Arctic Cap Nowcast Forecast System (ACNFS) end of summer 2014 Ice Extent Projection – June Report

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Executive Summary

The ACNFS outlook for September ice extent is 4.2 $Mkm^2 \pm 0.5$ Mkm^2.

The skill of the Arctic Cap model run in forward mode for a season is not yet quantified.

Rationale

The Arctic Cap Nowcast Forecast System (ACNFS) was run in forward model mode, without assimilation, initialized with a May 1, 2014 analysis, for nine simulations using archived Navy atmospheric forcing fields from 2004-2009 and 2011-2013. The mean ice extent in September, averaged across all ensemble members, corrected for forward model bias is our projected ice extent. The standard deviation for the ensemble mean ice extents is an estimate of the uncertainty of our projection given we do not know the atmospheric conditions that will occur this summer. Please note, this is a developmental model that has not been fully validated in non-assimilative mode, but the assimilative system has been validated to provide an accurate ice forecast [Posey et al. 2010].

Introduction

The ACNFS, developed by the Oceanography Division of the Naval Research Laboratory (NRL), is a ~3.5 km coupled ice-ocean model, with assimilation of passive microwave ice concentration, which has been developed to produce 7 day forecasts of the Arctic sea ice state. This system is currently operational at the Naval Oceanographic Office. The system is configured, and validated, for it's capability in producing an accurate 7 day sea ice forecast. The results

presented in this report come with a 'health warning' that they are preliminary and additional work is required in validating the capability of this model for seasonal projections.

The Arctic Cap Nowcast-Forecast System

The ACNFS ocean component is the HYbrid Coordinate Ocean Model (HYCOM) [Metzger et al. 2010], and is coupled to the Los Alamos National Laboratory Community Ice CodE (CICE) [Hunke and Lipscomb 2008] via the Earth System Modeling Framework (ESMF). The ocean and ice models are run in an assimilative cycle with the Navy Coupled Ocean Data Assimilation (NCODA) system [Cumming and Smedstad, 2013]. The system is run once per day, assimilating SSMI/S ice concentration into CICE to provide an initial condition for a 7 day forward model run (the forecast). Atmospheric forcing is provided by the Navy Operational Global Atmospheric Prediction System (NOGAPS) [Hogan et al. 1991]. Additional information on the system and its performance can be found in Posey et al. [2010].

Ensemble Model Runs for End of Summer Projection

The seasonal projection was made using an ensemble of forward model simulations. Nine model runs were made, using NOGAPS forcing from 2004-2009 and 2011-2013. Each model run was initialized with the same assimilative analysis field from May 1, 2014 (Fig. 1), and run forward for 5 months from May 1 for each specific year.

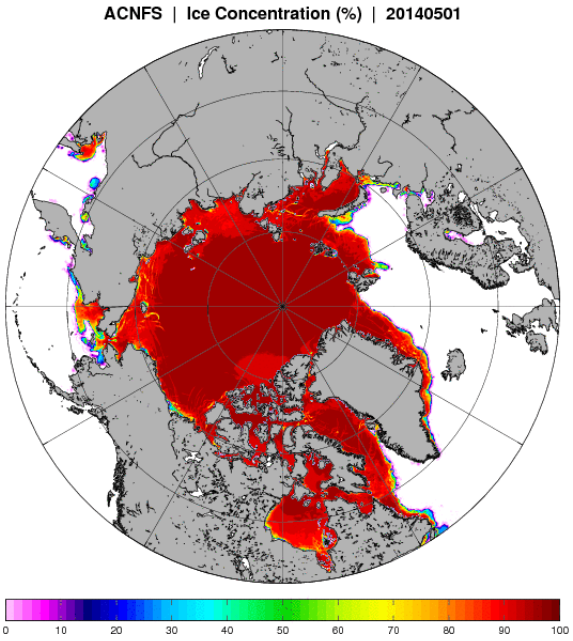

Figure 1: Ice concentration field (%), from ACNFS valid May 1, 2014. This is the initial condition for each ensemble member.

This ensemble of nine members gives an indication of how sea ice can respond to variable atmospheric conditions during summer. Figure 2 shows examples of ice concentration for two ensemble members.

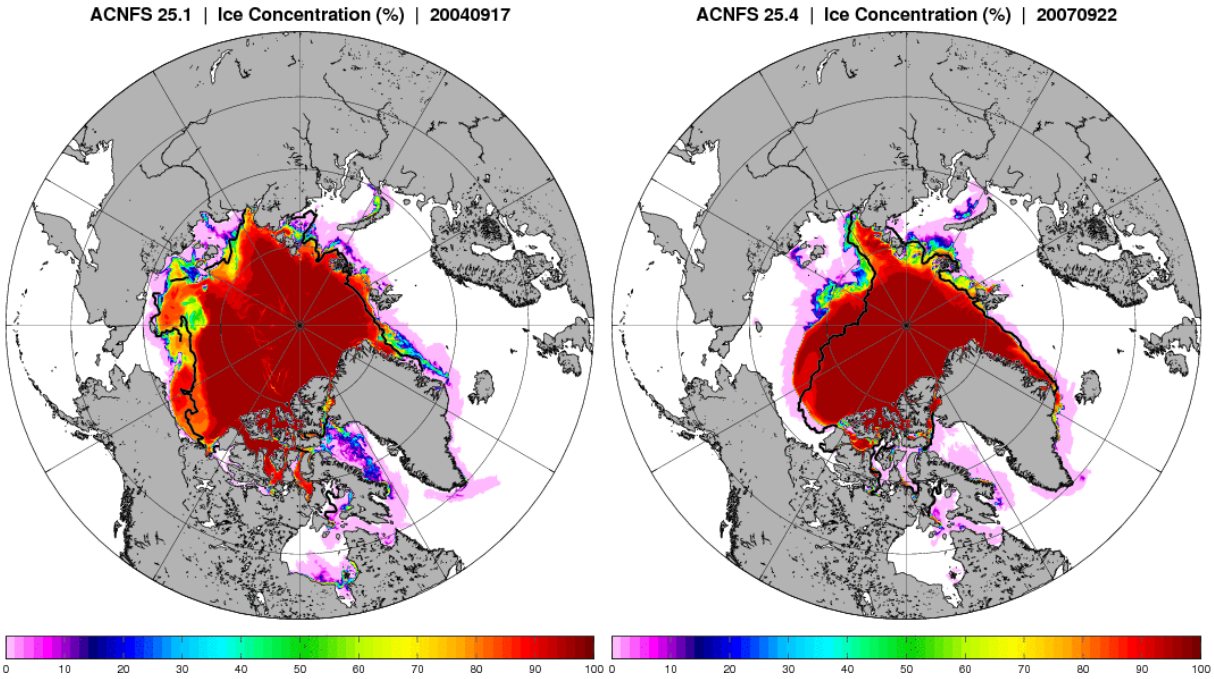

Figure 2: ACNFS ensemble ice concentration (%) on September 17, 2004 (left) and September 22, 2007 (right). The black line on the figures represents the ice edge provided in real time, i.e. 2004 and 2007, by the National Ice Center for these actual days. These two simulations have the maximum and minimum projected ice extents out of the nine ensemble members, respectively.

Ice extent was calculated using all grid cells with at least 15% ice concentration and then the minimum ice extent was determined for each September. Ice extent minimums averaged across all ensemble members during September is 6.5 Mkm^2, with a standard deviation of ± 0.5 Mkm^2. The ensemble appears to be doing a reasonable job of reproducing variability due to uncertainty in atmospheric forcing. The extent estimate, however, is high. We have applied a bias correction to our outlook to account for this bias. As ACNFS has been run in assimilative mode since fall 2007, the analysis fields from the assimilative run are used to identify forward model biases in mean September ice extent. The ACNFS has demonstrated good skill at predicting ice extent, hence it is reasonable to use the assimilative run analysis fields as 'truth' for our bias correction estimate. A set of control runs for 2008 through 2012 were performed using the May 1 analysis for initial conditions. Comparing the control runs mean September ice extent to ACNFS analysis mean September 2008/2012 ice extent, an estimate of the forward

model bias is -2.24 Mkm^2. As seen in Fig. 3, there is a spread in September ice extent between ensemble members (bias corrected). The mean of these values, 4.2 ± 0.5 Mkm^2, represents the projected ice extent for September 2014.

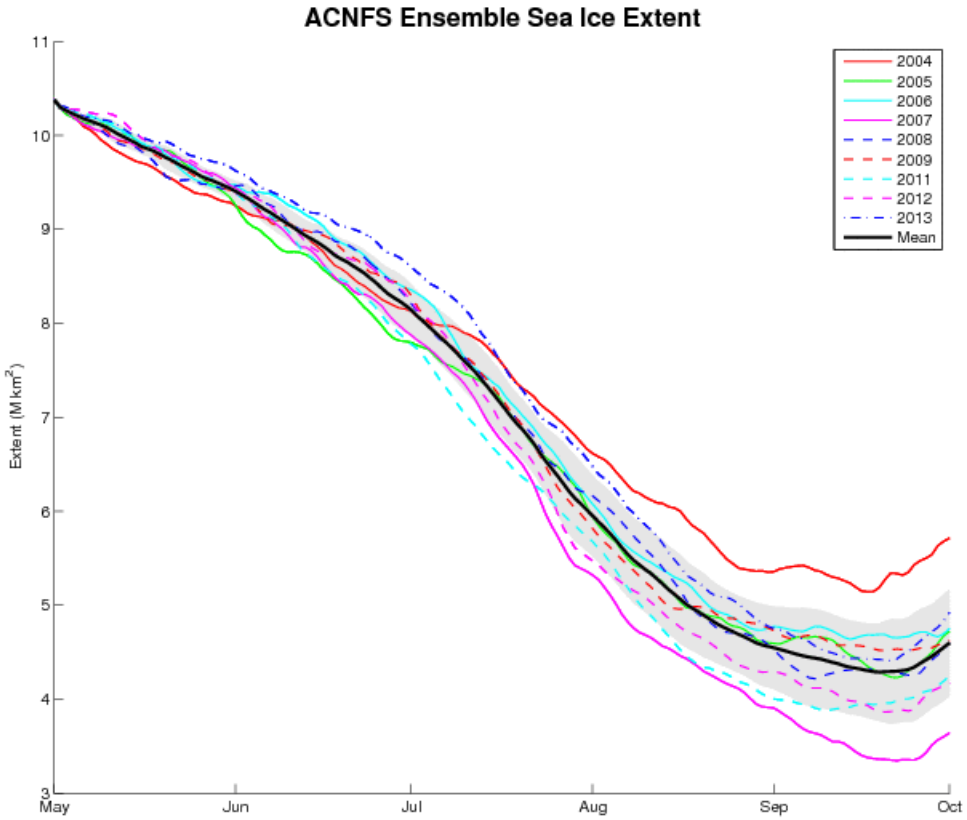

Figure 3: Time series of ice extent corrected using the May bias for each ensemble member. Black line represents the ensemble mean ice extent with the predicted September minimum of 4.2 ± 0.5 Mkm^2. The shaded area (± 1 standard deviation) denotes the variability during the May-Sept time period.

Also included (Fig. 4) is the spatial forecast map for the mean ensemble predicted minimum ice extent from ACNFS valid 19 September 2014.

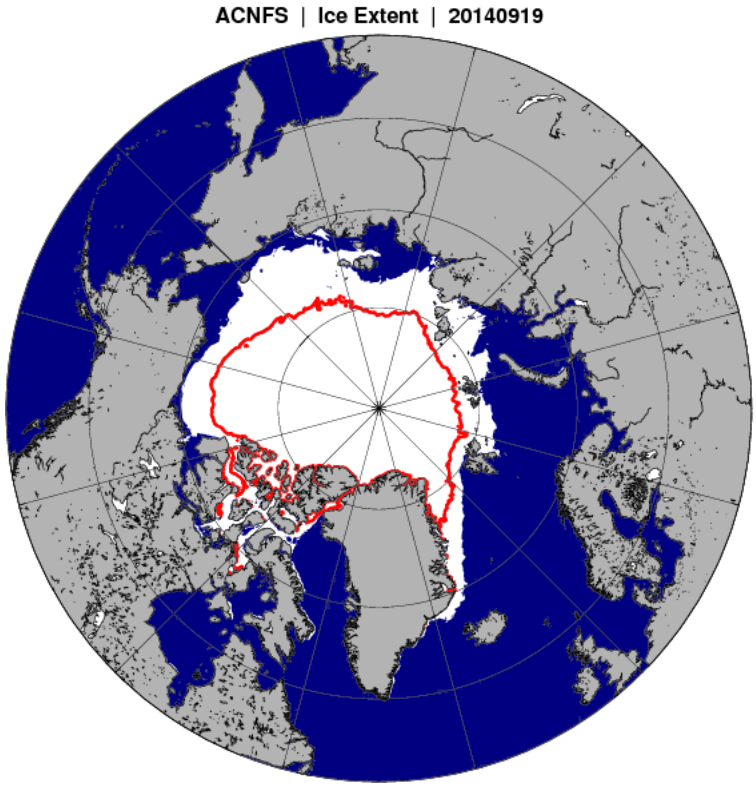

Figure 4: Spatial forecast map from the ACNFS ensemble September mean ice extent prediction for 19 Sept 2014. White area indicates ice concentrations > 15% in the unbiased simulation. The red line represents the bias-corrected predicted ice extent of 4.2 Mkm^2.

References

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