Sea Ice Outlook July 2009

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Extent projection

4.60 million km^2 based on the ensemble mean.

Objective

We have estimated the September mean sea-ice extent using an ensemble approach with a regional coupled ocean/sea-ice model and atmospheric forcing from ECMWF. The approach is similar to the method of Kauker et al. (2008) in that we based our prediction on atmospheric conditions from 20 different years and draw conclusion of the sea-ice evolution based on these realizations. Our prediction however uses a different reanalysis product, ECMWFs ERA-Interim and another advanced coupled ocean - multi-category sea-ice model. As the sea-ice and ocean conditions during winter are important factors for the predictability of the sea-ice extent during the subsequent summer, the usage of an advanced multi-category sea-ice model coupled to an high-resolution ocean model might increase the forecast skill because it has been shown earlier that with this type of sea-ice models biases in long-term hindcast simulations are significantly reduced (Vancoppenolle et al., 2009; Mårtensson et al., 2009).

Method

The Rossby Centre Ocean (RCO) model (Meier et al., 2003; Döscher et al., 2009) is a regional coupled ocean/sea-ice model, set-up over the Arctic Ocean and Northern Seas with a 0.25° resolution. The ocean model is coupled to a sea-ice component based on the multicategory sea-ice model HELMI (Happala, 2005) and forced at the surface by the fluxes of momentum, sensible and latent heat, and short- and long-wave radiation provided by an atmospheric model.

To obtain an initial state for our ensemble the RCO model was integrated forward in time starting in 1958, by first using a combination of the ERA-40 and ERA-Interim data set (only available to the end of March 2009), and then ECMWFs operational forecasts up to the end of June 2009. One of the lessons from the last years Sea Ice Outlook was that preconditioning is important. To get a good skill in the forecast, starting from the end of spring conditions, the initial state of the sea-ice model needs to be as realistic as possible. The mean sea-ice concentration during May (Figure 1) displays discrepancies between the simulated and satellite derived sea-ice extent, and also most likely there exists discrepancies between the modelled and real sea-ice thickness distributions. The latter is of course poorly known. These model errors will limit the skill of our prediction.

To account for the systematic model biases we have compared the 2007 and 2008 September total sea-ice extent results from the spin-up with satellite derived sea-ice extent and found an overestimation of about 0.7 million km^2, mainly due to sea-ice model shortcomings and uncertainties of the sea-ice thickness distribution. By doing a "test" ensemble of the summer of 2008 we have found that the model produces a bias of about 1.1 million km^2 for the ensemble mean. To account for the systematic model errors the ensemble mean bias have been subtracted from the September 2009 results.

The ensemble experiment was set-up by forcing the ocean/sea-ice model with July through September data from 20 different years (1989-2008) from the ECMWF reanalysis product ERA-Interim yielding 20 realizations of the sea-ice evolution over the period. All ensemble members started with the same initial conditions from the spin-up at the end of June 2009.

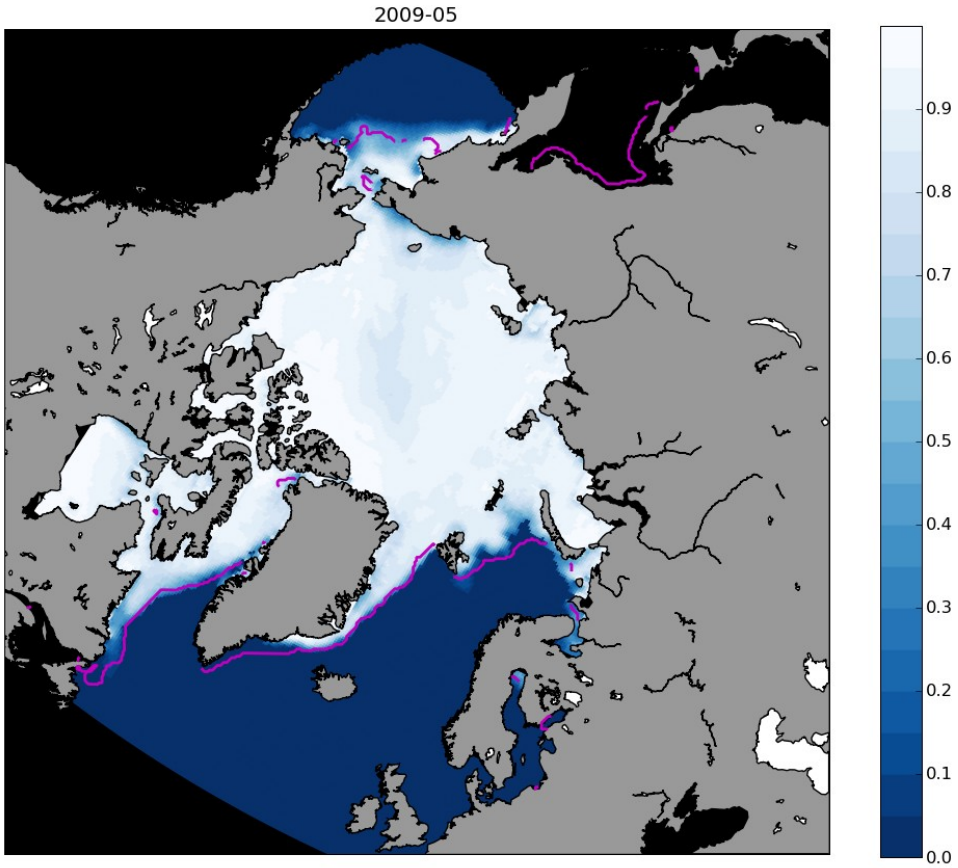

Figure 1. May 2009 mean sea-ice concentration in RCO and satellite derived sea-ice extent from www.nsidc.org (magenta line).

Ensemble results

The 20 different realizations of the total sea-ice extent for September 2009, with the bias removed, are shown in sorted order in Figure 2. The ensemble mean value is 4.60 million km^2 and the standard deviation 0.54 million km^2. The anomalous atmospheric conditions of 2007 clearly produces the lowest sea-ice extent prediction and all predictions are below the third lowest observed sea-ice extent, from the summer of 2005. Assuming that the realizations belong to a Gaussian distribution we can state probabilities that the sea-ice extent will fall below a certain value by calculating percentiles.

The probability that the 2009 September mean total sea-ice extent will fall below,

2007 satellite derived all-time minimum (4.28 million km^2) is 28 %

2008 second lowest satellite derived (4.67 million km^2) is 55 %

2005 third satellite derived (5.57 million km^2) is 96 %.

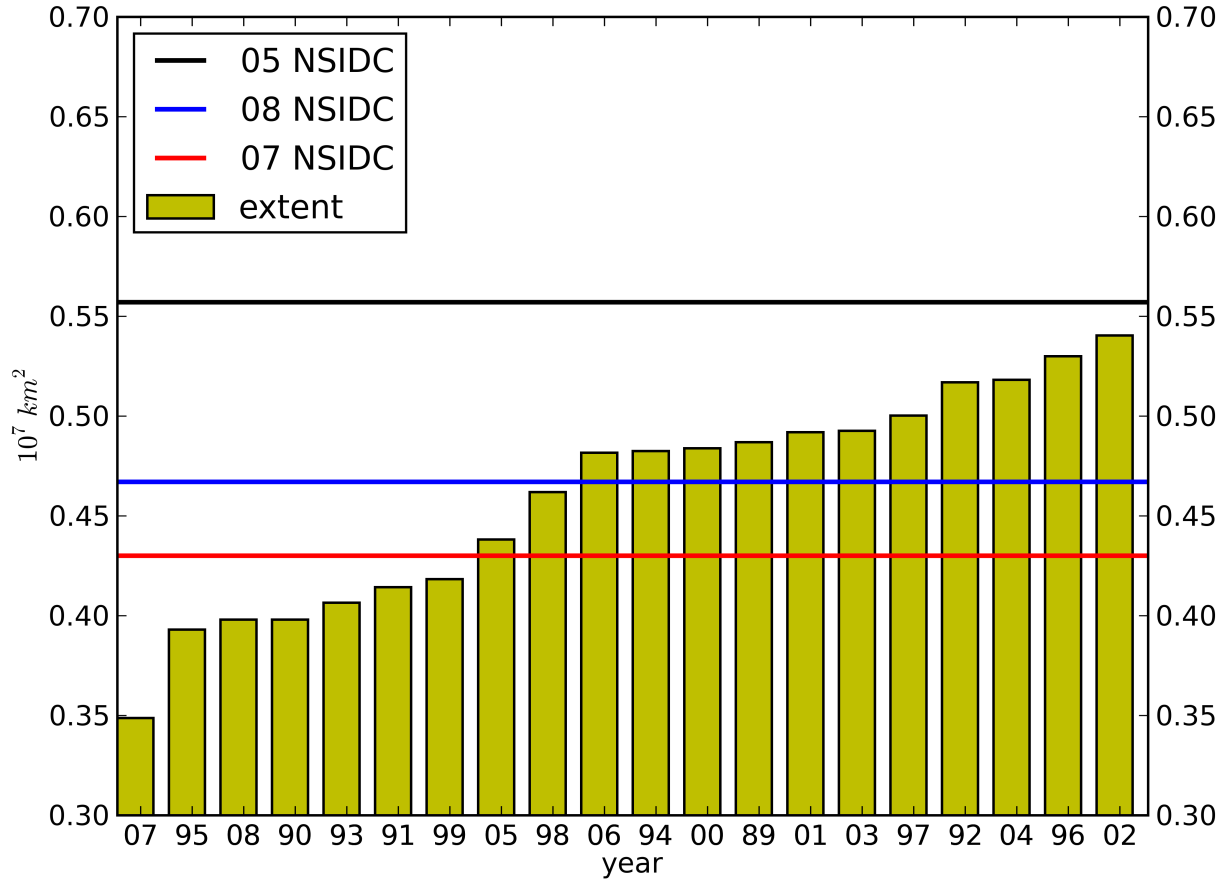

Figure 2. The 20 realizations of September 2009 mean sea-ice extent in sorted order. The horizontal lines show the minimum of 2005 (black), 2007 (red) and 2008 (blue) (data from www.nsidc.org).

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