Pan-Arctic Outlook for September 2013
June 1, 2013

Todd E Arbetter
US Army Cold Regions Research & Engineering Laboratory, Hanover, NH

Mark A Potts
Naval Research Laboratory, Washington, DC

Executive Summary: A minimum Arctic sea ice extent of 4.55 million km^2 is projected for the week of September 21, 2013. A statistical model using regional observations of sea ice area and global NCEP air temperature, sea level pressure, and freezing degree day estimates is used. Ten ensemble forecasts are run for each week. For Sept 21, the range is 4.54 – 4.56 million km^2. These forecasts continue the trend of projecting below-average summer sea ice conditions for the Arctic.
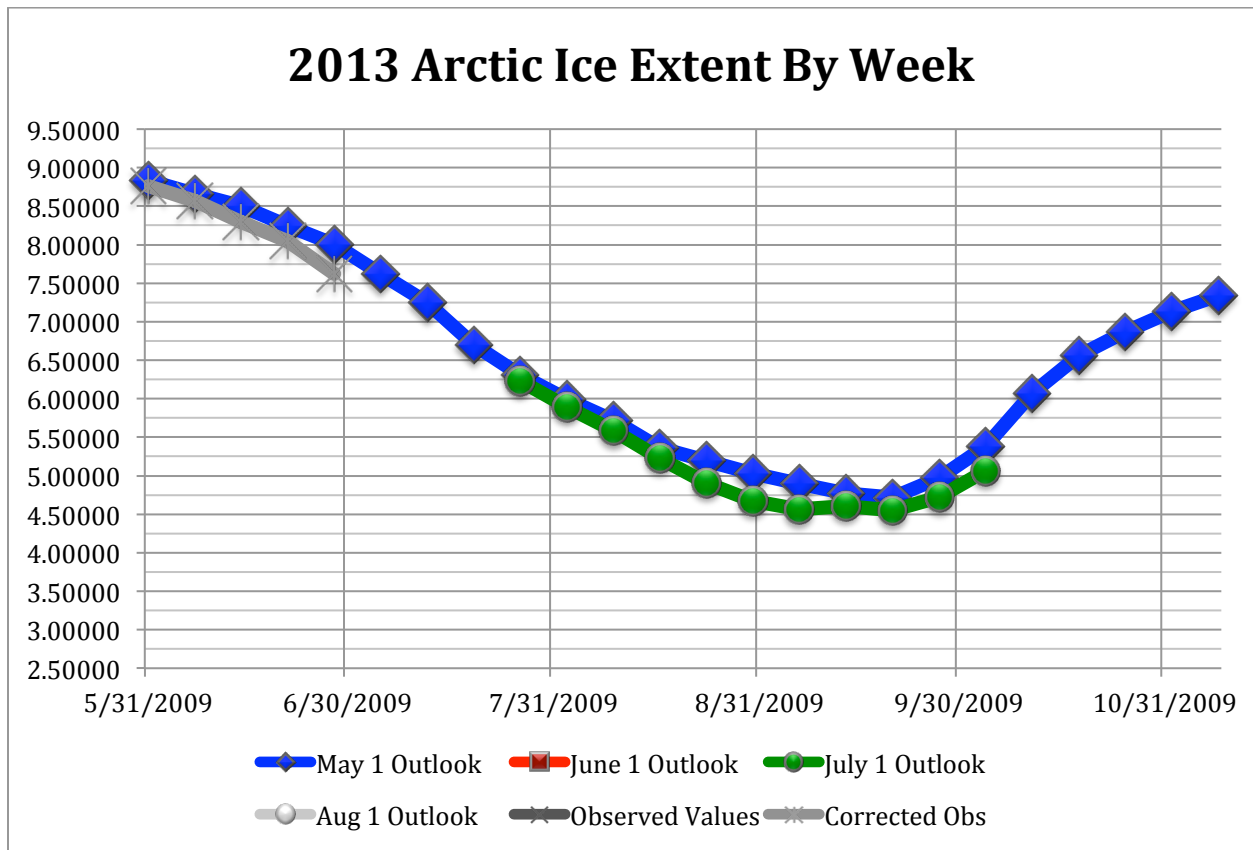
Figure 1: Projected 2013 sea ice extent by week, in millions of square kilometers.

Method: *Statistical*. A multi-linear regression model (NIC-ARIFS), initially developed at University of Colorado (Boulder, CO) and in use at the National Ice Center (Washington, DC),

correlates 10 years of historical SSM/I sea ice area (25km EASE grid), NCEP 2m air temperature analyses (global 1.8 degree resolution), NCEP sea level pressure analyses (global 2.5 degree resolution), and freezing degree days based on NCEP 2m air temperatures. For a given point, weekly-averaged conditions at the start date and projected date are compared over the past 10 years. Conditions at end end date at the point of interest are correlated against conditions at all points in the domain at the start date to produce a correlation map. A regression is performed against all 4 correlation matrices to produce a forecast ice extent value. The procedure is repeated for each grid point on a 25km EASE grid domain. The extent of sea ice is calculated by calculating the area with 10% or greater sea ice concentration, consistent with the World Meteorological Organization (WMO) definition and practiced by the National Ice Center and Canadian Ice Service. Waters with 0-10% sea ice are defined as "open water"; in order to be "ice free", there must be no ice of any kind; see, e.g., http://www.aari.nw.ru/gdsidb/docs/wmo/nomenclature/WMO_Nomenclature_draft_version1-0.pdf.

Ten ensemble model projections are run for each week from July 1 conditions, providing weekly outlooks through October 15, 2013. The minimum sea ice extent occurs the week of September 21, 2013.
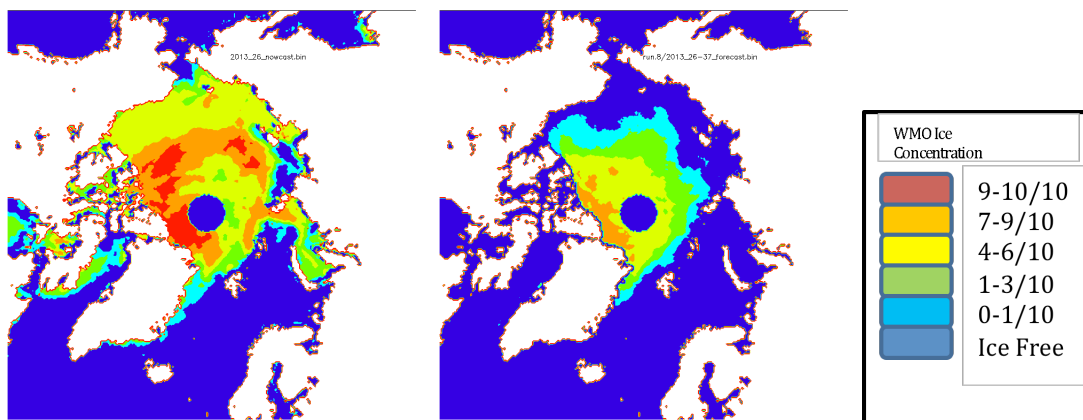

Figure 2: Observed SSM/I sea ice conditions on July 1, 2013 (the start date, right) and projected sea ice conditions on Sept 21, 2013(center). The WMO color code (right) is used. Conditions within the Canadian Arctic Archipelago and near the North Pole are not calculated. Ice extent is the total area within the 1-3/10 (green) contour (and includes the North Pole "hole"); The teal region is considered "open water" and not included in the projection of ice extent.

Rationale: The underlying assumption is that this year's summer sea ice conditions can be projected by comparing the conditions at the start and end date in recent years. The statistical relationships are derived from observations of physical values. ARIFS uses 25 km SSM/I sea ice extent (NSIDC-0051 and NSIDC-0081), global NCEP SLP and 2-meter Air Temperature analyses, and an estimate of freezing degree days based on NCEP and SSM/I data. The inclusion of freezing degree days, which are the cumulative number of days when the temperature is below freezing (1 freezing degree day = 1 day at -1 C, 10 freezing degree days = 10 days at -1 C, 5 days

at -2 C, 1 day, at -10 C, etc.) provide a proxy for ice thickness into the system (the larger the number of freezing degree days, the thicker the ice is expected to be). The inclusion of global air temperature and sea level pressure data allow for the possibility of lower-latitude teleconnections to be included in the correlations and projections.

Error Estimate:

(i) In order for a grid point to be considered, it must have contained sea ice at least once in the previous 10 years in either the initial or final values. For each forecast, values that have not had sea ice are masked out. Because each forecast point can be considered a linear combination of the previous 10 years of observed values, the forecast value cannot be higher than the maximum or lower than the minimum over the previous 10 years. Thus the model cannot project lower than any previous minimum; the likelihood of a record minimum will be seen by the robustness of the projected 2012 minimums with the July and August updates (see the Arbetter et al. contributions to the 2011 SIO, in which the observed minimum essentially tied the record low September sea ice extent of 2007).

(ii) The forecast model uses 25km gridded SSM/I ice concentration data as a predictor. These data underestimate ice concentration in summer and near the ice edge. The existence of open water and ponded ice and the large footprint of the passive microwave sensor affect the value of the brightness temperature observed by the sensor; the tendency is to underestimate the sea ice edge compare to other methods (eg synthetic aperture radar).

(iii) At 25 km, the model resolution is too coarse to consider ice conditions in the Canadian Arctic Archipelago; the projected value does not account for this. Once actual observations have been made; the model mask (which changes weekly) is applied to obtain a corrected value (Figure 1). Compared to observations, projections are lower than observed (Figure 3). But the model projections are directly comparable to the corrected observations.
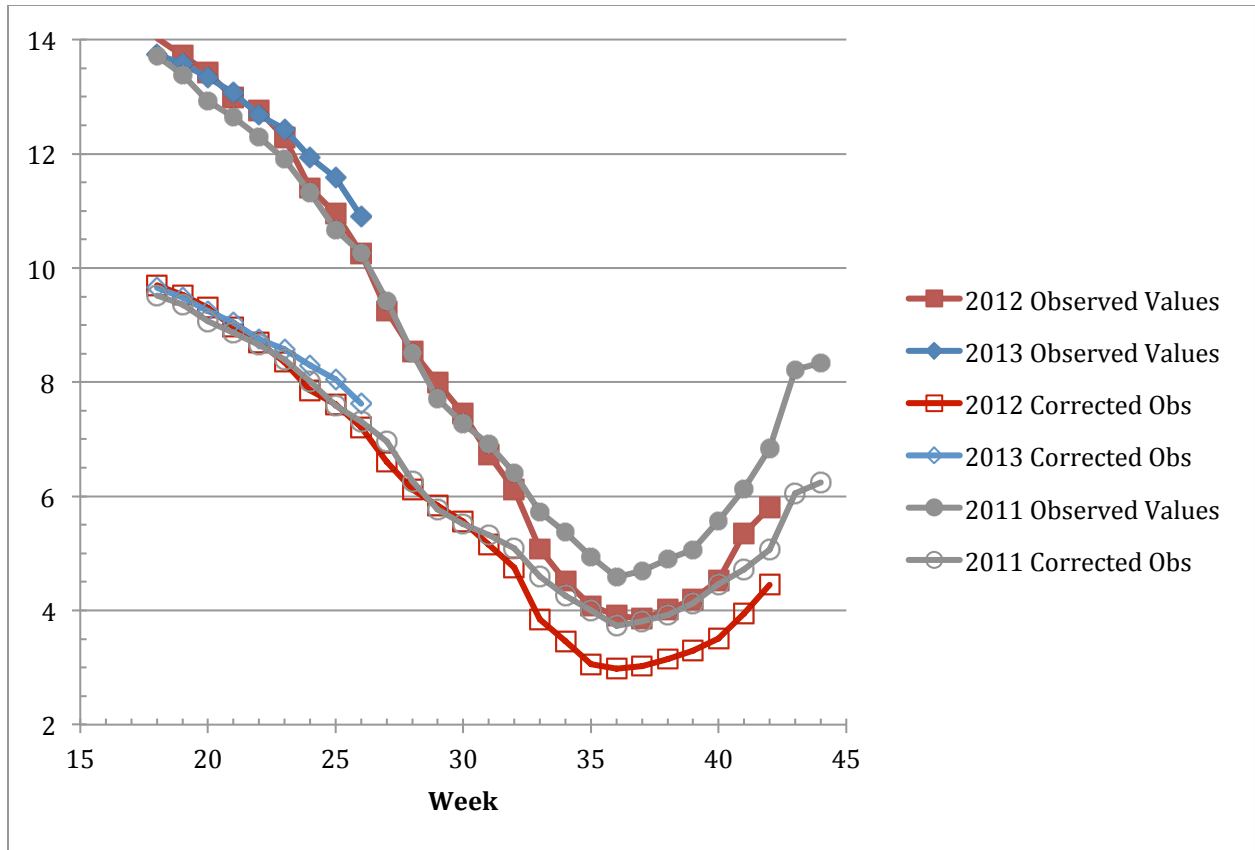
Figure 3: Time-series of observed ice extent (solid shapes) and corrected ice extent (hollow shapes) for summer 2011-2013. 2012 was the lowest summer sea ice extent recorded in the satellite era. 2011 minimum sea ice ice extent was nearly identical in magnitude to the previous record minimum set in September, 2007.