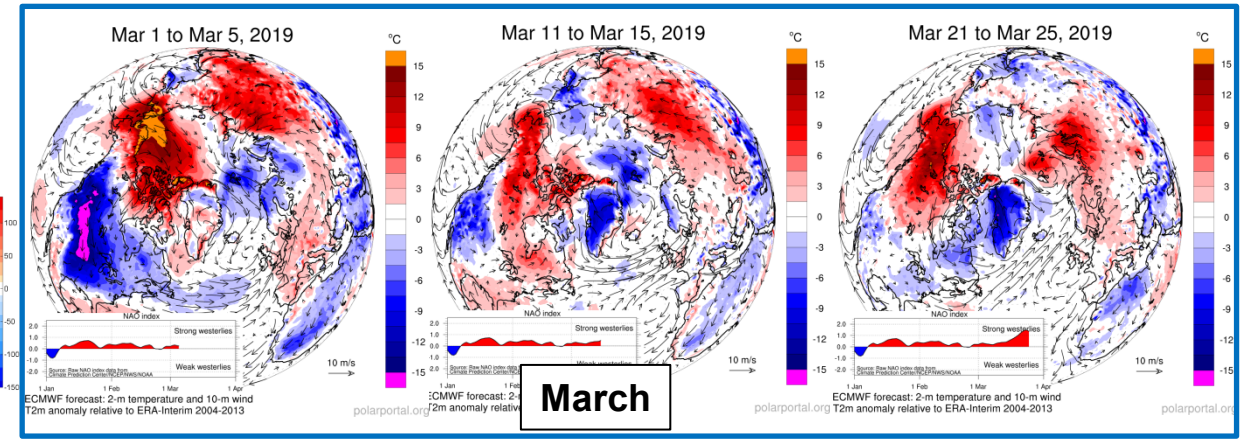


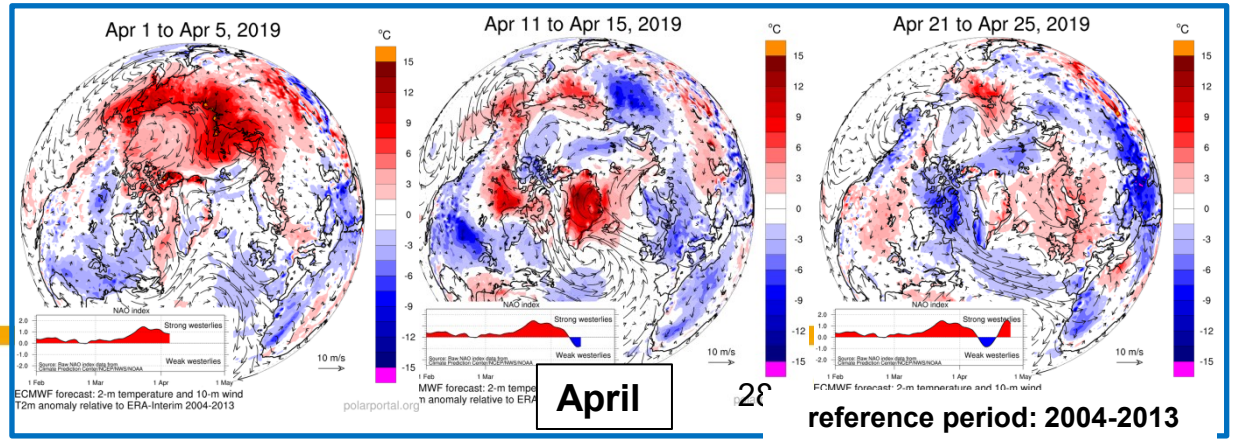
H200 gpm anomalies (norms 1981-2010). FMA 2019.



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





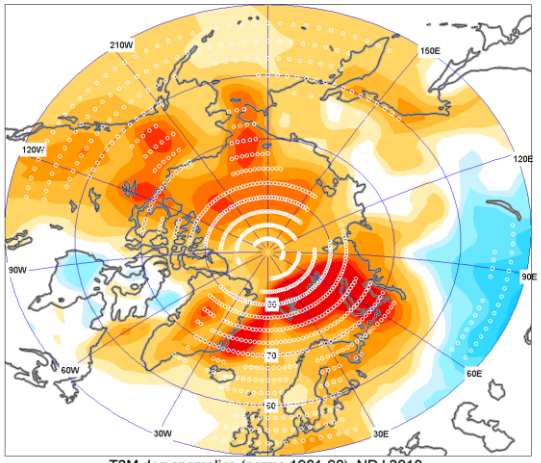


[HMC Moscow, DMI]

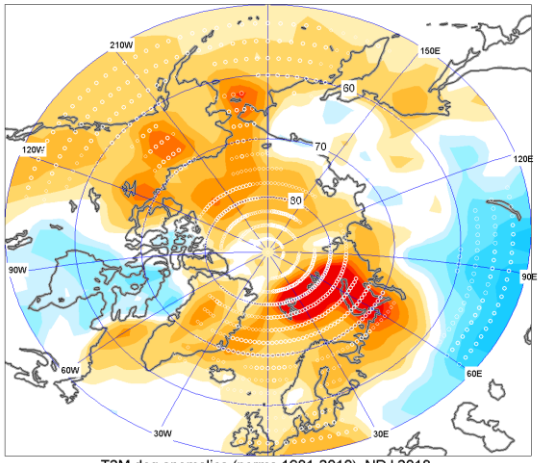
reference period: 2004-2013

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

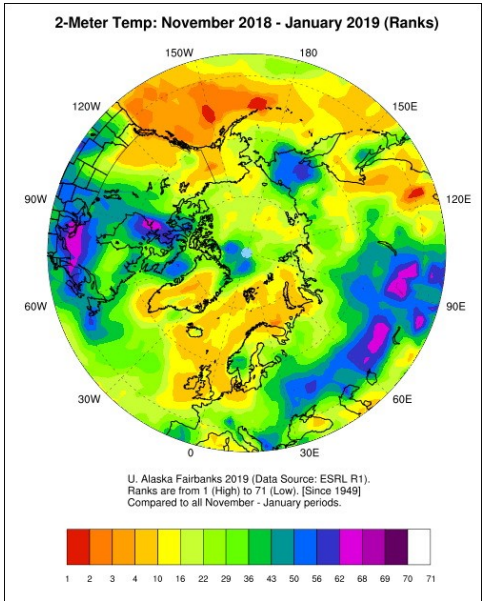
NDJ 2018/2019



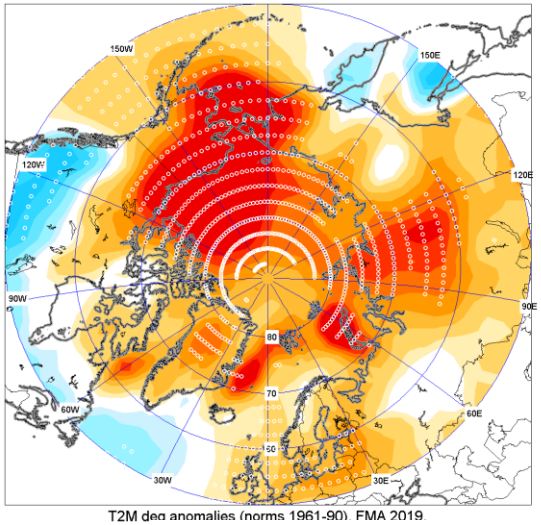
Ref [1961-1990]



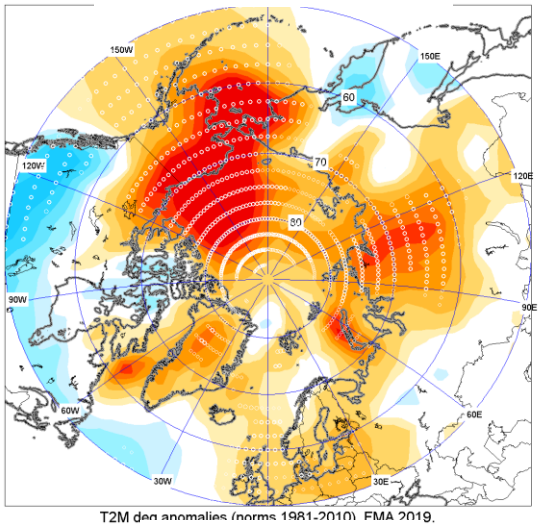
Ref [1981-2010]



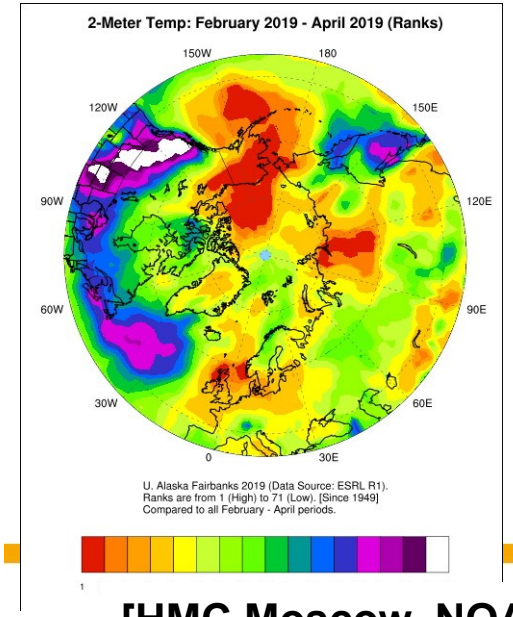
FMA 2018/2019



Ref [1961-1990]



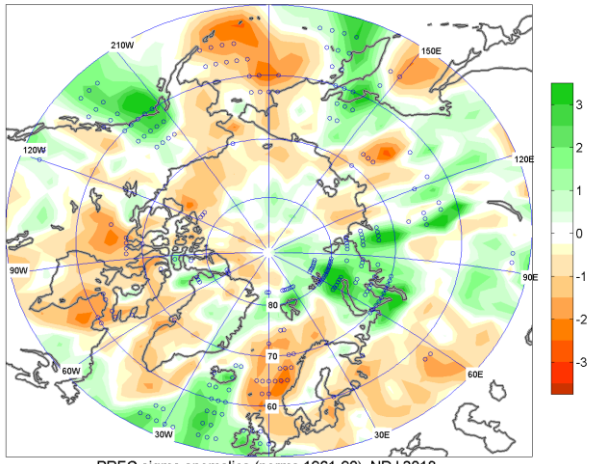
Ref [1981-2010]



[HMC Moscow, NOAAI]

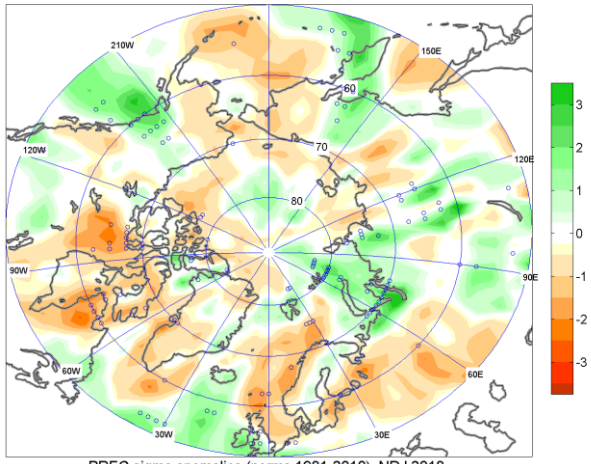
Precipitation NDJ and FMA 2018/2019: anomalies and ranks (reanalysis)

NDJ 2018/2019



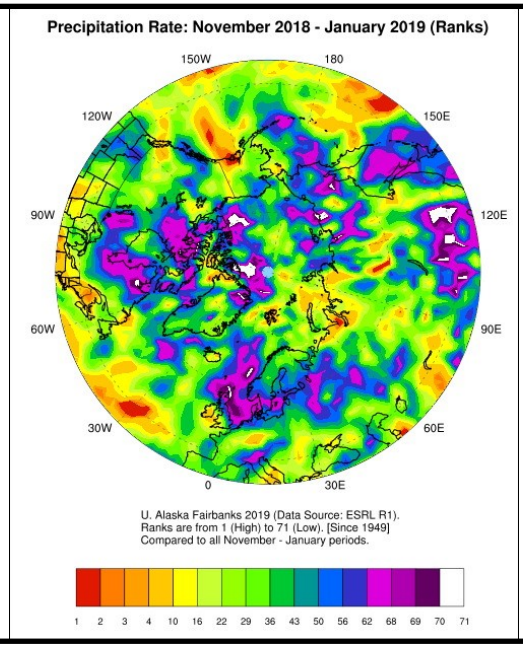
PREC sigma anomalies (norms 1961-90). NDJ 2018.

Ref [1961-1990]

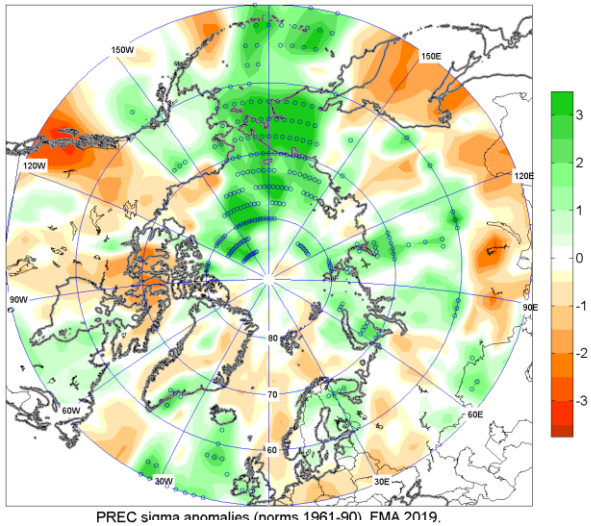


PREC sigma anomalies (norms 1981-2010). NDJ 2018.

Ref [1981-2010]

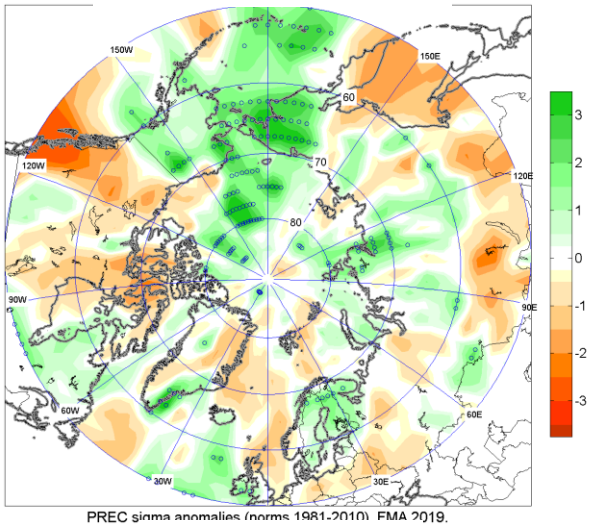


FMA 2018/2019



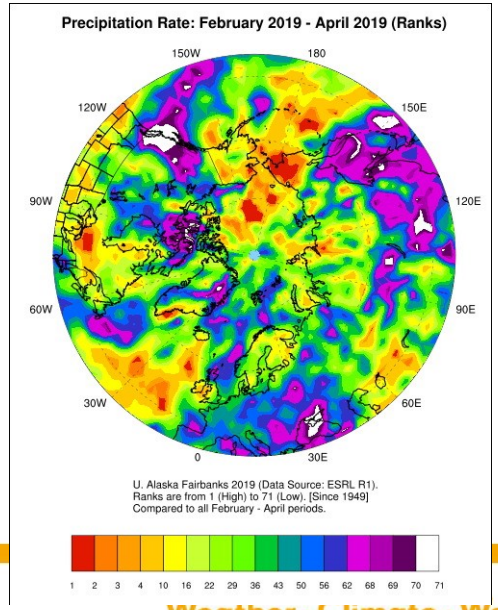
PREC sigma anomalies (norms 1961-90). FMA 2019.

Ref [1961-1990]



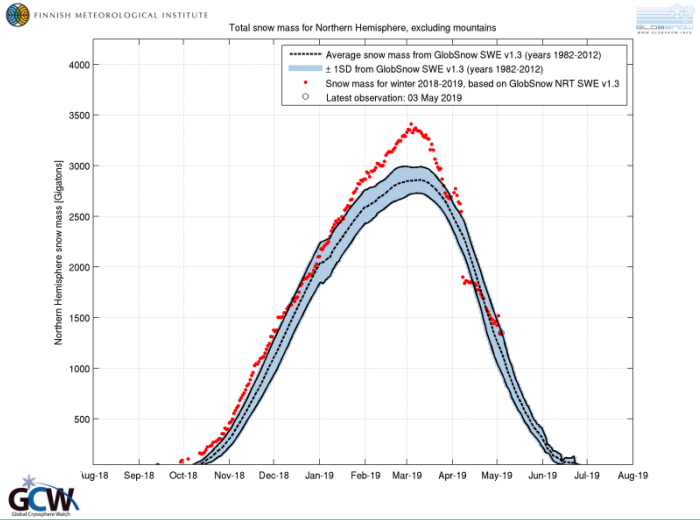
PREC sigma anomalies (norms 1981-2010). FMA 2019.

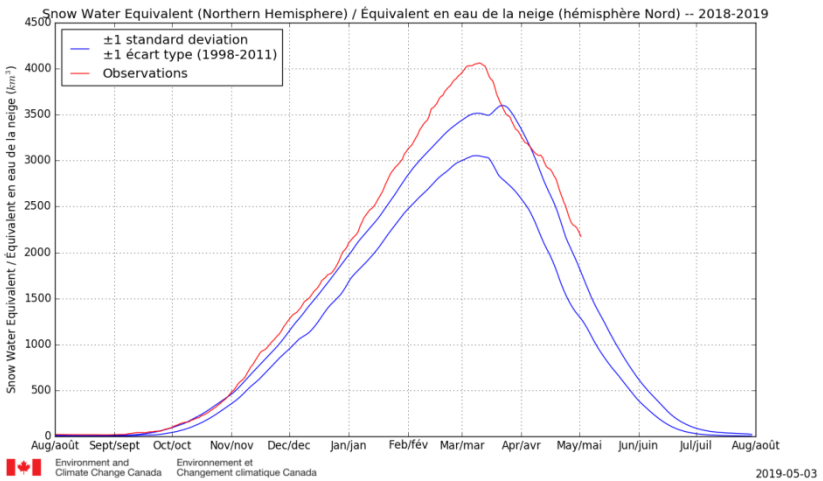
Ref [1981-2010]



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)