<table>
<thead>
<tr>
<th>Reference</th>
<th>Type</th>
<th>Created</th>
<th>Page</th>
<th>Revised</th>
<th>Source</th>
</tr>
</thead>
</table>
| 2018 | internal | 2018 | 1 | 1 | Sea Ice Outlook Key Statements

**Dynamic Model**

Ocean-sea ice model represents potential future scenarios, for example, by grid-point using a suite of atmospheric and sea ice variables as concentration above 15% or absent at each grid-point. These models are used to study the impact of climate change on the Arctic sea ice. The models are initialized from the latest sea ice concentration data and run for several years to simulate the future sea ice conditions. The models are driven by a near real-time atmospheric analysis and are updated daily.

**Heuristic**

This statistical model forecast is based on data-adaptive machine learning techniques and is used to predict the September monthly sea ice extent. The model is trained on historical sea ice concentration data and uses a combination of the words sea ice extent 'SIE' and 'dovekie', a small bird that migrates to the Arctic during summer.

**Not specified**

Various methods are used to estimate the sea ice extent, including linear regression, quadratic regression, and short-term time series data. The estimates are based on the ice map from 2004 to 2017 and the statistical models use machine learning techniques. The uncertainty estimate is the range of the 10 member ensemble run and reflects the lowest and highest sea ice extents in the 12-member ensemble run. The models are initialized from the latest sea ice concentration data and run for several years to simulate the future sea ice conditions.

**September 2018 Sea Ice Outlook**

Sea ice extent values from April 1, 2018 - July 10, 2018 are shown in the table below. The short-term, quadratic regression of daily-observed Arctic sea ice thickness data in a near-real time setting for the seasonal forecast system is used to predict the September monthly sea ice extent. The uncertainty estimate is the range of the 10 member ensemble run and reflects the lowest and highest sea ice extents in the 12-member ensemble run.

<table>
<thead>
<tr>
<th>Month</th>
<th>Method</th>
<th>June TOA-RSR</th>
<th>September TOA-RSR</th>
<th>September sea ice extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>Linear Regression</td>
<td>4.24</td>
<td>4.148614</td>
<td>4.95 million km²</td>
</tr>
<tr>
<td>2018</td>
<td>Quadratic Regression</td>
<td>0.57-0.66</td>
<td>0.33</td>
<td>0.48 million km²</td>
</tr>
<tr>
<td>2018</td>
<td>Short-term time series data</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**References**


**Additional Information**

The Arctic sea ice extent of 3.4 million square kilometers. This heuristic statistical model forecast is based on the ice map from 2004 to 2017 and the statistical models use machine learning techniques. The uncertainty estimate is the range of the 10 member ensemble run and reflects the lowest and highest sea ice extents in the 12-member ensemble run. The models are initialized from the latest sea ice concentration data and run for several years to simulate the future sea ice conditions.
Dynamic Model

Statistical

Not specified

4.96

4.93

4.75

4.69

0.502

bias-corrected median

4.94 Mio sqkm

ensemble

0.36 million square

+/- 0.5 mill. km^2

Standard deviation of the estimates using ice loss rates from

The uncertainty was estimated based on standard deviation

The given uncertainty is the mean forecast error based on

The uncertainty represents one standard deviation of the

confidence intervals.

low September extent will be reached in 2018 (lower than the 3.62 M km^2

approach looks at prior years and finds the best matches that most closely

movement from December to April. Predicted ice concentration map from

The predicted September average extent for 2018 is 4.57 (±0.36) million

square kilometers. The minimum daily extent is predicted to be 4.46

This method applies daily ice loss rates to extrapolate from the start date

This bias removal is standard procedure in seasonal

parametrization scheme (with shallow cumulus convection option only

This is a statistical prediction based on the correlation between the ice area covered by melt-ponds in

squares linear regression model is fit from the mean detrended SIC/SIE data. To produce the SIE forecast,

an ocean and sea ice analysis (FOAM/NEMOVAR) (Blockley et. al, 2014; Peterson et. al. 2014) and an

anomalies from altimeter data (AVISOv4). No assimilation of

The model needs to be further tuned for melt pond reduction

This approach does not take into consideration the

The predicted September extent for 2018 is 4.71 million square

July to September is available in our website: http://ccsr.aori.u-

This model is based on ice persistence. It uses incoming solar


dominates the seasonal cycle in the Arctic sea ice, and sea ice

The forecast model is based on ice persistence. It uses incoming solar

The model uses CFSR or CFSv2 output for RASM-WRF lateral boundary

We used one root case utilizing WRF371, including the Grell-3D

The expected northward transport will be reduced compared to

The ocean component of this climate model includes explicit parameterization of

The NSIDC El Niño/Southern Oscillation (ENSO) simulation (Kimura Dataset). Based on the relationship between particle density on April 30 and ice concentration in

The trajectory model looks at particle motion from December 1 to April 30, and then

For this analysis, we distributed particles homogeneously over the Arctic sea ice on December 1. We

The trajectories were traced using the daily ice velocity from MODIS. The

The ice-area at the calibrated forecast of 4.97 Mio sqkm that has been submitted as a contribution.

Skill improves as lead time decreases, and September is the month with highest skill.

This ice area estimate should be treated with caution!

Ice-loss(m) = Energy(solar in MJ)*(1-SIC) / icemeltenergy

In the forecast, we assume that solar input to the Arctic

Ice concentration is defined as the area covered by ice

Antarctic sea ice extent.

Antarctic sea ice extent.

The entrants were provided the

The given uncertainty is the mean forecast error based on

The uncertainty represents one standard deviation of the

The uncertainty was estimated based on standard deviation

The expected ice area estimate should be treated with caution!
The AWI consortium (Kauker et al.) used the Modified CanSIPS forecast system to regenerate their sea ice extent estimates for 2018. Their results indicate similarly high ice extent compared to their July 2018 contribution. They apply the Canadian Seasonal to Interannual Prediction System (CanSIPS), but modify the experimental setup for the statistical forecast value. The performance of this June forecast method for September ice extent over the 1992-2015 period is projected to be 5.19 Mio km² with a standard deviation of 5.6 Mio km². Past performance of the June land snow cover signal is clearly visible in the September sea ice extent. Specifically, their mean SIE for ice coverage and a shorter open-water season is estimated as 4.7 to 5.6 Mio km² for September 2018, with a standard deviation of 380 k km².

The interesting finding is that the June land snow cover signal is clearly visible in the September sea ice minimum, and serves as an important predictor. The regression of this June signal with the September sea ice minimum shows particularly strong correlation with the September sea ice concentration (SIC) and sea ice thickness (SIT). My projection is based on an estimate of how much heat the Northern Hemisphere ocean stores in the month of June, and how much of this heat is estimated to melt out between June and September. The formula which reflects this heat and melting is:

\[ \text{sept_extent-june_area} = \alpha + \beta \times (\text{Melt\_Formula}) \]

When I tweak the factors, to obtain the best fit over the 1992-2015 range, the 'Melt\_Formula' that obtains the best correlation (R=0.94) is this one (centered to (extent-area):

\[ \text{Melt\_Formula} = 0.434 \times \text{snowcover} - 0.61 \times \text{Melt\_Formula} \]

This suggests that this formula is realistic, and the effect is physically real. Using this formula, for the past 26 years, the model would have predicted an Arctic ice extent of 5.03 Mio km² and an Antarctic extent of 5.2 Mio km². The lower uncertainty bound is 4.7 Mio km², and the upper uncertainty bound is 5.6 Mio km².

This outlook has been run with Meteo France “System 6” global seasonal prediction system, which includes changes to the data used to initialize both sea ice and oceanic variables. The model setup has not changed with respect to the SIO in 2015. We used atmospheric forcing data from each of the years 2008 to 2017 for the ensemble prediction and thus obtained 10 different members (10 from CanCM3, 10 from CanCM4). The Arctic SIE anomaly was calculated for each individual member. The Arctic SIE anomaly was calculated for each individual member after adding the NSIDC climo of 6.5 m.

Statistics are based on the 51-member ensemble. Relative to our July 2018 contribution, our results indicate similarly high ice extent. The formula projects a September ice extent of 5.19 M with a standard deviation of 5.6 M. This means that the June “whiteness” signal is apparent in the September sea ice minimum, and serves as a predictor. Here are the results for what this method would have predicted for the past 26 years:

<table>
<thead>
<tr>
<th>Year</th>
<th>Arctic Extent</th>
<th>Antarctic Extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>5.03 Mio km²</td>
<td>5.2 Mio km²</td>
</tr>
<tr>
<td>2009</td>
<td>5.03 Mio km²</td>
<td>5.2 Mio km²</td>
</tr>
<tr>
<td>2010</td>
<td>5.03 Mio km²</td>
<td>5.2 Mio km²</td>
</tr>
<tr>
<td>2011</td>
<td>5.03 Mio km²</td>
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</tr>
<tr>
<td>2017</td>
<td>5.03 Mio km²</td>
<td>5.2 Mio km²</td>
</tr>
<tr>
<td>2018</td>
<td>5.03 Mio km²</td>
<td>5.2 Mio km²</td>
</tr>
</tbody>
</table>

This model setup has been forced with atmospheric surface forcing data from each of the years 2008 to 2017 for the ensemble prediction and thus obtained 10 different members (10 from CanCM3, 10 from CanCM4). The Arctic SIE anomaly was calculated for each individual member. The Arctic SIE anomaly was calculated for each individual member after adding the NSIDC climo of 6.5 m. Past performance of the June land snow cover signal is clearly visible in the September sea ice extent. Specifically, their mean SIE for ice coverage and a shorter open-water season is estimated as 4.7 to 5.6 Mio km² for September 2018, with a standard deviation of 380 k km². Past performance of the June land snow cover signal is clearly visible in the September sea ice extent.