

Met Office
September 2015 Pan-Arctic Sea Ice Outlook
August Report (Using July Data)

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Group: Met Office

Projection Type: Model based estimate.

September Monthly Averaged Extent Projection: $(3.7 \pm 0.7) \times 10^6$ km²

Model: HadGEM3, Global Coupled Model 2.0 [Williams et al., 2015]

Ice Component: CICE [Hunke and Lipscomb, 2010], Global Sea Ice 6.0 [Rae et al., 2015]

Ocean Component: NEMO [Madec, 2008], Global Ocean 5.0 [Megann et al., 2014]

Atmospheric Component: Met Office Unified Model (UM) [Brown et al., 2012], Global Atmosphere 6.0

Land Component: JULES [Best et al., 2011], Global Land 6.0

Coupler: OASIS3 [Valcke, 2006]

Method: Ensemble coupled model seasonal forecast from the GloSea5 seasonal prediction system [MacLachlan et al., 2014], using the Global Coupled 2 (GC2) version [Williams et al., 2015] of the HadGEM3 coupled model [Hewitt et al., 2011]. Forecast compiled together from forecasts initialized between 22 July and 9 August (2 per day) from an ocean and sea ice analysis (FOAM/NEMOVAR) [Blockley et al., 2014, Peterson et al., 2015] and an atmospheric analysis (MO-NWP/4DVar) [Rawlins et al., 2007] using observations from the previous day. Special Sensor Microwave Imager (SSM/I) ice

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concentration observations from ESA OSI-SAF [OSI-SAF, 2011] were assimilated in the ocean and sea ice analysis, along with satellite and in-situ SST, subsurface temperature and salinity profiles, and sea level anomalies from altimeter data. No assimilation of ice thickness was performed. The forecast (Figure 1) has a bias correction upward of $0.8 \times 10^6 \text{ km}^2$ due to a mean under forecast of the ice extent relative to the observed NSIDC ice extent over the hindcast period 1996 to 2009 [Peterson et al., 2015]. This bias correction, and therefore the forecast itself is heavily reliant on the hindcast being a good proxy of forecast performance. In particular, for sea ice prediction, it is dependent on hindcast sea ice thicknesses, which are not assimilated, having a good physical realization through time. Without an accurate set of summer sea ice thickness observations through both hindcast and forecast, this is extremely hard to validate.

Projection Uncertainty: $\pm 0.7 \times 10^6 \text{ km}^2$ representing two standard deviations of the ensemble spread around the ensemble mean.

Executive Summary: Using the Met Office GloSea5 seasonal forecast systems we have generated a model based mean September sea ice extent outlook of $(3.7 \pm 0.7) \times 10^6 \text{ km}^2$. This has been generated using startdates between 22 July and 10 August to generate an ensemble of 41 members (and 1 failed member). **Note: Given current capabilities for seasonal forecasting of sea ice, we consider this still an experimental forecast.**

Additional Information: Validation and calibration of the forecast was done using a 1996-2009 historical re-forecast (hindcast) using startdates of 25 July, 1 & 9 August (3 members each). Over the hindcast period, the correlation between the GloSea5 forecast and NSIDC sea ice extent observations was 0.94 which reduces to a correlation of 0.74 if the trend is removed from the time series. See figure 1 showing the time series of September sea ice predictions in the hindcast, along with the forecast for 2015. These correlation values are significantly different from 0 at the 95% confidence level, and are better than the value of July persistence (using July anomalies as a predictor for September; correlation values 0.86 and 0.51 after de-trending). The non-detrended correlation value is also marginally better than simply predicting the trend (correlation 0.86). After bias correcting, the hindcast has a root mean square error (rmse) of $0.3 \times 10^6 \text{ km}^2$ comparable to the quoted error.

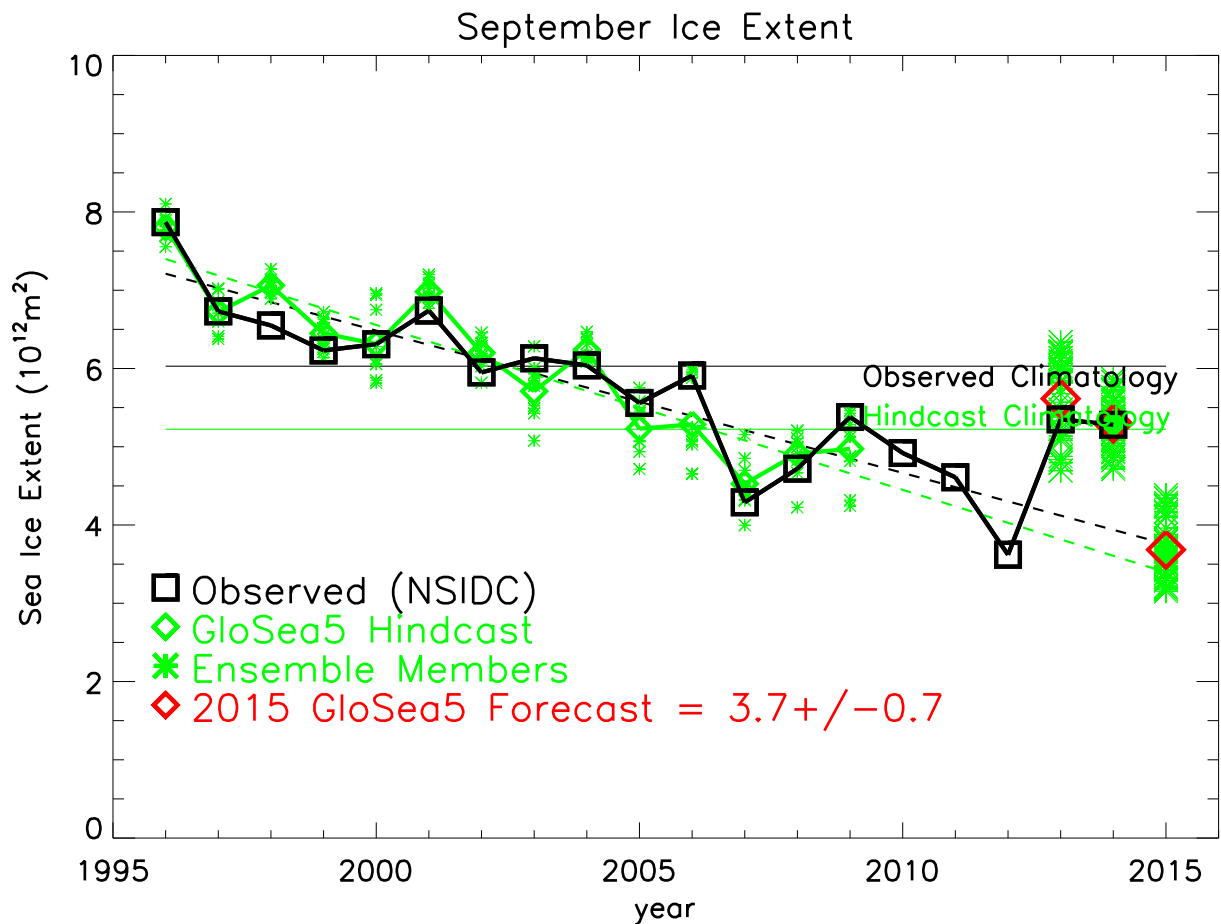


Figure 1: Time series of ensemble mean September sea ice extent from GloSea5 (green \diamond) and observations (NSIDC; black \square). Individual ensemble member sea ice extents are denoted by * (green). The green and black horizontal lines denote the hindcast and observed (1996-2009) climatology respectively. The forecast and hindcast values have all been adjusted upward by the amount between the two lines ($0.8 \times 10^{12} \text{m}^2$). The green and black dashed lines are the forecast and observed trends in the timeseries over the 1996-2009 hindcast period. Note: Due to changes made to the system since our 2014 forecast, the forecasts from 2013 and 2014 will not necessarily be representative of how the system will perform this year, however, the forecasts are added to the graph for informational purposes only. In addition, they have been bias corrected according to hindcasts consistent with that system, an upward correction of $1.8 \times 10^6 \text{ km}^2$.

September 2015 Monthly Mean Ice Edge

Y2015M08D01_m09 Forecast Ice Extents for 2015

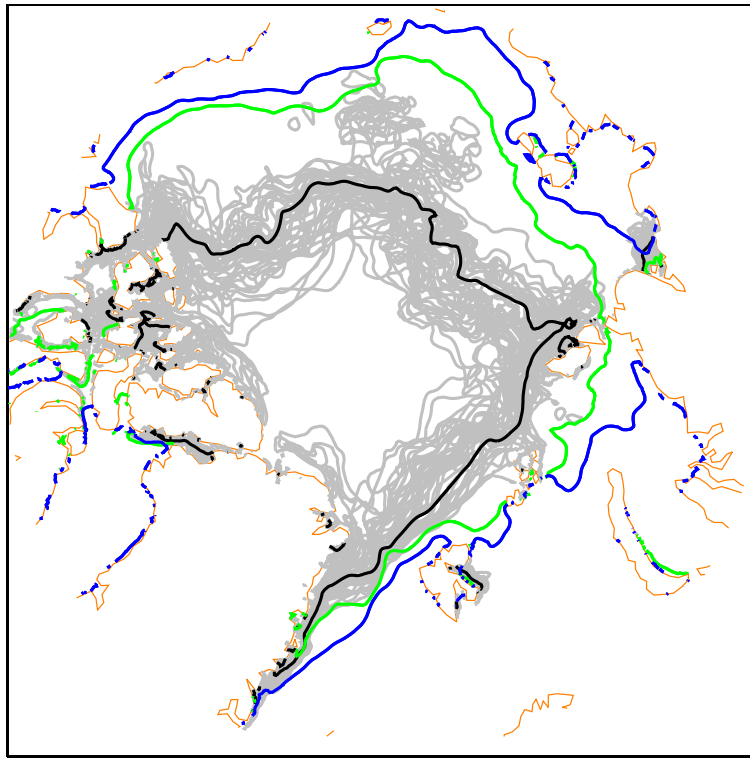


Figure 2: Plot of ice edge. Black line is the location of ice edge (ice concentration > 0.15) for the ensemble mean sea ice concentration. Individual grey lines are the ice edges for the individual ensemble members. No bias correction has been applied. The green and blue lines are the ice edges of the 1996-2009 sea ice concentration climatologies for the hindcast and observations respectively. Differences between these two climatological ice edges would indicate how and where the model climatology differs from the observed. In particular, one would expect that the retreat from the Asian Arctic coastline should not be as significant as the model would indicate.

September 2015 Probability of Ice

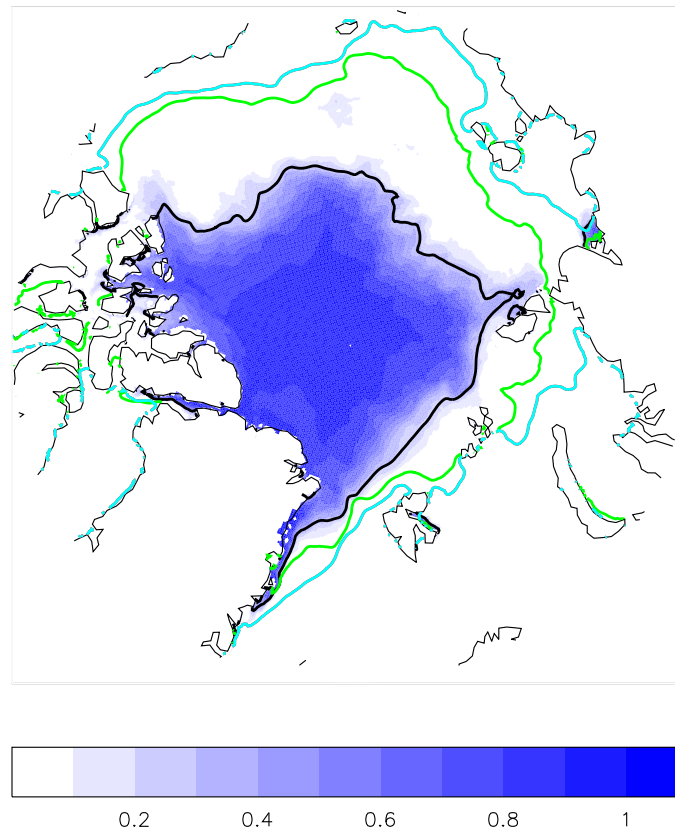


Figure 3: September 2015 monthly mean probability of ice (fraction of ensemble members with ice concentration > 0.15). Note: No bias correction has been applied here, and thus the numerical value of our sea ice forecast before bias correction, $2.8 \times 10^{12} \text{m}^2$, will be the area integral of the ice probabilities represented by this figure. The black line is the ice edge of the ensemble mean ice concentration as in figure 2. The green and cyan lines are the ice edges of the 1996-2009 sea ice concentration climatologies for the hindcast and observations respectively. In areas where the modeled climatological ice edge is inside the observed climatological ice edge, one would expect model bias to deflate the probability of ice.

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