June 2015 Sea Ice Outlook – AWI consortium contribution

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1. Extent Projection

We estimate a monthly mean September sea-ice extent of 5.67 +- 0.40 million km^2 (without assimilation of sea-ice/ocean observations).

2. Methods/Techniques

Sea ice-ocean model ensemble run (without and with assimilation of sea-ice/ocean observations)

3. Executive Summary

We estimate a monthly mean September sea-ice extent of 5.67 +- 0.40 million km2 (without assimilation of sea-ice/ocean observations). The method is a sea ice-ocean model ensemble run (without and with assimilation of sea-ice/ocean observations); the coupled ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to June 7th 2015.

3. Rationale

For the present outlook the coupled ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to June 7th 2015. This atmospheric forcing has been taken from the NCEP/NCAR reanalysis (Kalnay et al., 1996) from 1948 to 1979. From 1980 to 2010 the new NCEP Climate Forecast System Reanalysis (NCEP-CFSR, Saha et al. 2010) and for the period from 2011 to June 7th 2015 NCEP Climate Forecast System version 2 (CFSv2) (Saha et al., 2014) has been used. All ensemble model experiments have been started from the same initial conditions on June 7th 2015. In contrast to the outlook contributions of the previous years the model parameters have been adjusted. Compared to the OSISAF September sea-ice extent (based on the postprocessed ice concentration data from 1979 to 2009) the simulated extent slightly overestimates by about 0.02 million km^2 on average. This very small bias will be subtracted from the ensemble predictions. We have used atmospheric forcing data from each of the years 2005 to 2014 for the ensemble prediction and thus obtain 10 different realizations of potential sea ice development for the summer of 2015. The use of an ensemble allows to estimate probabilities of sea-ice extent minimum values in September 2015.

In an out-of-competion effort the benefit of remotely sensed ice thickness observations to constrain the models initial model state has been tested. The system was developed and validated for the years 2011 to 2014 within the project 'Arctic Climate Change, Economy, and Society (ACCESS)' within the Seventh Framework Programme Research and Technological Development of the European Commission (contract number 265863). It uses a variational assimilation system around NAOSIM and the Alfred Wegener Institute's CryoSat-2 ice thickness product, University of Bremen's snow depth product, and the OSI SAF ice concentration and sea-surface temperature products. Observations from March and April have been utilized. For 2011 to 2014 the skill of predictions of the summer ice cover starting in March was investigated whereby the atmospheric forcing has been assumed to be perfectly known (CFSv2 data have been employed). 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 (for a detailed description of the method see the project report D.1.83 at http://www.access-eu.org/en/deliverables2/wp1.html). However, because of the limited time period for which CryoSat-2 data are available the scheme could not be tested with fully independent data (the bias correction depends on CryoSat-2 data from 2011 to 2014). This test will be done here in the course of the SIO 2015.

The simulated ice extent for all 10 realizations is shown in Figure 1 for the period from June until end of September for the outlook without assimilation (a 'control') and with assimilation of sea-ice/ocean remotely sensed observations (b 'initialized').

The ensemble mean of the mean September sea-ice extent of the control outlook amounts to 5.67 million km^2. The ensemble standard deviation is 0.40 million km^2 which we serves as uncertainty estimate of the prediction. The ensemble mean of the initialized outlook is 5.07 million km^2 with a standard deviation 0.37 million km^2. Some remarks wrt Figure1:

1. The forcing from the year 2007 yields sea ice extends which on any given day are lower than for a forcing from 2012 which yields the second lowest values.
2. The main effects of the assimilation of the bias corrected CryoSat-2 ice thickness in March is a reduction of the ice thickness in the Beaufort Sea and an increase of the ice thickness in the eastern Eurasian Basin in March (see also ACCESS report D1.83). This leads to a reduction of the sea ice extent in September for all ensemble members although the reduction is not uniform (i.e. depends on the specific atmospheric forcing).
3. The assimilation of ice concentration reduces the sea-ice extent in June by about 0.6 million km^2 which is the consequence of a reduction of a model bias in the Nordic Seas (not shown).

As stated above, the main effect of the assimilation of the bias corrected CryoSat-2 ice thickness in March 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. Accordingly maps of the ensemble mean September ice concentration show a reduced ice cover in the Beaufort Sea and even stronger further upstream in the Chukchi Sea. The ice cover in in the eastern Eurasian Basin on the other hand is enhanced (Figure 2). For September ice thickness the effects are even stronger (Figure 3). Figure 4 depicts the probability of a grid cell to have an ice concentration larger then 15% for both outlooks and the probability for a grid cell to exhibit a mean ice thickness larger than 0.5m. According to these metrics both outlooks predict an ice free North West Passage for the section along the Alaskan coastline (The model resolution is too low to give reliable estimates within the Canadian

Archipelago.). Only the initialized outlook gives a large probability for an ice free North East Passage.

References:

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

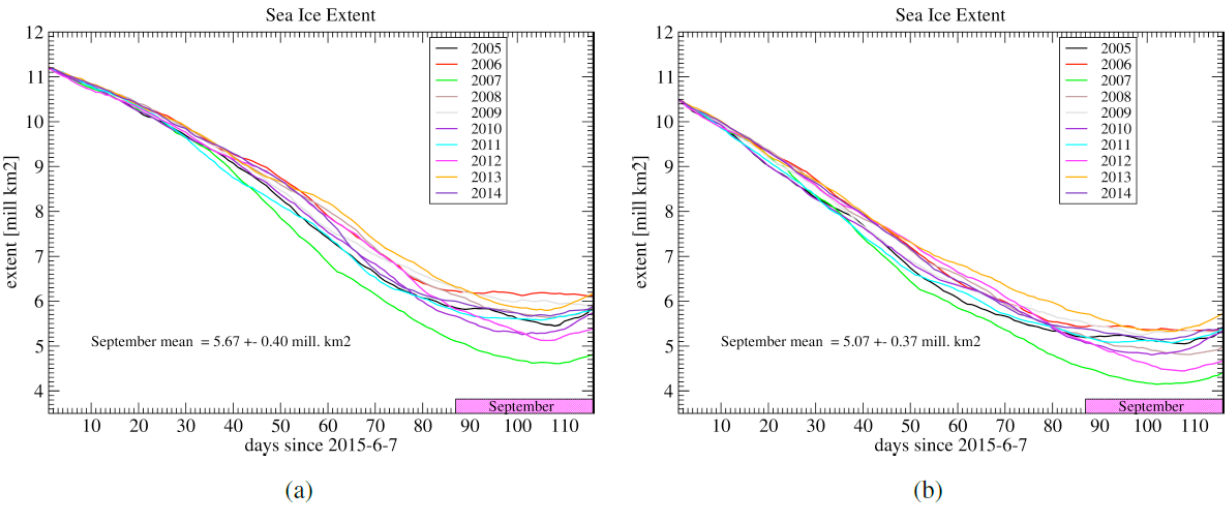

Figure 1: Simulated evolution of the ice extent [million km2] when forced with atmospheric data from 1995 to 2014 until end of September. The abscissa gives the days since the initialization of the forecast on June 7th 2015. Model-derived ice extents are averaged over day 87 to 116 (magenta box) and have been adjusted assuming a bias (see text). The left panel (a) shows the ice extent of the ctrl outlook and the right panel (b) the ice extent of the initialized outlook.

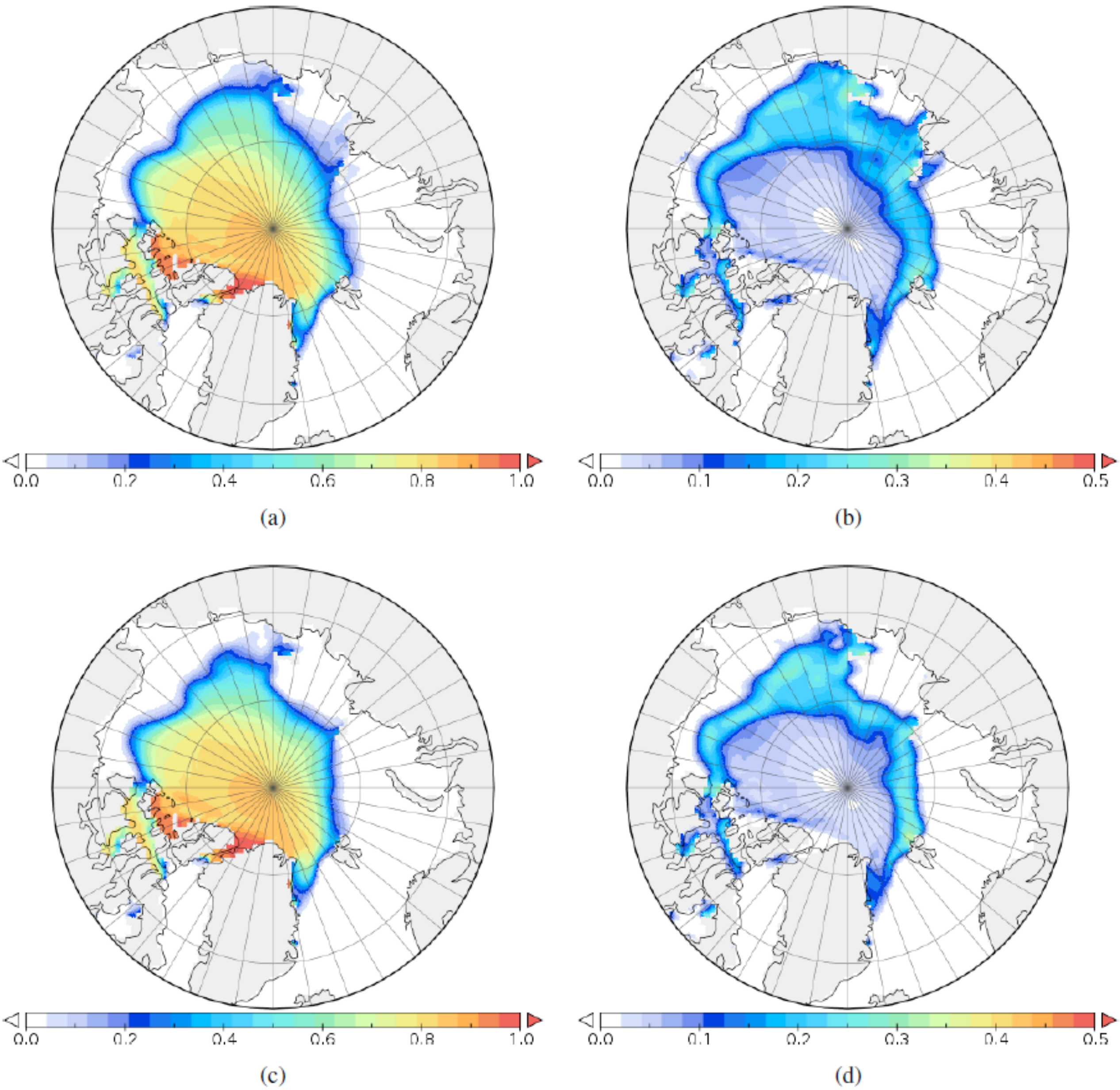

Figure 2: The simulated September ensemble mean ice concentratione [0-1] (a) and c)) and its ensemble standard deviation [0-1] (b) and d)) for the ensemble run without initialization (a) and b)) and with initialization (c) and d)).

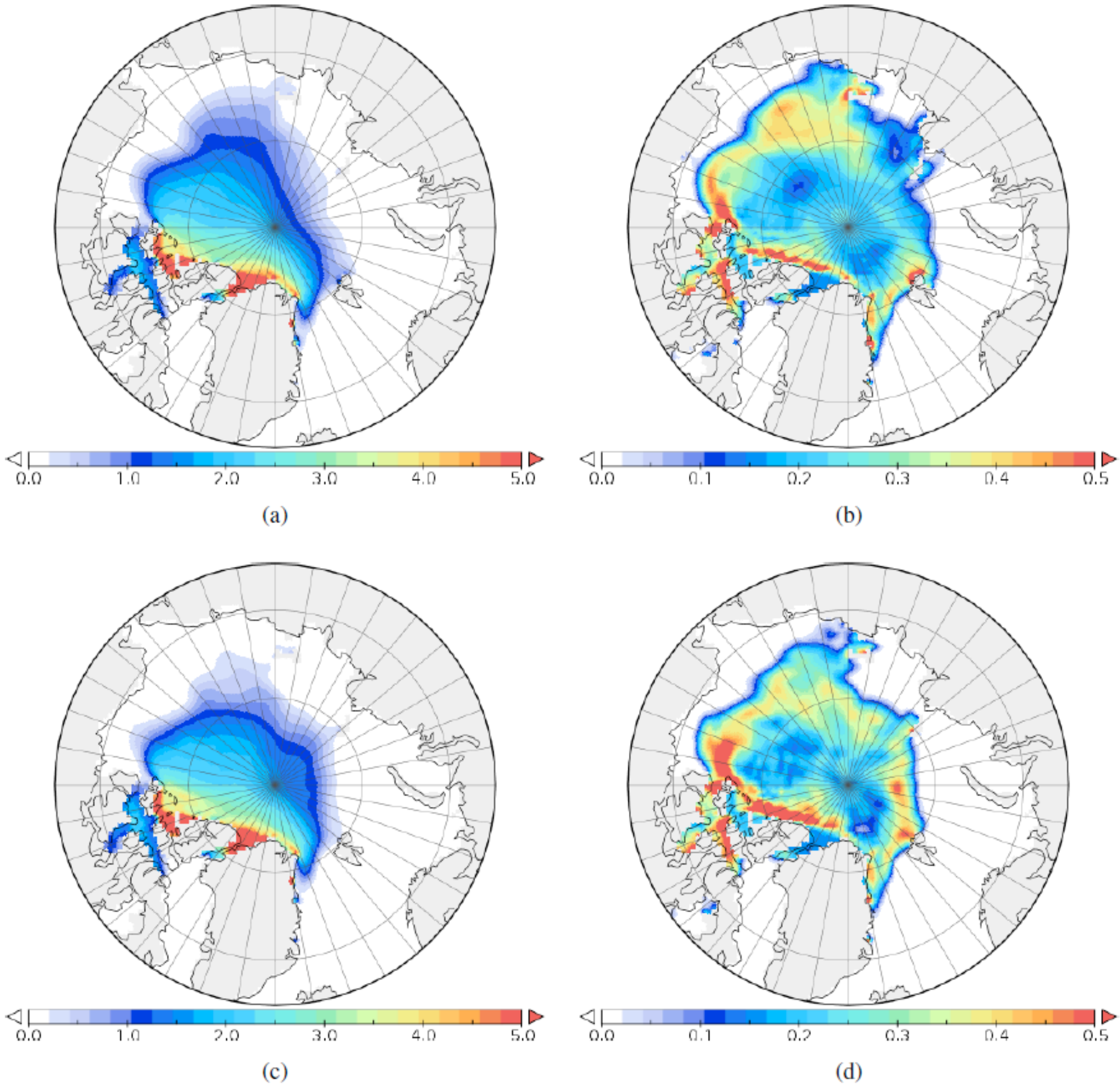

Figure 3: The simulated September ensemble mean ice thiclness [m] (a) and c) and its ensemble standard deviation [m] (b) and d)) for the ensemble run without initialization (a) and b)) and with initialization (c) and d)).

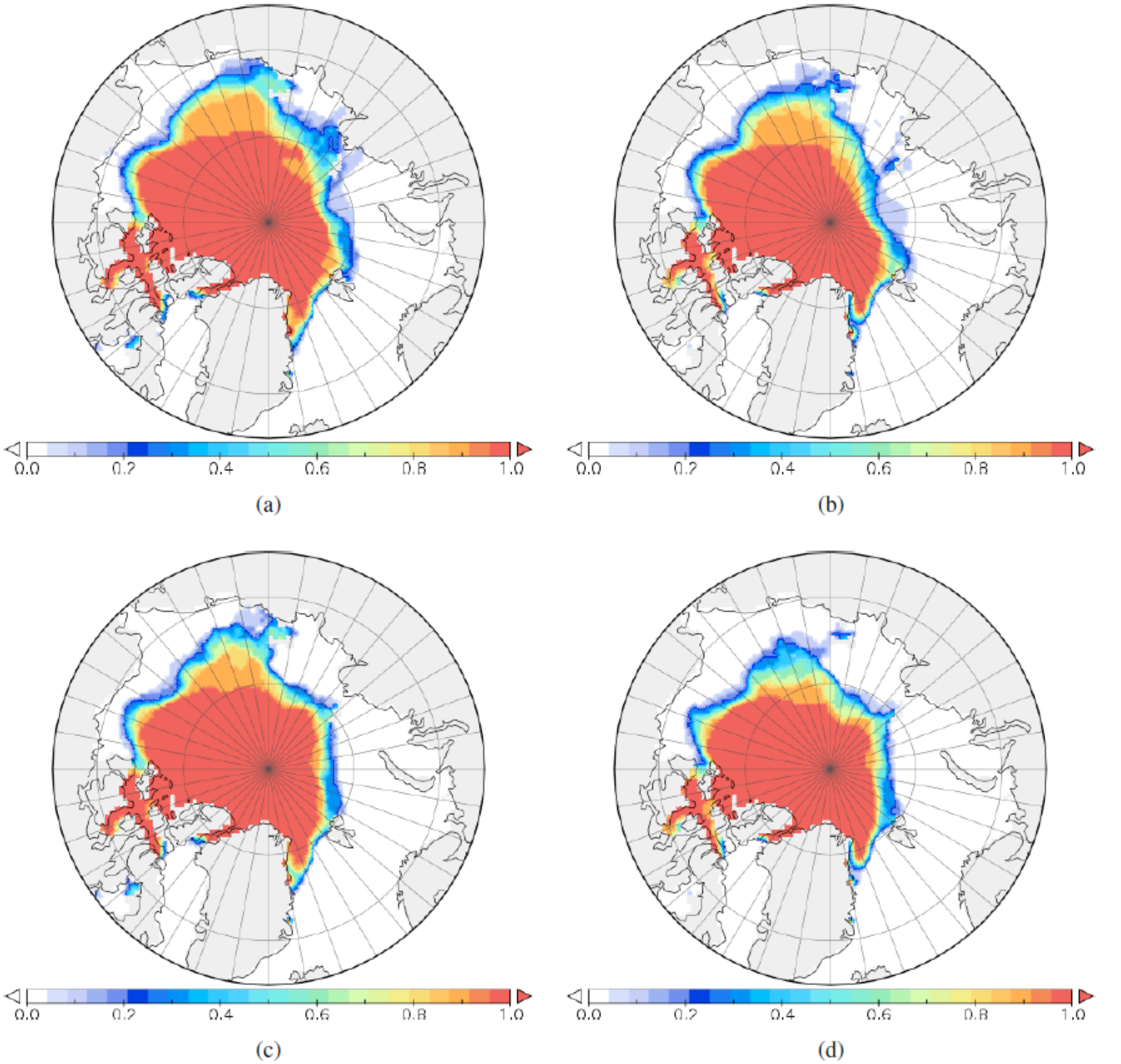

Figure 4: The probability in a grid cell to reach higher ice concentration then 15% (a) and c)) and the probability to reach higher ice thickness then 0.5m (b) and d)) for the ensemble run without initialization (a) and b)) and with initialization (c) and d)).