Canadian Ice Service Contribution

to the

September 2012 Sea Ice Outlook

June Report based on May Data

Environment Canada's Canadian Ice Service (CIS) is predicting the minimum Arctic sea ice extent to again be less than 5 million square kilometres in September, 2012. A value similar to or slightly less than the average extents observed in September 2008, 2010 and 2011 is expected. This value (~**4.7 million square kilometres**) will make the Arctic sea ice extent in September, 2012, either the second or third lowest in the 1979-2012 record. This value still lies well below the average September extent for 1979-2011 of 6.5 million square kilometres based on the NSIDC sea ice index.

As with CIS contributions in June 2009, 2010 and 2011, the 2012 forecast was derived using a combination of three methods: 1) a qualitative heuristic method based on observed end-of-winter Arctic ice thicknesses and extents, as well as an examination of Surface Air Temperature (SAT), Sea Level Pressure (SLP) and vector wind anomaly patterns and trends; 2) an experimental Optimal Filtering Based (OFB) Model which uses an optimal linear data filter to extrapolate NSIDC's September Arctic Ice Extent time series into the future; and 3) an experimental Multiple Linear Regression (MLR) prediction system that tests ocean, atmosphere and sea ice predictors.

Based on winter sea ice extents and thicknesses, a September 2012 minimum ice extent value of **$4.6 \leq x \leq 4.9$ million square kilometres** is heuristically predicted. The CIS experimental OFB model predicts a September 2012 average ice extent of **4.3 million square kilometres**. The CIS experimental MLR forecast system predicts a September 2012 minimum sea ice extent of **5.1** (5 model runs with a range of 4.4 to 5.6) **million square kilometres**. The average forecast value of the two model predictions is **4.7 million square kilometres**, which is consistent with the heuristic forecast for the September 2012 pan-Arctic minimum sea ice extent. The average forecast value of the three methods combined is **4.7 million square kilometres**.

The CIS will be continuing its verification studies of the predictions produced by these methods/models in the coming years.

Heuristic Forecast

Based on visual examination of the NSIDC time series for average September sea ice extent, it is rare to see sea ice extents continue to decrease for more than two consecutive years – simply due to inter-annual variability about the prevailing trend. This fact, combined with the fact that winter sea ice extents and thicknesses along the North American western, eastern and Arctic coastlines were greater than normal in 2012, leads CIS to heuristically predict a slight recovery year in terms of pan-Arctic sea ice extents for end-of-melt-season 2012.

September sea ice extents are still expected to be below the 1979-2011 average of 6.5 million square kilometres, but may experience a slight recovery to or flattening out near 2008, 2010 and/or 2011 values (**4.6 to 4.9 million square kilometres**).

Items of note regarding 2012 winter ice conditions in the North American Arctic:

- The sea ice in Nares Strait consolidated in December, ~1.5 months earlier than normal according to the Canadian Ice Service Digital Ice Chart Database.

- The sea ice in Lancaster Sound (eastern half of Parry Channel / Northwest Passage) became completely landfast, right up to its eastern entrance, in January, 2012, something that only occurs 2-3 times per decade. The last time was in 2002.

- A week of very strong northerly winds in January, 2012, pushed the tongue of multi-year ice that extends westward through the Beaufort Sea (from the main pack in the eastern part of the Canada Basin) southwards, so that this tongue lay further south than normal through most of the winter. At the beginning of June, 2012, the main area still being impacted by greater than normal multi-year ice concentrations is in the vicinity of Point Barrow.

- Air temperatures in the Canadian Arctic Archipelago and along the Alaskan coast were well below both the 1971-2000 and 1981-2010 normals this past winter, especially in March.

- Sea ice extents in Davis Strait were much greater than normal in 2012, and broke the 1983 record for mid-March maximum extents this year.

- Sea ice extents in the Bering Sea also broke records for maximum extent this year.

- Landfast ice thicknesses in the Canadian Arctic Archipelago north of 65N were near or slightly greater than the *1971-2000* normal in 2012.

Statistical Method #1: Optimal Filtering Based Model Forecast

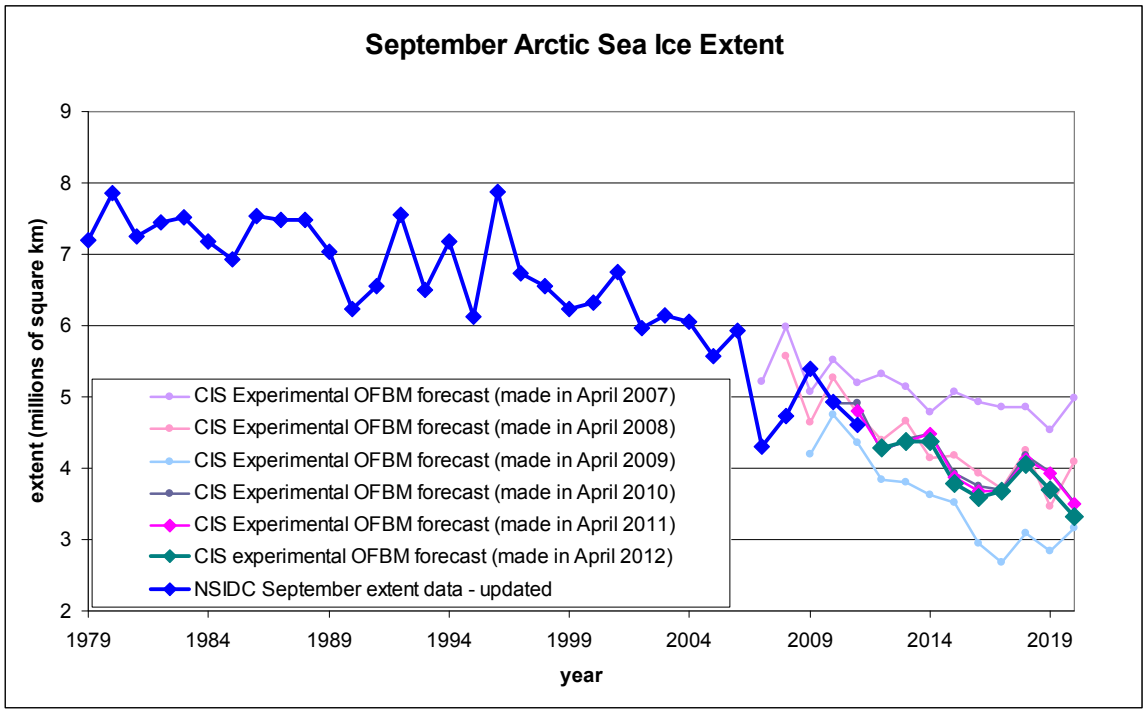

Figure 1. The Optimal Filtering Based model (OFBM) forecast for 2012-2020 (made in April 2012 – turquoise line, based on NSIDC September extent data – blue line). The **2012 forecast** is **$4.3*10^6$ km^2**. The forecasts out to 2020 made in previous years are also shown for comparison. Except for the forecasts made in 2007 and 2009, model predictions have been consistent from year to year.

Model Details

Details of the Optimal Filtering Based Model (OFBM) used here, as well as the model code, can be found in Press et al. (1992). Models based on optimal linear data filters have proven skilful at predicting other climate indices (e.g. Nino3 and Nino3.4 SSTs – Kim and North, 1998; 1999).

year	forecast	observed	difference
2007	5.21	4.3	0.91
2008	5.56	4.68	0.88
2009	4.2	5.36	-1.16
2010	4.91	4.9	0.01
2011	4.8	4.61	0.19

Table 1. Verification: CIS OFB model forecasts for past September sea ice extent (millions of square kilometres)

References:

Kim, K-Y., and G.R. North (1998): EOF-Based Linear Prediction Algorithm: Theory. *Journal of Climate*, **11**, 3046-3056.

Kim, K-Y., and G.R. North (1999): EOF-Based Linear Prediction Algorithm: Examples. *Journal of Climate*, **12**, 2076-2092.

Press, W.H., S.A. Teukolsky, W.T. Vetterling and B.P. Flannery (1992): Numerical Recipes in Fortran 77, Second Edition: The art of scientific computing. Cambridge University Press, Cambridge, UK. [Chapter 13, section 13.6].

Statistical Method #2: MLR Prediction System Forecast

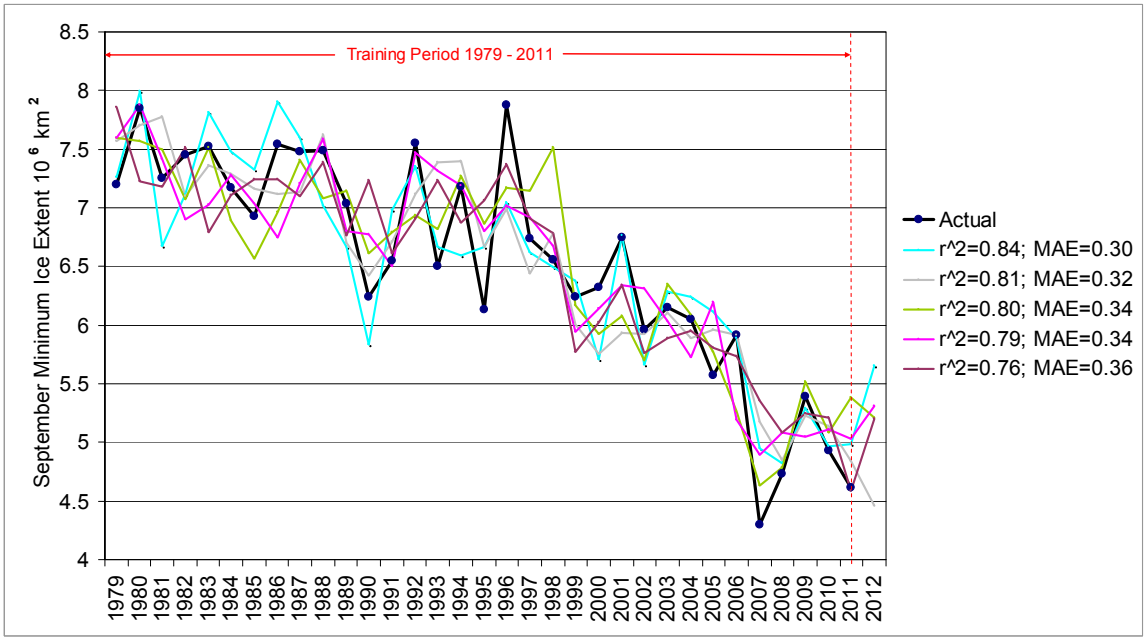

Figure 2. Regression based forecast for the 2012 September Ice Extent. The model is trained on the 33-year period from 1979-2011. The **2012 forecasts** from the 5 model runs range from 4.4 to 5.6 and average **$5.1*10^6$ km^2**.

Model Details

The regression models are generated using an automated selection scheme (Tivy et al., 2007) based in part on step-wise regression and where the maximum number of predictors is restricted to two. Predictors in the original predictor pool included: pan-Arctic sea ice concentration, SLP and z500, near-global SST, and indices for ENSO, the PDO, the AO, NAO and other atmospheric teleconnections. Each predictor was tested at lags ranging from 5 to 18 months. After each model run the first predictor was removed from the predictor pool, this process was repeated until no models were generated. Five regression equations were generated for the September minimum; it is important to note that they are not necessarily independent. The pairs of predictors for the 5 models are: JJA SLP & F WP, MJJ SST & J SIC, NDJ SIC & WAY FDD, MJJ MAT & J SIC, JJA z700 & J ESC.

Reference:

Tivy, A., B. Alt, S.E.L. Howell, K. Wilson, and J.J Yackel. (2007). Long-range prediction of the shipping season in Hudson Bay: A statistical approach. Weather and Forecasting, 22, 1063–1075, doi:10.1175/WAF1038. WAF10