September 2010 Sea Ice Outlook: August Report

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Outlook for 2010 September Arctic Sea Ice Extent Minimum, August Update

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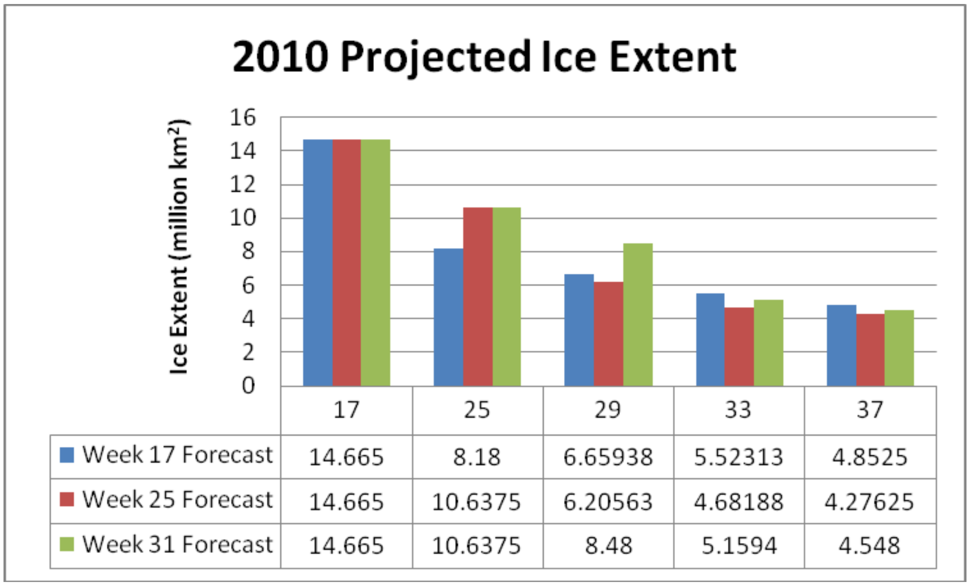
As in the June 1 Outlook, we used the most recent data available to produce a full forecast for the remainder of the summer. In this case we use week 31 data, 6 weeks later than the previous update. As in previous forecasts, we use NASA Team sea ice concentration, NCEP 2-meter air temperature, and NCEP Sea Level Pressure as predictors, and ice extent/concentration as the predictand. The statistical model used is the Arctic Regional Ice Forecast System, developed at the University of Colorado and being implemented operationally at the National Ice Center.

We again see a negative bias in the forecast values versus actual, reflecting the lack of predictive capability in the Canadian Archipelago, but note that the 2-week forecast (week 29) is much higher than in previous reports, and the final values, while lower than the initial (week 17) forecast, are higher than the week 25 update. Without a quantitative measure for the low bias, we can say that 4.548 million km^2 represents a lower bound on the predicted ice extent using this model, and the actual value may be somewhat higher. Thus while we will see another anomalously low year for sea ice extent, it will not be a new record, but the trend of severe ice retreat in the western Arctic and north of Eurasia will continue. However, the week 31 projections (Figure 2) suggests there will be some ice in the Northern Sea route and even the Kara Sea (although in low concentrations). This hints that previous projections of an open Northern Sea Route may have been optimistic. While we cannot predict the navigability of the Northwest Passage, there is every indication that M'Clure Strait will be blocked by heavy ice conditions while Amundsen Gulf will be accessible.

Also of note is the presence of some ice in the Chukchi Sea. This range (10-30%) is below what is typically measurable by SSM/I and AMSR-E satellite sensors, but it may be of sufficient thickness for the usual migration patterns of Pacific walrus, in which the females and cubs haul out on the ice floes over the shallow continental shelves while the males remain on the Siberian and Alaskan shore. This is in contrast to prior extreme years in which the ice retreated too far for females to feed, and there were reports of abandoned calves and malnourished females appearing on Wrangell Island and the continental coasts. The summer coastal walrus population included a mix of males and females, when normally they would remain segregated over the summer months.



	17	25	29	33	37
Week 17 Forecast	14.665	8.18	6.65938	5.52313	4.8525
Week 25 Forecast	14.665	10.6375	6.20563	4.68188	4.27625
Week 31 Forecast	14.665	10.6375	8.48	5.1594	4.548

Figure 1: Projected Arctic Sea Ice Extent over summer 2010, based on Week 17 conditions (blue), week 25 conditions (red), and week 31 conditions (green). Week 17 represents actual values for all 3 forecasts (i.e., nowcasts), while week 25 shows actual values for the week 17 and week 31 forecasts.

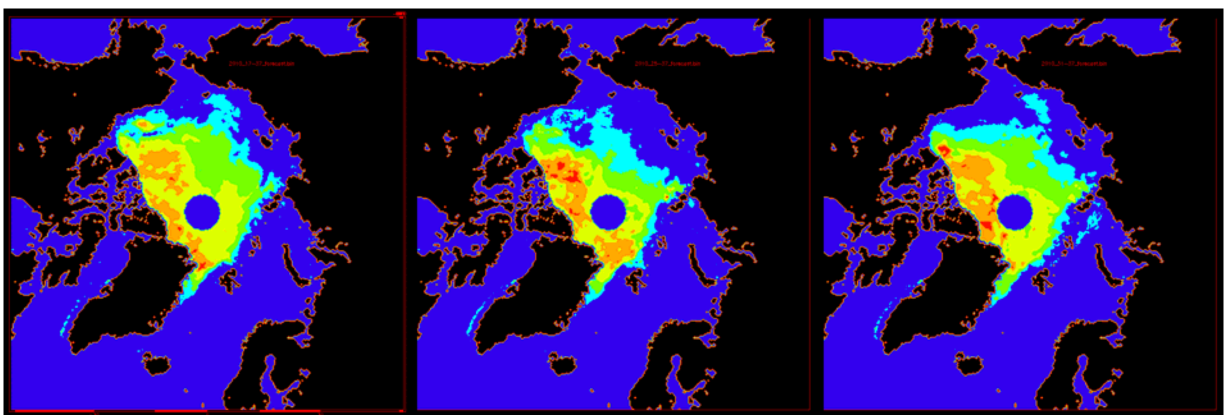


Figure 2: Progression of outlooks for September minimum ice extent for week 37 of 2010, as predicted in week 17 (left), week 25 (middle), and week 31 (right). WMO color codes are given in Figure 3.

Figure 3: WMO Sea Ice Color codes for Ice Concentration.

(CAVEAT: This is not an official National Ice Center forecast and should not be interpreted as advice for navigation. Only ice-capable ships with experienced ice pilots should attempt navigation in the Arctic, and should consult with local authorities for current ice conditions and navigational restrictions.)

2010 Sea Ice Outlook
August Update

Robert Grumbine
Xingren Wu
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The prior model-based prediction started from December, 2009 conditions. This one starts from April, 2010 conditions. As before, we adjust the raw output for the model's known bias towards high extent and thickness. After adjustment, the ensemble mean estimate is 4.60 million km^2 for September, down from the 5.13 of our first estimate. The 16 member ensemble's range is 4.37 to 4.94.

L. Hamilton August 16, 2010

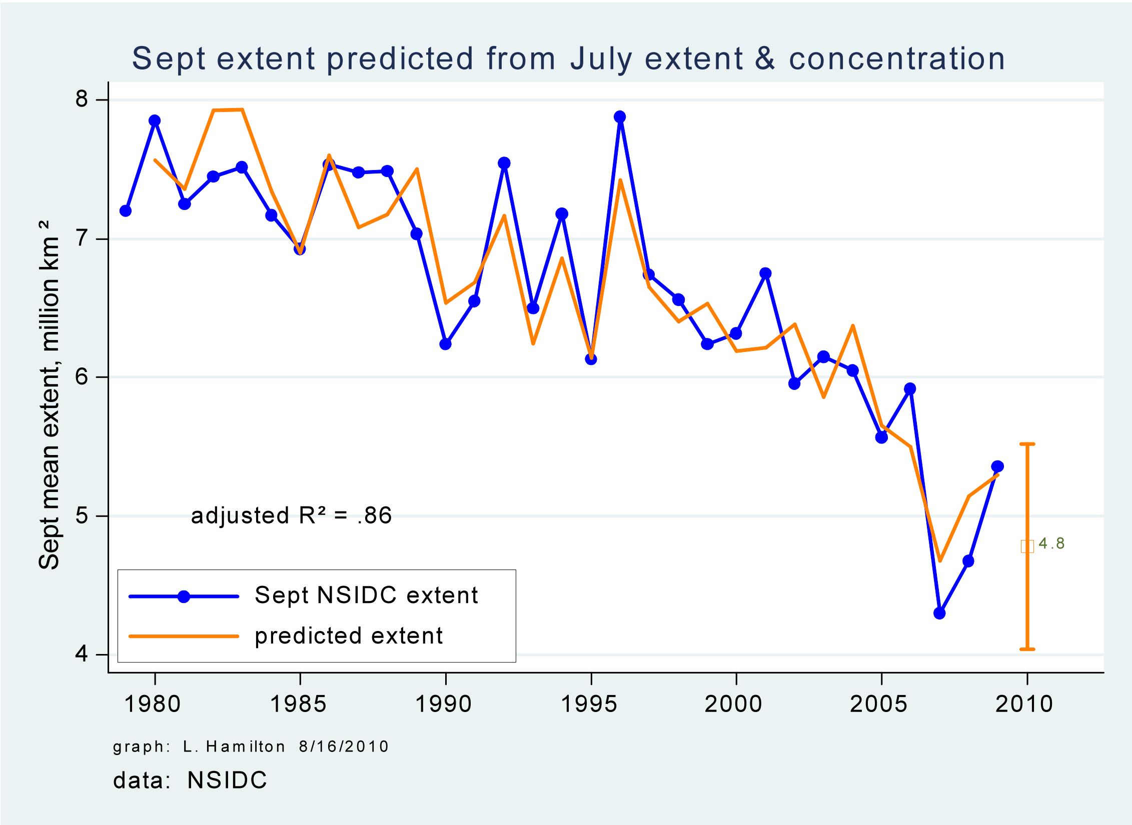
PAN-ARCTIC OUTLOOK — Hamilton

1. Extent Projection

Multiple regression analysis suggests a mean September 2010 ice extent of 4.8 million km^2 (NSIDC). The confidence interval for this forecast is 4.0 to 5.5 million km^2.

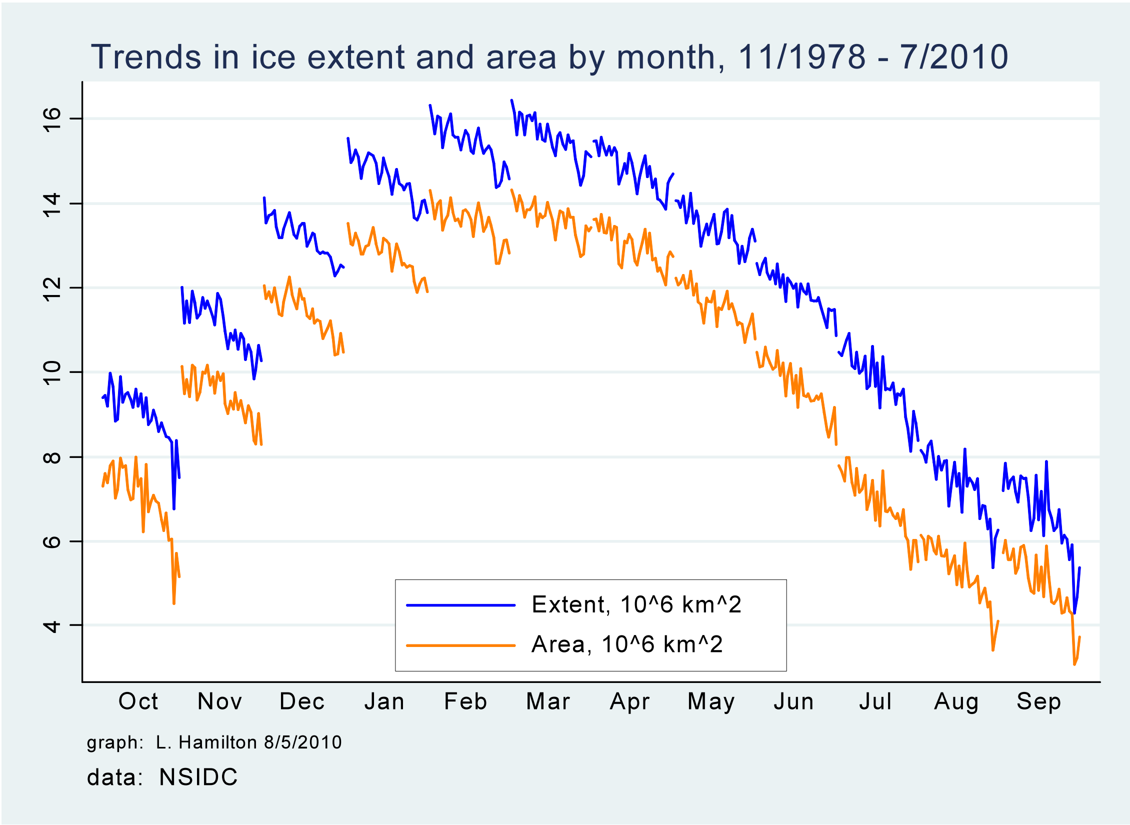
2. Methods / Techniques

The naive model used here is purely statistical. It predicts September mean extent from July extent, July concentration, and the previous year's September extent. Estimation data are the NSIDC monthly mean extent and area reports from November 1979 through July 2010.

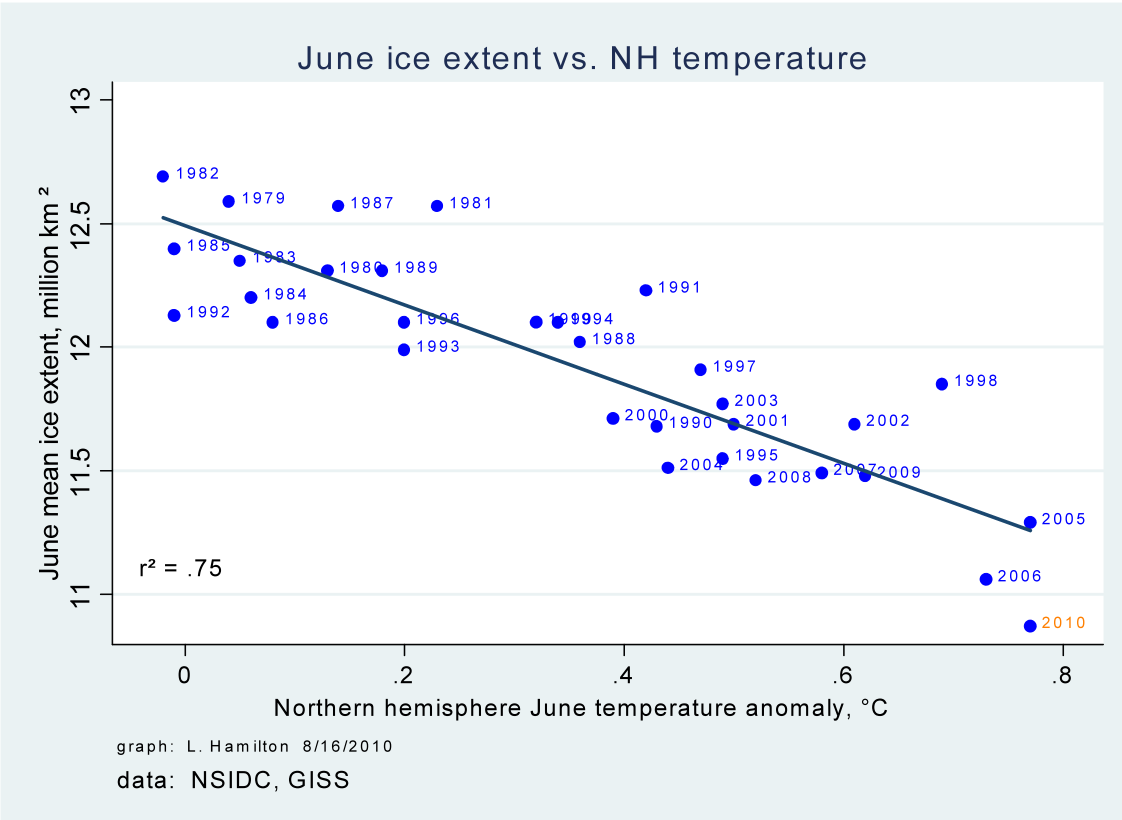


3. Rationale

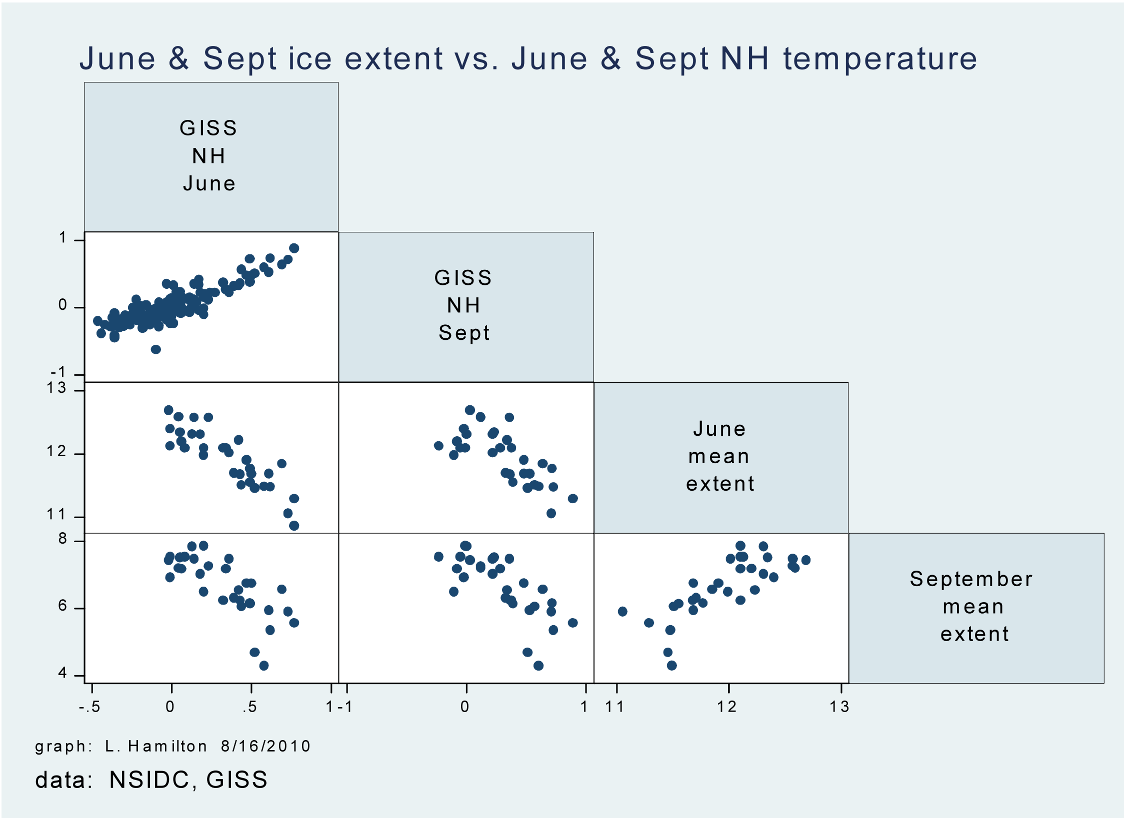
A cycle plot of monthly ice area and extent data, 1979–2010, highlights the strong pattern of decline in both area and extent, within each month of the year.



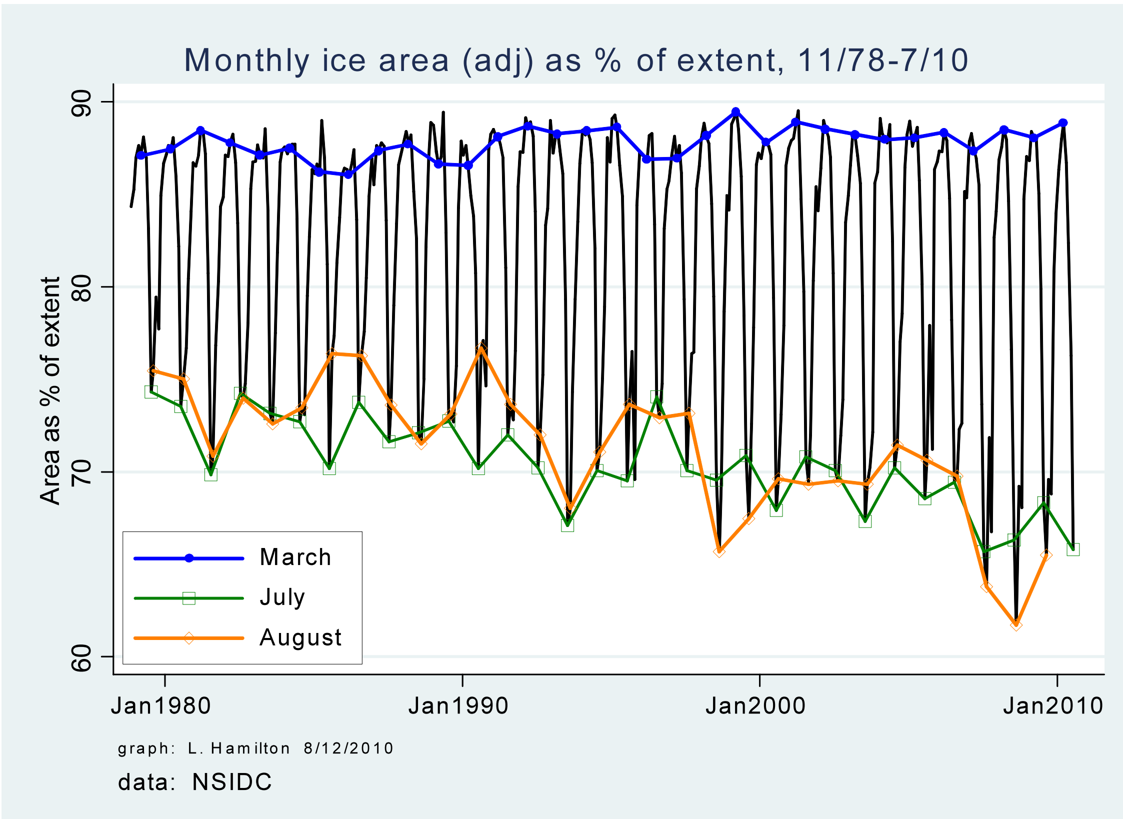
The cycle plot's monthly trends appear most uniform for June, which also turns out to be the month in which Arctic ice extent and area are most predictable from general Northern Hemisphere temperature.



September ice extent and area show more erratic variations than June, perhaps reflecting a relatively larger contribution from winds.



Concentration, here defined as mean area/mean extent, follows annual cycles with peaks just under 90% each March. Although maximum concentration has no apparent trend, the minimum concentration has been decreasing. The minimums occur in July or, more often in the last few years, in August. July 2010 concentration was the lowest ever for July, and this measure (along with July area, and previous September area) proves to be a significant predictor in our regression model.




```
. regress ext9 ext7  conc7 L1.ext9

      Source |       SS       df       MS              Number of obs =      30
-------------+------------------------------           F(  3,    26) =   58.88
       Model |  20.1110446     3  6.70368154           Prob > F      =  0.0000
    Residual |   2.9601701    26  .113852696           R-squared     =  0.8717
-------------+------------------------------           Adj R-squared =  0.8569
       Total |  23.0712147    29  .795559128           Root MSE      =  .33742

------------------------------------------------------------------------------
        ext9 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        ext7 |    .715886   .1529556     4.68   0.000     .4014813    1.030291
       conc7 |    .133224   .0407675     3.27   0.003     .0494251    .2170228
     L1.ext9 |   .1763631   .0919588     1.92   0.066    -.0126609     .365387
       _cons |  -10.93657   2.090988    -5.23   0.000    -15.23465   -6.638481
------------------------------------------------------------------------------
```

4. Executive Summary

September ice extent 1980–2009 has been reasonably well predicted (86% of variance explained) by July ice extent, July ice concentration, and September extent from the previous year. Additional predictors such as other months or temperature measures do not significantly improve the fit. There is no residual autocorrelation.

This naive statistical model yields a predicted mean September extent of 4.8 (or 4.0 to 5.5) million km^2.

June ice extent appears more predictable than September, a pattern that deserves further study.

Sea ice outlook 2010

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July 14, 2010

1 Extent Projection

We estimate a September 2010 monthly mean extent of **5.2 ± 0.1 million square kilometers**.

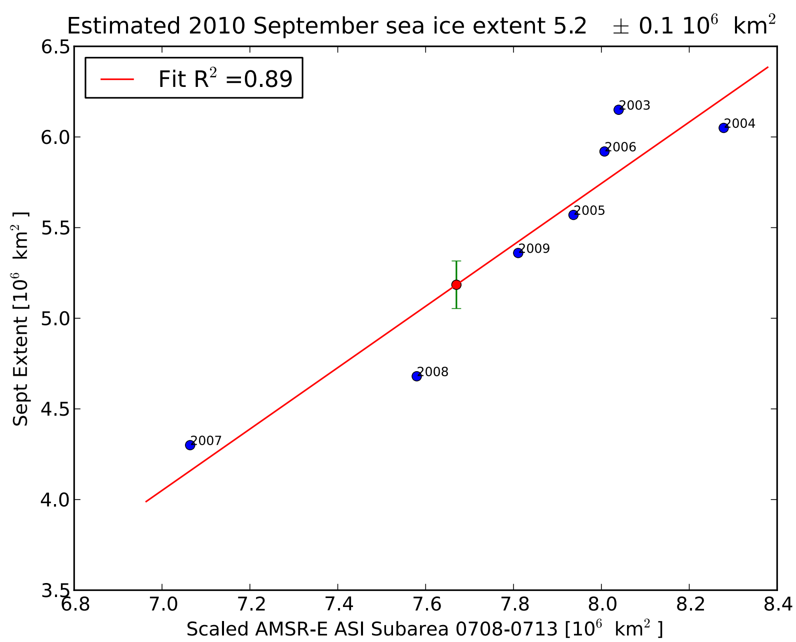


Figure 1: September 2010 sea ice extent estimate. Daily updates are available at ftp://ftp-projects.zmaw.de/seaice/prediction/

2 Methods and Techniques

The estimate is based on AMSR-E sea ice concentration data on a 6.25 km grid derived using the ARTIST sea ice (ASI) algorithm (Spreen et al., 2008; Kaleschke et al., 2001). We used two different sea ice concentration data sets, one based on the reprocessed gridded level 3 AMSR-E brightness temperatures for the years 2003-2010 (`ftp://ftp-projects.zmaw.de/seaice/AMSR-E_ASI_IceConc/`), the other is based on near-real-time AMSR-E level 1b brightness temperatures. Because the level 3 data is available only with some delay the level 1 data are used for the most recent year.

A five day median filter is applied on the data to reduce the atmospheric influence and coastal spillover effects (Kern et al., 2010; Maaß et al., 2010). Thus, any dates given below are not exactly for the individual day but include the previous four days.

To obtain an estimate we regress the ice area from the Arctic subregion shown in Figure 2 with the previous years and their September mean extents. As shown in Figure 2 the considered region contains the central Arctic and some of the Arctic marginal seas but excludes the multiyear sea ice region north of Greenland and the North Pole. To be able to regress the original AMSR-E sea ice area with the mean September sea ice extent two scalings are applied. First the 11-15 September five day median filtered sea ice area of the Arctic subregion for years 2003 to 2009 are regressed with the according mean September sea ice extent taken from NSIDC (Fetterer et al., 2002, updated 2009) (Figure 3). And second the near real time and reprocessed AMSR-E ice concentrations are scaled to each other to account for the small differences between the two datasets (Figure 4). Using these scalings the mean September sea ice extent is estimated from the current five day median sea ice area and the sea ice area of the same five day period of years 2003 to 2009 (Figure 1).

3 Rationale

Our assumption is that the Arctic sea ice is on decline with a constant trend over the last few years. In addition there is interannual variability due to the weather.

A hindcast experiment for last year was conducted to test the performance of the new method. The correlation between September mean extent and the selected training area increases as the time difference decreases. In 2009 the correlation R^2 increased from insignificant values earlier in Spring to values around $R^2 \approx 0.5$ at the the end of May (Figure 5).

The standard error of the prediction σ dropped from ± 4 million square kilometers to values below ± 1 million square kilometers after June 10 (Figure 6). As the deviation from the observed value is signifcantly smaller than the standard error we define its half as our uncertainty.

The prediction skill depends on the selected training area. The skill increased when we removed some of the seasonal ice covered areas in our analysis (Figure 6).

From this hindcast experiment we deduce that reliable forecasts seem to be possible in mid-June. Some predictive skill exists already at the end of May.

With the additional processing steps we considerably reduce the observational noise and improve the prediction skill as compared to our last years attempts using SSM/I data. The higher spatial resolution of AMSR-E compared to SSM/I allows to better resolve small scale sea ice openings like coastal polynyas. The size and number of these openings might inhere some predictive capability for the sea ice minimum. Which could explain parts of the improvement achieved in comparison to using SSM/I data.

4 Executive Summary

Our outlook is based on statistical analysis of satellite derived sea ice area. We introduced following improvements: high resolution (AMSR-E) sea ice concentration data, a time-domain filter that reduces observational noise, and a space-domain selection that neglects the outer seasonal ice zones. Thus, small scale sea ice openings like coastal polynyas that might inhere some predictive capability for the sea ice minimum can be better utilized.

References

Fetterer, F., K. Knowles, W. Meier, and M. Savoie (2002, updated 2009). *Sea Ice Index*, 1972-2009. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

Kaleschke, L., C. Lüpkes, T. Vihma, J. Haarpaintner, A. Bochert, J. Hartmann, and G. Heygster (2001). SSM/I Sea Ice Remote Sensing for Mesoscale Ocean-Atmosphere Interaction Analysis, *Can. J. Rem. Sens.*, 27(5), 526-537.

Spreen, G., L. Kaleschke, and G. Heygster (2008). Sea ice remote sensing using AMSR-E 89-GHz channels, *J. Geophys. Res.*, 113, C02S03, doi:10.1029/2005JC003384.

Kern, S., L. Kaleschke, and G. Spreen (2010). Climatology of the Nordic (Irminger, Greenland, Barents, Kara and White/Pechora) Seas ice cover based on 85 GHz satellite microwave radiometry: 1992-2008.Tellus A, Published Online: Apr 19 2010, DOI: 10.1111/j.1600-0870.2010.00457.x

Maaß N., and L. Kaleschke (2010). Improving passive microwave sea ice concentration algorithms for coastal areas: applications to the Baltic Sea. Tellus A, Published Online: Apr 1 2010, DOI: 10.1111/j.1600-0870.2010.00452.x

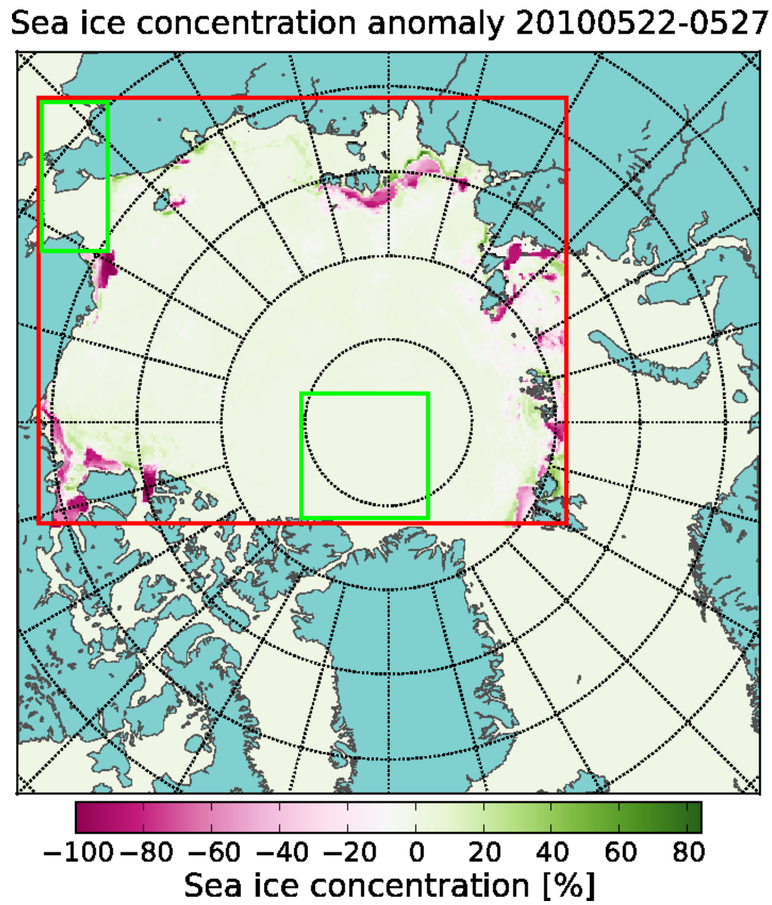


Figure 2: 2010 sea ice concentration anomaly derived from AMSR-E ASI data. The anomaly is calculated with respect to the years 2003–2009. The red rectangle indicates the subset for calculation of the ASI AMSR-E sea ice area. The green rectangles indicates areas that are not taken into account.

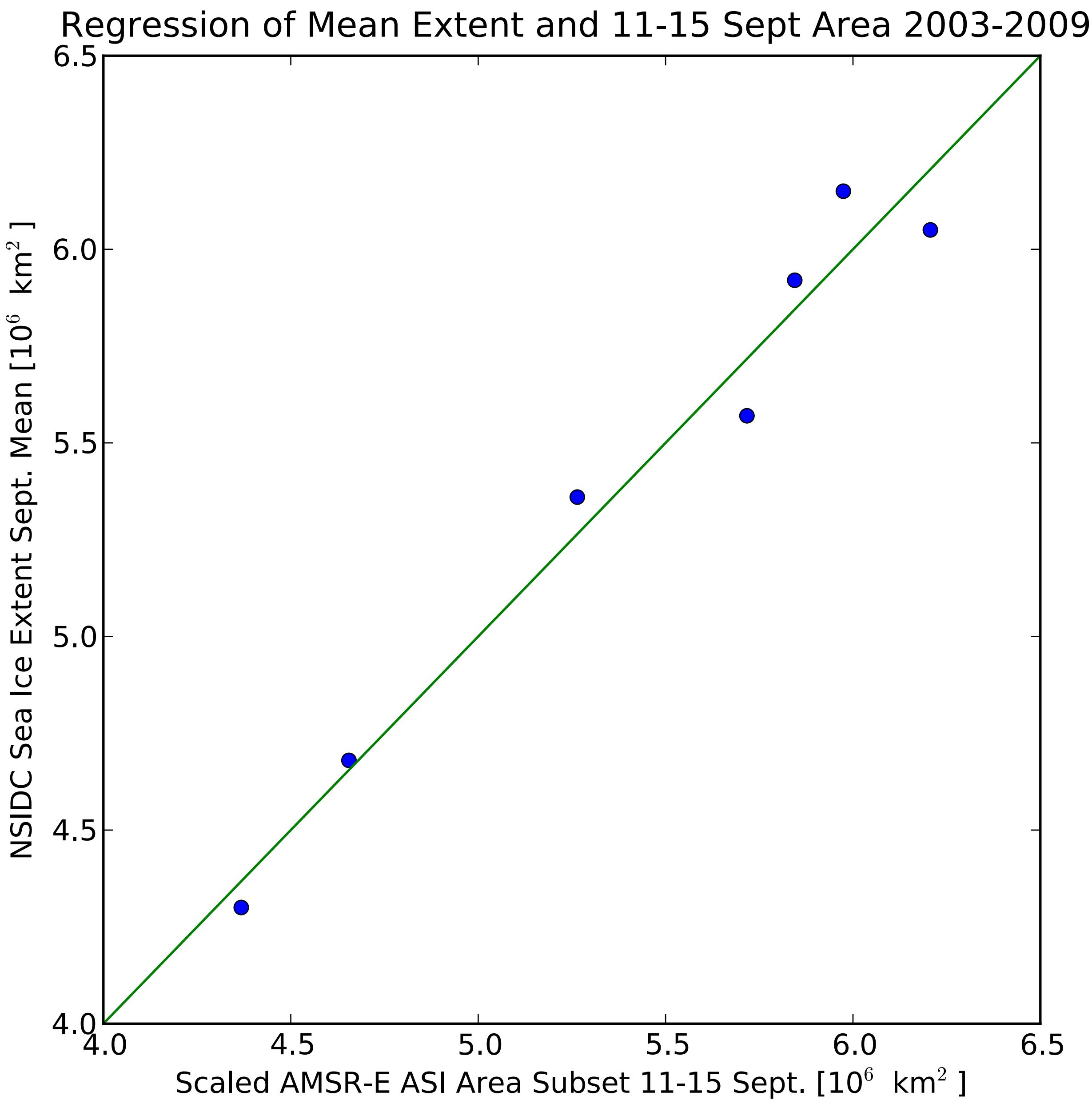


Figure 3: Regression of regional (region shown in Fig. 2) five-day median filtered AMSR-E ASI area and total NSIDC September mean extent.

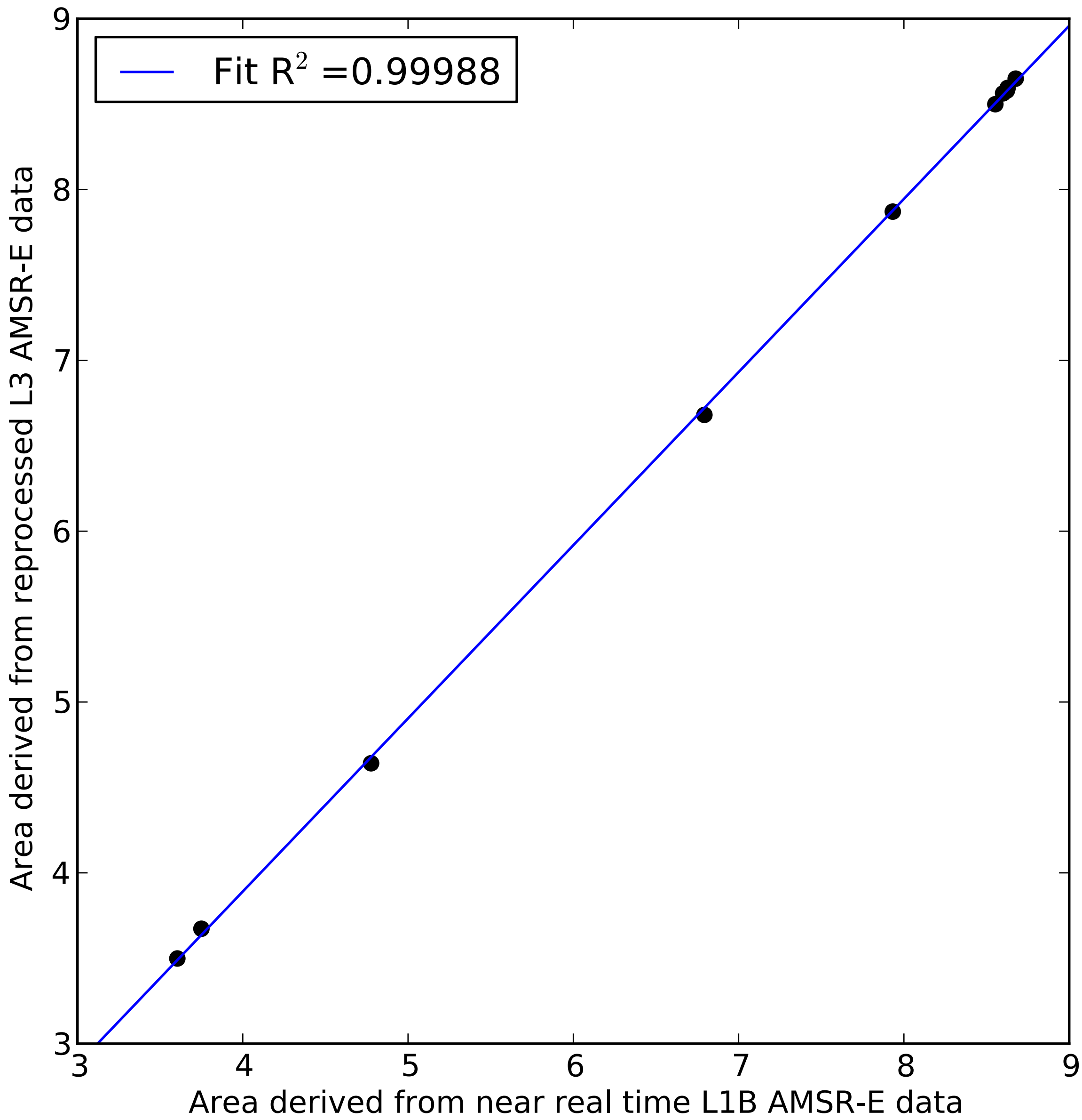


Figure 4: Regression of near real time and reprocessed data.

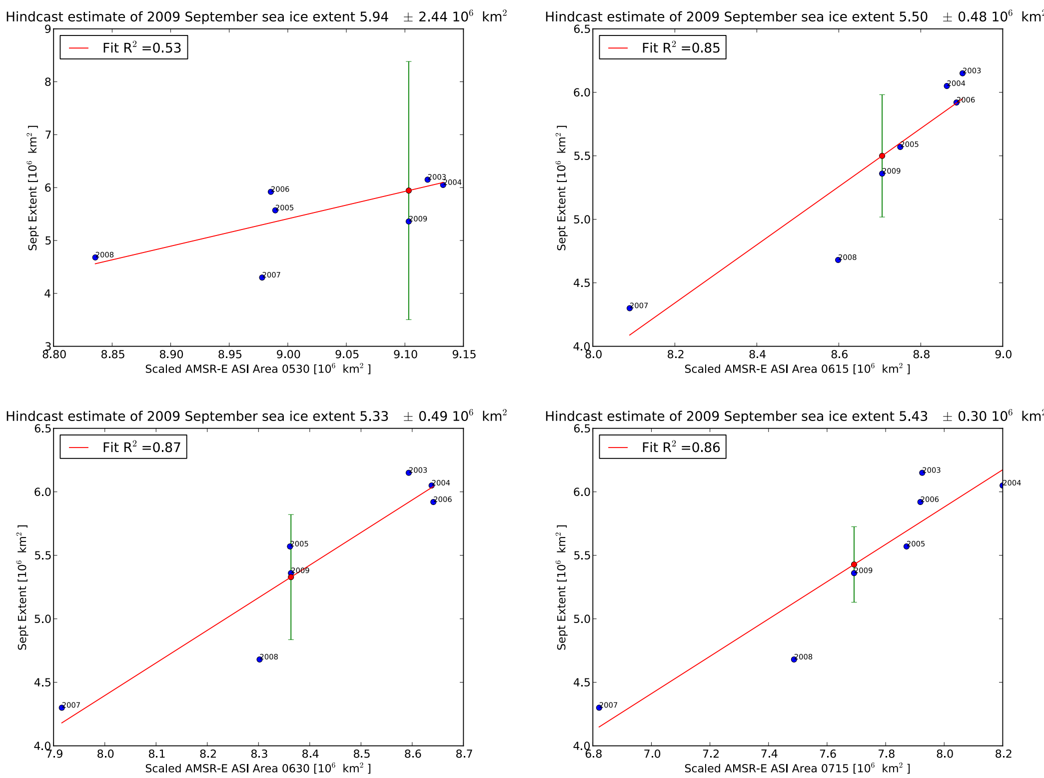


Figure 5: Hindcast prediction for September 2009.

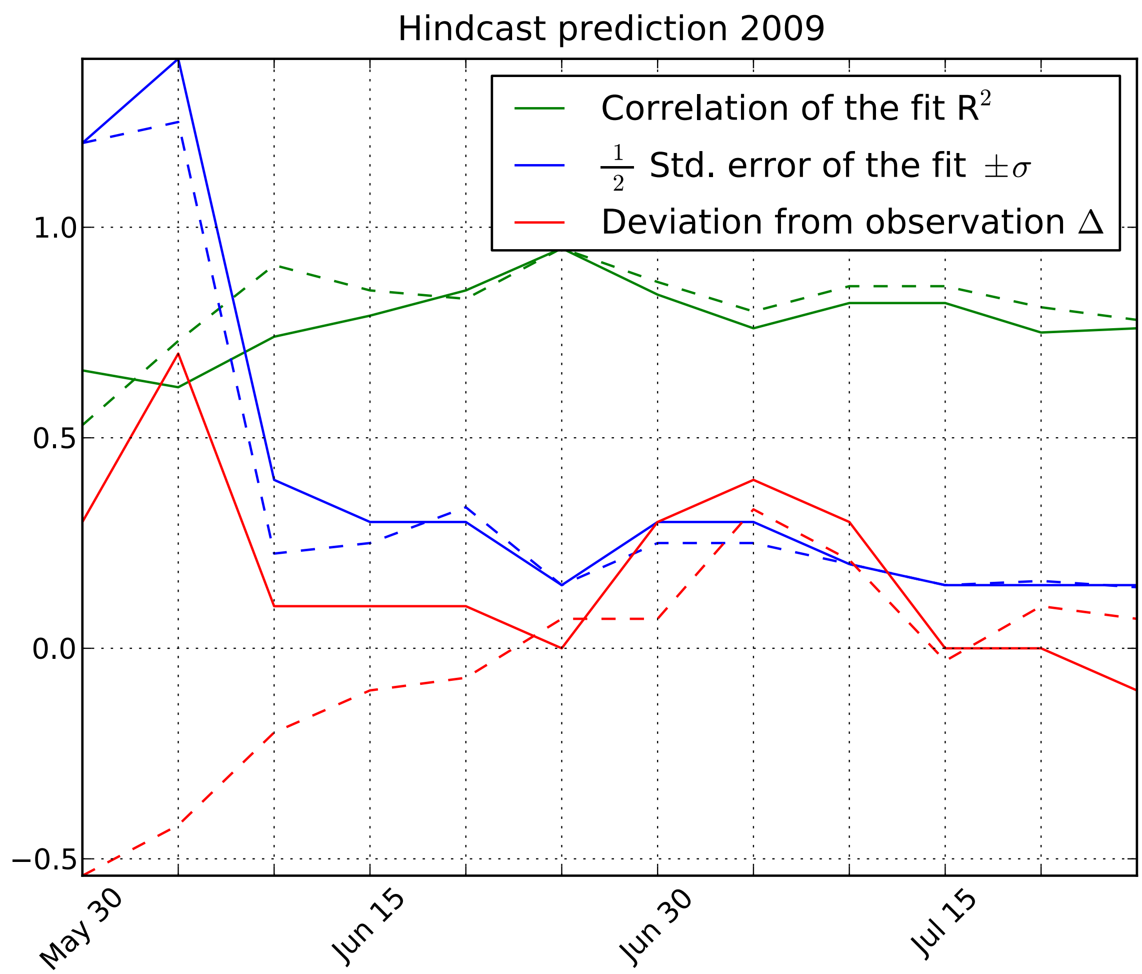
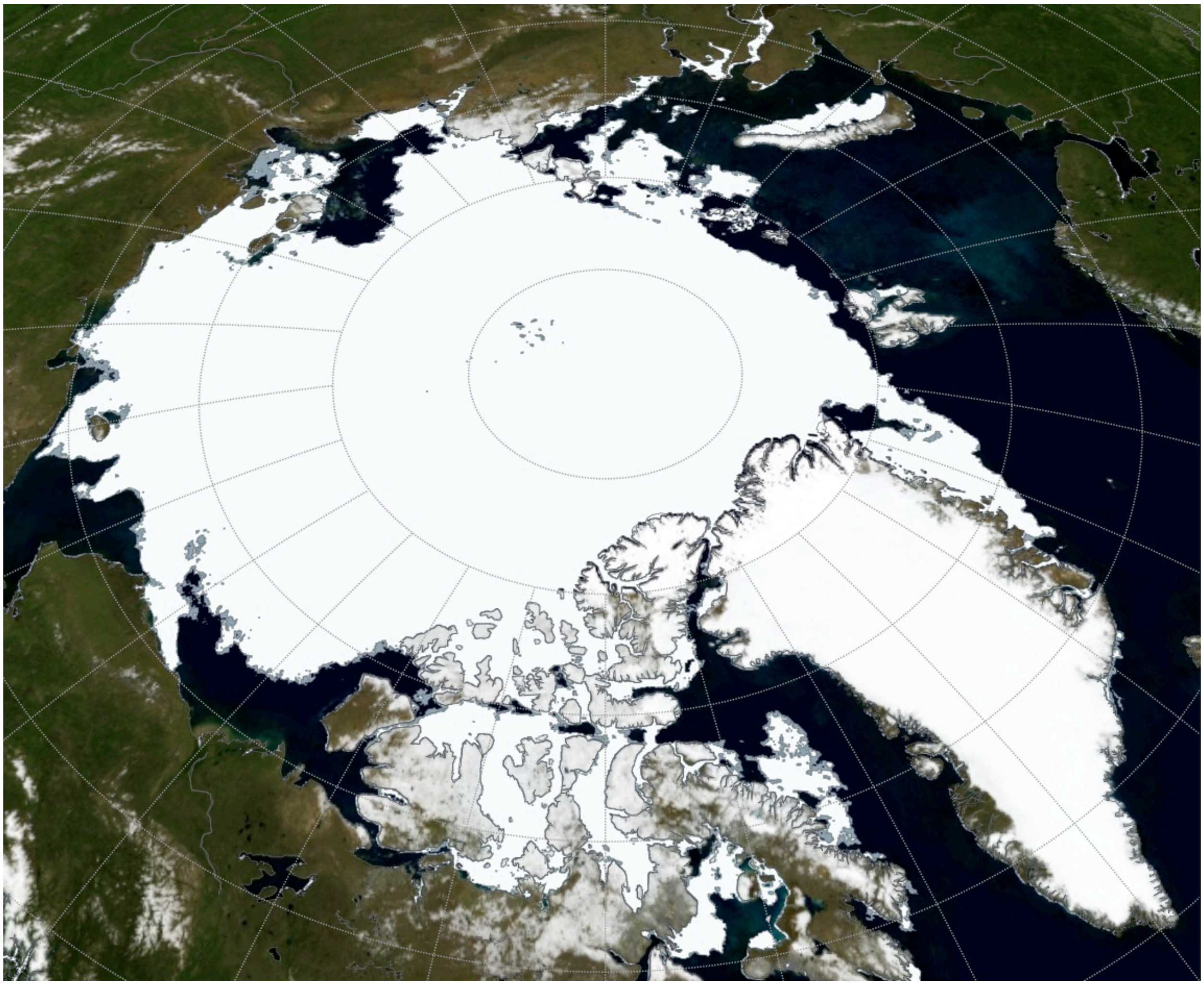


Figure 6: Hindcast prediction for September 2009. The results for the solid and dashed lines are for different training areas (see 2).



Recent AMSR-E map.

August 2010 Sea Ice Outlook – AWI/FastOpt/OASys contribution

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T. Kaminski[c], R. Giering[c], M. Vossbeck[c]

August, 2010

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As for the SIO of June and July 2010 we make use of the 4DVar data assimilation system NAOSIMDAS to perform an additional set of ensemble experiments starting from an initial state determined via data assimilation.

Experimental setup

For the present outlook the coupled ice-ocean model NAOSIM has been forced with atmospheric surface data from January 1948 to July 29th 2010. This atmospheric forcing has been taken from the NCEP/NCAR reanalysis (Kalnay et al., 1996). We used atmospheric data from the years 1990 to 2009 for the ensemble prediction. The model experiments all start from the same initial conditions on July 29th 2010. We thus obtain 20 different realizations of sea ice development in summer 2010. We use this ensemble to derive probabilities of ice extent minimum values in September 2010.

As in the June and July 2010 outlook two ensemble experiments with different initial conditions on July 29th 2010 were performed:

Ensemble I starts from the state of ocean and sea ice taken from a forward run of NAOSIM driven with NCEP/NCAR atmospheric data from January 1948 to July 29th 2010.

Ensemble II starts from an optimised state derived by NAOSIMDAS with an assimilation window from March 1, 2010 to July 29th 2010. The following observational data streams were assimilated:

- Hydrographic data from Ice Tethered Platform profilers (http://www.whoi.edu/page.do?pid=20756) which have been deployed as part of several IPY initiatives, covering part of the central Arctic Ocean
- Hydrographic data from ARGO profilers provided by the CORIOLIS data center (http://www.coriolis.eu.org/cdc/default.htm) mostly covering the Nordic Seas and the northern North Atlantic Ocean
- Daily mean ice concentration data from the MERSEA project, based on multi-sensor SSM/I analysis, kindly provided by Steinar Eastwood (OSI-SAF, met.no), with a spatial resolution of 10 km.

- Two-day mean ice displacement data for March to April from merged passive microwave (SSM/I, AMSR-E) or scatterometer (e.g. ASCAT) signals, which were kindly provided by Thomas Lavergne (OSI-SAF, met.no), with a spatial resolution of 62.5 km.

The 4DVar assimilation minimizes the difference between observations and model analogues, by variations of the model's initial conditions on March 1st and the surface boundary conditions (wind stress, scalar wind, 2m temperature, dew-point temperature, cloud cover, precipitation) from March 1st to July 29th 2010.

Brief comparison of 'free' versus 'optimized' initial state

Figure 1 displays the modeled ice concentration on July 29th 2010 for the "free" run and the run with data assimilation. We have expected that the benefit of the data assimilation will become more obvious in the August outlook (see June and July report). The ice thickness on July 29th 2010 (Fig. 2) exhibits major adjustments in the Eurasian basin and minor adjustments in the Canadian basin.

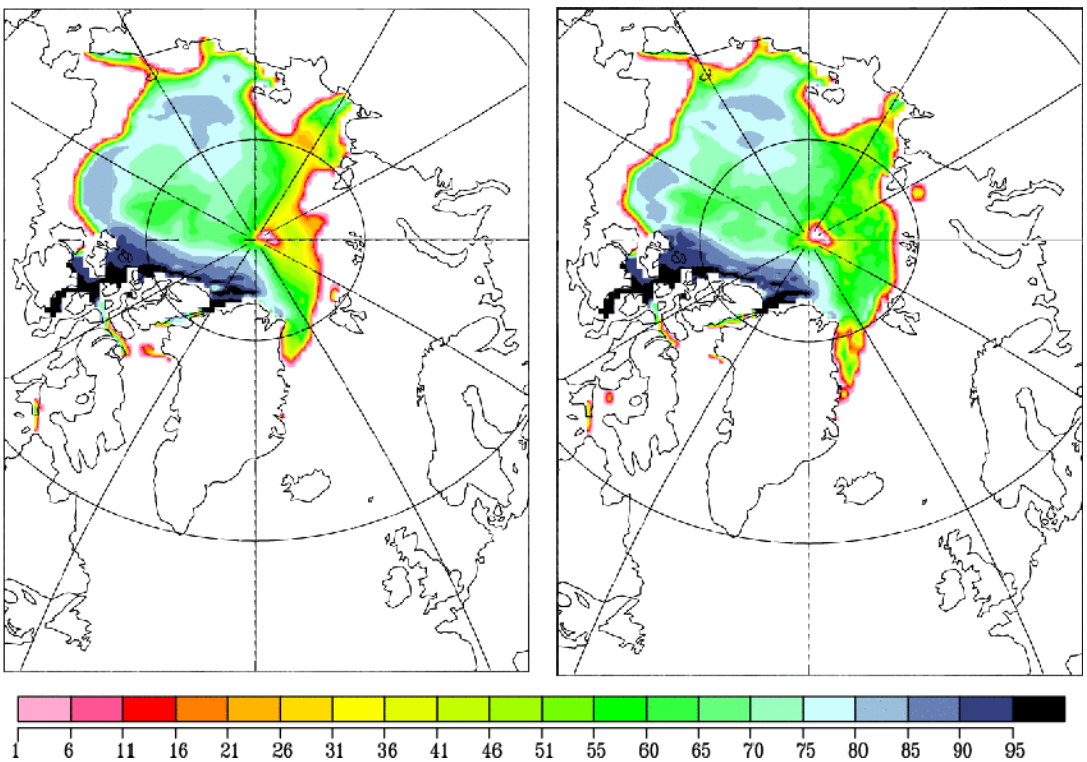

Fig. 1: The ice concentration [%] at the 29th of July 2010 in case of the "free" run (left) and in case with data assimilation (right).

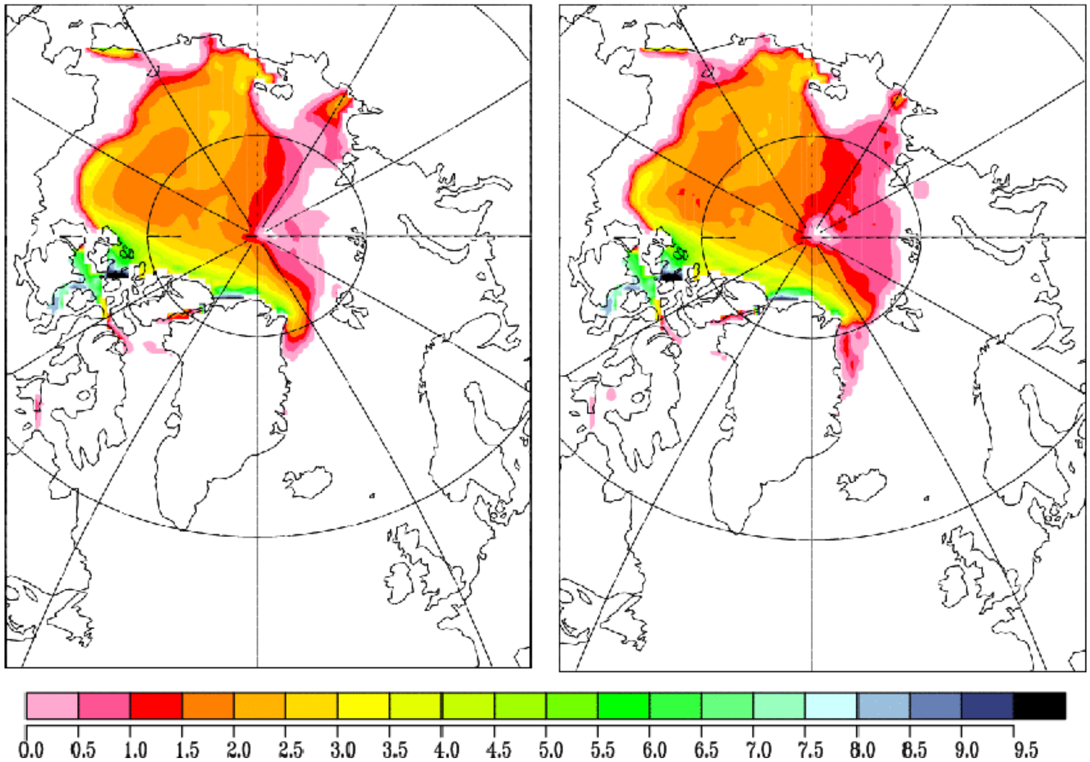

Fig. 2: The ice thickness [m] at the 29th of July 2010 in case of the "free" run (left) and in case with data assimilation (right).

Mean September Ice Extent 2010

Ensemble I (no assimilation)

The result for all 20 realizations ordered by the September ice extent is shown in Figure 3. Since the forward simulation underestimates the September extent compared with the observed extent minima in 2007, 2008, and 2009 by about 0.49 million km^2 (in the mean), we added this bias to the results of Ensemble I (see our June outlook).

The Ensemble I mean value is 5.65 million km^2 (bias included). The standard deviation of Ensemble I is 0.22 million km$^{2.}$. Assuming a Gaussian distribution we are able to state probabilities (percentiles) that the sea ice extent in September 2010 will fall below a certain value.

The probability deduced from **Ensemble I** that in 2010 the ice extent will fall below the three lowest September minima:

probability to fall below 2007 (record minimum) is below 1%,
probability to fall below 2008 (second lowest) is below 1%,
probability to fall below 2009 (third lowest) is about 9%.

With a probability of 80% the mean September ice extent in 2010 will be in the range between 5.37 and 5.93 million km^2.

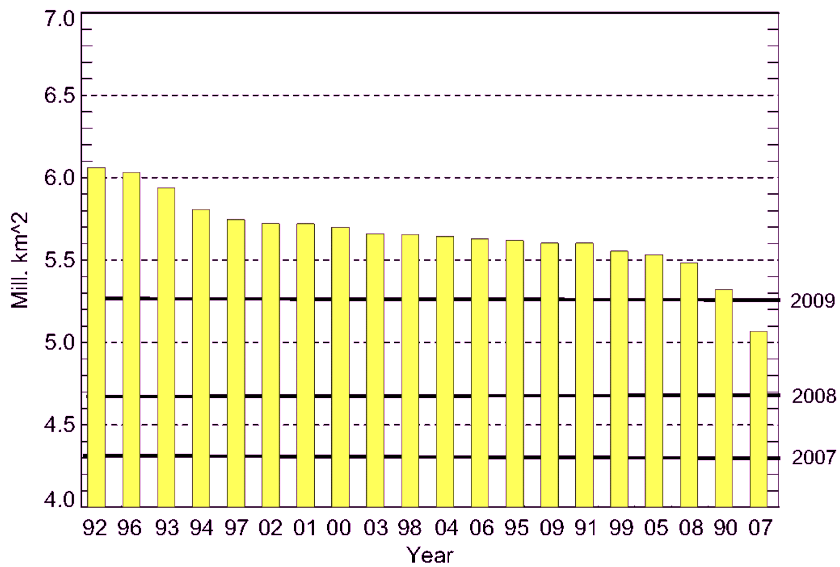

Figure 3: ***Ensemble I*** *- Simulated mean September ice extent in 2010 [million km^2] when forced with atmospheric data from 1990 to 2009 (initial state on July 29th 2010). Model derived ice extents have been adjusted assuming a systematic bias (see text). The thick black horizontal lines display the minimum ice extent observed in 2007, 2008 and 2009.*

Ensemble II (initial state from data assimilation)

The mean September sea ice extent for all 20 realizations starting from optimized initial conditions is shown in Figure 4. In this setup we expect the observations to correct the bias that was present in the free run. Therefore in ensemble II, in contrast to ensemble I, we do not explicitly correct for a bias.

The Ensemble II mean is 5.60 million km^2. The standard deviation of Ensemble II is also 0.22 million km^2.

<u>The probability deduced from **Ensemble II** that in 2010 the ice extent will fall below the three lowest September minima:</u>

<u>probability to fall below 2007 (record minimum) is below 1%,</u>
<u>probability to fall below 2008 (second lowest) is below 1%,</u>
<u>probability to fall below 2009 (third lowest) is about 12%.</u>

<u>With a probability of 80% the mean September ice extent in 2010 will be in the range between 5.32 and 5.88 million km^2.</u>

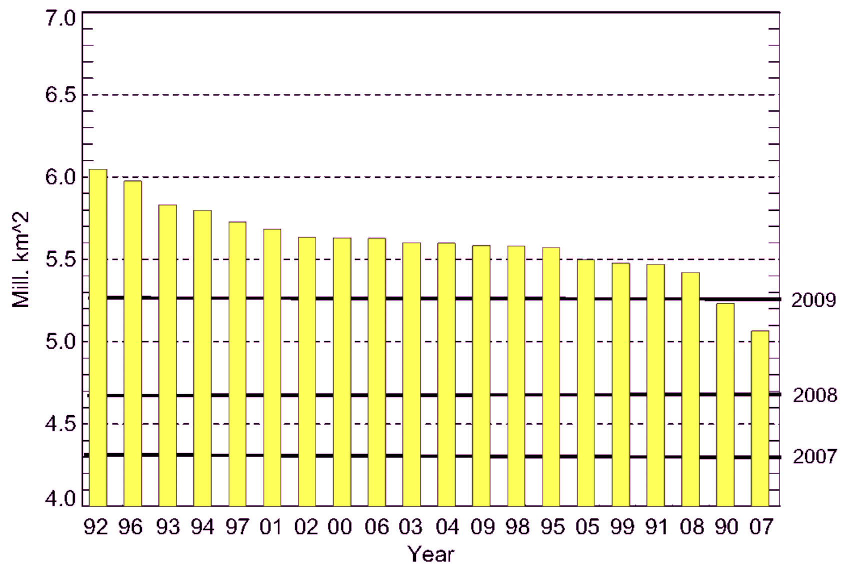

Figure 4: ***Ensemble II*** *- Simulated mean September ice extent in 2010 [million km*^{2}*] when forced with atmospheric data from 1990 to 2009 from the initial state on July 29*th *2010 with data assimilation. The thick black horizontal lines display the minimum ice extent observed in 2007, 2008 and 2009.*

Discussion – back to before 2007 situation?

The June and July outlook yielded a difference between Ensemble I and Ensemble II of about 0.42 and 0.45 million km^2, respectively. This difference has nearly vanished for the August outlook, i.e. the bias correction applied in Ensemble I and the data assimilation utilized in Ensemble II give almost the some result.

Overall the August outlook confirms the June and July outlook – it is very likely that the mean September ice extent will be higher than in 2009 and hence will be similar to the prior to 2007 situation.

References:

Kalnay et al. (1996), The NCEP/NCAR 40-year reanalysis project, Bull. Amer. Meteor. Soc., 77, 437-470.

2010 Sea Ice Outlook
July Report

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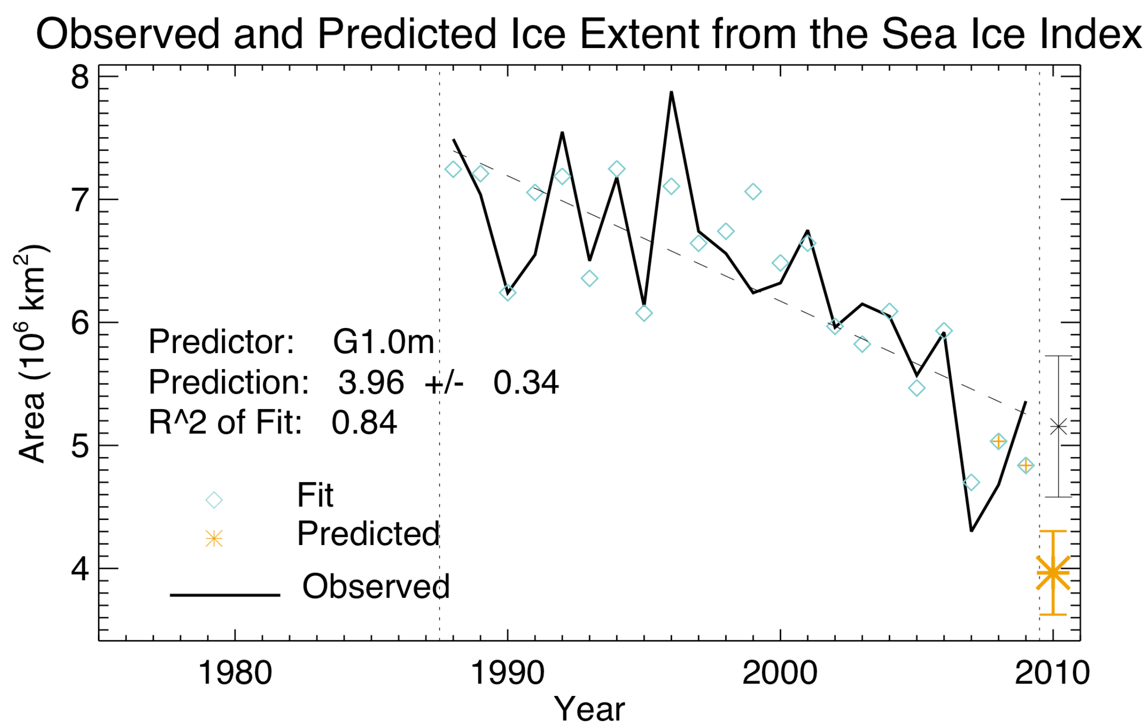
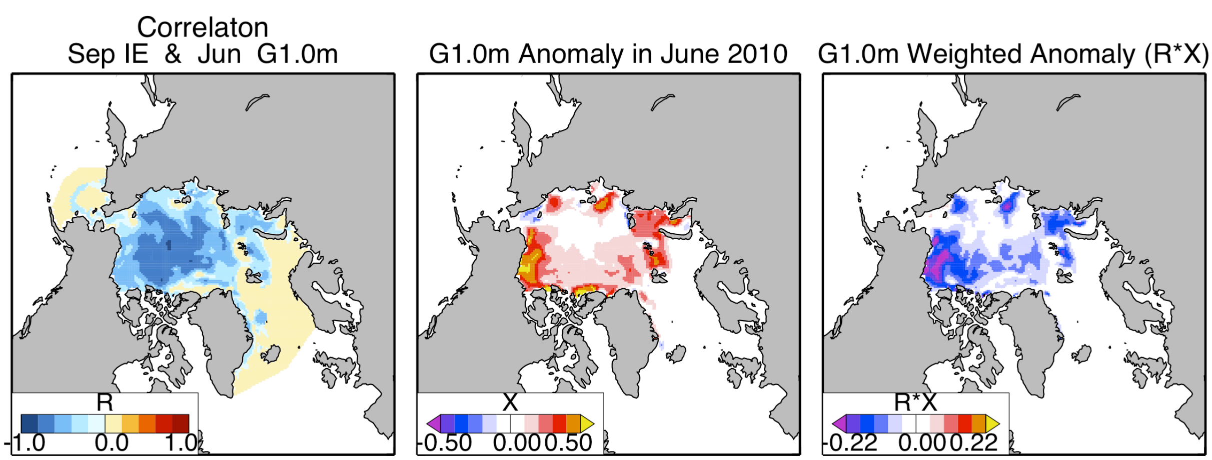
End of June: According to our model retrospective simulations, the ice in the Arctic has continued to thin at a remarkable rate. The statistical method based on the PIOMAS model analysis now is projecting a new record low ice extent. The best predictors are G1.0 (area with less than 1.0 m of ice) and G0.4 (area with less than 0.4 m of ice) which give nearly identical results. Using the same one as last month (G1.0) **the predicted extent is 3.96 +/- 0.34 million square kilometers**. The R2 value for this predictor is 0.84, which now indicates a high degree of skill in the forecast. Here is the diagnostic plot for this month:

Predictions for September 2010 from June





Sea ice outlook in 2010: Atmospheric forcing and sea ice extent

July Report

Jennifer V. Lukovich[1], Matthew G. Asplin[1], David G. Barber[1]

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1) Extent projection

Estimate for sea ice extent for September, 2010; less than the value for the 2007 minimum in sea ice extent , with a value on the order of $\sim 4.0 \cdot 10^6 km^2$.

2) Methods/Techniques

A heuristic assessment of the surface, stratosphere and ice conditions in 2010 relative to 2007 atmospheric and ice conditions in June provides the basis for a projection of sea ice extent less than the record minimum in ice extent encountered in September, 2007. Comparison of SAT and SLP anomalies, in addition to temperature anomalies at 850 mb for 2007 and 2010 relative to the 1979 – 2010 climatological mean highlight differences in near-surface atmospheric conditions leading up to the minimum in summertime ice extent. Upper atmospheric contributions to sea ice extent are examined in the context of relative vorticity to highlight variations in wintertime preconditioning events when the cold core polar vortex governs surface phenomena (Hare, 1968; Overland, 2009). Examined in particular are the stratospheric (10 mb) relative vorticity fields in 2007 and 2010 for March and April during the breakup of the wintertime polar vortex. Monthly means of ECMWF ERA-Interim relative vorticity used in this study were obtained from the ECMWF data server.

Stratospheric winds for March and April are also examined and compared with composites for years characterized by minima in sea ice extent, as presented in the 2009 June and July SIO submissions, and additional information may be found therein (Lukovich and Barber, 2009). Stratospheric winds were once again obtained from the NCEP reanalysis dataset provided by the NOAA/ESRL Physical Sciences Division. Revised composites (relative to the 2009 SIO outlook submission) based on record minima in sea ice extent in September include the years 2002 - 2009, in accordance with time series for monthly records of sea ice extent (http://earthobservatory.nasa.gov/Features/WorldOfChange/sea_ice.php).

Zonal and meridional surface wind anomalies, composites for vector surface winds and SLP for years associated with record lows in ice extent for June also provide an indication of anticipated dynamical properties at the surface during years characterized by record minima in ice extent. Differences in patterns for surface winds and in record minimum composites for SLP minimum in June provide a reference for regional differences in advection and convergence/divergence properties that will accelerate or inhibit summertime sea ice decline. A comparison of ice extents for June, 2007 and June, 2010 is also presented to illustrate regional differences in ice conditions leading up to the September minimum in ice extent.

Figures

1. SAT, SLP and 850 mb temperature anomalies relative to the 1979 – 2010 climatological mean.
2. Stratospheric relative vorticity in March and April for 2007 and 2010
3. Vector stratospheric winds in March for 2007, 2010, and years characterized by minima in sea ice extent.
4. Zonal surface wind anomalies and composites in June
5. Meridional surface wind anomalies and composites in June
6. Vector surface wind composites for minima in sea ice extent. Minima in sea ice extent and dipole anomaly pattern.
7. SLP composites and differences for 2007 and 2010
8. Sea ice extent in June, 2007 and June, 2010.

3) Results and Rationale

SLP and SAT anomalies for 2007 and 2010

Positive surface air temperature anomalies in 2010 are spatially comparable to those found in 2007, with the exception being the presence of positive temperature anomalies over much of the Canadian Archipelago and Hudson Bay in 2010. Considerable breakup of fast ice in Parry Channel and McClure Strait has been observed in June 2010 (more so than 2007), and sea ice cover is rapidly being removed within Hudson Bay. It is therefore expected that the Northwest Passage will be navigable by icebreakers (using satellite and helicopter reconnaissance) as early as late July, and by any vessel by mid-August.

A dipole structure in mean sea level pressure is present for both June 2007 and 2010, with low (high) pressure anomalies over central Siberia (the North pole). A stronger pressure gradient is indicated in 2010 versus 2007, which suggests stronger surface winds, and temperature advection which may enhance both sea ice motion and sea ice decay. The prevalence of high pressure over much of the Arctic pack ice during June 2010 maintained lower amounts of cloud cover, having a net positive effect on the radiation balance of the sea ice surface.

The state of the El Nino Southern Oscillation and the Arctic Oscillation play an important role on winter atmospheric circulation in the Northern hemisphere. Winter 2009/2010 was characterized by a moderate El Nino, resulting in a deepened westward-shifted Aleutian Low, and a split jet stream. Although the El Nino event has now subsided in the tropics, meridional circulation patterns have persisted in the Northern hemisphere into

June. This has resulted in deepened ridges and troughs persisting over North America and Eurasia into June, and has resulted in numerous warm air intrusions into the High Arctic. The Arctic oscillation was strongly negative, and is attributed to cold air outbreaks in Europe, and a deepened Icelandic Low. Meridional temperature advection is observed at the 850mb level. 850mb air temperature anomalies are somewhat less in magnitude than in 2007, but describe the advection of warm air aloft into the ridge of high pressure that is centred over the North Pole, which helps maintain the surface high pressure zone.

The frequency and intensity of summer cyclones will place a key role in the reduction of sea ice cover this summer, particularly if large areas of open water characteristic in the past 3 years are present. Summer storms can form over Eurasia and track into the Arctic Basin, increasing winds and subsequent divergence in the sea ice cover. Storms that are maintained by deep upper-level lows can persist for weeks, and even cause the Beaufort Gyre to reverse direction (McLaren et al., 1986; LeDrew et al., 1991). These summer reversals have become more frequent in recent years, with an increase in mobility of the ice pack that accompanies decreased summer sea ice coverage (Lukovich and Barber, 2006; Asplin et al., 2009). Reversals of the BG lead to ice divergence, lower sea ice concentrations, and lead to increased export of multi-year ice through Fram Strait.

Stratospheric relative vorticity fields

Stratospheric (10mb) relative vorticity fields in March of 2007 exhibit a pattern comparable to the dipole anomaly presented in studies by Wang et al. (2009), with predominantly anticyclonic (cyclonic) circulation over the western (eastern) Arctic Ocean (Figure 2a), as noted in previous sea ice outlook submissions (Lukovich and Barber, 2009). A similar, albeit less distinctive pattern in relative vorticity is observed in March of 2010 (Figure 2b). The transition from positive to negative vorticity, or between cyclonic and anticyclonic circulation in April is oriented parallel to Fram Strait and over the transpolar drift stream in 2007 (Figure 2c). The transition from cyclonic to anticyclonic circulation is however shifted westward in 2010 and oriented over Baffin Bay, suggesting differences in zonal and meridional stratospheric dynamical contributions and their anomalies to surface preconditioning phenomena in late winter.

It is also interesting to note that relative vorticity fields in April, 2010 resemble those in March, 2007. Moreover, patterns in SLP fields in June, 2007, reflect the reversal in relative vorticity fields in April, 2007; east-west asymmetry in the SLP low (high) in the western (eastern) Arctic in June is also apparent in the stratospheric anticyclonic (cyclonic) circulation in the western (eastern) Arctic in April.

Stratospheric winds in March and April

Stratospheric (10 mb) winds and composites for years associated with minima in sea ice extents in March 2007 exhibit maximum wind speeds in the western Arctic in a manner similar to composites for vortex displacement events noted in previous SIO submissions (Figure 3). As noted by Hare (1968) and Overland (2009) the cold core polar vortex governs surface winter conditions; as described in the June, 2009 submission, a similarity in composites for years associated with vortex displacements and minimum sea ice extent may be attributed to coherent deformation of the vortex during vortex displacement events, in contrast to vortex splitting events where cyclonic remnants erode stratosphere-surface connections in late winter. Differences between 2010 and 2007 and composite stratospheric winds in March and April (Figure 3b) and Figure 3e) compared to Figure 3c) and Figure 3f)) suggest that wintertime preconditioning events due to stratospheric dynamical phenomena in 2010 will not contribute to accelerated ice loss and retreat in summer due to dynamical phenomena in winter, relative to ice loss and retreat in 2007.

Surface zonal and meridional wind anomalies in June

Surface zonal wind anomalies in June, 2007 and 2010 indicate strong easterlies in the Beaufort Sea region relative to the 1979 – 2010 climatological mean, indicating enhanced advection of sea ice out of this region throughout summer (Figure 4a) and Figure 4b). Similarity between the spatial patterns in surface zonal wind anomalies in June, 2007, 2010 and sea ice minimum composite (Figures 4 a), b), and e) suggests a continued decline in sea ice due to dynamic contributions associated with advection.

Similarity in spatial patterns for meridional wind anomalies in June, 2007, 2010 and for the difference between the climatological mean and sea ice minimum composite (Figures 5 a), b) and e) indicate advection and entrainment associated with northerly flow to the west of Banks Island in 2010, in addition to enhanced export through Fram Strait due to stronger northerly flow. Also of interest is the maximum in southerly winds over the Laptev Sea which, if sustained during the summer, could lead to enhanced ice retreat in this region. Increased northerly flow to the west of Banks Island and decreased southerly flow in the southern Beaufort Sea for 2010 (Figure 5b) also indicates dynamical contributions to a decline in sea ice due to advection, rather than advanced retreat from the coastline, depending on ice conditions and the persistence of meridional winds in this region.

Surface wind anomalies for June

Surface vector winds for June, 2007, 2010, sea ice minima composites and the difference between 2010 and sea ice minima composite summarize spatial patterns from zonal and meridional wind anomalies (Figure 6). Noteworthy in particular is the aforementioned eastward shift in maxima and enhanced southerly flow in the Laptev Sea region (Figure 9d), indicating contributions to enhanced ice retreat due to southerly flow in this region.

SLP composite and differences for June

Information on regions of convergence and divergence associated with SLP highs and lows (and associated anticyclonic and cyclonic circulation) is illustrated, and regional differences highlighted, through investigation of the SLP composites and differences for June (Figure 7). East-west asymmetry in high and low SLP in the eastern and western Arctic region evident during vortex displacement events and minimum ice extent components in June (as noted in a previous SIO submission) is also apparent in June of

2007 and 2010 (Figures 7a) and 7b)). Noteworthy is the difference field for 2010 – 2007 in Fram Strait compared to the difference field for 2010 and the sea ice minimum composite, indicating export through Fram Strait comparable to that encountered in 2007. SLP patterns in the Beaufort Sea region are also similar in 2007 and 2010, with an eastward and poleward shift in the SLP high for 2010.

Recent studies have noted the role of persistent SLP over the Beaufort Sea during July, August and September and strong meridional flow in the retreat of, and record reduction in, sea ice in the summer of 2007 (Kwok, 2008; Ogi et al., 2008). Comparison of SLP for 2010 with sea ice minimum composites illustrates a strengthened SLP high in the Beaufort Sea region and raises the question as to whether June conditions will now play a role due to the earlier onset of ice melt, and act as a dynamical predictor for ice retreat in September.

Ogi et al. (2008) also highlighted in their assessment of the record reduction in sea ice in 2007 the role of free drift conditions in ice retreat. In particular, buoys will travel to the right of the surface winds and towards the centre of an anomalous anticyclone if in a state of free drift. Also of interest is convergence/divergence of the ice pack depending on free drift conditions of sea ice and ice thickness. Recent updates of ice conditions in the Arctic have indicated a reduction in ice loss due to a filament of multi-year (two- to three-year) ice that may inhibit Ekman drift towards the centre of the SLP high and further ice retreat

Sea ice extent for June 2007 and 2010

The occurrence of large areas of open water during the summer months (July – August) represent large areas of fetch distance, where persistent winds from cyclones may churn up long period waves that can propagate across the open water, and into the pack ice where they cause large ice floes to fracture (Figure 8). Such an event was observed in situ by the authors in September 2009. A longwave swell of period 16s with wavelength 200m was observed to cause flexural failure in large multi-year floes (5km+ diameter) approximately 250nm from the ice edge (Asplin et al., 2010 *in prep*). Furthermore, heavily decayed (rotten) first-year ice, interspersed with small old ice floes were observed in the Beaufort sea during the same cruise (Barber et al., 2009). The effects of flexural fracture in the old ice, and remnant rotten ice may have resulted in a weaker ice cover in 2010. Although speculative, it could prove to be a critical factor this year as much old ice was observed in the Southern Beaufort and Chukchi seas in April 2010, and will be more resistant to melting. It will be very interesting to observe this sector of the Arctic Basin as the surrounding first-year ice decays, leaving predominantly old ice to persist later into the summer.

4) Executive Summary

Similarity in the surface air temperature (SAT) and sea level pressure (SLP) fields in June 2007 and 2010, with increased temperatures over Hudson Bay and the Canadian Archipelago, and stronger winds associated with a strengthened SLP high over the western Arctic indicate that sea ice decline will exceed the 2007 record minimum in ice extent. Differences in wintertime stratospheric dynamical phenomena in late winter between 2007 and 2010 suggest that dynamic contributions to ice loss will not be as significant in September 2010 as in 2007. June conditions of surface meridional anomalies however highlight the possibility of enhanced ice loss due to advection out of the Beaufort Sea region and through Fram Strait, and ice retreat in the Laptev Sea region. Further investigation of ice thickness and free ice drift conditions, in addition to persistence of SLP maxima will provide further insight as to whether convergence (divergence) of sea ice associated with SLP highs (lows) will give rise to increased ice retreat in the Arctic and the Beaufort Sea region in particular.

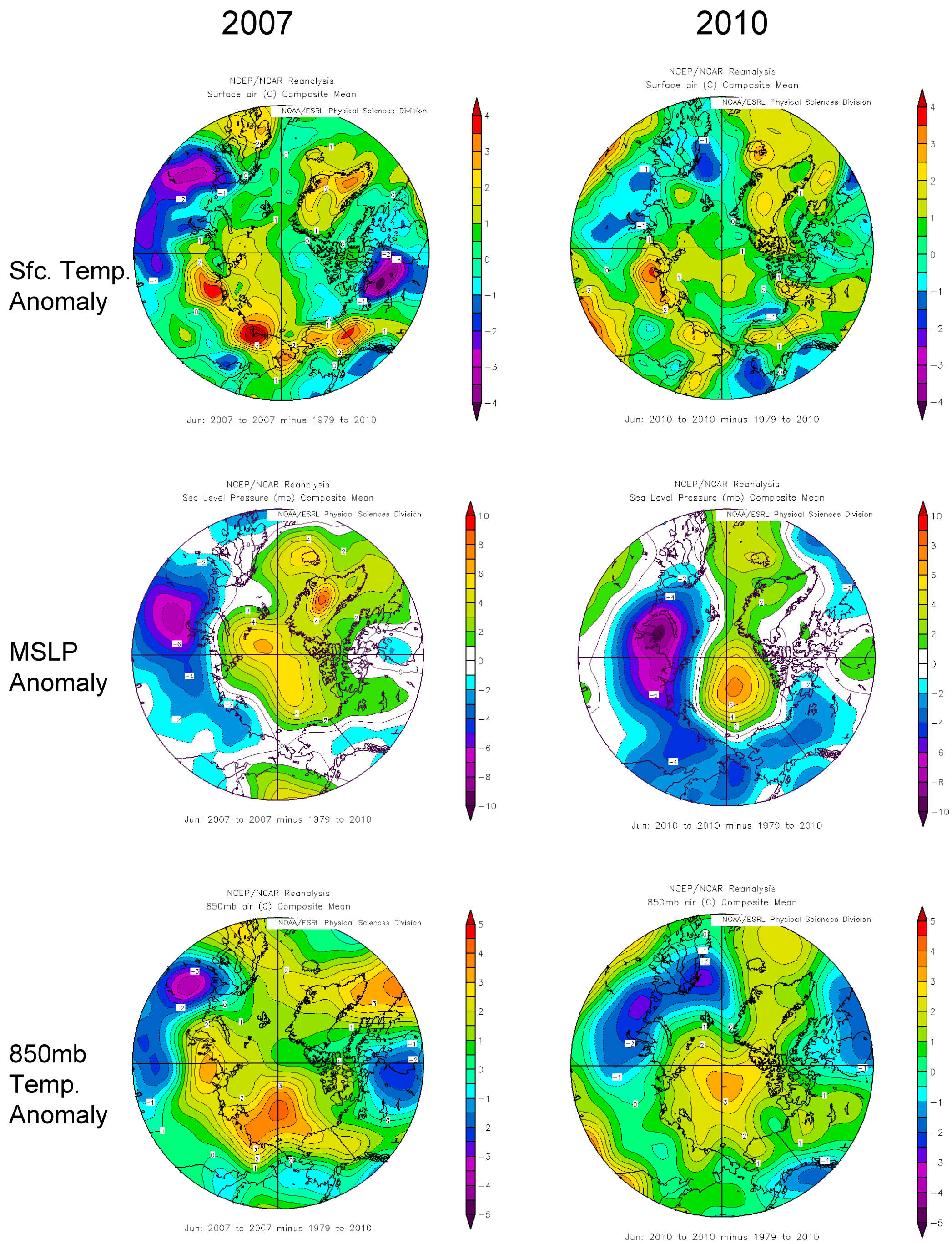

Figure 1. SAT, SLP and 850 mb temperature anomaly for 2007 (left column) and 2010 (right column). Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/

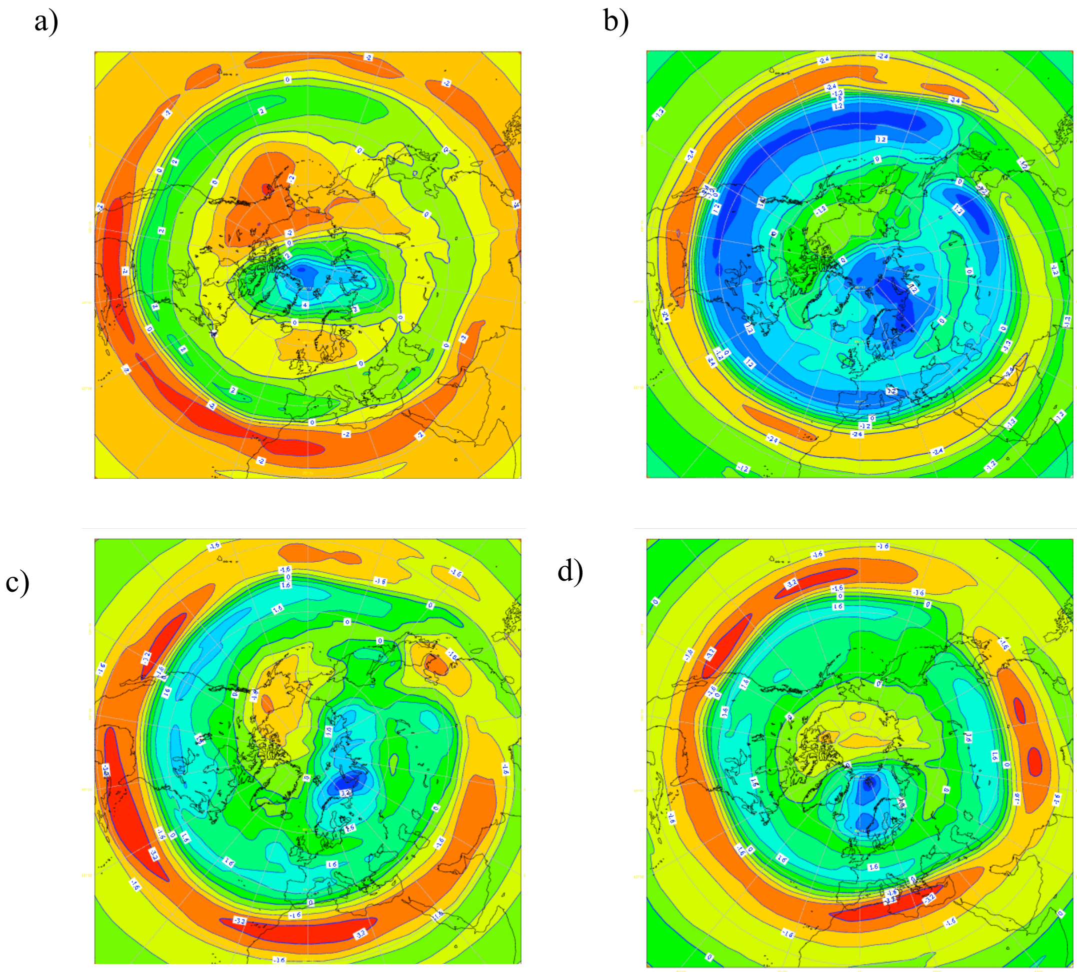

Figure 2. Stratospheric (10 mb) relative vorticity fields for March in a) 2007 and b) 2010, and April in c) 2007 and 2010 d). Anticyclonic activity (negative relative vorticity) is depicted by red shading. Image provided by the ECMWF ERA-Interim data portal at http://data-portal.ecmwf.int/data/d/interim_moda/levtype=pl/.

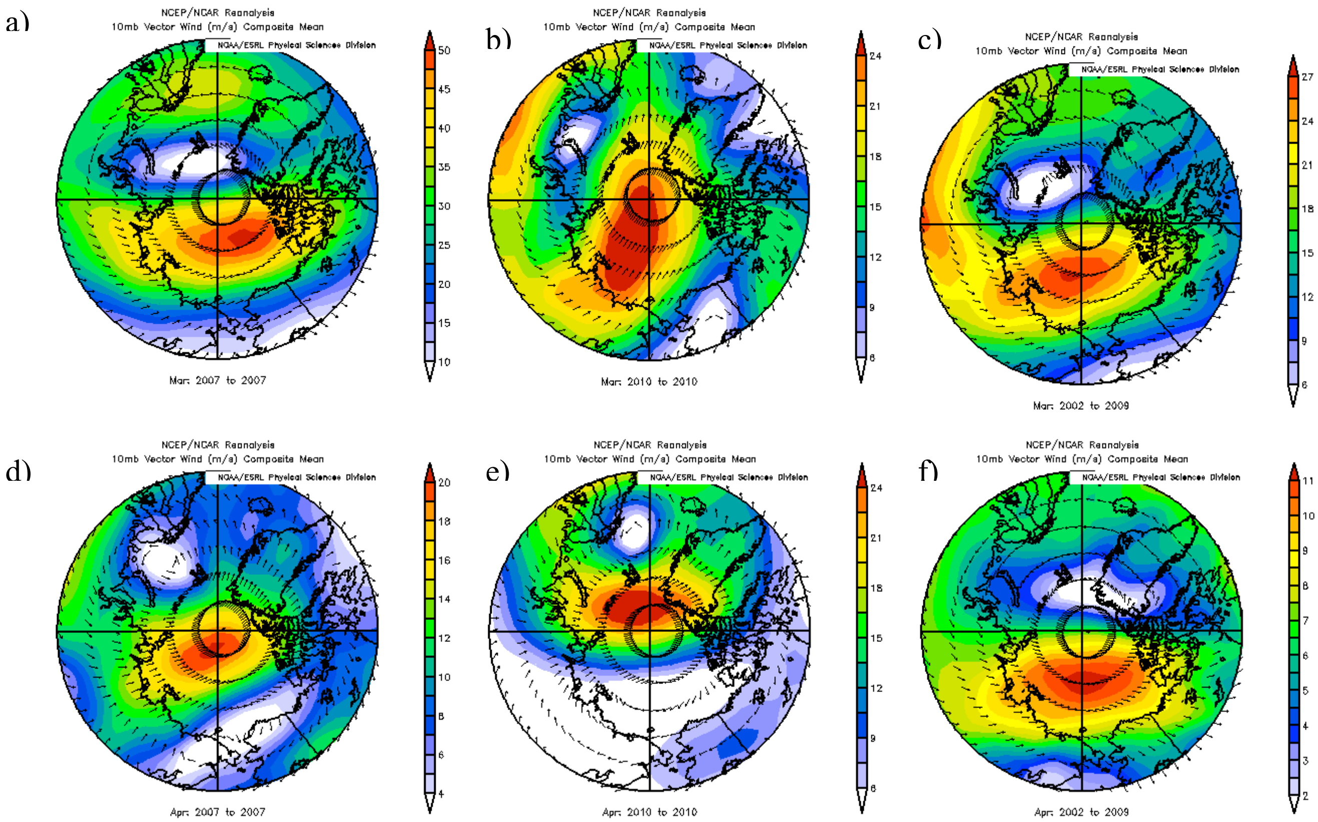

Figure 3. Stratospheric winds in March in a) 2007, b) 2010 and for minima in sea ice extent, and in April in d) 2007, e) 2010, and f) for minima in sea ice extent. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/

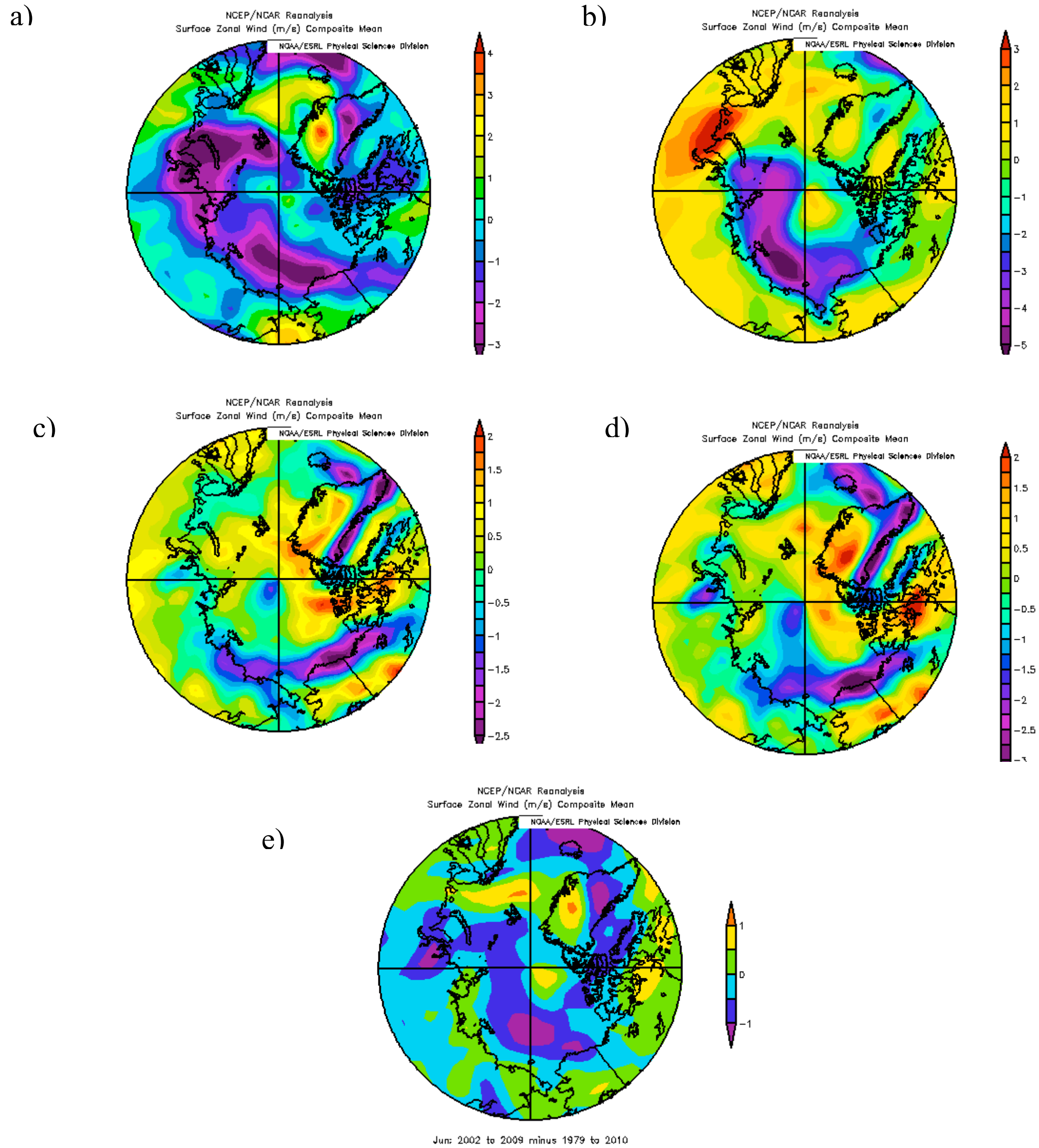

Figure 4. Surface zonal wind anomalies in June in a) 2007 and b) 2010, and c) average zonal winds from 1979 – 2010 c), d) composites for minima in sea ice extent and e) difference between composite and climatology. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/

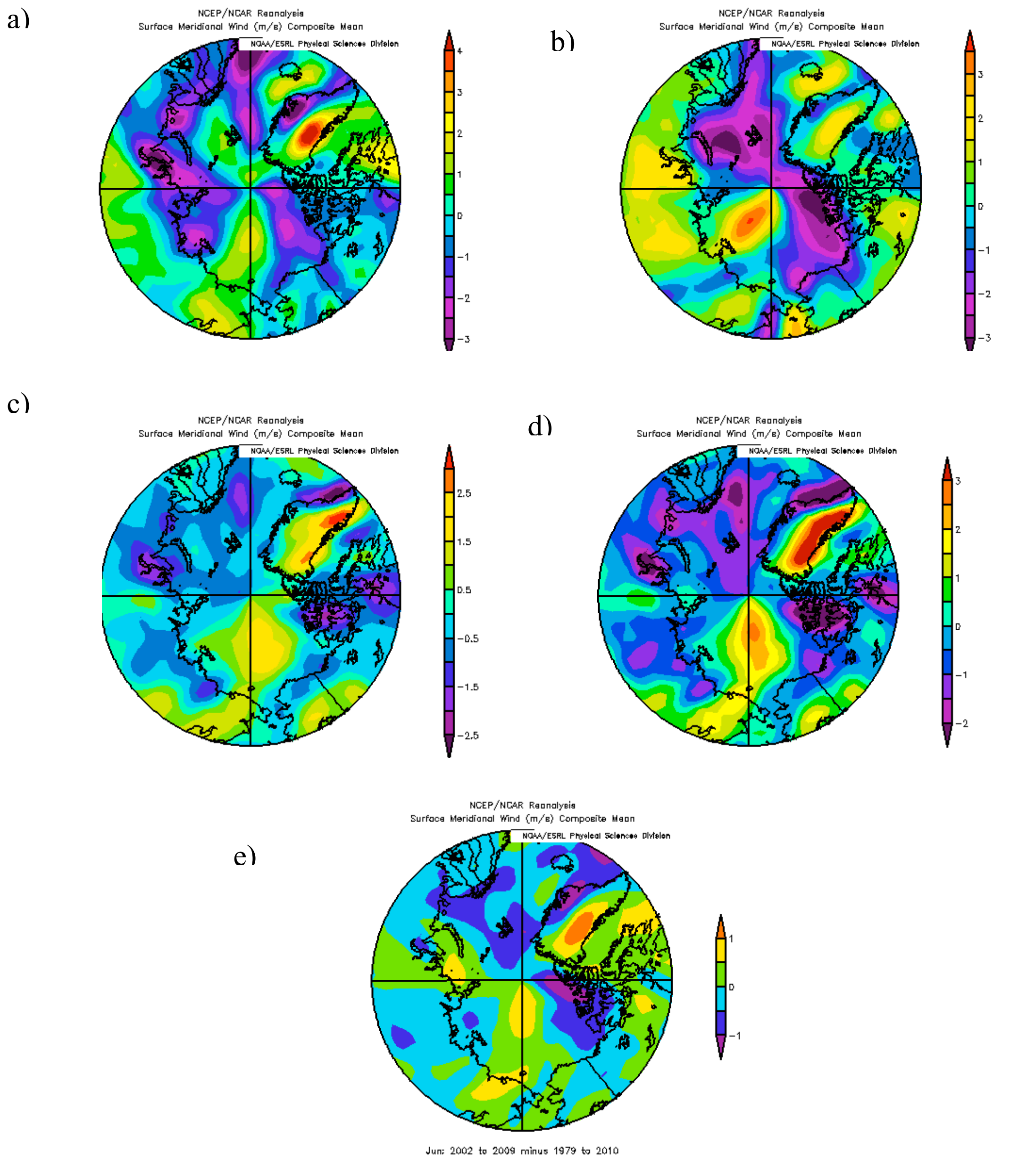

Figure 5. Meridional wind anomalies in June in a) 2007, b)2010 and mean meridional winds from c) 1979 – 2010, and d) composite for years associated with minima in sea ice extent.

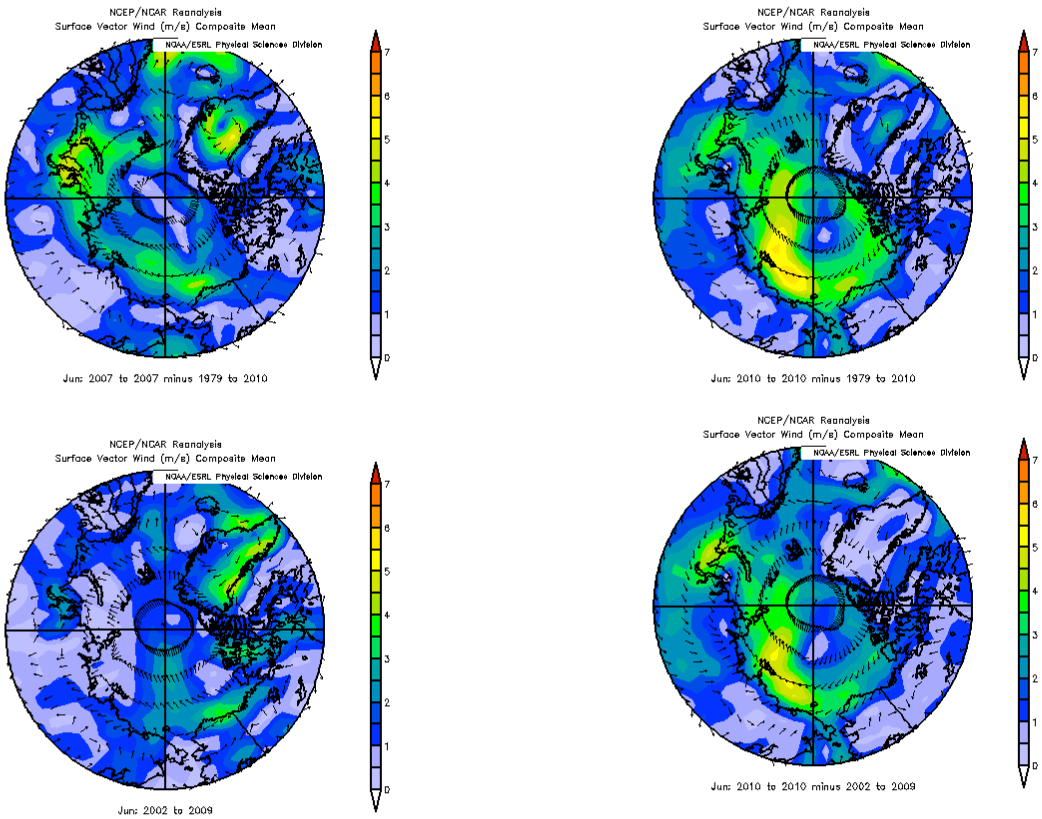

Figure 6. Vector winds for June in a) 2007, b) 2010, c) sea ice extent minimum composite for 2002 to 2009 and d) difference between June, 2010 and sea ice extent composite. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/.

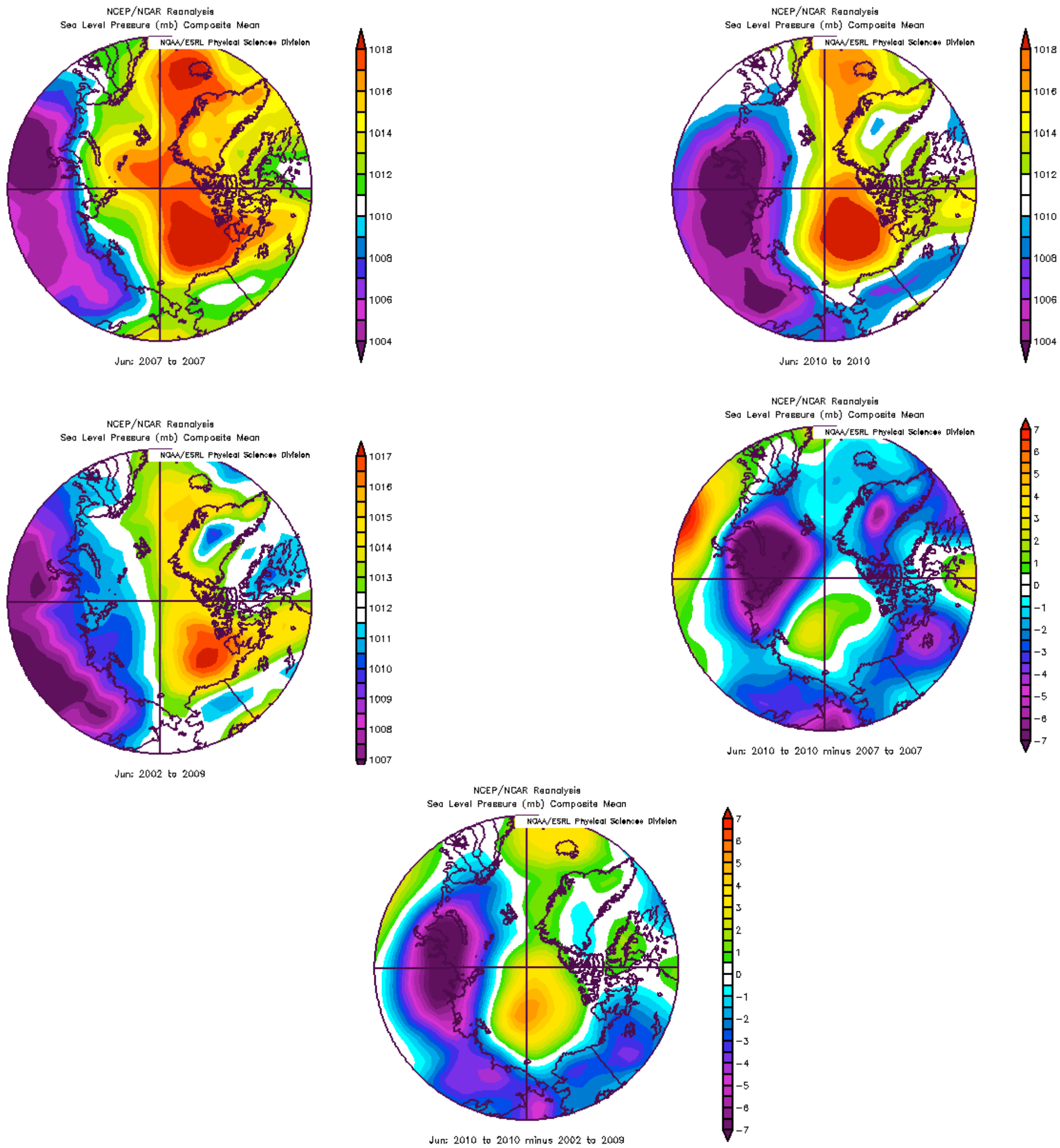

Figure 7. SLP for June in a) 2007, b) 2010, c) sea ice minimum composite from 2002 to 2009, d) difference between 2010 and 2007, and e) difference between 2010 and sea ice minimum composite.

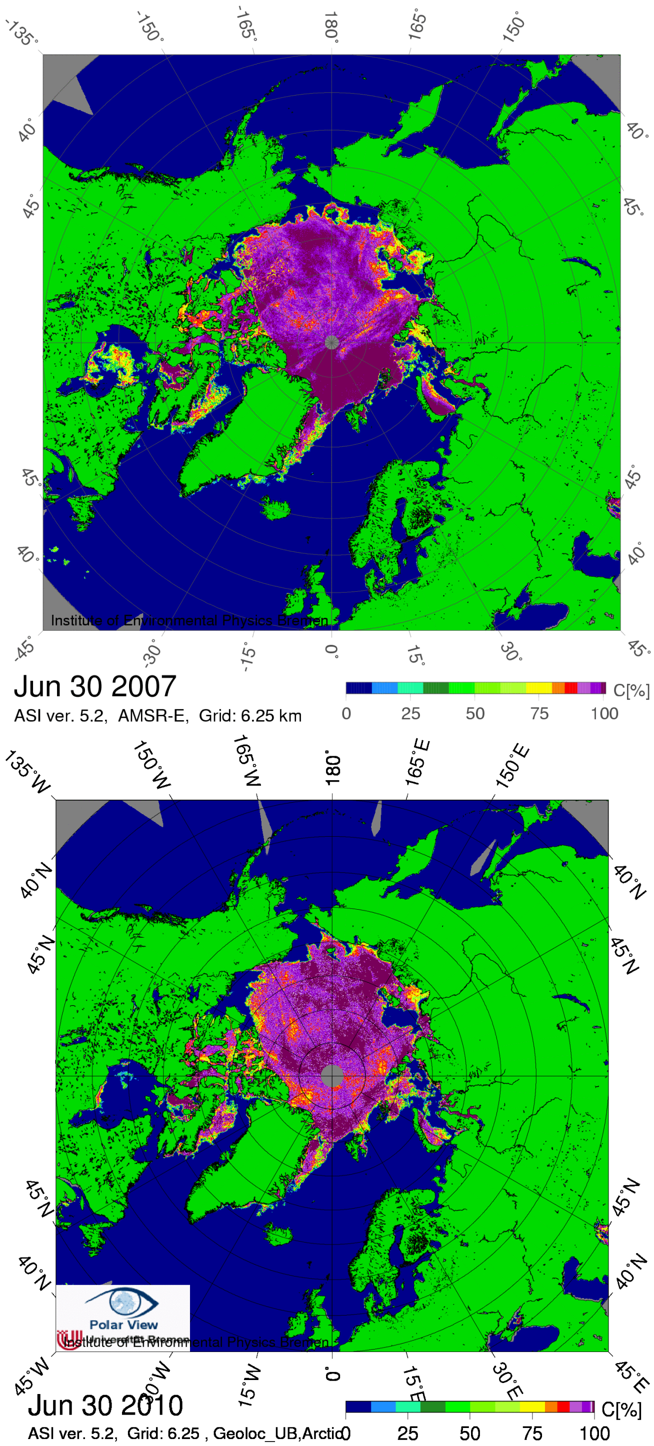

Figure 8. Sea ice extent and ice concentrations for a) June 30, 2007 and b) June 30, 2010.
Source: http://www.iup.uni-bremen.de:8084/amsr/

September 2010 Sea Ice Outlook
July Report

A. McLaren, H. Hewitt, A. Maidens, A. Arribas and D. Peterson
Met Office Hadley Centre

Caveat: This is an experimental projection, not an official Met Office forecast

Extent Projection

5.5 million square kilometres.

Method (Coupled atmosphere-ice-ocean model ensemble runs)

This projection is an experimental model prediction from the Met Office Hadley Centre seasonal forecasting system (GloSea4). GloSea4 is an ensemble prediction system and became operational in September 2009 (Arribas *et al*., 2010). It uses the same coupled model as the latest Hadley Centre coupled climate model (Hewitt *et al.*, 2010) consisting of the following model components:

- atmosphere = UM (Met Office Unified Model; Davies *et al.*, 2005)
- ocean = NEMO (Nucleus for European Modelling of the Ocean; Madec, 2008)
- sea ice = CICE (Los Alamos sea ice model; Hunke and Lipscomb, 2010)
- land surface = MOSES (Met Office Surface Exchange Scheme; Essery *et al.*, 2003).

The GloSea4 system has a real-time forecasting component, together with an accompanying set of hindcasts (or historical re-forecasts) which are used for bias correction and skill assessment. The forecasts and hindcasts differ only by their initial conditions and are typically run for 6 months. The hindcasts are currently done for the period 1989-2002.

The ocean is initialised using an ocean data assimilation scheme (Martin *et al.*, 2007) which assimilates ocean SST (in-situ and satellite) and ocean profiles (temperature and salinity). The atmosphere initial conditions are provided by the Met Office operational numerical weather predition analyses for the forecast run and from ERA-interim (ECMWF, 2009) reanalysis for the hindcast runs. Currently sea ice is initialised from a previous coupled model climatology (HadGEM1 under pre-industrial conditions). This is a major limiting factor in our ability to attempt to forecast the sea ice over a timescale of months. Work is ongoing to assimilate sea ice concentration observations into the ocean data assimilation scheme, which should become operational within the next year.

Both GloSea4 and the coupled model are under continual development. For example, work is currently being done to improve the Arctic ice thickness distribution which is not as realistic as the previous Hadley Centre climate models (HadGEM1 and HadGEM2). This is also the first time that the sea ice in the GloSea4 system has been investigated, as the focus for seasonal forecasts has generally been looking at ENSO and its teleconnections. Given these issues and the lack of realistic sea ice initial conditions, the September sea ice extent prediction is given here with low confidence as a prediction, but more as an illustration of our potential to provide such estimates in the future. It will also act as a useful benchmark for assessing the impact of future developments.

Further information on GloSea4 is available on the Met Office website: (http://www.metoffice.gov.uk/research/modelling-systems/unified-model/climate-models/glosea4).

Hindcast Results and the Summer 2010 Forecast

September ice extent anomalies for 1989-2002 from the May hindcast ensemble are shown in figure 1. The ensemble for each year consists of 9 model runs (3 different start dates each used for 3 runs with different physics perturbations). The correlation of the ensemble mean with the observational data set HadISST (Rayner *et al.*, 2003) is low (0.31) which is probably to be expected given the issues discussed above.

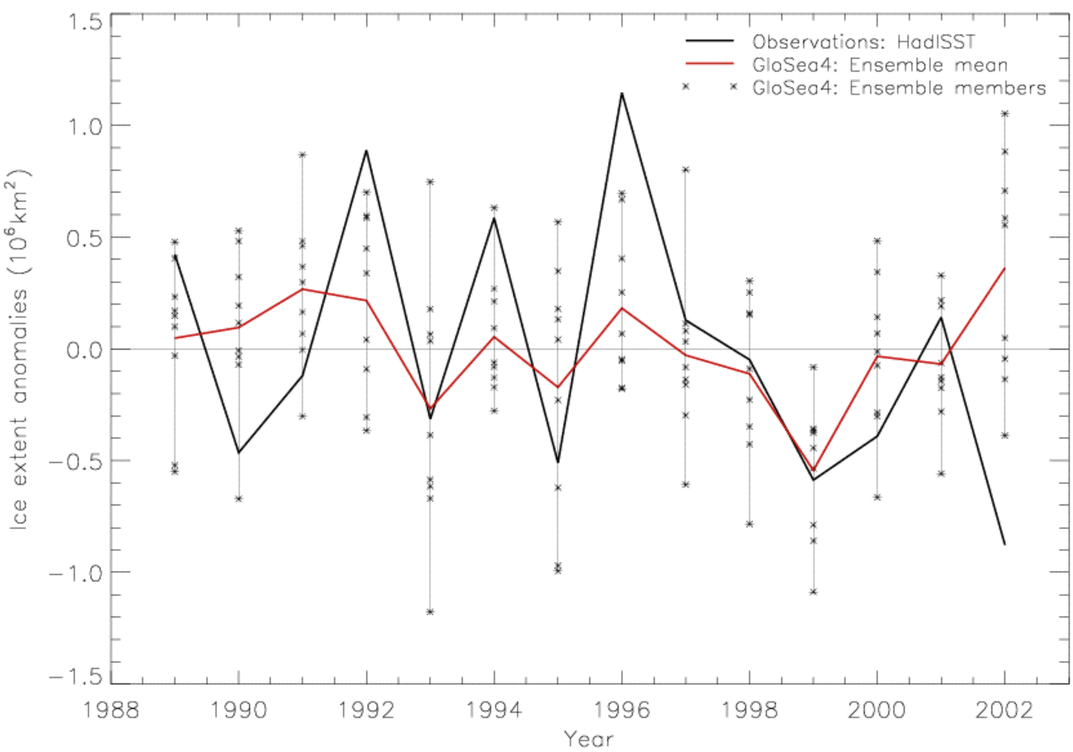

Figure 1: Arctic ice extent anomalies of the September monthly mean for the HadISST observational data set (Rayner *et al.*, 2003) (red line) and the GloSea4 hindcast ensemble mean (thick black line) for 1989-2002. Observed (model) anomalies are relative to the observed (model) climatology for 1989-2002. Results from the individual ensemble members are shown by the asterisks.

The September 2010 prediction uses the ensemble mean from 42 runs (3 different start dates each used for 14 runs with different perturbed physics) starting in May. The ice extent anomalies for the different ensembles are shown in figure 2, relative to the hindcast 1989-2002 climatology. The ensemble mean anomaly is then added to the HadISST dataset 1989-2002 climatology to give a prediction for September 2010 of 5.5 million square kilometres. Despite the known model deficiencies, it is encouraging that this estimate lies in the range of the June Outlook report projections.

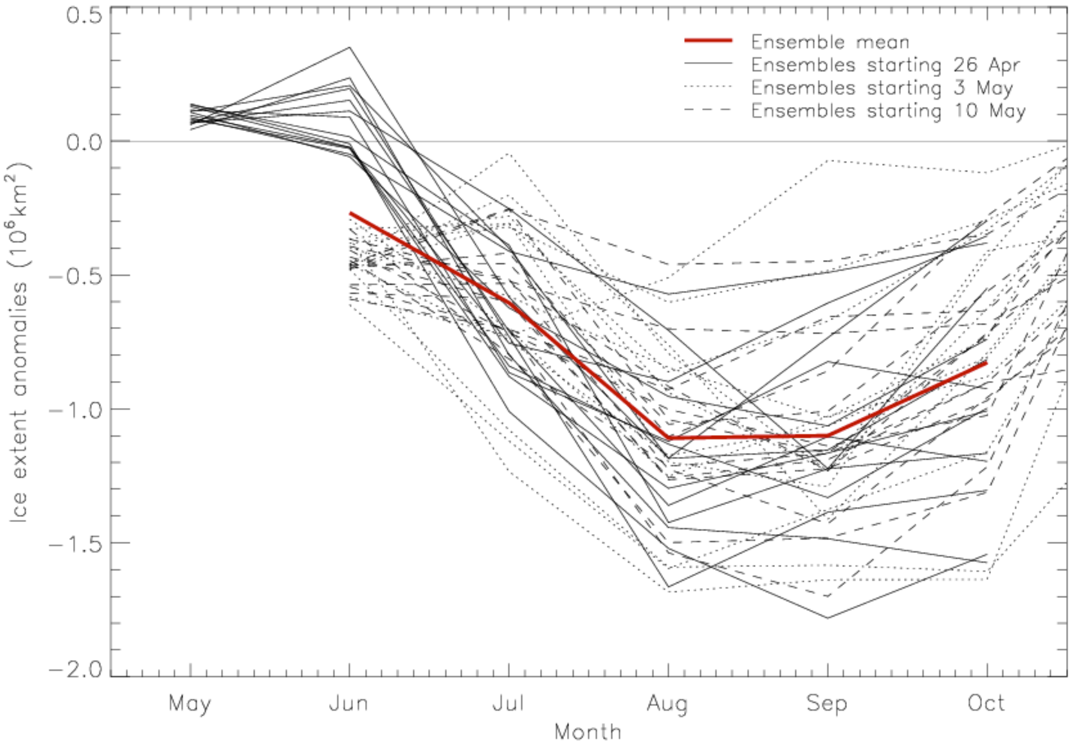

Figure 2: GloSea4 forecast for summer 2010 Arctic sea ice extent anomaly relative to the model climatology for the hindcast period 1989-2002. The ensemble mean (red line) is shown together with the 42 ensemble members (black lines).

Executive Summary

The September monthly mean sea ice extent for the Arctic is predicted to be 5.5 million square kilometres.

This experimental estimate is from the Met Office Hadley Centre seasonal forecasting system (GloSea4). GloSea4 is an ensemble prediction system that uses the same atmosphere-ice-ocean coupled model as the latest Hadley Centre climate model. Both the system and the model are under continuous development; for example the sea ice in the seasonal forecast is currently initialised with a model climatology, but this will be improved to use assimilated ice concentration observations soon. Hindcast runs indicate that there is little skill in our *current* system for predicting September ice extent. Therefore the 2010 prediction is given with low confidence, but illustrates our methods and our potential to provide improved model estimates in the future.

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NSIDC Sea Ice Outlook, August Update

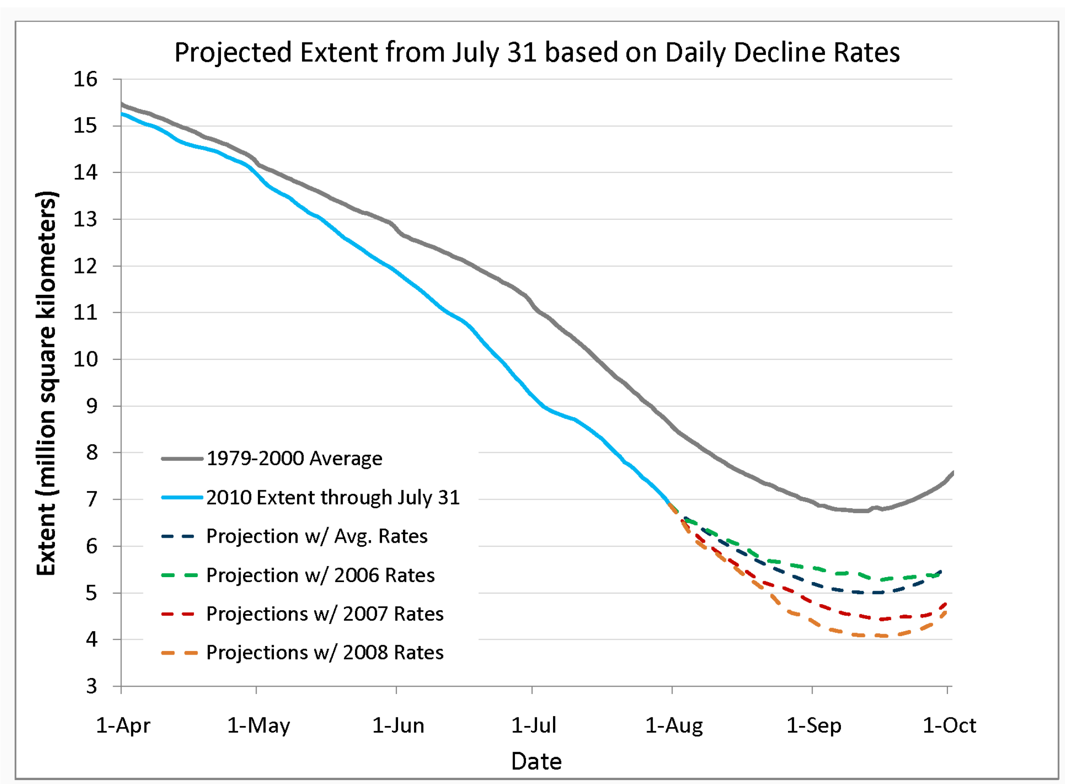
Walt Meier, Julienne Stroeve, Mark Serreze, Ted Scambos

Projection: 5.00 million square kilometers (range: 4.08 – 5.27 million square kilometers)

Summary

NSIDC's first outlook for May based on survival rates of different ice age classes from the end of March, designated as Stroeve et al. This yielded a range between 5.21 and 5.76 million square kilometers based on average survival rates for 2005-2009 and 2000-2009 respectively, with an average estimate of 5.5 million square kilometers. This estimate is unchanged. See the previous report for details of this method.

Here we update our alternative NSIDC method, by Meier, Stroeve, Serreze, and Scambos, used for the June Report. This is based on daily decline rates from August 1 until the minimum extent is reached. Using average daily decline rates from 1979-2000, the minimum extent is estimated to be 5.00 million square kilometers. To provide a range, we estimate the minimum based on decline rates for two recent years. Using 2006 rates, when the decline through August and September was slower than normal, yields a minimum estimate of 5.27 million square kilometers. Using 2008 rates, when the late summer decline was rapid, yields a minimum estimate of 4.09 million square kilometers.



Projected timeseries of extent starting July 1, 2010 through October 1, 2010 using decline rates from: (dark blue) 1979-2000 average, (green) 2006 rates, and (red) 2007 rates. The light blue line is the observed data through June 30. The gray line is the 1979-2000 average extent.

Methods/Techniques/Rationale

After the solstice, the melt rate and hence rate of extent loss starts to become more and more constrained as the incoming solar energy decreases. The extent loss rates from different years essentially represent the effect of weather variations during the remainder of the summer with the observations representing initial conditions. Our method projects a minimum daily extent by simply stepping forward day-by-day using a rate from a given year or average of years for each day. As we are now well past the solstice, the amount of available energy is rapidly decreasing. Surface melt basically ends during early to mid-August and the remaining ice loss is due to bottom and lateral melt or compaction of the pack through ice motion. Thus the window for extent loss is beginning to close and envelope of potential extent loss is narrowing. Here we use climatological rates for an "expected" minimum, bracketed by the extremes from recent years – a very slow August decline during 2006 and a rapid August decline during 2008.

Simply using **climatological daily rates** from 1979-2000, we obtain an estimate of **5.00 millions square kilometers**. Rates from different individual years can provide a range. Here we selected two recent years, 2006 and 2008, to provide a range around the climatological average. Both 2006 and 2008 both have relatively less multiyear ice than during the earlier part of the record and thus are more consistent with the initial thickness character of the ice in 2010. However, the evolution of the extent loss differed greatly between the two years due to different weather conditions. In 2006, the late summer loss was quite slow, while 2008 experienced the most rapid August decline in the satellite record. In 2006, extent declined by an average of 47,000 square kilometers per day (about 8000 kilometers per day slower than the 1979-2000 average). However, in 2008, the August average decline rate was 77,000 square kilometers per day, more than 50% higher than in 2006. Using **2006 rates**, the slowest August rates in recent years, we obtain a 2010 estimate of **5.27 million square kilometers**; for **2008 rates**, the fastest rate during August, we obtain an estimate of **4.08 million square kilometers**.

There are important issues to keep in mind. First, the weather may differ significantly from other years or the climatological average. In addition, the initial extent (July 31) for this year is different from other years or climatology on which the rates are determined. In other words, the rate of extent loss is a function not only of the weather conditions through the summer, but also the starting extent. Conditions exactly like 2006 would not necessarily result in the same daily decline rate if the starting extent was some other value than the July 31, 2006 extent. Not only the total extent, but the distribution of ice within the Arctic and, as mentioned above, the thickness distribution (e.g., multiyear vs. first-year), will also affect the decline rates.

One thing we note in terms of current conditions is that there is a large region in the Beaufort Sea of unconsolidated ice with low concentration, as indicated in higher resolution passive microwave data from the University of Bremen (http://www.iup.uni-bremen.de/seaice/amsr/) as well as high resolution visible imagery from the NASA MODIS Arctic Mosaic (http://rapidfire.sci.gsfc.nasa.gov/). Significant open water is seen in the higher-resolution imagery even though it is all considered "ice-covered" in our data. This region is prone to rapid melt resulting in a relatively fast August decline, similar to the situation during 2008. Winds will also play a role, depending on whether they help compact the ice (and thus lowering extent) or spread the ice over a larger region (at concentrations above 15%). If the rates match 2008 through the remainder of the melt season, there will be a new record minimum. However, such a rapid decline rate would require optimal conditions that are not likely. Thus, it seems more likely that the minimum extent will be closer to the high range of the estimates (e.g., close to the value using climatological decline rates).

PAN-ARCTIC OUTLOOK As of July 13, 2010

J. Morison and N. Untersteiner
University of Washington

1. Extent Projection
5.6 million square kilometers

2. Methods / Techniques
Heuristic: judgment based on recent observations, e.g., previous winter AO, ice conditions observed during NPEO hydro surveys, atmospheric and ice surface conditions observed with the NPEO buoys and Web Cams, recent ice trajectories.

3. Rationale
- The winter AO was negative, which we feel contributed to the relatively great amount of deformed ice we directly observed in the central Arctic Ocean in April. Consequently, we think the central Arctic ice, in spite of still being predominately young, tends to be thicker than in recent years.
- Recent buoy trajectories in the central Arctic Ocean also have a more anticyclonic, export adverse, trajectory than in recent years, and our buoys don't appear to be crossing towards Fram Strait as fast.
- Our NPEO Web cams show more melt ponds than last year, but less than in other recent years. This is in spite of there having been more snow in April 2010 than the previous 2 springs. For the most part, the ice at both 2010 Web Cam locations looks fairly well drained, presumably contributing to increased albedo
- As evidenced by the number of times we have seen the 2010 melt ponds freeze over already, we think the early summer input of heat to the ice from the atmosphere is less than average.
- Based on some AXCTD drops done in May, we think there is some ocean heat from 2009 directly below the mixed layer in the Beaufort Sea. However, the mixed layer was reasonably deep (40-50 m) this spring so if there has been enough melt in quiet to normal wind conditions, a new shallower seasonal pycnocline may be established and the ocean heat may be trapped for the rest of this summer.

4. Executive Summary
Last month's estimate of 5.3 million square kilometers was based on considering the 2009-2010 winter AO and ice conditions observed in the field in April. The conditions observed with the Web Cams, buoy trajectories, and the present trends in ice extent have prompted us to raise our estimate to 5.6 million square kilometers, recognizing that the Arctic weather in the next couple of months will trump all.

2010 PAN-ARCTIC OUTLOOK
July Outlook

Chris Petrich - Geophysical Institute, University of Alaska Fairbanks

1. Extent Projection

The projected sea ice extent for September 2010 is 4 Mm^2, with a possible range of 3.4 to 5.4 Mm^2, and most likely range of 3.4 to 4.9 Mm^2.

2. Methods / Techniques:

heuristic, statistical

It is assumed that the mean sealevel pressure in June in the Pacific sector of the Arctic and sub-Arctic (90E to 270E and 45N to 90N) is a useful indicator for the inter-annual change of September sea ice extent. June mean sealevel pressure is calculated from the NCEP/NCAR reanalysis product, and individual years are visually compared to 2010. The pressure distribution in June 2010 resembles the situation of 1997 most closely and is in tune with many years that showed a considerable decrease in ice extent with respect to the previous year. However, it also resembles 1965 which was most likely a year like any other. Sea ice extent anomalies were kindly provided by Walt Meier, NSIDC, and are based on the NASA Team algorithm from SMMR-SSM/I (1979-present) and Hadley ISST dataset, with monthly extents adjusted to be consistent with the SMMR-SSM/I data (1953-1979).

The best estimate is based on the 1.4 Mm^2 reduction observed from 1996 to 1997. The bounds are based on the 2006 to 2007 and 1964 to 1965 reductions of 2 Mm^2 and 0 Mm^2, respectively.

3. Rationale

Sealevel pressure is related to both surface winds and clouds (and hence insolation) which are known to drive Arctic ice reduction in summer. The mean sealevel pressure of June is used as a proxy for September sea ice extent reduction because the association appears to be stronger than for any other month.

4. Executive Summary

The June sealevel pressure distribution is used as proxy for the inter-annual change in sea ice extent. September 2010 is most likely to see a lower sea ice extent than September 2009, potentially even less than in 2007.

2010 PAN-ARCTIC OUTLOOK
JULY REPORT

Prepared by Oleg Pokrovsky
Main Geophysical Observatory, Russia

1. Extent Projection
Sea ice projection for the September monthly mean arctic sea ice extent – 4.9 (in million square kilometers)
2. Methods / Techniques
Statistical analysis of the AMO, PDO and AO time series based on specific regression model

3. Rationale

Substantial bias in previous sea ice projection for the September was obtained because of principal change in atmospheric circulation over Asia and Eastern part of European Russia, which was found in recent monthly SLP fields (fig.1). It is in contrast to Jan-Apr average wind field (fig.2). Southward flow direction was turned in Northward. The reason of this change is related to increasing of SST in North-East Atlantic domain (fig.3) and development of considerable SLP low anomaly. As a result hot air masses from South Asia and Africa have arrived in Siberia and Russian Arctic (fig.4). Relatively thin ice cover will be subjected to rapid melting due to the SAT substantial increasing in Russian Arctic and in North East of Canada.

4. Executive Summary

Future SIE estimates in Arctic might be obtained by joint analysis of time series of three climate indicators: AMO, PDO, AO for last thirty years. I used a modified regression analysis approach.

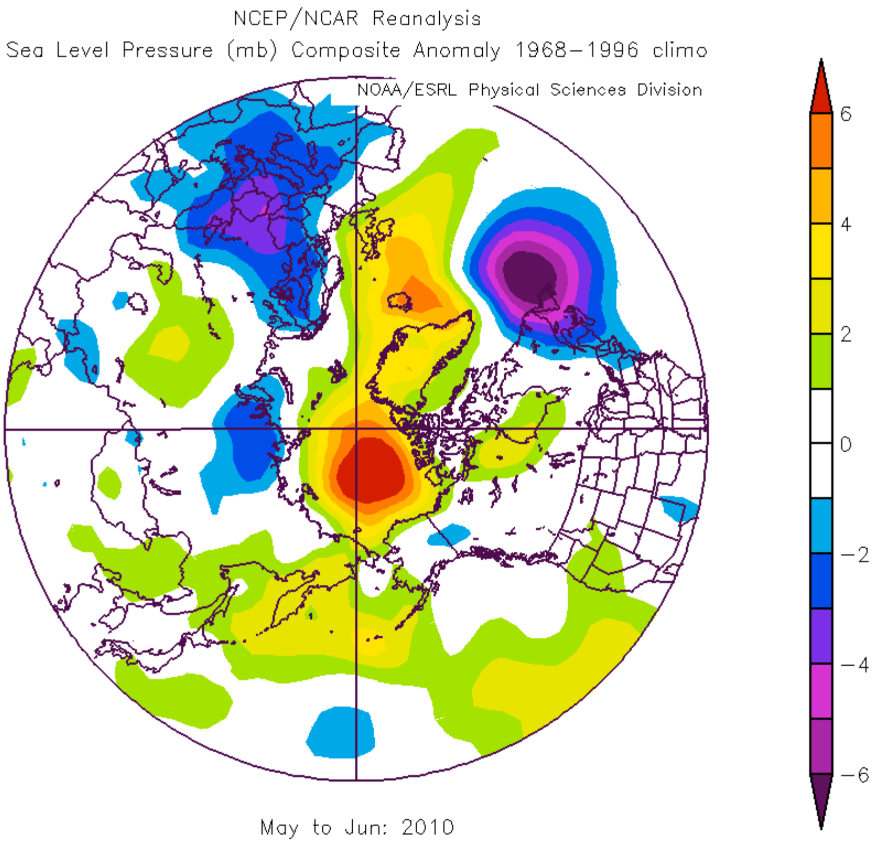


Figure 1. May-June SLP field

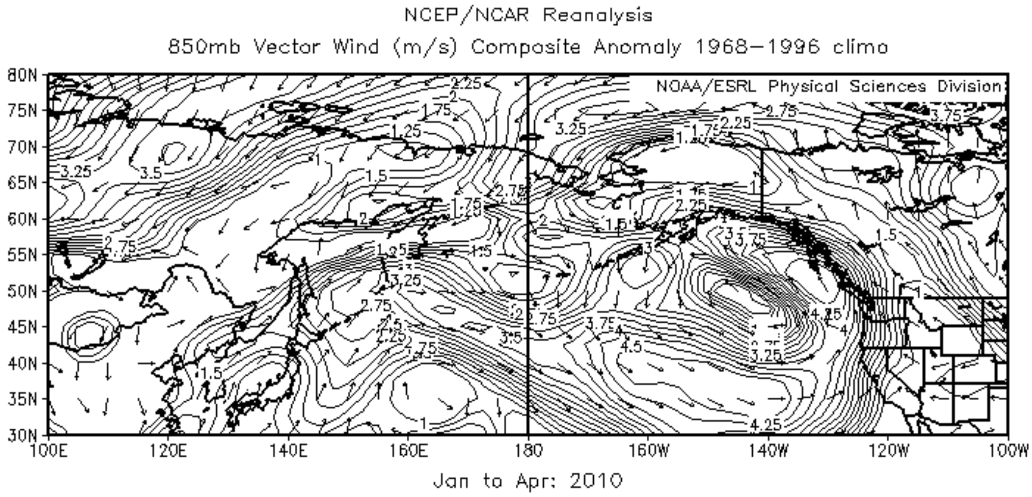


Figure 2. Jan-April vector wind field

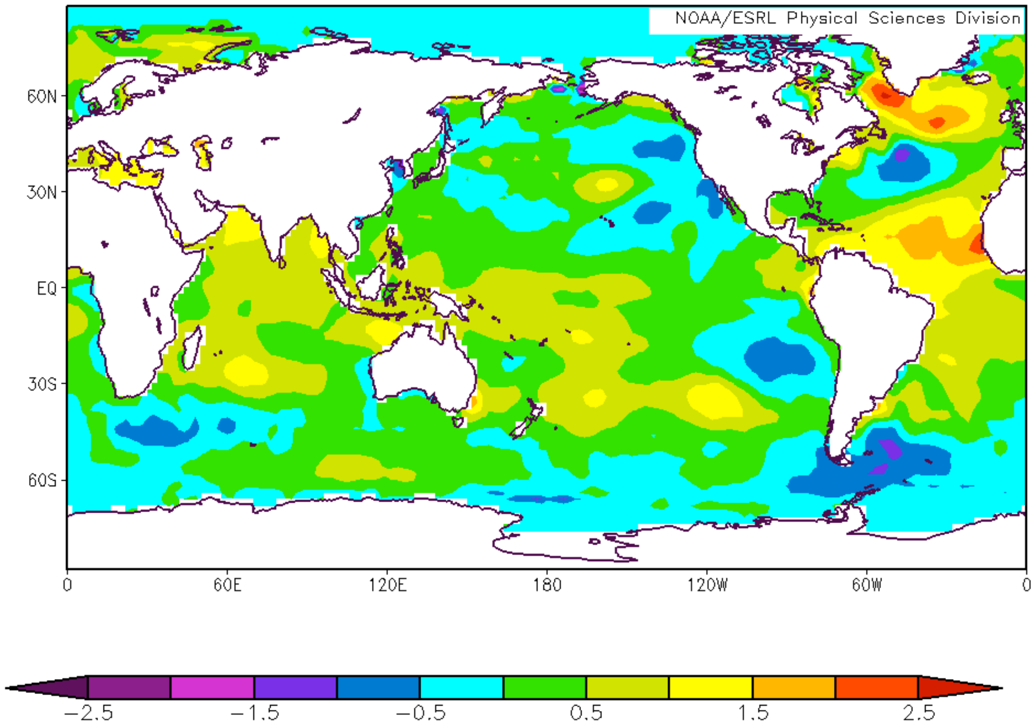


Figure 3. May-June SST field

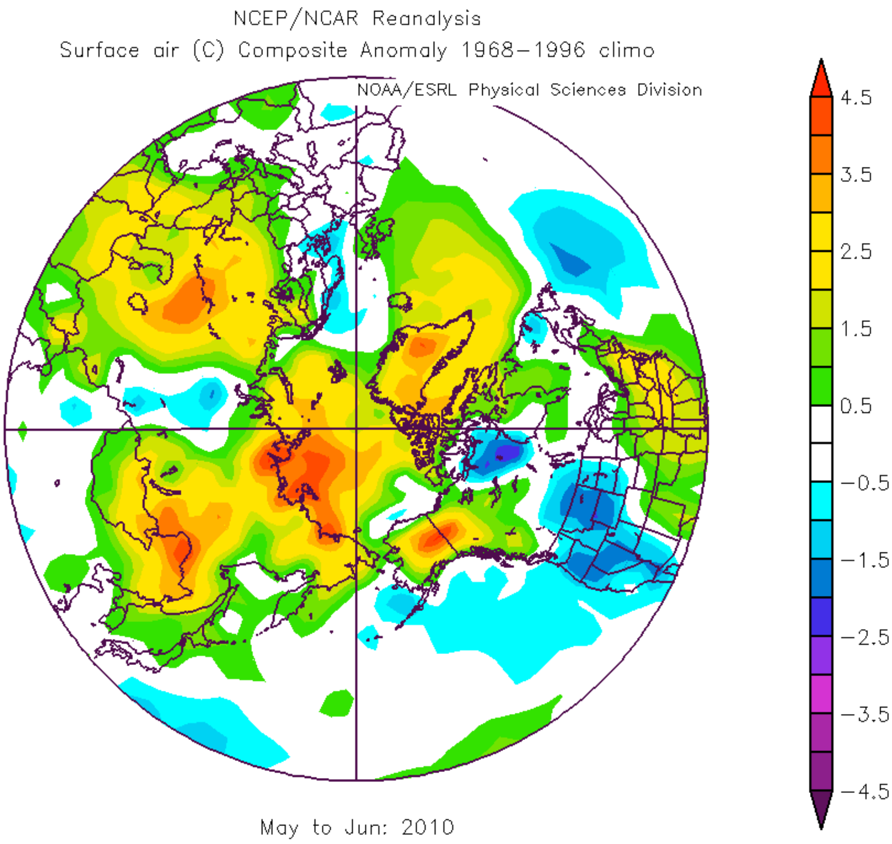


Figure 4. May-June SAT field

Sea Ice Outlook for September 2010 (August Update)

Ignatius G. Rigor[1], Son V. Nghiem[2], Pablo Clemente-Colón[3]
[1]Polar Science Center, Applied Physics Laboratory, University of Washington (UW)
[2]Jet Propulsion Laboratory, California Institute of Technology
[3]Naval/National Ice Center

1. Extent Projection

   5.4 million sq. km. We estimate that the September 2010 mean sea ice extent will remain below the mean September sea ice extent (1979 – 2009).

2. Methods and Techniques

   This estimate is based on the prior winter AO conditions, and the spatial distribution of the sea ice of different ages as estimated from a Drift-age Model (DM), which combines buoy drift and retrievals of sea ice drift from satellites (Rigor and Wallace, 2004, updated). The DM model has been validated using independent estimates of ice type from QuikSCAT (e.g. Fig. 1 left; and Nghiem et al. 2007), and *in situ* observations of ice thickness from submarines, electromagnetic sensors, etc. (e.g. Haas et al. 2008; Rigor, 2005). For this analysis, we used the NCEP operational SIC analysis to determine which areas of sea ice survived in Sept. 2009, but the Bootstrap SIC analysis for previous years.

3. Rationale

   Figure 1 shows the estimated age of sea ice this spring. The average age of sea ice has been increasing since the record minimum ice extent in September 2007. There is more second year ice this spring, compared to last spring. This increase in the basin wide average age of sea ice was a result of extremely low Arctic Oscillation (AO) conditions during the winter of 2009/2010 (L'Heureux et al. 2010, and www.cpc.noaa.gov), which sequestered sea ice the larger Beaufort Gyre (e.g. Fig. 2; and Rigor et al. 2002), and compacted sea ice into the East Siberian Sea. However, these conditions are still far younger and thinner than the condition of sea ice prior to the 1990's, and it would take a few years of similar conditions to allow sea ice to recover (Rigor 2005).

   Regionally, we expect alternating areas of faster and slower retreats of sea ice due to the extreme low AO conditions during the past winter. Figure 2 shows the regression map of summer sea ice concentration and winter ice motion on the winter AO index. Note that the areas where sea ice extent is currently retreating (e.g. Banks Island, west of Barrow, and east coast of the Laptev Sea), are areas of much younger, thinner first-year ice where the low AO conditions blew sea ice away during the past winter. We realize that the current sea ice extent is 0.5 million sq. km. below the pace of 2007, but we also note that much of these decreases are primarily in the lees of the coast and fast ice, where the younger, thinner sea ice simply does not have enough mass to survive the onset of summer. In the East Siberian Sea and east of Barrow, where sea ice has been packing into the coast we expect sea ice to hold out longer and thus slow the overall retreat of Arctic sea ice extent.

4. Executive Summary

Our outlook based on June data has not changed from May. As hypothesized in our outlook based on May data, the retreat of sea ice extent has slowed and is now behind the pace of the record minimum in 2007. The winds during the past two weeks have reversed the flow of the buoys and sea ice in the Beaufort Gyre and Transpolar Drift Stream, slowing export, and sequestering sea ice in the Arctic (Fig. 3). We continue to expect the September sea ice extent just above the minimum in 2009.

Figures

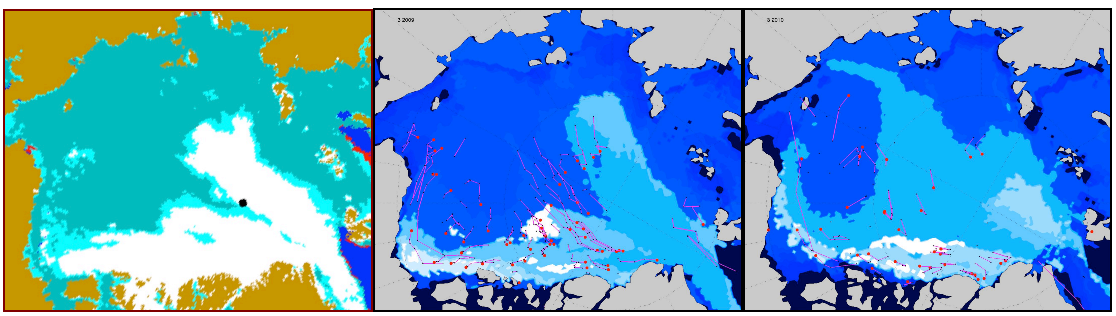


Figure 1. Maps of Arctic sea ice distribution based on QuikSCAT (QS) for March 2009 (left), and the age of sea ice based on the Drift-Age Model (DM) for each March 2009 and March 2010 (middle and right). The colors on the QS map shows perennial ice (white), mixed ice (aqua), seasonal ice (teal). The red dots on the DM maps show the current positions of buoys, while the black dots behind these show the positions of the buoys during the previous 6 months.

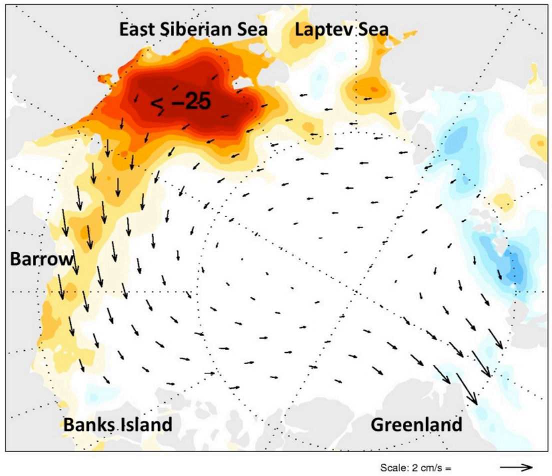


Figure 2. Regression map of summer sea ice concentration and prior winter sea ice motion on the prior winter Arctic Oscillation index. After low AO winters, the reds imply that sea ice concentrations should be higher I these areas, while blues imply lower that normal sea ice concentrations during the following summer. Based on Rigor et al. 2002.

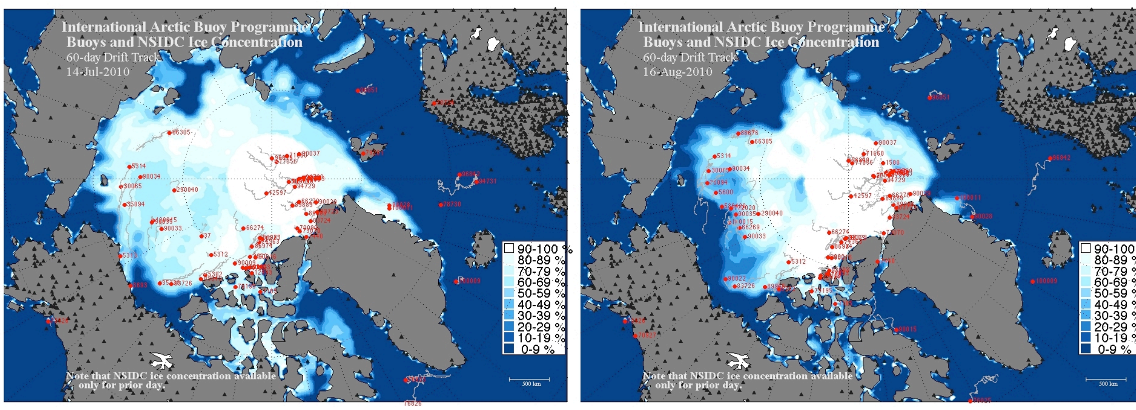


Figure 3. Map of buoys drifting on the Arctic Ocean on July 14 (left), and August 16 (right), 2010. The red dots show the current position of the buoys, while the grey tails behind these dots show how the buoys have drifted during the last 60 days. Following the drift of buoys reporting from July 14 to August 15, the drift and advection of sea ice out of the Arctic continues to be slower than normal. Most of the retreat of sea ice extent during the past month has been due to the melt of the sea ice in the marginal seas. Source http://iabp.apl.washington.edu.

2010 Sea Ice Outlook

August Report

Hiroki Shibata[1], Kazutaka Tateyama[1], Masahiro Hori[2], Kazuhiro Naoki[2] and Hiroyuki Enomoto[1]
1: Kitami Institute of Technology
2: Japan Aerospace Exploration Agency (JAXA)

1. Extent Projection

We estimate that the September 2010 mean sea ice extent is 5.0 million sq km.

2. Methods / Techniques

This prediction is based on sea ice thickness, summer melt, outflow and cloudiness. In summer 2007, a particularly large Arctic sea ice decrease occurred when sea ice extent plunged to its lowest level since satellite observations of sea ice began in the 1970s. In 2007, the contribution of the atmospheric effect to the melt was large. But atmospheric effects don't accelerate the melting of the Arctic sea ice in 2010 that is different from the case of 2007 (Fig.1). We assumed that there is no special atmospheric influence on the sea ice reduction in 2010. We estimated the sea ice thickness using the polarization ratio of the 36GHz observed with the satellite borne passive microwave radiometer AMSR-E. Fig. 2 shows the distribution of the ice thickness on 30 April 2010.We estimated the distributions of the Arctic sea ice thickness on 30 April since 2003 for evaluating the initial ice condition before summer melt starts. We assume in this report that the annual minimum ice extent in September is determined only through the processes of melting and outflow into the Atlantic Ocean during summer. We defined the regional summer melting rates as 171cm in the 65-80N, 74 in the 80-85N, and 48cm in the 85-90N, respectively, from the Ice Mass Balance buoys data which are opened in the CRREL web site (http://imb.crrel.usace.army.mil). We also considered sea ice outflow rate into the Atlantic Ocean through the Fram Strait during summer is 0.4 million sq km by referring Kwok (2009). Fig. 3 shows the predicted sea ice extent and the past minimum sea ice extent reported from IARC-JAXA Information System (IJIS). IJIS has opened Arctic Sea-Ice Monitor by AMSR-E to the public on its web site (http://www.ijis.iarc.uaf.edu/cgi-bin/seaice-monitor.cgi?lang=e). The predicted sea ice extents shows good correlation (correlation coefficient is 0.852) with the past minimum sea ice extents as shown in Figure 3. Although there are still constant biases (underestimation approximately 1.0 million sq km) and thus uncertainties in our method, we tuned our prediction model by adding this offset (Fig.4). Finally we predicted sea ice extent in September 2010 will be 5.0 million sq km.

3. Rationale

Figure 1 shows mean cloudiness anomaly in June-July 2007 and 2010. Cloudiness anomaly in 2010 has no remarkable sunny condition and outstanding wind to decrease sea ice different to atmospheric condition in 2007. Therefore, we thought the influence of the atmospheric conditions on sea ice reduction as the average in 2010. We assumed that sea ice minimum extent depends on the initial sea ice thickness on April 30 and melting and outflow during summer season.

4. Executive Summary

Our outlook is primarily based on the estimation of sea ice thickness in spring. We considered sea ice in 2010 has not received special atmosphere effect. Therefore we estimate that the September 2010 mean sea ice extent from sea ice thickness and sea ice export from Fram strait. As a result, we estimate September 2010 mean sea ice is 5.0 million sq km.

5. References

R. KWOK, 2009: Outflow of Arctic Ocean Sea Ice into the Greenland and Barents Seas: 1979–2007, JOURNAL OF CLIMATE, VOLUME 22, pp2438-2457

Figures

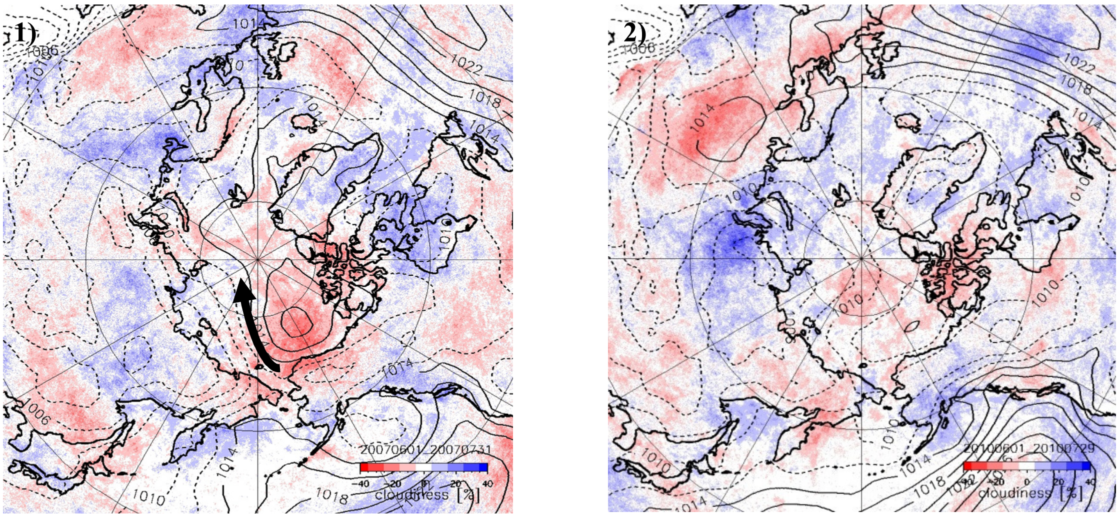


Fig.1 Cloudiness anomaly in June-July (2 month average), 1) 2007, 2) 2010.

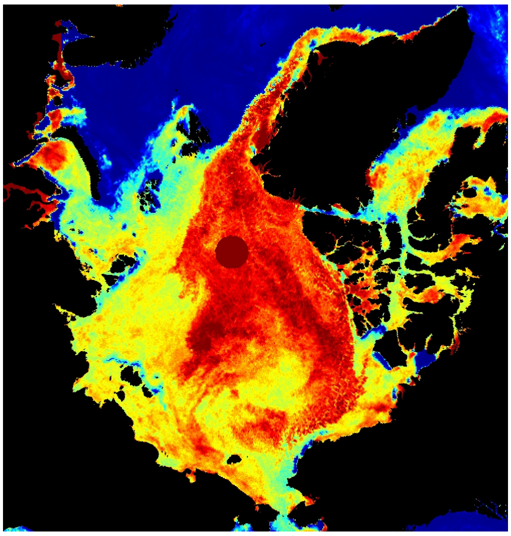


Fig.2 Sea ice thickness in Arctic Ocean on 30 April 2010.

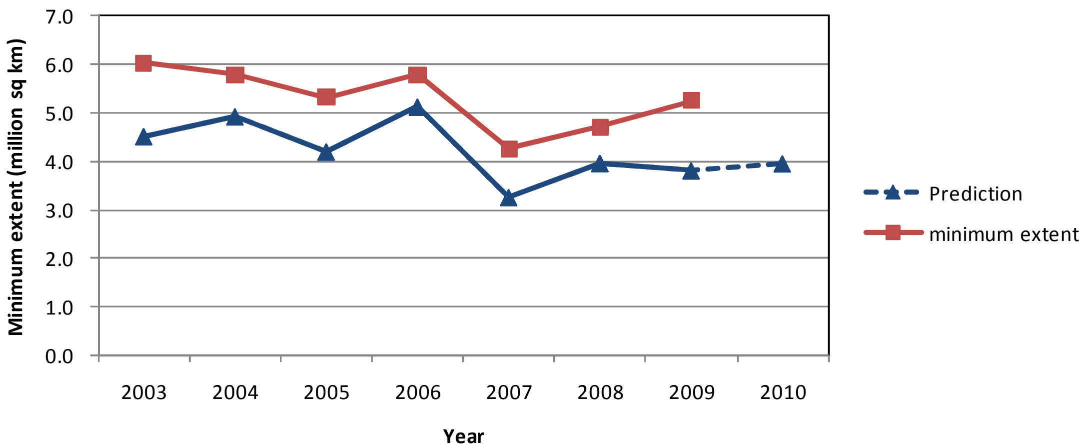


Fig.3 Prediction of sea ice in Arctic Ocean, minimum extent shows actual minimum sea ice extent data from IJIS web site during 2003-2009.

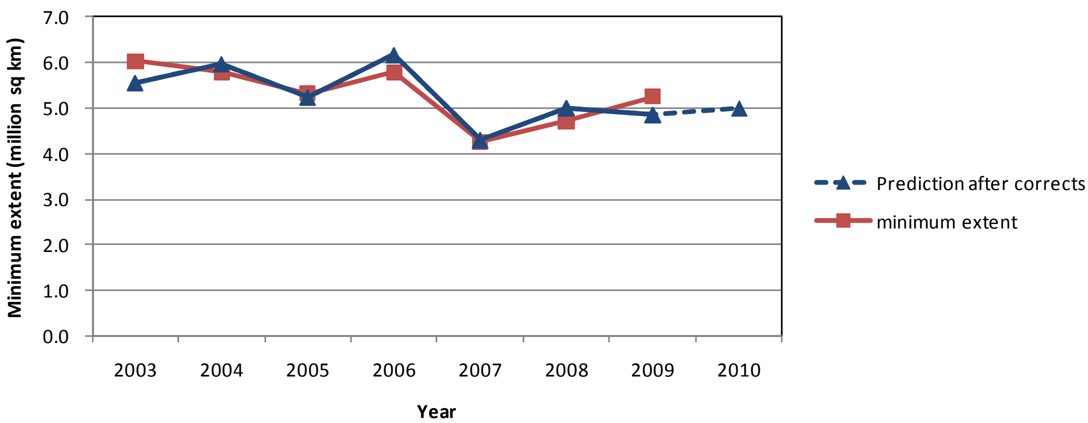


Fig.4 Prediction of sea ice in Arctic Ocean after the corrections

Sea Ice Outlook:
Use Dipole Anomaly (DA) index to predict Arctic summer ice minima

PI: Jia Wang; and Xuezhi Bai, NOAA GLERL

Sponsor: NOAA CPO Office of Arctic Research

- DA is defined as the second SLP mode in the Arctic; the first mode is Arctic Oscillation (AO)
- Using winter-spring mean DA index and summer DA index, we have proven ice minima in 1995, 1999, 2002, 2005, 2007, and 2008
- Using 2009 winter-spring (+0.61) and summer (+1.06) DA indices, now we can project that 2009 summer ice was projected to be 4.5 million sq. km (in the 2009 Sea Ice Outlook)
- Reference: Wang et al. 2009, GRL, “Is the Dipole Anomaly a major driver to record lows in Arctic summer sea ice extent?”
- Collaborators: IARC/UAF, UW. Hokkaido Univ.

EOF Analysis and Regression

- Conduct EOF analysis of SLP north of 70N
- Plot the 2010 DA index into the scatter plot (Fig. 1)
- Regress the SIA to summer DA indices on the 4^{th} quadrant to obtain a regression equation
- Using this equation to project the SIA in September 2010

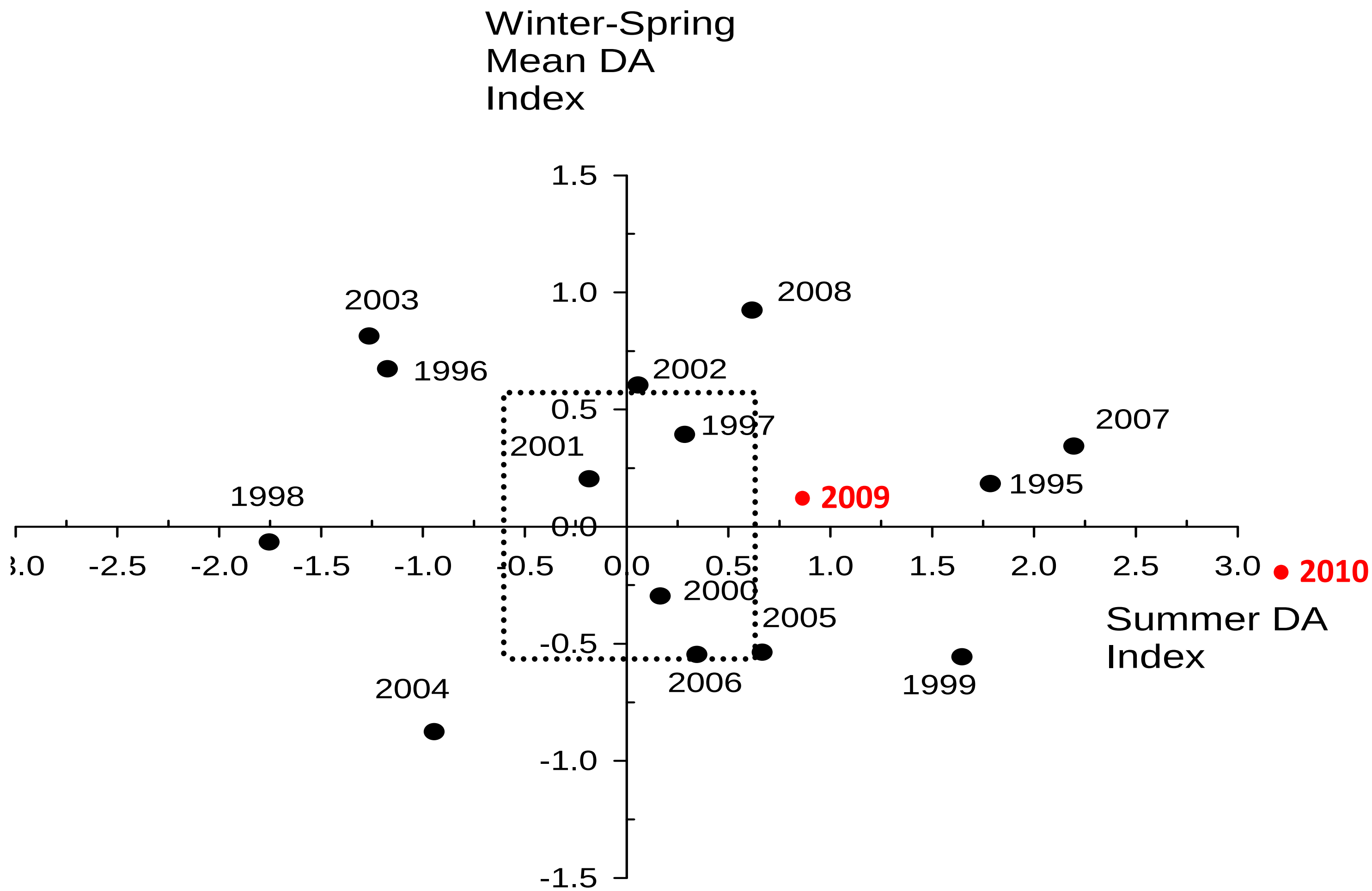


Figure 1. DA predicts record lows: 1995, 2002, 2007, 2008, and 2009 (+DA persists from Win-Spr-o Sum); 1999 and 2005 (-DA in Win-Spr, but +DA in summer). So, summer DA is the key! The 2009 DA is similar to 2007 and 2008, while 2010 DA is similar to 1999 and 2005.

Regression of September ice area to summer DA index if DA is negative during winter-spring, and positive in summer:

SIA_DA sep=6.4399-0.47xDA_sum (million sq. km)

Since summer DA (so far using June and July) index is 3.218, the projected SIA in September 2010 will be 6.4399-0.47x3.218=4.9274 million sq. km.

However, this projection may vary depending on August's DA index (sign and magnitude) that will change the magnitude of the summer DA index, since summer is defined as June, July, and August.

Outlook of 9/2010 Arctic sea ice from 8/1/2010

Jinlun Zhang
Polar Science Center, Applied Physics Lab, University of Washington

Based on ensemble predictions starting on 8/1/2010, the predicted September 2010 ice extent is **4.8 million square kilometers**. This number is the same as that predicted one month ago. However the predicted spatial distribution of September ice thickness and the shape of ice extent are different from those predicted last month.

The ensemble predictions are based on a synthesis of a model, NCEP/NCAR reanalysis data, and satellite ice concentration data. The model is the Pan-arctic Ice-Ocean Modeling and Assimilation System (PIOMAS), which is forced by NCEP/NCAR reanalysis data. It is able to assimilate satellite ice concentration data. The ensemble consists of seven members each of which uses a unique set of NCEP/NCAR atmospheric forcing fields from recent years, representing recent climate, such that ensemble member 1 uses 2003 NCEP/NCAR forcing, member 2 uses 2004 forcing, …, and member 7 uses 2009 forcing. Each ensemble prediction starts with the same initial ice–ocean conditions on 8/1/2010. The initial ice-ocean conditions are obtained by a retrospective simulation that assimilates satellite ice concentration data. No data assimilation is performed during the predictions. More details about the prediction procedure can be found in Zhang et al. (2008) http://psc.apl.washington.edu/zhang/Pubs/Zhang_etal2008GL033244.pdf. Additional information can be found in http://psc.apl.washington.edu/zhang/IDAO/seasonal_outlook.html.

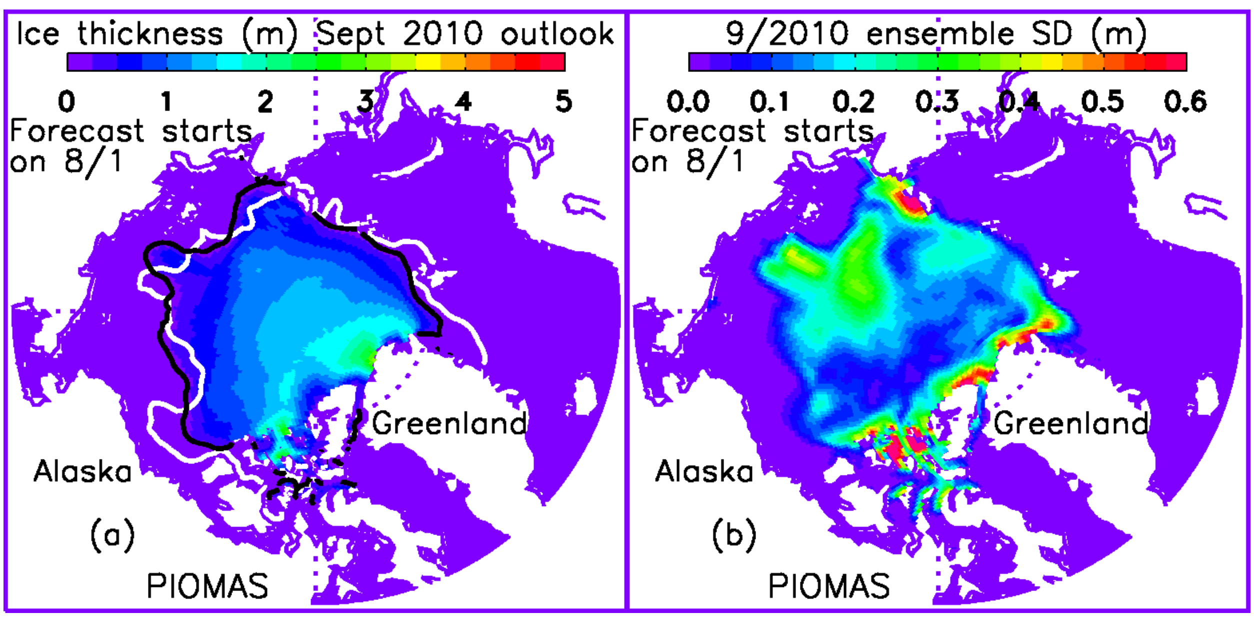


Figure 1. Ensemble prediction of September 2010 sea ice thickness (a) and ensemble standard deviation (SD) of ice thickness which shows the uncertainty of the prediction (b). The white line represents satellite observed September 2009 ice edge defined as of 0.15 ice concentration, while

the black line model predicted September 2010 ice edge. The prediction shows less ice in the Beaufort and Greenland seas in September 2010 than last September.

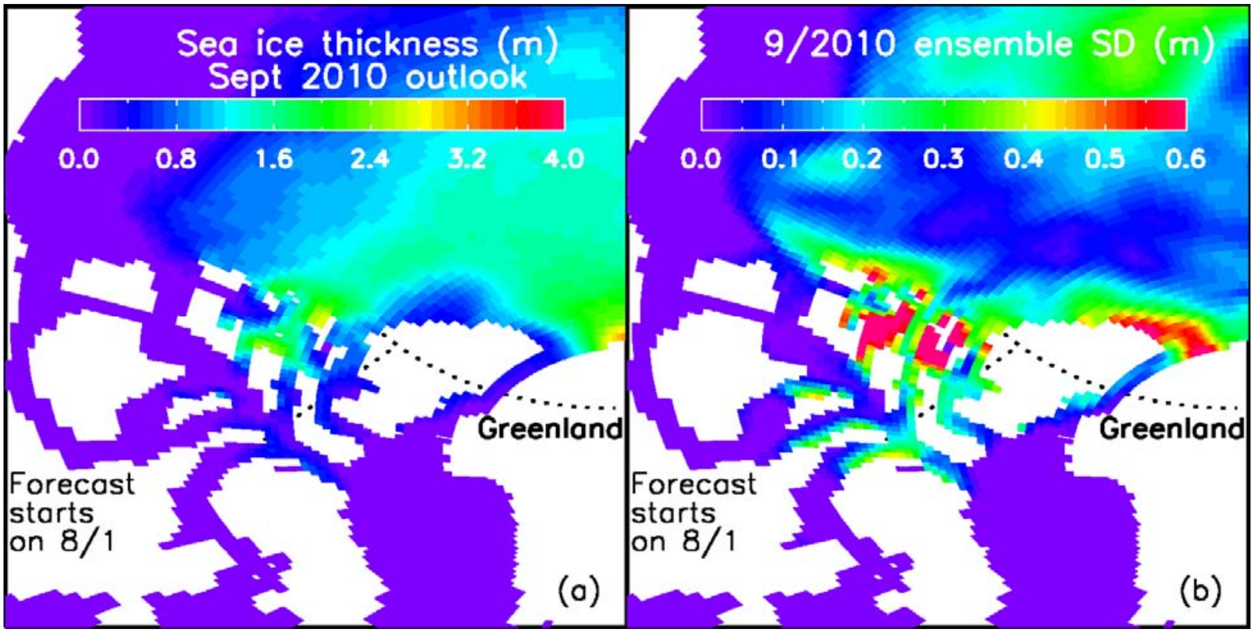


Figure 2. Ensemble prediction of September 2010 sea ice thickness (a) and ensemble standard deviation (SD) of ice thickness (b) in the Northwest Passage (NWP) region. Most of the NWP is ice free except some thin ice in the Lancaster Sound. However, because of the significant uncertainty (with relatively high SD) in the Lancaster Sound, it is possible that no ice will be there in September.

2010 Sea Ice Outlook
August Report

Steve Goddard
contributor at whattsupwiththat.com blog

Summary:

Method is based on numerical and visual comparison of the PIPS2 model thickness distributions in the Arctic Basin for the last ten years vs.the current year. May 2010 had less ice than May 2006, but similar distribution ratios of ice thickness - so the prediction was that the 2010 minimum would be lower than 2006 and higher than 2009. This hindcast method was effective for all years except 2007 - when wind appears to have piled the ice up at higher latitudes at the expense of extent loss. Similar winds developed in mid-August, requiring the forecast to drop by 8%. It is now expected that the season will end with ice extent slightly below 2009.

\- - - - - - - - - -

Complete Text:

Extent Projection
5.1 million km^2 based on JAXA. Reduced from initial June projection of 5.5 million

Methods / Techniques - Statistical.

Rationale
In late May, I performed a numerical and visual comparison of the PIPS2 thickness distributions in the Arctic Basin for the last ten years vs. the current year - and found a closest match with 2006. I also calculated the ice volume by integrating the thickness across all pixels. It showed that 2010 should come in below 2006 and above 2009. Verification of previous years showed that this is a highly accurate forecasting technique, with the exception of 2007 - which was dominated by unusual winds which compacted and melted vulnerable areas of ice. Until mid-August this approach appeared to be working very accurately. Since then, strong southerly winds have developed and extent has dropped below predicted values. Thus the 8% reduction from the initial forecast.

Executive Summary
Our projection is based on comparing short term PIPS2 thickness forecasts with those of previous years. It was found that May 2006/ May 2010 made a close match of ice thickness distribution inside the Arctic Basin, though absolute 2010 extent/volume was lower. We now expect 2010 to finish the summer slightly below 2009.

2010 Sea Ice Outlook
August Report

Charles Wilson

New Outlook: Averages 4 Calculations = 2.5 million square kilometers.

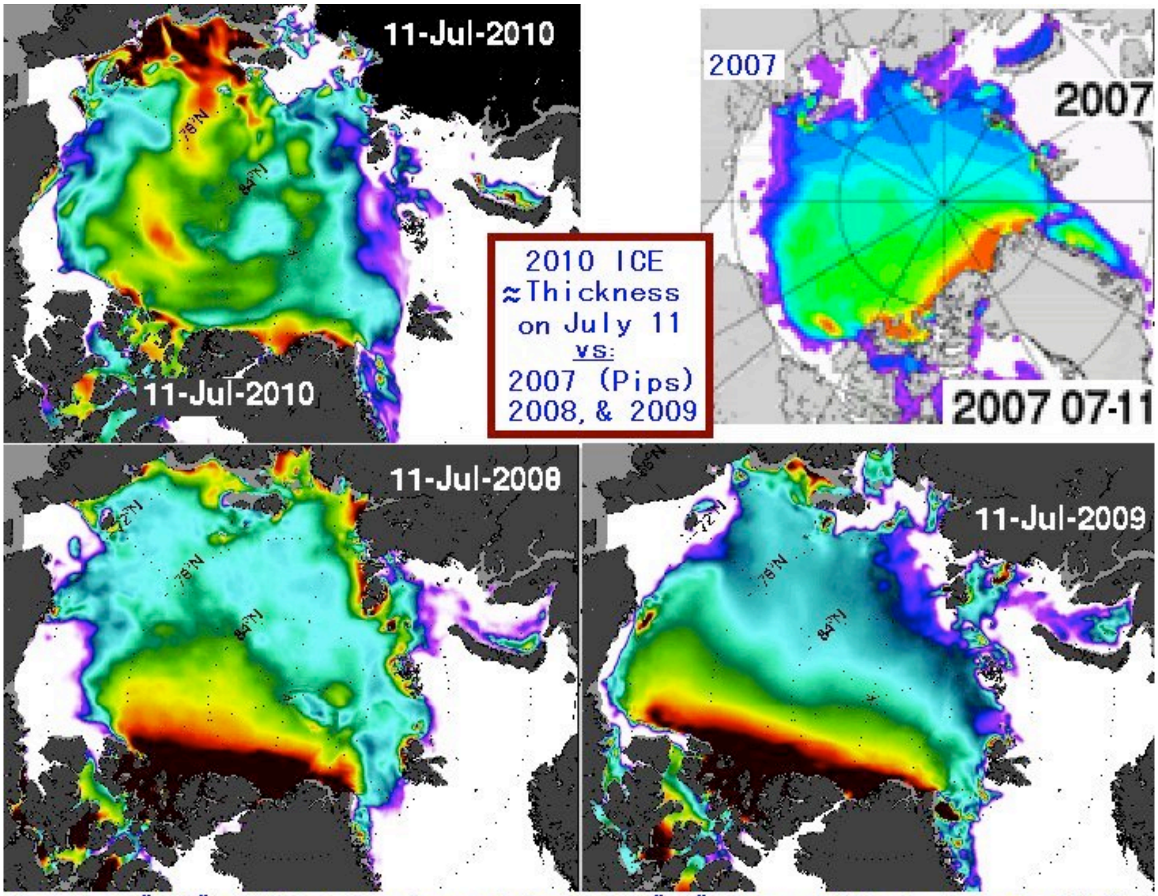
The Dominant Change is 2010's change from an El Nino (hot Equator) to a La Nina (cold).
Next time, the finding of Wayne Davidson's work on this will allow us to PREDICT: after a El Nino heats the Water, & next a Cloudy LULL ... WHEN a La NINAwill VANISH THE CLOUDS. **Wayne Davidson's work says a quick TRANSITION is what made 2007's Mega-Melt.** My July 14 Update was Mostly a discussion of alternatives for how long the "lull" will last (see below). (a June 30 E-mail unfortunately got published, so I append my "real" July Update at the end)

Four Models: (the first is the Original)

1.0 million sq. km = If Melt is proportionate to the strength of 2010 & 2007's El Ninos, the loss Volume of Ice is 1.8/1.1 x 2007's 4000 km3 = 0 left - - so the Area must decline to ONLY the stationary 30 foot thick Ice "always" attached to the Greenland & the Canadian Islands.
... Clouds, were specified as the Major Uncertainty.

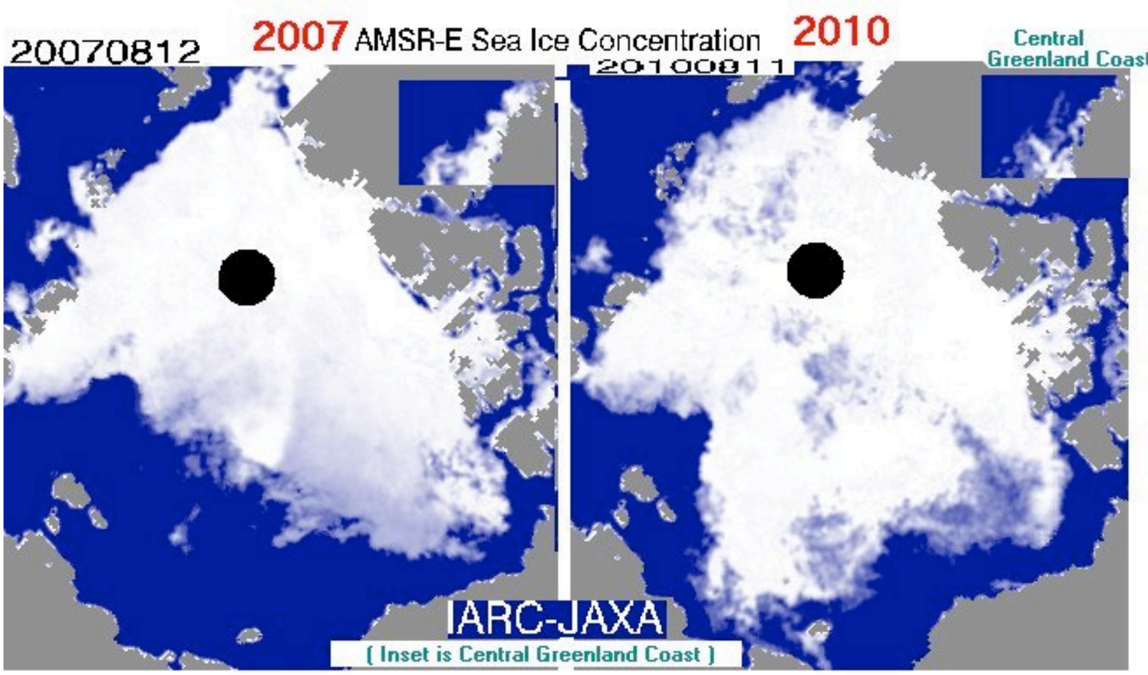
What Happenned ?
First, the Ice that 'Never breaks off' -- broke off.
Second, the Clouds came & kept Sun off the Ice since late June.
& Third, Low Pressure reversed the Winds & spread the Ice out.
Also: Lowest Temps ever in mid-year at Pole, & Russian Peat fires.

Public Contribution



The wide "BAR" of Thick Ice Rotated Straight "UP", Rammed Siberia & Broke UP ?

Note: the 3 Topaz maps are "hice", but Pips' is derived from Concentration (used as 2007 Topaz not available). It has more Data Points but is less directly a true thickness.



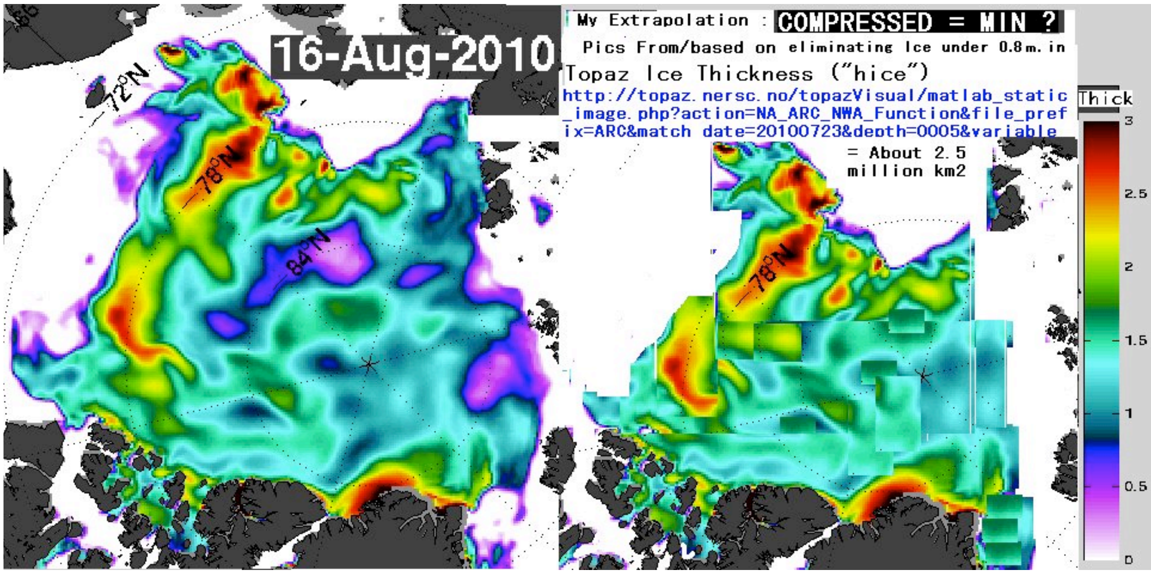
Look at all the Holes in 2010 ! ! Is there More Ice or not ?

So likely 1.0 is WRONG. But to further test the Basic Principle
- - that **a VERY strong El Nino trumps the Normal Modelling**
- - I will average several Other ways to use my Basic Principle thus:

4.4 m. km2 = By the Rapid transition to La Nina
... by repeating the conditions of 2007: Melt should be the same as 2007's from this date,times the strength ratio 1.8/1.1. Since I am using the JAXA data this is just a hair ABOVE the 2007 Melt (4.3 to 4.25).

2.2 m. km2 = By Volume measure:
... Piomas has the Anomaly at -10,150 km3 on 31 July ... implying 4,400 as I write & 3400 or less at minimum i.e. 13,400 Median for September, see: http://psc.apl.washington.edu/ArcticSeaiceVolume/images/PIOMAS_daily_mean.png>. . However, the Anomaly HAS been getting Smaller since -11,300 peak in Late June & -10,600 July 17. Nonetheless, we should have about HALF 2007's & we MIGHT get a "Cascade Melt" as in Hudson Bay earlier this year. Again, a LOT less likely as the Sun is so much nearer the Horizon now, being August.

2.6 m. km2 = Compression halves Area (see Topaz map):
... The TRANSITION put a weather "Low" (=Clouds) over the Arctic, REVERSING all normal Ice motion so UNLIKE 2007 the Ice was __DISPERSED__ with wide gaps (see pic). - - Wayne Davidson's work on this transition -- 25 years at Resolute in the Canadian Arctic -- implies this is a Permanent recent return to High Pressure &, long Range forecasts indicate a Dipole Anomaly next week - - so 2007 is back. As I looked at previous years, Ice less than 0.8 meters dissappeared between now & minimum, so I just cut & pasted a Map to squeeze it out, as shown in another pair of pics below.



PREVIOUS OUTLOOK HISTORY:

June Outlook: 1.0 m. km2 - - Assumed volume of Ice varies by El Nino strength = 0 ice save the Coastal Stuff that never moves. Submitted May 30.

June 30 E-mail: 1.0 m. km2 - - The Coastal Ice has rotated like the hour Hand on a Clock, Rotation Center = Greenland.

6 July : NSIDC (not me), using Mr. Maslanik's excellent Maps, sees the Old Ice, now a Curve, is sheltering the vulnerable Thin Ice inside its curve, & (correctly) forsees a slowing of the rapid melt.

July (14) Outlook: 1.0 m. km2 - WAYNE DAVIDSON's ZERO ICE FORECAST & Consequences:
... As he was unaware of the El Nino being a "Modoki" which fades slower, his conditional "IF the La Nina swiftly follows the El Nino" ... must expect a TIME-LAG.
... Just in July, the Month with nearly half the Ice-loss by Volume. My July Update (which I give as an appendix, in the confusion over Mr. Overland giving up the reins at Arcus, the wrong "Outlook" got published) .. I gave 3 Scenarios:

Lag =
1. 3 Weeks - - by the speed Weather Fronts Move
2. 6 weeks - - by the CTI index
3. 9 weeks - - = 2 months by the usual El Nino indexes.

... I thought (2) most likely as the Cold Tongue Index is specifically designed for La Ninas ... What we actually got was NOT just 1 correct result:

3 weeks = TEMPerature dropped ... below ANY year back to at least 1958 (cf DMI pic).

6 weeks = High Pressure Returns
7 weeks = Fram Strait Export resumes (see Navy Pips website)
7.5 weeks = Dipole anomaly Returns (tomorrow ?)
9 weeks = ????
20+ weeks = Hot water from the Pacific finally stops coming.

...ALL Possibilities seem to DO some thing.
It's like Vitamins: they all do different things.
The WORST is if the normally-Cold La Nina gives Clear Skies = SUN = Ice-albedo effect, **while the HOT WATER is still coming**, poking along at its measely 3-5 mph all the way around Africa. Which takes MONTHS. In fact the water is still coming long after the AIR has changed, & <u>I expect Melt to continue INTO OCTOBER -- if slowly.</u>

... There are a LOT of Requirements for what I fear most - - the RAPID MELT. Apparently, an El Nino cannot be a "Modoki" for even though the skies clear, it will be too late. Although given our Lack of certainty, a fraction of a percent Chance still exists of a Great Disaster.
Note the La Nina should cause VERY rapid build-up of ICE due to Clear Skies this winter. However, we may have lost another 40%. It is up in the air -- literrally -- whether the Ice will build up more than 2010's melt. The 2 La Ninas the last 2 years built up 15% more volume than 2007 & remember the Long-term trend -- LESS 2007 -- is only a 2% loss per year. 15% is a LOT. And the 60-year PDO says we will be getting twice the number of La Nina as El Nino -- plus: stronger -- for the next 27 more years. But ... another 2010 would finish the job. Easily. HALF a 2010.

The Greenland/Canada "Attached" Ice cannot ride again to save the Day.
It's been used up.
Nonetheless, even if it builds up again, remember the 60-year Pacific Cycle will cause the Ice to Thin again -- plus whatever Global Warming gives us -- and, if Cap & Trade CONTINUES to encourage soot (which darkens the Ice) by "forgiving" it if it reduces CO2, and discourages replacing the 1/1,000 th of our Sulfur cuts that are high-altitude & thus beneficial (according to NASA's Drew Shindell this combo QUADRUPLES Arctic Warming) ... in 50 years we will face a VERY SCARY time again.

PS: UNKNOWN EFFECT - - Russian Peat Fires. From late July, there HAVE been some Clear days but the melts seemed maybe 2/3rds what a Clear Day ought to have done. The Smoke Pall MIGHT be the Reason. However Next year this might make for Dirty Ice = easier to melt.

<u>Executive Summary:</u>

Wayne Davidson's Work showed CLOUDINESS responds to the El Nino-La Nina transition which, as this year's El Nino lasted longer than usual, produced a LULL in melting right at the most rapid-melting part of the Year.

This cancels the "Hot Arctic" scenario = 300mph Winds. At least 2 expected Cold years before the next Warm one MAY restore the Ice enough to avoid the "slow" consequences drying out California, etc, as well (see REAL July Outlook). But we WILL have half the Ice we did Last year at Minimum (by Volume), even if it LOOKS like more because the thick stuff along Greenland spread out & covered the Basin.

A less-Western, or oddly, a WEAKER El Nino, would have melted MORE in the RIGHT MONTH.

We dodged a Russian Roulette Bullet here (Similarly this El Nino made Hurricanes do the opposite of what was expected, because like 1998's it was SO STRONG it ignited Saharan Dust Storms, which quelled the "Hot Spot" off Africa - - Weather is just - - COMPLICATED).

But ask New Orleans about how many times you can IGNORE a weather Danger before it hits you between the Eyes.

There is NOTHING in the Warming, that has danger like Melting the Arctic off.

>> We must establish some Procedure for dealing with Dangers that are not 100%

However, after this year, I think we can SPECIFY WHEN A SUPER-MELT WILL HAPPEN.

Just Remember everything I got wrong:

>> Attached Ice need not not stay that way

>> An El Nino's strength is not as important as WHEN it transitions to a La Nina.

>> The various "parts" of 2007's Melting Recipe have different Time-Lags.

- - - - - - - - - - - - -

APPENDIX: WILSON ["REAL"] JULY OUTLOOK

[Any changes from Aug 16 email to helen@arcus in Brackets]

[PS: I was a little over the top on Wayne as 'like a Nobel Prize Winner" : think of Me as an "armchair" general sitting in with the Real Generals/Modellers (thank you, by the way). Wayne is like a Master Chief Sergeant or Petty Officer (as so many Modellers came form the Navy) with **Experience** of a kind that Generals & Admirals can Respect. But in a Different if related field - - Weather, not Climate. But it has relevance, here. Myself, I try to be a "Synthesist" as proposed by A.C.Clarke: I bring in bits of knowledge from another Expert's field. This should be "helpful" but often is unwanted.]

2010 Sea Ice Outlook (July)

Charles Wilson

1. September 2010 Ice Extent Projection = 1 million Square km

(essentially: an Open Arctic, save the 30 foot thick land-fast Ice of, & near, Greenland)

2. Methods:

2a. Statistically, I use 2007 as a base & compute Ice Loss from the relative strength of each's El Nino (Pacific Heat Index) & 2010's (the 4th strongest in 60 years). Using:
6000 cubic km (ICESAT figure for September 2007)
4000 cubic Km (ICESAT's number for 2007's reduction from Previous year Volume)
El Nino rating = 1.8 (2009-2010 El Nino)) /(divided by)/ 1.1 (2006-2007's peak ONI rating)
Thus:
6000 km3 - (4000 km3 x 1.8/1.1) = - 545 cubic km

= ZERO ... PLUS, the negative amount means it will melt off EARLY.
If I used the 2009 PIOMAS estimate of 5800 km3 for 2009's minimum,
it would be negative 745.
The Million km2 is because SOME Ice is up to 30 feet thick & will take years to melt.
2b. Heuristically, as I use 2007 as a base - - I check each unique characteristic of 2007, the "Year that Melted 20 years's Decline in One", & see if it has recurred.
2c. ... And I found a Meteorologist who ALSO predicted Zero Ice -- by August (!) - - and he is Famous in his field - - like a Nobel Prize Winner in Science ! ... I 've asked him to submit an Outlook himself, but as he fills a Gap in my ignorance of Clouds, I Quote him below.
3. Rationale:
2007 had more change than the average DECADE & so I multiply 2007's Ice Loss by the ratio between 2007's El Nino & 2010's. The Small changes of 1980-2006 made the Ice thin enough for large areas to melt off & SUNLIGHT to heat the dark Water ("Deep Blue Sea" = 3 to 4 times Ice & Snow's absorbance -- remember, they REFLECT most Sunlight) - - producing a FEEDBACK effect. But Now, an EL Nino does not just thin the ice a bit - - it may melt it ALL OFF.
>> Heuristics: since I am using 2007 as a Model, I can check DETAILS:
2007's El Nino did 3 things to melt off 40% of Ice Volume relative to 2006:
3-a. 2007 was Hot ... 2010 was MORE so: December was the highest monthly anomaly ever, Feb
was #4, March #10, April #7 (& the warmest April ever), May #8, but June ... only half as much over normal as the others (save January).
(I use figures from the Satellite (uah) Lower Troposphere breakout for N. Polar OCEAN)
3-b. Winds pushed Ice to form Open Water areas the size of the Great Lakes ... the Most SPECTACULAR melting of 2007 came from the New Siberian Islands Polynnya which in the week after August 26 seemed like it would roll up the entire basin like a Carpet.
>> In June: all 3 of 2007's Polynnya formed, and at the Same Places.

[pic deleted, showed 3 spots similar in 2007 & 2010, & not in other years]

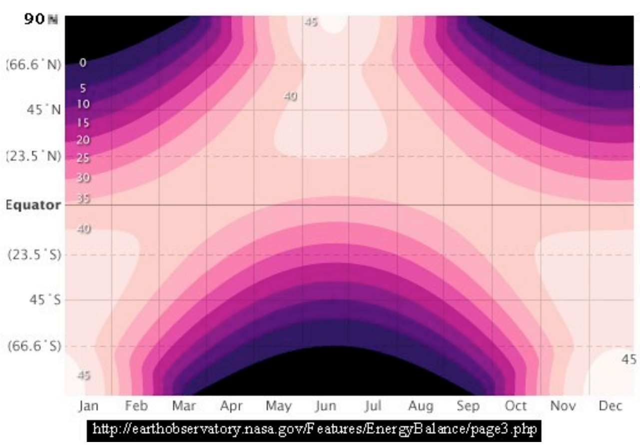
(3-b2) The Nares Ice Dam broke, however NSIDC says it has not exceeded 2007's flow. Yet.
3-c Clouds: 2007 Cloudiness was 16% Less than Norm.
In June I considered this the Wild Card.

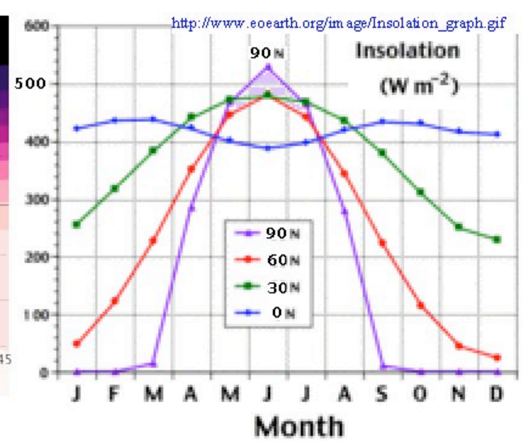
Then I discovered the famous "Resident Meteorologist of the Arctic": Wayne Davidson, 25 years at Resolute. In September 2009 he stated: "If El-Nino persists till the spring, and La-Nina follows, ships at the Pole will wander unobstructed in August 2010".
More recently:
"Big blue is expanding everywhere in the high Arctic" ... "This will accelerate the melting tremendously, since it [is] occurring at the solstice, very high sun, and will further demolish previous ice extent records. Everything is coming about as expected.... Unfortunately....
WD June 18 2010"
W.D. considers Clouds PRIMARY -- and a RAPID shift from El Nino to La Nina as 2007's BIG Gun.
... However, he did NOT expect this El Nino to linger (the west-more are called El Nino "Modoki" & this is apparently standard).
The Shift is LATER in the Year - - but happenening Faster than 2007, perhaps.
This implies a Lag as the two switch over - - remember the North Atlantic is warmed by the Pacific waters that left many months ago - - at 3 knots - - totally aside from his "anvil-Cloud-seeding" Theory - - we can see where a rapid shift can give us El Nino (hot) water & La Nina (cool) skies, due to the time-lag.
To summarize: the Clear Skies of 2007 that encouraged the Melt -- especially by causing the 40 degree (F) water near the NORTH end of the New Siberian Islands Polynnya -- WILL return.
Now I know for sure.
But now ... I don't know WHEN.
Two ENSO/El NINO/LA Nina Indexes
-- 2007's accellerated melt from clear La Nina Skies began about July 1
-- CTI implies 6 weeks but the Standard Indexes maybe 9-10 weeks ?
-- over 8 weeks might leave the ice there too late - - the September Sun is almost a Twilight (see below) - - but then, if the Transition is FASTER, the Wait might be, say, halved.
Then again the effects could be Very fast, as they come by AIR & the weaker 2007 June came about because there was a "lull" that month, in the coldness of the La Nina. That would mean WHEN June 2010's -.28 doubles, we get the Clear Skies.
>>> Bear in Mind: 2007's Big SUN months were JULY & AUGUST.
Cold tongue index (CTI) = SST anomalies over 6N-6S, 180-90W
<http://jisao.washington.edu/data/cti/>
(Better for La Nina watching)

2006 -65 -46 -51 -27 -2 -4 -1 31 61 62 94 93
2007 55 15 -7 -25 -30 -36 -45 -50 -72 -121 -137 -119
2008 -157 -128 -98 -86 -58 -53 -14 -6 -24 -35 -37 -75
2009 -59 -61 -54 -15 23 17 30 39 67 66 103 119
2010 111 85 58 30 -11 June
Here are the Standard Indexes but I have added an "Average"
YEAR _Average___________at:
<http://www.cpc.ncep.noaa.gov/data/indices/sstoi.indices>

2007 1 +.72__ NINO1+2 ANOM NINO3 ANOM NINO4 ANOM NINO3.4 ANOM
2007 2 +.26__ 26.24 0.21 26.45 0.09 28.62 0.61 26.81 0.12
2007 3 -.07__ 25.74 -0.73 26.79 -0.30 28.57 0.48 27.18 0.03
2007 4 -.24__ 24.30 -1.18 27.13 -0.27 28.70 0.30 27.78 0.10
2007 5 -.58__ 22.73 -1.60 26.35 -0.70 28.86 0.21 27.57 -0.19
2007 6 -.40__ 21.59 -1.44 25.83 -0.55 28.98 0.34 27.55 0.06
2007 7 -.60__ 20.27 -1.55 24.79 -0.79 28.81 0.24 26.79 -0.29
2007 8 -.78__ 19.16 -1.64 23.86 -1.10 28.58 0.12 26.20 -0.50
2010 4 +.69__ 26.05 0.57 28.05 0.65 29.25 0.84 28.36 0.68
2010 5 +.14__ 24.28 -0.05 26.97 -0.09 29.03 0.37 27.68 -0.09
2010 6 -.28__ 22.81 -0.22 25.87 -0.51 28.69 0.06 27.06 -0.43
The ONI ratings are 3 month averages & cannot show a transition in enough detail for here.

4. Discussion:
- - -
Beyond the Projection:
4. Effects of a 1-year Melt-off are Dire: Possible Ocean Current Shutdown.
> IF ... 2007's cloudlessness (3c above) was from it's El Nino AND is Proportional &
> IF ... our currents today are close enough to those 11,000 years ago for Ocean Current
Shutdown, & 300 mph winds (as occurred then)
The KEY is that the Long Polar Summer DAY actually provides more SUNLIGHT than the Equator -- for 3 months.From:
<http://earthobservatory.nasa.gov/Features/EnergyBalance/page3.php>





Thus IF the center area melts off, it can heat up HOTTER than the area SOUTH of it, or at least close enough to destroy the Temperature gradient that powers the Currents' South-to-North heat Transfer. Even a large part of it: there is a Weak Area right Now north of Russia's Taimyr Peninsula stretching well past 85 degrees North. At any Moment, this could GO CRAZY - -
From: <http://www7320.nrlssc.navy.mil/pips2/index.html>
[Topaz pic same as above, showing THICK Ice attached to Greenland UNTIL 2010]

Consequences:
A general "Open Polar Sea" occurred in Summer from the End of the Ice age until 5-to-6 thousand years ago -- it formed beaches, only recently discovered -- and you cannot do that with ANY Ice left -- you cannot have any Landfast Ice at all or the Surf acannot reach the Beach. But of course, only in Summer. In Winter it Ices up -- there is NO SUN AT ALL.
- - This was part of the 1960's Ewing-Donner Theory & predicted a Wet Sahara:
And a Sand Dune Desert in Kansas & Nebraska. If you watch History's Mysteries, you will have heard that that area was UNINHABITABLE.
>> Simple calculation shows that 3% of the Earth's surface changing from 80% relective to 20%, accounts for the temperature jump at the end of the Ice Age: 12 degrees F for the Northern Hemisphere over a 3 year period -- heating the Earth about 6 degrees F - - typically the South only reacts on Millenial scales (3000 years in this case).
1st Precautionary Action: Prepare for emergency use of massive "Hydrogel" mats to cover those states. (H. is used in Diapers). California will also lose half its water.
But the WORST Consequence is if the Transition is LIKE the one that started it: at the End of the Last Ice Age.
>See "Climate Crash" by Cox, interviewing the Greenland Ice Core crews:
wee, wee, wee, wee, BOING! WEEP! WOP! ... and then it stayed down."
- - that is the sound of "Pegging the meter" = winds higher than ANY Hurricane ... as those sounds were made by a ph meter every 22.5 days: we have both High winds & what appears to be 3 WEEKS in ZERO wind = the EYE of a Storm -- leading to the supposition these storms stretched from Arctic Circle to the Nearer Tropic.
As the Oceans weigh 1900 times the air, but only a tenth is involved in the Great Conveyor Belt Currents which move at 3mph but meander due to Coriolis & shorelines
... IF the Conveyor STOPS = winds must travel at 1900 x .1 x3 x .5 = 300 mph roughly, to convey the same Heat.
= Destruction of nearly ALL aboveground structures North of 10 Degrees Latitude
= 99% Deaths in USA, Europe, etc. within 2 years.
... In the Worst Case:
Immediate Action can create Clouds with: Airplane contrails, seawater mists, or highaltitude
sulfur (e.g. heightening Smokestacks at Norilsk).
But it needs to be done in the next few Weeks - - - months before we can be sure an Early Melt WILL happen.
But is it CERTAIN ?????

Now OPEN water above 85 degrees will reverse the currents in Summer -- because of the 24-hour-a-day SUN.
In Winter there will be no Warm current to slow temperature's fall -- which will go all the way to freezing out the Atmosphere because there is NO SUN. For six Months.n Every Night the temp falls a couple degrees ...
BUT:

> SHUTDOWN was feared when salinity flipped around 2000. You see, currents move for Both
salinity & temperature reasons
- - - I suspect it needs BOTH salinity & temperature to be reversed, for the current to reverse totally ...
Overall, It is a fair toss-up whether:
-- it will go SUNNY soon enough not to just Melt, but for a 50 degree F Ocean.
-- Salinity cooperates
-- The Ocean Currents "see" only whether there is Ice Cover over the Arctic OCEAN.
It OUGHT to respond like the Arctic is Covered, ie, in an Ice Age.
But are we identical to then? Certainly not, exactly. So... maybe...
... I'm giving it a bit over 1-in-8 because "weak" area North of the Taimyr may melt, then heat, and stop the Currents even if #1 does not happen. A Local melt at Just the WRONG sopt -- even without a General melt.
Overall:
>> Is Volume Loss Ocurring ?:
The Piomas model at the Polar Science Center has not been updated in nearly a Month (Ouch)
Here is summation of the last Update: in cubic km (km3)
------------- ICESAT / PIOMAS
'06-7 Change: 4000 ------- 2700 Change
(ie next 2 rows will show Piomas 1300 "high")
2007 Sept.___ 5050d ------ 6350 km3 Left @ minimum
2007 Nov. ___ 6000 ------- 7300 km3 Left "
2009 Sept. ---- ? -------- 5800 km3 Left " (P+I)
..Zero Ice at __-14200 Anomaly
2010 17 Apr. ____-7800 An.=6400 km3 Left @ " (P+I)
2010 18 June ___-10700 An.=3500 km3 Left "

Thus in 62days: 6400 -3500 = LOSS OF 2900 km3
= LOSS RATE of 327.4 km3 lost/week = in 10.7 weeks = 0
P+I = Piomas + Icebridge
(Better Data as add Airplane-Laser Measured Thicknesses)
d = derived by subtracting Sept -to- November change (assuming it is the same as Piomas' 950) from ICESAT's 6000 for November (ICESAT only available in March & November due to damage)

[Pic removed to save space - - it showed my effort to derive a "ZERO" from the website pic, but as Princeton Consultants came to a similar conclusion (Zero = 14,400, Me = 14,200) I don't need it. The PSC's Daily Mean Chart (at website below, see graphs' captions) says September mean = 13,400 ... but the "Zero" is the minimum, not September's monthly mean -- and it does sound like the big Dots are Monthly Means, not 1st of the Months -- but that could be, its ambiguous. I now have 6 different lines of reasoning, but most imply 2007 was near 5000 km3 at minimum so leave it at that, I guess]

... From Superimposing the 2 graphs on the Webpage
<http://psc.apl.washington.edu/ArcticSeaiceVolume/IceVolume.php>

Is PIOMAS Accurate? It did match ICESAT's numbers almost perfectly -- except once -- in late 2007. So, IF the Central Arctic Ocean melts, PIOMAS will understate the Melt (as in 2007) as PIOMAS sums up airplane, ship & shore data for thickness - - and while satellites are overhead, who risks flying so far from shore ? E.g. Icebridge has stopped except over Greenland.
I sent an E-mail that Cryosat 2 should share preliminary data with PIOMAS - - I've heard Nothing. If there is no Satelite DATA - -
WE NEED ICEBRIDGE BACK.
... If we do not have confirmation that WE WILL LIVE...
The Military Point of view I learned says: PREPARE, just in case.
It's life & Death of 6 BILLION ! . . . MAYBE. POSSIBLY.

Executive Summary:
Overall, I stand by my Calculation that 2010's Strong El Nino has done enough more than 2007's to FINISH the Ice, based on the total VOLUME of Ice being so Low an Ice-albedo feedback will Occur.
Wayne Davidson echoes my prediction with his Much gtreater Experience & fills my knowledge-gap in Re: Clouds.

In the Day-to-Day Saga, June was a Record Melt in every way ... but suddenly SLOWED in Early July at the Crossover between El Nino & La Nina. El Nino gives THIN ICE. La Nina: CLEAR SKIES. If Wayne is right, it WILL get SUNNY. Given the low VOLUME of Ice left ... the END will come VERY QUICKLY -- like Hudson Bay when it melted so early this year.
A "Bar" of thicker Ice may remain but further towards Alaska than the 2007 Ice-Front ... its persistance may avert - - or its being too far West may encourage -- Ocean Current Shutdown/or Reversal.
Actions Needed: Circle Planes over un-clouded Open Water (Contrails = artificial Clouds), Resume Icebridge, stockpile Hydrogel, Heighten Smokestacks at Norilsk & increase July-August output there.
Volume of Ice & Icesat numbers at the Polar Science Center
<http://psc.apl.washington.edu/ArcticSeaiceVolume/IceVolume.php>
ONI ratings are at:
<http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml>
Also see:
uah Arctic Ocean air temp: <http://vortex.nsstc.uah.edu/data/msu/t2lt/uahncdc.lt>
Wayne Davidson Website: <http://www.eh2r.com/>
<http://www.ngu.no/en-gb/Aktuelt/2008/Less-ice-in-the-Arctic-Ocean-6000-7000-years-ago>
The Following may be superfluous:

Public Contribution

These 4 pics from 4 years show HOW different that "Bar" breaking loose makes 2010 look:
Note how the "Bar" squashed the Siberian part of the Behring Strait Polynnya:
Note also the "Blue Corridor" of weak ice in 2010 Pointing near the Pole:

PS: Beaches Older than 7000 years were not found but as the Great ICECAP had not completely melted off & Sea Level was 100+ feet below today's -- they would be underwater. Ends of Ice Ages occur 101,000 years apart & are NOT triggered by Milankovitch as the Longer Vostok cores showed transitions happenning 50,000 years off (the cycle is 108,000 years but Ice Ages cycle @ 101,000 average, but vary to match the Jupiter Orbit cycle EXACTLY. Besides, Milankovitch's requires a mysterious disappearing Augmentation Factor - - that no one has ever found - - and which must apply only to the 108,000 year cycle & not the 41,000, etc.
--- Although Jupiter's Plane of orbit EXACTLY matches the ICE AGE TIMING in He3 studies, the DUST theory that Jupiter proponents used has just a month ago been proven orders of magnitude too weak. Then How do Ice Ages End? Well, we KNOW, from Comet Shoemaker-Levy, that getting BETWEEN Jupiter & Io produced a "Zap" & Auroral Display equal to a Month's Solar Radiation. This is FACT. That the Ends of Ice Ages MATCH the Jupiter/Earth/Sun eclipse date, and the 11,000 B.P. Numerical temperature Increase, MATCHES what an Open Polar Sea creates -- are FACTS. Thus I argue: the Ice Ages are now Explained. Period. Well: the ENDS, anyway. I considered whether I should mention this -- too much New, at one time = Scientific indigestion ? But Science is not about being Politic, and it is relevant... partly.