ACF
Arctic Climate Forum

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

Arctic summer (May - Oct) 2020 seasonal Review

Vasily Smolyanitsky
Anna Danshina, Anastassiya Revina
Arctic and Antarctic Research Institute (AARI)
Rick Thoman
International Arctic Research Center (IARC), Alaska
Gabrielle Gascon
Environment and Climate Change Canada (ECCC)

WMO OMM
World Meteorological Organization
Organisation météorologique mondiale

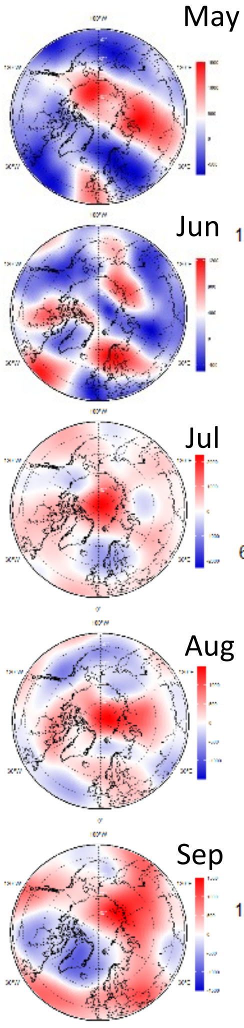
Content of seasonal review

- Review for MJJAS 2020 (May…September 2020)
  - Atmosphere variables include:
    - Atmospheric circulation
    - Surface air temperature (SAT), precipitation (prec)
    - Influence of precipitation on river discharge
  - Sea ice variables include:
    - Precursors in atmosphere and polar ocean
    - Ice extent and ice conditions
    - Arctic ocean sea ice thickness and volume
  - Polar Ocean variables include:
    - SST, waves and swell height (storminess)
    - pH (acidification/alkalization estimates)
  - Solid precipitation include: land snow
- Briefs for October 2020: SAT, winds, prec, sea ice, snow
- Explanation of normals, extremes, ranks

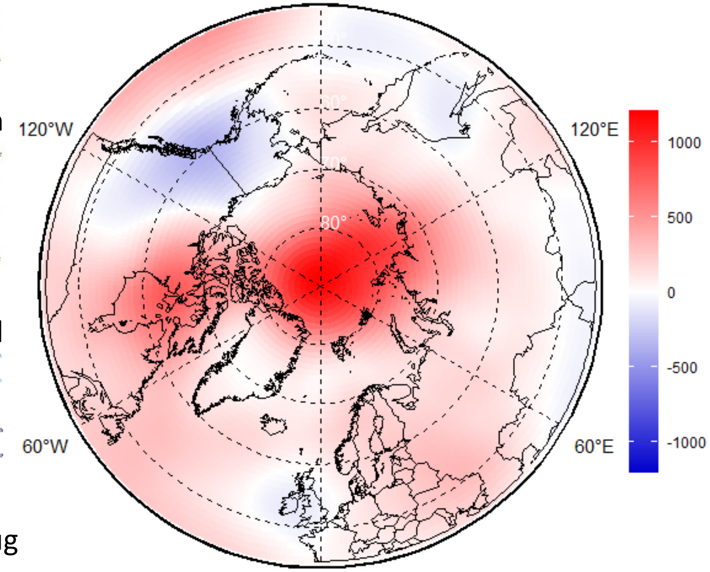
Atmosphere:

- Precursors - atmospheric circulation patterns
- Surface air temperature
- Precipitation and river discharge

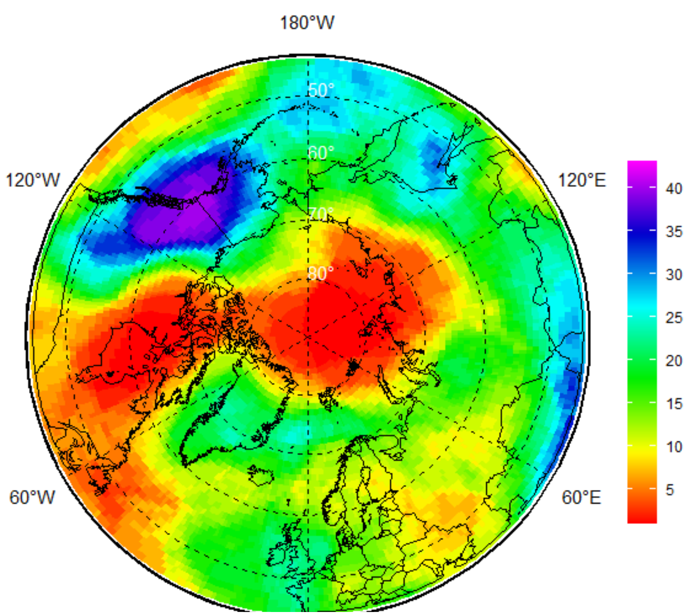
MJJAS 2020 upper atmosphere circulation (H500)



MJJAS 2020
H500 anomaly
(1981-2010)



JJA 2020 H500 anomaly (1981-2010)

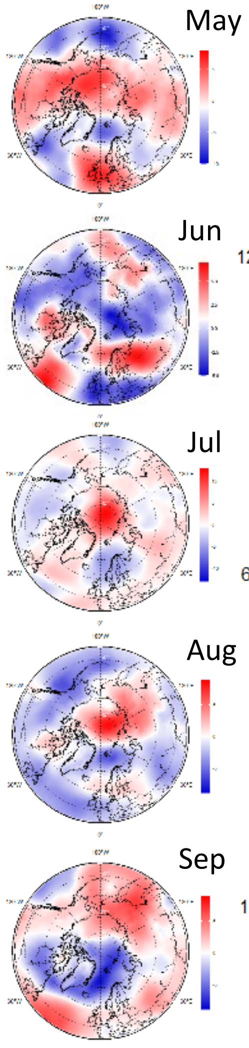


JJA 2020 H500 rank (1979-2020)

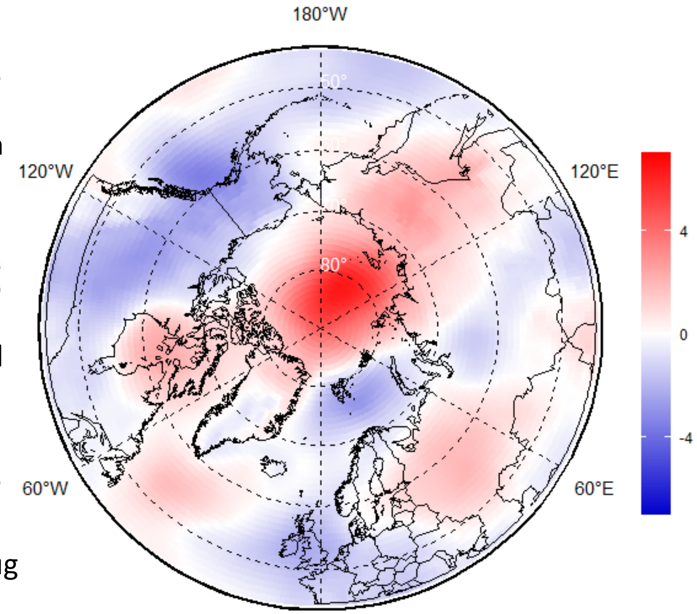
- Based on atmosphere numerical model (reanalysis)
- Intense upper atmosphere circulation in May – June 2020 finalized in July with a 2-3 centered system of polar vortex (lower pressure and lower H500 height, marked in blue) with centers with the centers of polar vortex over North Atlantic - Greenland - Alaska – Chukchi regions as seen on the five monthly 500 hPa geopotential height plots

[AARI / ERA5 reanalysis]

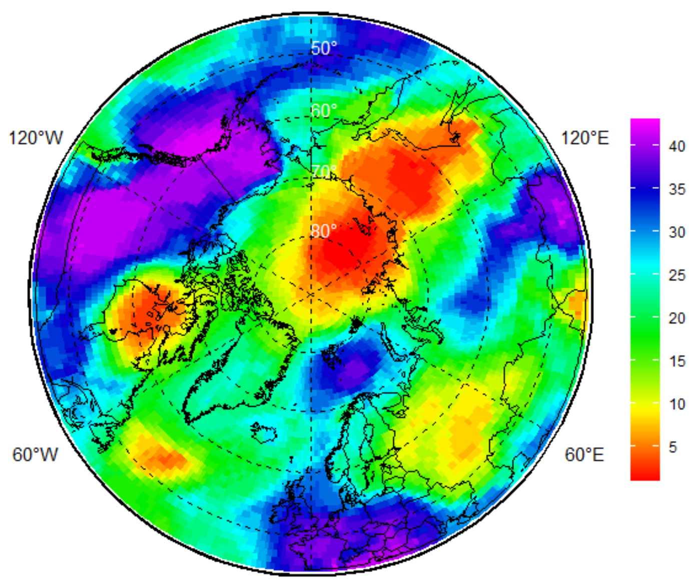
MJJAS 2020 surface atmospheric circulation



MJJAS 2020
MSLP anomaly
(1981-2010)



JJA 2020 MSLP anomaly (1981-2010)

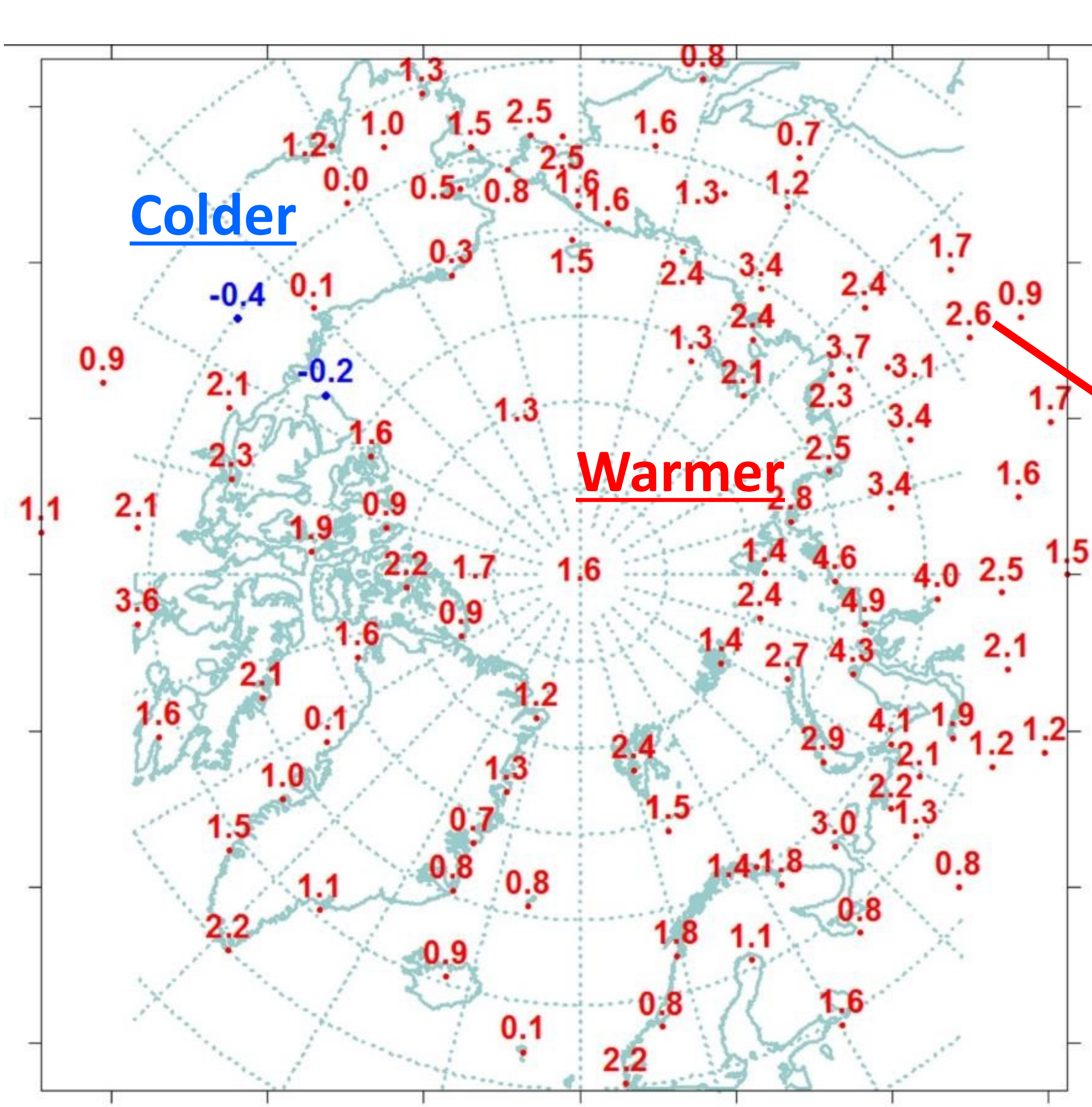


JJA 2020 MSLP rank (1979-2020)

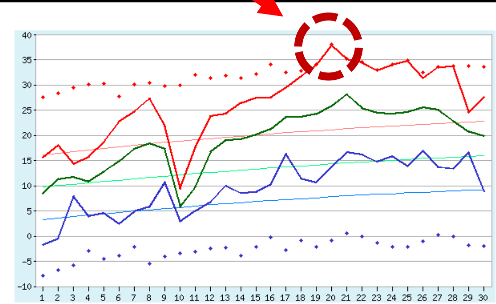
- Based on atmosphere numerical model (reanalysis)
- In general negative mean sea level atmospheric pressure (MSLP) anomalies (lower pressure, cyclonic, marked in blue) dominated through the Eastern Nordic and Western Canada and Alaska regions
- Opposite situation (higher pressure, anticyclonic, marked in red) was observed in a band from the Hudson Bay over the Central Arctic to Eastern Siberia, though significant monthly variations occurred
- That led to prevalence of meridian form of circulation (transfer of heal/cold north /south) in the troposphere with several heat waves in Eastern Siberia in June-July 2020

[AARI / ERA5 reanalysis]

JJA 2020 Surface Air Temperature 2m (obs)



- ❖ The summer air temperature across Arctic was above normal except small part of Alaska & Western Canada region
- ❖ The most notable positive anomalies were present across of Western and Eastern Siberia due to several heat waves in Jun-Jul 2020
- ❖ Record high temperatures were observed in Eastern Siberia in June at Verkhoyansk



WMO ID 24266
20th June 2020
+38.0C –
record for zone N of Polar Circle

Zone, latitudes, °N.	Anomaly	Rank	The warmest year (anomaly)	The coldest year (anomaly)
70-85	1,8	3	2012 (2,0)	1963 (-0,7)
60-70	1,7	3	2016 (2,0)	1949 (-0,8)
60-85	1,7	2	2016 (2,0)	1949 (-0,8)

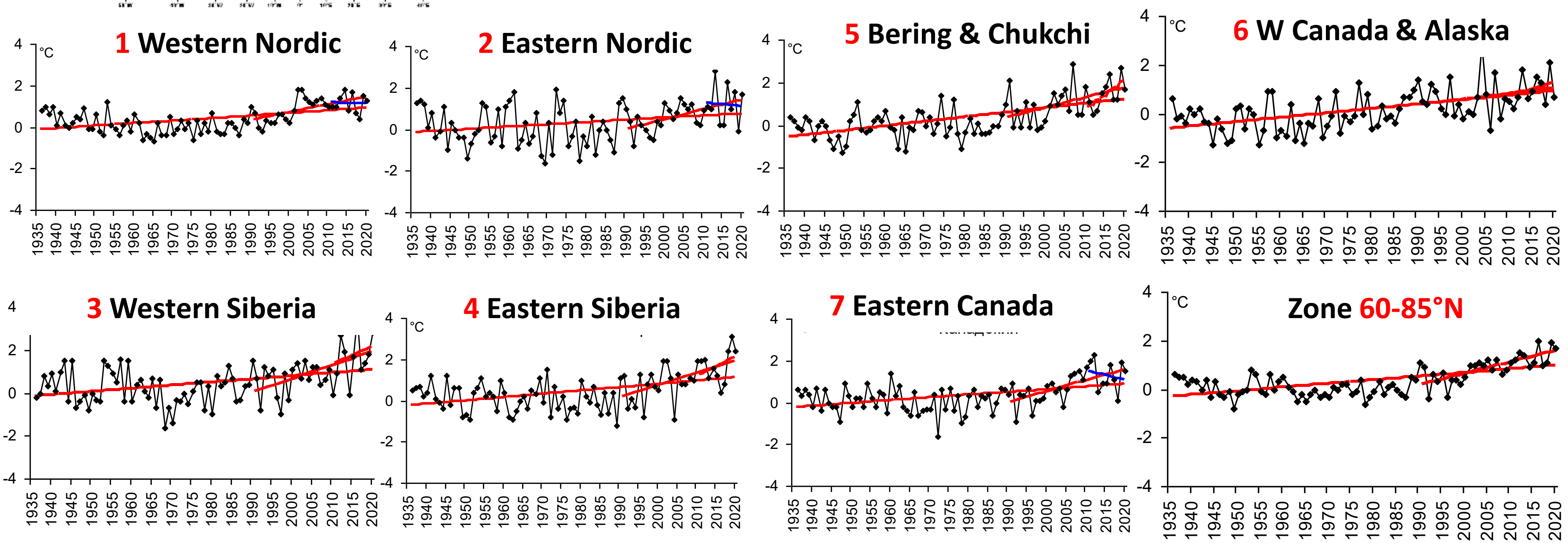
[AARI]

JJA 2020 Surface air temperature by regions (obs)

Region	Anomaly 2020 (2019)	Rank 2020 (2019)	The warmest year (anomaly)	The coldest year (anomaly)
Western Nordic*	1,3 (1.5)	5 (3)	2003 (1,9)	1965 (-0,7)
Eastern Nordic*	1,7 (0.0)	5 (20)	2013 (2,8)	1969 (-1,6)
Western Siberia	2,8 (1.7)	2 (4)	2016 (3,6)	1968 (-1,6)
Eastern Siberia	2,4 (2.9)	2 (1)	2019 (2,9)	1989 (-1,2)
Bering &Chukchi*	1,7 (2.7)	6 (2)	2007 (2,9)	1949 (-1,3)
W Canada &Alaska*	0,7 (1.9)	12 (2)	2004 (2,9)	1945,1955(-1,3)
Eastern Canada*	1,5 (1.7)	6 (5)	2012 (2,3)	1972 (-1,6)

* Old boundaries

Reference period: 1961-1990

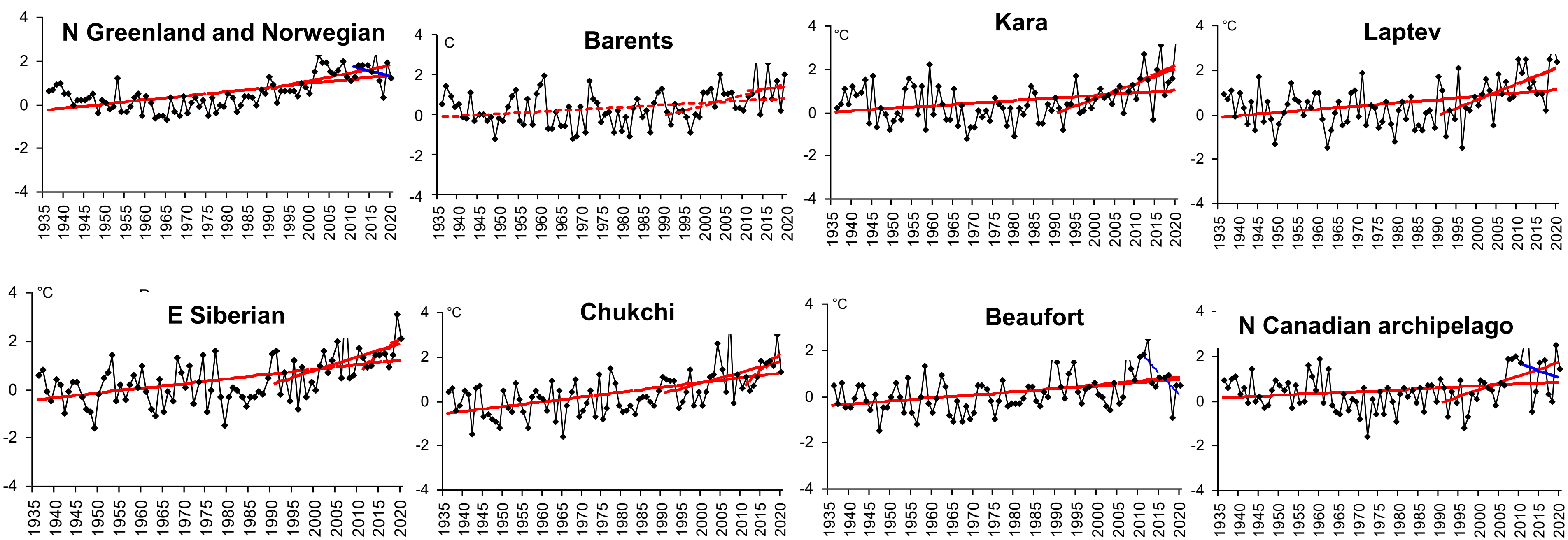


[AARI]

JJA 2020 Surface Air Temperature by seas (obs)

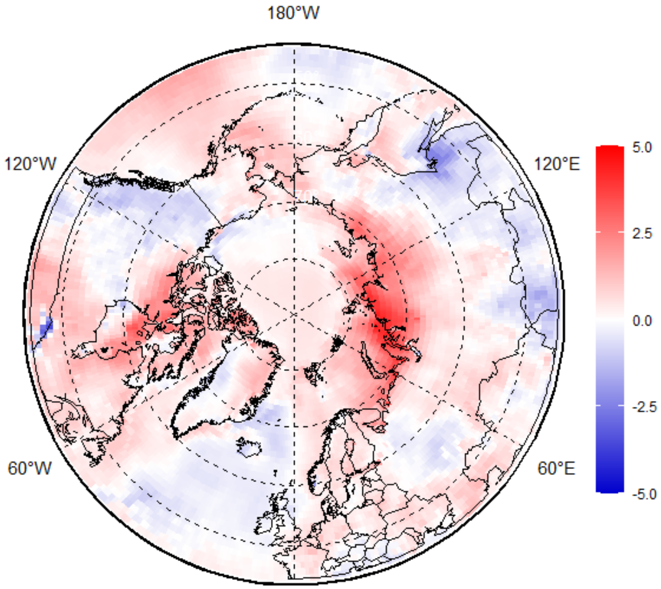
Sea	Anomaly 2020(2019)	Rank 2020(2019)	The warmest year (anomaly)	The coldest year (anomaly)
N Greenland and Norwegian Seas	1,2 (1.9)	10 (4)	2016 (2,4)	1965 (-0,7)
Barents Sea	2,0 (0.2)	**3** (18)	2013 (2,8)	1949 (-1,2)
Kara Sea	3,5 (1.6)	**1** (6)	**2020** (3,5)	1968 (-1,2)
Laptev Sea	2,4 (3.2)	**3 (1)**	2019 (3,2)	1962 (-1,5)
Eastern Siberian Sea	2,1 (3.1)	**3 (2)**	2007 (3,7)	1949 (-1,6)
Chukchi Sea	1,3 (3.2)	9 **(2)**	2007 (3,9)	1965 (-1,6)
Beaufort Sea	0,5 (0.2)	14 (19)	2012 (2,5)	1947 (-1,5)
N Canadian archipelago	1,4 (2.3)	8 **(2)**	2011, 2012 (2,7)	1972 (-1,6)

Reference period: 1961-1990



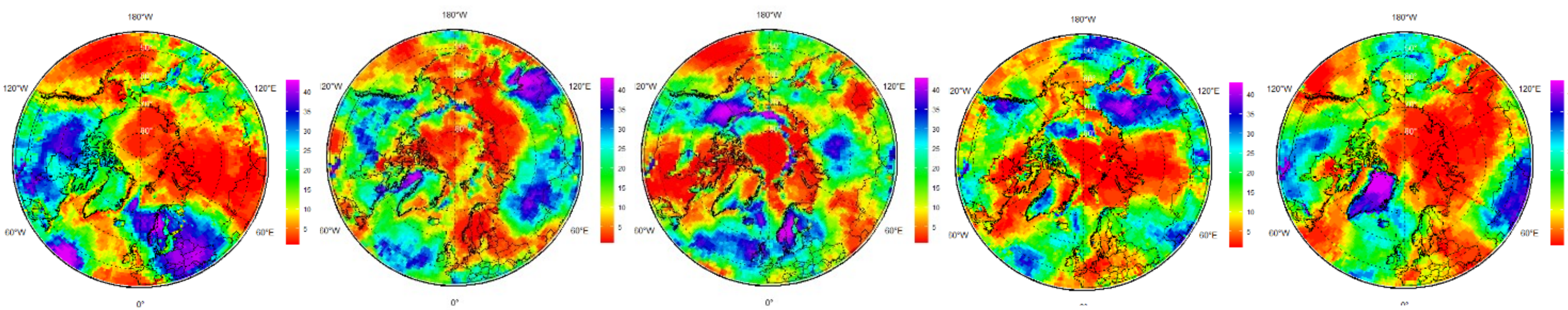
[AARI]

MJJAS 2020 Surface Air Temperature (reanalysis)



JJA 2020 SAT anomaly (1981-2010)

- For the whole season from May to September 2020 close to maximum air temperature anomalies prevailed over Western and Eastern Siberia, partly Bering and Chukchi, Eastern Nordic with negative anomalies prevailing in parts of Western Canada
- Western Nordic and Eastern Canada experienced both positive and negative anomalies



May Jun Jul Aug Sep

MJJAS 2020 SAT ranks (1979-2020)

AARI / ERA5 reanalysis

JJA 2020 surface precipitation by regions (obs)

Region	Relative anomaly, % 2020 (2019)	Year (maximum anomaly, %)	Year (minimum anomaly, %)
Western Nordic*	95.9 (98.0)	1964 (120,5)	1968 (75,2)
Eastern Nordic*	111.2 (104.5)	1981 (128,4)	1980 (68,5)
Western Siberia	**98.1** (112.3)	2002 (122,6)	1946 (72,4)
Eastern Siberia	86.8 (81.7)	1988 (125,2)	1967 (78,4)
Bering & Chukchi*	78.0 (81.1)	1954 (139,6)	1982 (60,2)
W Canada & Alaska*	85.0 (113.1)	1951 (164,4)	1968 (54,1)
Eastern Canada*	86.2 (111.6)	2005 (123,5)	1977 (75,0)
60-70°N	**96.6** (102.6)	1954 (115)	1968 (88)
70-85°N	91.7 (103.2)	1989 (127)	1998 (84)
60-85°N	**93.2** (100.6)	1954 (117)	1980 (90)

* Old boundaries

Reference period: 1961-1990

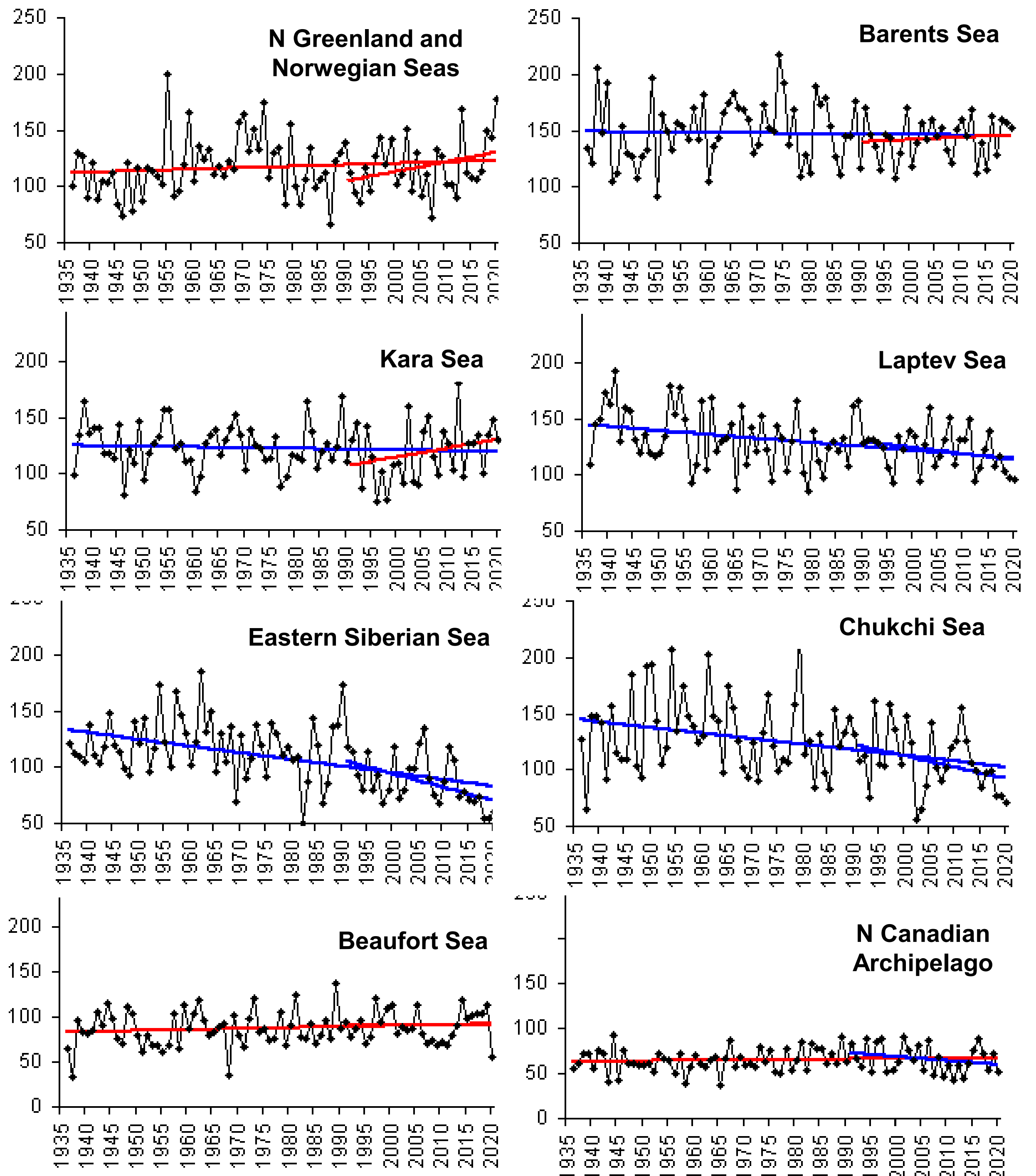
111.2 – wetter
98.1 – close to normal
86.8 - drier

[AARI]

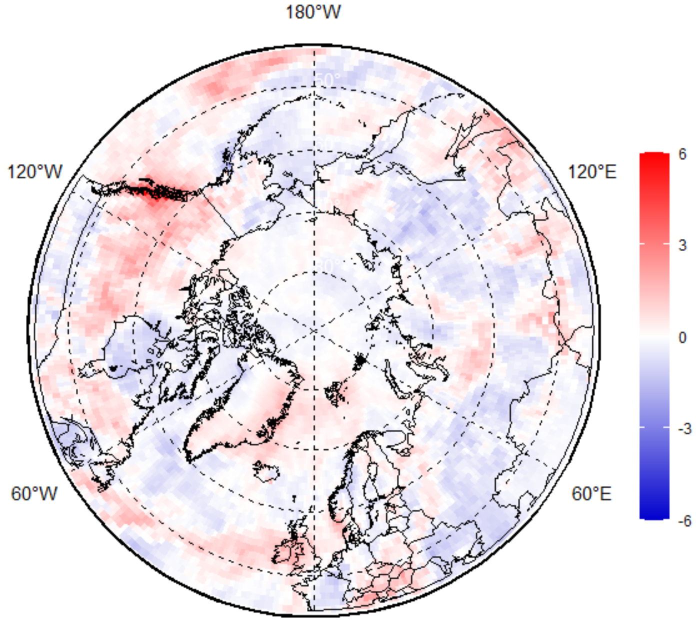
JJA surface precipitation trends by seas (obs)

- 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 Barents Sea and Canadian Arctic regions

[AARI]

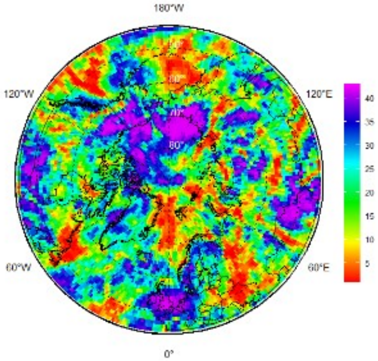


MJJAS 2020 (surface) precipitation (reanalysis)

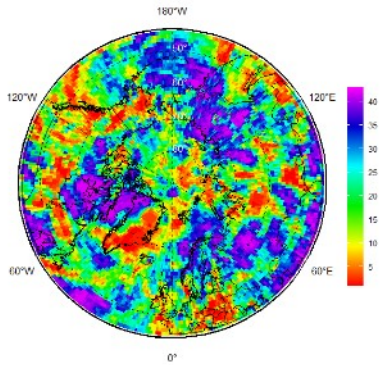


JJA 2020 precipitation anomaly (1981-2010)

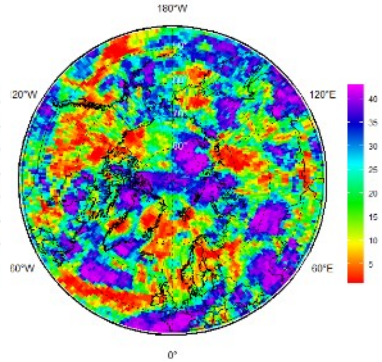
- ❖ During JJA 2020 most of the Western and Eastern Siberia experienced drier conditions
- ❖ Wetter conditions were observed for Alaska, Western Canada and Western Nordic regions



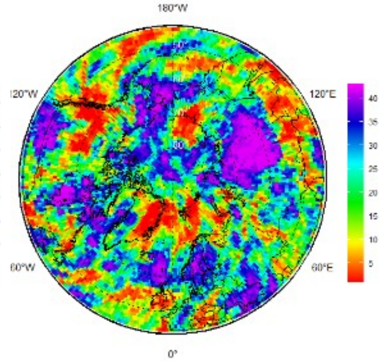
May



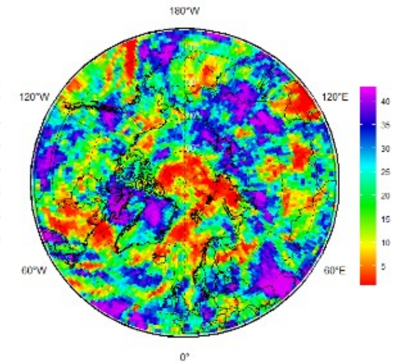
Jun



Jul



Aug



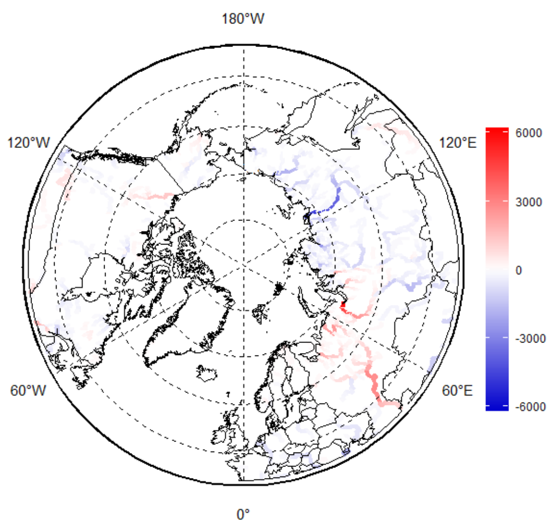
Sep

MJJAS 2020 precipitation ranks (1979-2020)

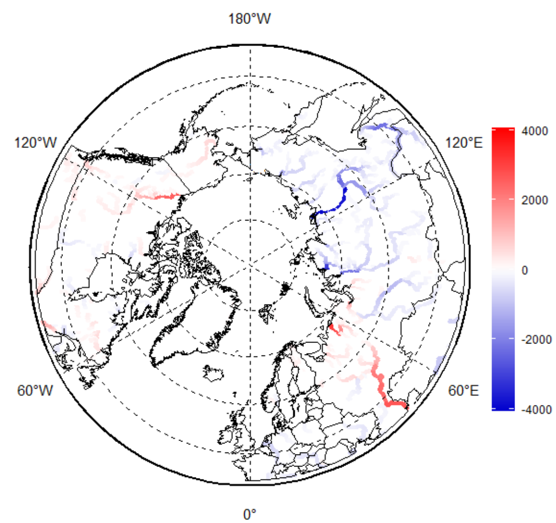
AARI / ERA5 reanalysis

Impacts of suumer 2020 precipitation on river discharge (reanalysis)

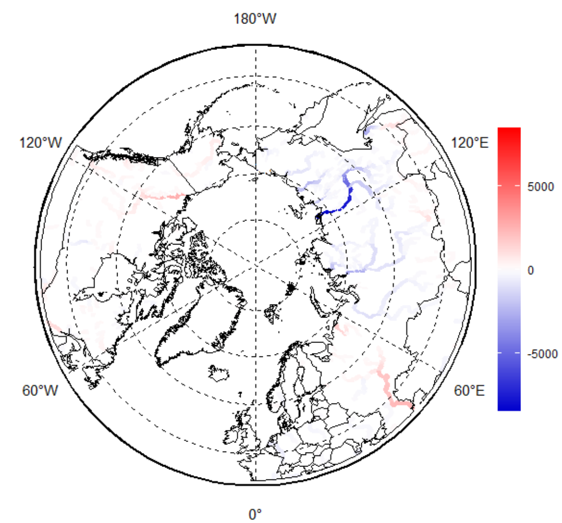
- ❖ **Impacts of wetter/drier regions were reflected in the JJA 2020 Arctic rivers discharge:**
  - ❑ **lesser drainage than normal is seen for Ob', Enisey and Lena rivers, and further eastward (blue areas),**
  - ❑ **Mackenzie and Yukon rivers experienced greater discharge than normal over that same time period (red areas) which is opposite to summer 2019**



Jun



Jul



Aug

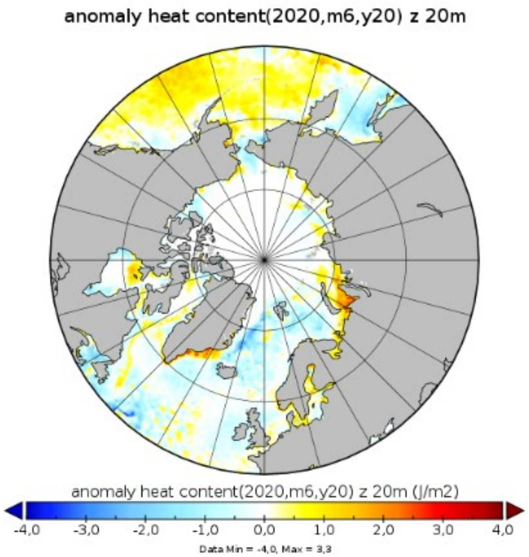
JJA 2020 river discharge anomaly (2000-2019)

AARI / ERA5 reanalysis

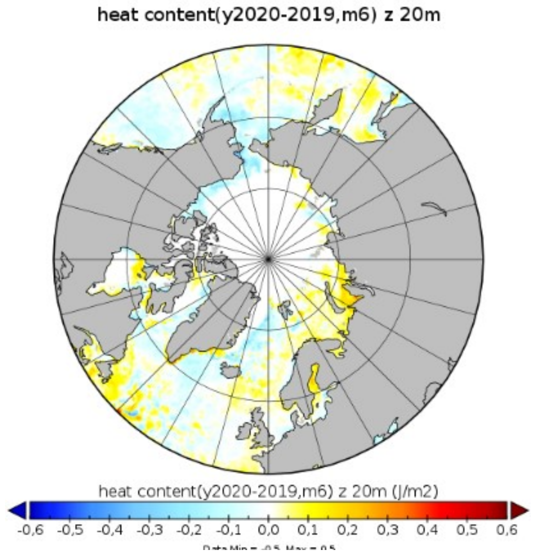
Sea ice variables:

- ❖ Precursors in atmosphere and polar ocean
- ❖ Ice extent and ice conditions based on ice charting
- ❖ Sea ice thickness and volume based on reanalysis

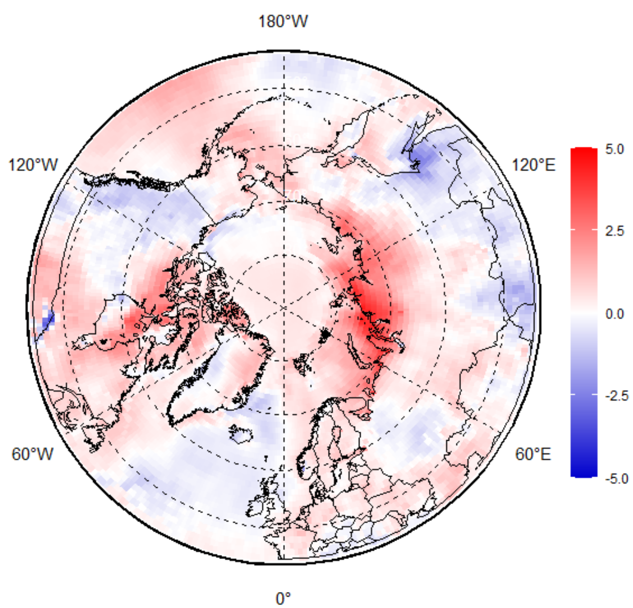
Precursors in atmosphere and polar ocean for JJAS 2020 ice conditions



Jun 2020 Heat Capacity anomaly (2000-2019)



Jun 2020 Heat Capacity anomaly (2019)

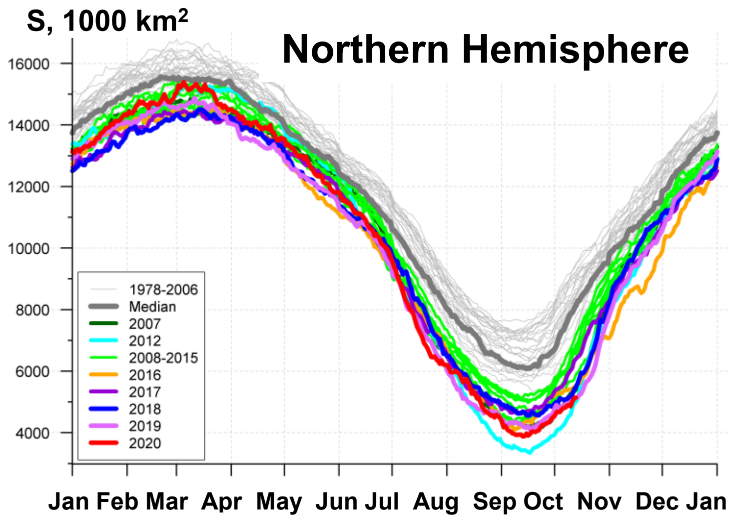


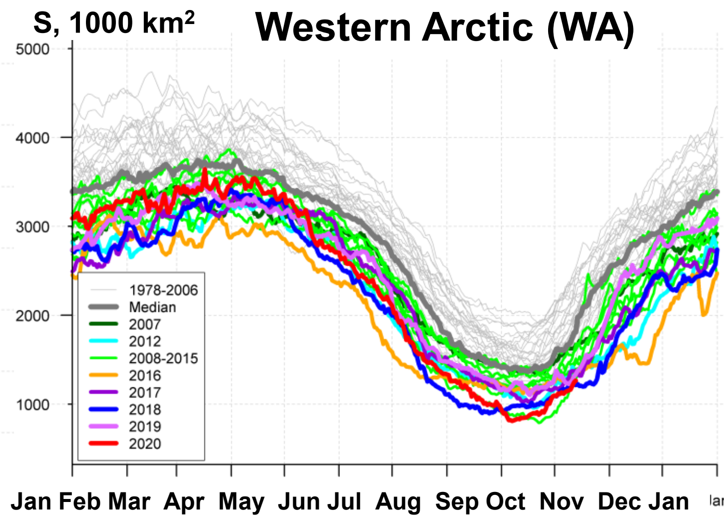
JJA 2020 SAT anomaly (2000-2019)

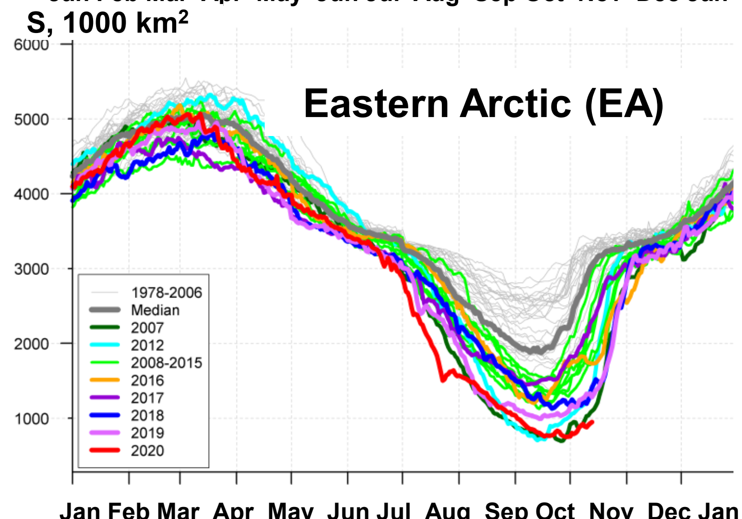
- Prevailing positive ocean heat capacity (HC) anomaly (to 2000-2019 and to 2019) in upper 20 m during June 2020 for the Kara, parts of Laptev and ESS seas stimulated earlier and faster start of ice melt in these regions
- Oppositely, zero or slightly negative HC anomalies in June 2020 in Beaufort and Chukchi Seas slowed ice reduction in these regions
- Dominance of very significant positive SAT anomalies throughout the summer over Eurasian Arctic and opposite negative anomalies in Alaska region preserved the above tendencies and led to corresponding feedbacks (lower albedo -> faster heating -> greater HC)

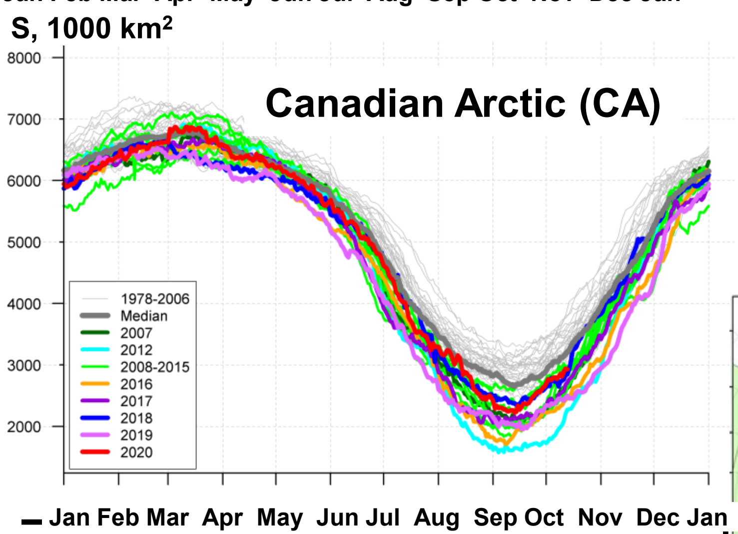
[AARI / Copernicus Climate Change Service (ERA5 & MERCATOR reanalysis)]

Arctic (NH) seasonal ice extent 1978…. 2020



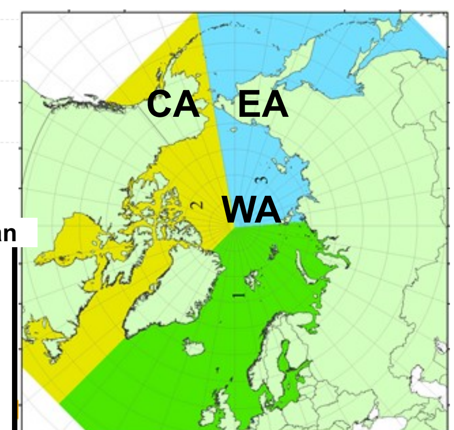






S, 1000 km²

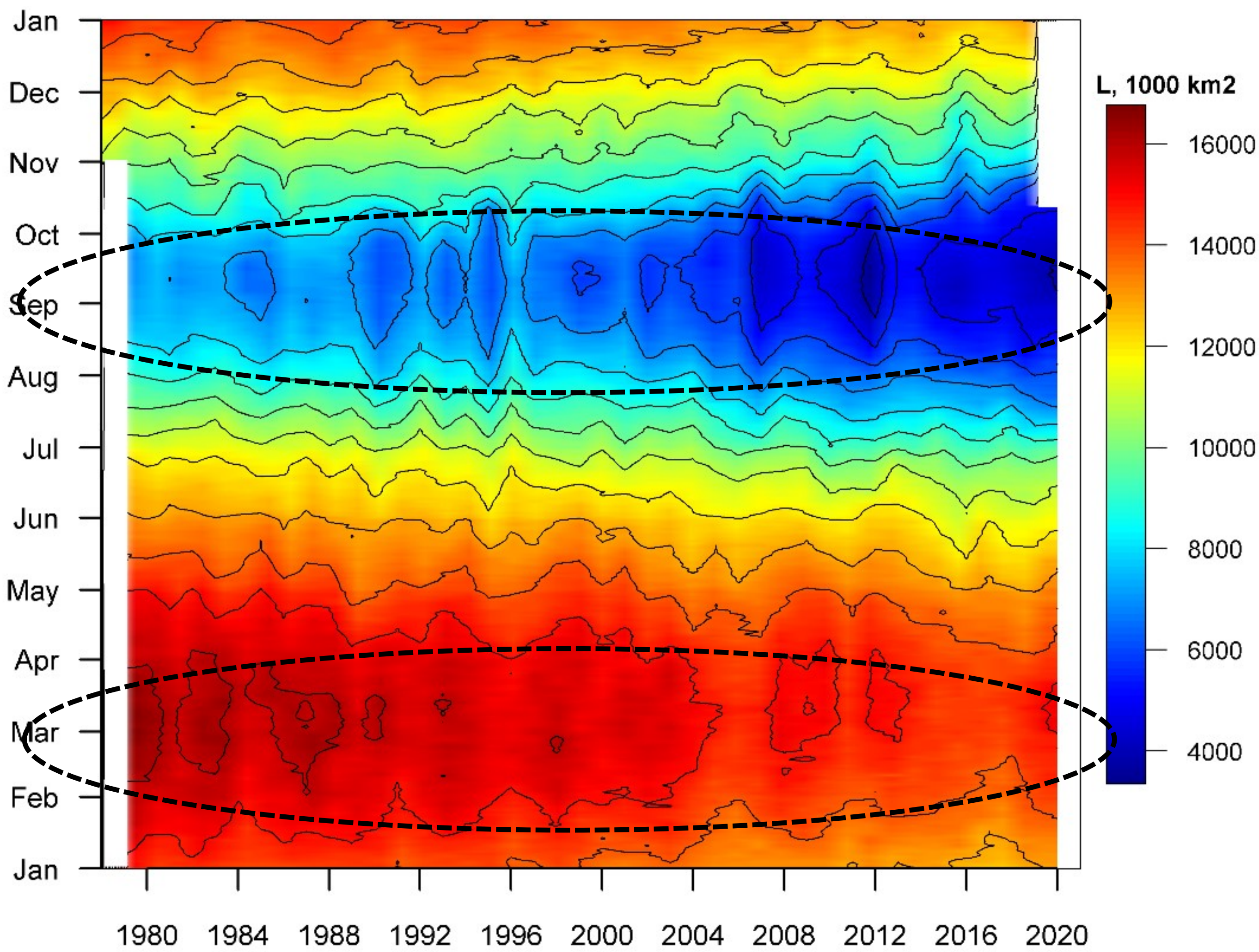
Sep (Min)		March (Max)	
2012	3346	2017	14467
2020	3882	2018	14516
2016	4099	2015	14526
2019	4103	2016	14580
2007	4189	2011	14701
2011	4312	2006	14867
2015	4350	2019	14891
2018	4557	2007	14931
2008	4588	2014	14972
2017	4622	2005	15101
2010	4641	2020	15159
…	…	…	…
1982	7246	1988	16461
1983	7285	1983	16547
1980	7611	1979	16769



[AARI, NSIDC]

- Minimum summer ice extent, 2nd in row, 3.9 mln km² (4,1 in 2019) reached 12-13 September 2020 (17-18 September in 2019)
- Summer 2nd in row extent does not correlate with winter 11th in row in 2020
- During melting period the lowest on record Arctic ice extent was observed in July due to occurred minimum in Eurasian Arctic

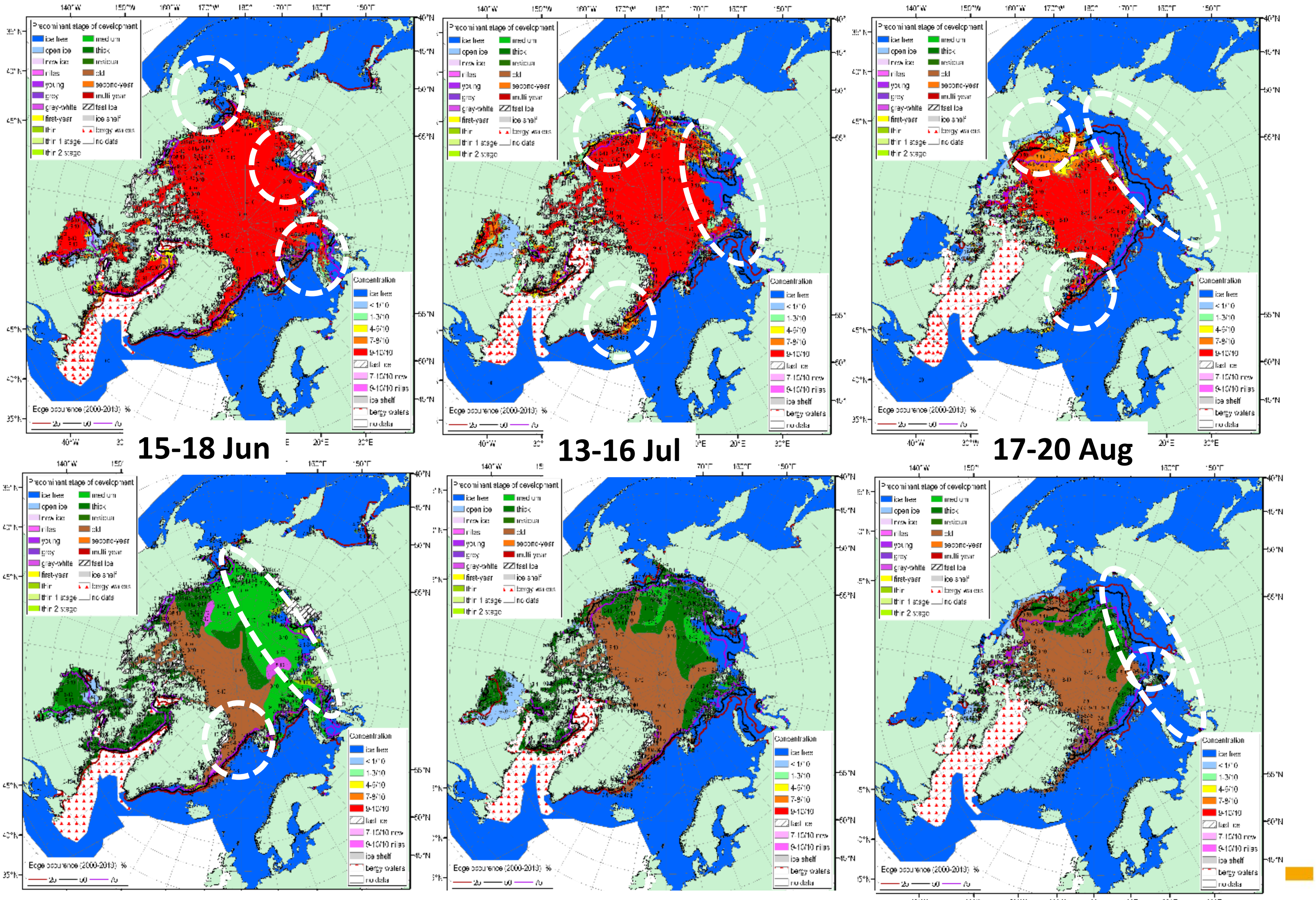
Seasonal NH ice extent variability: 1978 - 2020



- ❖ Seasonal patterns of daily ice extent allow to analyze interseasonal variability of ice extent
- ❖ Both winter maximums and summer minimums continue to diminish
- ❖ However significant interannual variability of ice extent occurs, which is a hint to a more mobile ice and variable ice conditions

[AARI, NSIDC]

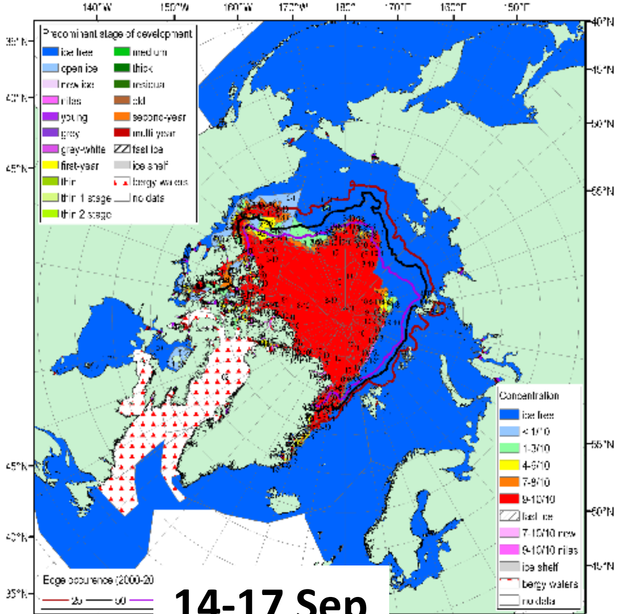
JJA 2020 Arctic sea ice – concentration and stage of development



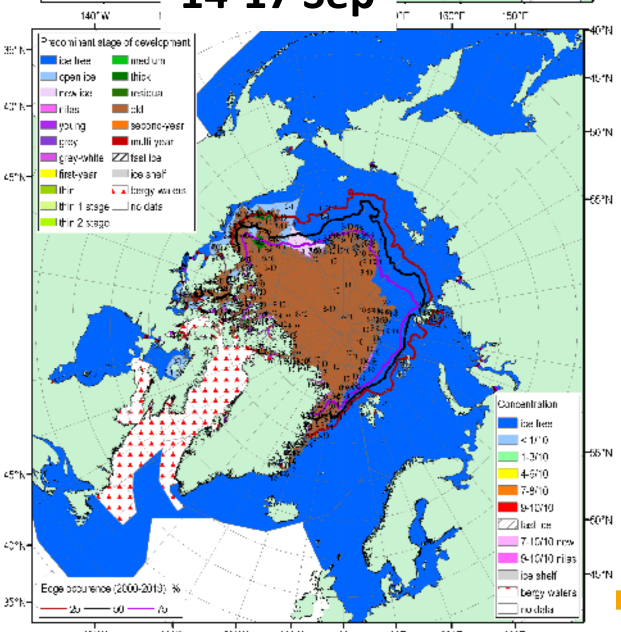
Blended AARI/CIS/NIC ice charts; ice edge – nearest 5days, reference period: 2000-2019

Weather • Climate • Water

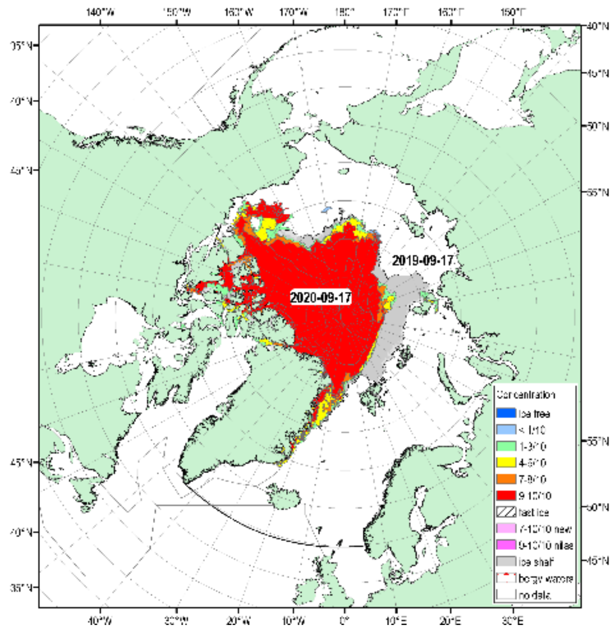
Sea ice conditions during September 2020 minimum



14-17 Sep



17 Sep: 2020 & 2019

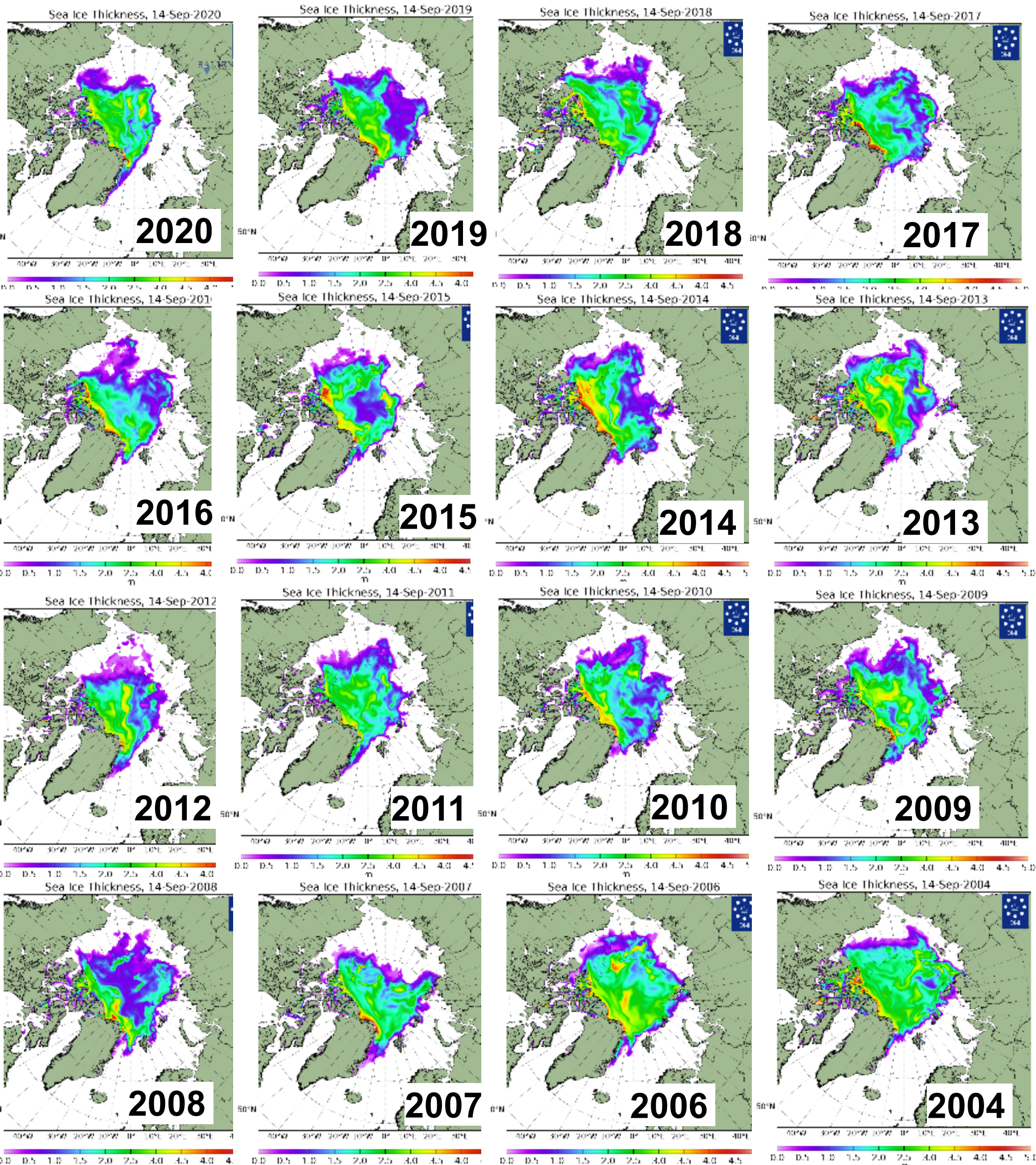


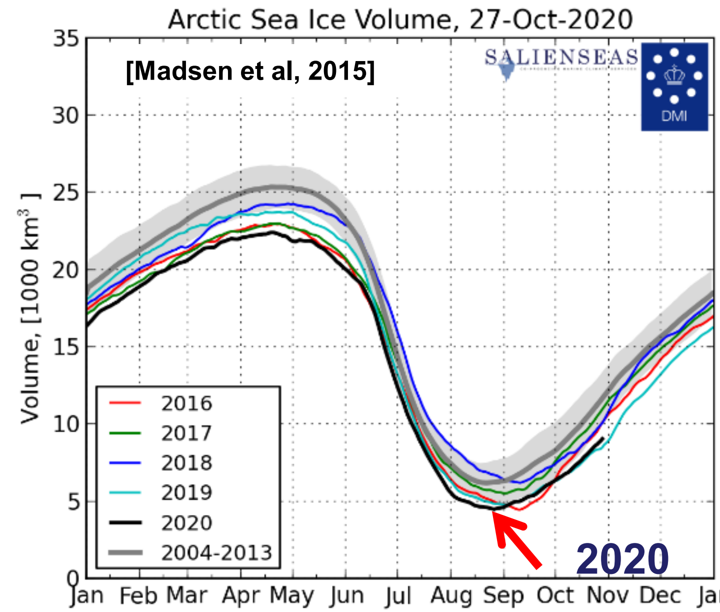
- Observed in September 2020 2nd extreme reduction of the Arctic ice cover significantly differs in shape with that for 2019
- While Eurasian shelf seas were completely ice free (same for the NSR) with the ice edge significantly northward of Severnaya Zemlya, FJL or Svalbard, the ice conditions in the Beaufort Sea and Canadian archipelago were close to normal for the past 20-30 years (NW passage closed)

[AARI]

Blended AARI/CIS/NIC ice charts; ice edge – nearest 5days, reference period: 2000-2019

Sea ice thickness for 14 Sep 2004…2020 and ice volume





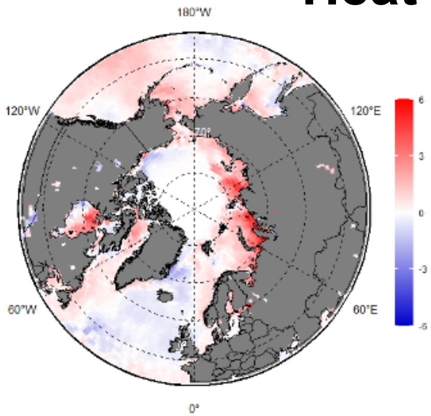
- Models show Arctic ice volume in 2020 the lowest from Oct 2019 within period 2004-2020 with comparable values in 2016 and 2019
- As the summer ice extent in 2020 is not considerably lower than in 2019, that suggest somewhat higher summer ice thicknesses in 2020

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

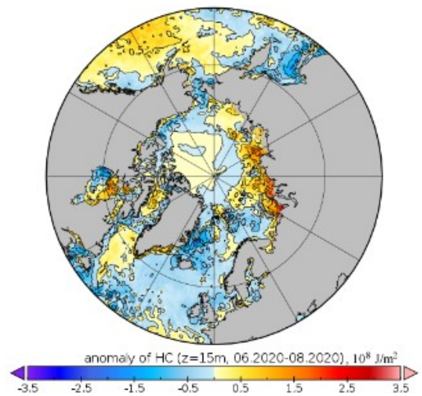
Polar Ocean:

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

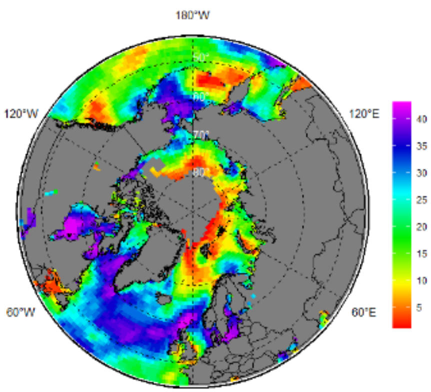
Heat content, waves and pH – JJAS 2020



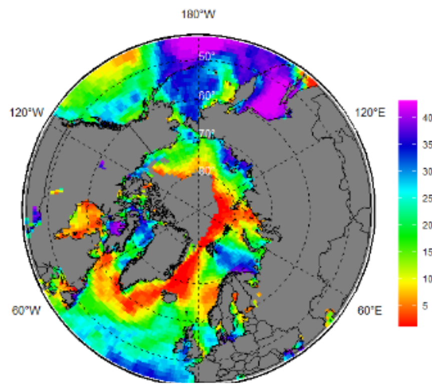
JJA 2020 SST anomaly (2000-2019)



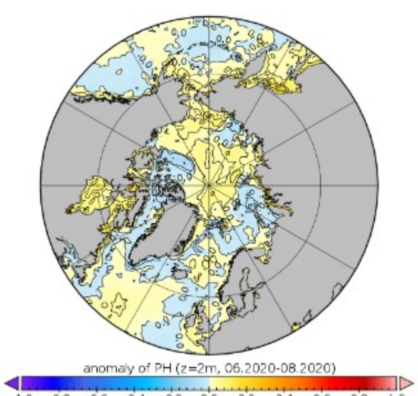
JJA 2020 HC 15m anomaly (2000-2019)



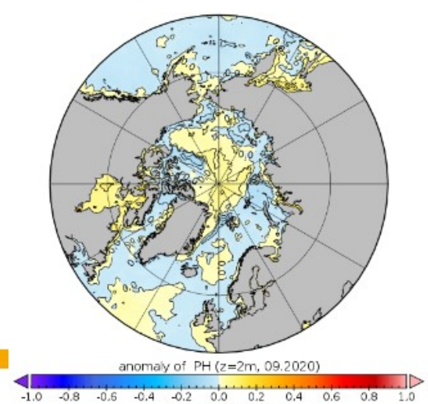
Aug 2020 WW&S height rank (1979-2020)



Sep 2020 WW&S height rank (1979-2020)



pH anomaly 2m JJA (2000-2019)



pH anomaly 2m Sep (2000-2019)

- Very prominent higher temperatures and surface layer heat content were observed in Eurasian, Bering Seas, parts of Baffin Sea and Hudson Bay with lower than for the last 20 years surface heating for Beaufort Sea, parts of Greenland and Barents Seas
- Due to absence of ice, most of the boundary seas and adjacent Arctic Basin were exposed to higher than in past stormy conditions with exceptions ESS, Beaufort (calmer)
- Numerical models show positive (Arctic Basin, Hudson Bay) and negative pH (Eurasian shelf seas) anomalies to the last 20 years, the latter points to acidification processes

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

Land Snow:

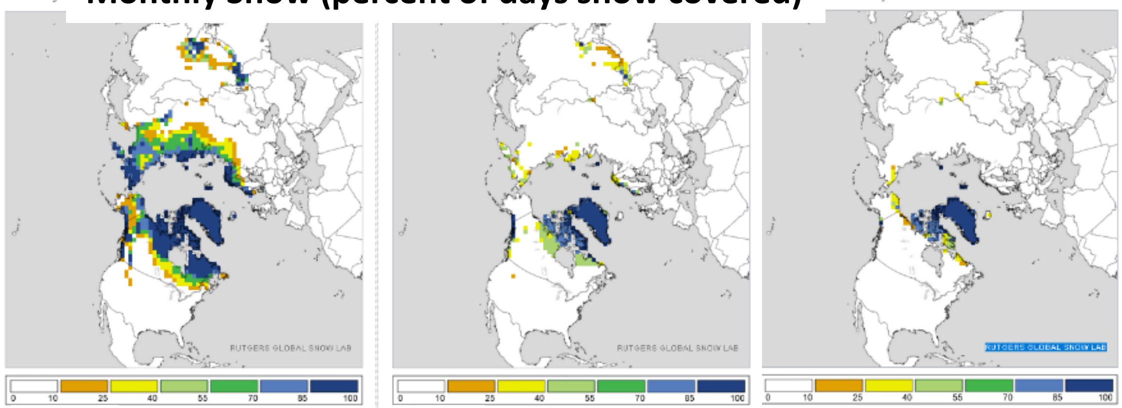
- Snow water equivalent
- Snow extent

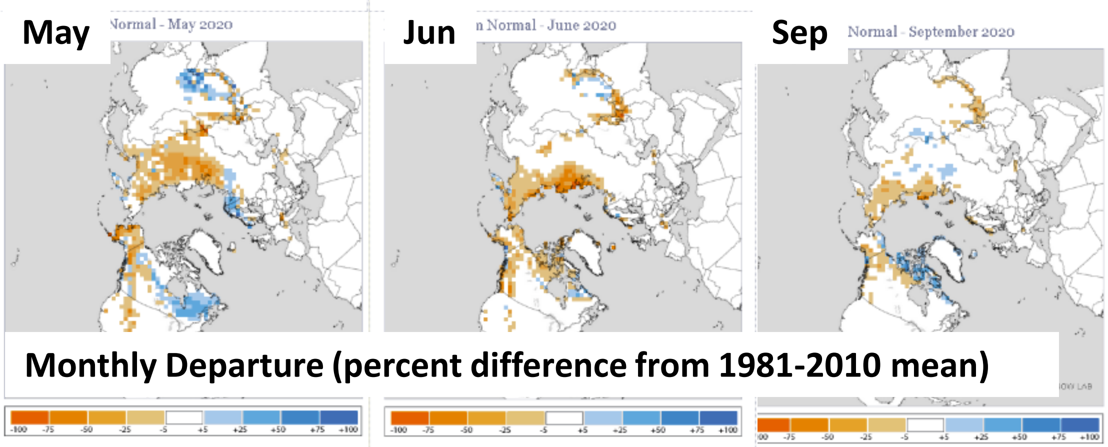
MJJAS 2020 Land snow (satellite, obs)

[FMI, ECCC,
Rutgers Glob SnowLab
/ GCW)]

- Snow extent in May-Sep 2020 was much less than normal with extreme negative anomalies (no snow) in most of Siberia and Alaska
- Positive anomalies (more snow) were observed in May in parts of Scandinavia, E Canada and in Sep for N Canada

Monthly Snow (percent of days snow covered)





Monthly Departure (percent difference from 1981-2010 mean)

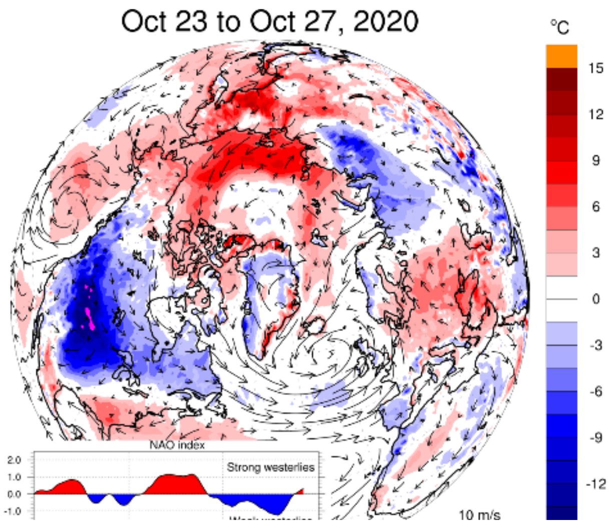
S, 1000 km²	Northern Hemisphere					
	2020	1981-2010 Normal		Period of Record from 11-1966		
Month	Area	Mean	Departure	Rank	Maximum (Year)	Minimum (Year)
9	4,505	5,235	-730	42/52	7,762 (1972)	3,838 (1990)
8	2,292	2,797	-505	50/52	5,308 (1967)	2,089 (1968)
7	2,406	3,665	-1,259	50/51	8,210 (1967)	2,325 (2012)
6	5,961	9,418	-3,457	49/53	14,972 (1978)	4,922 (2012)
5	16,659	19,019	-2,360	49/54	23,093 (1974)	15,377 (2010)

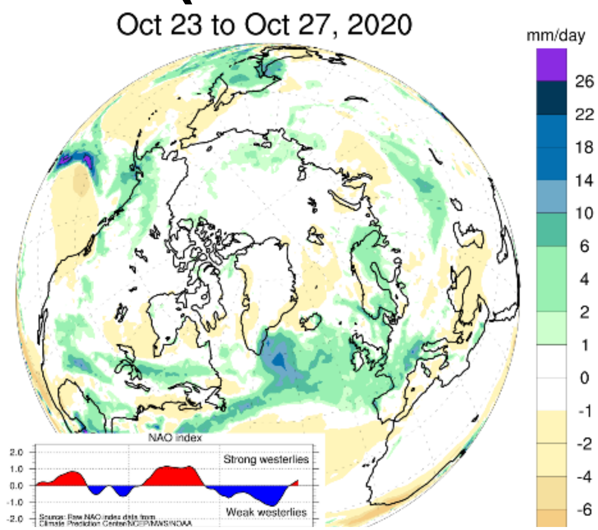
S, 1000 km²	Eurasia					
	2020	1981-2010 Normal		Period of Record from 11-1966		
Month	Area	Mean	Departure	Rank	Maximum (Year)	Minimum (Year)
9	582	1,526	-944	50/52	3,409 (1977)	540 (1984)
8	72	375	-303	52/52	1,859 (1967)	72 (2020)
7	141	765	-624	50-51/51	3,551 (1967)	141 (tie)
6	1,123	3,609	-2,486	52/53	7,129 (1978)	1,068 (2012)
5	7,574	9,723	-2,149	52/54	12,511 (1976)	7,262 (2013)

S, 1000 km²	Canada					
	2020	1981-2010 Normal		Period of Record from 11-1966		
Month	Area	Mean	Departure	Rank	Maximum (Year)	Minimum (Year)
9	1,606	1,395	211	19/52	2,812 (2018)	647 (1968)
8	202	375	-174	45/52	1,569 (1978)	132 (2009)
7	190	772	-582	50/51	2,718 (1978)	143 (2012)
6	2,577	3,258	-681	43/53	4,899 (1978)	1,604 (2012)
5	6,246	5,905	341	17/54	7,902 (1974)	4,762 (2010)

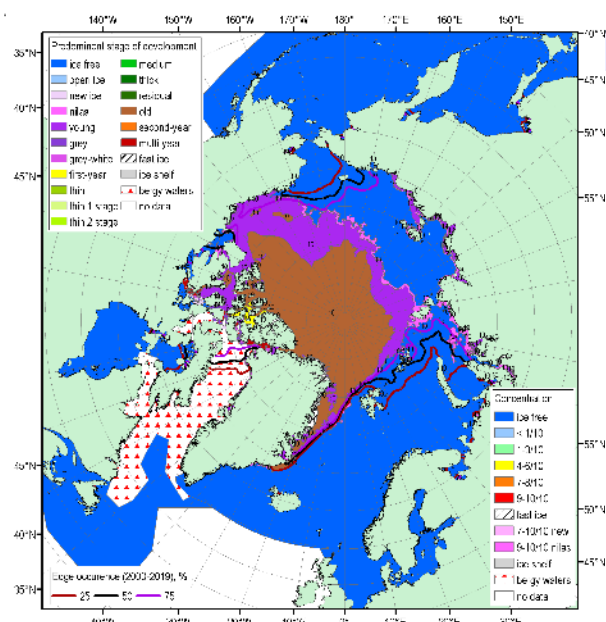
S, 1000 km²	Alaska					
	2020	1981-2010 Normal		Period of Record from 11-1966		
Month	Area	Mean	Departure	Rank	Maximum (Year)	Minimum (Year)
9	140	194	-54	34/52	417 (1996)	35 (1974)
8	0	55	-55	42-52/52	546 (1967)	0 (tie)
7	32	74	-42	41/51	445 (1967)	0 (tie)
6	145	329	-184	48/53	856 (1985)	37 (2015)
5	655	1,033	-378	52/54	1,486 (1985)	595 (2016)

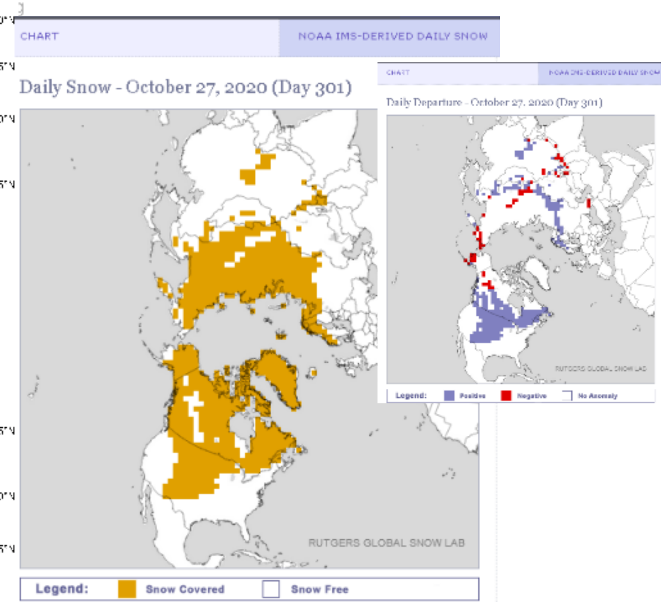
Current Conditions (22-27 Oct 2020)





SAT, precipitation, mean wind vectors, NAO for 23-27 Oct 2020 (http://polarportal.dk)





- Since end of Sep week westerly, moderate northern winds in European sector with somewhat opposite patterns over Siberia and Canada (due to bi-polar vortex) led to lower SAT in European and Alaska and W Canadian regions with a higher SAT over E Siberia, Chukchi and Greenland
- Northern Scandinavia, Arctic coasts, Siberia are already under snow with negative anomalies over Alaska
- Though Arctic Basin and in particular the Canadian Arctic are under the intense freeze-up, the NSR is still open

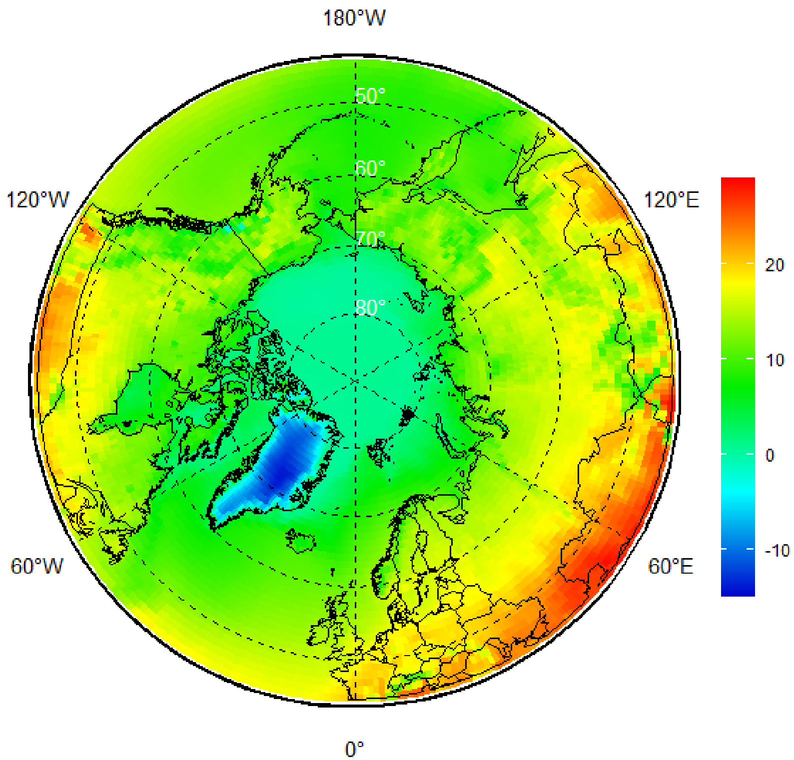
AARI/NIC ice chart for 22-27 Oct 2020

Snow extent for 27 Oct 2020, NOAA/Rutgers Global snow lab

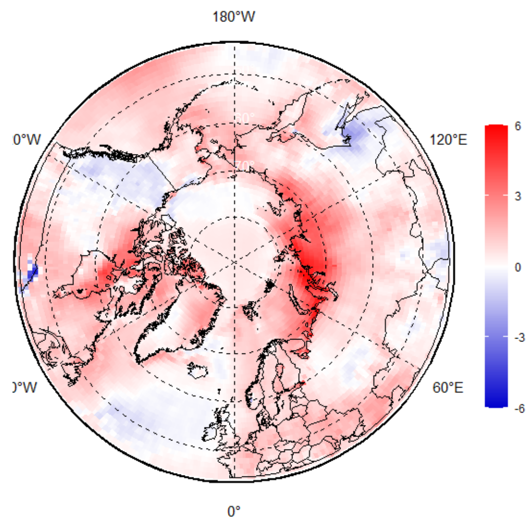
Normals, extremes and ranks

- In most of the cases the climate monitoring variables are shown as occurred values paired with certain statistic to show how this 'rolled value' corresponds to climate
- Different statistics are used for different variables with most common 'normal', 'anomaly', 'rank', 'extreme' to underline certain event
- Usually we call the occurred variable 'normal' when it falls into certain interval of values - usually 2nd tercile or central 1/3 of distribution histogram, which means that:
  - distribution law of the variable should be close to normal (gaussian), if not, the 2nd tercile may make no sense, e.g. for 'U'-shape distribution (e.g. sea ice concentration)
  - reference period should be defined and used jointly with 'normal', if not, in case of oscillation periods greater than reference period we would have false idea that conditions are false high or low
- Instead of 'normal', 'anomaly' defines difference of occurred variable from the center of reference period, which may be defined as:
  - average value for reference period, again when distribution law is close to normal
  - median or such value that 50% of cases are lower and 50% are greater, that is suitable for most of variables, including those with 'U', 'J', 'L' distribution laws
- Rank shows digital position of occurred value in the observed row of values during defined reference period, rank '1' usually corresponds to highest value or maximum extreme, while rank 'N' corresponds to the lowest value or minimum extreme

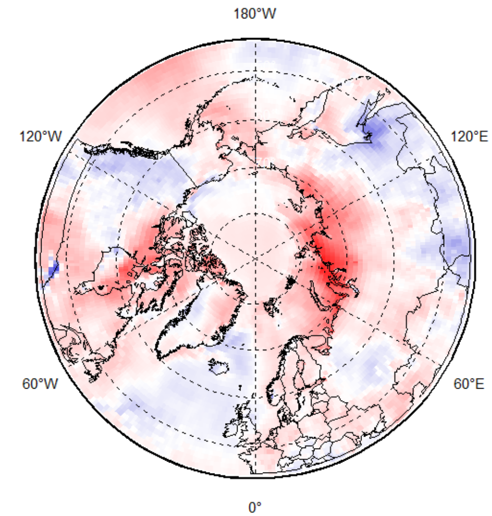
Example: surface air temperature (SAT)



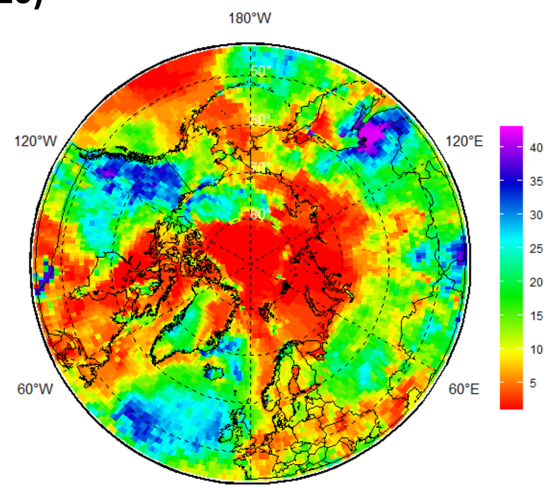
JJA 2020 SAT



JJA 2020 SAT anomaly
(1981-2010)

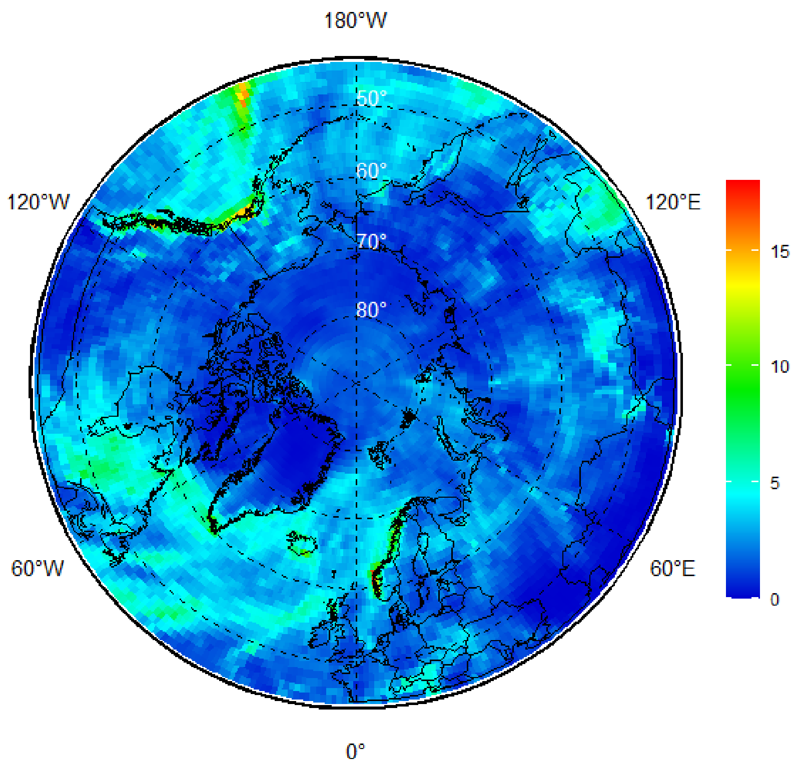


JJA 2020 SAT anomaly
(2000-2019)

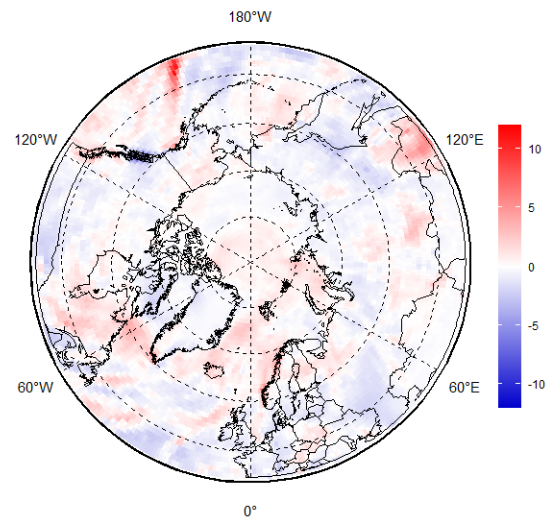


JJA 2020 SAT rank
(1979-2020)

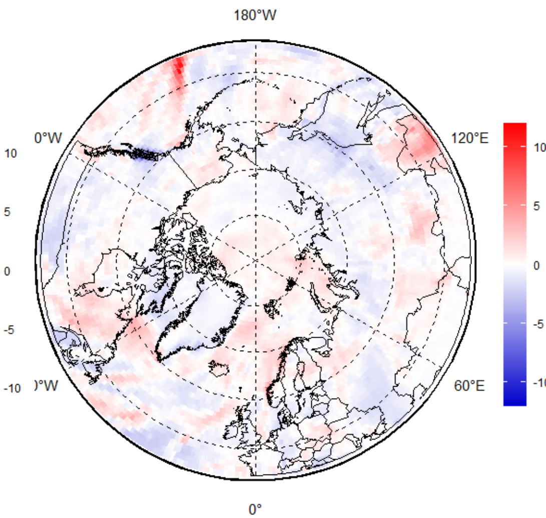
Example: surface precipitation (prec)



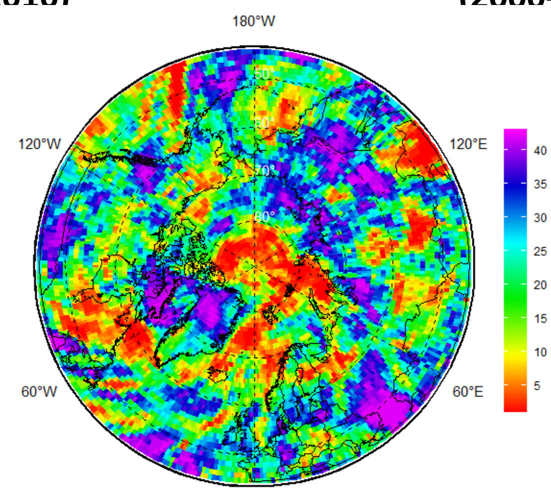
Sep 2020 prec



Sep 2020prec anomaly (1981-2010)



Sep 2020 prec anomaly (2000-2019)



Sep 2020 prec rank (1979-2020)

Thank you! Merci! Takk! Спасибо!
Tak! Tack! Kiitos! þakka þér fyrir!
Naqurmiik ! Qaĝaasakuq !
Grazie! Giitu! Vielen Dank!
Dhanyavaad !

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale