2010 Regional Sea Ice Outlook
Data for July Report

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This outlook is a statistical forecast, which relies on empirical relationships between pre-season climate variables and the variable being predicted—in this case, September sea ice area. The 2010 forecast results are summarized in Table 1.

Pan-arctic ice area is expected to be greater than in 2009 but still remain below normal. Regionally, increases in ice area compared to 2009 are expected in the Beaufort/Chukchi Seas, the East Siberian/Laptev Seas, the Barents/Kara Seas, and the Central Arctic Ocean. Decreases in ice area compared to 2009 are expected in the Greenland Sea and the Canadian Arctic Archipelago.

	September Ice Area (10^5 km^2)	
	2009 actual	2010 forecast
Northern Hemisphere	37.30 Below Normal	45.39 Below Normal
Beaufort/Chukchi Seas	5.30 Below Normal	8.03 Below Normal
East Siberian / Laptev Seas	2.26 Below Normal	3.80 Below Normal
Barents / Kara Seas	0.49 Below Normal	1.64 Near Normal
Greenland Sea	1.85 Near Normal	0.95 Below Normal
Canadian Arctic Archipelago	2.20 Below Normal	1.72 Below Normal
Central Arctic Ocean (> 85N)	25.04 Near Normal	25.9 Near Normal

Table 1. Categorical and deterministic forecasts of September ice area for 2010; the actual ice area for 2009 is shown for comparison.

MODEL DETAILS

The pan-arctic (Figure 1, below) and regional forecasts (Figures 3 to 8, below) for September ice area were generated from simple linear regression models. This statistical approach follows work done by Drobot et al. (2006, 2003) for forecasting the Beaufort Severity Index and the September minimum ice extent.

The predictors were chosen using an automated selected scheme (Tivy et al., 2007) based in part on step-wise regression and where the maximum number of predictors is restricted to two. Predictors included in the original predictor pool are: Sea Ice (Northern Hemisphere ice concentration, Northern Hemisphere multi-year ice concentration); Ocean (Near-global sea surface temperature, ENSO, PDO); and Atmosphere (Northern Hemisphere z500, Pan-Arctic [north of 60N] SAT and SLP, teleconnection indices). Each

predictor was tested at lags ranging from 5 to 18 months. The models are trained on the 27-year period from 1981–2006. Independent forecasts were generated for 2007–2010. The 2010 forecast is expressed both categorically and deterministically (Table 1, above).

Pan-Arctic (Figure 1)

The predictor for pan-arctic (northern hemisphere) September ice area is the preceding summer (May-June-July) sea surface temperature in the North Atlantic and North Pacific close to the marginal ice zone (14-month lag), where warm sea surface temperature (SST) anomalies are associated with reduced ice area. The regression r2 and cross-validated r2 are 0.83 and 0.78 respectively; the categorical forecast skill over the training period is 81%. While the model overestimated ice area for the three independent forecast years (2007–2009), the categorical forecasts of below normal ice area were correct for each year.

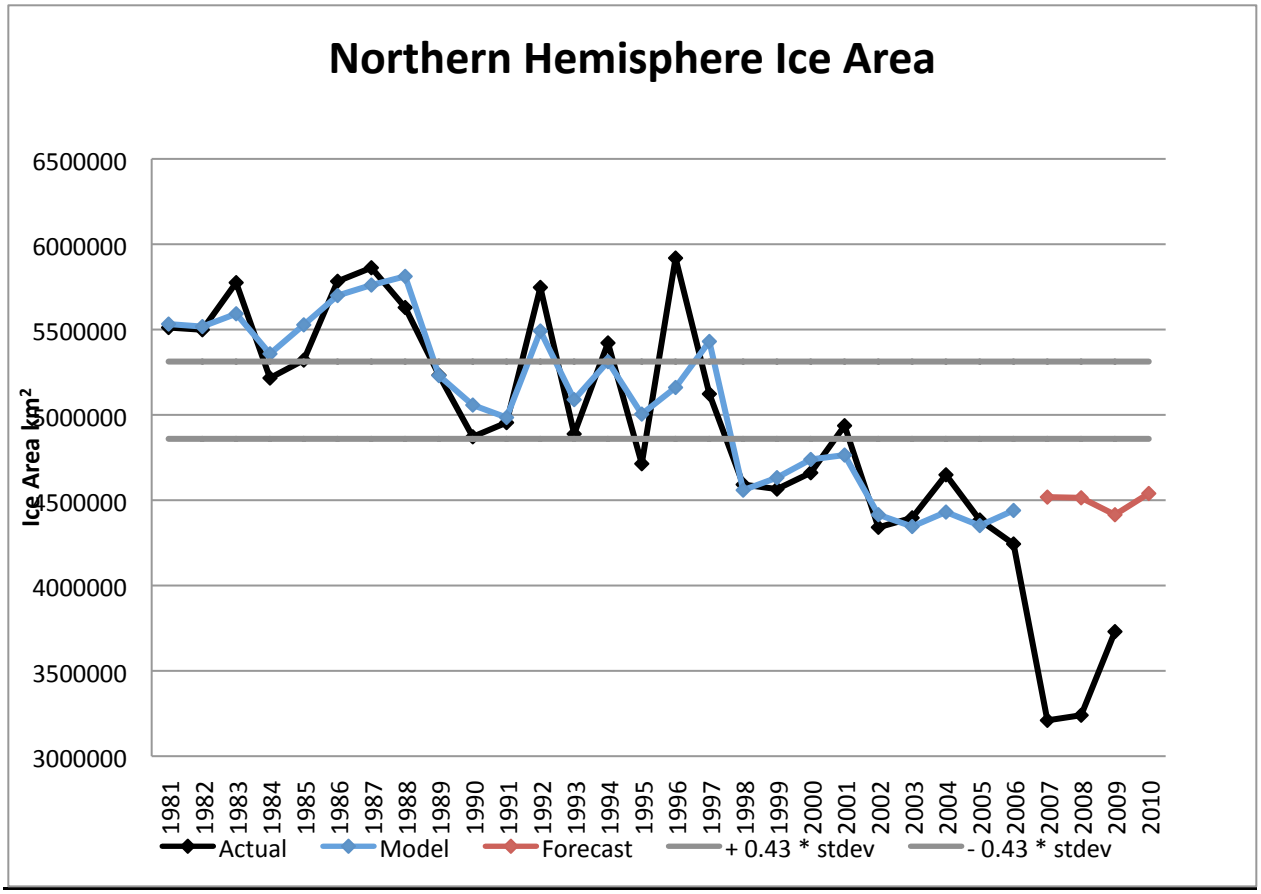

Figure 1. Regression-based forecast for the 2010 September Ice Area. The model is trained on the 27-year period from 1981-2006 (dark red) and independent forecasts were generated for 2007–2010 (red); actual values are shown in black. The **2010 forecast** is expressed both categorically, **Below Normal**, and deterministically, **$5.7*10^6$ km^2**.

Regional Outlooks

Six regional forecasts were completed for the following regions: Beaufort/Chukchi Seas, East Siberian/Laptev Seas, Barents/Kara Seas, Greenland Sea, Canadian Arctic Archipelago, and Central Arctic Ocean (> 85N).

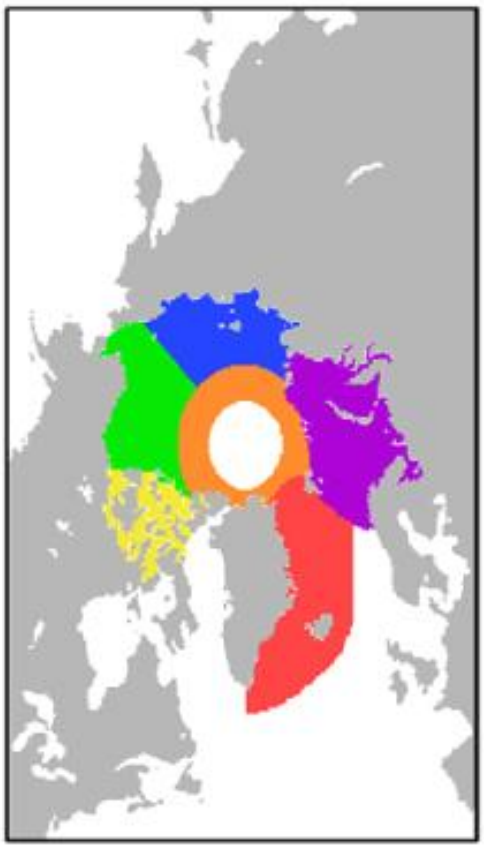

Figure 2. Sea ice regions: A – Beaufort/Chukchi Seas; B – East Siberian/Laptev Seas; C-Barents/Kara Seas; D- Greenland Sea; E- Canadian Arctic Archipelago; F- Central Arctic Ocean (>85N).

Beaufort/Chukchi Sea (Figure 3)

The main predictor is winter (Dec-Jan-Feb) air temperature over the Beaufort Sea, Alaska and the Canadian High Arctic (7-month lag), where warm surface air temperature (SAT) anomalies are associated with reduced ice area. The regression r2 and cross-validated r2 are 0.79 and 0.69 respectively; the categorical forecast skill over the training period is 77%. The model over-estimated ice area for the three independent forecast years (2007–2009), the model incorrectly predicted near normal years for 2007 and 2008 but correctly predicted 2009 as below normal.

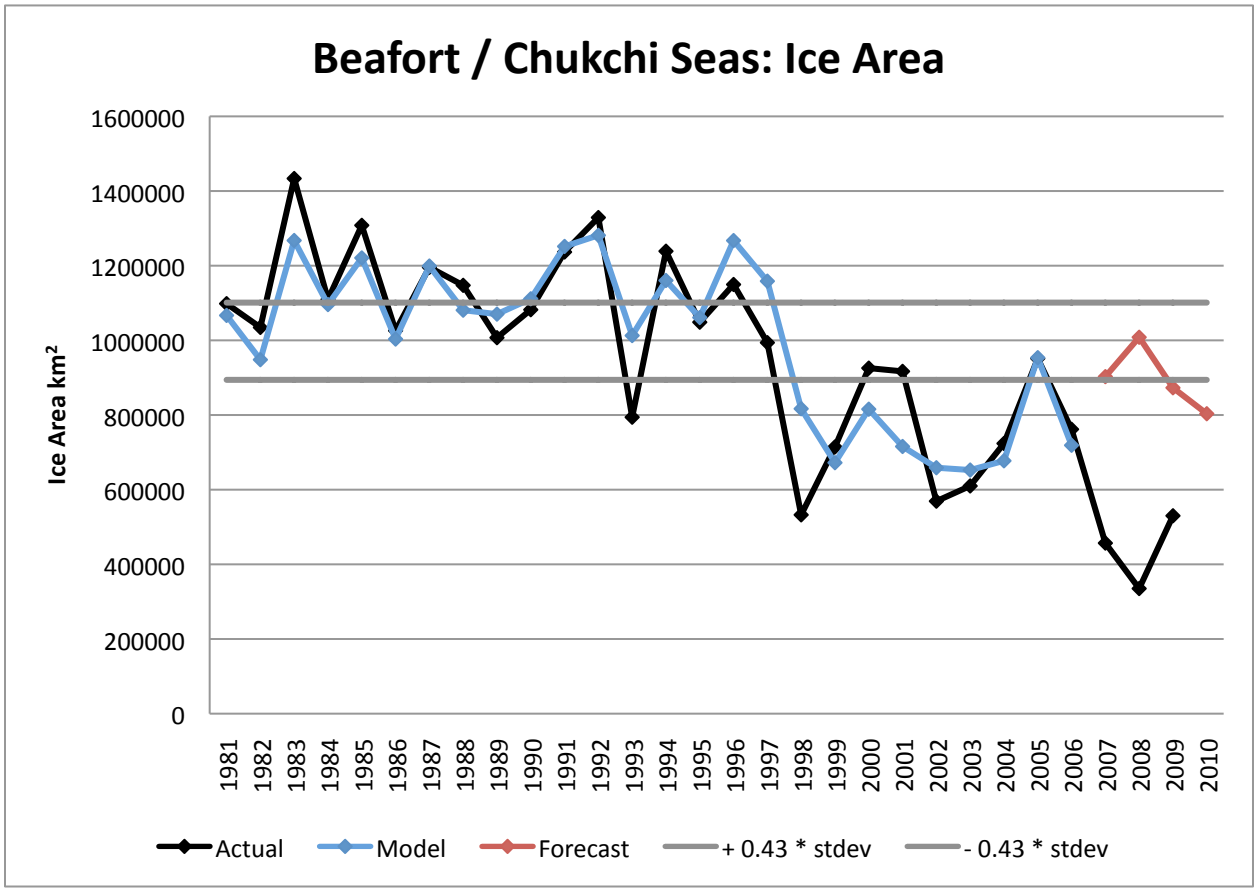

Figure 3. Regression based forecast for the 2010 Beaufort / Chukchi Seas September Ice Area. The model is trained on the 27-year period from 1981-2006 (dark red) and independent forecasts were generated for 2007–2010 (red); actual values are shown in black. The **2010 forecast** is expressed both categorically, **Below Normal**, and deterministically, **$5.7*10^6$ km²**.

East Siberian/Laptev Seas (Figure 4)

The main predictor is summer (Aug-Sept-Oct) sea surface temperature in the North Atlantic (10-month lag), where warm SST anomalies are associated with reduced ice area. The regression r2 and cross-validated r2 are 0.62 and 0.56 respectively; the categorical forecast skill over the training period is 69%. While the model over-estimated ice area for the three independent forecast years (2007–2009), the categorical forecasts of below normal ice area were correct for two of the three years.

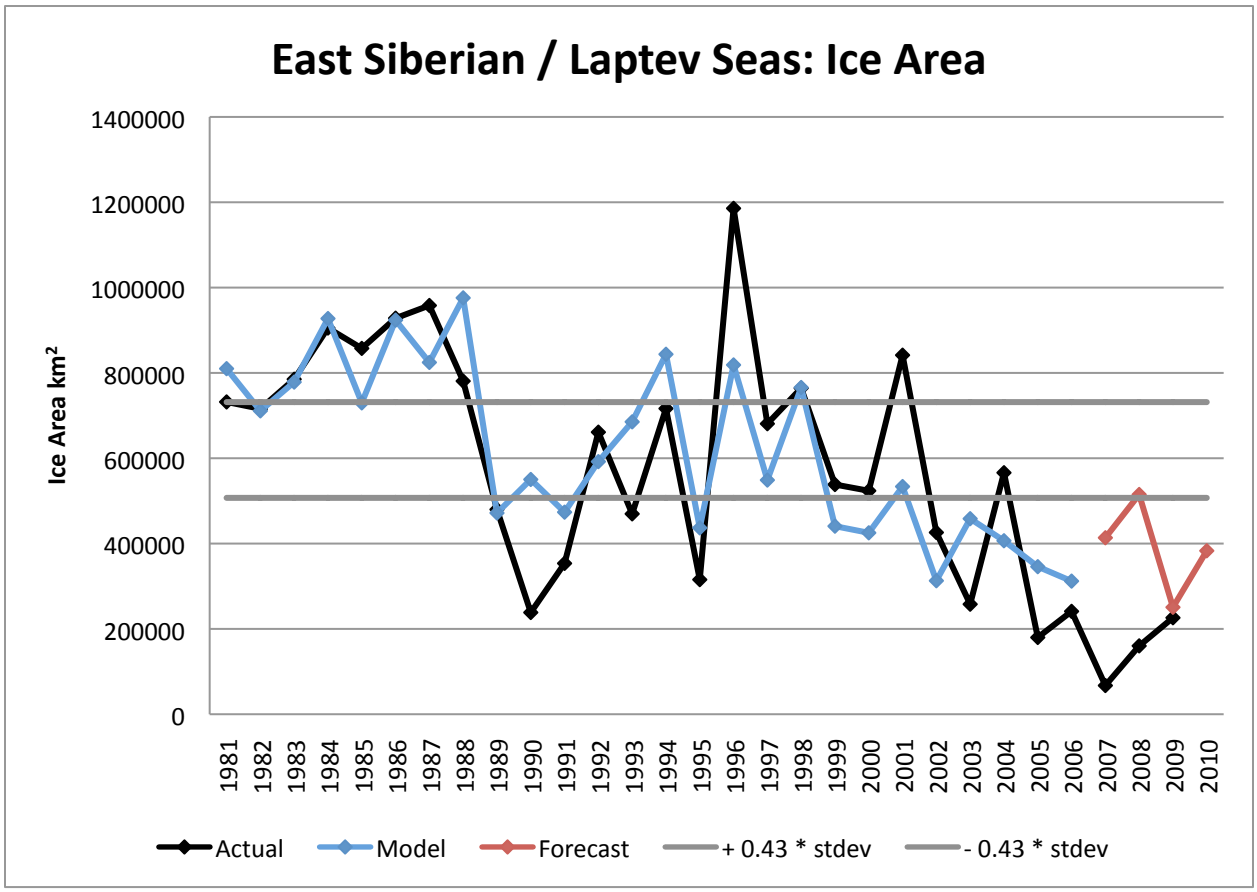

Figure 4. Regression based forecast for the 2010 East Siberian / Laptev Seas September Ice Area. The model is trained on the 27-year period from 1981-2006 (dark red) and independent forecasts were generated for 2007–2010 (red); actual values are shown in black. The **2010 forecast** is expressed both categorically, **Below Normal**, and deterministically, **$5.7*10^6$ km²**.

Barents/Kara Seas (Figure 5)

The main predictor is winter (Jan-Feb-Mar) sea level pressure over the Kara and Laptev Seas (6-month lag), where high sea level pressure (SLP) anomalies are associated with increased ice area. The regression r2 and cross-validated r2 are 0.72 and 0.65 respectively; the categorical forecast skill over the training period is 69%. The model over-estimated ice area for the three independent forecast years (2007-2009), the model incorrectly predicted near normal ice area for 2007 and 2009 but correctly predicted 2008 as below normal.

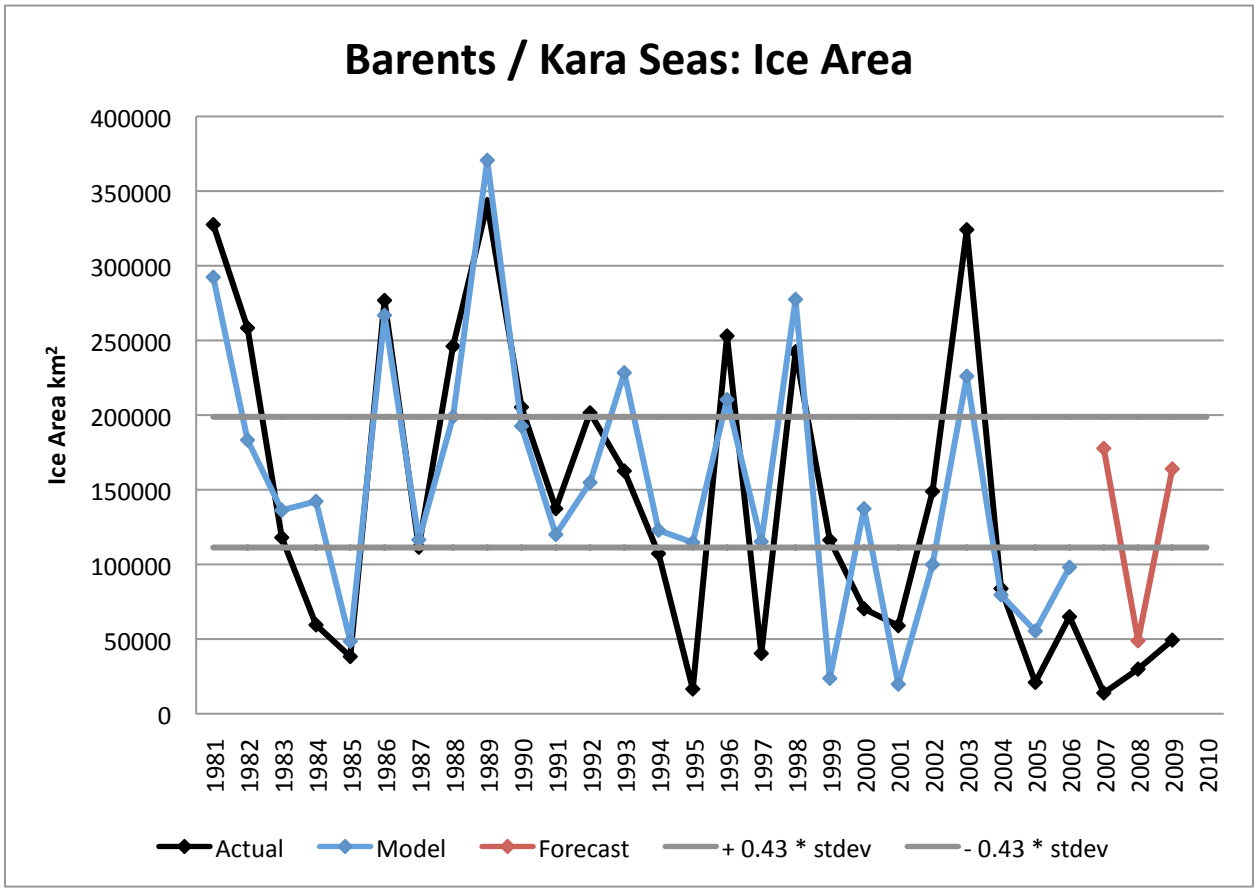

Figure 5. Regression based forecast for the 2010 Barents / Kara Seas September Ice Area. The model is trained on the 27-year period from 1981-2006 (dark red) and independent forecasts were generated for 2007–2010 (red); actual values are shown in black. The **2010 forecast** is expressed both categorically, **Below Normal**, and deterministically, **$5.7*10^6$ km²**.

Greenland Sea (Figure 6)

The main predictor is fall (Sept-Oct-Nov) sea surface temperature in the North Atlantic (9-month lag), where warm SST anomalies are associated with reduced ice area. The regression r2 and cross-validated r2 are 0.62 and 0.44 respectively; the categorical forecast skill over the training period is 58%. The model under-estimated ice area for the three independent forecast years (2007-2009), the model incorrectly predicted below normal ice area for 2007 and 2009 but correctly predicted 2008 as below normal.

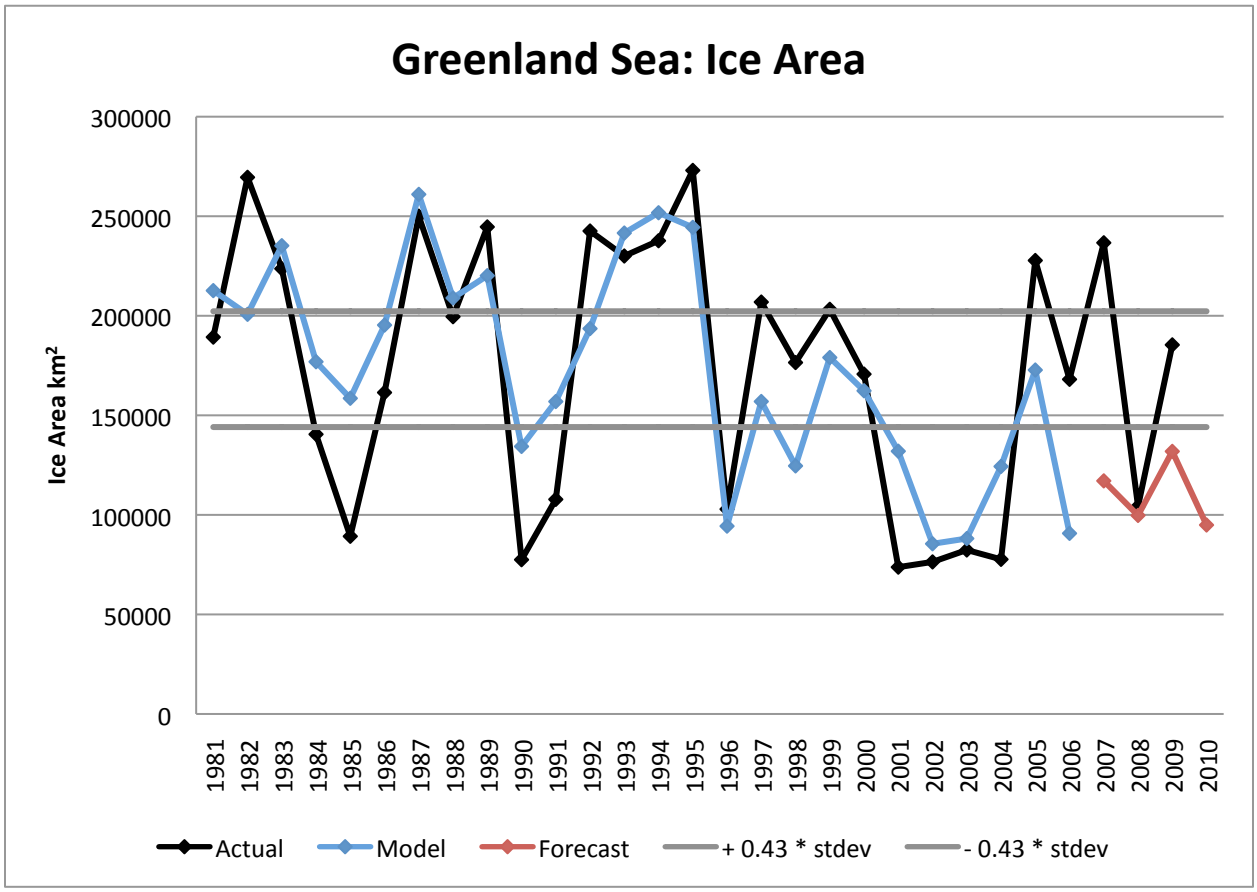

Figure 6. Regression based forecast for the 2010 Greenland Sea September Ice Area. The model is trained on the 27-year period from 1981-2006 (dark red) and independent forecasts were generated for 2007–2010 (red); actual values are shown in black. The **2010 forecast** is expressed both categorically, **Below Normal**, and deterministically, **$5.7*10^6$ km²**.

Canadian Arctic Archipelago (Figure 7)

The main predictor is summer (May-June-July) multi-year ice (MYI) concentration in the Beaufort Sea (14-month lag), where increased MYI concentrations are associated with increased ice area. The regression r2 and cross-validated r2 are 0.6 and 0.56 respectively; the categorical forecast skill over the training period is 58%. The model incorrectly predicted near normal ice area for 2007 and below normal ice area for 2009 but correctly predicted 2008 as below normal.

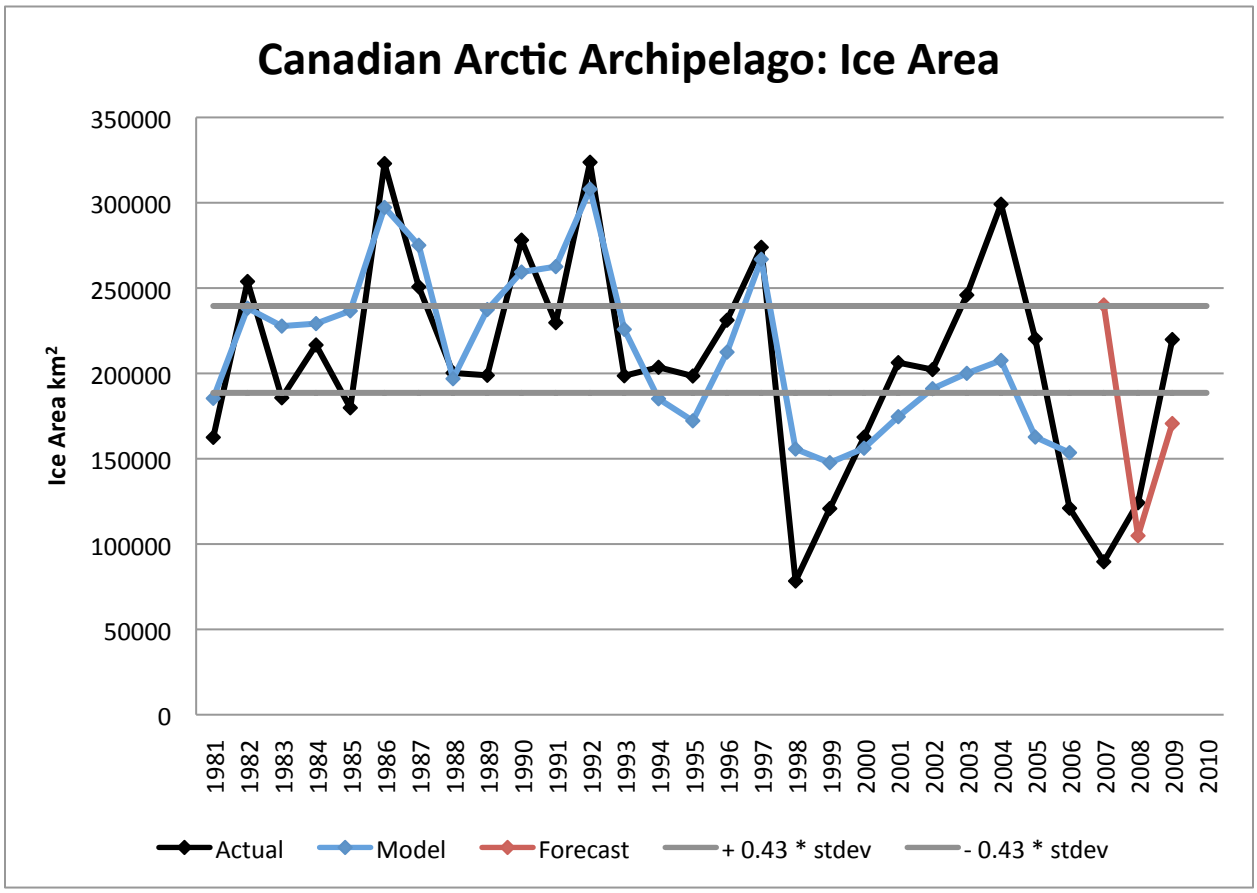

Figure 7. Regression based forecast for the 2010 Canadian Arctic Archipelago September Ice Area. The model is trained on the 27-year period from 1981-2006 (dark red) and independent forecasts were generated for 2007–2010 (red); actual values are shown in black. The **2010 forecast** is expressed both categorically, **Below Normal**, and deterministically, **$5.7*10^6$ km²**.

Central Arctic Ocean (Figure 8)

The main predictor is preceding spring (March-April-May) multi-year ice (MYI) concentration in the Greenland Sea (17- month lag), where increased MYI concentrations are associated with increased ice area. The regression r2 and crossvalidated r2 are 0.79 and 0.73 respectively; the categorical forecast skill over the training period is 65%. While the model over-estimated ice area for the 3 independent forecast years (2007–2009), the categorical forecasts of below normal ice area were correct for each year.

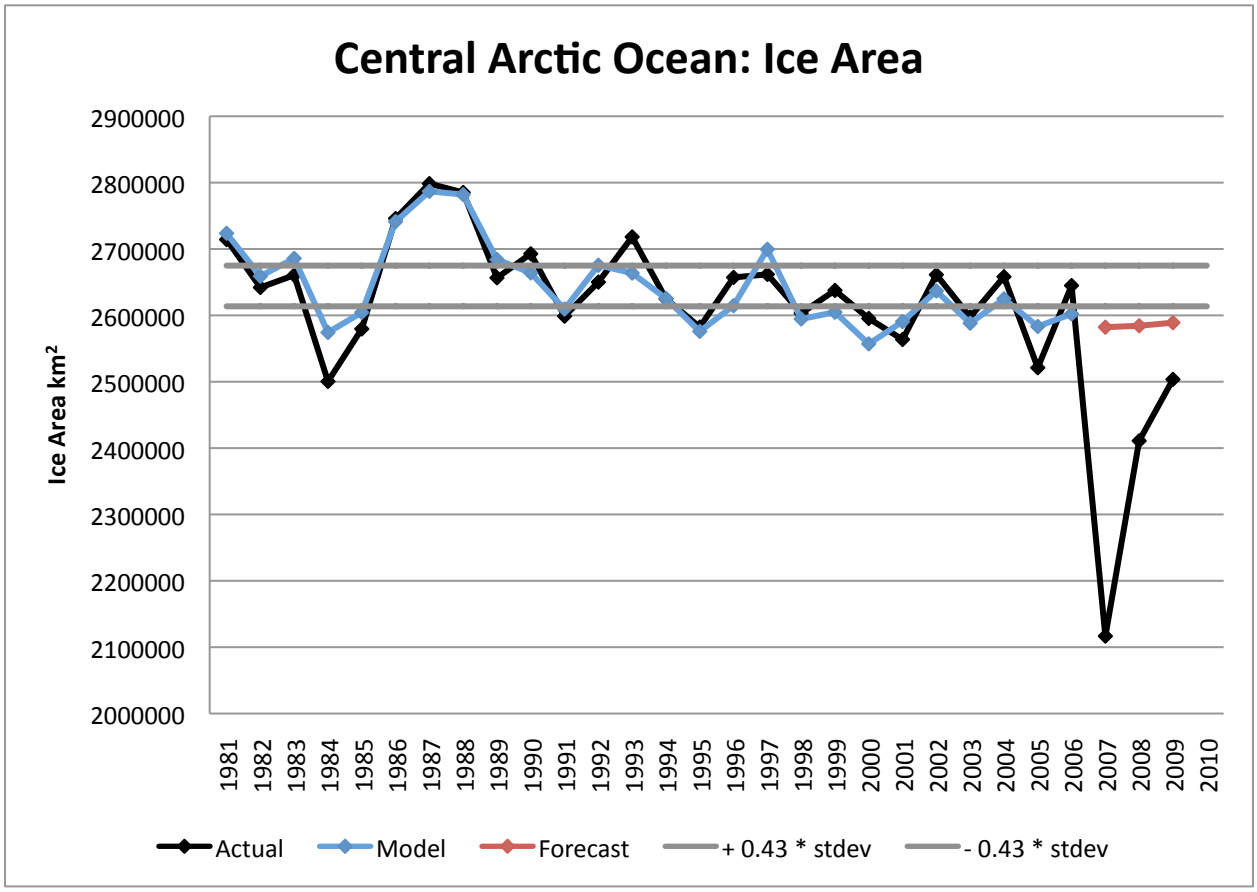

Figure 8. Regression based forecast for the 2010 Central Arctic Ocean September Ice Area. The model is trained on the 27-year period from 1981-2006 (dark red) and independent forecasts were generated for 2007–2010 (red); actual values are shown in black. The **2010 forecast** is expressed both categorically, **Below Normal**, and deterministically, **$5.7*10^6$ km²**.

References

Drobot, S.D, (2003). Long-range statistical forecasting of ice severity in the Beaufort/Chukchi Sea. Weather and Forecasting, 18:1161-1176.

Drobot, S.D., J.A. Maslanik, C.F. Fowler (2006). A long-range forecast of Arctic summer sea-ice minimum area. Geophysical Research Letters, 33, L1051, doi:10.1029/2006GL026216.

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.

Acknowledgements

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