

Sea Ice Outlook
2022 September Report
Individual Outlook

Name of contributor or name of contributing organization:

RASM@NPS (Maslowski et al.)

Is this contribution from a person or group not affiliated with a research organization?

Name and organization for all contributors. Indicate primary contact and total number of people who may have contributed to your Outlook, even if not included on the author list.

RASM@NPS (Maslowski et al.)

**Do you want your June contribution to automatically be included in subsequent reports?
(If yes, you may still update your contribution via the submission form.)**

[Do you want your contribution for this month to automatically be included in subsequent reports?]

What is the type of your Outlook projection?

Dynamic Model

Starting in 2017 we are accepting both pan-Arctic and pan-Antarctic sea ice extent (either one or both) of the September monthly mean. As in 2016, we are also collecting Alaskan regional sea ice extent. To be consistent with the validating sea ice extent index from NSIDC, if possible, please first compute the average sea ice concentration for the month and then compute the extent as the sum of cell areas > 15%.

a) Pan-Arctic September extent prediction in million square kilometers.

4.751

b) same as in (a) but for pan-Antarctic. If your method differs substantially from that for the Arctic, please enter it as a separate submission.

c) same as in (b) but for the Alaskan region. Please also tell us maximum possible extent if every ocean cell in your region were ice covered.

0.401

"Executive summary" of your Outlook contribution (using 300 words or less) describe how and why your contribution was formulated. To the extent possible, use non-technical language.

The Arctic sea ice extent September 2022 minimum is predicted to roughly continue the September declining trend (of $-0.528 \times 10^6 \text{ km}^2/\text{decade}$) based on 2000-2021 output from the Regional Arctic System Model (RASM) fully-coupled hindcast simulation. The difference between the 31-member ensemble mean September sea ice extent prediction and the extrapolation 2000-2021 linear trend into 2022 is $0.198 \times 10^6 \text{ km}^2$. Compared to the RASM sea ice extent minimum September 2021 ($4.695 \times 10^6 \text{ km}^2$ from the hindcast), the ensemble mean forecast for September 2022 minimum ($4.751 \times 10^6 \text{ km}^2$) is slightly higher by $0.056 \times 10^6 \text{ km}^2$, suggesting a brief rebound like the 2007 and 2012 minima. According to the RASM ensemble mean predicted September sea ice thickness distribution, the majority of surviving ice thickness ranges between 1.0 m and 1.5 m, with the thickest sea ice north of the Canadian Archipelago and Greenland within the range of 1.5 m-2.5 m, and almost no sea ice thicker than 3.0 m (see Fig. 3 in the supplementary material). The RASM September outlook has been commonly biased high in recent years (bias of $0.070 \times 10^6 \text{ km}^2$ and standard deviation of $0.415 \times 10^6 \text{ km}^2$) compared to the NSIDC observation (2000-2021), especially in the northern Barents/Kara and East Siberian seas.

Brief explanation of Outlook method (using 300 words or less).

We used RASM2_1_00, which is a recent version of the limited-area, fully coupled climate model consisting of the Weather Research and Forecasting (WRF), Los Alamos National Laboratory (LANL) Parallel Ocean Program (POP) and Sea Ice Model (CICE), Variable Infiltration Capacity (VIC) land hydrology and routing scheme (RVIC) model components (Maslowski et al. 2012; Roberts et al. or 2015; DuVivier et al. 2015; Hamman et al. 2016; Hamman et al. 2017; Cassano et al. 2017). The RASM fully-coupled hindcast simulation is only

forced along WRF lateral boundaries with CFSR/CFSv2 reanalysis output, and winds and temperature are nudged above 500 mb for September 1979-August 2022. Then, the dynamically down-scaled RASM used the global NOAA/NCEP CFSv2 7-month forecasts for 6-month prediction. The CFSv2 forcing (<https://www.ncei.noaa.gov/data/climate-forecast-system/access/operational-9-month-forecast/>) streams used for the forecast ensemble members were initialized every day (at 00:00) between August 1st and August 31st and used for RASM forcing at 00:00 on September 1st, 2022 and onward until the end of February 2023. Each of the 31 ensemble members ran forward for 6 months using outputs from the CFSv2 forecasts since we skip the first calendar month of each CFSv2 forcing.

Tell us the dataset used for your initial Sea Ice Concentration (SIC).

The initial sea ice conditions for the September Sea Ice Outlook were derived from the RASM fully-coupled hindcast (September 1979-August 2022) and are physically and internally consistent across all the model components. Neither data assimilation nor bias correction was used.

Tell us the dataset used for your initial Sea Ice Thickness (SIT) used. Include name and date.

See the above.

If you use a dynamic model, please specify the name of the model as a whole and each component including version numbers and how the component is initialized:

The version of Regional Arctic System Model (RASM v2_1_00) used for this contribution consists of the following components:

Ocean: POP2.1

Atmosphere: WRF3.7.1

Sea-ice: CICE 5.1.2

Land hydrology: VIC 4.0.6

River streamflow routing: RVIC 1.0.0

Flux Coupler: CPL 7

This model initial condition for ensemble forecast was derived from the RASM fully-coupled hindcast simulation, forced with CFSR/CFSv2 reanalysis for September 1979 through August

2022. The ocean and sea ice initial conditions at the beginning of the hindcast were derived from the 32-year spin-up of the ocean-sea ice model only (RASM G-case) forced with CORE2 reanalysis for 1948-1979.

If available from your method.

a) Uncertainty/probability estimates:

Median

4.747

Lower error bound

4.611

Lower error bound

4.93

Standard Deviation

0.071

b) Brief explanation/assessment of basis for the uncertainty estimate (1-2 sentences).

The uncertainty of pan-Arctic September sea ice extent was estimated from the 31 ensemble members: see also Fig.4 in the supplementary material.

c) Brief description of any post-processing you have done (1-2 sentences).

Daily mean sea ice with concentration $\leq 15\%$ and thickness ≤ 20 cm was excluded in the estimates of September sea ice extent.