

**September 2014 sea ice outlook (from June 1, 2014):
Pan-arctic and all Arctic regions**

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Prediction type: Model – Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS, Zhang and Rothrock, 2003), with coupled sea ice and ocean components.

Pan-arctic outlook: The September 2014 Arctic sea ice extent predicted from June 1, 2014 is **4.6 ± 0.6 million square kilometers**.

All Arctic regions: The September 2014 Arctic sea ice thickness field and ice edge location are predicted and presented here (Figure 1).

Method: These results are obtained from a numerical ensemble seasonal forecasting system. The forecasting system is based on a synthesis of PIOMAS, the NCEP/NCAR reanalysis data, and satellite observations of ice concentration and sea surface temperature. The ensemble consists of seven members each of which uses a unique set of NCEP/NCAR atmospheric forcing fields from recent years, representing recent climate, such that ensemble member 1 uses 2007 NCEP/NCAR forcing, member 2 uses 2008 forcing ..., and member 7 uses 2013 forcing. These seven years of the reanalysis atmospheric forcing fields are used to represent the climate variability expected for 2014. Each ensemble prediction starts with the same initial ice–ocean conditions on 1 June 2014. To obtain the “best possible” initial ice-ocean conditions for the forecasts, we conducted a retrospective simulation that assimilates satellite ice concentration and sea surface temperature data through the end of May using reanalysis forcing data from this year. More details about the ensemble prediction procedure can be found in Zhang et al. (2008).

In addition, sea ice thickness data from the NASA mission Operation IceBridge (data courtesy of Nathan Kurtz) were used to correct the PIOMAS sea ice thickness distribution estimates. The data were collected between 12 March and 3 April across broad regions of the Beaufort and Chukchi seas and the Canadian Basin. The point data were clustered into 50-km averages and thickness distributions. The distributions were then merged with the PIOMAS estimates for 1 April 2014 using optimal interpolation (Lindsay et al, 2012). The model was then integrated from 1 April to 1 June using the reanalysis data from April and May of this year and then integrated from 1 June through 31 October 2014 using reanalysis data from the last seven summers to create the ensemble of predictions. The reported ice extent is the median of the estimates of the September mean extent.

Uncertainty: The uncertainty of the predicted September 2014 Arctic sea ice extent is ± **0.6 million square kilometers** and the uncertainty of the predicted ice thickness field is reflected in the ensemble standard deviation (SD) of ice thickness field (Figure 1b). These uncertainties are derived from the 7 prediction ensemble members.

Executive summary: Our seasonal prediction focuses not only on the total Arctic sea ice extent, but also on sea ice thickness field and ice edge location. We feel that, for all practical and scientific reasons, it is particularly important to improve our ability to predict the ice thickness and the ice edge. Needless to say, this is a difficult goal. However, we hope that our effort would contribute to this goal.

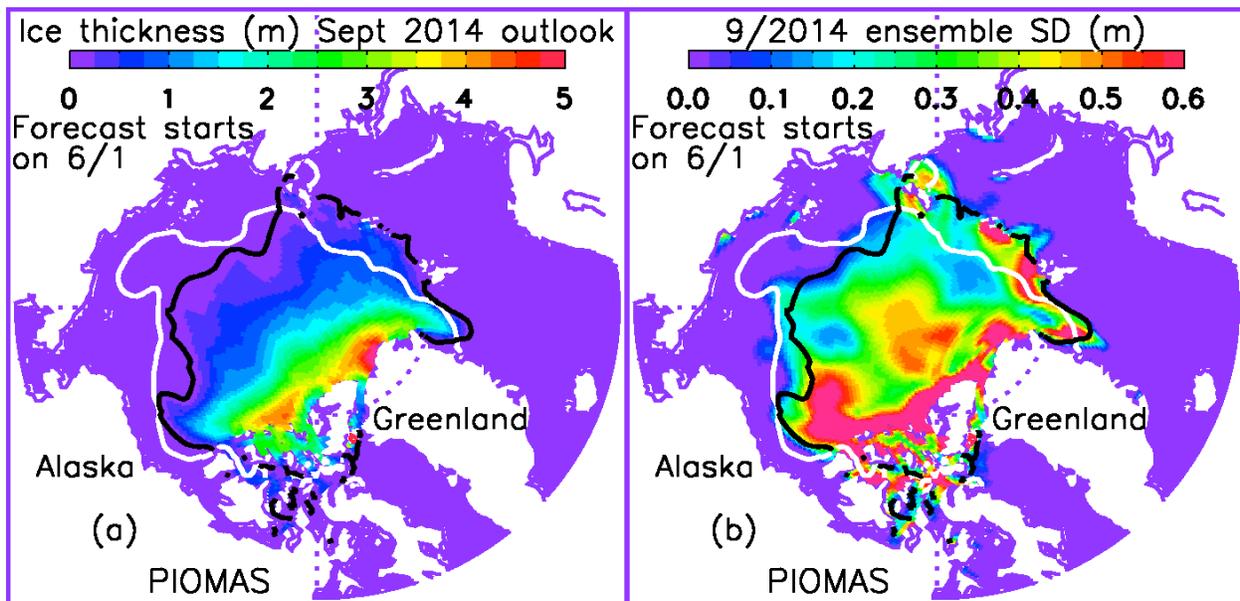


Figure 1. (a) Ensemble median prediction of September 2014 mean sea ice thickness and edge location, and (b) ensemble standard deviation (SD) of ice thickness which shows the uncertainty of the prediction. The white line represents the satellite-observed mean September 2013 ice edge defined as the line of 0.15 ice concentration, while the black line is the model predicted September 2014 ice edge.

References:

Lindsay, R., C. Haas, S. Hendricks, P. Hunkeler, N. Kurtz, J. Paden, B. Panzer, J. Sonntag, J. Yungel, and J. Zhang, Seasonal forecasts of Arctic sea ice initialized with observations of ice thickness, *Geophys. Res. Lett.*, 39, L21502, doi:10.1029/2010GL053576, 2012.

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.