June 2019 – August 2019
Arctic Summer
Seasonal Review

Hydrometcenter of Russia
Arctic and Antarctic Research Institute

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

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World Meteorological Organization
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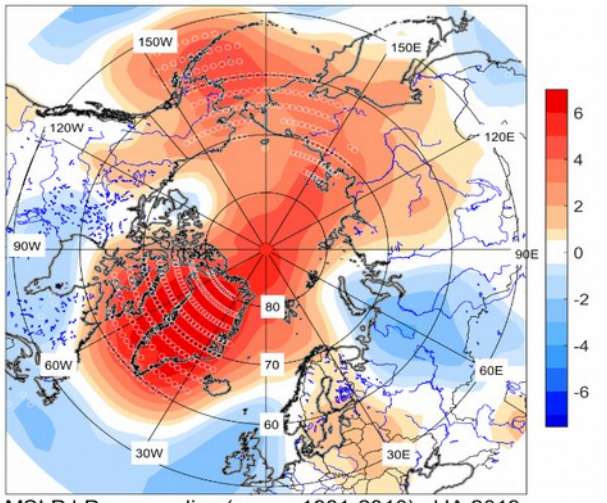
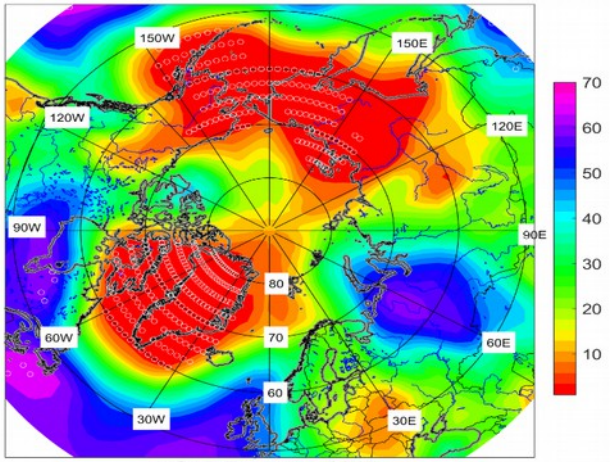
Content of JJA 2019 review

- Atmospheric circulation conditions (mean sea level pressure and geopotential height)
- State of surface climate (air temperature and precipitation)
- Sea ice characteristic analysis
  - Ice extent
  - Ice conditions
  - Ice thickness and volume
- Solid precipitation (snow)
- Summer highlights

JJA 2019 atmospheric circulation



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



MSLP Rank JJA 2019.

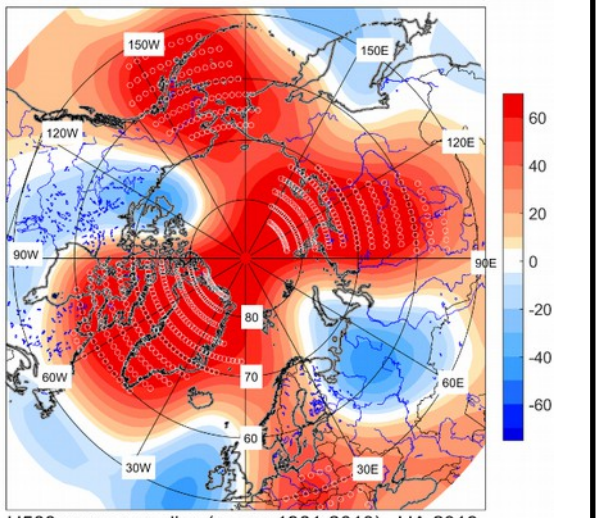
Low troposphere

- Intensification of polar and subpolar anticyclones led to large positive anomalies in pressure fields.
- Record high pressure was observed in parts of Greenland, Alaska and Siberia.
- Atlantic cyclones moved along Arctic sea coast and frequently were blocked in North of European Territory of Russia where low pressure system had been persisted with notable negative anomalies.

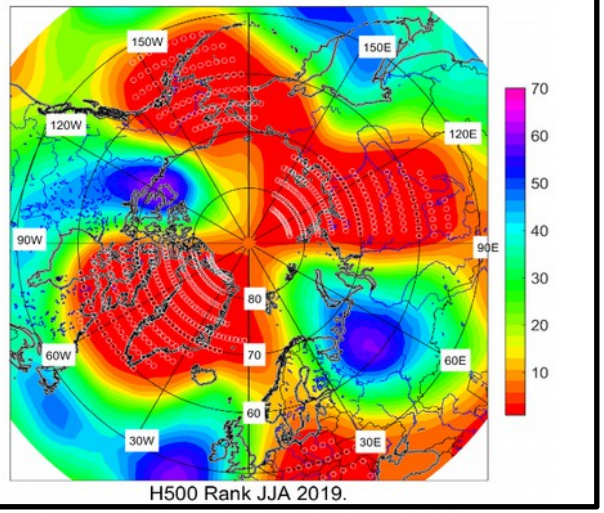
HMC, Moscow/ NCEP/NCAR reanalysis

JJA 2019 atmospheric circulation

Middle troposphere



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



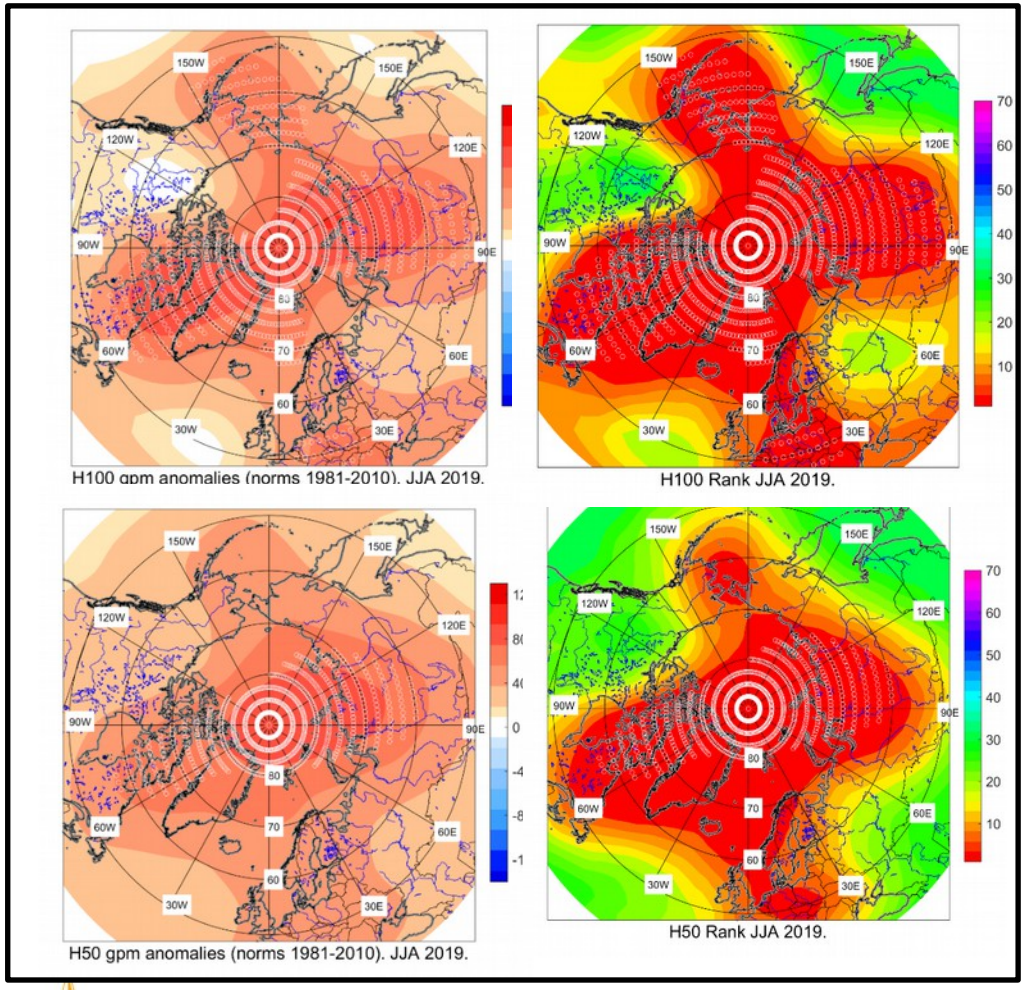
H500 Rank JJA 2019.

- High pressure system was intensified over Greenland, central Arctic, North Siberia, and North of Pacific ocean by tropospheric Atlantic, Pacific and West Siberia ridges.
- The dominance of meridional form of circulation in the middle troposphere has been observed.
- Polar vortex was weak and separated into two low-pressure zones (north of Canada, north of Siberia).

HMC, Moscow/ NCEP/NCAR reanalysis

JJA 2019 atmospheric circulation

Upper troposphere and low stratosphere

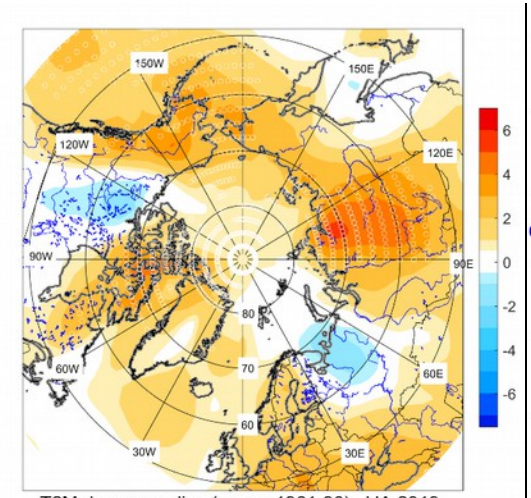


- Location of center of stratospheric anticyclone was close to normal.
- Near record positive geopotential anomalies were observed in the upper troposphere and low stratosphere.

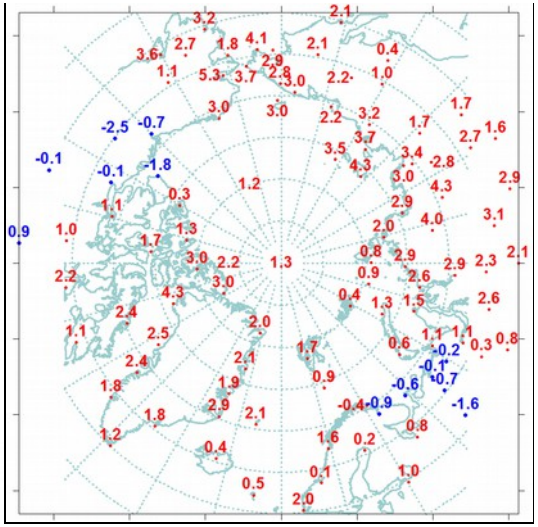
HMC, Moscow/ NCEP/NCAR reanalysis

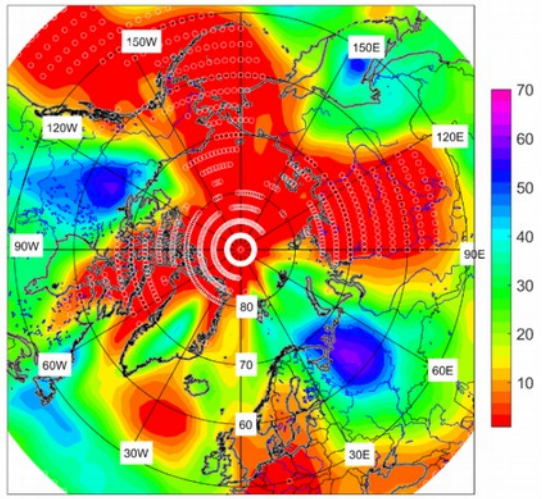
June – August 2019 T2m: anomalies and ranks (reanalysis)

Jun – Aug 2018



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





T2M Rank JJA 2019.

- The summer air temperature across Arctic was above normal except northern part of Canada and north-west of Russia.
- The most notable positive anomalies were present across of Alaska and surrounding sea, Canadian Archipelago, North of Siberia.
- The record temperatures were observed in East Siberia.

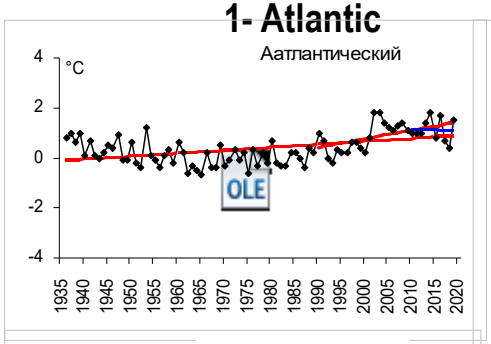
HMC, Moscow/ AARI/
NCEP/NCAR reanalysis

SAT anomalies by regions in 2019 (observations)

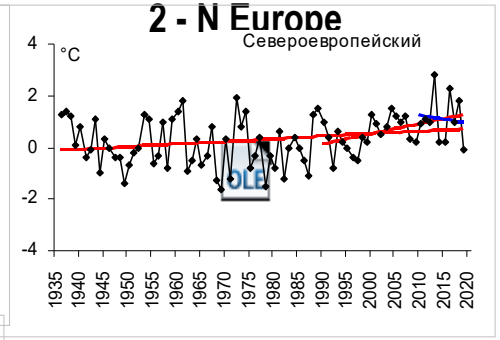
Region	Anomaly	Anomaly number in row	The warmest year (anomaly)	The coldest year (anomaly)
Atlantic	1,5	3	2003 (1,9)	1965 (-0,7)
N Europe	0,0	20	2013 (2,8)	1969 (-1,6)
West Siberia	1,7	4	2016 (3,6)	1968 (-1,6)
East Siberia	2,9	1	2019 (2,9)	1989 (-1,2)
Chukchi	2,7	2	2007 (2,9)	1949 (-1,3)
Alaska	1,9	2	2004 (2,9)	1945, 1955 (-1,3)
Canadian	1,7	5	2012 (2,3)	1972 (-1,6)

Reference period: 1961-1990

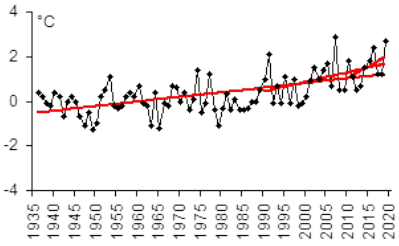
1- Atlantic



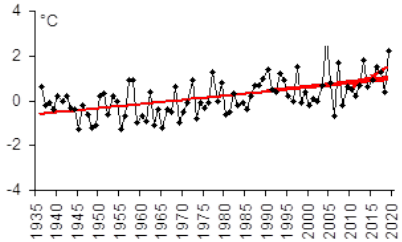
2 - N Europe

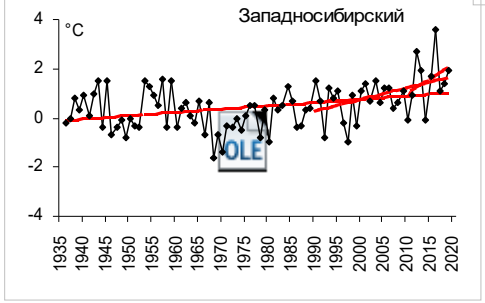


5 - Chukchi

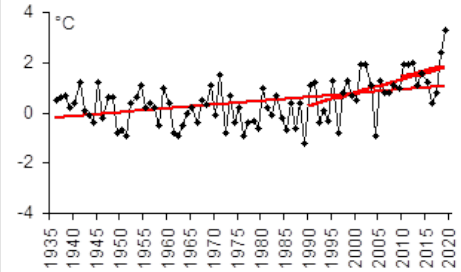


6 - Alaska

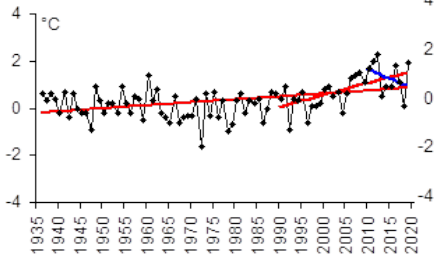




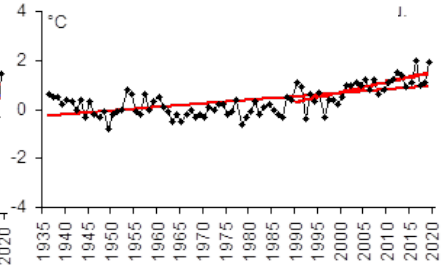
3 - West Siberia



4 - East Siberia



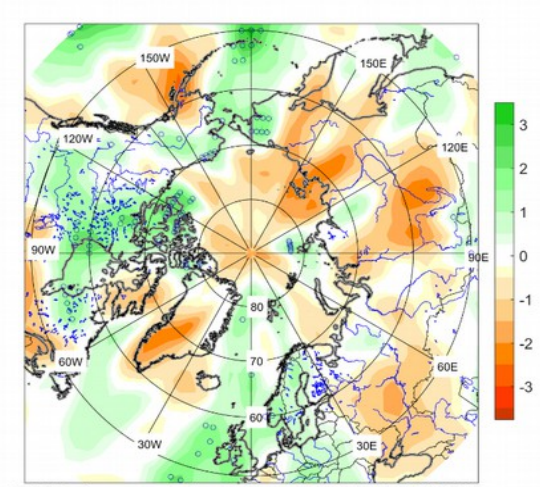
7 - Canadian



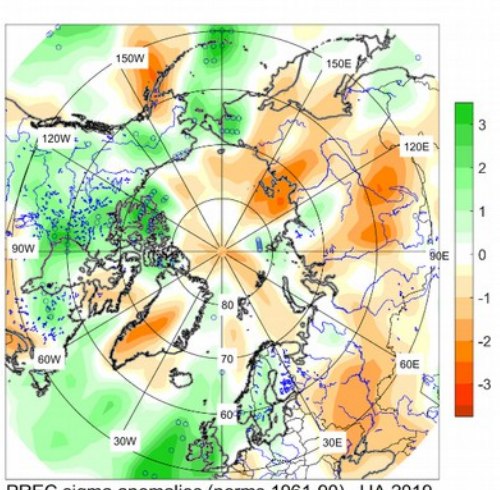
Zone 60-85 °N

May – Sep 2019 Precipitation anomalies and ranks

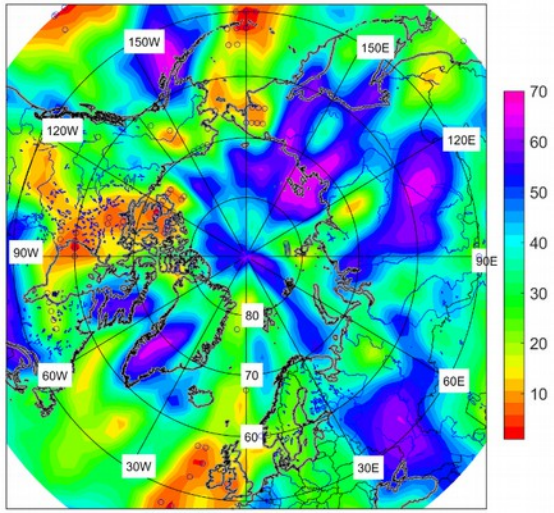
Jun – Aug 2019



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



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



PREC Rank JJA 2019.

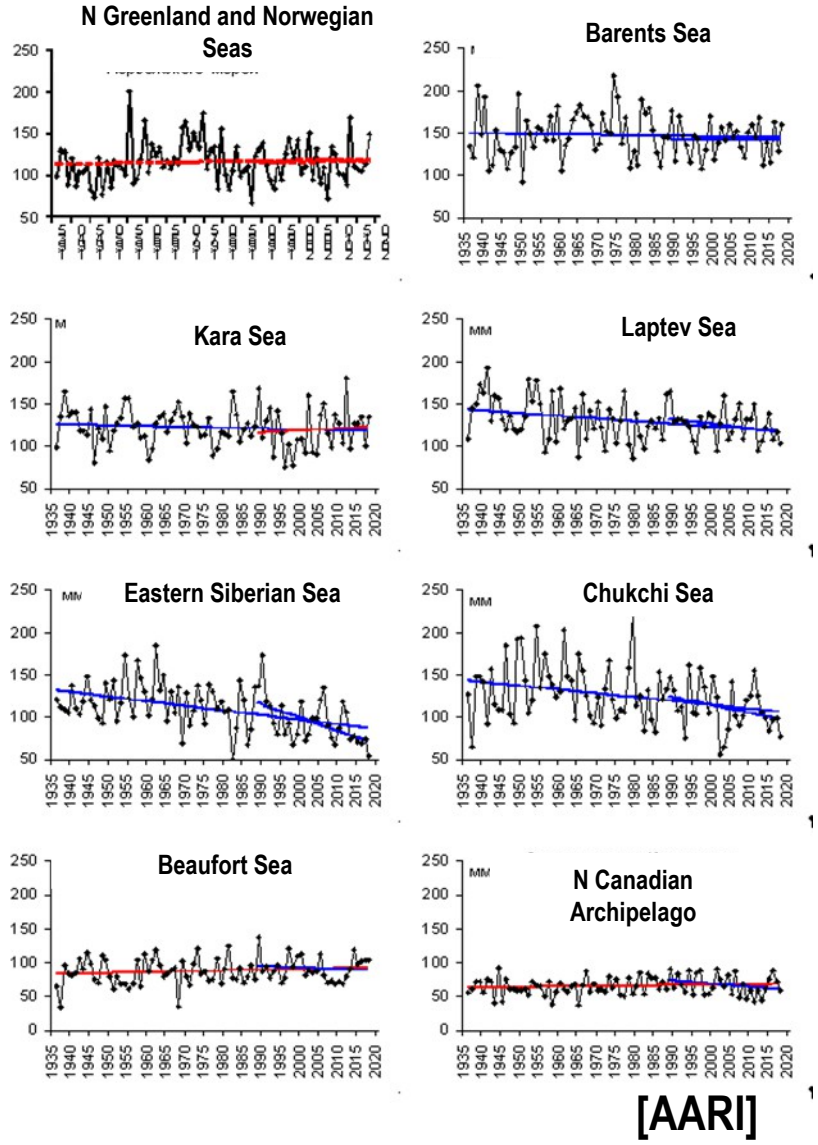
- Drier than average conditions were observed across much of North Eurasia except North Europe and East of Chukotka.
- The summer precipitation for the central Arctic and Greenland was bellow average.
- Above normal precipitation were present across much of Canada (near record), North of Atlantic, Okhotsk sea.

HMC, Moscow/
NCEP/NCAR reanalysis

Precipitation anomalies by regions in 2019

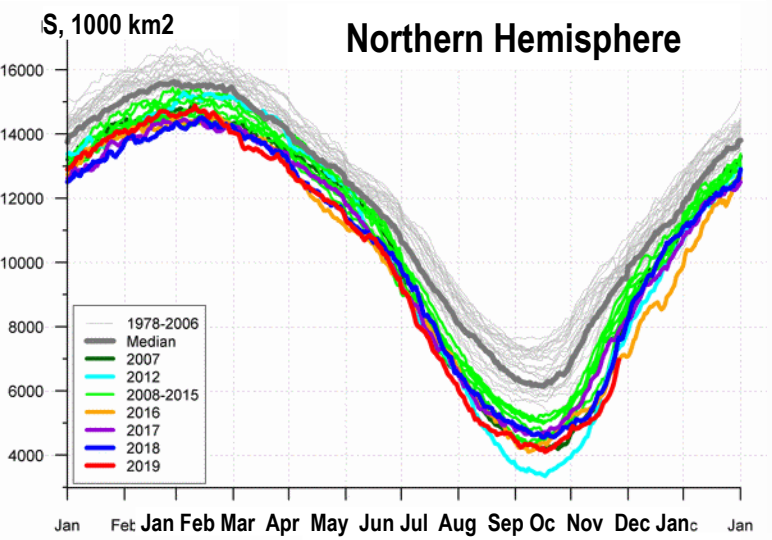
Region	Relative anom, %	The greatest value	The lowest value
Atlantic	98,0	1964 (120,5)	1968 (75,2)
N Europe	104,5	1981 (128,4)	1980 (68,5)
West Siberia	112,3	2002 (122,6)	1946 (72,4)
East Siberia	81,7	1988 (125,2)	1967 (78,4)
Chukchi	81,1	1954 (139,6)	1982 (60,2)
Alaska	113,1	1951 (164,4)	1968 (54,1)
Canada	111,6	2005 (123,5)	1977 (75,0)
60-70°N	102,6	1954 (115%)	1968 (88%)
70-85°N	103,2	1989 (127%)	1998 (84%)
60-85°N	100,6	1954 (117%)	1980 (90%)

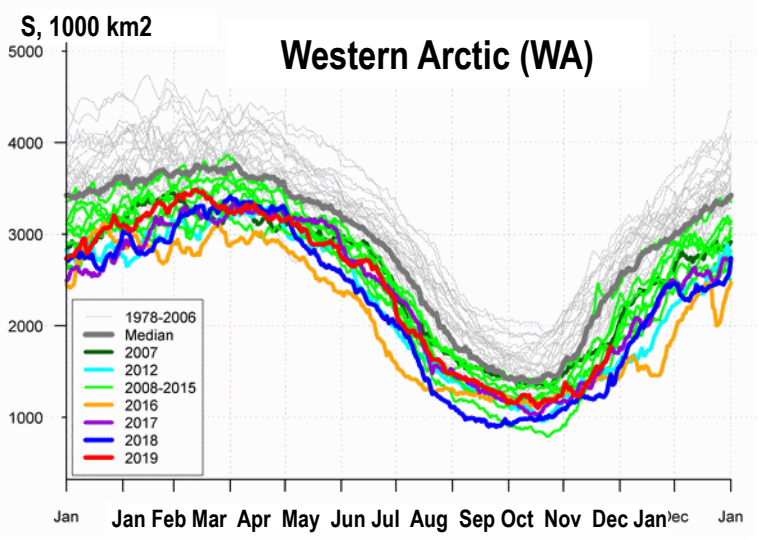
Reference period: 1961-1990



[AARI]

Arctic (NH) seasonal ice extent – 2019 …. 1979

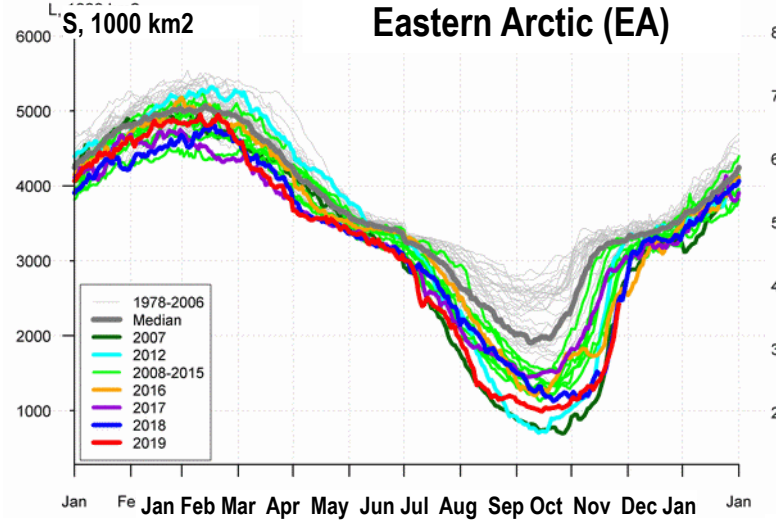


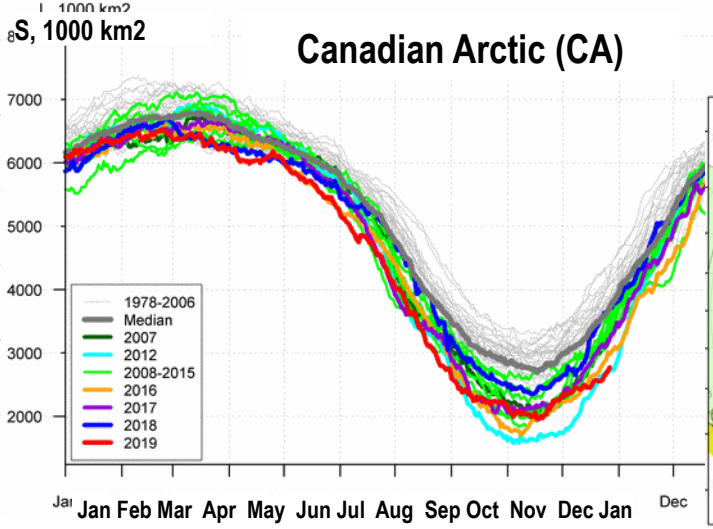


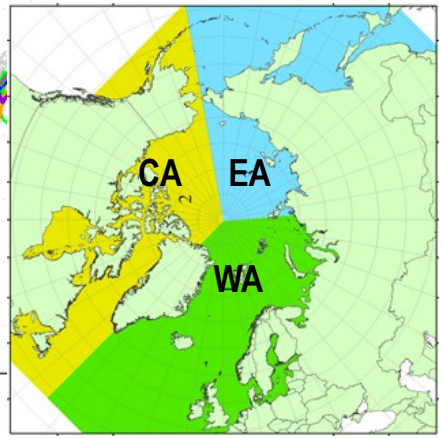
S, 1000 km2*

2012	3346.2
2016	4099.7
2019	4103.4
2007	4189.4
2011	4312.7
2015	4350.3
2018	4557.5
…	…
1986	7230.6
1982	7246.1
1983	7285.2
1980	7611.3

* - minimum for Sep (AARI)



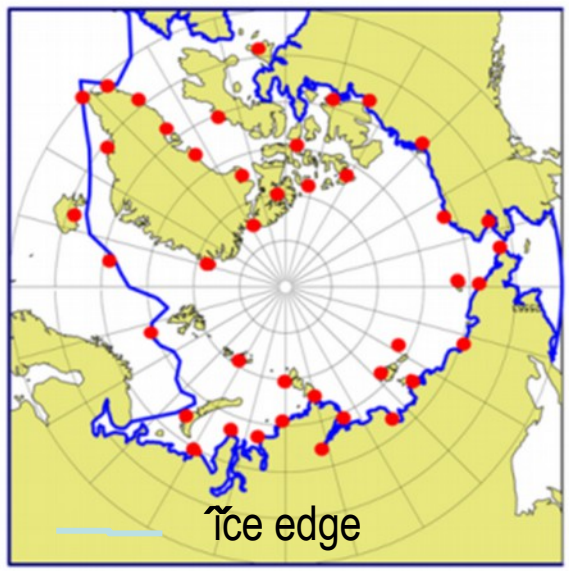




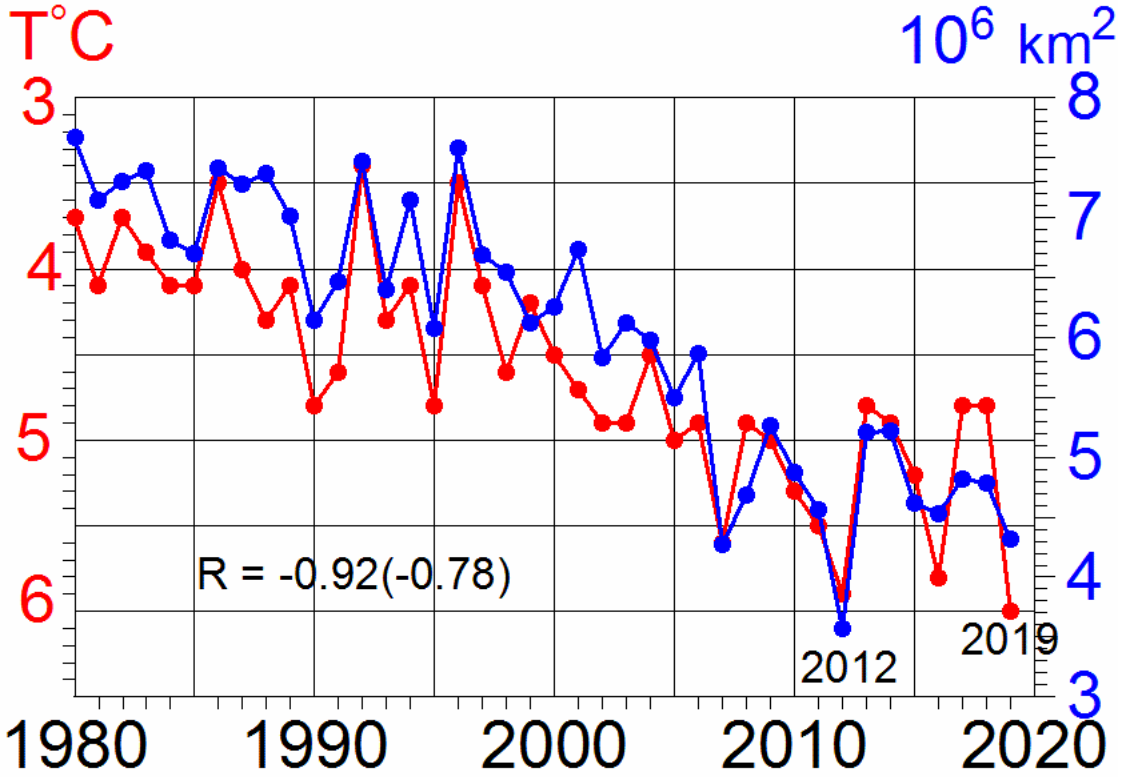
Minimum ice extent 4,103 mln km2 (4.56 in 2018) 3rd/2nd from 1979 reached 17/09/2019

[AARI, NSIDC]

Summer SAT and September SIE in the marine Arctic

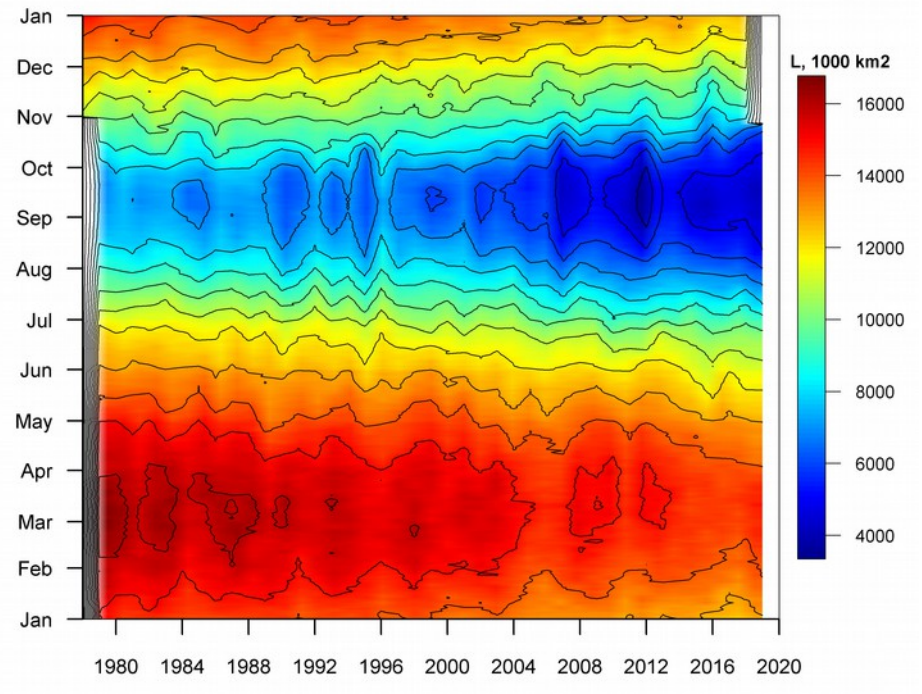


41 stations •

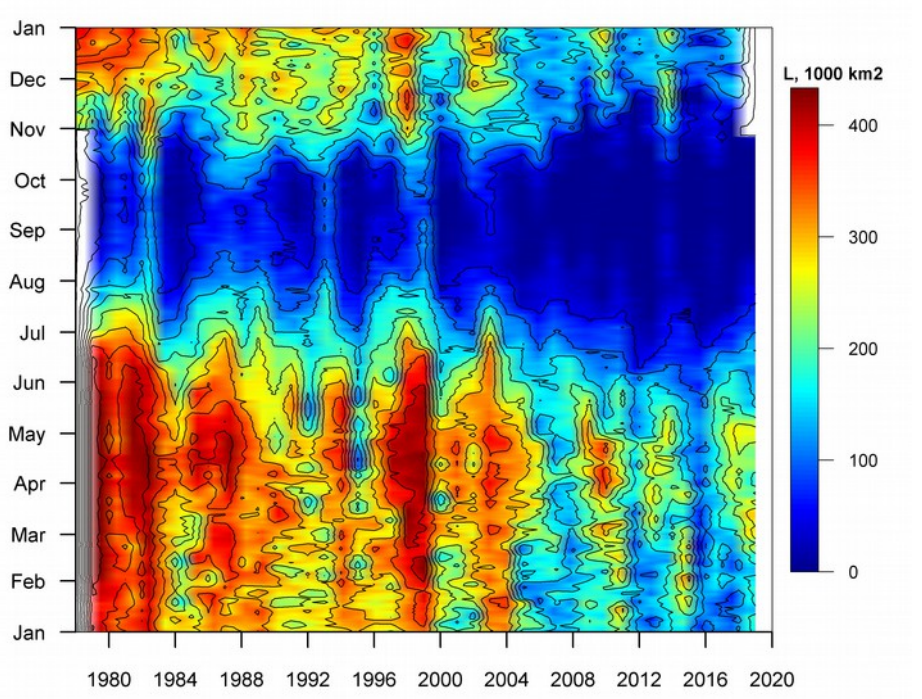


Seasonal NH (Arctic Ocean in summer) and regional (NE Barents) ice extent variability: 1978 - 2019

Northern Hemisphere

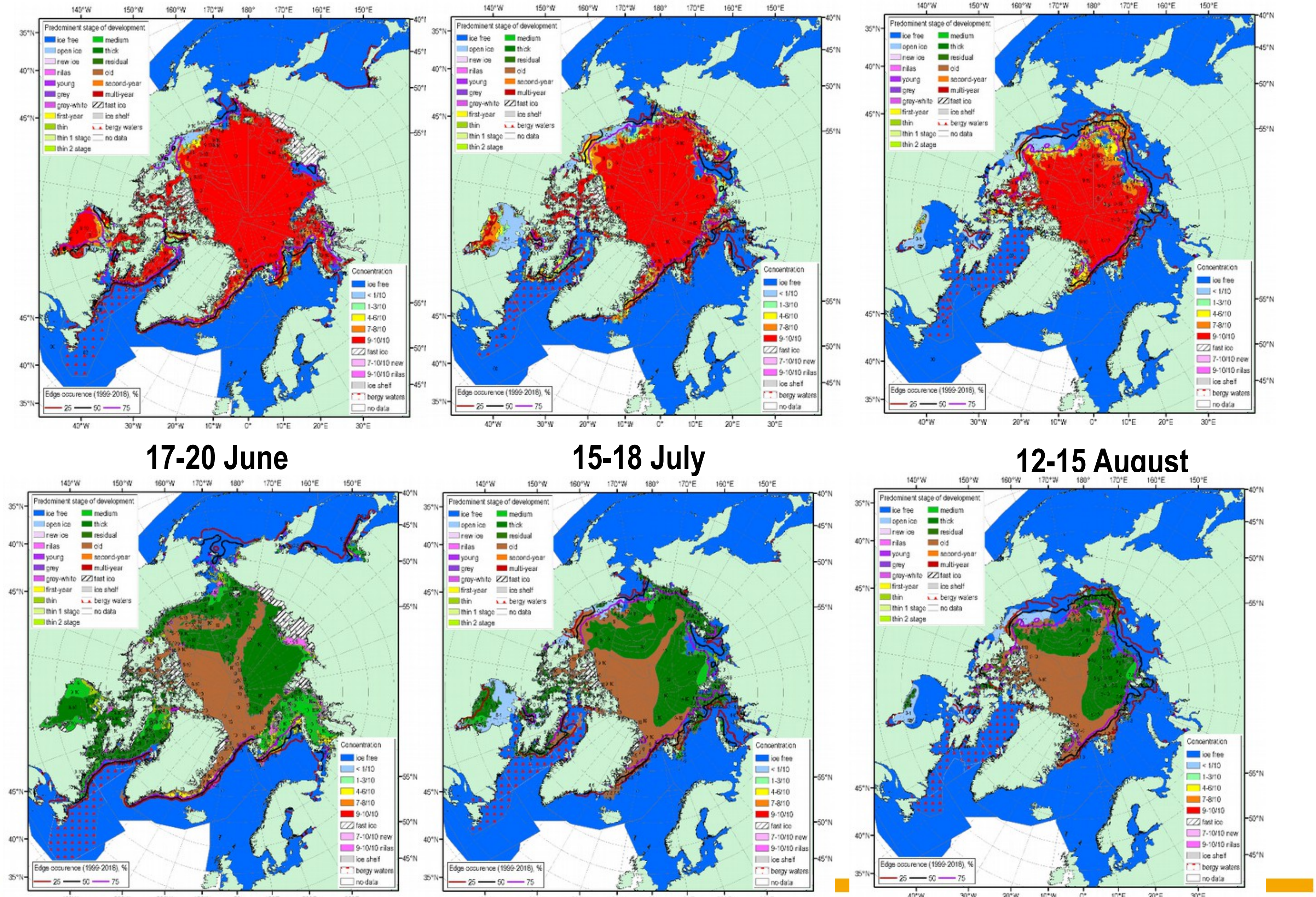


NE Barents Sea



[AARI, NSIDC]

JJA 2019 Arctic sea ice – conc. and stages of development



Blended AARI/CIS/NIC ice charts; ice edge – nearest pentade, reference period: 1998-2018

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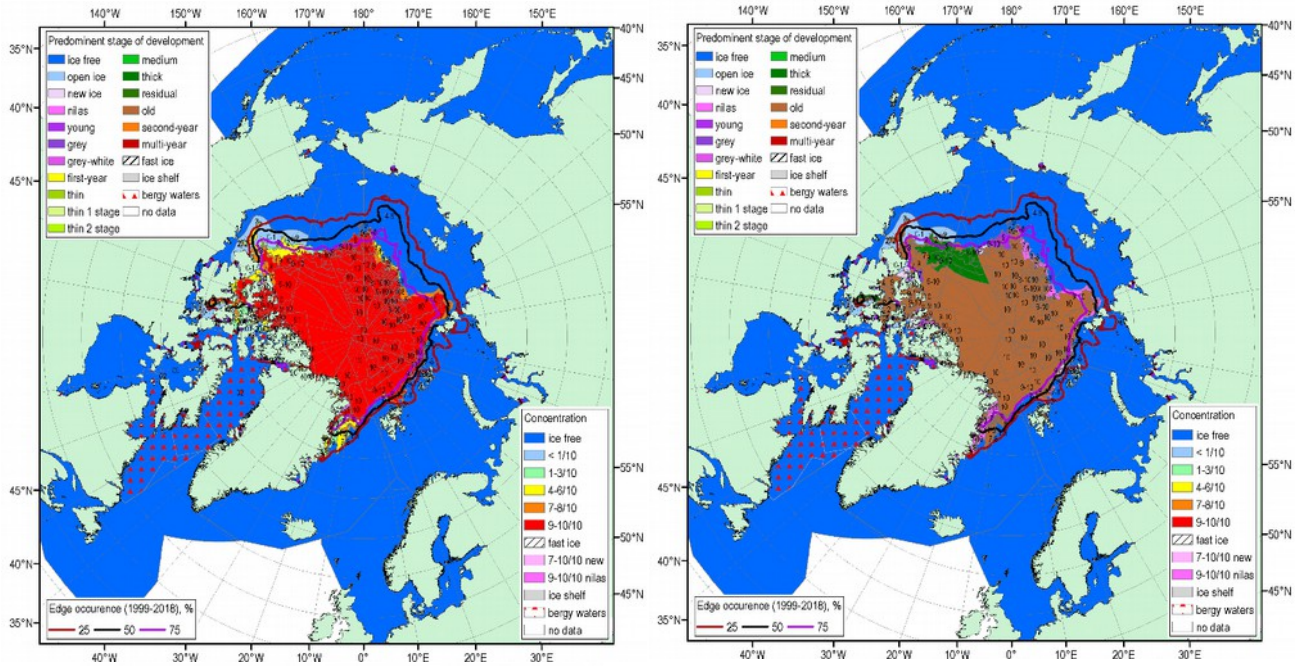
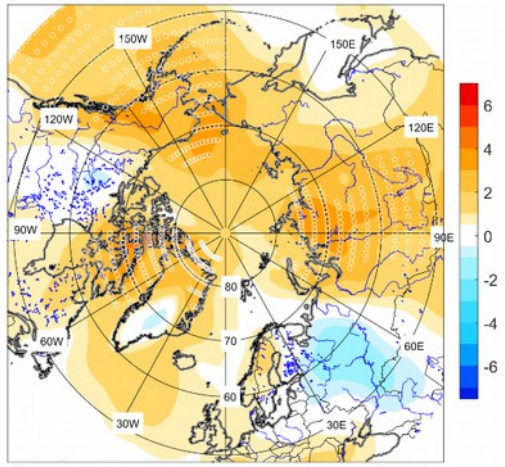
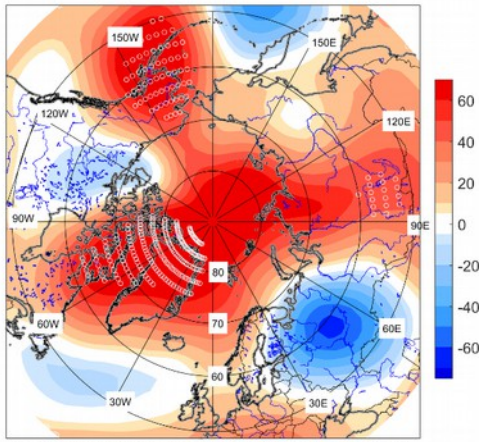
September 2019 minimum (3 October-8 October 2019)





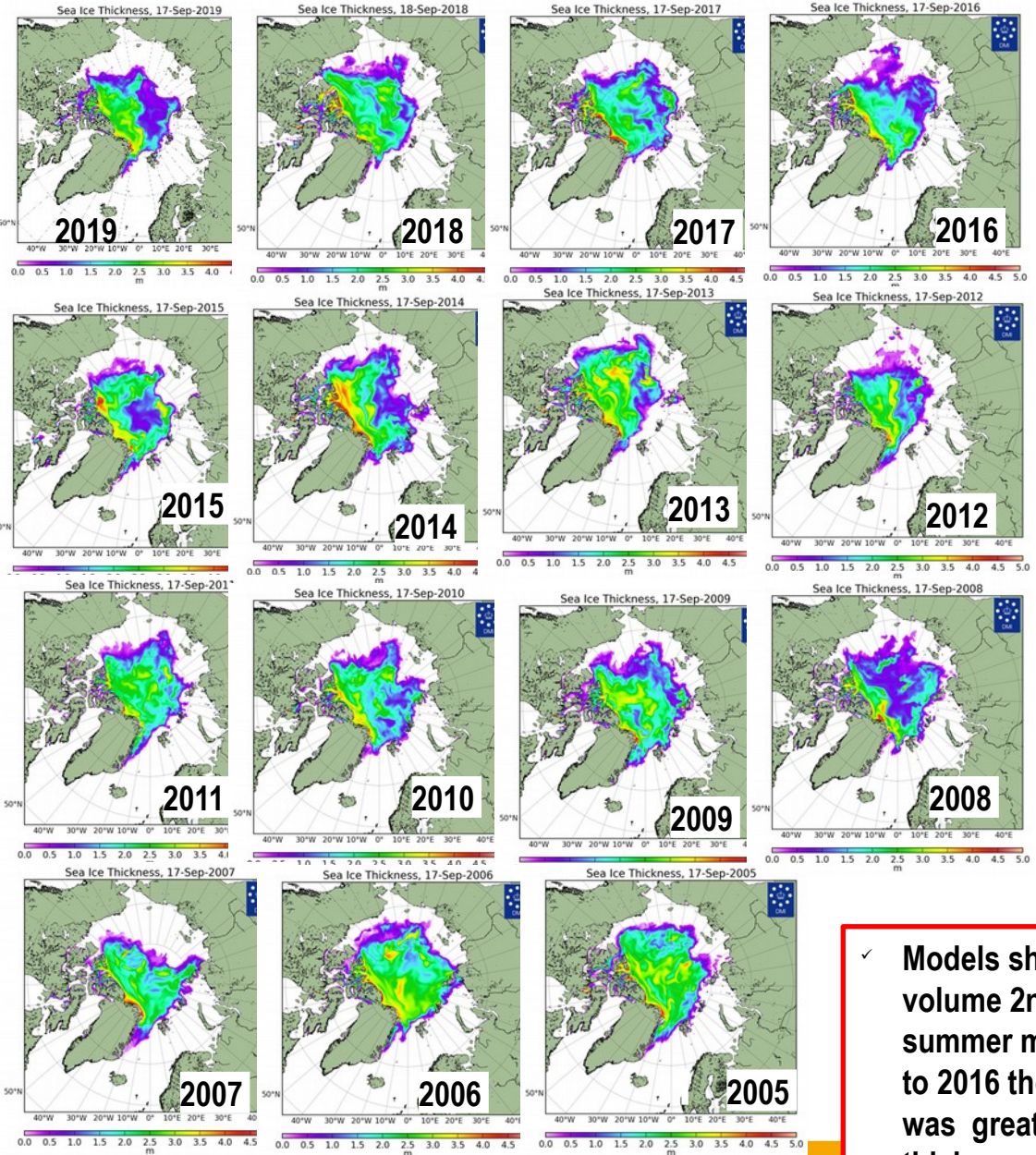
T2M deg anomalies (norms 1981-2010). JAS 2019.

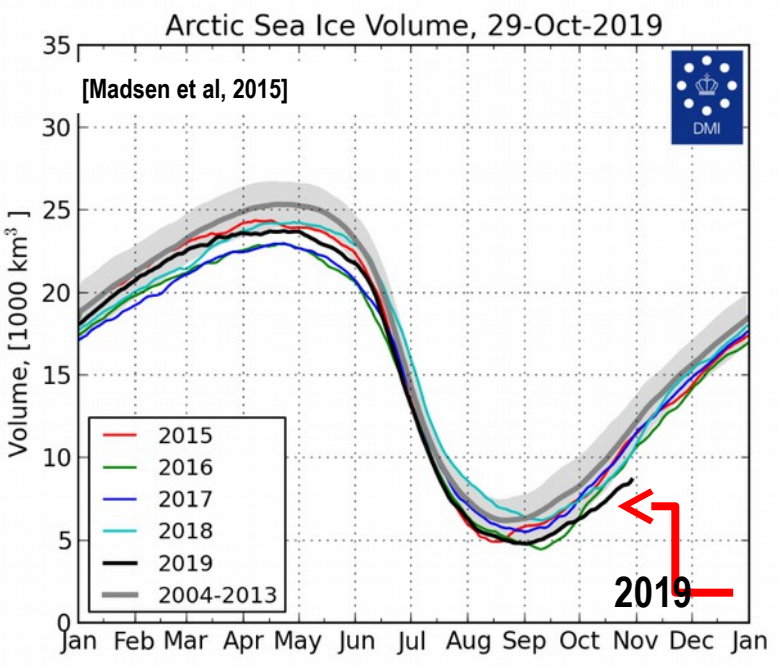


H500 gpm anomalies (norms 1961-90). JAS 2019.

Arctic Oscillation was negative during JJA and turned to positive phase in September. Dominance of ridging/positive Geopotential height anomalies with above normal temperatures resulted in extreme bellow normal sea ice extent in summer 2019 throughout majority of the Arctic Ocean areas, though not all

Arctic Sea Ice Reanalysis – HYCOM-CICE and PIOMAS





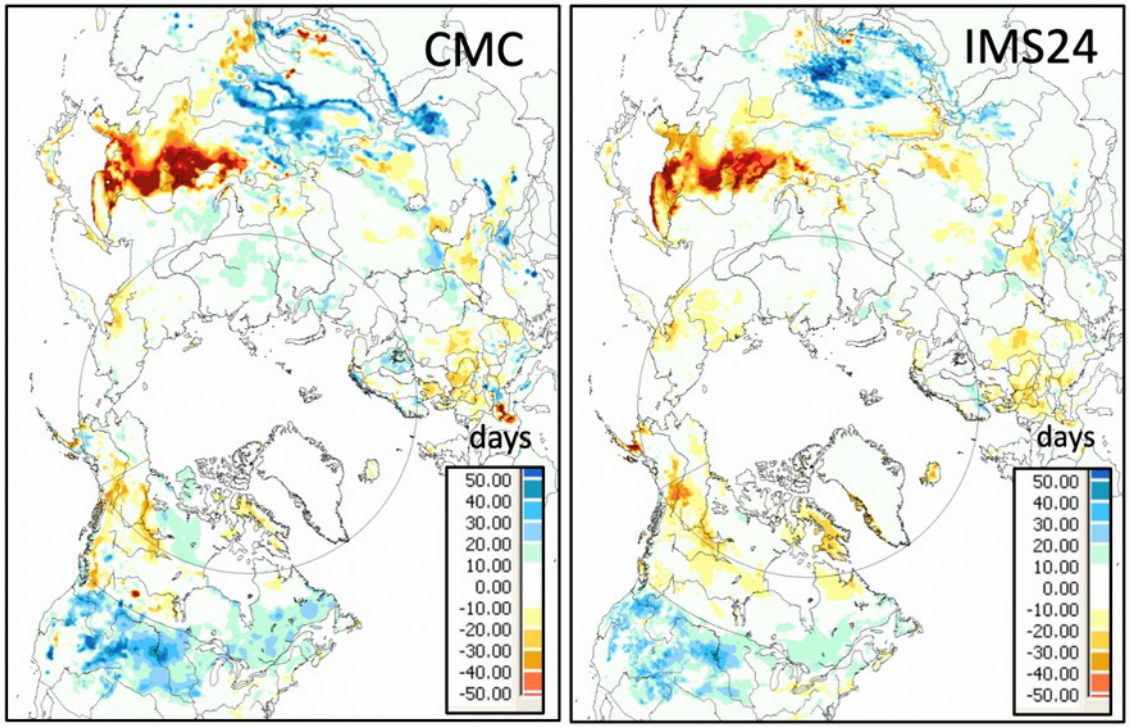
**V,1000 km3 **(PIOMAS)

2012	3.787
2019	4,06
2011	4,48
2016	4,53
2017	4.679
2010	4.742
2018	5,09
2013	5.479
2015	5.852
…	…
1986	16.076
1980	16.316
1979	16.911

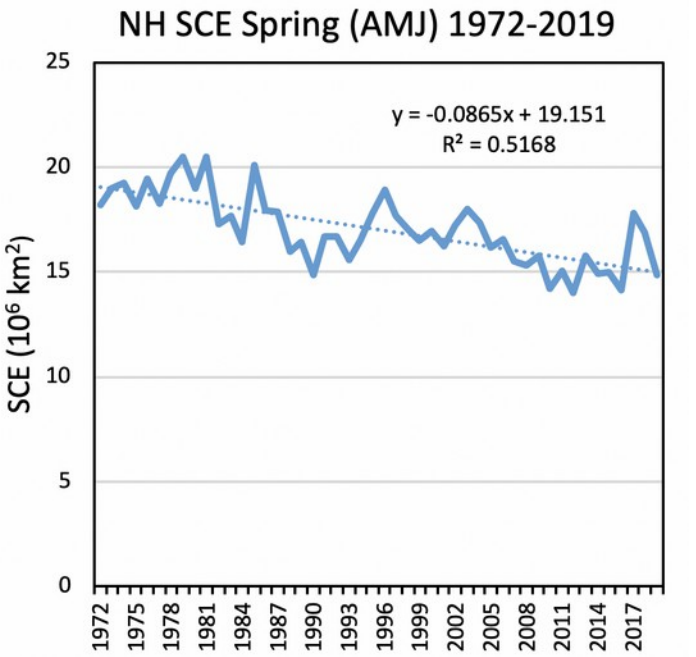
- ✓ **Models show Arctic ice volume 2nd minimum at summer minimum or similar to 2016 though ice extent was greater, i.e. overall ice thickness in 2019 is lesser**

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

Terrestrial snow: spring 2019 snow cover



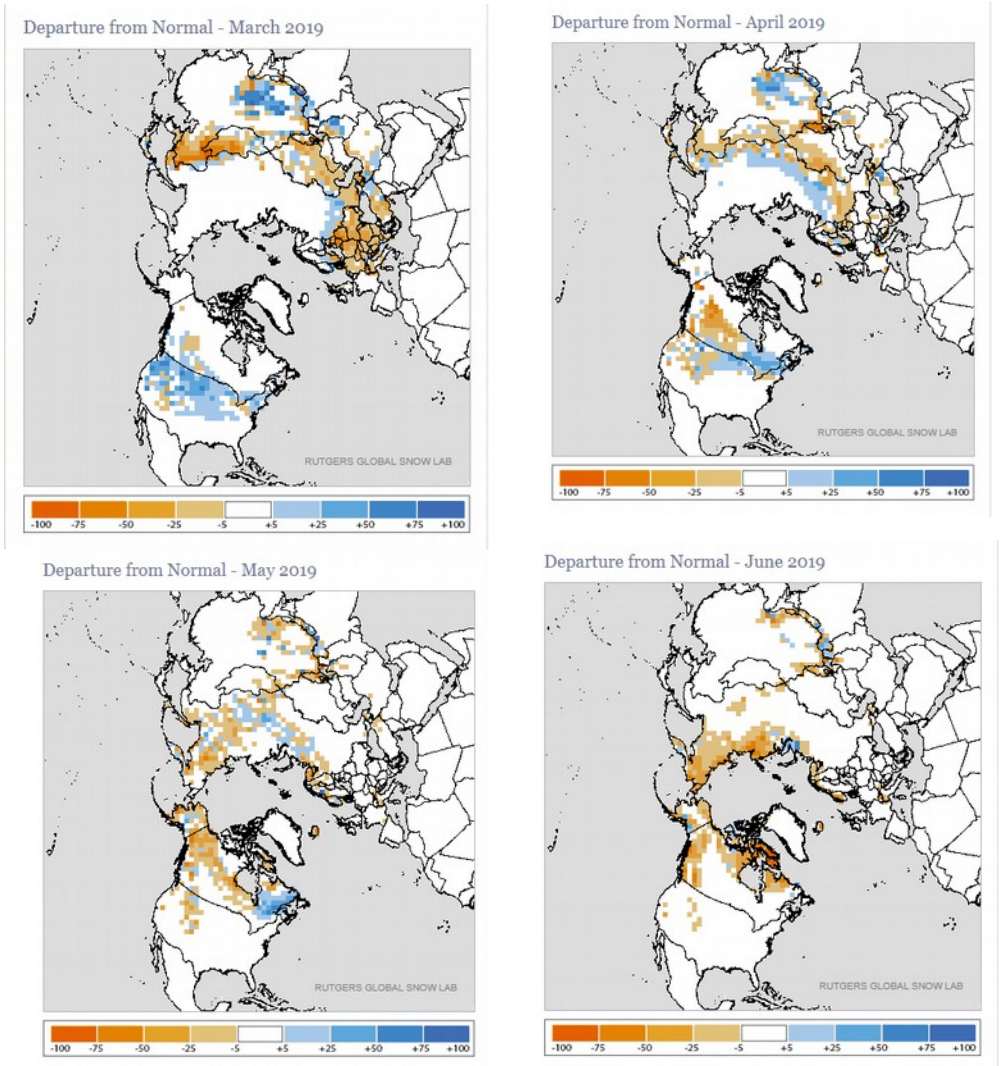
Difference in January-June snow cover duration (days) between 2019 and the 1998-2017 average for the CMC operational snow depth analysis (left) and the NOAA IMS24 daily snow cover analysis (right).



NH land area (excluding Greenland) spring (April, May, June) snow cover extent variability over 1972-2019.
Source: NOAA-CDR snow product at Rutgers University

- ✓ NH spring (April, May, June 2019) snow cover extent has decreased significantly (0.05 level of significance) over the period 1972-2019 at a rate of 0.865 million km2 per decade. *The 2019 June SCE value of 3.63 million km2 was 1.48 standard deviations below the 1981-2010 reference period average.*

Terrestrial snow: snow depth anomaly, MAMJ 2019



- ✓ Snow cover extent for most parts of N. Eurasia was normal to bellow average during MAMJ. Slightly above average for April in south Siberia. (relative to the 1981-2010).
- ✓ For Canada it was slightly bellow normal in April, May, June except eastern region.

Snow depth anomaly (% of the 1981-2010 average) in 2019 for (a) March, (b) April, (c) May, and (d) June. Source: RUTGERS GLOBAL SNOW LAB

Arctic Summer Highlights

Atmospheric circulation (summer, JJA)

High pressure system was intensified over Greenland, central Arctic, Siberia, and North of Pacific ocean with influence of tropospheric Atlantic, Pacific and West Siberia ridges. Record high pressure was observed in Greenland, Alaska and Siberia regions. The dominance of meridional form of circulation in the middle troposphere was noted. Polar vortex was weak and separated into two low-pressure zones (north of Canada, north of Siberia). Location of center of stratospheric anticyclone was close to normal. Near record positive geopotential anomalies were observed in the upper troposphere and low stratosphere.

Temperature & Precipitation (summer, JJA)

Air temperature across Arctic was above normal except northern part of Canada and north-west of Russia. The most notable positive anomalies were present across of Alaska, Canadian Archipelago, North of Siberia. The record positive anomalies (2.9C) were in East Siberia. Drier than average conditions were observed across much of North Eurasia except North Europe and East of Chukotka. Above normal precipitation were present across much of Canada and Atlantic.

Arctic Summer Highlights

Arctic (NH) Sea Ice (summer, JJAS)

Minimum ice extent 4,1 mln km2 (4.56 in 2018) reached 17 September 2019 and was 3rd/2nd in row (close to 2016) moving 2007 to 4th row. With some regional exceptions like N Barents, Greenland Seas ice edge was in northward positions. Estimated ice volume could be 2nd or 3rd in row which tells the ice thickness was much less in 2019 in comparison to 2018 and 2017 years.

Terrestrial Arctic Snow (pre-summer, MAMJ)

Snow cover extent for most of N.Eurasia was normal to bellow average during MAMJ2019 For Canada it was slightly bellow normal in April, May, June except eastern parts. NH spring snow cover extent has tendency to decrease during the period 1972-2019. *The 2019* June SCE was 1.48 standard deviations below the 1981-2010 reference period average.

World Meteorological Organization

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