August 2011 Sea Ice Outlook – AWI/FastOpt/OASys contribution

F. Kauker[a,b], R. Gerdes[a], M. Karcher[a,b]

T. Kaminski[c], R. Giering[c], M. Vossbeck[c]

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[a] Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
[b] O.A.Sys - Ocean Atmosphere Systems, Hamburg, Germany
[c] FastOpt, Hamburg, Germany

Experimental setup

For the present outlook the coupled ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to July 21nd 2011. This atmospheric forcing has been taken from the NCEP/NCAR reanalysis (Kalnay et al., 1996). We used atmospheric data from the years 1991 to 2010 for the ensemble prediction. The model experiments all start from the same initial conditions on July 21nd 2011. We thus obtain 20 different realizations of sea ice development in summer 2011. We use this ensemble to derive probabilities of ice extent minimum values in September 2011.

Mean September Ice Extent 2011

The simulated ice extent for all 20 realizations is shown in Figure 1. Since the forward simulation underestimates the September extent compared with the observed extent minima in 2007, 2008, and 2009 by about 0.49 million km^2 (in the mean), we added this bias to the results of the ensemble. It is not clear whether the bias is caused by an imperfect sea ice-ocean model or by imperfect initial or boundary conditions.
The mean September value of the ensemble mean is 5.45 million km² (bias corrected). The standard deviation of the ensemble is 0.42 million km^2. Compared to the July outlook the predicted September extent is almost unchanged, and the uncertainty is slightly reduced (0.42 million km^2). The highest value is generated by the forcing of the year 1996 (6.42 million km^2) and the lowest by the forcing of the year 2007 (4.55 million km^2). Now the 2007-forcing yields also the minima on daily time-scales (compare July outlook).

The probability deduced from the ensemble that in 2011 the ice extent will fall below the three lowest September minima:

probability to fall below 2007 (4.28 mill. km^2 - record minimum) is about 1%,
probability to fall below 2008 (4.67 mill. km^2 - second lowest) is about 7%,
probability to fall below 2009 (4.90 mill. km^2 - third lowest) is about 12%.

With a probability of 80% the mean September ice extent in 2011 will be in the range between 4.8 and 6.0 million km^2.

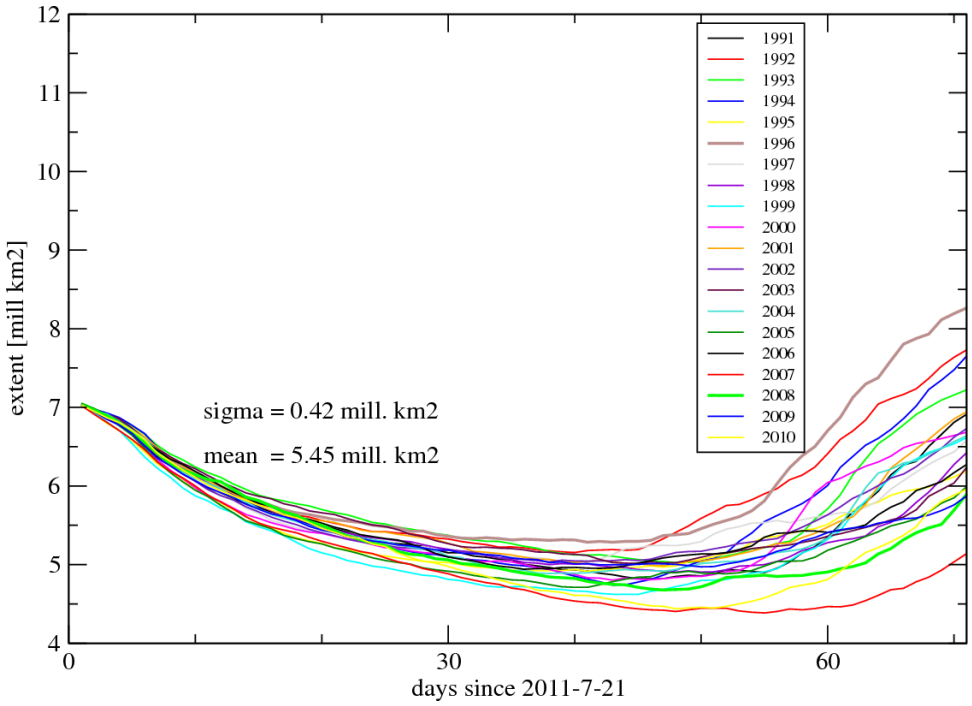

Figure 1: Simulated evolution of the ice extent [million km^2] when forced with atmospheric data from 1991 to 2010 until end of September. The the abscissa gives the days since the initialization of the forecast on July 21nd 2011. The range from day 42 to 71 is used for the calculation of the September mean. Model-derived ice extents have been adjusted assuming a bias (see text).

Critical examination of the results

In 2008 and 2009 our approach underestimated the September mean ice extent by about 0.2-0.4 million km², and in 2010 we overestimated the ice extent by about 0.7 million km² (see Table 1). Comparing this year's estimate of about 5.45 million km² with the results of the other groups (June and July outlook) suggests that we overestimate the sea ice extent this year again.

Our method has several sources of uncertainties. First the model-system (sea ice-ocean model and surface forcing (NCEP/NCAR reanalysis)) is imperfect. This is at least partly reflected by the applied bias correction. There are several ways to estimate this bias correction. We estimated the bias correction by calculating the difference between the modeled and observed ice extent for September of the years 2007 to 2009. Thereby, the modeled ice extent is taken from a hindcast simulation with NCAR/NCEP forcing from 1948 to 2010 (see Fig. 2). If we had taken, for instance, the mean difference from 1990 to 2010 for the calculation of the bias correction it would have been 0.27 million km² instead of 0.49 million km². This would have reduced our estimated September 2011 ice extent by about 0.2 million km². The difference in the calculation of the bias correction reflects the strong temporal variability of the difference (see Fig. 2). It varies from +0.33 million km² to -0.95 million km² with a standard deviation of 0.35 million km².

	June	July	August	Observed
2008	4.42± 0.40	4.43± 0.21	4.42± 0.15	4.68
2009	4.60± 0.55	4.92± 0.39	5.02± 0.39	5.36
2010	5.61± 0.41	5.78± 0.37	5.66± 0.22	4.90

Table 1: The prognosed mean September extent [million km²] for the June, July, and August outlook of the years 2008 to 2010, its uncertainty and the observed value [NSIDC].

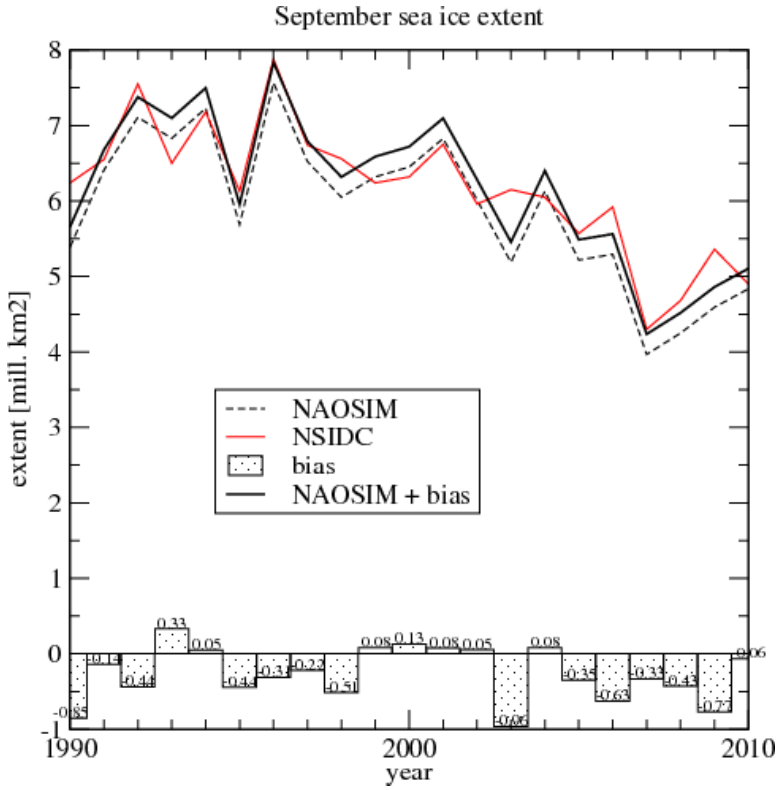

Figure 2: The modeled (black dashed line) and observed (red line) September ice extent from 1990 to 2010. The difference is plotted in bar style. The thick black line gives the modeled ice extent corrected by the time-mean bias from 1900 to 2010.

Another source of uncertainty is the number of years (and the period of time) taken into account for the ensemble calculation. Although we found no large dependence of the predicted value in recent years we calculated the ensemble mean by applying only the forcing years 2001 to 2010. The ensemble mean and uncertainty are 5.22 million km² and 0.33 million km², respectively. Although the dependence on the number of years taken into account for the building of the ensemble is still not very large, a prediction based on the last ten years of surface forcing would reduce the ensemble mean by about 0.2 million km².

If we had used the bias correction calculated from 1990 to 2010 and had used only the last ten years of surface forcing our prediction would have been 5.02 million km² with an uncertainty of 0.33 million km².

Recall that in the previous year we presented two outlooks with NAOSIM, one using the same procedure as this year, and one using an alternative outlook procedure, which employs the intial state derived from the variational NAOSIM Data Assimilation System (NAOSIMDAS). One of the main advantages of this alternative procedure it that it avoids any bias correction and the associated uncertainties.

Crucial for the ensemble prediction is of course also the initial state of the sea ice-ocean system at the starting time of the prediction. Fig. 3 shows the initial ice thickness at July 21th 2011. It is eye-catching that the ice thickness in the southern Beaufort Sea reaches still up to 3.5m whereas ice concentration observations suggest much lower ice thickness in that area (shttp://www.iup.uni-bremen.de:8084/amsr). This might also contribute to a too high September prediction.

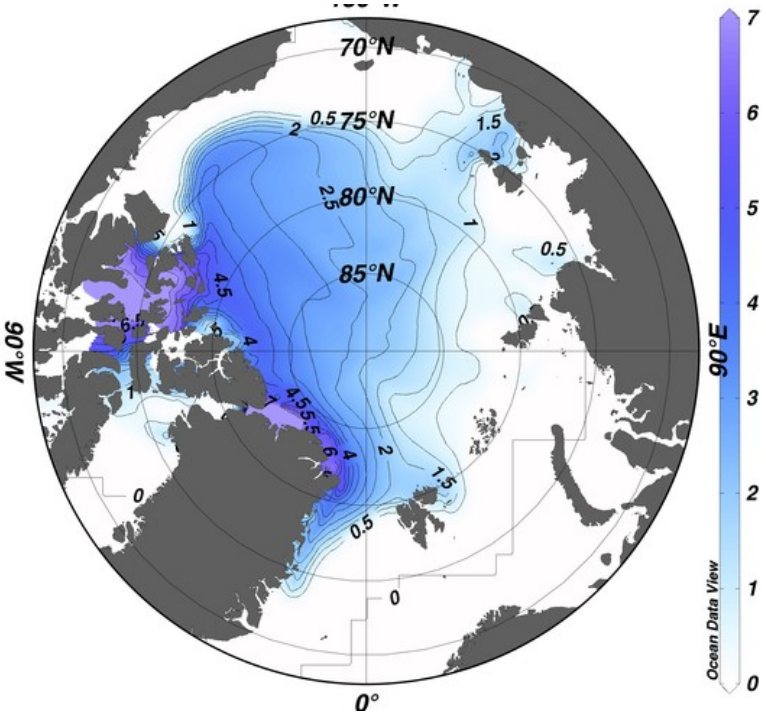

Figure 3: The initial ice thickness [m] at July 21th 2011.

References:

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