September 2013 Sea Ice Outlook
June Report

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Caveat: this is an experimental projection and is not an official Met office forecast.

1) Extent Projection

3.36 ± 1.51 million km^2

2) Method (ensemble of global coupled model runs)

This projection is based on results from the UK Met Office seasonal forecasting system GloSea4 (Arribas et al., 2011, Peterson et al., submitted), which is an ensemble prediction system using a configuration of the HadGEM3 coupled climate model (Hewitt et al, 2011). HadGEM3 has the following components:

- Atmosphere: Met Office Unified Model (UM), Davies et al, 2005
- Ocean: Nucleus of European Modelling of the Ocean (NEMO), Madec, 2008
- Sea Ice: Los Alamos sea ice model (CICE), Hunke and Lipscomb, 2010
- Land Surface: Met Office Surface Exchange Scheme (MOSES), Essery et al, 2003.

The GloSea4 system has a real-time forecasting component, and an accompanying set of hindcasts which are used for bias correction and skill assessment. The hindcasts and forecasts are typically run for 7 months, using the same methodology and differing only in their initial conditions.

For the hindcast runs, the atmosphere is initialised from ERA-interim reanalysis data (Dee et al, 2009), and the ocean and sea ice are initialised from an ocean-ice reanalysis based on a run of NEMO-CICE with data assimilation, using bulk forcing derived from the ERA-interim reanalysis (Large and Yeager, 2009; Brodeau et al, 2010). Ice concentration, SSTs, and temperature and salinity profiles are assimilated, but note that there is no assimilation of ice thickness. Hindcasts are run for each of the fourteen years 1996-2009; four times a month, three 7-month hindcasts are started for each year, with differing stochastic physics perturbations.

For the forecast runs the atmosphere is initialised from a re-gridded NWP analysis (Rawlins et al, 2007), and the ocean and sea ice are initialised from a NEMO-CICE assimilation run forced by atmospheric fluxes derived from the NWP analysis. Two 7-month forecasts are started each day, having the same initial conditions but different stochastic physics perturbations (Bowler et al, 2009). Our projection of ice extent is based on results from an ensemble of 42 forecast runs, initialised on 21 consecutive days.

As there is a bias between the hindcast and observed ice extents, we apply a correction to the forecast ice extent. For the bias correction used in our projection, we use hindcasts initialised on the four dates best matching the range of forecast start dates, giving twelve hindcast values for each year. As the forecast system has had only minor changes since November 2010, we are also able to include the equivalent hindcasts run on the same dates in 2011 and 2012, giving a total of thirty six hindcast values for each year. The forecast ice extent is bias corrected using the mean difference between the observed extent and the mean hindcast extent.

The use of the GloSea4 forecasting system to predict September ice extent (Peterson et al, submitted) remains experimental, and some of the caveats are discussed in section 5.

3) Rationale

Our projection is based on forecasts initialised between 25th March and 14th April 2013 inclusive (the choice of start dates is discussed in section 5 below), bias-corrected using hindcasts initialised on 25th March, and 1st, 9th, and 17th April. Figure 1 shows the September sea ice extent for each of the hindcast years, together with the forecasts for 2011, 2012 and 2013. All values plotted on this figure (except the observations) have been bias corrected by adding 0.14 million km^2; the mean (low) bias of the hindcasts. Note that there is no modelled value for 2010, as the latest hindcast year is 2009, and there was no 2010 forecast made using the current version of the GloSea4 system. The range of forecast values of the 2013 September ice extent is shown in figure 1. Our projection of 3.36 million km^2 is the bias-corrected mean of the 42 forecasts, and the quoted error range is ±1 standard deviation.

4) Executive Summary

Our projection of the mean September 2013 ice extent is 3.36 ± 1.51 million km^2. This projection is based on an ensemble of 42 forecast runs of the GloSea4 seasonal forecast system, initialised between 25th March and 14th April 2013. GloSea4 comprises a global coupled atmosphere-land surface-ocean-sea ice model, initialised from analyses. The forecast has been bias-corrected using results from a matching set of hindcast runs.

The quoted error is based on the standard deviation of the ensemble members; however this does not take into account all sources of error. In particular, the projected ice extent may be biased low compared to the bias in the hindcasts, due to the forecasts being initialised with thinner ice than the hindcasts. It is hoped that in future this will be improved by planned upgrades to the GloSea system.

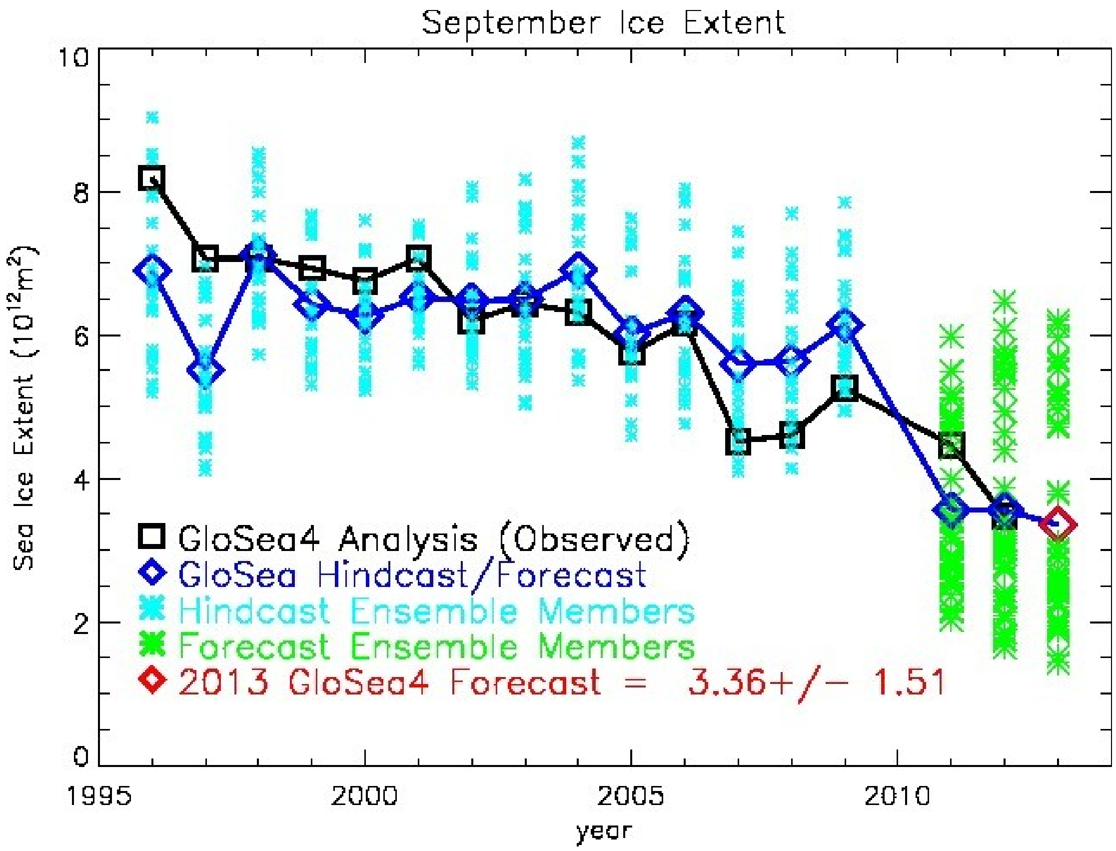

Figure 1: September sea ice extents (million km^2) from the GloSea4 seasonal forecasting system, for hindcasts initialised on 25th March, and 1st, 9th, and 17th April and forecasts initialised between 25th March and 14th April. All values (except the observations) have been bias-corrected.

5) Estimate of Forecast Skill

The quoted uncertainty associated with our projection is based solely on the spread of the members of the forecast ensemble. However this is not the only source of uncertainty, and here we briefly discuss some other aspects of the performance of the forecasting system. Peterson et al (submitted) provides a fuller discussion.

The correlation between the hindcasts and observations is 0.63, which is significantly different from zero at the 94% confidence level. The correlation increases slightly to 0.64 (98% confidence level) when the values are de-trended. The de-trended correlation is greater because the hindcast does not capture the observed decline in ice extent. Hence the correlation suggests that the hindcast shows some skill in capturing the interannual variability in September ice extent.

Our projection is based on forecasts initialised in March, whereas ideally we would have chosen later forecast dates so that more recent data could be included in the initialisation, and to maximise the possibility of skill in predicting the atmospheric circulation during the summer months. However the sea ice in the forecast initialisation is currently too thin relative to recent climatological observations (and thinner than the hindcast initialisation), and hence more vulnerable to significant melting over the summer. This may lead to a low bias in our forecast. With the current system and the same set of start dates, our bias-corrected 2011 forecast would have been 3.56 million km^2, which is lower than observed (Figure 1). The equivalent forecast for last year was 3.55 million km^2, close to the observed record low extent of 3.47 million km^2.[1]

The bias worsens as the sea ice melt season continues, and for forecasts initialised from April onwards it is anticipated that the (low) bias in the forecast September ice extent is too large to be compensated by the hindcast bias correction. For this reason it is unlikely that we will issue an update to this forecast as the melt season progresses. It is hoped that planned upgrades to the GloSea system will improve the ice thickness in the forecast initialisation for next year's Outlook.

6) References

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[1] Note that that actual projection submitted to the June Outlook last year was 4.36 million km^2, and was made using forecasts initialised at earlier start dates than those considered here.

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