

**September 2016 sea ice outlook (from June 1, 2016):
Pan-arctic and all Arctic regions**

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Yes, use this contribution for all of the 2016 SIO reports.

Prediction type: Dynamic model: **Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS)**, Zhang and Rothrock, 2003), with coupled sea ice and ocean model components. The ocean model is the POP (Parallel Ocean Program) model and sea ice model is the TED (Thickness and Enthalpy Distribution) model. Atmospheric forcing is from the NCEP Climate Forecast System (CFS) version 2 (Saha et al., 2014) hindcast and forecast.

Pan-arctic outlook: The September 2016 Arctic sea ice extent predicted from June 1, 2016 is **4.2 ± 0.6 million square kilometers**.

Outlook of all Arctic regions: The September 2016 Arctic sea ice thickness field and ice edge location are predicted and presented here (Figure 1).

Method: These results are obtained from a numerical seasonal forecasting system. The forecasting system is based on a synthesis of PIOMAS, the NCEP CFS hindcast and forecast atmospheric forcing, and satellite observations of ice concentration. The CFS forecast ranges from hours to months: there are a total of 16 CFS forecast runs every day, of which four runs go out to 9 months, three runs go out to 1 season, and nine runs go out to 45 days (Saha et al., 2014). These runs all create 6-hourly forecast atmospheric data that are widely accessible in real time, thus ideal for forcing PIOMAS forecasts on daily to seasonal time scales. To obtain the “best possible” initial ice-ocean conditions for the forecast, we conducted a retrospective simulation that assimilates satellite ice concentration and sea surface temperature data through the end of May 2016 using the CFS hindcast forcing data. The model was then integrated forward to generate a PIOMAS prediction for September 2016 by using a single CFS forecast to drive the ice-ocean model. Future outlooks may use an ensemble of forecasts from the CFS. More details about PIOMAS prediction can be found in Zhang et al. (2008).

Uncertainty for pan-Arctic extent: The uncertainty of the predicted September 2016 Arctic sea ice extent is **± 0.6 million square kilometers** based on past ensemble forecasts. In the future, we will conduct CFS-driven ensemble forecasts and estimate uncertainties from the ensemble.

Executive summary: Driven by the NCEP CFS forecast atmospheric forcing, PIOMAS is used to predict the total September 2016 Arctic sea ice extent as well as ice thickness field and ice edge location, starting on June 1. The predicted September ice extent is **4.2± 0.6 million square kilometers**. The predicted ice thickness fields and ice edge locations for June–August 2016 are also presented.

Data used:

NCEP CFS hindcast and forecast atmospheric data for forcing.
Satellite sea ice concentration data (NASA team) for data assimilation.

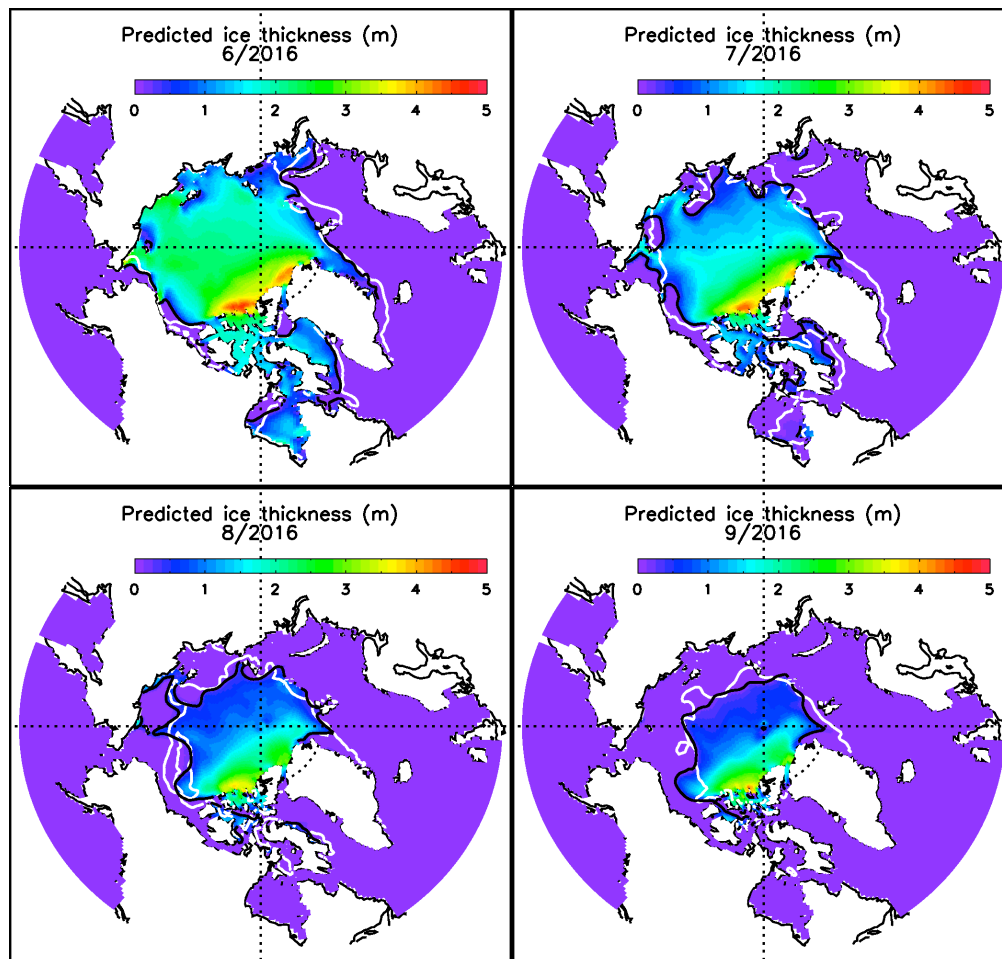


Figure 1. PIOMAS predicted Arctic sea ice thickness for June–September 2016. The white line represents satellite-observed 2015 monthly mean ice edge defined as the contour of 0.15 ice concentration, while the black line is the model predicted 2016 monthly mean ice edge.

References:

- Saha, S., and others, The NCEP climate forecast system version 2, *J. Climate*, 27, 2185–2208, 2014.
- Zhang, J., and D.A. Rothrock: [Modeling global sea ice with a thickness and enthalpy distribution model in generalized curvilinear coordinates](#), *Mon. Wea. Rev.*, 131(5), 681–697, 2003.
- Zhang, J., M. Steele, R.W. Lindsay, A. Schweiger, and J. Morison, [Ensemble one-year predictions of arctic sea ice for the spring and summer of 2008](#). *Geophys. Res. Lett.*, 35, L08502, doi:10.1029/2008GL033244, 2008.