August 2016 Sea Ice Outlook – AWI consortium contribution

F. Kauker [a,b], T. Kaminski [c], R. Ricker [a], S. Hendricks[a] , L. Toudal-Pedersen[d], G. Dybkjaer[d], C. Melsheimer [e], S. Eastwood [f], H. Sumata [a], M. Karcher [a,b], R. Gerdes [a,g]

August, 2016

[a] Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
[b] O.A.Sys - Ocean Atmosphere Systems, Hamburg, Germany
[c] The Inversion Lab, Hamburg, Germany
[d] Danish Meteorological Institute, Copenhagen, Denmark
[e] University of Bremen, Institute for Environmental Physics, Bremen, Germany
[f] The Norwegian Meteorological Institute, Oslo, Norway
[g] Jacobs University, Bremen, Germany

1. Extent Projection

We estimate a monthly mean September sea-ice extent of 4.29 +- 0.29 million km^2.

2. Methods/Techniques

Sea ice-ocean model ensemble run initialised through assimilation of sea-ice/ocean observations (CryoSat-2 ice thickness, OSI SAF sea ice concentration and SST, and University of Bremen snow depth) in March and April.

3. Rationale

For the present outlook the coupled sea ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to August 4th 2016. This atmospheric forcing has been taken from the NCEP/NCAR reanalysis (Kalnay et al., 1996) from 1948 to 1979, the new NCEP Climate Forecast System Reanalysis (NCEP-CFSR, Saha et al. 2010) from 1980 to 2010, and the NCEP Climate Forecast System version 2 (CFSv2) (Saha et al., 2014) from 2011 to August 4th 2016. All model runs composing the ensemble were started from the same initial conditions on August 4th 2016. The model setup has not changed with respect to the last year. We used atmospheric forcing data from each of the years 2006 to 2015 for the ensemble prediction and thus obtain 10 different realisations of potential sea ice evolution for the summer of 2016. The use of an ensemble allows a probabilistic forecast of the sea-ice extent in September 2016. A variational assimilation system around NAOSIM was employed to initialise the model at March 1st using the following four observational data streams in March and April 2016: The Alfred Wegener Institute's CryoSat-2 ice thickness product (version 1.2, Hendricks et al., 2016), the University of Bremen's snow depth product, and the OSI SAF ice concentration and sea-surface temperature products.

For the years 2011 to 2014 the skill of predictions of the summer sea ice cover starting in March was investigated whereby the atmospheric forcing has been assumed to be perfectly known. Direct assimilation of the four data streams resulted in slight improvements over some regions (especially in the Beaufort Sea) but reduced the over-all fit to independent observations (ice concentration in summer). A bias correction scheme for the CryoSat-2 ice thickness, which employs a spatially variable scaling factor, could enhance the skill considerably (Kauker et al, 2015a). Given the success of this test (Kauker et al., 2015b) we reapply the approach for this year's edition of the SIO.

The simulated ice extent for all 10 realisations is shown in Figure 1 for the period from beginning of August until end of September for the outlook initialised with assimilation of sea ice/ocean observations (in March and April) (left panel - 'with initialisation') and (as a control experiment) without assimilation (right panel - 'w/o initialisation'). Note that no sea ice/ocean observations from May-Augiust are assimilated, even though they might further improve the forecast.

The ensemble mean of the mean September sea-ice extent of the control outlook amounts to 4.83 million km². The ensemble standard deviation is 0.53 million km² which serves as uncertainty estimate of the prediction. The ensemble mean of the outlook that was initialised through assimilation is 4.29 million km² with a standard deviation of 0.29 million km².

The main effect of the assimilation is a reduction of the ice thickness in the Beaufort Sea in March and an increase of the ice thickness in the eastern Eurasian basin (not shown). This explains the much higher standard deviation of the control outlook: In the control outlook much more ice is left beginning of August in the Beaufort and Chukchi Seas – the atmospheric forcing of only a few years of the ensemble can remove the ice totally. In the outlook with initialisation of sea ice/ocean variables (in March and April) the ice is much thinner and almost all atmospheric forcing of the respective years is removing the ice (Figure 2).

Correspondingly, the probability of an ice concentration above 15% in September for the ensemble initialised with assimilation of sea ice and ocean variables (in March and April) is much lower in the Beaufort and Chukchi Seas as for the control ensemble without assimilation of sea ice/ocean variables (Figure 3). North of the Laptev Sea the probability is larger because of the thicker ice there (see Figure 2).

References:

Hendricks et al. (2016), User Guide - AWI CryoSat-2 Sea Ice Thickness Data Product (v1.2), July 2016, http://data.meereisportal.de/data/cryosat2/doc/AWI_CryoSat2_Documentation_current
Kalnay et al. (1996), The NCEP/NCAR 40-year reanalysis project, Bull. Amer. Meteor. Soc., 77, 437-470.
Kauker et. (2015a), Seasonal sea ice predictions for the Arctic based on assimilation of remotely sensed observations. The Cryoshere Discuss., 9, 5521-5554, doi:10.5194/tcd-9-5521-2015.
Kauker et. (2015b), Bewertung des AWI-Konsortium Sea Ice-Outlook Beitrags für Sommer 2015 (in german), http://www.meereisportal.de/services/archiv/2015-kurzmeldungen-gesamttexte/nachlese-sio-2015.html
Saha et al. (2014), The NCEP Climate Forecast System Version 2, J. of Climate, 27, 2185–2208. http://dx.doi.org/10.1175/JCLI-D-12-00823.1.
Saha et al. (2010), The NCEP Climate Forecast System Reanalysis, Bull. Amer. Meteor. Soc., 91, 1015–1057, http://dx.doi.org/10.1175/2010BAMS3001.1.

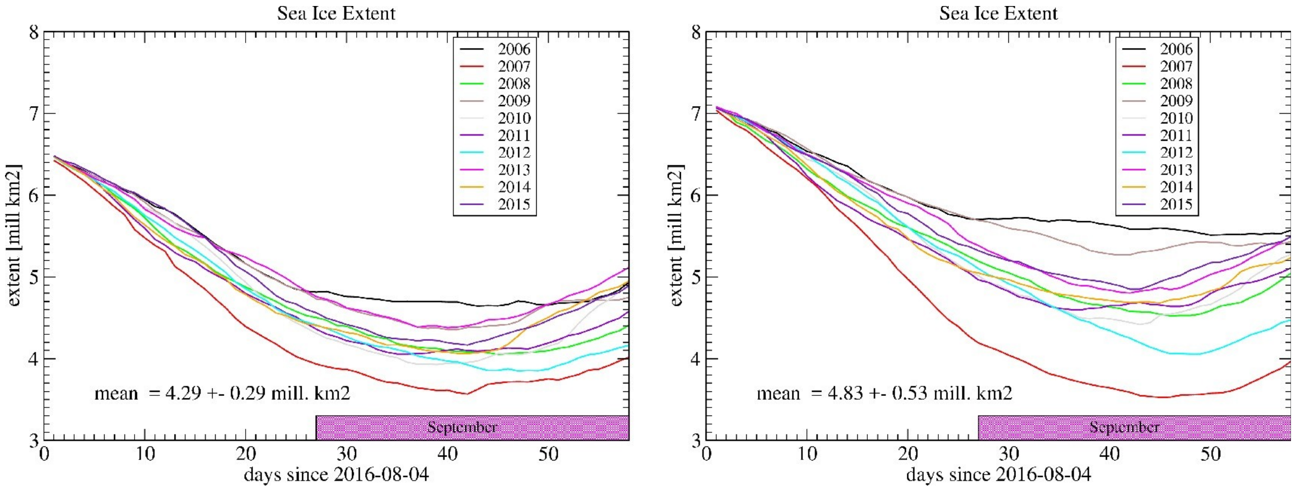

Figure 1: Simulated evolution of the sea ice extent [million km^2] when forced with atmospheric data from 1996 to 2015 (different colours) from August 4th to end of September. The abscissa gives the number of days since initialization of the forecast. Model-derived September ice extents are averaged over day 27 to 58 (magenta box). The left hand panel (a) shows the simulated evolution from a state initialised with assimilation of sea ice/ocean observations (in March and April) and the right panel without.

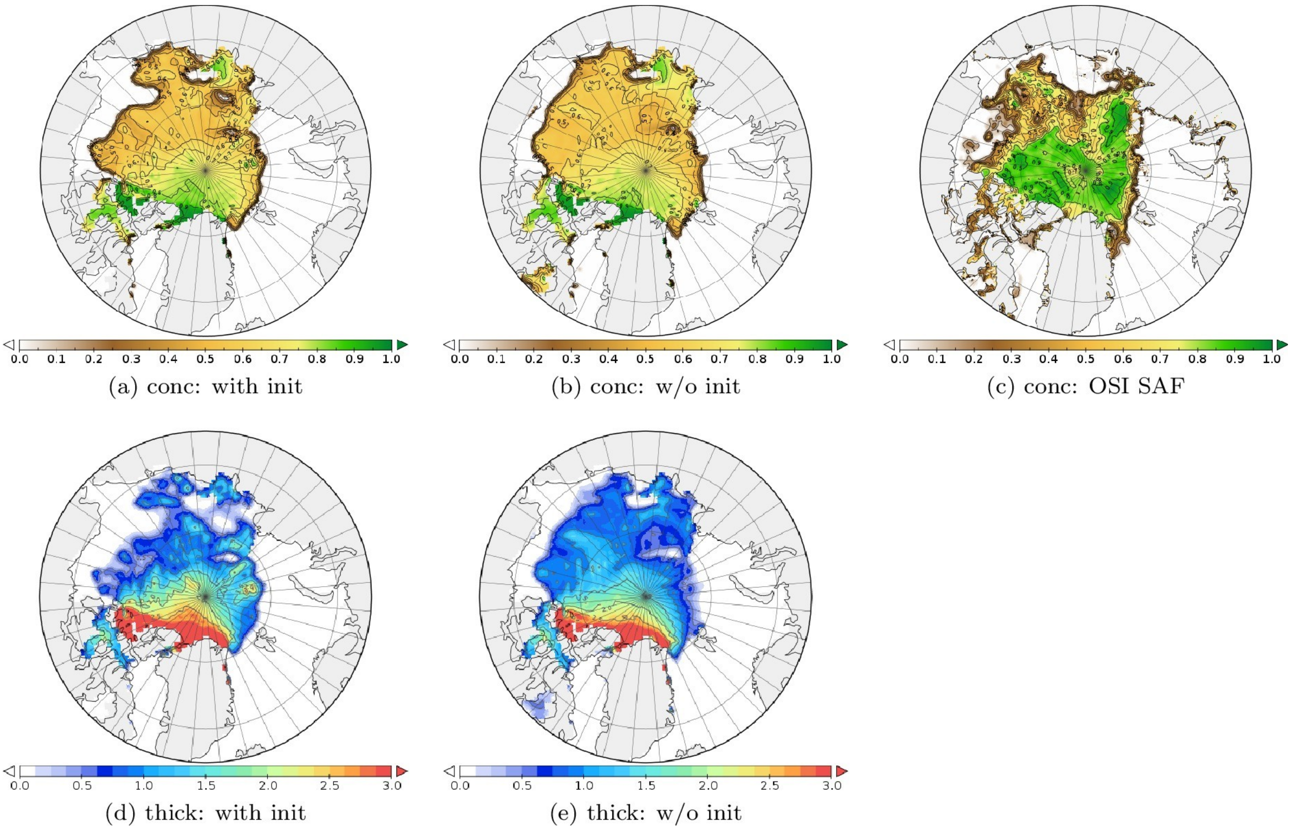

Figure 2: The sea ice state at the beginning of the ensemble outlooks on Augusts 4th 2016. The ice concentration of 'with initialization' (panel a) and 'w/o initialization' (panel b) and observed (panel c – from OSI SAF) and the ice thickness 'with initialization' (panel d) and 'w/o initialization' (panel e).

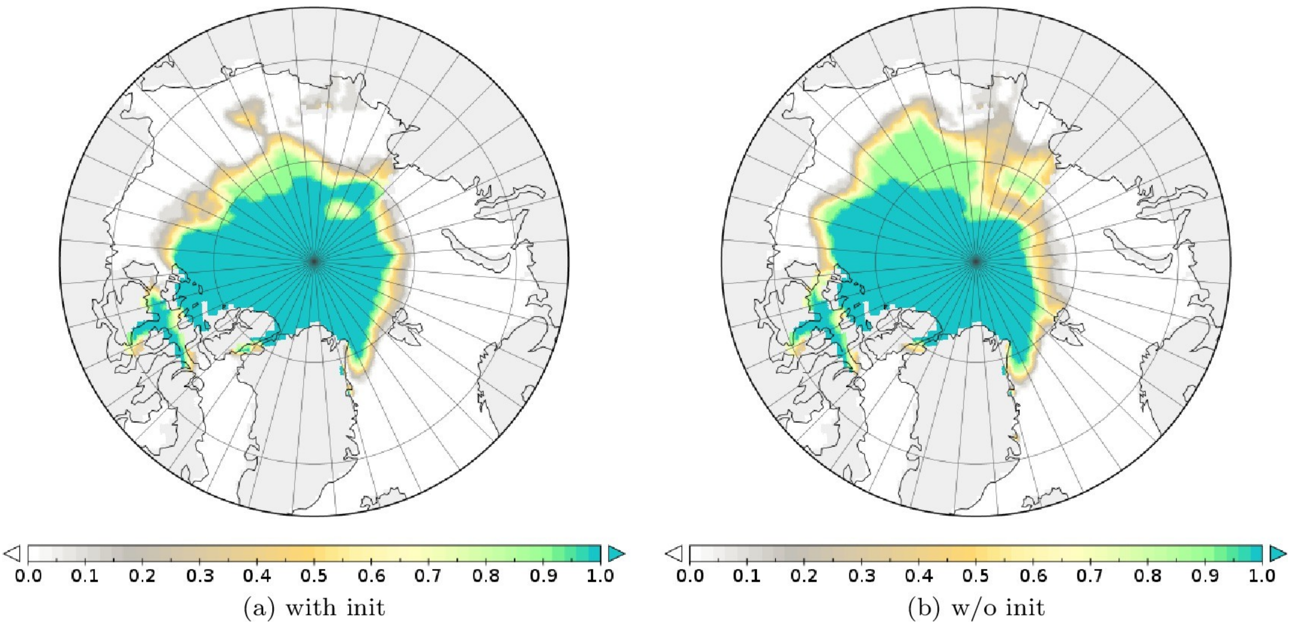

Figure 3: The probability of an ice concentration above 15% in September 2016 for the ensemble initialised with assimilation of sea ice and ocean variables (in March and April – panel a 'with init') and without assimilation (panel b 'w/o init').