SEA ICE OUTLOOK
2016 Report

Template with Core Requirements for Pan-Arctic Contributions and Guidelines for Submitting Optional Alaskan Regional Outlook, Figures, and Gridded Data

Submission Guidelines:

The submission deadline is 6:00 pm (AKDT) Monday, 8 JAugust 2016 (firm) and all submissions should be sent to sio2016@arcus.org. Contributions received after the deadline will be posted to the website but not incorporated into the Outlook report or discussion.

Questions may be directed to Betsy Turner-Bogren, ARCUS (betsy@arcus.org)

Core Requirements for Pan-Arctic Contributions:

* REQUIRED

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.)).

   BSC-ES (Fučkar et al.)

1b. (Optional but helpful for us): Primary contact if other than lead author; name and organization for all contributors; total number of people who may have contributed to your Outlook, even if not included on the author list.

Neven S. Fučkar, Earth Sciences Department, Barcelona Supercomputing Center, Barcelona, Spain (neven.fuckar@bcs.es, nevensf@gmail.com) - lead author
François Massonnet, Earth Sciences Department, BSC, Barcelona, Spain
Virginie Guemas, Earth Sciences Department, BSC, Barcelona, Spain
Martin Menegoz, Earth Sciences Department, BSC, Barcelona, Spain
Francisco J. Doblas-Reyes, Earth Sciences Department, BSC, Barcelona, Spain

2. * Contributions submitted by a person or group not affiliated with a research organization, please self-identify here:
   _____ Yes, this contribution is from "Citizen Scientists."

3. * Do you want your contribution to be included in subsequent reports in the 2016 season?
   ____X___ Yes, use this contribution for all of the 2016 SIO reports (this contribution will be superseded if you submit a later one).
   _____ No, I/we plan to submit separate contributions for subsequent reports.
   _____ No, I only want to participate this time.

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 produced September 2016 forecast of Arctic sea ice conditions using coupled climate model (EC-Earth2.3) initialized on May 1st, 2016. This state-of-the-art coupled general circulation model includes dynamic-thermodynamics model of sea ice, LIM2, embedded in NEMO2 ocean model with horizontal resolution of about 1 degree (ORCA1L42). We employ dynamical models for seasonal forecast because they have capability to resolve and predict details of sea ice cover in non-stationary and physically consistent manner.

5. *Type of Outlook method:
_X__dynamic model ___statistical ___heuristic ____mixed or other (specify)

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

SIC from sea ice reconstruction method using ERA-Interim surface forcing fields as described in Guemas V, Doblas-Reyes FJ, Mogensen K, Tang Y, Keeley S (2014) Ensemble of sea ice initial conditions for interannual climate predictions. Clim Dyn. doi:10.1007/s00382-014-2095-7

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

SIT from sea ice reconstruction method described in Guemas et al. (2014)

8. If you use a dynamical model, please specify:

a) Model name: EC-Earth2.3

b) Information about components, for example:

Component	Name	Initialization (e.g., describe Data Assimilation)
Atmosphere	IFS	IC based on ERA-Interim
Ocean	NEMO2	ORAS4 IC
Ice	LIM2	IC produced as described in Guemas et al. (2014)

c) Number of ensemble members and how they are generated: 19

Using 5 ensemble members of ORAS4 ocean reanalysis and 5 associated ensemble members of sea ice reconstruction (using ERA-Interim) as described in Guemas te al. (2014). We used five atmospheric IC based on ERA-Interim on selected May 1st in the first decade of 21st century: 2001, 2004, 2007 and 2010, so that each ocean and sea ice IC is coupled with atmospheric IC from 4 different years (and 1 ensemble member did not complete run).

d) For models lacking an atmosphere or ocean component, please describe the forcing:

9. *Prediction of September pan-Arctic extent as monthly average in million square kilometers. (To be consistent with the validating sea ice extent index from NSIDC, if possible, please first

compute the average sea ice concentration for the month and then compute the extent as the sum of cell areas > 15%.)

Dynamical forecast (with 19 ensemble members) empirically adjusted with the quadratic bias correction method across start years using 1979-2011 hindcast archive of the same coupled forecast system initialized on May 1st and NSIDC NASA sea ice extent over the same period:

Mean of SIE = 4.72 M km^2, Median of SIE = 4.78 M m^2

(Just for additional record - raw dynamical forecast without any bias correction: Mean of SIE = 5.57 M km^2, Median of SIE = 5.53 M km^2)

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).

11. *Short explanation of Outlook method (using 300 words or less). In addition, we encourage you to submit a more detailed Outlook, including discussions of uncertainties/probabilities, including any relevant figures, imagery, and references.

First we used ocean-sea-ice NEMO2-LIM2 setup forced by the ERA-Interim surface fields with ocean nudged to ORAS4 5-member reanalysis (by restoring temperature and salinity to reanalyzed data) to produce 5 members of sea ice initial conditions (IC) on May 1st, 2016, as described in Guemas et al. (2014). These five sea-ice IC along with five associated ORAS4 oceanic IC were used to initialize seasonal forecast with the state-of-the-art coupled climate model EC-Eath2.3 on 05/01/2016. Due to some unforeseen technical issues we were not in position to obtain 05/01/2016 atmospheric IC before the submission deadline for this call, so we used five atmospheric IC on selected May 1st in the first decade of 21st century: 2001, 2004, 2007 and 2010, so that each ocean and sea ice IC is coupled with atmospheric IC from 4 different years. Finally, we produced 19-member forecast of Arctic sea ice concentration and extent in September of 2016 on time to be submitted for this SIPN SIO call for August 2016. EC-Earth2.3 seasonal forecast system has significantly different long-term tendency in the Arctic sea ice from the observed one, with a hint of nonlinear behavior, hence we applied a quadratic bias correction method with respect to start years (where a quadratic background fit of model results is subtracted and replaced by a quadratic background fit of observations).

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).

Dynamical forecast (with 19 ensemble members) adjusted with a quadratic bias correction method in forecast years using 1979-2011 hindcast archive of the same forecast system initialized on May 1st and NSIDC NASA Team sea ice extent over the same period:

Standard Deviation of SIE = 0.47 M km^2, Quartiles of SIE = {4.40, 4.78, 4.98} M km^2 => IQR = 0.58 M km^2

(Just for additional record - raw dynamical forecast without any bias correction: Standard Deviation of SIE = 0.44 M km^2, Quartiles of SIE = {5.19, 5.53, 5.93} M km^2 => IQR = 0.74

M km^2)

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

Standard deviation and interquartile range (IQR) of this ensemble forecast primarily stem from differences in 5 members of reconstructed sea ice IC (HistERAnudg: Guemas et al., 2014), and 5 members of ECMWF ORAS4 oceanic IC, combined with 5 members of atmospheric IC in 2001 and 2004 (two years with September SIE above trend time), and 2007 and 2010 (two year with September SIE below trend line).

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

Dynamical forecast is empirically adjusted with a quadratic bias correction method in forecast years (conceptually equivalent to trend bias correction method, but instead of 1st order polynomial fit in time we are using 2nd order polynomial fit) using 1979-2011 hindcast archive of the same forecast system initialized on May 1st and NSIDC NASA Team sea ice extent over the same period. Each of 5 different oceanic and associated sea ice IC conditions are combined with 4 different atmospheric IC.

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).

See BSC_contribution_sea_ice_outlook_2016_raw_hindcast_table.xlsx for raw 1979-2011 hindcast and raw 2016 forecast NH SIE values.

---------- no BSC input below this line

Submitting an Alaskan Regional Outlook (Optional, yet encouraged):

Please submit a total extent for the Alaskan region, defined here as the combination of the Bering, Chukchi, and Beaufort seas. If possible use the definition from the NSIDC Arctic sea ice regional graphs and time series from the mask below, which is on the 25km by 25km polar stereographic projection used for the passive microwave satellite data. The mask, provided as a netcdf file, is available on the SIPN Call for Sea Ice Contributions (https://www.arcus.org/sipn/sea-ice-outlook/2016/june/call). For questions about the format or this request, please contact Muyin Wang (muyin.wang@noaa.gov).

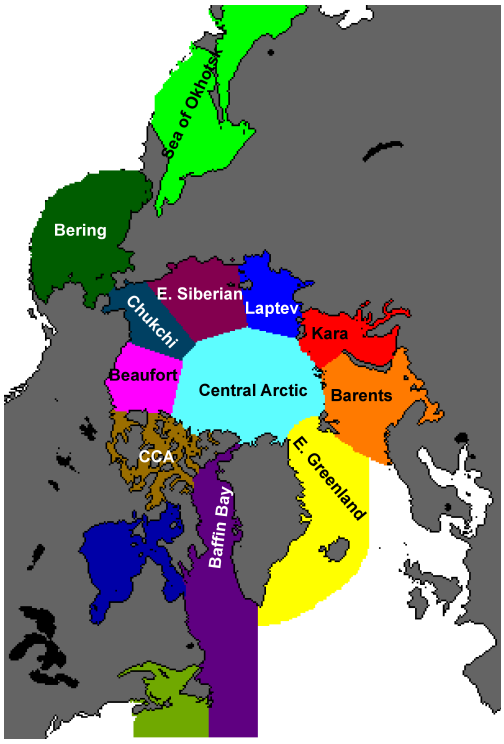
For your submission:

Provide responses for the Alaska Regions for items 9-12 from the pan-Arctic Outlook template above, and respond to items 13 and 14 below.

13) Tell us how you defined the region: either say NSIDC definition, or if you must use your own definition, describe it.

14) Tell us the maximum possible ice extent if every ocean cell in your region were ice covered. For example, if your model uses exactly the same grid as the satellite data, the area would be

4.00×10^6 km^2. The maximum possible extent is probably much larger than your actual Alaskan Regional Outlook. Be sure to exclude land and islands.



Submitting Figures and Gridded Data for Other Regional Contributions (Optional):

These are optional but strongly encouraged for all participants whose methods provide information at the local scale. If you cannot contribute now, please read on anyway so you can take steps to provide the information in the future.

Please contact Edward Blanchard-Wrigglesworth via email (ed@atmos.uw.edu) for questions and to arrange submission of your figures and/or data.

1. Provide a spatial forecast map for September mean ice extent (e.g., jpg, tiff, pdf). If your method predicts sea ice extent (SIE) directly, average it in time and across ensemble members, if you have them, for September (giving values between 0 and 100% inclusive). If your method predicts sea ice concentration (SIC) directly, please average it in time to make a monthly mean SIC, then convert it to SIE (grid cells with SIC<15% are assigned SIE=0% and SIC>=15% are assigned SIE=100%). Finally

average across ensemble members, if you have them. We refer to this field as a sea ice probability (SIP).

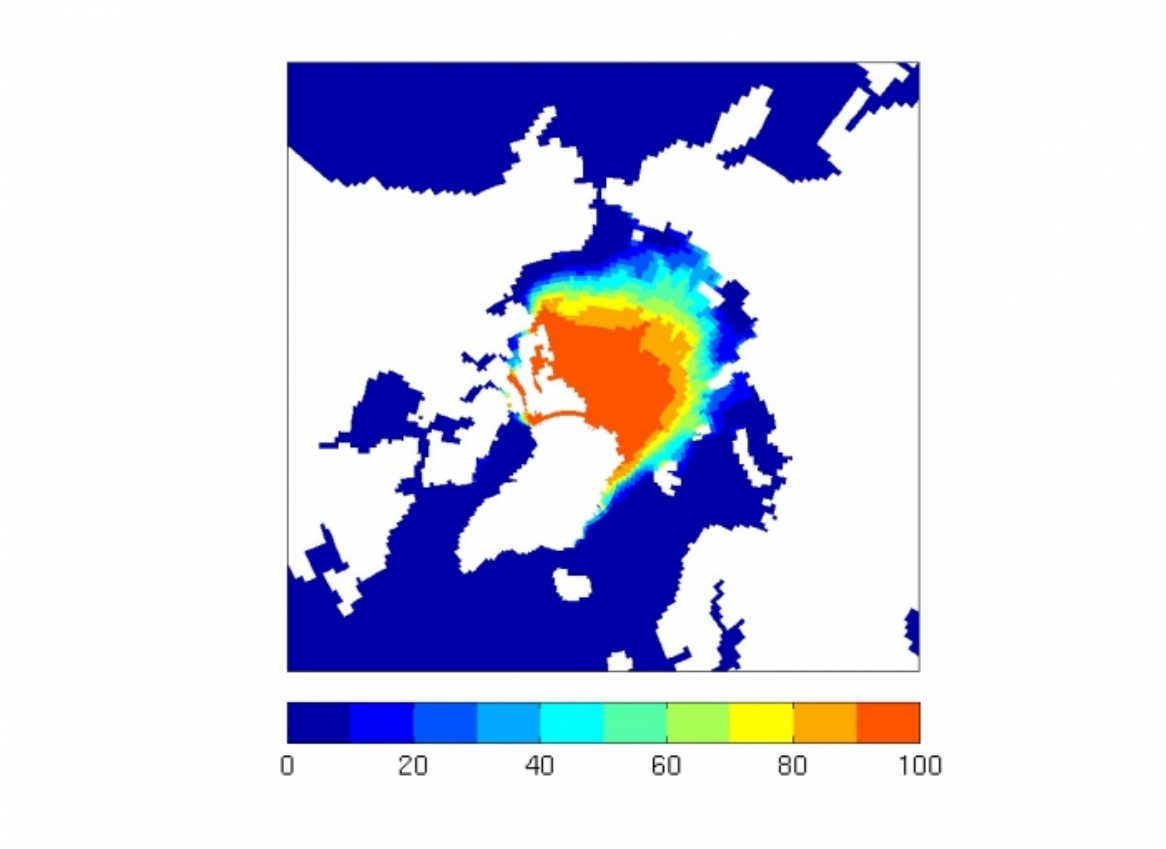


Figure above is sample of SIP (i.e., ensemble mean SIE) in percent for a random year from CESM1.1.

2. Provide a spatial map of the first ice-free date (IFD; Julian Day when SIC<15% or SIE=0%) in 2015. Ideally the date is derived from daily frequency output of SIC. For IFD, identify ocean (SIC<15% upon initialization) with the Julian day of the start date (July 1 is day 182) and ice points that always have SIC>15% with the end date (Sep 31 is day 273). Also provide a map of one standard deviation across ensemble members, if you have them.

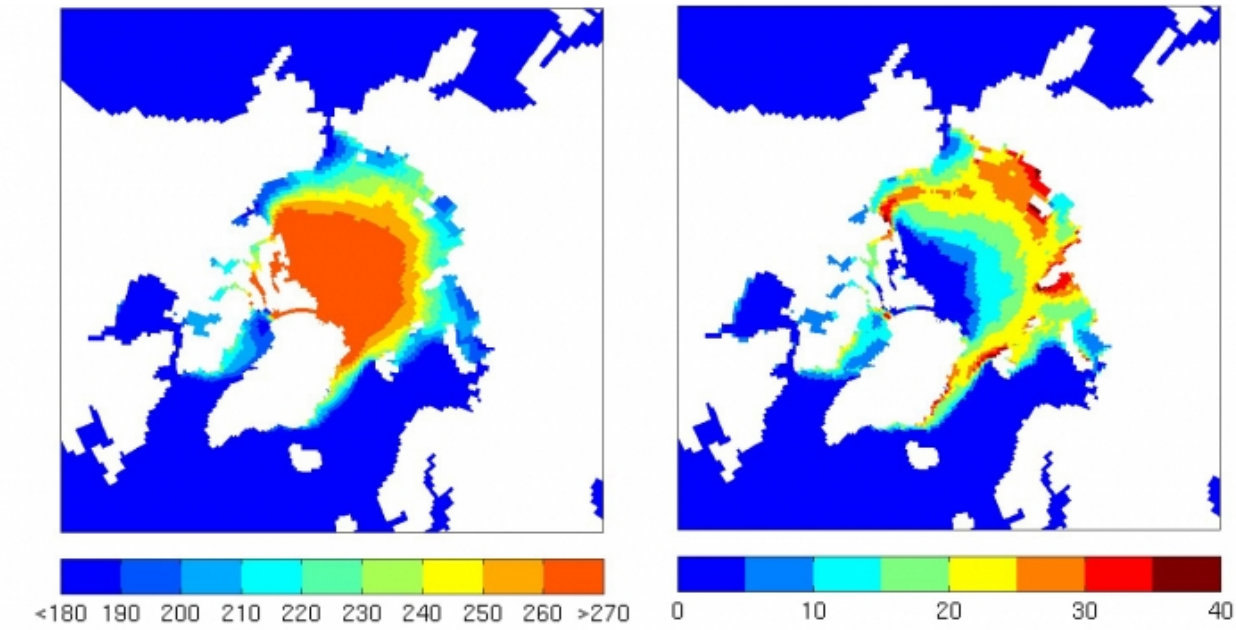


Figure on left: Sample of IFD (first ice free date as Julian Day) ensemble mean.
Figure on right: Sample std dev of IFD across the ensemble. Data are from a random year from CESM1.1.

Use the following naming convention for filenames (for example if your surname is Smith) and you are forecasting September 2016 using June initial data:
Smith_Sep2016_Junedata_SIP.jpg
Smith_Sep2016_Junedata_IFD.jpg
Smith_Sep2016_Junedata_stdIFD.jpg
Smith_Sep2016_Junedata_README.txt (explaining how you computed SIP and IFD, follow link for an example)

3. Provide your data for SIP and IFD (see maps in #1 and #2 above) in a format with geographic information included or in NetCDF, if possible. We will work with the format provided as long as all relevant grid/projection/data format information is provided.

   a) Provide the data on your native grid and, if possible, on a common 1-degree grid.

   b) Include latitude (lat) and longitude (lon) grid information in degrees, and for your native grid, include gridcell area (areacello) in square meters. For SIP and IFD, identify land points in your data field with the identifier -999. Include the std. dev. of IFD (stdIFD) in the same file with IFD.

   Note: If you must submit text, please use a column format in the order: lat, lon, areacello (for the file that is on your native grid), and finally the data field. Separate columns with spaces (preferred), commas, or tabs. Do not include any information such as variables names at the beginning. Provide that information in a separate metadata file with all the information needed to understand the file.

c) For the common grid, please include latitudes 60N, 61N, 62N … 89N and longitudes 180W, 179W, … 179E (or 0 to 360E). No need to include areacello for the common grid.

d) If you provide NetCDF files use the following naming convention (or as necessary for an equivalent set of GeoTIFF files) follow links for an example of each:
Smith_Sep2016_Junedata_SIP_native.nc
Smith_Sep2016_Junedata_IFD_native.nc
Smith_Sep2016_Junedata_SIP_common.nc
Smith_Sep2016_Junedata_IFD_common.nc

e) Or if you must use text, please provide all of the following files:
Smith_Sep2016_Junedata_SIP_native.txt
Smith_Sep2016_Junedata_SIP_native_meta.txt
Smith_Sep2016_Junedata_IFD_native.txt
Smith_Sep2016_Junedata_IFD_native_meta.txt
Smith_Sep2016_Junedata_SIP_common.txt
Smith_Sep2016_Junedata_SIP_common_meta.txt
Smith_Sep2016_Junedata_IFD_common.txt
Smith_Sep2016_Junedata_IFD_common_meta.txt

For questions, please contact Edward Blanchard-Wrigglesworth via email (ed@atmos.uw.edu)