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

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Executive Summary

The Arctic Cap Nowcast Forecast System (ACNFS) was run in forward mode without assimilation, initialized with a July 1, 2014 analysis, for ten simulations using archived Navy atmospheric forcing fields from 2004-2013. The mean minimum ice extent in September, averaged across all ensemble members and corrected for forward model bias, is our projected ice extent. The ACNFS outlook for September minimum ice extent is 4.1 Mkm^2 ± 0.4 Mkm^2.

Rationale

The Arctic Cap Nowcast Forecast System (ACNFS) was run in forward mode without assimilation, initialized with a July 1, 2014 analysis, for ten simulations using archived Navy atmospheric forcing fields from 2004-2013. The mean minimum ice extent in September, averaged across all ensemble members and corrected for forward model bias is our projected ice extent. The standard deviation across the ensemble ice extents is an estimate of the uncertainty of our projection given the unknown 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 is a coupled ice-ocean model that assimilates passive microwave ice concentration daily and is run with a horizontal resolution of approximately 3.5 km near the North Pole. It

was developed by the Oceanography Division of the Naval Research Laboratory to produce 7 day forecasts of the Arctic sea ice states. This system is operational at the Naval Oceanographic Office. The system is configured and validated for its 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.

For the August report, NRL is submitting two minimum September ice extents to the Sea Ice Outlook; one estimate from Global Ocean Forecast System (GOFS) 3.1 and one from ACNFS.

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 (Cummings and Smedstad, 2013). The system is run once per day, assimilating SSMIS ice concentration into CICE to provide an initial condition for a 7 day forward model run (the forecast). Atmospheric forcing for all the ensemble members used in the minimum estimate 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. Ten model runs were made using NOGAPS forcing from 2004-2013. Each model run was initialized with the same assimilative analysis field from July 1, 2014 (Fig. 1), and run forward for 3 months from this initial state for each specific year.

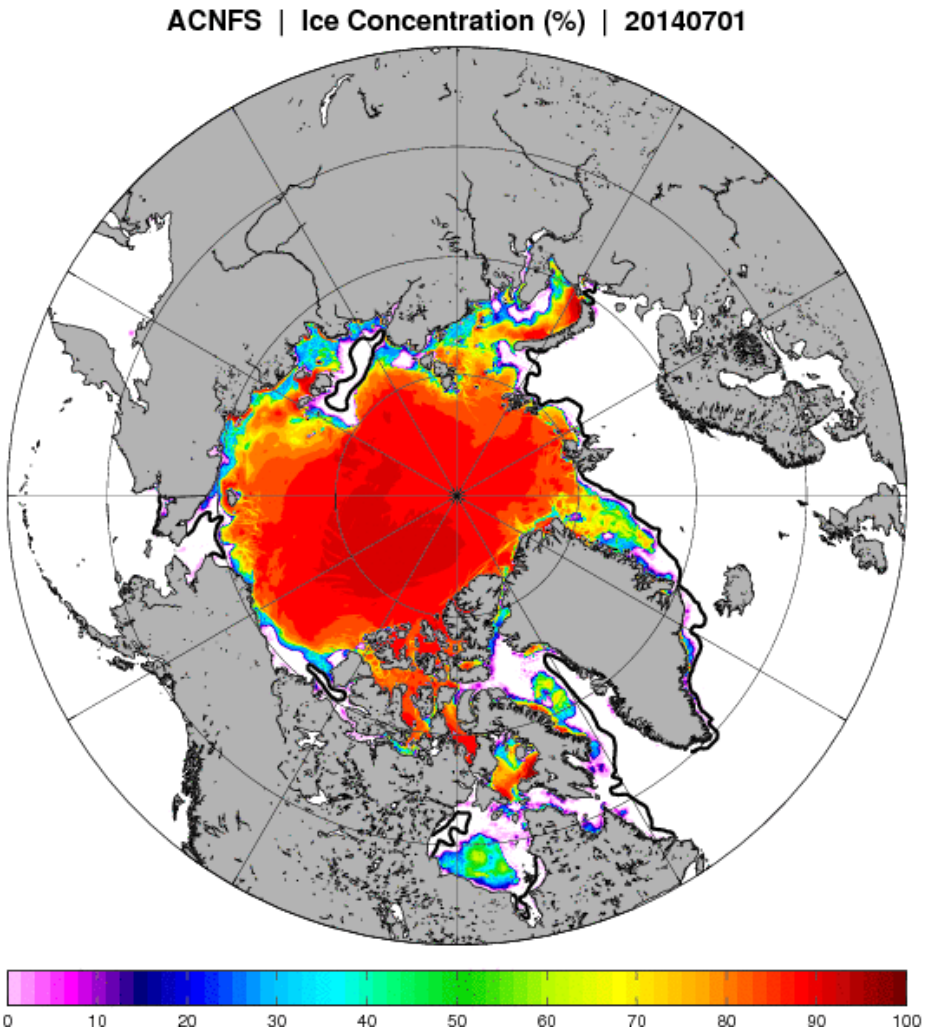

Figure 1: Ice concentration field (%), from ACNFS valid July 1, 2014. This is the initial condition for each ensemble member. The black line on the figure represents the independent ice edge provided in real time by the National Ice Center.

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

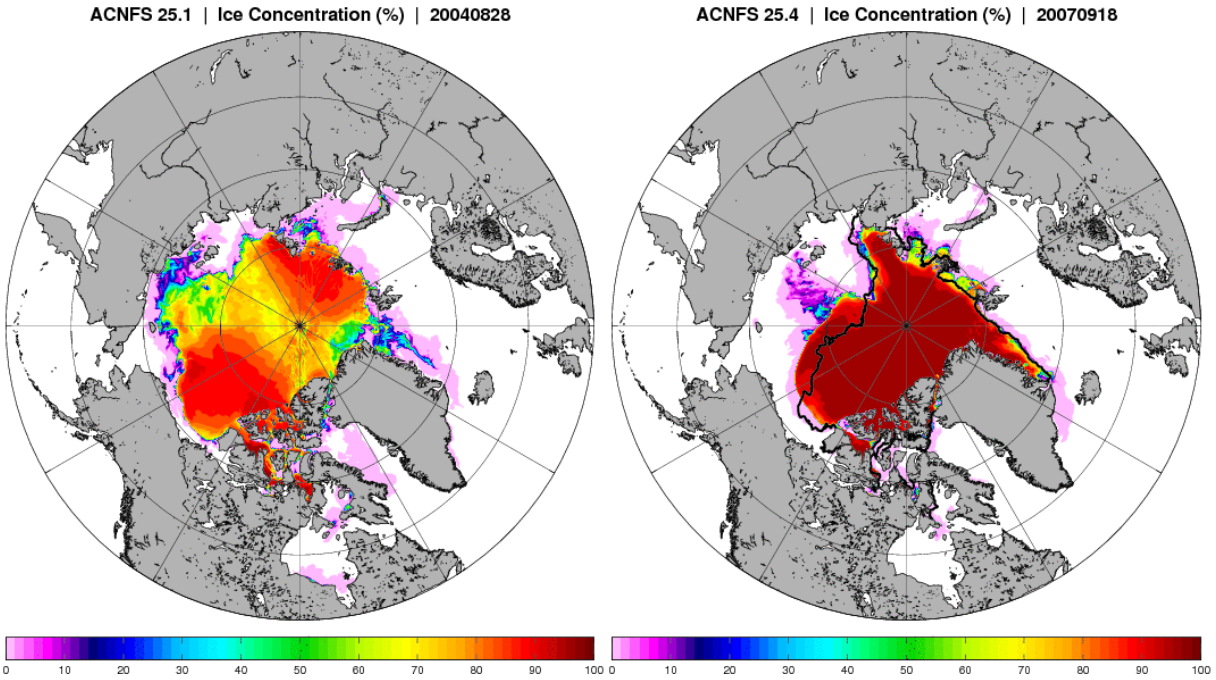

Figure 2: ACNFS ice concentration (%) on August 28, 2004 (left) and September 18, 2007 (right). The black line on the figure (on right) represents the independent ice edge provided in real time by the National Ice Center. These two simulations have the largest and smallest projected minimum ice extents out of the ten ensemble members, respectively.

Ice extent was calculated using all grid cells with at least 15% ice concentration. Averaging the September minimum extent from each ensemble member yields a minimum extent of 5.9 Mkm^2, with a standard deviation of 0.4 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. 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 2013 were performed using the July 1 analysis for initial conditions. Comparing the mean September extent from the control runs to that of the assimilative ACNFS analyses, an estimate of the forward model bias is -1.8 Mkm^2. This bias is higher than that of the NRL GOFS 3.1 system because of these differences: 1) the GOFS hindcast started from more realistic initial conditions (primarily a better ice thickness) than ACNFS, 2) GOFS assimilates ice concentration data across the full Arctic domain (not just along the ice edge as in ACNFS), 3) GOFS uses an up-to-date and improved version of the ocean model code, and 4) GOFS applies a monthly varying heat flux offset to CICE in an attempt to improve ice forecast

skill. As seen in Fig. 3, there is a spread in September minimum extent among the bias-corrected ensemble members. The mean of these values, 4.1 ± 0.4 Mkm^2, represents the projected minimum ice extent for September 2014.

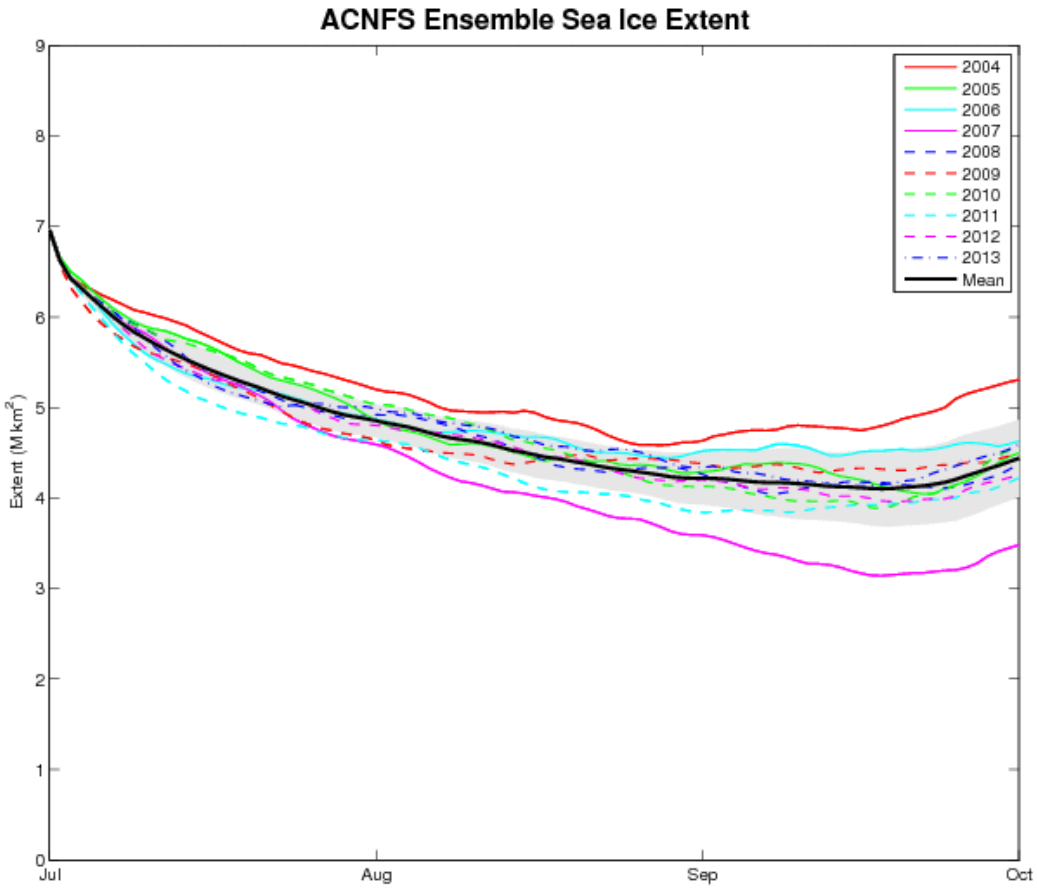

Figure 3: Time series of bias-corrected ice extent for each ensemble member. Black line represents the ensemble mean ice extent with the predicted September minimum of 4.1 ± 0.4 Mkm^2. The shaded area (± 1 standard deviation) denotes the variability during the June-Sept time period.

Also included (Fig. 4) is the spatial forecast map for the predicted minimum ice extent from ACNFS valid 18 September 2014.

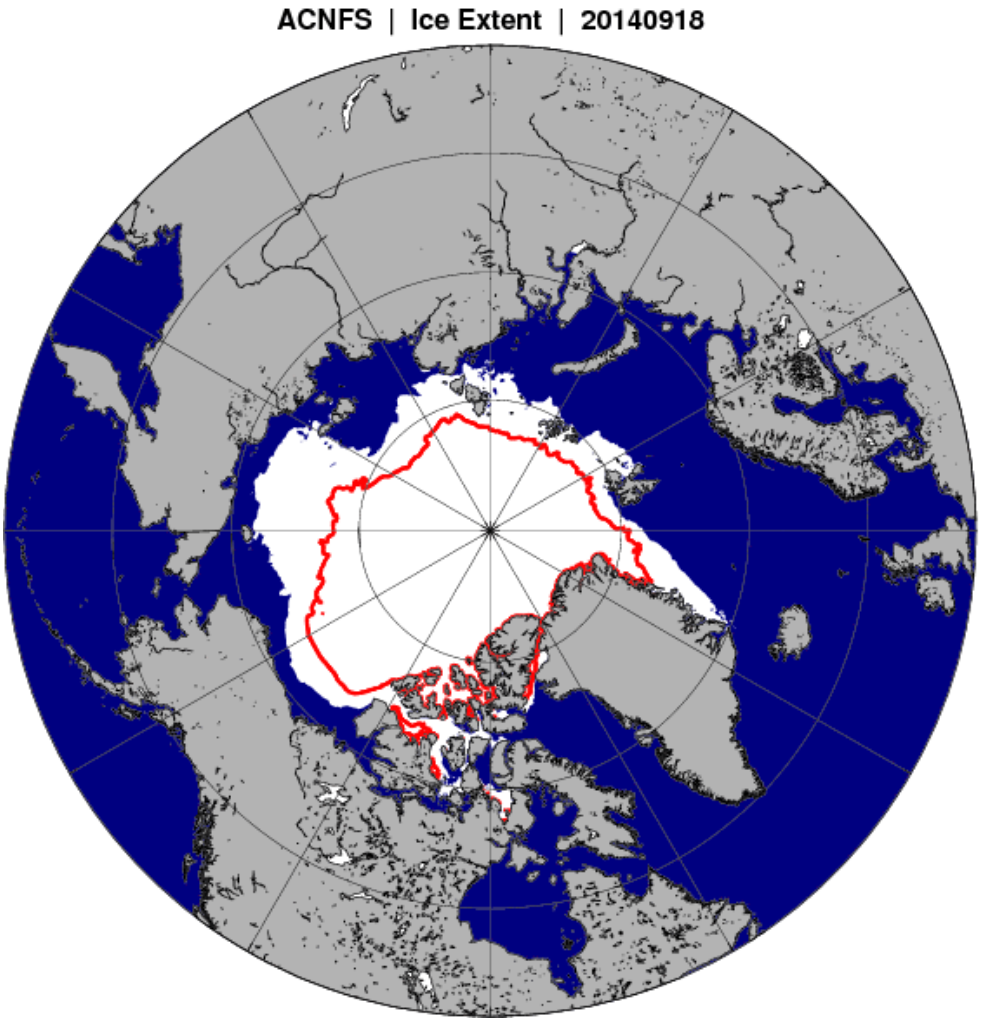

Figure 4: Spatial forecast map of the projected ACNFS September minimum ice extent for 18 Sept 2014. White area indicates ice concentrations > 15% in the uncorrected simulation. The red line represents the bias-corrected predicted ice extent of 4.1 Mkm^2. This represents the 79% concentration isoline.

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