1. *Name of Contributor or name of Contributing Organization and associated contributors as you would like your contribution to be labeled in the report (e.g., Smith, or ARCUS (Wiggins et al.)).

   RASM (Kamal et al.)

   Regional Arctic System Model (RASM) - NPS Research Group:
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2. * Contributions submitted by a person or group not affiliated with a research organization, please self-identify here:

   None

3. * Do you want your contribution to be included in subsequent reports in the 2016 season?

   No, we plan to submit a separate contribution for the subsequent August report.

4. *"Executive summary" of your Outlook contribution: in a few sentences (using 300 words or less) describe how and why your contribution was formulated. To the extent possible, use non-technical language.

   We used the Regional Arctic System Model (RASM), which is a limited-area, fully coupled climate model consisting of the Weather Research and Forecasting (WRF) model, Los Alamos National Laboratory (LANL) Parallel Ocean Program (POP) and Sea Ice Model (CICE) and the Variable Infiltration Capacity (VIC) land hydrology model (Maslowski et al. 2012; Roberts et al. 2014; DuVivier et al. 2015; Hamman et al. 2016). WRF and VIC are configured on a polar stereographic grid, using the same grid at 50-km resolution, and POP and CICE sharing a rotated spherical grid at $1/12^{o}$ (~9 km). In this contribution we present the results of a 3-member ensemble.
   The three ensemble members (EM) were initialized 12 hours apart, starting on July 1 at 0000 (#1), then at 1200 (#2) and on July 2 at 0000 (#3), using the NCEP version 2 Coupled Forecast System model (CFSv2) seasonal forecast output through September. The National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR) data were used for atmospheric forcing along WRF lateral boundaries from 1979 until the respective initialization date and time. In addition, planetary-scale temperature and wind fields were spectrally nudged beginning ~500 hPA with a strength of zero and linearly ramped up to 0.0003 s^{-1} at the top of the atmosphere, to constrain the large-scale circulation but still allow for free evolution of the boundary layer states. Raw model sea ice concentration data was processed using a simple linear regression model and satellite derived ice extent to produce bias corrected predictions. For all the ensemble members, we used one regression model using 27 years of past model data and NSIDC Merged SMMR and SSM/I sea ice concentration data to estimate and correct for systematic model bias.

5. *Type of Outlook method:

Dynamic with statistical model bias correction

6. *Dataset of initial Sea Ice Concentration (SIC) used (include name and date; e.g., "NASA Team, June 2016"):

   RASM-produced from the hindcast of model simulation from 1979 through June 2016 forced with CFSR renalaysis.

7. Dataset of initial Sea Ice Thickness (SIT) used (include name and date):

   Same as in #6.

   8. a) Model name: Regional Arctic Climate Model (RASM)

   b) Information about components

Component	Name	Initialization (e.g., describe Data Assimilation)
Atmosphere	WRF	CFSR
Ocean	POP	self-produced after 1979-2016 (June) hindcast
Ice	CICE	self-produced after 1979-2016 (June) hindcast
Hydrology	VIC&RVIC	self-produced after 1979-2016 (June) hindcast

   c) Number of ensemble members and how they are generated:
   Our ensemble has 3 members. The following table summarizes the data used and results of each one of the ensemble members.

	CFSR till	CFSv2 initialized on	Daily min	date of min	Monthly min
EM# 1	07-01-2016 00:00	07-01-2016 00:00	3.29 Mln km^2	Sept 13	3.47
EM# 2	07-01-2016 12:00	07-01-2016 12:00	3.41 Mln km^2	Sept 13	3.52
EM# 3	07-02-2016 00:00	07-02-2016 00:00	3.78 Mln km^2	Sept 16	3.85

Mean of daily minima	-	3.49 Mln km^2
Mean of monthly minima	-	3.61 Mln km^2

   9. Prediction of September's pan-Arctic extent as monthly average:

   Our prediction for September is 3.61 ± 0.5 million square kilometers

   10. Prediction of the week that the minimum daily extent will occur (expressed in date format for the first day of week, taking Sunday as the start of the week (e.g., week of 4 September)

   For all ensemble members, the minimum sea ice extent happened between Sept 13th and 16th

   11.*Short explanation of Outlook method (using 300 words or less)

   Sea ice extent (i) monthly average annual cycle was calculated for 1988-2014 and (ii) trend for 1996-2014 both from RASM simulation and from NSIDC Merged SMMR and SSM/I sea ice

concentration data. Three independent ensemble members were run by invoking 3 different CFSv2 forecasts, initialized 12 hours apart of each other.
All 3 EMs share the data from 1979 to 2014, so one statistical model was used. Model residual monthly ice extents were calculated by removing model monthly average annual cycle and model linear trend. These residuals only carry information about the model hindcast or predicted inter-annual variability. To correct for the known model biases we added to these model residuals the observed monthly average annual cycle and observed linear trend to estimate biases corrected monthly ice extents from 1996 through September 2016. Bias between the observed values and those from RASM after statistical correction from 1996 to 2014 is trendless and is used to estimate uncertainty in the September 2016 prediction.

12. If available from your method for pan-Arctic extent prediction, please provide:

a) Uncertainty/probability estimate such as median, ranges, and/or standard deviations (specify what you are providing).

To estimate uncertainty, we had two options

1- Use the standard deviation of the September model bias which is ~0.5 million square kilometer
2- The standard deviation of the sea ice extent from the 3 ensembles which is ~0.20 million square kilometers.

We define the standard deviation based on the first option as the second option would be based on a small sample.

b) Brief explanation/assessment of basis for the uncertainty estimate (1-2 sentences).

c) Brief description of any post processing you have done (1-2 sentences).

d) Raw (and/or post processed) forecasts for this year and retrospective forecasts in an excel spreadsheet with one year on each row and ensemble member number on columns (specifying whether raw or post processed)

References

DuVivier, A.K., J. Cassano, A. Craig, J. Hamman, W. Maslowski, B. Nijssen, R. Osinski, and A. Roberts, 2016: Winter atmospheric buoyancy forcing and oceanic response during strong wind events around southeastern Greenland in the Regional Arctic System Model (RASM) for 1990-2010. *Journal of Climate*,doi:10.1175/JCLI-D-15-0592.1.

Hamman, J., B. Nijssen, M. Brunke, J. Cassano, A. Craig, A. DuVivier, M. Hughes, D.P. Lettenmaier, W. Maslowski, R. Osinski, A. Roberts, and X. Zeng, 2016: Land surface climate in the Regional Arctic System Model. *Journal of Climate*, accepted.

Maslowski, W., J. Clement Kinney, M. Higgins, and A. Roberts, 2012: The Future of Arctic Sea Ice. *Ann. Rev. Earth Plant. Sci.* Vol. 40: 625-654, DOI: 10.1146/annurev-earth-042711-105345.

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