CNRM pan-Arctic sea ice outlook for September 2016 sea ice extent initialized in early July

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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.)).

CNRM (Chevallier 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.

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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   _____x_____ Yes, use this contribution for all of the 2016 SIO reports (this contribution will be superseded if you submit a later one).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.

CNRM outlook is based on the operational seasonal forecast issued by Météo France in early July 2016 with the System 5 (component of the European multi-model EUROSIP). Mean September sea ice extent outlook is 4.39 Mkm^2 (ensemble mean of 51-member initialized during the 2 weeks before 1 July and perturbed using stochastic perturbations).

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"):

Initial conditions for the ocean and sea ice (concentration and thickness) are provided by Mercator Océan.
Basis is the Mercator Océan operational analysis, run at a 1/4° horizontal resolution using NEMO-LIM2 and the SAM ocean data assimilation system. There is no data assimilation of sea ice concentration in this analysis.

The 1/4° analysis is upscaled to the 1° horizontal grid of CNRM-CM. These fields are used to nudge the ocean-sea ice component of CNRM-CM (NEMO3.2-Gelato5, 1° resolution), run in forced mode (forced by ECMWF Op. analysis). A strong restoring is applied towards Mercator SST, which acts as a constraint on sea ice concentration. Sea ice fields (concentration, thickness…) from this 1° run are used to initialize CNRM-CM (as well as ocean fields from this run).

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

Sea ice thickness information is output from the 1° simulation described above.

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

a) Model name:
Météo France System 5

b) Information about components, for example:

Component	Name	Initialization (e.g., describe Data Assimilation)
Atmosphere	ARPEGE-Climat v6	ECMWF Operational Analysis
Ocean	NEMO3.2	Based on Mercator Op. Analysis (DA SEEK)
Ice	Gelato 5	Based on Mercator Op. Analysis (no DA)

Basis of System 5 is the global coupled model CNRM-CM5 (Voldoire et al., 2014).

Horizontal resolution of the atmosphere component is T255 (70km). Nominal resolution of the ocean-sea ice component is 1° at the equator (nearly 50km in the Arctic). The sea ice model uses 4 sea ice categories (0-0.3; 0.3-0.8, 0.8-3 and >3m).

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

51 members, lag average and stochastic physics (Batté and Déqué, 2016).

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%.)

The predicted September pan-Arctic extent is 4.39 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).

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.

The CNRM outlook is a model estimate based on a dynamical ensemble forecast. Initial conditions from the week before July 1 are used. We generate a total 51 members by adding statistical perturbations during the run.

Our system hindcast is done over the period 1993-2014, using the same techniques, yet with only 15 members. In the hindcast, correlation anomaly coefficient for detrended data is 0.61. Sea ice extent is generally underestimated, and the linear decreasing trend is too steep (see figure 1) : we used this information to correct both forecasts in 2015 and 2016 (see figure 2).

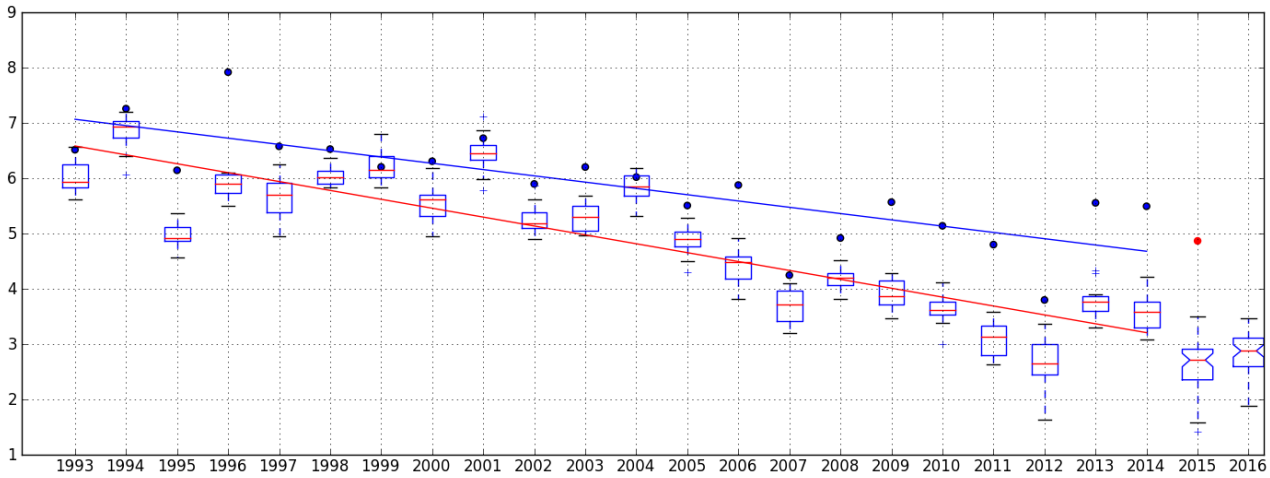

Figure 1 : September sea ice extent (SIC>15%). CNRM raw hindcast (1993-2014, boxplots) and raw forecasts (2015-2016, notched boxplots) initialized in early July. Red line is the linear trend for 1993-2014 hindcast. Blue/red dots are NSIDC estimates for observations, and blue line is the linear trend for observations.

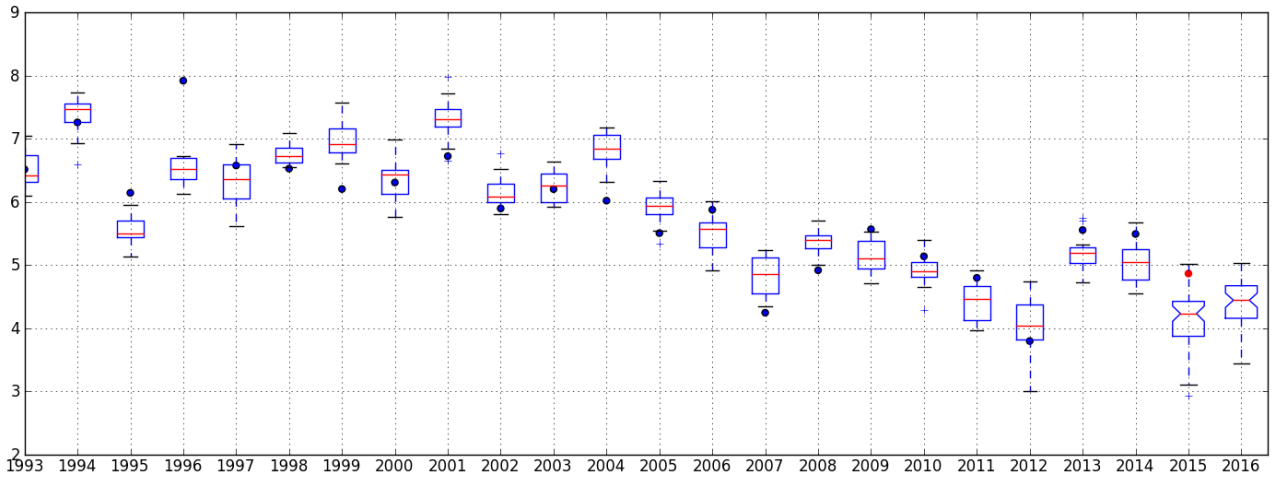

Figure 2 : September sea ice extent (SIC>15%) : CNRM re-calibrated hindcast (1993-2014, boxplots) and forecasts (2015-2016, notched boxplots) initialized in early July. Blue (1993-2014) and red (2015) dots denote observations (sources : NSIDC). Million km^2.

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).

Statistics from the 51-member ensemble are given below :
Min : 3.45 Mkm^2
25% : 4.17 Mkm^2
Median : 4.44 Mkm^2
75% : 4.67 Mkm^2
Max : 5.03 Mkm^2

Mean : 4.39 Mkm^2
IQR : 0.50 Mkm^2
STD : 0.37 Mkm^2

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).

The prediction is corrected using both mean bias and linear trend deduced from the hindcast over the period 1993-2014.

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:

Batté, L. and Déqué, M. (2016): Randomly correcting model errors in the ARPEGE-Climate v6.1 component of CNRM-CM: applications for seasonal forecasts, accepted for Geosci. Model Dev., doi:10.5194/gmd-2015-270

Voldoire, A., Sanchez-Gomez, E., Salas Y Mélia, D., Decharme, B., Cassou, C., Sénési, S., Valcke, S., Beau, I., Alias, A., Chevallier, M., Déqué, M., Deshayes, J., Douville, H., Fernandez, E., Madec, G., Maisonnave, E., Moine, M.-P., Planton, S., Saint-Martin, D., Szopa, S., Tyteca, S., Alkama, R., Belamari, S., Braun, A., Coquart, L. and Chauvin, F., 2013. The CNRM-CM5.1 global climate model : description and basic evaluation. *Climate Dynamics, Special Issue : IPSL-CM5 and CNRM-CM5*, **40(9-10)**, 2091-2121, doi :10.1007/s00382-011-1259-y.