WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

AARI

May – September 2022 Arctic Seasonal Review

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WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

ACF
Arctic Climate Forum

Content of seasonal review

1) Review for MJJAS 2022 (May – September 2022)

- Atmosphere:
  - Precursors in atmospheric circulation
  - Surface air temperature and precipitation – anomalies and ranks by Arctic regions
- Sea ice:
  - Precursors in atmosphere and polar ocean
  - Ice extent, conditions, thickness and volume variability including September 2022 summer minimum
- Polar Ocean:
  - Heat content, waves and swell height (storminess) - anomalies
  - pH (acidification/alkalization estimates) - anomalies
- Land hydrology:
  - river discharge – anomalies
  - snow extent – anomalies and ranks
- Briefs on bioclimatic weather severity
  - particular report by Anastassiya Revina and Svetlana Emelina

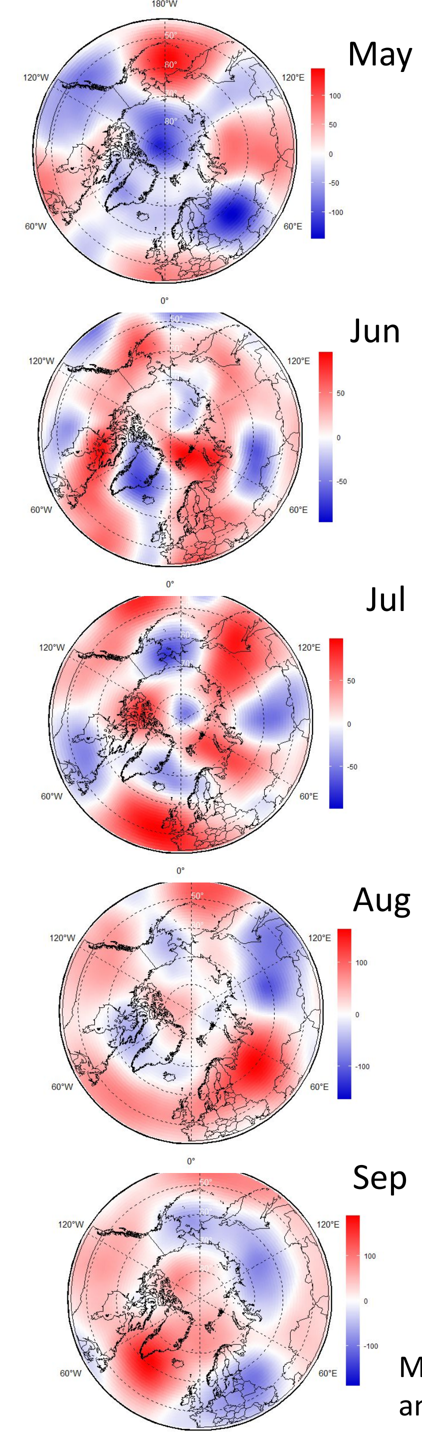
2) Briefs for end of Oct 2022: SAT, winds, precipitation, sea ice, snow

Majority of the described parameters are the WMO Essential Climate Variables (ECV). Anomalies are given relative to the latest **3rd WMO period 1991-2020** while ranks are given for **1950…2022** period.

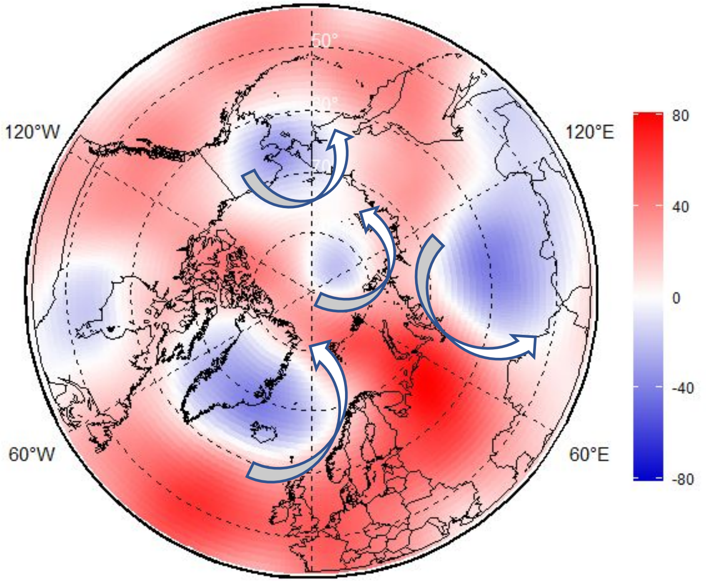
Atmosphere

- Precursors: atmospheric circulation
- Surface air temperature
- Precipitation

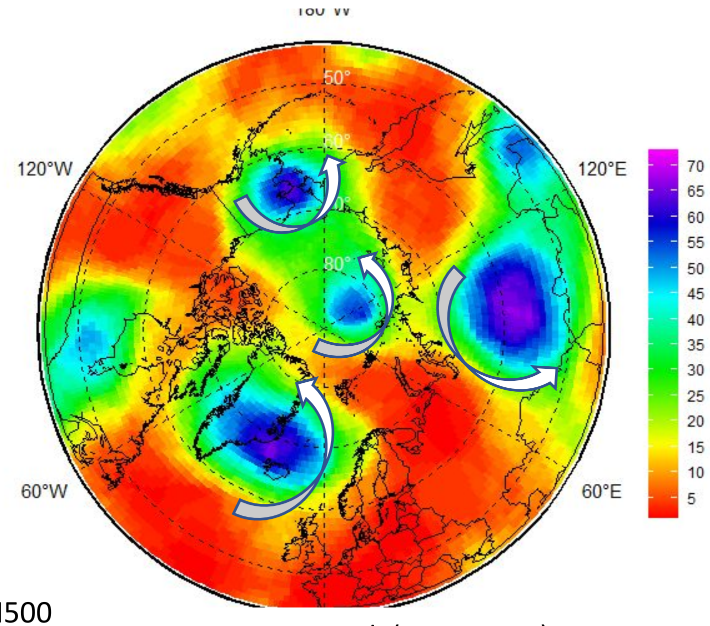
MJJAS 2022 upper atmosphere circulation (H500)



MJJAS 2022 H500 anomaly (1991-2020



JJA 2022 H500 anomaly (1991-2020)



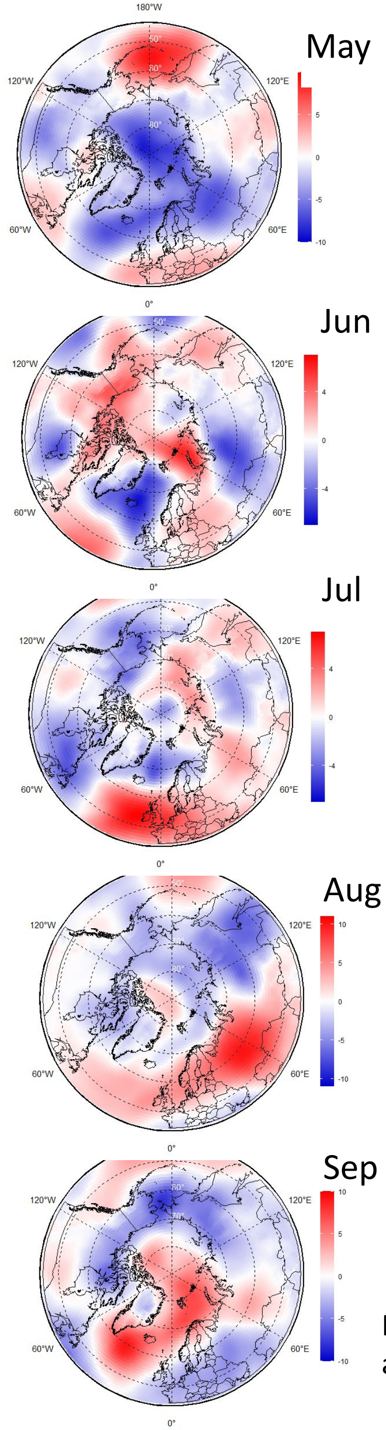
JJA 2022 H500 rank (1950-2022)

For the whole period May – September 2022 polar vortex (on the 500 hPa isobaric surface) typically had 3-4 nodes over Central Arctic, Greenland, Alaska and Siberia causing corresponding cyclonic activity underneath and blocking anticyclone features in other regions

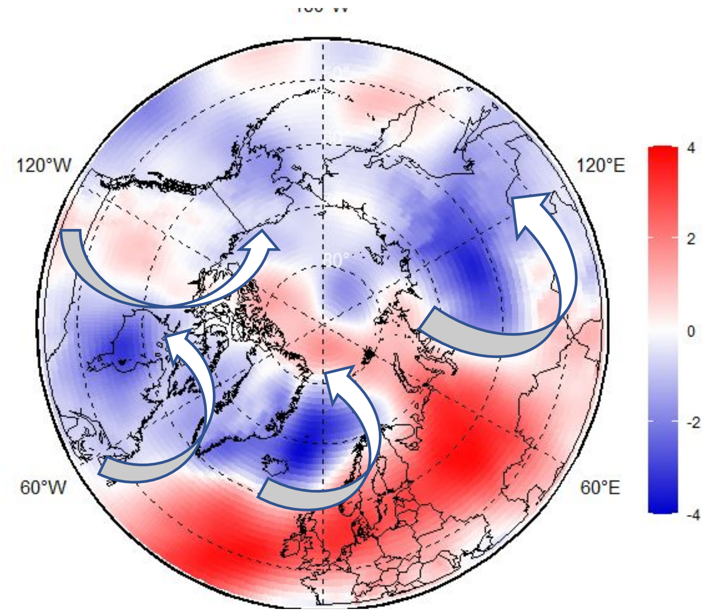
- May – major centers of the vortex over N Pole and E Nordic region
- June, July – major center over Greenland (June) and Alaska (July) with cyclone underneath and the anticyclone over Canada, Alaska and Eastern Siberia
- August – major center over Central Siberia with blocking anticyclone over Eastern Nordic and Western Siberia
- September – diffuse region from Eastern Nordic to Western Siberia and further to Alaska region with a stable anticyclone over Greenland, Central Arctic and Canada

[AARI / ERA5 analysis and reanalysis]

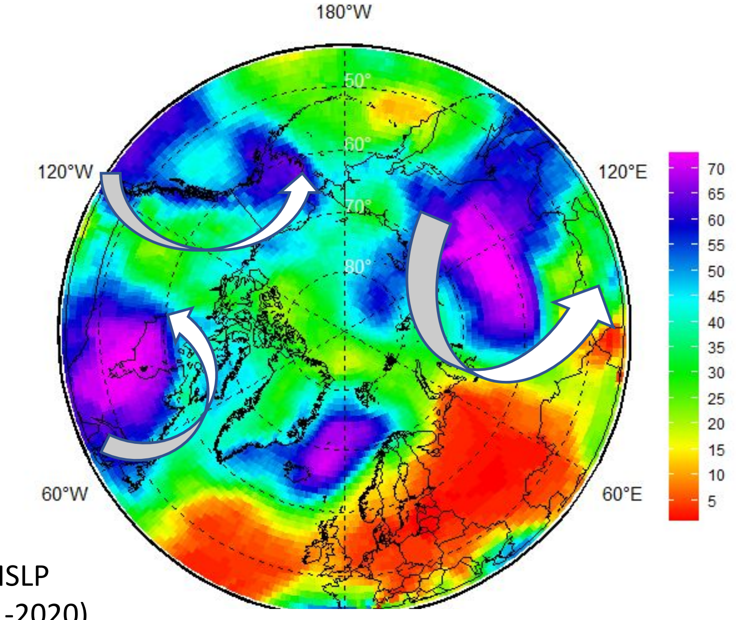
MJJAS 2022 surface atmospheric circulation



MJJAS 2022 MSLP anomaly (1991-2020)



JJA 2022 MSLP anomaly (1991-2020)



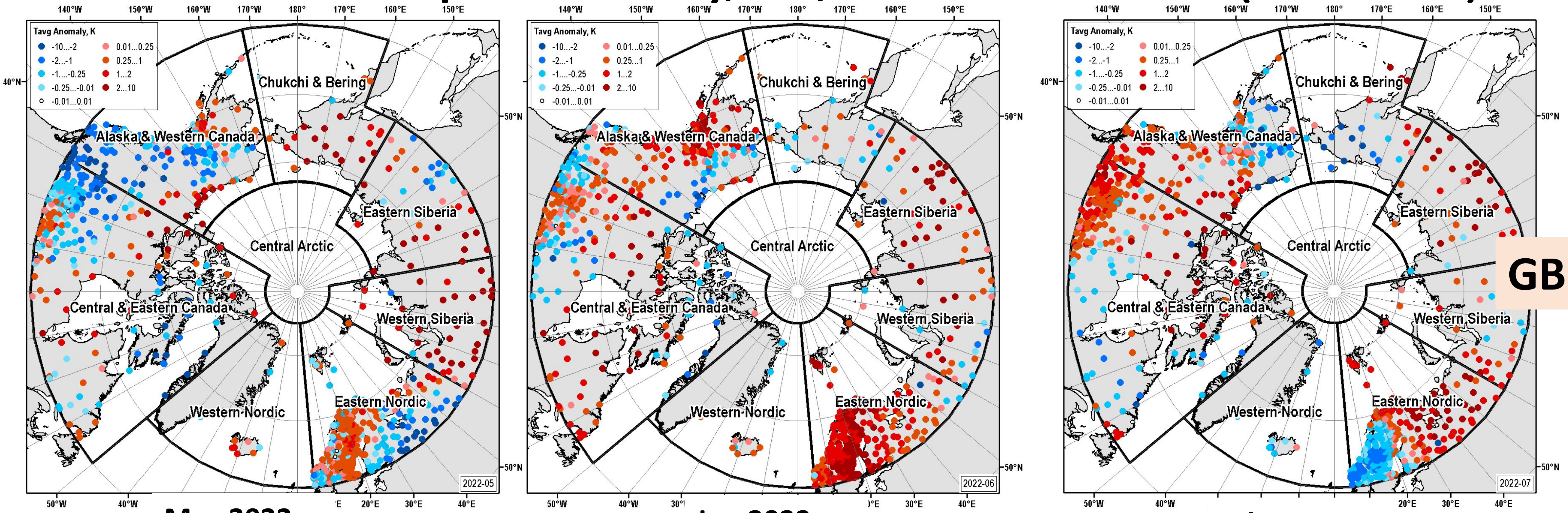
JJA 2022 MSLP rank (1950-2022)

Surface atmosphere inherited features of the upper processes with a sequence of changes from the zonal to meridian forms of circulation in corresponding regions:

- All sectors are characterized by a complexity of circulation patterns during the season
- In the Atlantic-Eurasian sector, atmospheric processes in May and August are characterized by a occurrence of the western zonal circulation. In September a large-scale meridional form of circulation may be noticed
- In the Pacific-American in June meridional processes are steadily predominant, but in July and September they are replaced by the prevailing zonal type of atmospheric circulation.
- In the polar region in May, partly July and August trajectories of the North Atlantic cyclones are normal or shifted northward, while in June and September, trajectories are shifted southward in comparison with the norm.

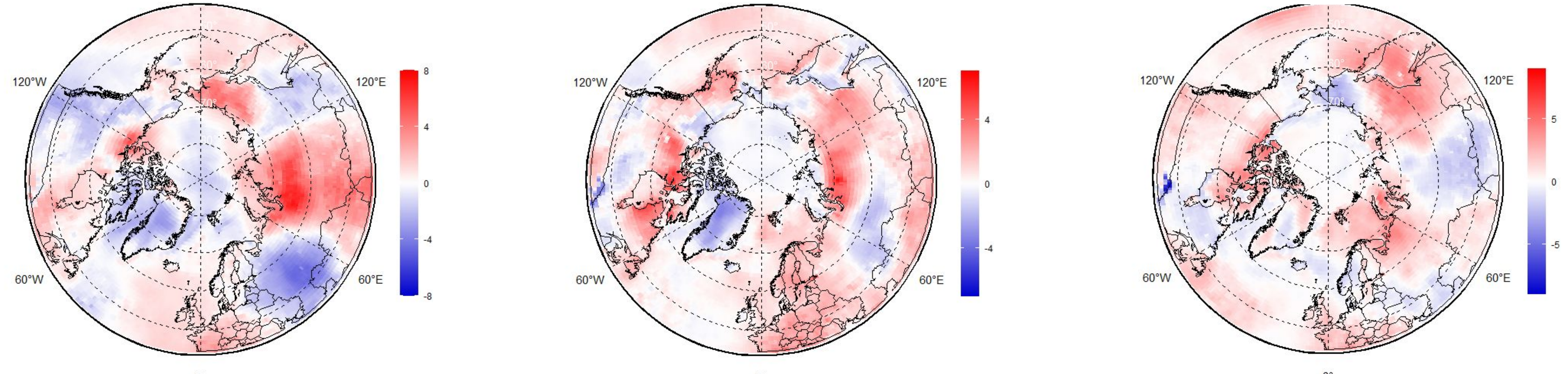
[AARI / ERA5 analysis and reanalysis]

Surface air temperature: May, Jun, Jul 2022 anomalies (1991-2020)



May 2022 | Jun 2022 | Jul 2022

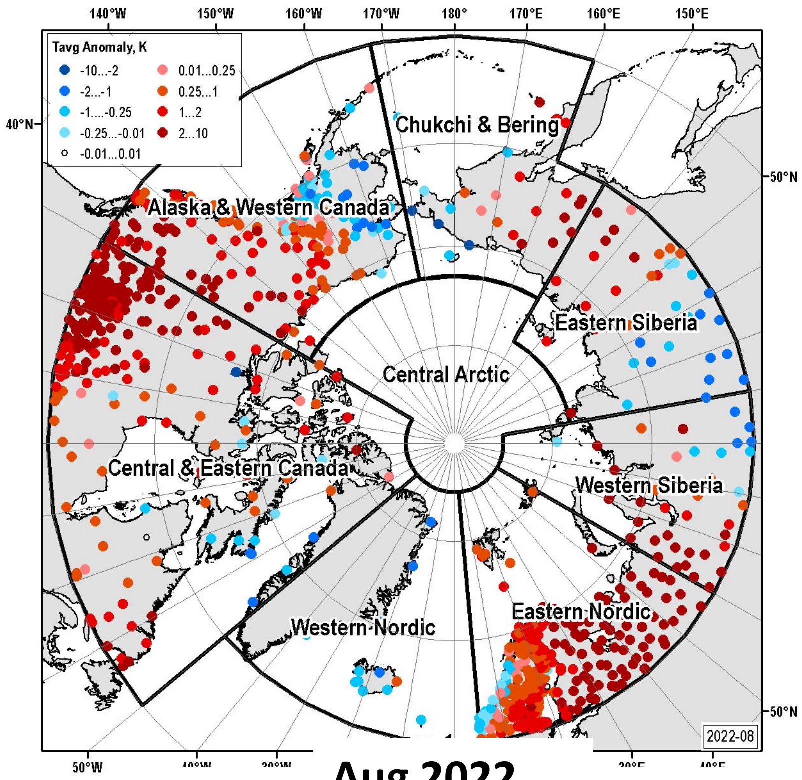
GBON

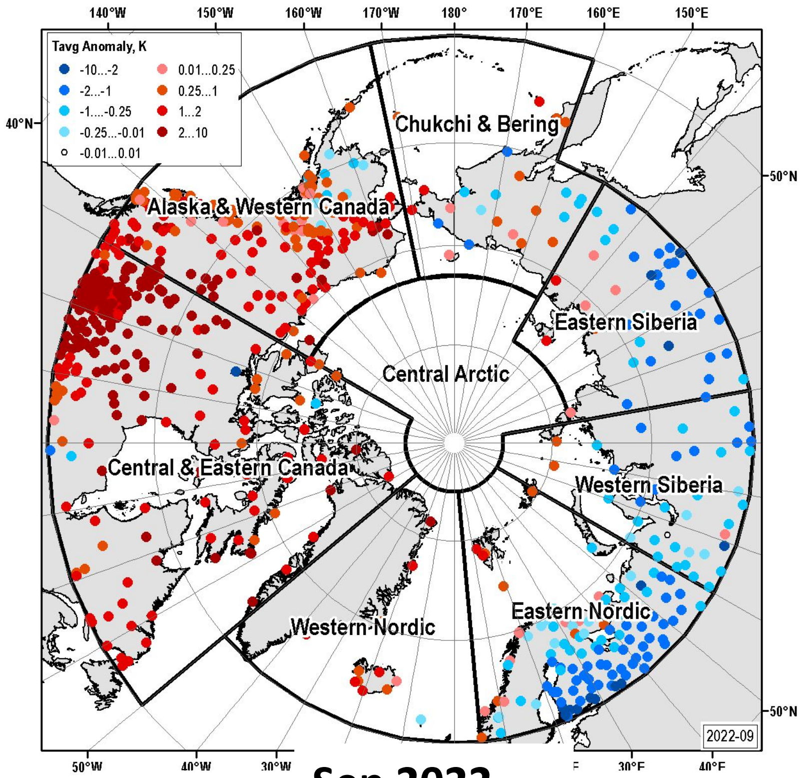


ERA5

[AARI / ERA5]

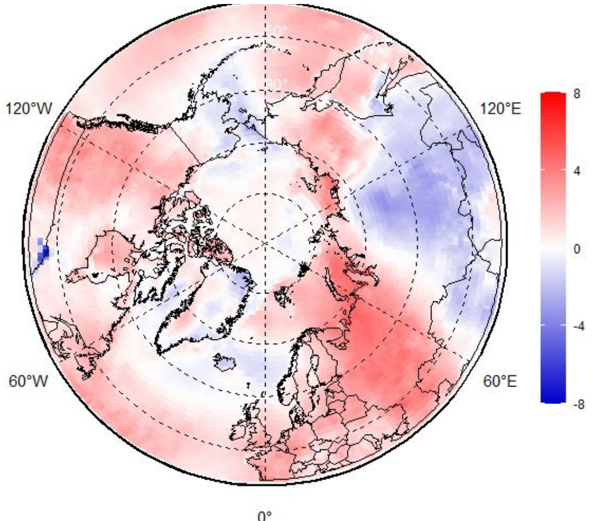
Surface air temperature: Aug, Sep 2022 anomalies (1991-2020)



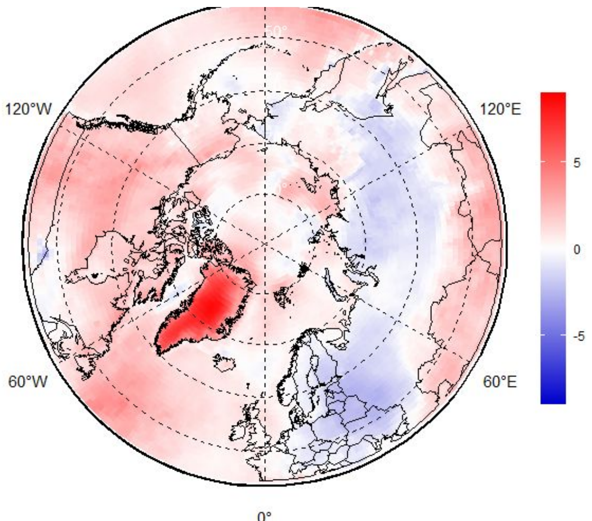


GBON

Aug 2022



Sep 2022

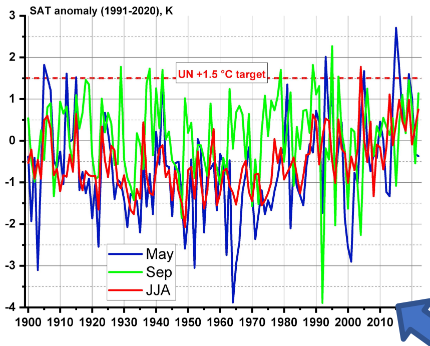


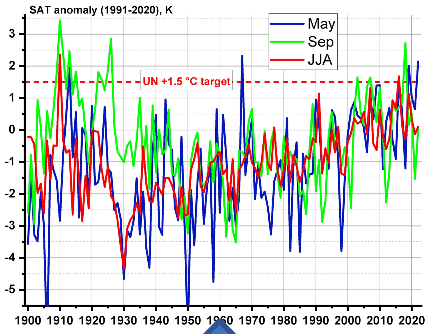
ERA5

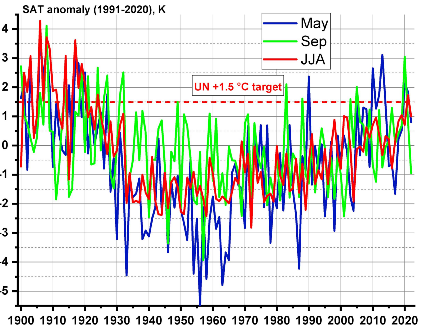
[AARI / ERA5]

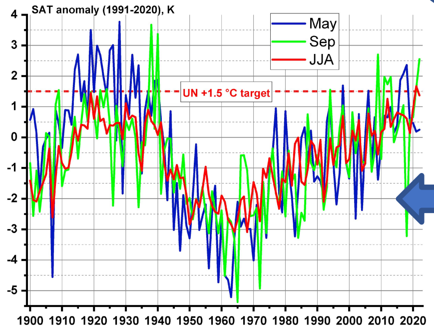
Surface air temperature (stations)

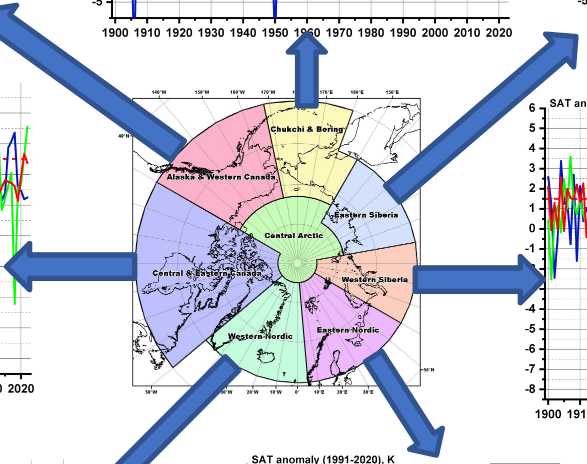
May – Sep 2022 anomalies and ranks (1093 st.), anomalies relative to: 1991-2020, ranks: 1950-2022

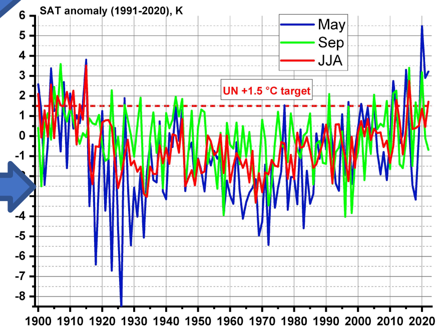


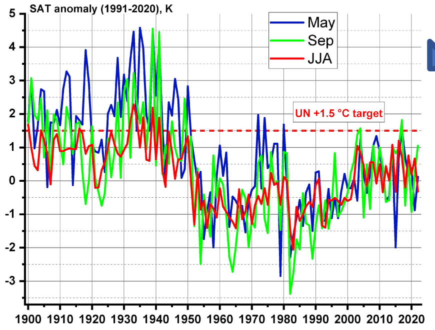


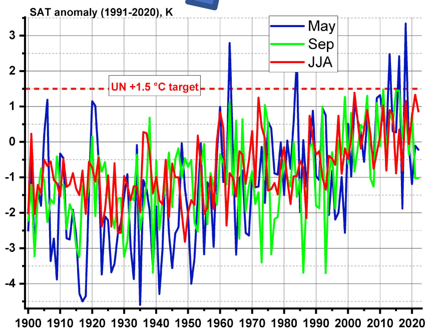












Region	Alaska & W Canada				Central & E Canada			
2022-05	-0.37	31	1964	2015	0.25	20	1963	1928
2022-06	0.95	5	1949	2004	0.65	11	1902	1921
2022-07	0.42	14	1922	2019	1.11	5	1972	2021
2022-08	0.86	10	1969	2004	2.26	1	1968	2022
2022-09	1.14	10	1992	1995	2.55	2	1965	1938
JJA 2022	0.75	5	1949	2004	1.37	2	1968	2021

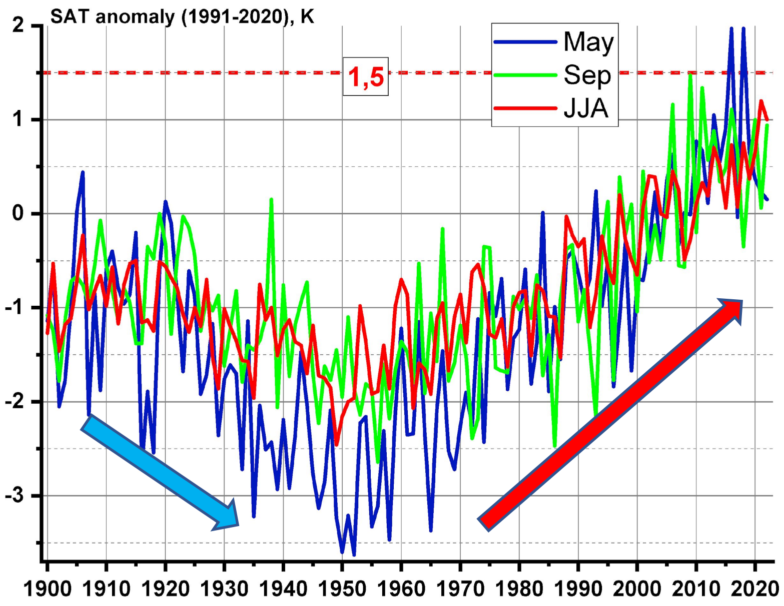
Region	Western Nordic				Eastern Nordic			
2022-05	0.12	32	1979	1935	-0.22	33	1935	2018
2022-06	0.02	21	1983	1909	1.37	13	1941	2020
2022-07	-0.48	37	1970	1933	-0.07	23	1949	2018
2022-08	-0.53	41	1983	1939	1.29	3	1918	2006
2022-09	1.05	6	1982	1939	-1.02	44	1993	2011
JJA 2022	-0.32	32	1983	1933	0.86	8	1949	2002

Region	Western Siberia				Eastern Siberia				Chukchi & Bering			
2022-05	3.21	3	1926	2020	0.80	12	1956	1906	2.14	2	1906	1967
2022-06	2.10	5	1933	2012	1.36	6	1958	1906	-0.03	20	1933	2016
2022-07	1.30	7	1934	1911	1.54	5	1939	1908	-0.30	24	1930	2010
2022-08	1.78	7	1917	1907	0.10	23	1915	1909	0.60	15	1998	1910
2022-09	-0.69	45	1996	1907	-0.95	48	1957	1908	0.02	22	1965	1910
JJA 2022	1.71	3	1968	1915	1.00	4	1972	1906	0.10	14	1930	1910

Anom(Rank|Yearmin|Yearmax)

[AARI / WMO GTS]

Surface air temperature



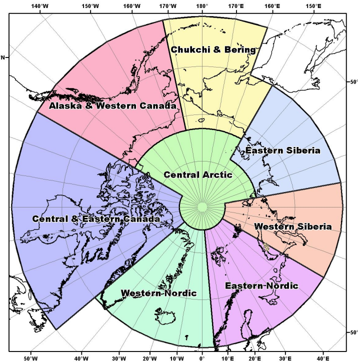
Region	Arctic total
2022-05	0.15| 15|1952|2016
2022-06	**1.02**| 4|1949|2021
2022-07	0.52| 8|1949|2018
2022-08	**1.41**| 1|1956|2022
2022-09	0.94| 6|1956|2009
JJA 2022	**1.00**| 2|1949|2021

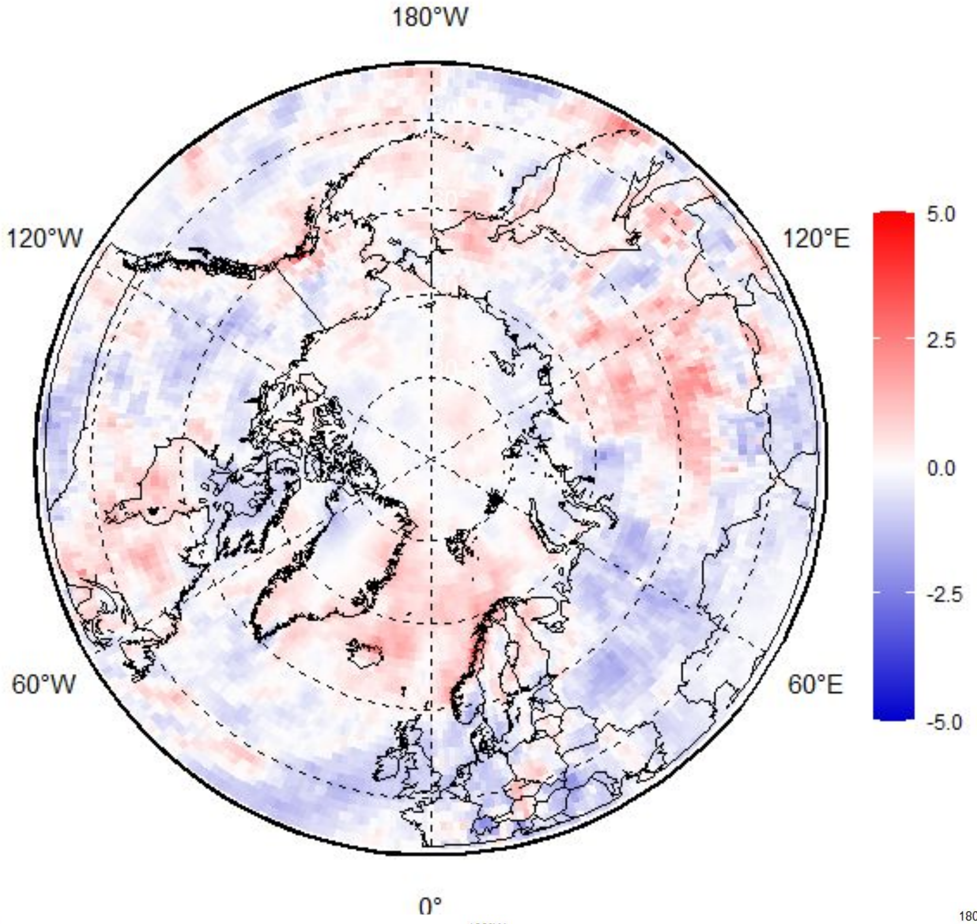
Anom(Rank|Yearmin|Yearmax)

- **The start of summer 2022 (May-Jun) surface air temperature strong positive anomalies** occurred **in Western** (3rd – 5th in row) and **Eastern Siberia** (12th – 6th in row). **Alaska and Western Canada** (31st – 5th) switched from strong negative to strong positive anomalies. Other strong positive anomaly occurred in May in **Chukchi and Bering** (2nd in row).
- **During mid-summer (Jul-Aug) strong strong positive anomalies** were observed over the **Eastern Nordic** in August (3rd in row), **W and E Siberia** (5th - 7th in row) and **extremely positive** in Central and Eastern Canada (5th – 1st in row). **Negative** anomalies were observed in July for **W Nordic region** (37th in row).
- **Further by the end of summer in September 2022** similar **extremely positive** anomalies occurred over **Central and Eastern Canada** (2nd in row) and **Western Nordic** (6th in row), while **Eastern Nordic** (44th in row), Western (45th in row) and Eastern Siberia (48th in row) experienced **negative** anomalies which is opposite to previous months.
- **Due to lack of surface marine observations conclusions for the Central Arctic done on reanalysis, include partly colder conditions in May 2022, close to normal in Jun – August and colder in September April 2022**.
- For the whole **land Arctic** during May – August 2022 period only **positive** anomalies occurred with extremes in June (4th in row) and August (**1st in row**). Preliminary resulting rank for JJA 2022 for the land Arctic is the **2nd in row** (from 1950), though large regional and inner season variations and changes in anomaly sign do occur.
- Opposite to winter conditions (when the comparable positive anomalies also occurred in 1920s), the summer months of the 2010s-2020s Arctic **experiences 2-4 times greater positive** anomalies than in 1910s-1920s, but that is again NOT the SAME for the regions. The quantitive estimates of anomalies depend on the WMO reference period chosen and density of the stations, in particular for the marine Arctic.

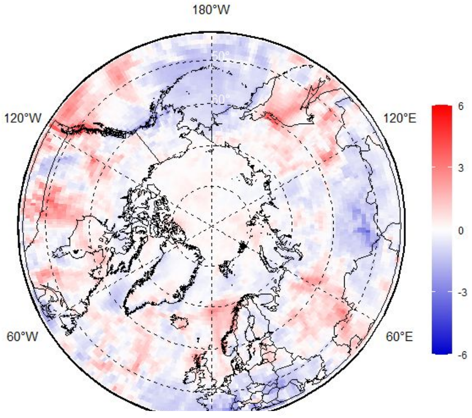
[AARI / CCCS ERA5]

Surface precipitation: monthly JJA 2022 anomalies (1991-2020)

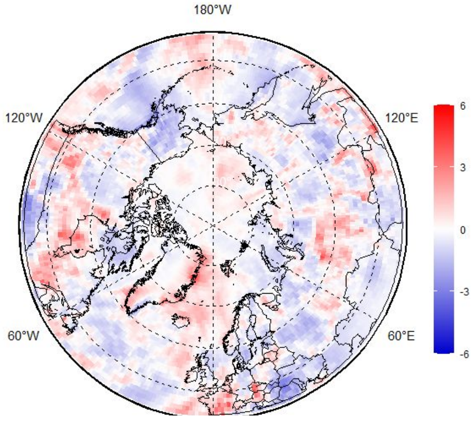




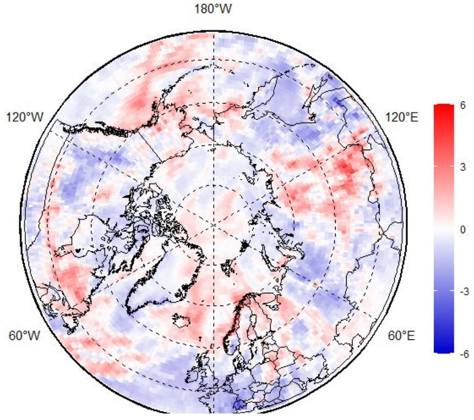
- In general, during the summer season **wetter** conditions dominated over most parts of Western Nordic, Eastern Siberia, Chukchi and Bering and Eastern Canada regions
- **Drier conditions** dominated over Western Siberia and Central Canada
- Eastern Nordic, Alaska and Western Canada, Central Arctic regions experienced both wetter and drier conditions



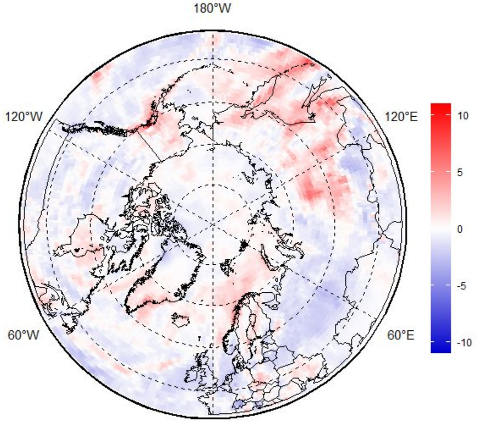
May



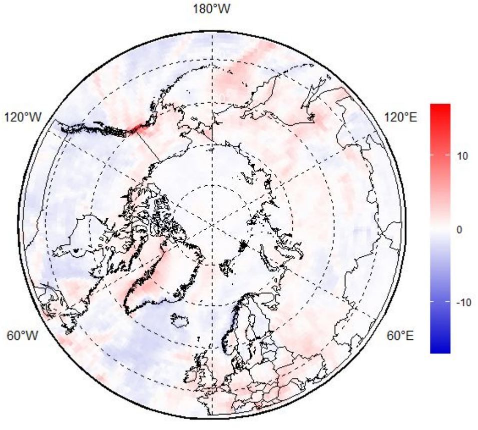
Jun



Jul



Aug



Sep

Surface precipitation: seasonal MJJAS 2022 anomalies (reanalysis)

Region	JJA 2022
Western Nordic	wetter
Eastern Nordic	wetter/drier
Western Siberia	drier
Eastern Siberia	wetter
Bering & Chukchi	wetter/drier
W Canada & Alaska	wetter/drier
Central & E Canada	wetter/drier
Central Arctic	near normal

Reference period: 1991-2020

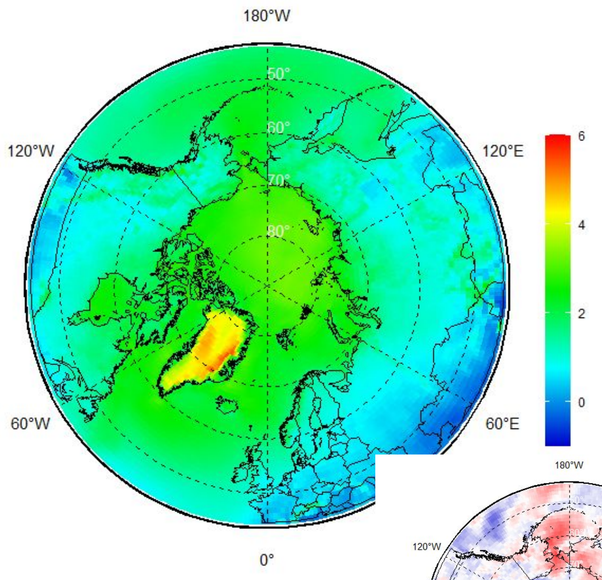
- **Lesser** precipitation occurred in the **Western Siberia** and **parts of Western Canada** regions
- **Greater** precipitation was observed in the **Western Nordic, Central Siberia, parts of Eastern Canada and Chukchi and Canada and Alaska regions**.
- Somewhat close to normal conditions are estimated for the Central Arctic

[AARI / CCCS ERA5]

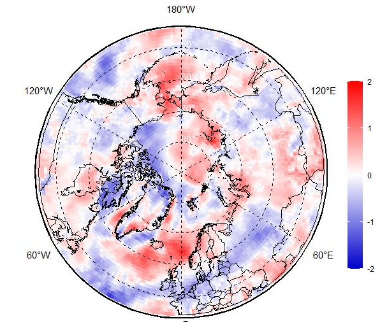
Bioclimatic weather severity

- During summer 2022 milder than for the last 30 years, though still severe, weather severity can be attributed on a basis of Bodman's index to the most of Siberia, Eastern Nordic, Canadian regions.
- Opposite situation – more severe weather can be attributed to parts of Western Nordic, Alaska, Chukchi regions.
- Particular report on bioclimatic indexes synopsis and forecast will follow.

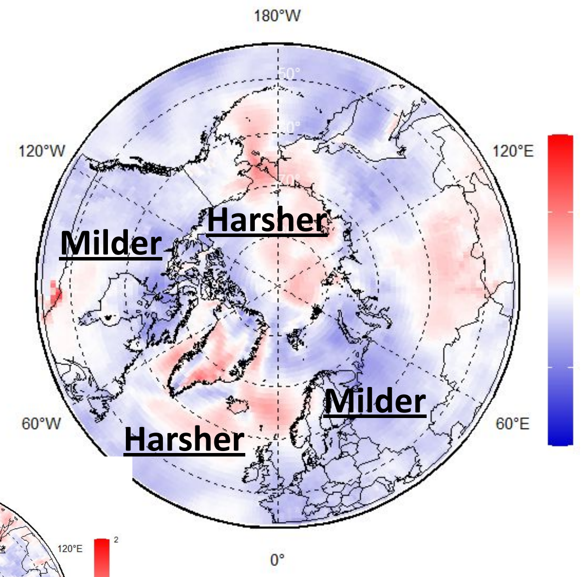
Bodman's weather severity index (S) (dimensionless) is used for bioclimatic evaluation of weather conditions for winter half year and is calculated according to Bodman's formula as
follows: $S = (1 - 0.04\,T)(1 + 0.272\,v)$ where: v is wind speed (in m/s) at 10 m above ground level and T is air temperature (in °C)
The scale in use to assess using S is:
> 6 extraordinary severe 5– 6 extremely severe
3– 5 severe & very severe 1– 3 slightly&less severe
< 1– mild



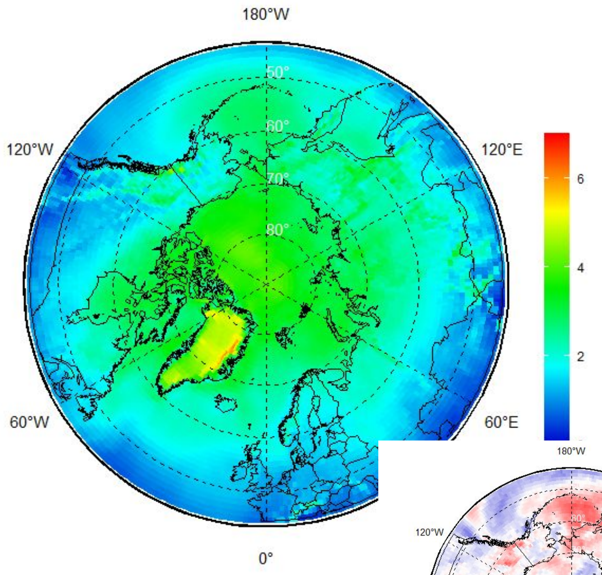
JJA 2022 Bodman's index



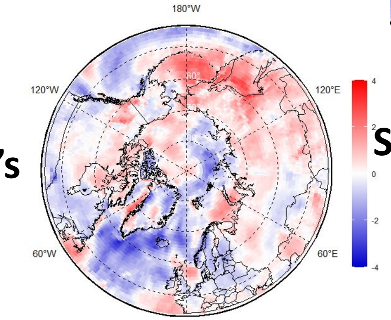
JJA wind gust anomaly



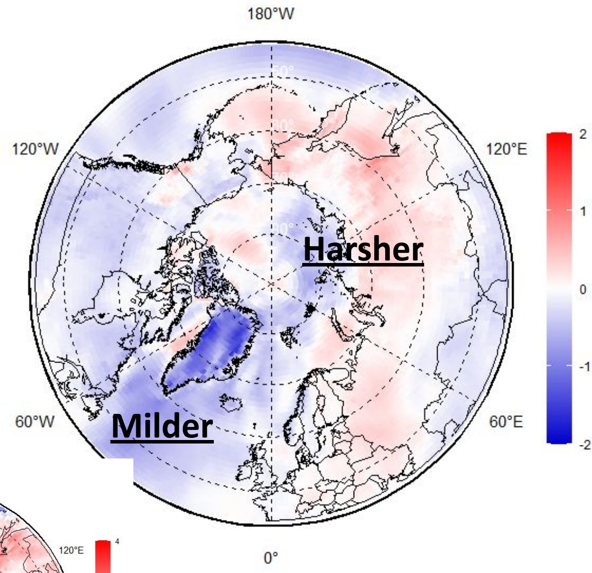
JJA 2022 Bodman's index anomaly (1991-2020)



Sep 2022 Bodman's index



JJA wind gust anomaly



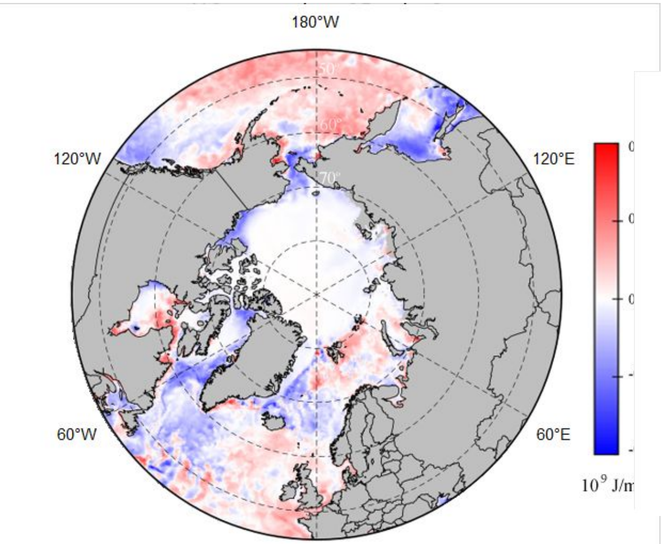
Sep 2022 Bodman's index anomaly (1991-2020)

[AARI / CCCS ERA5]

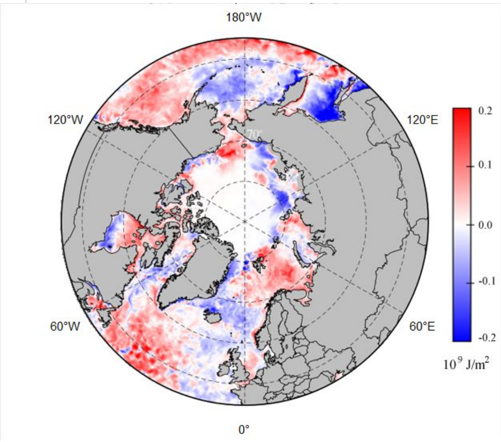
Sea ice

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

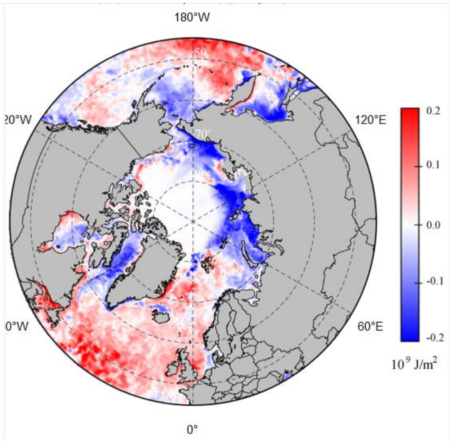
Precursors in atmosphere and polar ocean for JJAS 2021 ice conditions



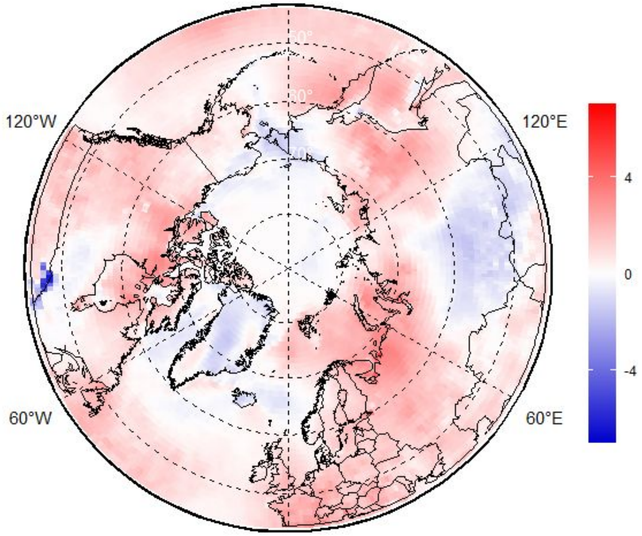
Jun 2022 Heat Capacity 15m anomaly, 1993-2020



Jun 2022 HC against Jun 2021 HC



Jun 2022 HC against Jun 2020 HC

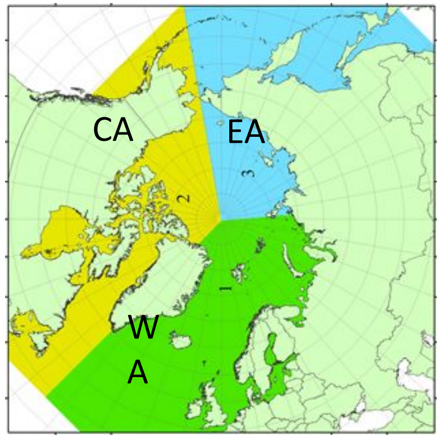


JJA 2022 SAT anomaly, 1991-2020

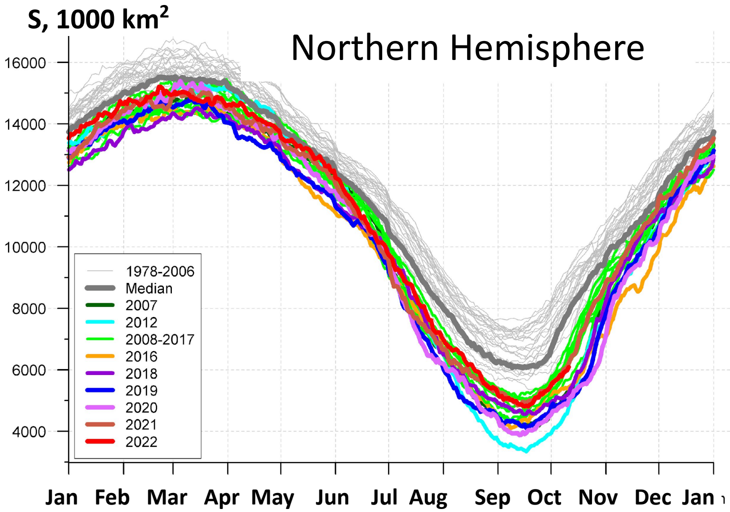
- **Negative and close to normal ocean heat capacity (HC) anomaly (to 1993-2020 and more important - to 2020) in upper 15m during June 2022 for most of the Arctic slowed ice melt in these regions in similar way as in 2021 (exceptions – Barents, NE Kara)**
- Further in season, dominance of **positive** surface air temperature anomalies over Western Eurasian Arctic, Laptev Sea, Hudson Bay and Canadian Archipelago stimulated ice melt, however, opposite negative or zero anomalies preserved ice cover in parts of Eastern Siberia and Beaufort Seas
- **Resulting ice conditions in September 2022 resembled the previous year situation including the amount of minimum ice extent which is again strongly opposite to 2019 and 2020.**

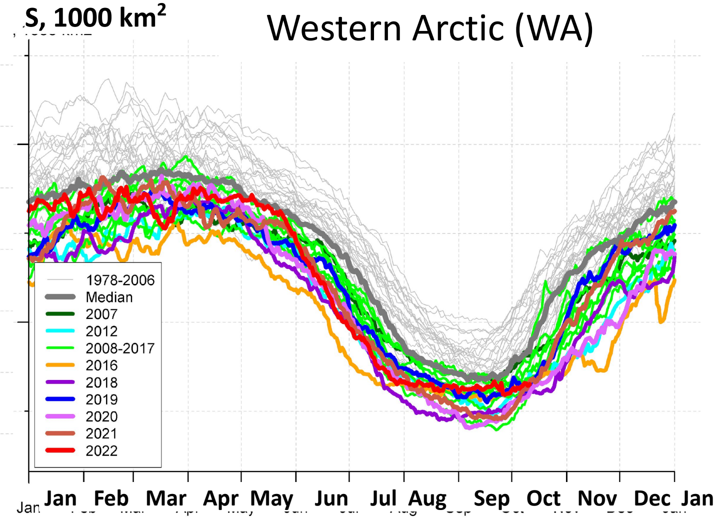
[AARI / CCCS MEMS & ERA5]

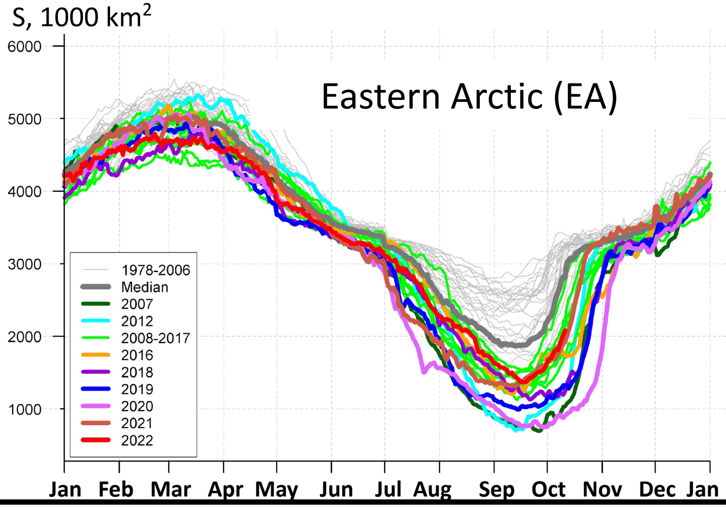
Arctic (NH) seasonal ice extent 1978…. 2022

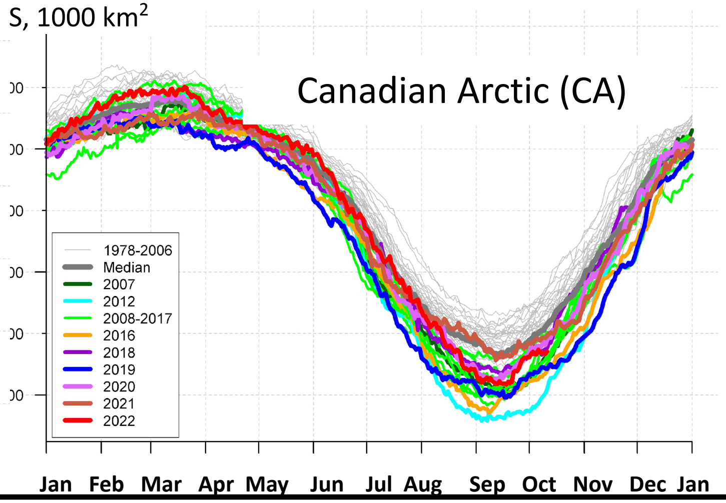


[AARI / NSIDC]







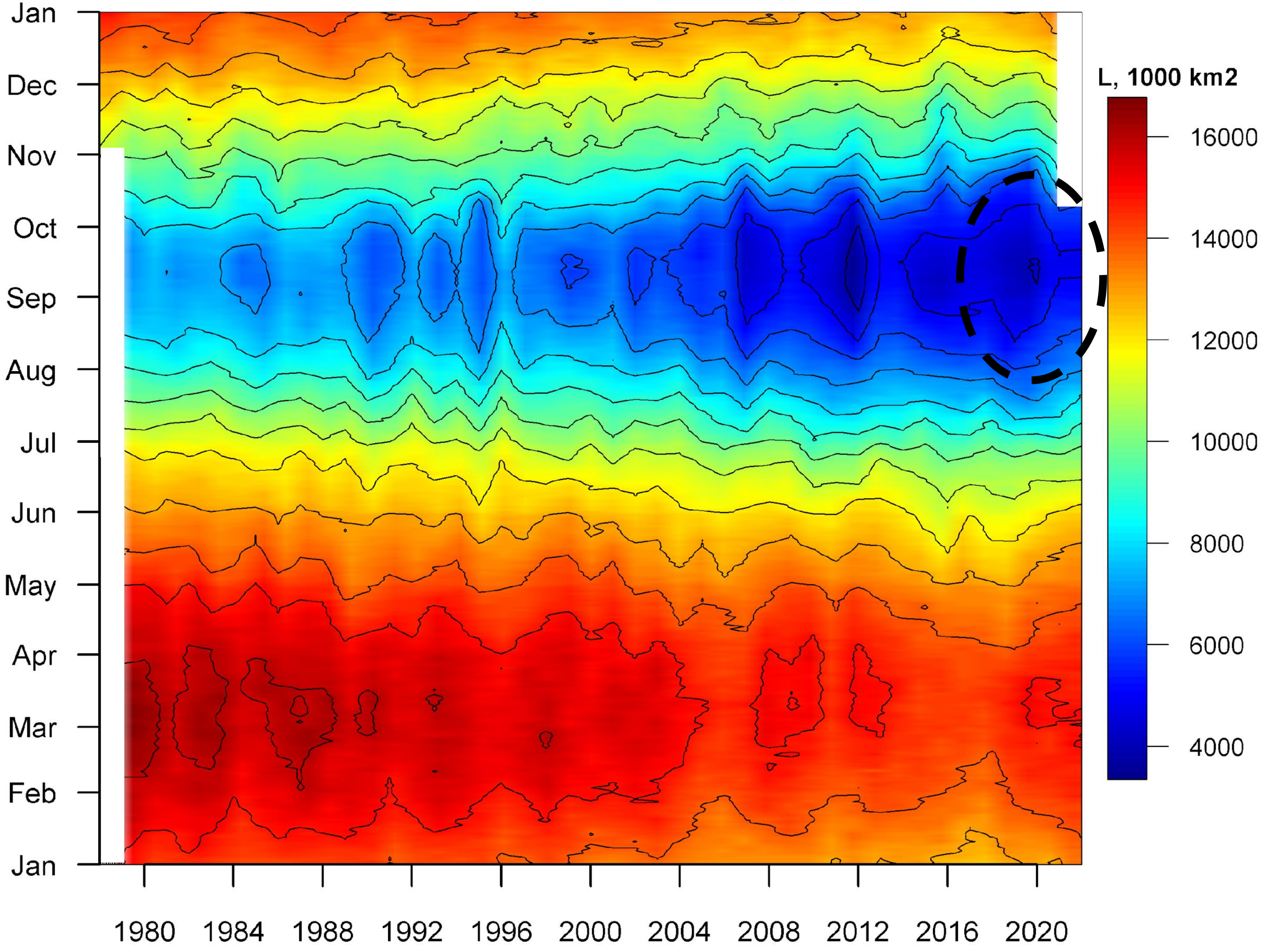


S, 1000 km²

Sep (Min)		Feb/Mar (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	2021	15100
2010	4641	…	…
2022	4808	2022	15210
2021	4848	…	…
…	…	1988	16461
1983	7285	1983	16547
1980	7611	1979	16769

- Minimum summer ice extent, 12th in row, ~4.8 mln km², reached 18 Sep 2021 is just slightly less than that for 2021 (13th in row, reached 12 Sep 2021) and again by 0.9 mln km² greater than the 2020 summer minimum. This summer 12th in row minimum also somewhat correlates with the winter 12th in row maximum.
- During melting period most of the Arctic Seas experienced ice extent decline at top of the last 10-15 years but below the 40 years median. The Sea of Okhotsk in addition to very mild winter ice conditions, experienced very quick decline of ice cover by May 2022.

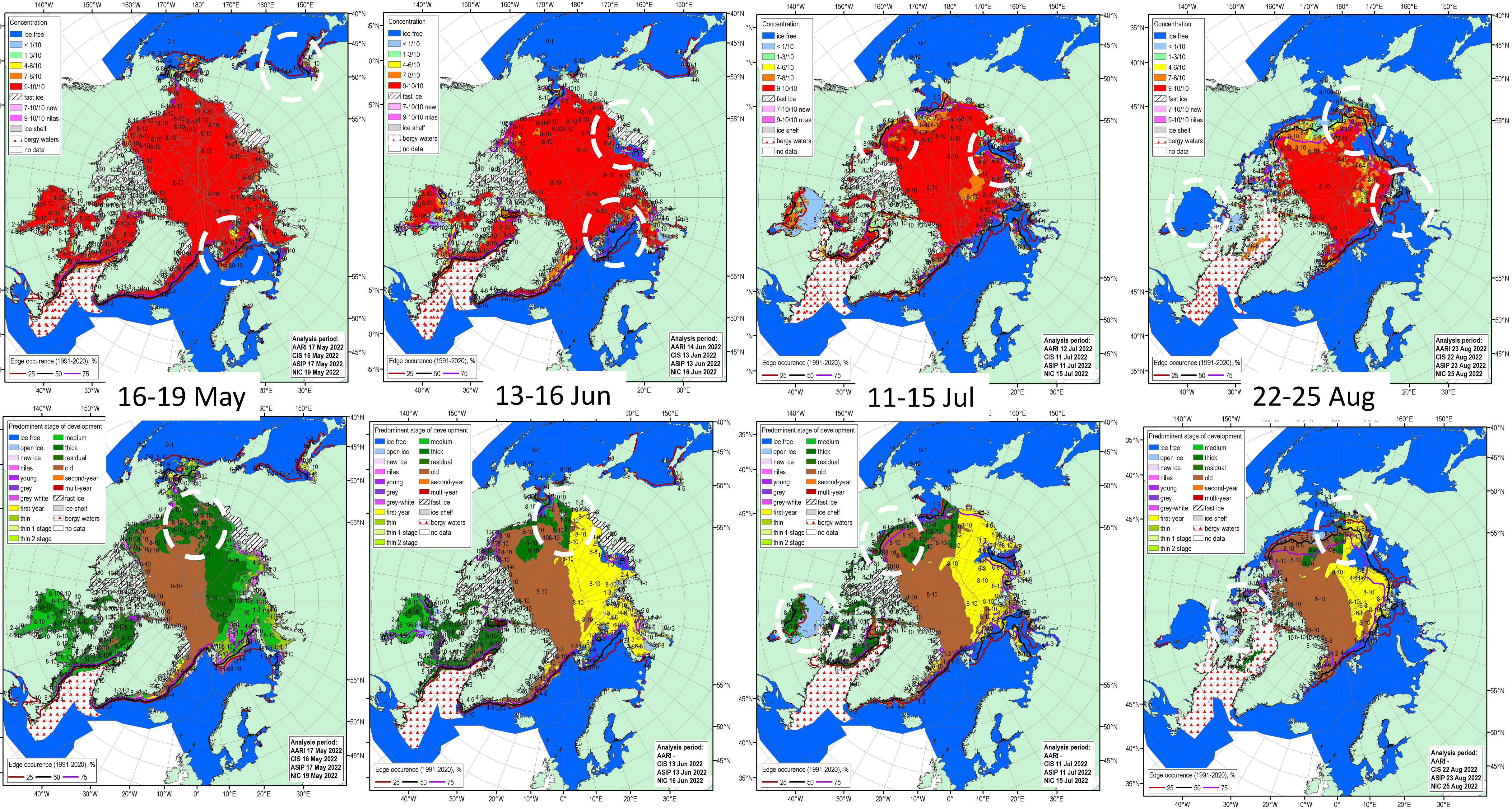
Seasonal NH ice extent variability: 1978 -2022



- Seasonal patterns of daily ice extent allow to retrieve additional information on interseasonal variability of ice extent
- Though both winter maximums and summer minimums continue to diminish hints in the pattern proved the assumption made at ACF9 that summer ice cover in 2022 will be greater or similar to 2021

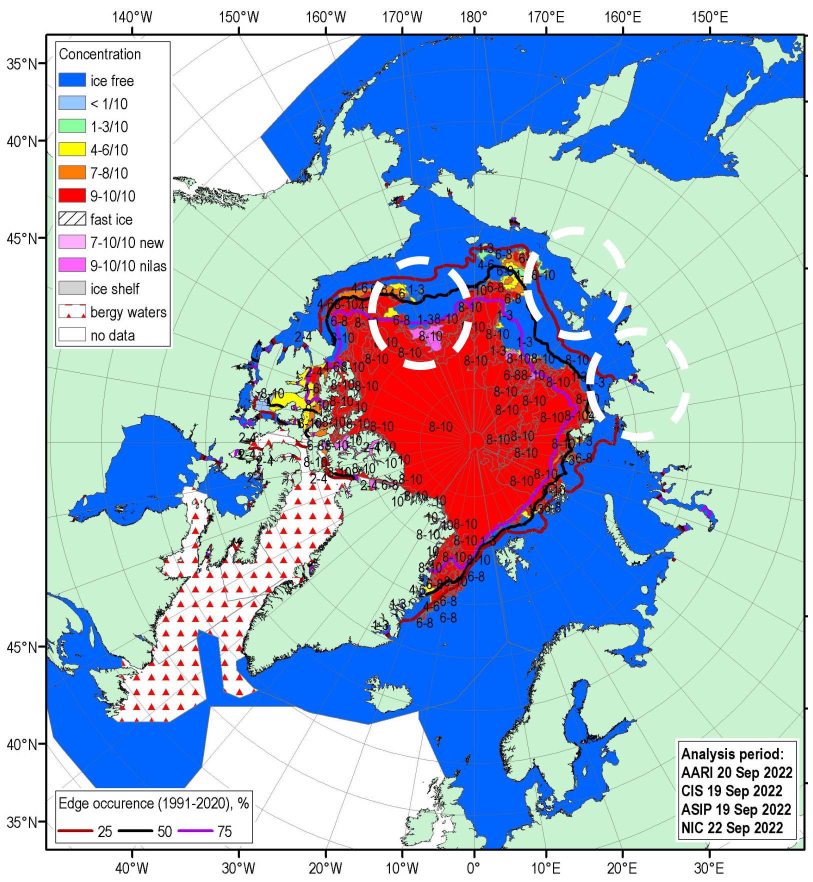
[AARI / NSIDC]

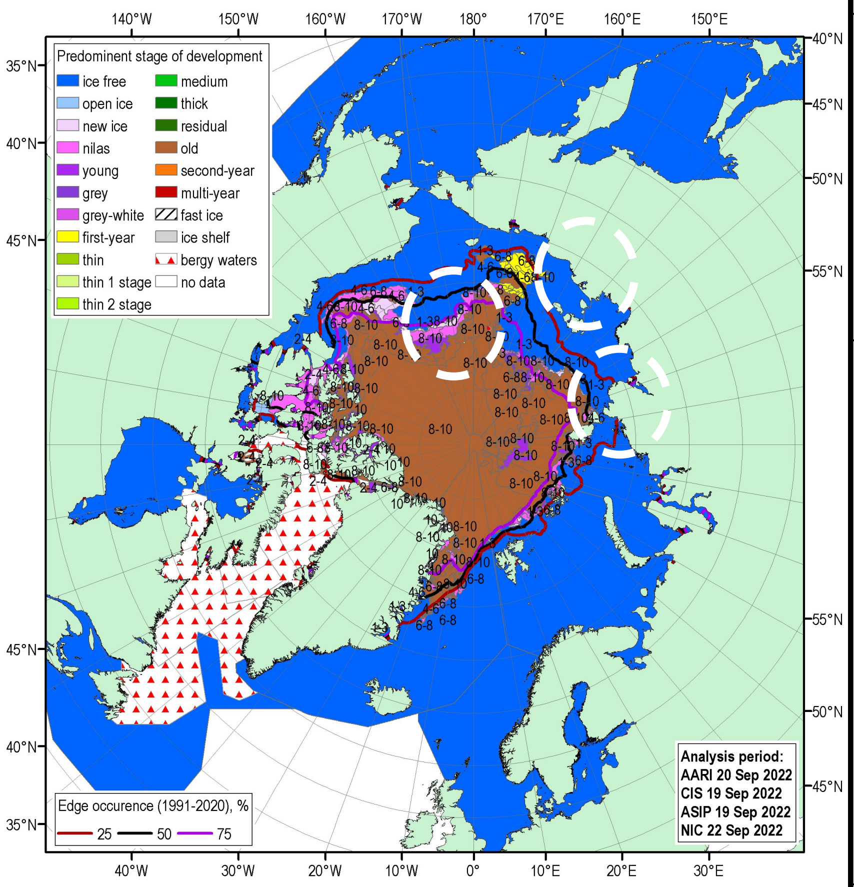
May – Aug 2022 Arctic sea ice – concentration and stage of development



[sea ice analysis - AARI/CIS/ASIF/NIC; ice edge – AARI/NSIDC, nearest 5days, reference period: 1991-2020]

Sep 2022 Arctic sea ice – concentration and stage of development at the moment of summer minimum



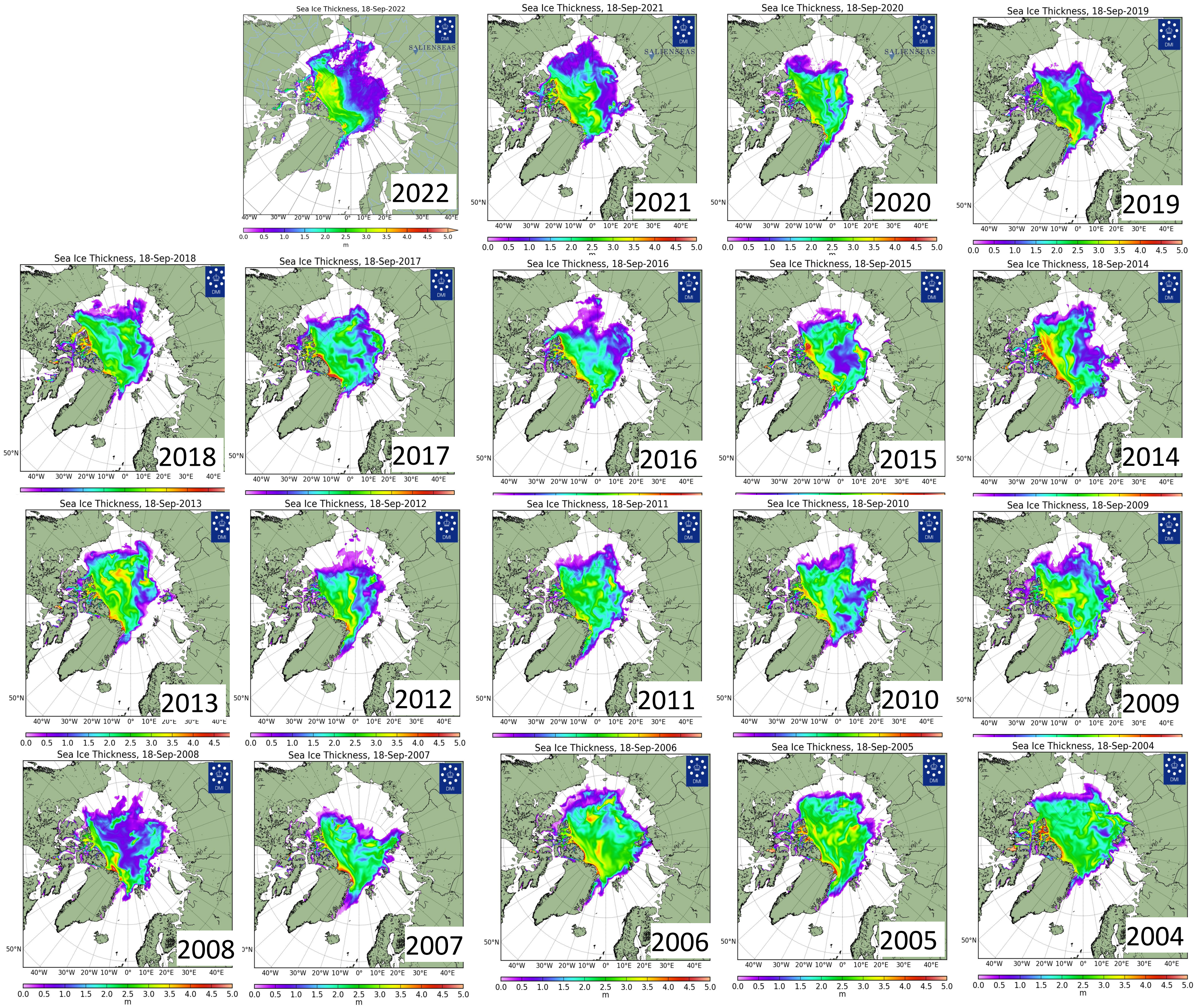


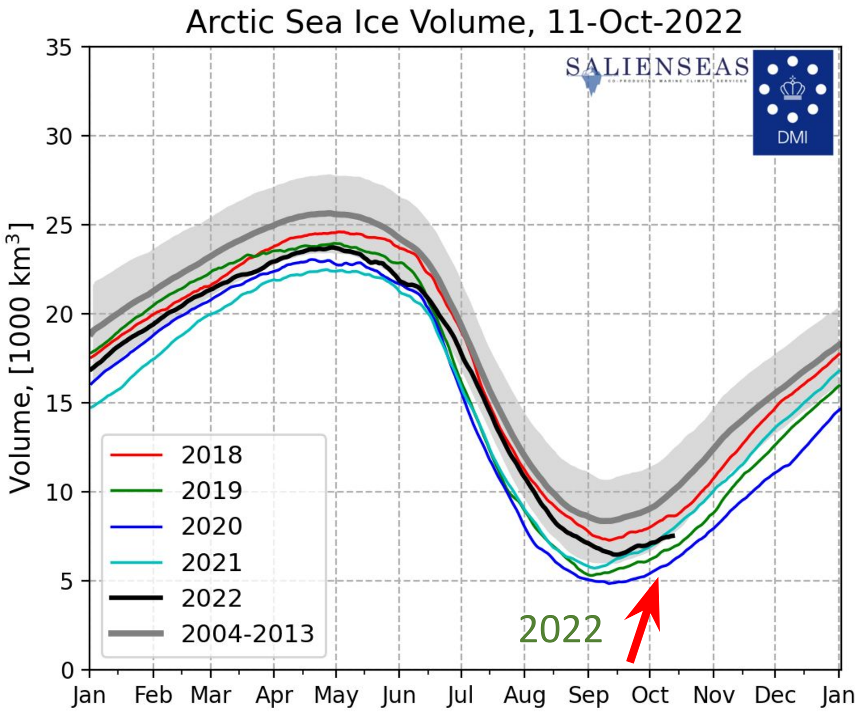
19-22 Sep 2022 (minimum)

- Observed in September 2022 12th in row summer Arctic ice cover minimum as well as general ice conditions are very similar to the 2021 and second time in row significantly differ from 2019 or 2020
- While Eurasian Barents, Kara (that is opposite to 2021) shelf seas were completely ice free with the ice edge significantly northward of Svalbard, the ice conditions in parts of the Laptev, ESS, Beaufort Seas were close to 40 years normal with both the NW passage and the NSR formally remaining blocked in the transit straits which is again opposite to last pentade
- Area and thickness of both residual and second year ice in September this year for the Arctic Basin was similar as in 2021 as recorded during summer cruise on “Akademik Treoshnikov”

[sea ice analysis - AARI/CIS/ASIF/NIC; ice edge – AARI/NSIDC, nearest 5days, reference period: 1991-2020]

Sea ice thickness for 18 Sep 2004…2022 and ice volume





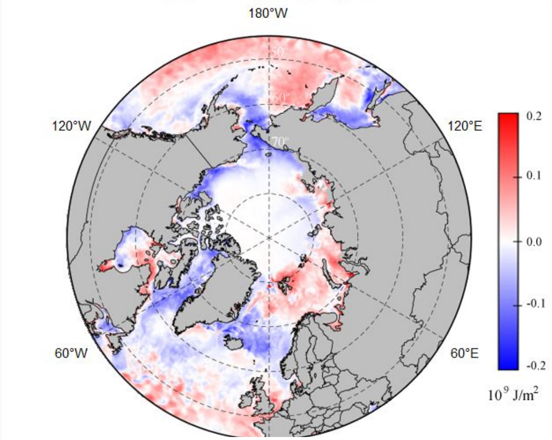
❖ Estimate of the total Arctic ice volume, based on modelling is for September 2022 somewhat ~3rd - 4th lowest for 2004-2022 after 2019-2021

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

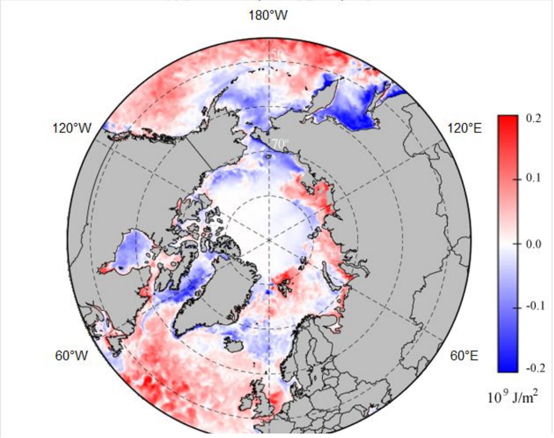
Polar Ocean:

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

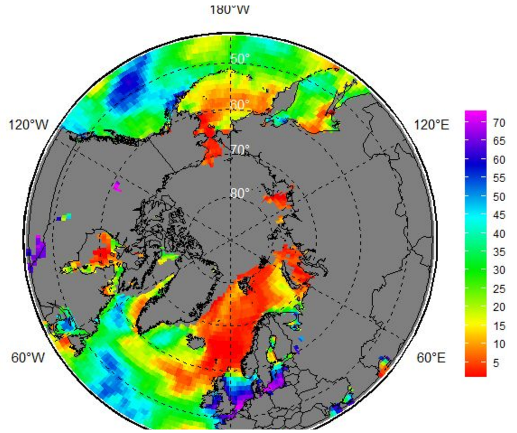
Heat content, waves and pH – JJAS 2022



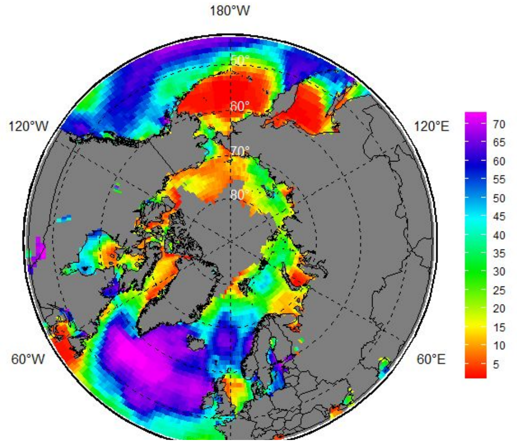
JJA Heat Content 15m anomaly, 1993-2020



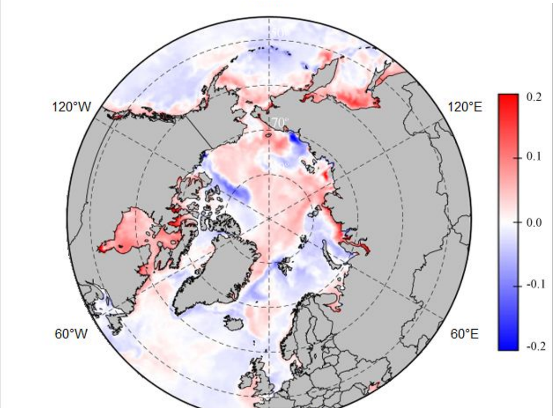
Sep Heat Content anomaly, 1993-2020



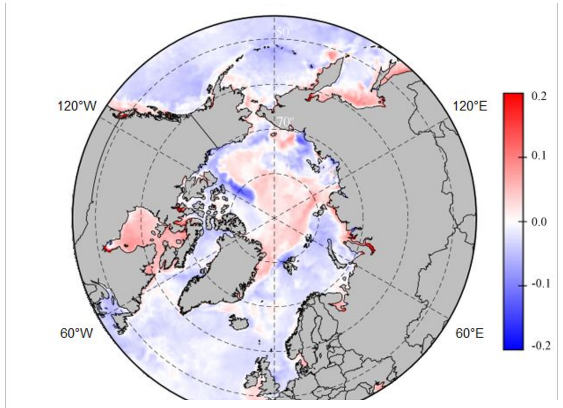
JJA WW&S height rank, 1950-2022



Sep WW&S height rank, 1950-2022



JJA pH anomaly 2m, 1993-2020



Sep pH anomaly 2m, 1993-2020

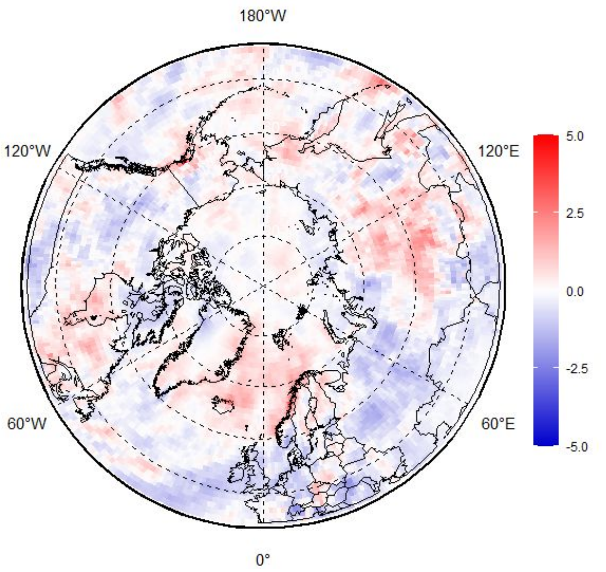
- Prominent **lower** Heat Content (HC) anomaly (to 1993-2020) was noticed in the Greenland, N Laptev, Chukchi, E Bering and Okhotsk Seas with **higher** HC for the Barents, Kara, S Laptev, Svalbard and FJL waters
- Due to lesser ice extent Chukchi, Bering Seas, parts of Eurasian shelf seas and Canadian Arctic were exposed to **higher** than in past stormy conditions with **calmer** conditions in parts of the Nordic regions
- Numerical models show for the current summer season both **positive pH anomalies** (Arctic Basin, Laptev Sea, coastal parts of Kara Sea, Chukchi, Hudson Bay) and **negative pH** (Kara, ESS, Greenland Sea) anomalies to the 1993-2020 period, which is in general similar to previous summer 2021. The **negative anomalies** may point to **acidification** processes though need further verification with e.g. through additional sensors on IABP buoys or AMAP data

[AARI / CCCS MEMS & ERA5]

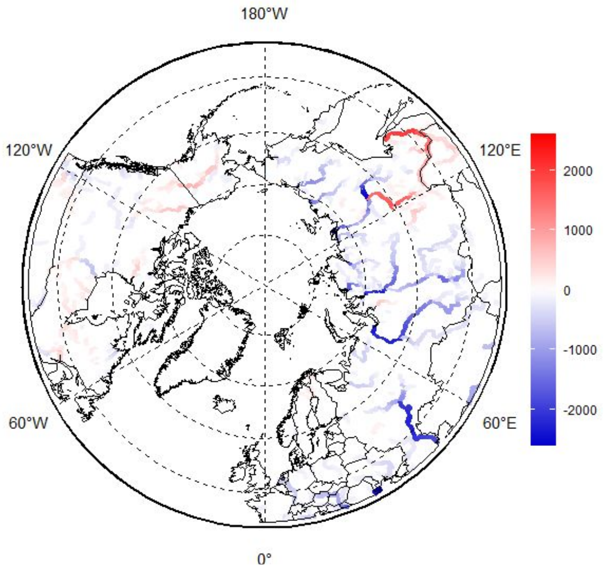
Hydrology and land Snow:

- ❖ River discharge
- ❖ Snow water equivalent
- ❖ Snow extent

Impacts of summer 2022 precipitation and evaporation on river discharge (reanalysis)



JJA 2022 precipitation anomaly, 1991-2020

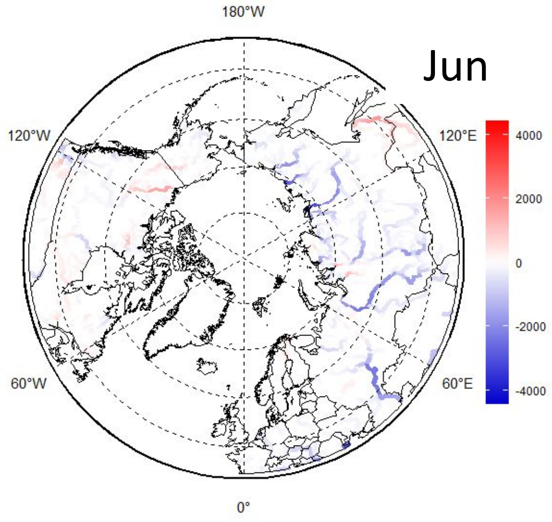


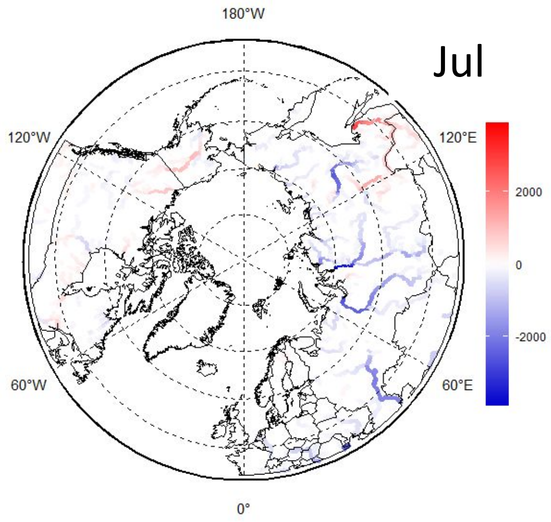
JJA 2022 river discharge anomaly, 1991-2020

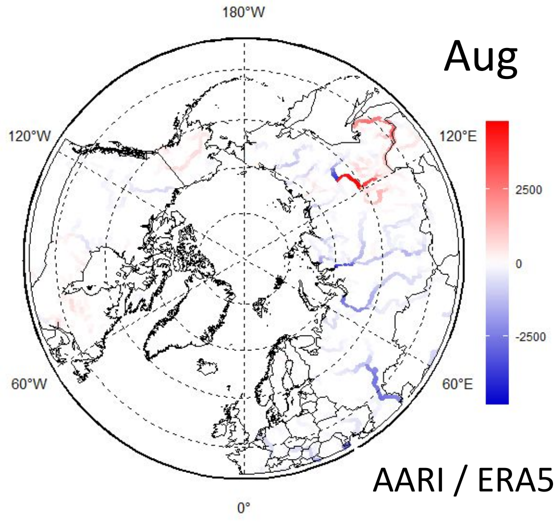
Impacts of wetter/drier conditions and evaporation were reflected in the JJA 2022 Arctic rivers discharge:

- **Lesser** drainage than normal was seen for practically all Great Arctic rivers with more significant negative anomalies for Ob, Yenisei, Indigirka for all months
- **Greater** drainage was seen for Mackenzie and Yukon and parts of Lena river system
- With exception of Yenisei such **drier** situation this summer is similar for Eurasian Arctic to summer 2021 but is opposite for American sector as in summer 2021 Mackenzie and Yukon rivers experienced normal or **lesser** discharge

2022 river discharge anomaly (1991-2020)



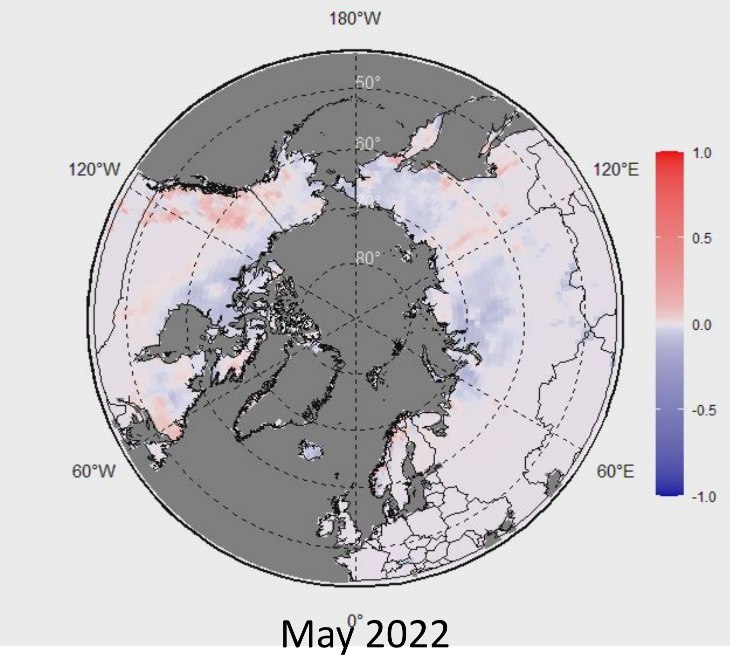




AARI / ERA5 reanalysis

MJJAS 2021 land snow

- In May 2022 **lesser** snow height as well as snow extent dominated over Siberia, parts of Chukchi and Northern Canada with somewhat **positive** anomalies in parts of W Canada, Alaska and E Nordic regions
- In September 2022 only **negative** anomalies were observed in Alaska and Canadian regions



May 2022
snow height anomaly
(1991-2020)

[AARI / CCCS ERA5 / WMO GCW SnowWatch]

S, 1000 km²

Northern Hemisphere

2022		1991-2020 Normal		Period of Record from 11-1966		
Month	Area	Mean	Departure	Rank	Maximum (Year)	Minimum (Year)
9	5,930	5,508	423	14/54	7,762 (1972)	3,838 (1990)
8	2,445	2,682	-237	43/54	5,308 (1967)	2,089 (1968)
7	2,670	3,191	-521	45/53	8,210 (1967)	2,325 (2012)
6	5,509	8,134	-2,624	53/55	14,972 (1978)	4,922 (2012)
5	17,955	18,216	-261	40/56	23,093 (1974)	15,377 (2010)

Eurasia

2022		1991-2020 Normal		Period of Record from 11-1966		
Month	Area	Mean	Departure	Rank	Maximum (Year)	Minimum (Year)
9	2,522	1,636	886	6/54	3,409 (1977)	540 (1984)
8	148	272	-125	45/54	1,859 (1967)	72 (2020)
7	159	487	-329	51/53	3,551 (1967)	141 (tie)
6	1,107	2,853	-1,746	54/55	7,129 (1978)	1,068 (2012)
5	8,560	9,179	-619	44/56	12,511 (1976)	7,262 (2013)

Canada

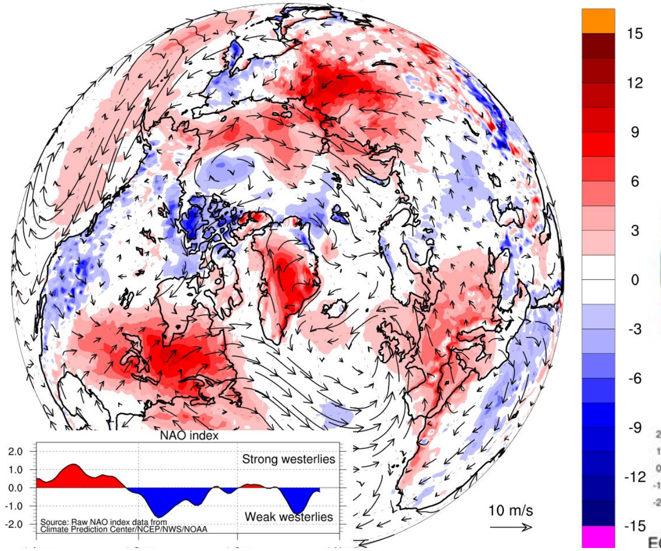
2022		1991-2020 Normal		Period of Record from 11-1966		
Month	Area	Mean	Departure	Rank	Maximum (Year)	Minimum (Year)
9	1,133	1,544	-411	46/54	2,812 (2018)	647 (1968)
8	252	355	-103	42/54	1,569 (1978)	132 (2009)
7	354	593	-239	45/53	2,718 (1978)	143 (2012)
6	2,085	2,843	-758	51/55	4,899 (1978)	1,604 (2012)
5	6,080	5,797	283	23/56	7,902 (1974)	4,762 (2010)

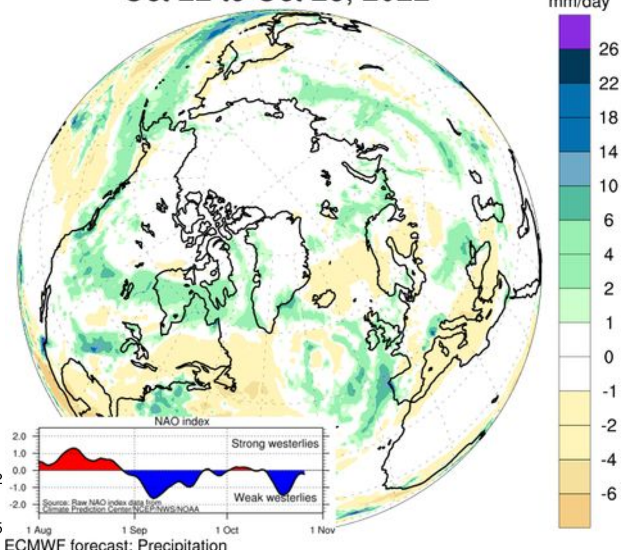
Alaska

2022		1991-2020 Normal		Period of Record from 11-1966		
Month	Area	Mean	Departure	Rank	Maximum (Year)	Minimum (Year)
9	149	181	-32	33/54	417 (1996)	35 (1974)
8	23	36	-13	34/54	546 (1967)	0 (tie)
7	54	53	1	29/53	445 (1967)	0 (tie)
6	161	258	-96	45/55	856 (1985)	37 (2015)
5	997	956	41	32/56	1,486 (1985)	595 (2016)

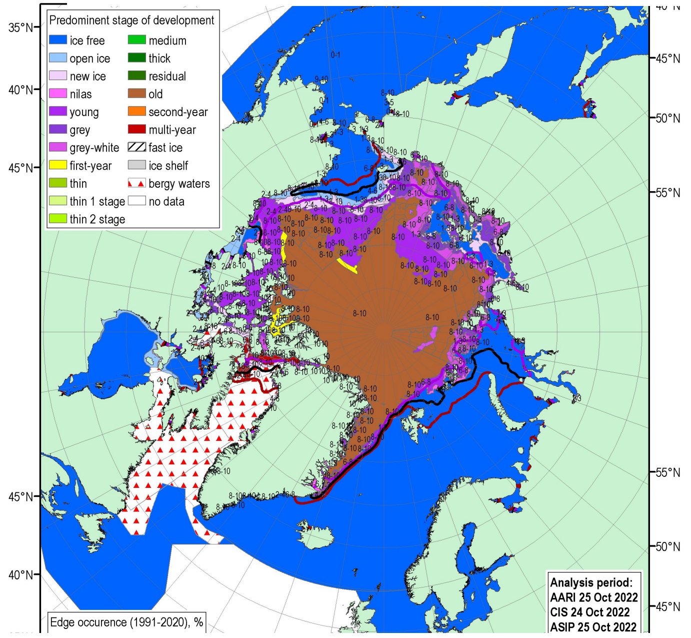
[GCW / Rutgers Global SnowLab]

Current Conditions (20-26 Oct 2022)

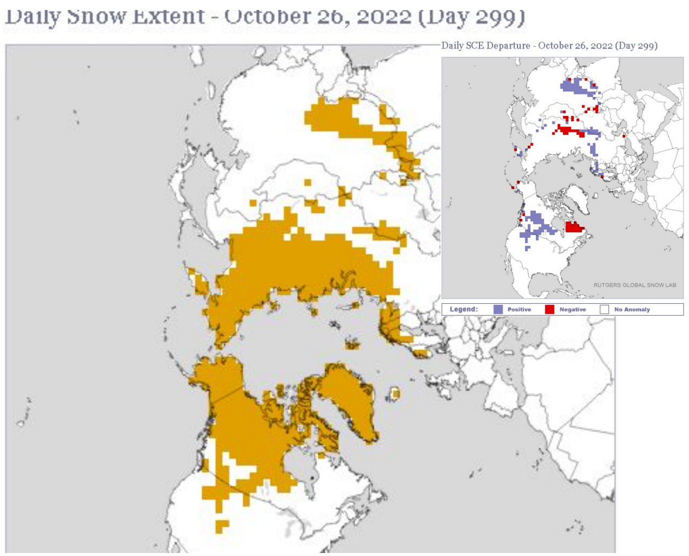




SAT, precipitation, mean wind vectors, NAO for 20-26 Oct 2022 (http://polarportal.dk)



AARI/ASIP/ASIP/NIC ice chart for 20-25 Oct 2022



Snow extent and anomaly for 26 Oct 2022, Rutgers Global snow lab

- For the current week (20-26 Oct 2022) cyclonic circulation and positive SAT anomalies dominate over Eastern Canada, Greenland, parts of Eastern Nordic and Eastern Siberia regions. Opposite negative SAT anomalies – colder weather is over parts of Western and Central Canada, Svalbard, Scandinavia, Western Siberia, Central Arctic
- Resembling conditions are for precipitation with wetter weather over Hudson Bay, parts of Greenland, Central and Eastern Siberia and drier weather over Labrador, Iceland, Scandinavia
- The Beaufort Sea, Canadian Archipelago, Eastern Siberian and Laptev Seas, FJL area as well as the Central Arctic are under intense freeze-up/ice growth. Negative SAT anomalies initiated freeze-up in coastal areas of the Bering Sea. The Hudson Bay, Labrador and Chukchi Seas, most of the Kara Sea, Barents Sea are still at the first stages of freeze-up.
- Alaska, Western and most of the Central Canada, northern Scandinavia, Siberia and Chukchi are under the snow which is normal, with negative snow cober anomalies over parts of Labrador.

Data sources:

1. AARI Review of Hydrometeorological Processes in the Northern Polar Region (http://old.aari.ru/misc/publicat/gmo.php)
2. Copernicus Climate Change Service
   - ❖ ERA5 monthly averaged data on pressure and single levels (ERA5)
   - ❖ Marine environment monitoring service (CMEMS)
   - ❖ GloFAS operational global river discharge reanalysis (ERA5-GloFAS)
3. WMO GCW IceWatch / GDSIDB project (weekly ice charts from AARI, CIS, NIC, ASIP - http://wdc.aari.ru)
4. NSIDC Near-Real-Time DMSP SSMIS Daily Polar Gridded Sea Ice Concentrations
5. DMI PolarPortal (http://polarportal.dk)
6. WMO GCW SnowWatch (FMI, ECCC, Rutgers Glob Snow Lab, http://climate.rutgers.edu/snowcover/)

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

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

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

Monthly and seasonal graphs at full resolution and for all ECVs are available at:

- http://wdc.aari.ru/prcc/reanalysis/
- http://wdc.aari.ru/datasets/d0040/arctic/png/