September 2009 Sea Ice Outlook: July Report
By: AWI/FastOpt/OASys contribution

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Experimental setup

For the July outlook the coupled ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to July 2nd 2009. This atmospheric forcing has been taken from the NCAR/NCEP- reanalysis. A detailed description of the method can be found accompanying the June outlook.

Two ensemble experiments with different prescriptions of the initial conditions on July 2nd 2009 were performed:

Ensemble I starts from the state of ocean and sea ice as it is calculated by a forward run of NAOSIM driven with NCEP atmospheric data from January 1948 to July 2nd 2009.

Ensemble II starts from an optimised state derived by applying the variational assimilation system NAOSIMDAS (*Kauker et al.*, 2009) for April and May 2009, followed by a one month forward integration (driven with NCEP June 2009 surface data) until July 2nd 2009. NAOSIMDAS is being developed in the EU FP6 project DAMOCLES (http://www.damocles-eu.org). Observational data used are:

- 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 EUMETSAT Ocean and Sea Ice SAF (www.osi-saf.org), based on multi-sensor SSM/I analysis, with a spacial resolution of 10 km.
- Two-day mean ice displacement data from merged passive microwave (SSM/I, AMSR-E) or scatterometer (e.g. ASCAT) signals provide by EUMETSAT Ocean and Sea Ice SAF (www.osi-saf.org), with a spatial resolution of 62.5 km. For May, only the ASCAT instrument is used. The uncertainty in the formulation of the costfunction associated to this data stream is set to 2cm/s for April and 4cm/s for May.
- Sea ice thickness (5 km mean) obtained by an airborne electromagnetic induction sounder (EM-Bird). Data were collected along transects from various air strips in the western part of the Arctic in April during the PAM-ARCMIP campaign (Herber et al., 2009).

The variational assimilation system minimises the difference between observations and model analogues, by variations of the models initial conditions on April 1st and the surface boundary conditions (wind stress, scalar wind, 2m temperature, dew-point temperature, cloud cover, precipitation) in April and May 2009.

EM-Bird data

The EM-Bird (*Haas et al.*, 2009) was operated for the first time from the AWI research aircraft (POLAR 5, DC3-Turbo) during the PAM-ARCMIP (Pan-Arctic Measurements and Arctic Regional climate model simulations) field campaign in the western Arctic from April, 4th to April, 26th 2009. Surveys were conducted based from the airports in Longyearbyen (Svalbard), Station Nord (Greenland), Canadian Forces Station Alert (Ellesmere Island, Canada), Sachs Harbor (Banks Island, Canada) and Barrow (Alaska).

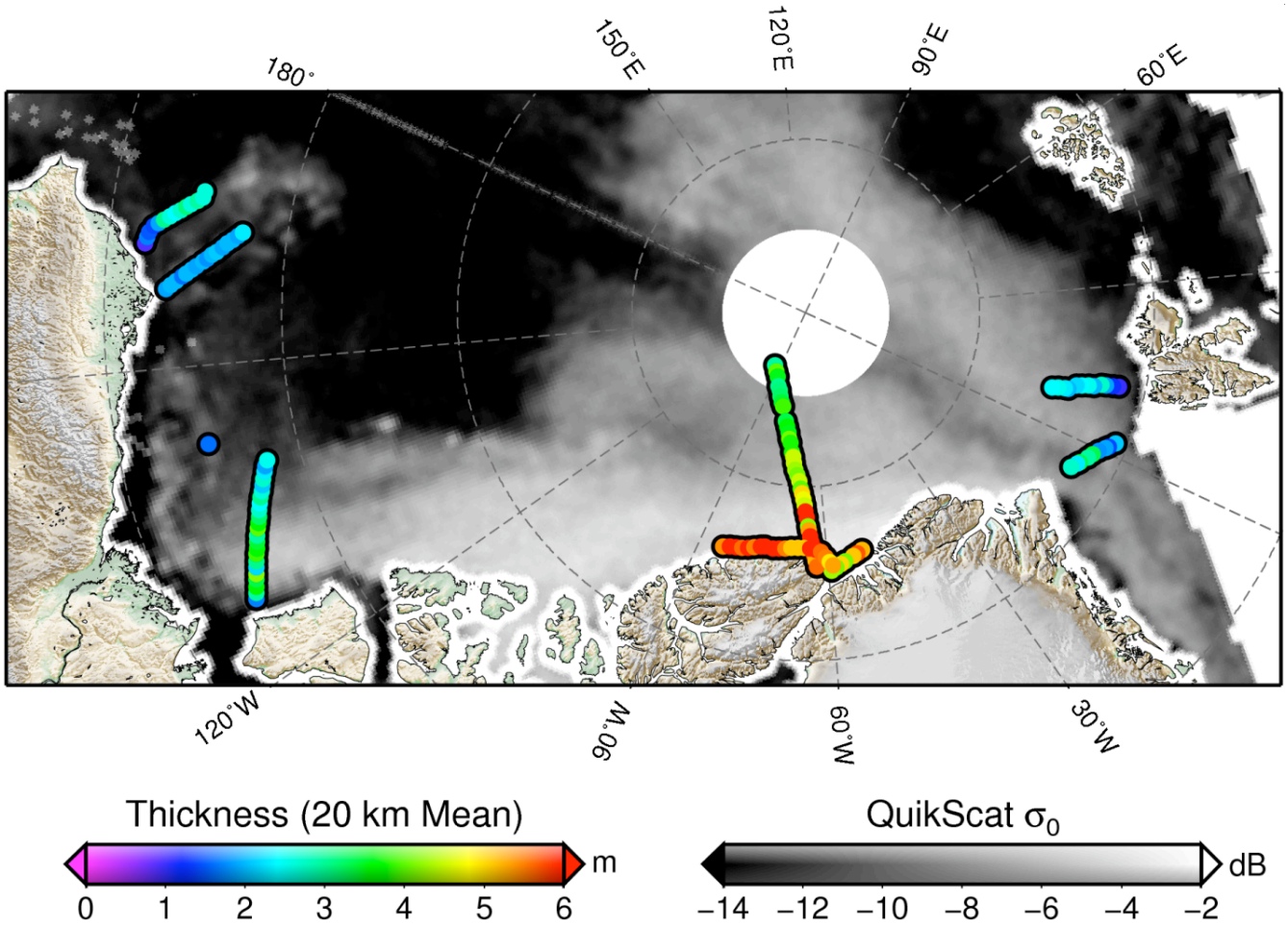

Figure 1. EM-Bird ice thicknesses from the PAM-ARCMIP aircraft campaign in April 2009 (shown here: 20 km mean) with QuikScat backscatter map (pers. comm. Stefan Hendricks, AWI).

Mean September Ice Extent 2009

Ensemble I

The result for all 20 realizations ordered by the September ice extent is shown in Figure 2. Since the forward simulation underestimates the September extent compared with observed extent minima in 2007 and 2008 by 0.40 million km^2, we added this systematic bias to the results of Ensemble I. The Ensemble I mean value is 4.92 million km² (bias added). This is the most likely value. The standard deviation of Ensemble I is 0.39 million km^2, which is twice the uncertainty of last years AWI/OASys July-outlook that was initialized on June 30th (standard deviation of 0.20 million km^2.). Assuming a Gaussian distribution we are able to state probabilities (percentiles) that the sea ice extent in September 2009 will fall below a certain value.

The probability deduced from **Ensemble I** that in 2009 the ice extent will fall below the three lowest September minima is:

probability to fall below 2007 (record minimum) is about 5%,
probability to fall below 2008 (second lowest) is about 26%,
probability to fall below 2005 (third lowest) is about 95%.

With a probability of 80% the mean September ice extent in 2009 will be in the range between 4.42 and 5.42 million km^2.

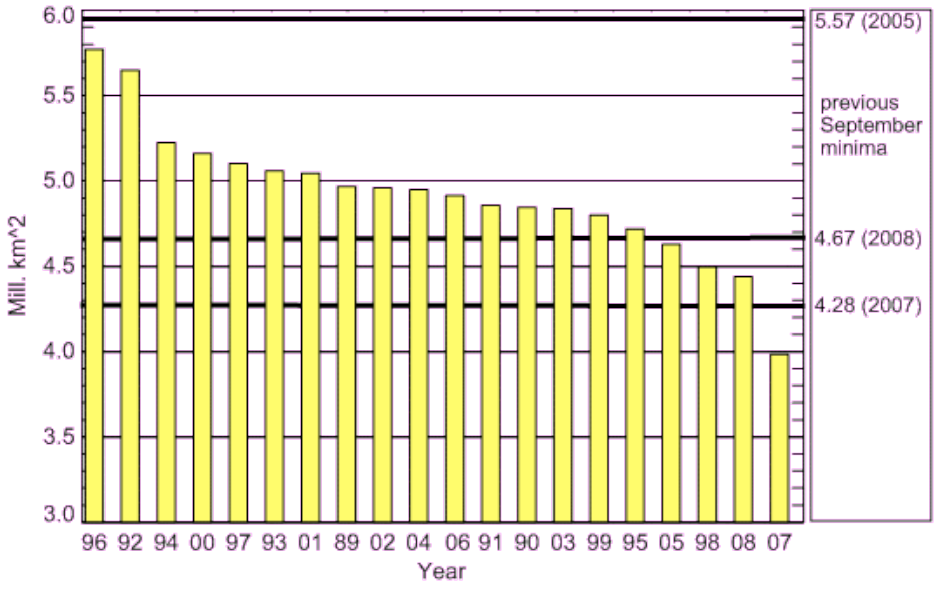

Figure 2. **Ensemble I** - Simulated mean September ice extent in 2009 [million km^2] when forced with atmospheric data from 1989 to 2008 (non-optimised initial state on July 2nd 2009). Model derived ice extents have been adjusted assuming a systematic bias (see text). The thick black horizontal lines display the minimum ice extents observed in 2005, 2007 and 2008.

Ensemble II (optimised initial conditions)
The mean September sea ice extent for all 20 realizations starting from optimised initial conditions is shown in Figure 3. Note that for Ensemble II we applied no (summer) bias correction. Hence, the Ensemble II mean of 4.42 million km^2 is somewhat lower than the mean of Ensemble I. As for Ensemble I the standard deviation of Ensemble II is 0.39 million km^2.

The probability deduced from **Ensemble II** that in 2009 the ice extent will fall below the three lowest September minima is:

probability to fall below 2007 (record minimum) is about 36%,
probability to fall below 2008 (second lowest) is about 74%,
probability to fall below 2005 (third lowest) is about 99%.

With a probability of 80% the mean September ice extent in 2009 will be in the range between 3.92 and 4.92 million km^2.

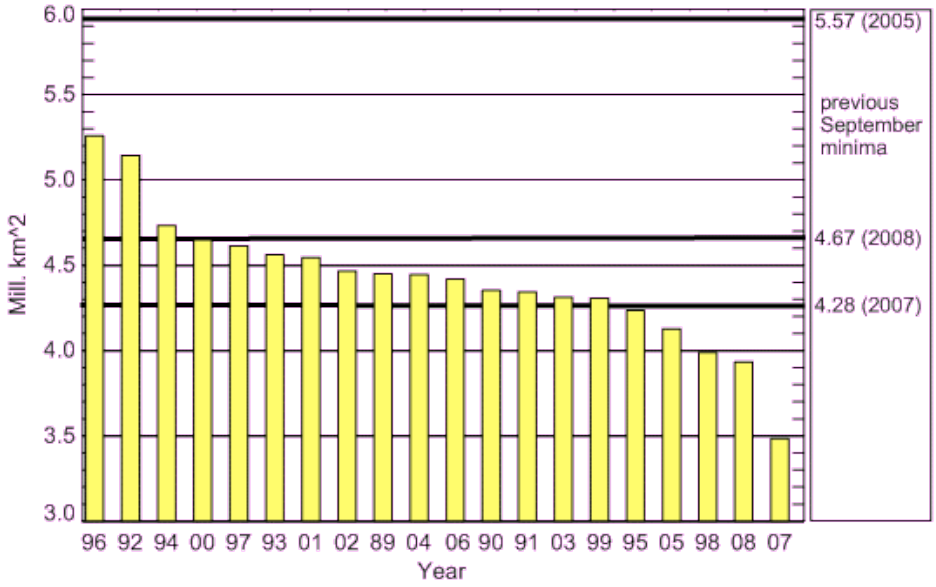

Figure 3. **Ensemble II** - Simulated mean September ice extent in 2009 [million km^2] when forced with atmospheric data from 1989 to 2008 from the optimised initial state on July 2nd 2009. The thick black horizontal lines display the minimum ice extents observed in 2005, 2007 and 2008.

References:

Haas, C., J. Lobach, S. Hendricks, L. Rabenstein, and A. Pfaffling (2009), Helicopter-borne measurements of sea ice thickness, using a small and lightweight, digital EM bird, Journal of Applied Geophysics, 67, 234-241.

Herber, A., et al., (2009), PAM-ARCMIP. Pan-Arctic measurements and Arctic regional climate model simulations (internal AWI report available from *Andreas.Herber@awi.de*).

Kauker, F., T. Kaminski, M. Karcher, R. Giering, R. Gerdes, and M. Voßbeck (2009), Adjoint analysis of the 2007 all time Arctic sea-ice minimum, Geophys. Res. Lett., 36, L03707, doi:10.1029/2008GL036323.