

# **June 2013 Sea Ice Outlook – AWI/FastOpt/OASys contribution**

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June, 2013

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## **1. Extent Projection**

We estimate a monthly mean September sea-ice extent of 3.49 +/- 0.45 million km<sup>2</sup>.

## **2. Methods/Techniques**

Sea ice-ocean model ensemble run

## **3. Rationale**

For the present outlook the coupled ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to May 31st 2013. This atmospheric forcing has been taken from the NCEP/NCAR reanalysis (Kalnay et al., 1996). The ensemble model experiments all start from the same initial conditions on May 31st 2013. The model system is unchanged since the last year's outlook (see the reports). Compared to the NSIDC ice extent the simulated extent is underestimated in the mean by about 0.18 million km<sup>2</sup>. This bias is added to the ensemble prediction. Likely reasons for the bias are imperfections in sea ice-ocean model and the atmospheric forcing (see below).

We use atmospheric forcing data from each of the years 1993 to 2012 for the ensemble prediction and thus obtain 20 different realizations of sea ice development for the summer of 2013. The use of an ensemble allows to estimate a probability of sea-ice extent minimum value in September 2012. The simulated ice extent for all 20 realizations is shown in Figure 1 for the period from June (initialization) until end of September. The ensemble mean of the (bias corrected) mean September value is 3.49 million km<sup>2</sup>. The ensemble standard deviation is 0.45 million km<sup>2</sup> which we provide as uncertainty estimate of the prediction.

The robustness of the forecast with respect to the ensemble size and composition was explored by calculating the ensemble mean and standard deviation for a 10 year (2003 to 2012) subset of the our 20 year set. The differences are small (Fig.2), suggesting a high impact on the prediction from factors other than the forcing, e.g. the initial sea ice state. Also the mean state and the standard deviation of the

mean September ice concentration and ice thickness for both ensembles (years 1993 to 2012 and 2003 to 2012) are similar (Figs. 3 and 4).

It can be deduced from Figs. 3 and 4 that our simulation system is likely to underestimate the September ice concentration and ice thickness especially in the area north of the Laptev Sea. To test the sensitivity of the simulation to biases in the forcing, we repeated the simulations with the more recent NCEP-CFSR reanalysis (Saha, 2010). Fig. 5 shows a climatology of simulated ice concentration and ice thickness from 1990 to 2008 for the summer season JJA. The NCEP-CFSR is favorable for a number of reasons. For example it has a better representation of radiation fluxes in the Arctic, as illustrated by the JJA climatology of the total cloud cover (Fig. 6), an important component of the atmospheric forcing. Comparisons between the older reanalyses products (NCEP/NCAR, JRA25) and the modern products (NCEP-CFSR, ERAinterim) show that biases with respect to observations have been very much reduced (not shown).

Unfortunately the NCEP-CFSR reanalysis is only available until 2010. For the future years of the SIO as well as for other applications near real time availability would be very much welcomed, as is the case for NCEP/NCAR.

**Kalnay et al. (1996)**, The NCEP/NCAR 40-year reanalysis project, *Bull. Amer. Meteor. Soc.*, 77, 437-470.

**Saha et al. (2010)**, The NCEP Climate Forecast System Reanalysis. *Bull. Amer. Meteor. Soc.*, 91, 1015–1057. doi: [10.1175/2010BAMS3001.1](https://doi.org/10.1175/2010BAMS3001.1).

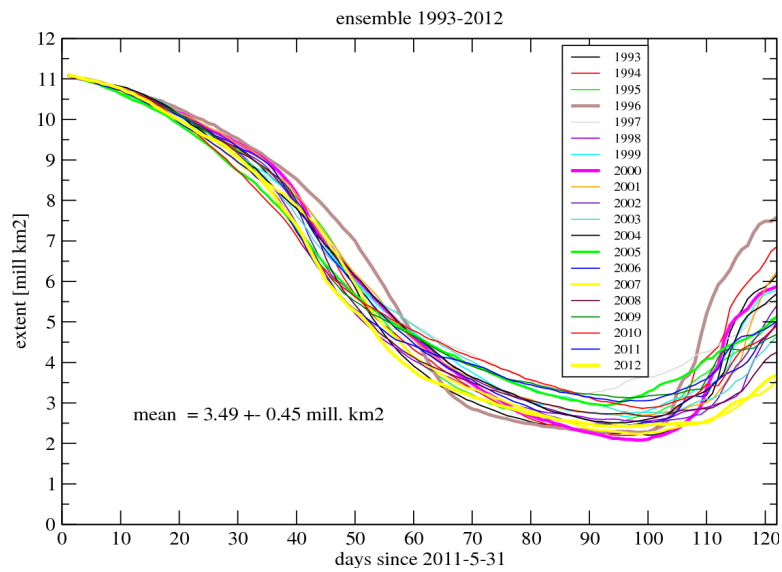


Figure 1: Simulated evolution of the ice extent [million km<sup>2</sup>] when forced with atmospheric data from 1993 to 2012 until end of September. The abscissa gives the days since the initialization of the forecast on Mai 31<sup>th</sup> 2013. Model-derived ice extents are averaged over day 103 to 122 and have been adjusted assuming a bias (see text).

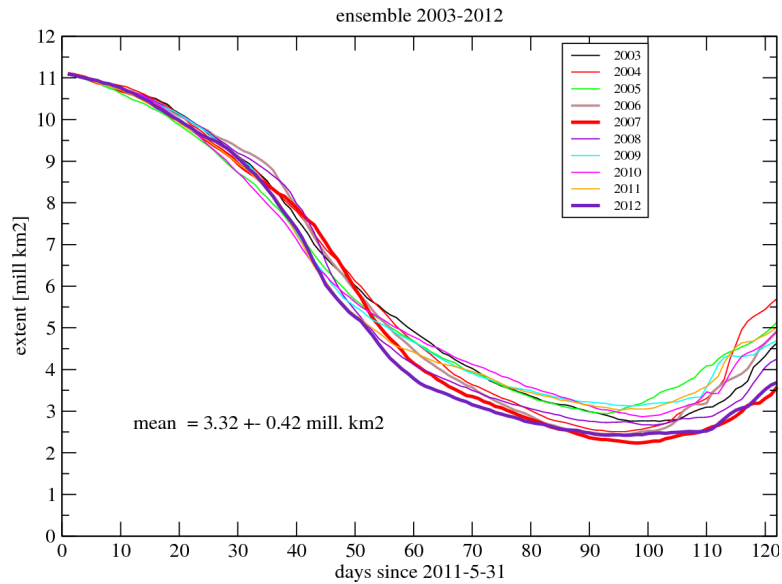


Figure 2: Simulated evolution of the ice extent [million km<sup>2</sup>] when forced with atmospheric data from 2003 to 2012 until end of September. The abscissa gives the days since the initialization of the forecast on Mai 31<sup>th</sup> 2013. Model-derived ice extents are averaged over day 103 to 122 and have been adjusted assuming a bias (see text).

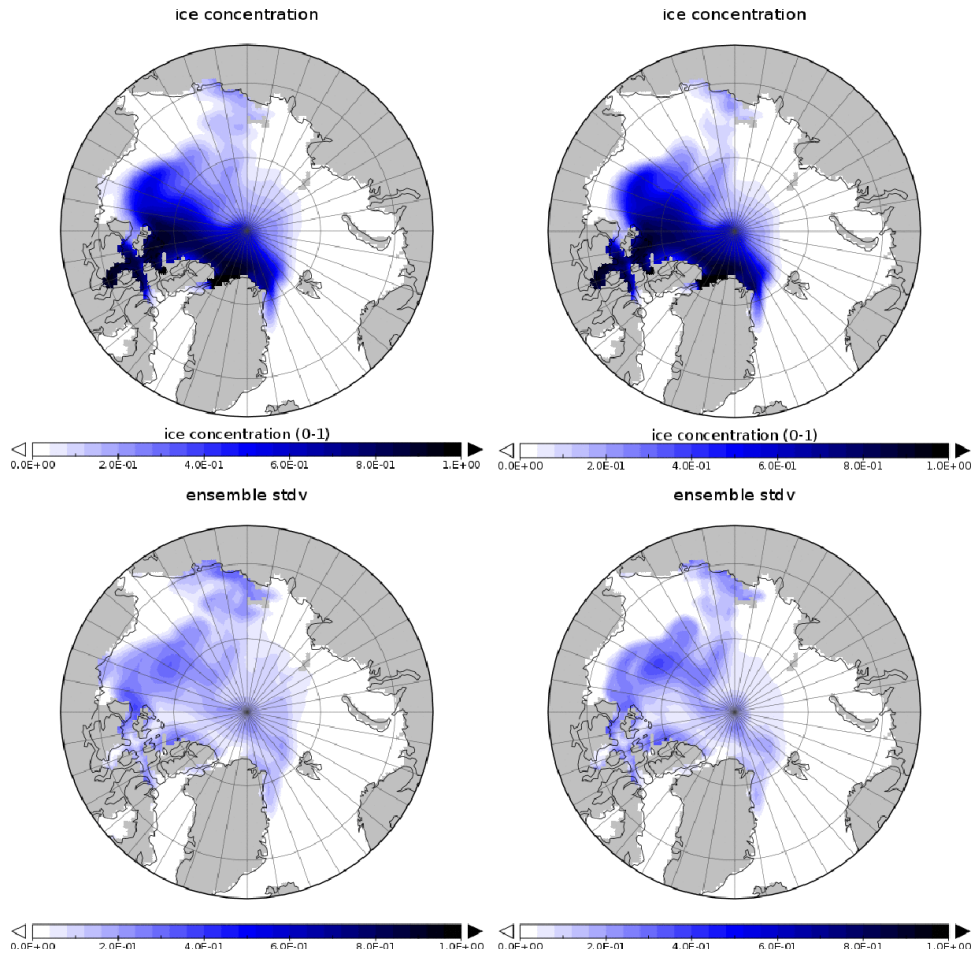


Figure 3: Simulated September ensemble mean ice concentration (top row) and the ensemble standard deviation (bottom row) for the ensemble consisting of the years 1993 to 2012 (left) and the ensemble consisting of the years 2003 to 2012 (right).

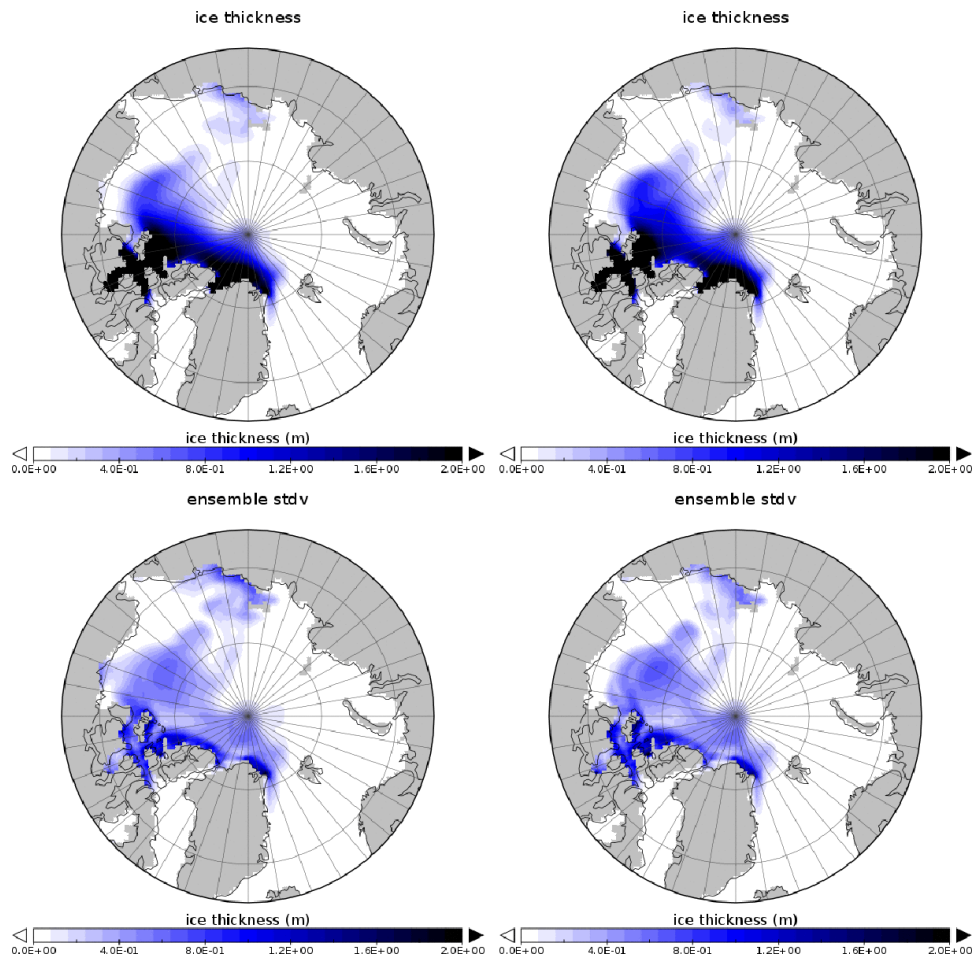


Figure 4: Simulated September ensemble mean ice thickness (top row) and the ensemble standard deviation (bottom row) for the ensemble consisting of the years 1993 to 2012 (left) and the ensemble consisting of the years 2003 to 2012 (right).

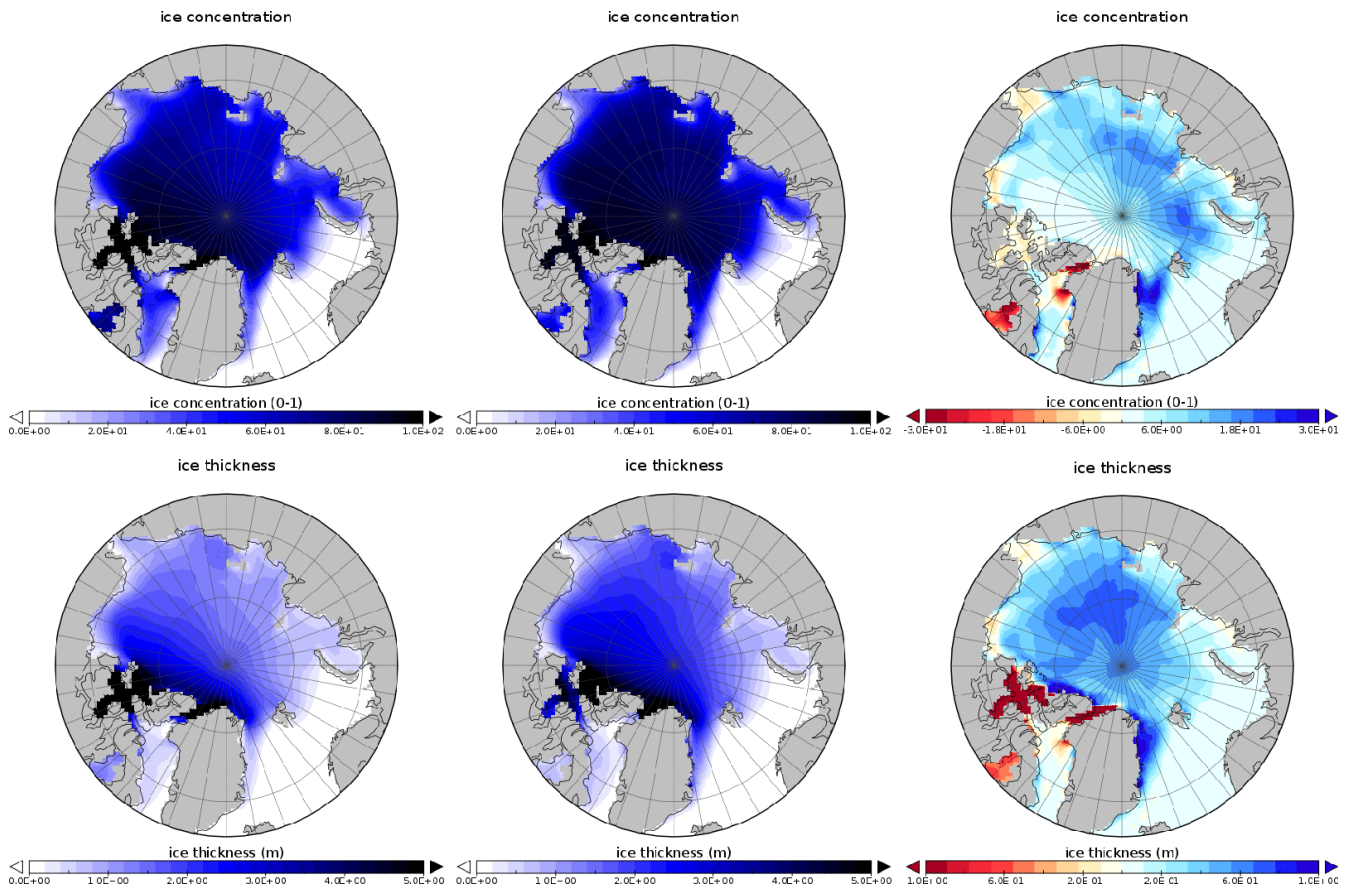


Figure 5: Simulated climatological JJA ice concentration (top row) and ice thickness (bottom row) when forced with NCEP/NCAR (left) NCEP-CFSR (middle) and the difference (right). The climatology is calculated for 1990 to 2008.

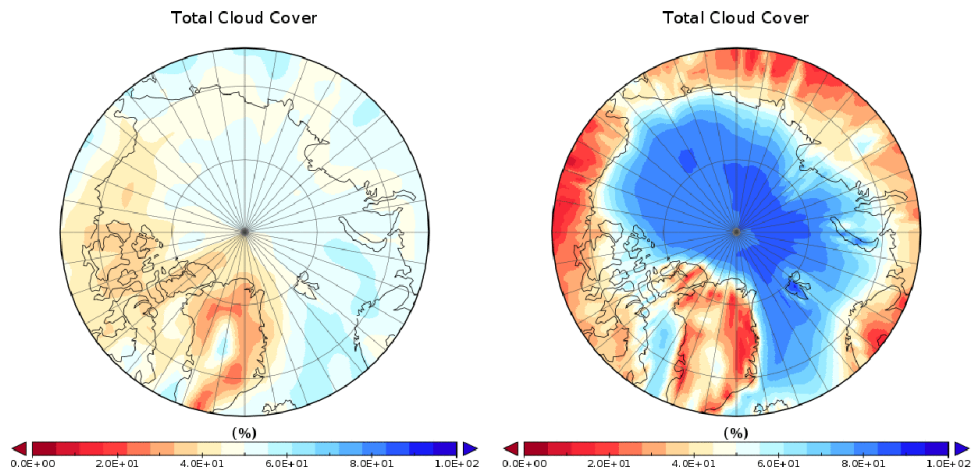


Figure 6: Climatological JJA total cloud cover of NCEP/NCAR (left) and NCEP-CFSR (right). The climatology is calculated for 1990 to 2008.