

## **ARCTIC SEA ICE,NO MINIMUM RECORD IN SEPTEMBER 2023**

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In spite of heat waves in the atmosphere and ocean and a relative warm Arctic in 2023, the summer ice in September has stood up well and has not reached a total minimum since 1979, when high quality satellite data started to be available on a daily basis. However, the ice extent from the Nansen Center in Bergen Ice Information System «iceobs.nersc.no» is less when compared with the minimums in 2021 and 2022. The ice extent reached a yearly minimum on 13 September of 4,972 million square kilometers (mill.km<sup>2</sup>). This is 0,420 mill.km<sup>2</sup> less than in 2022, but 0,797 mill.km<sup>2</sup> more than the minimum record in 2012, which was 4,175 mill.km<sup>2</sup>.

The upper figure shows the map of the sea ice extent in the Arctic on 17 September, three days after the minimum, where the ice extent has now slightly increased to 5.011 mill.km<sup>2</sup>. It is seen that the Northern Searoute along the coast of Russia is ice free, but the ship traffic through it by non Russian ships has ceased due to sanctions. Several of the routes through the North West Passage are also free for ice, but the traffic here is strongly regulated by the Canadian rules. Furthermore there is no ice around Svalbard.

The lower figure shows the daily curves for the ice extent from 2007 up to 17 September this year, see the coded color curves for each year in the lower left corner. The red curve represent 2023, the black curve 2022 and the purple curve the record minimum in September 2012. These two figures are from the Nansen Center's real time ice information system «iceobs.nersc.no». This system use daily satellite data from USA and a Norwegian-developed algorithm to calculate the ice extent. It should however be

mentioned that other ice information systems that use different algorithms, but the same data, show different absolute values for the minimum ice extent, see for example the EuroGoos Arctic Ross System which gives the ice extent from 6 European Centres, including the Nansen Centre, «arctic.eurogoos.eu» and the National Snow and Ice Data Centre in USA «nsidc.org», but the trends are the same for all these systems.

The future of summer ice in the Arctic is uncertain. The global climate models predict different times for a summer ice free Arctic Ocean, varying between 2030 and 2100, see a brief review about these different model results by Johannessen and Shalina(2023). Therefore they need to be improved. In addition they are driven with different CO<sub>2</sub> scenarios. Which of these scenarios is correct is also uncertain.

In contrast to the varying results from the global models predictions for the ice extent up to 2100, Johannessen and Shalina(2023) hypothesized that the summer ice in the Arctic will not disappear, «no tipping point», if a major reduction of the CO<sub>2</sub> concentration in the atmosphere can be achieved. They based their hypothesis on a simple statistical analysis for the period 1979-2022, where they for September correlated the ice extent with the CO<sub>2</sub> in the atmosphere, actually the  $\ln(\text{CO}_2/\text{CO}_{2r=\text{reference}})$  (1979) since this is the empirical law for long wave radiation back to space from the surface of the earth. The increase in CO<sub>2</sub> in the atmosphere could explain 81% (R<sup>2</sup>) of the decline of the sea ice extent in September, the remains by natural variability. Solving the regression equation gave an ice free Arctic Ocean if the CO<sub>2</sub> concentration would reach 563 +/- 17,5 parts per million(ppm). This is far above the Paris Agreement which is 450 ppm in 2060 and 425 ppm in 2100.

The average for the CO<sub>2</sub> concentration in the atmosphere in August 2023 was 419,68 ppm, in 2022 417,15 and in 2021 414,42 ppm, an increase of 2,53 ppm from 2022 to 2023 (co2.earth). If this yearly increase continues, the Paris Agreement will already be reached be reached in 16 years, around 2040, 20 years before

450 ppm in 2060. This demonstrates how urgent it is to drastically reduce the CO<sub>2</sub> concentration in the atmosphere.

As mentioned, our calculation shows that the Arctic will be ice free if the CO<sub>2</sub> concentration in the atmosphere reaches 563 ppm. If the yearly increase continues as today, 2,53 ppm, the Arctic will be ice free in September 57 years from now, that is around 2080. This is one of the many examples that a major reduction of the CO<sub>2</sub> concentrations in the atmosphere is urgently required in parallel with strong implementation of renewable energy and reduction in the per capita consumption, at least in the industrialized world.

In addition it is also necessary to limit the population growth in the World, since there is a perfect correlation between the population increase and the increase of the CO<sub>2</sub> concentration in the atmosphere in the period 1963-2019, which needs to be broken, Johannessen and Shalina(2022). Here we also used the Arctic as an example where we showed that the population growth impacts the climate there. In 1959 when I (omj) was a student the population was 3 billion people, today it is 8 billion, an increased of 166%, not sustainable for life on earth.

## References

Ola M. Johannessen and Elena V. Shalina. 2022. Population increase impacts the climate, using the sensitive Arctic as an example. Atmospheric and Oceanic Science Letters, Volume 15. (aosl.iapjournals.ac.cn)

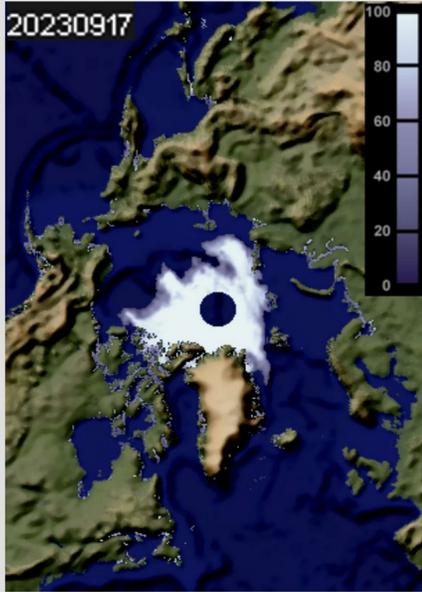
Ola M. Johannessen and Elena V. Shalina. 2023. Will the summer sea ice in the Arctic reach a tipping point? Atmospheric and Oceanic Science Letters, Volume 16. (aosl.iapjournals.ac.cn)



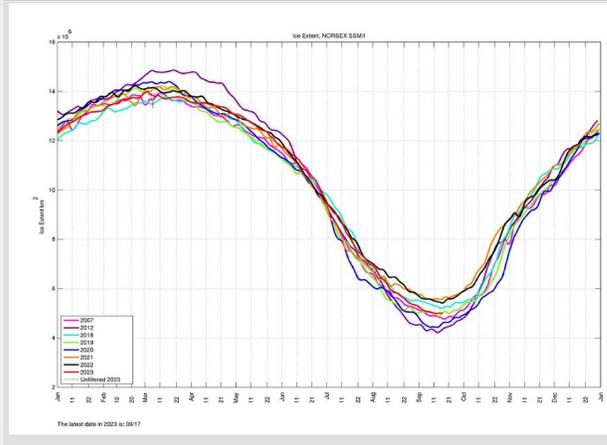
### Daily ice maps and statistics in the Arctic region

DAILY ICE MAP FROM SSM/I, NERSC

The service is under periodic maintenance (from 02.05.2023)



### SEASONAL ICE EXTENT IN MIII SQ.Km



The latest date in 2023 is: 09/17

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