September 2011 Sea Ice Outlook
August Report

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Caveat: This is an experimental projection and ***does not*** *represent an official UK Met Office forecast.*

1) Extent Projection

4.0 ± 1.2 million square kilometres (continued status quo from June Report)

2) Method/Techniques (Coupled Atmosphere-ice-ocean-land surface model ensemble runs)

This projection is an experimental prediction from the UK Met Office seasonal forecast system, GloSea4 (Arribas et al., 2011). GloSea4 is an ensemble prediction system using the HadGEM3 coupled climate model (Hewitt et al., 2011). A more complete description of the GloSea4 system can be found in the June report and accompanying references (http://www.arcus.org/files/search/sea-ice-outlook/2011/06 /pdf /pan-arctic/petersonetalpanarcticjune.pdf)

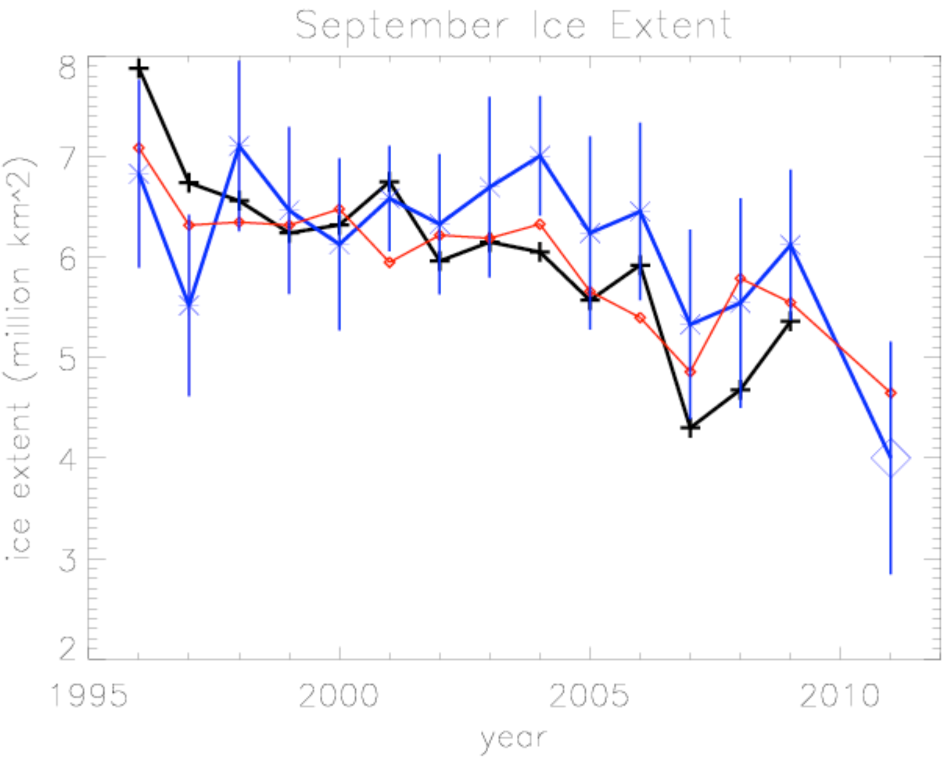

Figure 1: September Ice extent during the 1996-2009 hindcast, plus the 2011 forecast. The black line with + symbols is the observed ice extent as given by NSIDC, the blue line with the ∗ symbols culminating in the ◊ symbol are the GloSea4 hindcast and 2011 forecast values respectively (there is no 2010 hindcast). The red line is the July persistence forecast, again as derived from NSIDC July anomalies added to the NSIDC September climatology. The whiskers added to the GloSea forecast represent the variance of the ensemble members that constituted our forecast. This figure differs from the time series of September ice extents in our previous outlooks in that external NSIDC observations where added instead of using the GloSea4 analysis. Note that only two early years are outside the range of possibilities expressed through the various ensemble members during the hindcast.

3) Rationale

Our forecast of 4.0±1.2 million square kilometres was based on the seasonal forecast data for September 2011 from two forecasts of seven month length initiated each day between 21/03/2011 and 10/04/2011, for a total of 42 ensemble members. The hindcast dates used for calibration were initiated on 25/03, 01/04, and 09/04 of each of the hindcast years from 1996-2009, with three ensemble members generated per start date and a total of 9 per year. Our original June outlook used these late March and early April start dates, and we continue to base our September forecast on that set of forecasts, as subsequent start dates have less skill in their interannual variability as judged by the detrended correlations between the ice extent seen in the hindcast and those actually observed. We are actively investigating why this particular March start date has such good apparent skill, but suspect it may be due to a relationship between mean ice thickness during March and September ice extent (Stroeve et al, 2011). Conversely, why the subsequent forecasts suffer from a deteriorating skill is also of upmost importance to us, but undoubtedly relates to poorly initialized sea ice thicknesses coming out of the sea ice (concentration) and ocean analysis, particularly over the summer months. Figure 1 shows the 1996-2009 hindcast predictions plus the 2011 forecast for September ice extent along with observed values from National Snow and Ice Data Center (NSIDC; Fetterer et al). We have used the NSIDC values as the GloSea4 analysis appears to have a post 2008 bias in summer ice extents possibly due to internal and external observational system changes made when switching from using O&SI-SAF re-analysis SMMR and SSM/I sea ice concentration data (Eastwood et al, 2010) to (archived) real time O&SI-SAF SSM/I data (Eastwood et al, 2011) starting with the 2008 analysis. In principle, this would also affect the initialization of the system, but this bias is much smaller in the analysis during spring. When measured against the NSIDC observations, our forecast has a correlation of 0.62. Similarly the correlation of our detrended forecast against the detrended NSIDC data is 0.61. These are both significantly different from zero at the 95% and 98% confidence levels after accounting for serial correlation. For comparison, we have also added the July persistence forecast onto the series of September ice extents. The July persistence forecast is simply adding the NSIDC anomalies for July onto the NSIDC September climatology. The September and July climatologies used for anomaly calculation were both calculated using 1996-2009 values as in the hindcast. This was also done for 2011, resulting in a persistence forecast of 4.6 million square kilometres. This is worthy of note, since July persistence can be shown to be quite skilful in both raw (0.84) and detrended (0.48) correlations. In particular, this is the first month in which persistence shows any skill in interannual variability, and not just in the trend. Also, the persistence forecast has fallen from 5.7 million sq. kilometres in April, to 5.6 in May, through 5.4 in June, and finally 4.6 in July. We would fully expect this to be reflected in the forecasts of our colleagues using statistical methods – presumably in a far more sophisticated fashion. We are continuing to track the forecast coming out of the GloSea4 system, but have chosen not to release the current forecast, even as an aside to the 21 March to 10 April initialized forecast given above. This is due to large biases leading to unphysically small ice extents that have developed in the hindcast and forecast when using ice initialized with the summer time ice analysis.

One benefit of using the forecast based on initialization between 21 March and 10 April is are ability to evaluate the performance of the system through the intervening months. Figure 2 shows the validation of the forecast to date. During April through May the forecast was tracking above the observed values, as is shown in the figure which plots the monthly anomalies based on the 1996-2009 climatology for both forecast and observations. However, in July, the forecast anomaly has crossed over and is now below the observations. Given the large acceleration in this anomaly expected by the system in August, with subsequent recovery in September, this does not perhaps bode well for our September forecast. Although the difference between the August and September anomalies looks quite large, it is not true for the total extent. The system marginally predicts a mean August ice extent 0.2±0.6 million square kilometres below the September ice extent. So far, the GloSea4 forecast has been within the expected error of the observations both when considering the variance between the ensemble members (blue whiskers on forecast) and when considering the past performance of the system throughout the hindcast (black whiskers on observations).

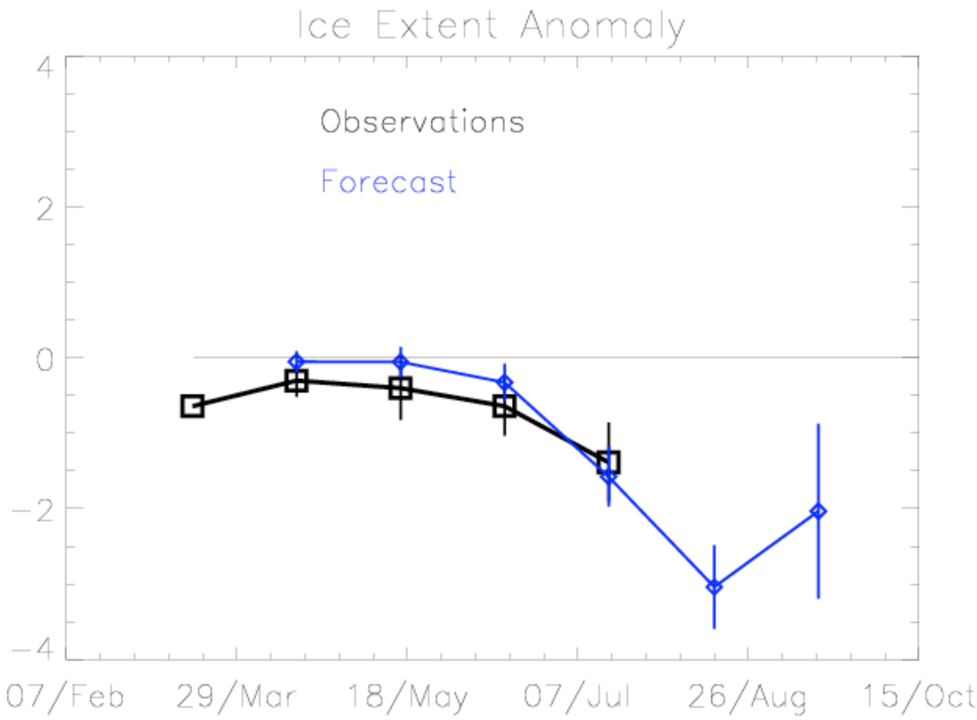

Figure 2: Monthly ice extent anomalies through the summer. Shown are the available observations (black line with ’s) and the GloSea4 forecast (blue line with ◊’s). Both the observations and forecast are anomalies based upon their respectively 1996-2009 climatologies. The blue whiskers on the forecast are the variance in the ensemble members comprising the forecast, while the black whiskers on the observations are the root mean square (rms) error between the hindcast and observations. **Note:** The black whiskers should not be interpreted as the observational error, but rather an error in the forecast based upon past performance.

4) Executive Summary

Our 2011 September ice extent forecast remains at 4.0±1.2 million square kilometres. This is based upon a forecast from the UK Met Office seasonal forecast system, GloSea4, using a coupled atmosphere/ocean/sea ice model initialized between 21 March and 10 April using observations present before those dates. The quoted error is based on the standard deviation of the ensemble members’ sea ice extent from their average value. A bias correction of 0.2 million square kilometres has been added to the forecast to account for the climatological bias of lower ice extents forecast in the model over the hindcast period. Verification of the forecast in the April through July period shows the forecast to be tracking above the observations through June and then starting to track below observations in July. So far the system forecast has been within the expected error as based on the variance between ensemble members, as well as the root mean squared error over the hindcast. Although sea ice forecasts are available from the GloSea4 system initialized with more recent start dates, we continue to issue the forecast based on the 21 March through 10 April initialization, as it provides the best skill in forecasting both the interannual variability and trend of the sea ice extent over the 1996-2009 hindcast. Furthermore, the most recent forecasts initialized with the sea ice concentration and ocean analysis over the summer months possess a large bias in ice thickness leading to far too small ice extents in September. Instead, we have merely updated the apparent progress of our original prediction over the intervening months in this update.

5) Estimate of Forecast Skill

GloSea4 is an ensemble forecast system. The spread of the forecast members allows us to place an uncertainty error on the forecast. The standard deviation of the spread of ensemble members for 2011 is 1.2 million square kilometres, which we have assigned as the error in our forecast of 4.0 million square kilometres. This value is comparable to the root mean square (rms) error between hindcast and observations, and the mean variance of ensemble members during the hindcast, which are 0.7 and 0.8 million square kilometres respectively. So far through the duration of this forecast, which would encompass April through July, the forecast has been within the error prescribed by the variance in the ensemble members – suggesting at least one ensemble member should be close to the "truth." Additionally, the system has been within the error expected by its past performance as judged by the rms error during the hindcast.

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