July 2010 Sea Ice Outlook – AWI/FastOpt/OASys contribution

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As for the SIO of June 2010 we make use of the 4DVar data assimilation system NAOSIMDAS to perform an additional set of ensemble experiments starting from an initial state determined via data assimilation.

Experimental setup

For the present outlook the coupled ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to June 26th 2010. This atmospheric forcing has been taken from the NCEP/NCAR reanalysis (Kalnay et al., 1996). We used atmospheric data from the years 1990 to 2009 for the ensemble prediction. The model experiments all start from the same initial conditions on June 26th 2010. We thus obtain 20 different realizations of sea ice development in summer 2010. We use this ensemble to derive probabilities of ice extent minimum values in September 2010.

As in the June 2010 outlook two ensemble experiments with different initial conditions on June 26th 2010 were performed:

Ensemble I starts from the state of ocean and sea ice taken from a forward run of NAOSIM driven with NCEP/NCAR atmospheric data from January 1948 to June 26th 2010.

Ensemble II starts from an optimised state derived by NAOSIMDAS with an assimilation window from March 1, 2010 to June 26th 2010. The following observational data streams were assimilated:

- Hydrographic data from Ice Tethered Platform profilers (http://www.whoi.edu/page.do?pid=20756) which have been deployed as part of several IPY initiatives, covering part of the central Arctic Ocean
- Hydrographic data from ARGO profilers provided by the CORIOLIS data center (http://www.coriolis.eu.org/cdc/default.htm) mostly covering the Nordic Seas and the northern North Atlantic Ocean
- Daily mean ice concentration data from the MERSEA project, based on multi-sensor SSM/I analysis, kindly provided by Steinar Eastwood (OSI-SAF, met.no), with a spatial resolution of 10 km.

- Two-day mean ice displacement data for March to April from merged passive microwave (SSM/I, AMSR-E) or scatterometer (e.g. ASCAT) signals, which were kindly provided by Thomas Lavergne (OSI-SAF, met.no), with a spatial resolution of 62.5 km.

The 4DVar assimilation minimizes the difference between observations and model analogues, by variations of the model's initial conditions on March 1st and the surface boundary conditions (wind stress, scalar wind, 2m temperature, dew-point temperature, cloud cover, precipitation) from March 1st to June 26th 2010.

Brief comparison of 'free' versus 'optimized' initial state

Figure 1 displays the modeled ice concentration on June 26th 2010 for the "free" run and the run with data assimilation. As for the June outlook differences can be mainly seen next to the ice margin especially in the Barents Sea. We have expected that the benefit of the data assimilation will become more obvious in the July outlook (see June report) but this is not the case. The ice thickness on June 26th 2010 (Fig. 2) exhibits some differences at the ice edge but also some minor differences in the Canadian basin. We assume that this is driven by a slight weakening of the Beaufort gyre in case of data assimilation (see June report).

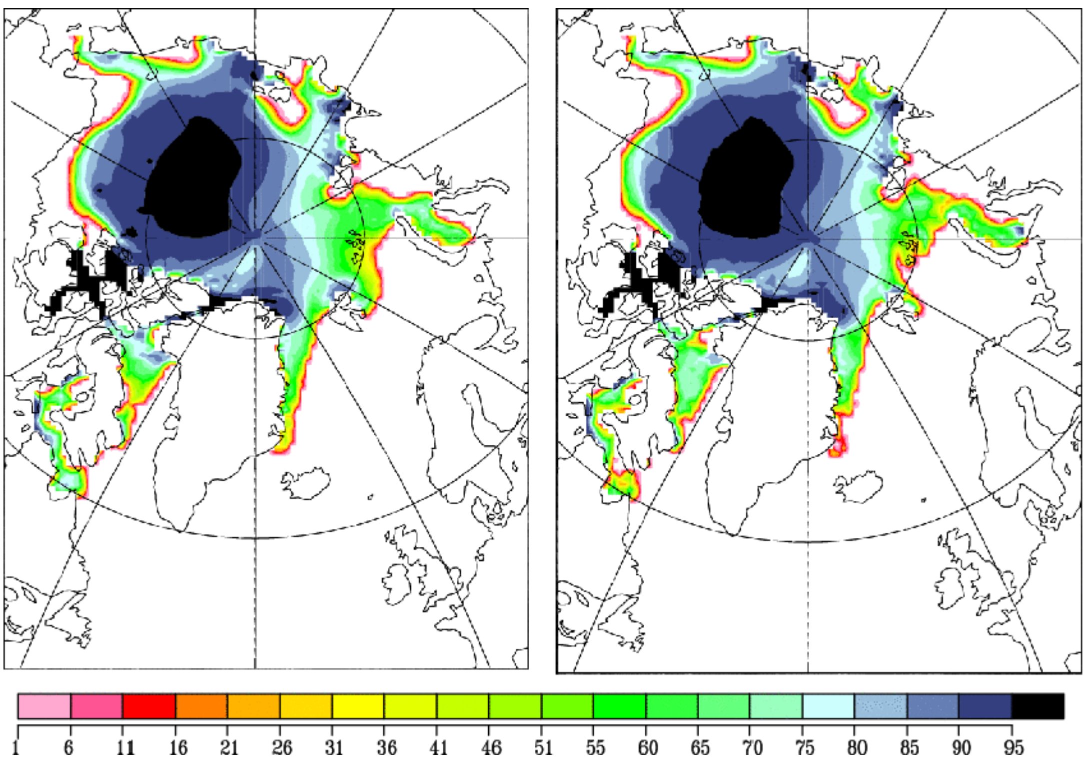

Fig. 1: The ice concentration [%] at the 26th of June 2010 in case of the "free" run (left) and in case with data assimilation (right).

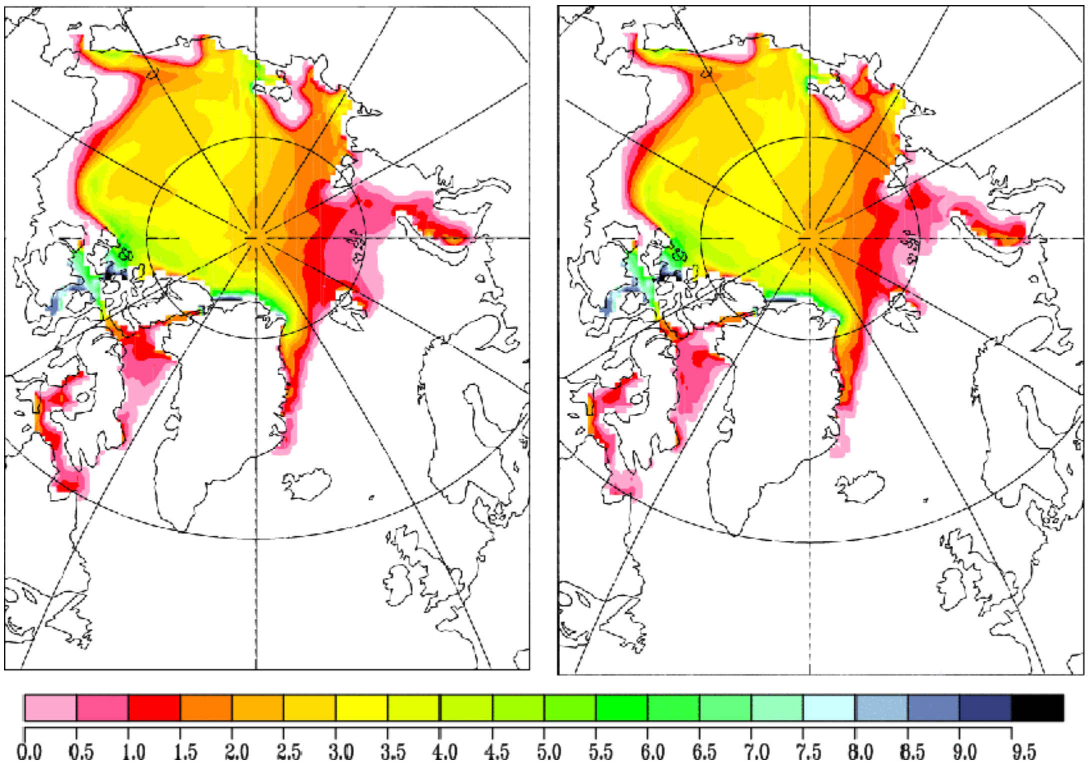

Fig. 2: The ice thickness [m] at the 26th of June 2010 in case of the "free" run (left) and in case with data assimilation (right).

Mean September Ice Extent 2010

Ensemble I (no assimilation)

The result for all 20 realizations ordered by the September ice extent is shown in Figure 3. 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 Ensemble I (see our June outlook).

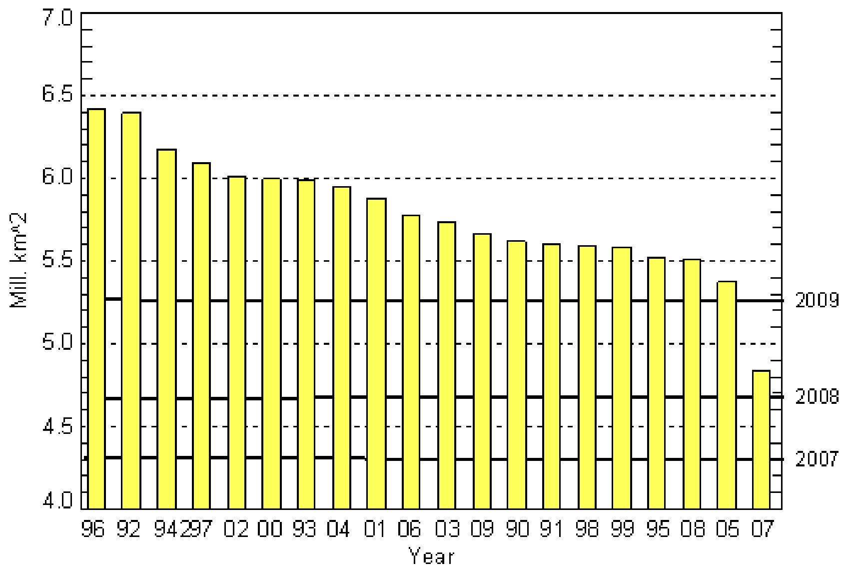

Figure 3: ***Ensemble I*** *- Simulated mean September ice extent in 2010 [million km^2] when forced with atmospheric data from 1990 to 2009 (initial state on June 26th 2010). Model derived ice extents have been adjusted assuming a systematic bias (see text). The thick black horizontal lines display the minimum ice extent observed in 2007, 2008 and 2009.*

The Ensemble I mean value is 5.78 million km² (bias included). The standard deviation of Ensemble I is 0.37 million km$^{2.}$. Assuming a Gaussian distribution we are able to state probabilities (percentiles) that the sea ice extent in September 2010 will fall below a certain value.

The probability deduced from **Ensemble I** that in 2010 the ice extent will fall below the three lowest September minima:

probability to fall below 2007 (record minimum) is below 1%,
probability to fall below 2008 (second lowest) is below 1%,
probability to fall below 2009 (third lowest) is about 12%.

With a probability of 80% the mean September ice extent in 2010 will be in the range between 5.3 and 6.3 million km^2.

Ensemble II (initial state from data assimilation)

The mean September sea ice extent for all 20 realizations starting from optimized initial conditions is shown in Figure 4. In this setup we expect the observations to correct the bias that was present in the free run. Therefore in ensemble II, in contrast to ensemble I, we do not explicitly correct for a bias. We expect the observations to have a larger impact in the upcoming outlooks.

The Ensemble II mean of 5.33 million km^2. The standard deviation of Ensemble II is also 0.37 million km^2.

The probability deduced from **Ensemble II** that in 2010 the ice extent will fall below the three lowest September minima:

probability to fall below 2007 (record minimum) is below 1%,
probability to fall below 2008 (second lowest) is about 3%,
probability to fall below 2009 (third lowest) is about 50%.

With a probability of 80% the mean September ice extent in 2010 will be in the range between 4.9 and 5.8 million km^2.

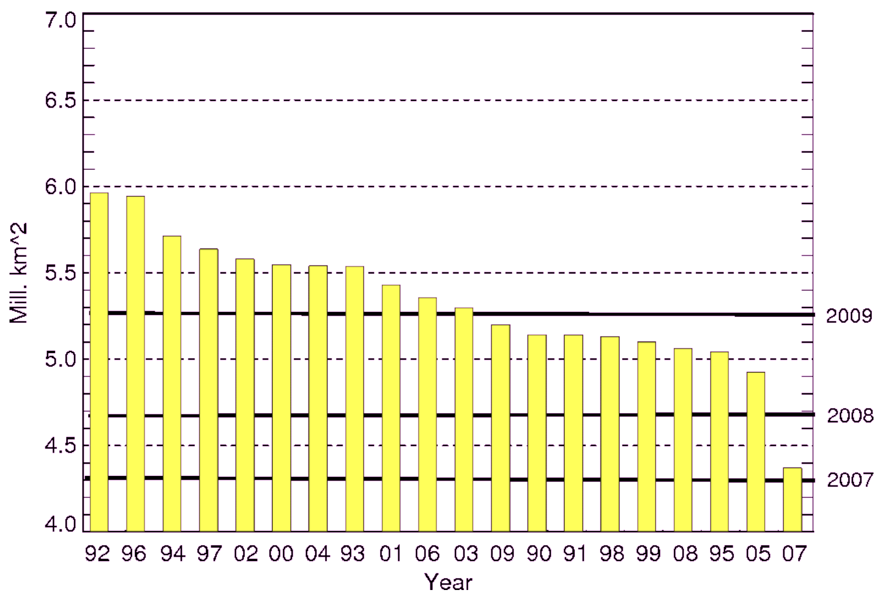

Figure 4: ***Ensemble II*** *- Simulated mean September ice extent in 2010 [million km^2] when forced with atmospheric data from 1990 to 2009 from the initial state on June 26th 2010 with data assimilation. The thick black horizontal lines display the minimum ice extent observed in 2007, 2008 and 2009.*

Discussion – back to before 2007 situation?

With respect to the June outlook the July prediction has even increased slightly (about 0.2 million km^2). In previous analyses we showed the importance of the initial ice thickness distribution for the ensemble prediction. A comparison of the modeled ice thickness on July 1st 2007, 2008, and 2009, and the initial ice thickness on June 26th 2010 reveals, as for the June outlook, considerably larger ice thickness mainly in the East Siberian Sea, north of the East Siberian Sea, and in the vicinity of the North Pole in 2010 compared to the years 2007 to 2009 (Fig. 5). The 'observed' ice concentration on June 25th 2010 (Fig. 6) shows still a large ice concentration in the areas where large ice thicknesses are modeled, i.e. there is no obvious contradiction between the two fields.

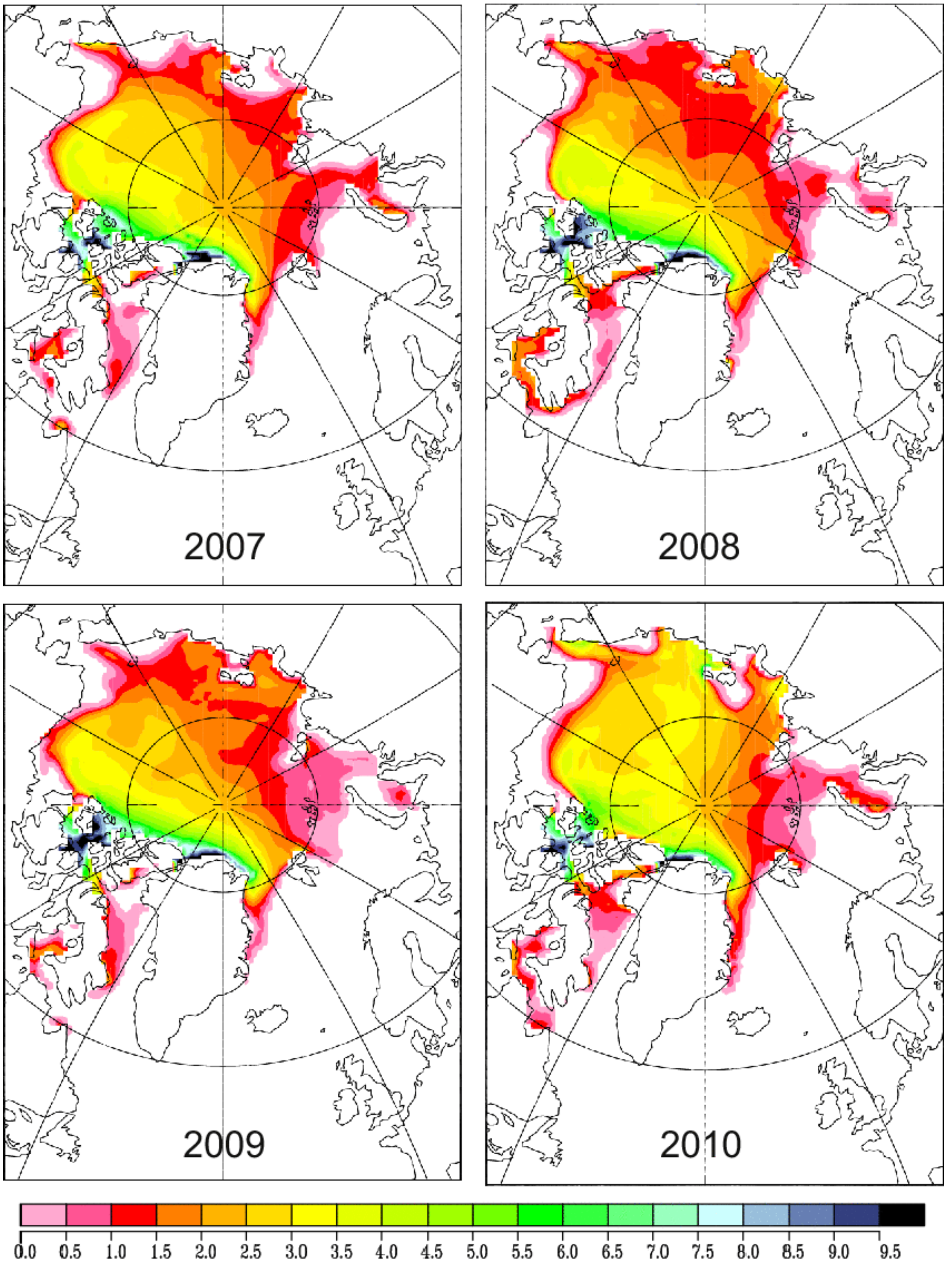

Figure 5: The ice thickness [m] at end of June 2007, 2008, 2009, and at the 26th of June 2010 (equal to Fig. 2 left).

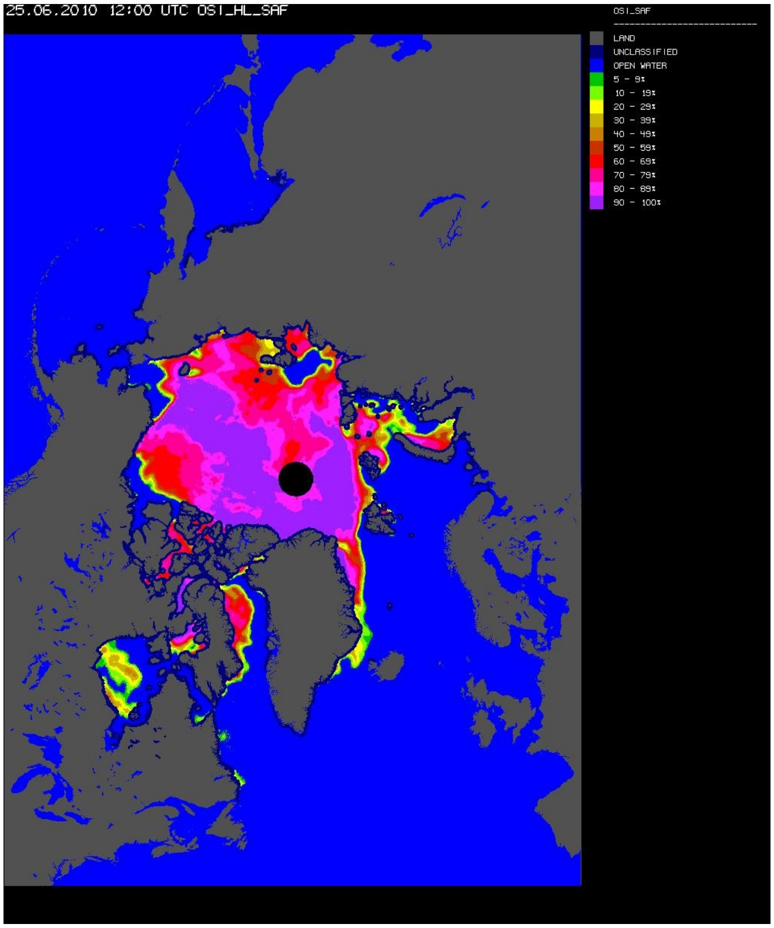

Figure 6: The 'observed' ice concentration on June 25th 2010 (courtesy OSI-SAF).

References:

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