September 2010 Sea Ice Outlook: June Report

Community Contributions

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Outlook for 2010 September Arctic Sea Ice Extent Minimum
June Report based on May Data

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In Spring, 2010, NIC acquired the Arctic Region Ice Forecast System (ARIFS, Drobot et al. 200x) from the University of Colorado, with a view toward implementing the system operationally for weekly to seasonal support of Navy, Coast Guard, and other maritime clients. This code employs a multi-linear regression system to correlate the conditions of week X (the predictor week) with the conditions of week Y (the predicted week). In this case, we use NCEP 2 meter Air Temperatures, NCEP Sea Level Pressure, and Ice Extent from the NASA Team algorithm as predictors, with Sea Ice Extent as the predicand. The past 10 years of data (2000-2009) are correlated to determine a series of correlations between Week X and Week Y for each predictor, and this is passed through a multilinear regression to arrive at a predition for Week Y. All data are on the NSIDC EASE (equal area scalable earth) grid, so comparisons with the NSIDC Sea Index (considered "truth" in the SEARCH Sea Ice Outlook) are straightforward. While the color on the charts follow the World Meteorological Organization color codes for sea ice concentration, we only include ice of greater than 15% concentration per 25 km^2 grid cell, allowing a direct comparison with the NSIDC Sea Ice Index. The extent is the sum of the areas of the grid cells containing at least 15% ice coverage. This is different than the concentration, which is the sum of all ice covered area, and will always be less than the extent. The "donut hole" in the middle of the ice is due to the blind spot on the SSM/I sensor. No predictions are made in this area as there are no ice measurements. Replacement or supplementation with digitized NIC ice charts may solve this problem in future outlooks.
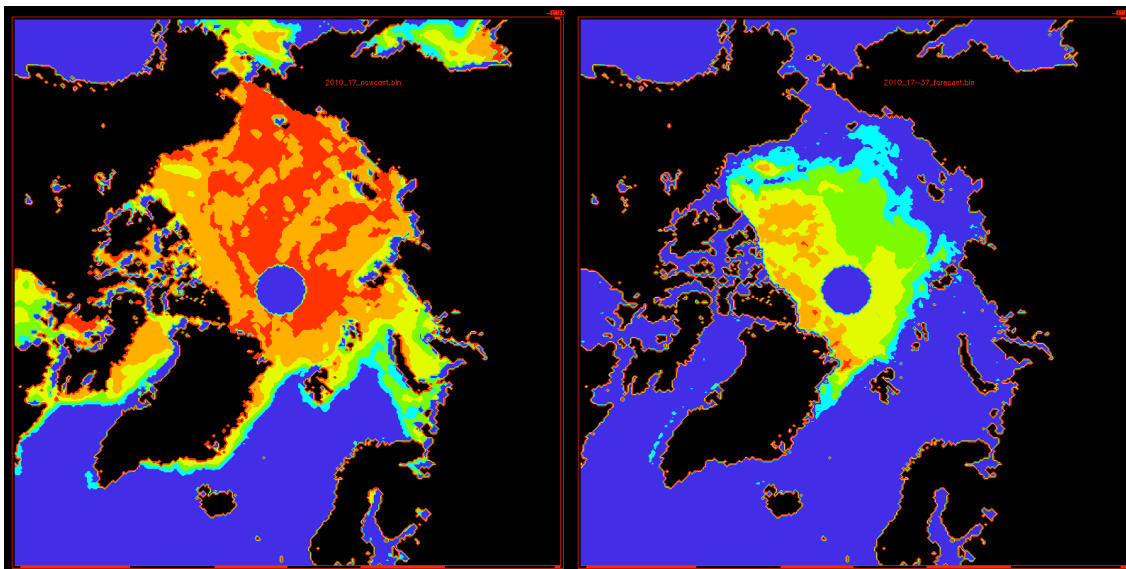
Figure 1: Sea ice extent and concentration for 2010, end of April conditions (left) and projected conditions for 2010, mid-September conditions (right). The blue area in the center (surrounding the North Pole) is the SSM/I blind spot; no projections are done for this region. WMO color codes are given in Figure 2.
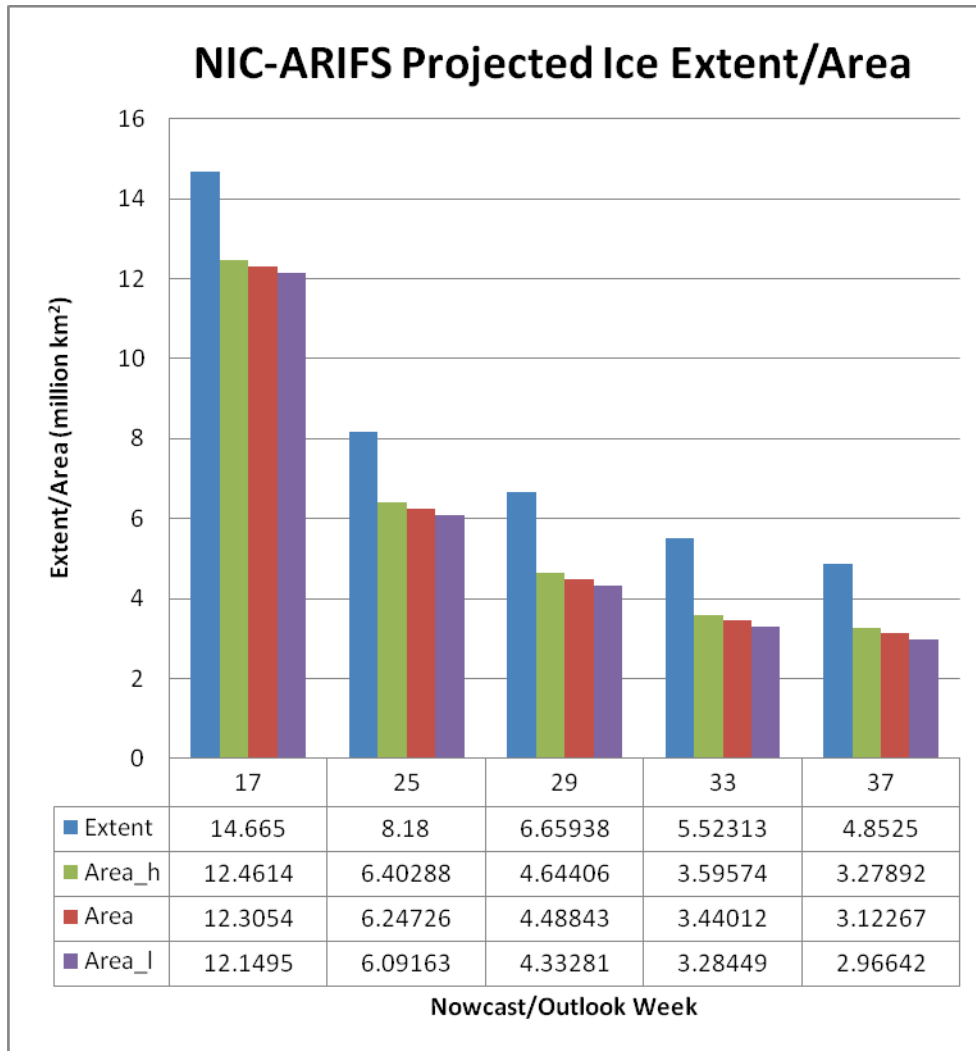

Figure 2: WMO Sea Ice Color codes for Ice Concentration.

The current and projected conditions for 2010 are shown in figure 1. Despite the reasonably large current extent (14.665 million km2 and compact concentration (12.461 million km2) in late April, the projected extent for mid-September is another near-record low (4.852 million km^2), while the actual ice-covered area could be 3.123 million km^2. As indicated in by the WMO Sea Ice Concentration legend (Figure 2), the most compact ice is on the Canadian side of the Arctic Ocean, while the pack on the Siberian side is diffuse (1-3/10th concentration). While no information is known about the blind spot in the center of the figures, it is assumed that there will be ice present and therefore the area of the circle is included in the calculations of ice extent and ice area (detailed below). The projection suggests an open and navigable Northern Sea Route at the September Minimum. At this point, ARIFS is not configured to compute ice conditions within the Canadian Archipelago, so no statement can be made about the Northwest Passage, and its area is not figured into the total extent and ice area of the Arctic. Thus there is a potential low bias in concentration and extent.

Figure 3 shows the progression of Ice Extent and Ice Area from the Nowcast (Week 17) through 4 forecast weeks (25, 29, 33, 37) corresponding to June 20, July 18, August 15, and September 12, 2010. Again, the ice extent is the largest number, while now there is a range of values for ice area, assuming 100%, 50%, and 0% ice coverage in the blind spot. For the nowcast, it is most likely that the ice-covered area is near 100%; based on the surrounding area, it is assumed that the ice-covered area in the circle at September 12 is around 50%.

Future work will quantify the variability and error statistics of the input fields (ice area, surface air temperature, and sea level pressure) and compute new projections based on end-of-June conditions.

NIC-ARIFS Projected Ice Extent/Area

Nowcast/Outlook Week	17	25	29	33	37
■ Extent	14.665	8.18	6.65938	5.52313	4.8525
■ Area_h	12.4614	6.40288	4.64406	3.59574	3.27892
■ Area	12.3054	6.24726	4.48843	3.44012	3.12267
■ Area_l	12.1495	6.09163	4.33281	3.28449	2.96642

Y-axis: Extent/Area (million km²)

Figure 3: Projected Arctic Sea Ice Extent and Area over summer 2010, based on Week 17 conditions. The range of areas is bsased on the assumption of 100%, 50%, and 0% concentration within the blind spot of the SSM/I sensor.

The NIC also generated a simple linear regression model (Helfrich and Arbetter Regression Model) based on the past ten years of data. While the sample size is significantly low, F-test statistics (Sig F = .03) suggest that a proposed regression model fits the data well even proving the small sample size. Correlation coefficients suggested a high level of correlation between the regression model and past observations (R^2 = .927). Independent variables considered for this model include, multiyear ice concentration for May, zonal and meridional winds over the Arctic in March, Northern Hemispheric snow extent for April, and average sea ice area for April, air temperatures in April. Each was found to be correlated with the September minimum ice extent. The forecasted 2010 minima from this model suggests 5.14 million km^2 for ice extent. We will continue to track differences between the NIC ARIFS prediction and the Helfrich and Arbetter Regression Model.

(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.)

References

Drobot, S. D., J. A. Maslanik, and M. R. Anderson, 2008: Interannual variations in the opening date of the Prudhoe Bay shipping season: links to atmospheric and surface conditions. *International Journal of Climatology*, **29** (2), 197-203.

Canadian Ice Service Contribution

to the

September 2010 Sea Ice Outlook

The Canadian Ice Service (CIS) is predicting the minimum Arctic sea ice extent to be less than 5 million square kilometres in September, 2010. A value equal to or slightly greater than the average extent observed in September, 2008, is expected. This value ($4.7 \leq x < 5.0$ million square kilometres) will make the Arctic sea ice extent in September, 2010, the third lowest in the 1979-2010 record. This value lies well below the average September extent for 1979-2009 of 6.63 million square kilometres based on the NSIDC sea ice index.

The above CIS value was derived empirically, based on the following: Although the extent of the Arctic Ocean multi-year ice pack at the beginning of May, 2010, was greater than the extents witnessed at the beginning of May in 2007, 2008 and 2009 (the result of new areas of second and third year ice), multi-year ice floe concentrations within the pack in 2010 were less than those of previous years (the result of extensive fracturing and the repeated formation of large open water leads within the multi-year ice pack during the winter months of 2010). The extensive fracturing that occurred within the Arctic Ocean multi-year ice pack in the winter of 2010 was the result of: 1) a delayed freeze-up and warmer than normal winter temperatures (which averaged 2-5°C warmer than normal during January to March over the area); and 2) persistent periods of east-northeasterly winds associated with generally higher than normal sea level pressures near the North Pole and a generally negative January-March Arctic Oscillation Index (which led to large ice flow divergences within the MY ice pack along the northwest coasts of the Canadian Arctic Islands). Taking the above into consideration, the operational staff at CIS are predicting a 2010 summer sea ice minimum extent similar to but slightly greater than that of 2008.

CIS is also currently testing two models for long-range sea ice prediction. A Multiple Linear Regression (MLR) prediction system, that tests ocean, atmosphere and sea ice predictors, predicts a September, 2010, Arctic sea ice extent of 5.7 million square kilometres. An Optimal Filtering based model (OFBM) applied to the ice extent time-series predicts 4.9 million square kilometres. The average of these model predictions, 5.3 million square kilometres, represents an extreme upper limit of the empirically determined range of values 4.7 to 5.0 million square kilometres. CIS will be continuing its verification studies of the predictions produced by these models in the coming years. In 2009, the OFBM model under-predicted the sea ice extent at 4.2 million square kilometres, while the MLR model over-estimated it at between 5.5 and 6 million square kilometres. However, the average of the two models corresponded well with the empirically determined forecast of 5.0 million square kilometres, both of which did better than all the other predictions submitted to SEARCH in June 2009.
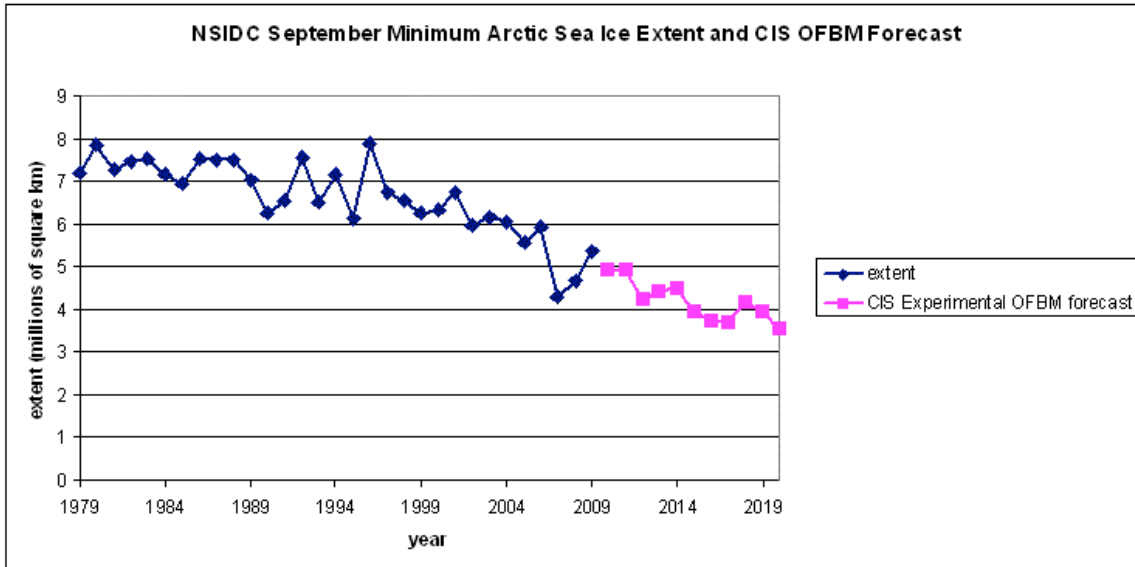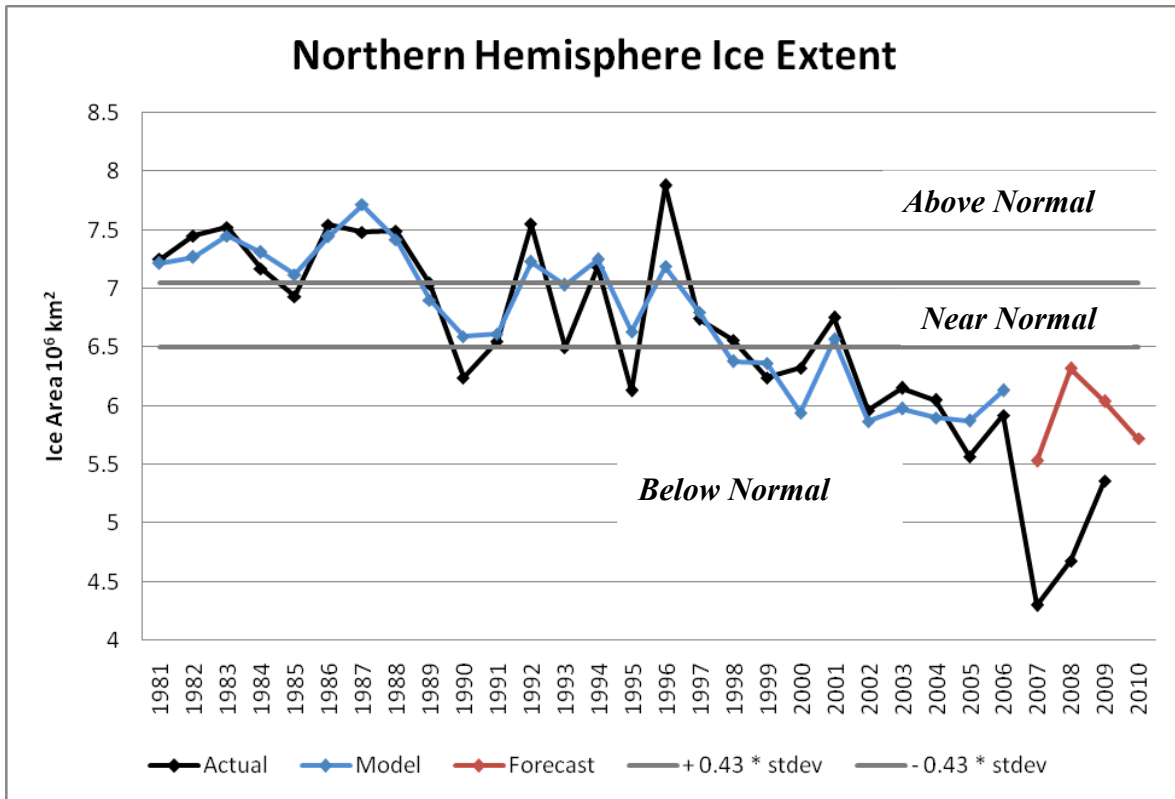
Figure 1. The Optimal Filtering Based model (OFBM) forecast for 2010-2020. The **2010 forecast** is **4.9*10^6 km^2**.

Model Details

Details of the OFBM used here, as well as the model code, can be found in Chapter 13, section 6, of Numerical Recipes in Fortran 77, 2nd Ed. (1992).

Figure 2. Regression based forecast for the 2010 September Ice Extent. The model is trained on the 27-year period from 1981-2006. Independent forecasts were generated for 2007–2010. The **2010 forecast** is expressed both categorically, **Below Normal**, and deterministically, **$5.7*10^6$ km^2**.

Model Details

The regression model is generated using an automated selection scheme (Tivy et al., 2007) based in part on step-wise regression and where the maximum number of predictors is restricted to two. The predictor for northern hemisphere September ice extent is the preceding summer (May-June-July) sea surface temperature in the North Atlantic and North Pacific close to the marginal ice zone, which represents a 14-month lag. The regression r^2 and cross-validated r^2 are 0.82 and 0.78 respectively; the categorical forecast skill over the training period is 80%. While the model over-estimated ice extent for the 3 independent forecast years (2007-2009), the categorical forecasts of below normal ice extent were correct for each year and 2007 is an extreme minimum in the model time-series. Predictors in the original predictor pool included: Sea Ice (Northern Hemisphere ice concentration, Northern Hemisphere multi-year ice concentration); Ocean (Near-global sea surface temperature, ENSO, PDO); and Atmosphere (Northern Hemisphere z500, Pan-Arctic (north of 60N) SAT and SLP, teleconnection indices). Each predictor was tested at lags ranging from 5 to 18 months.

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

2010 Sea Ice Outlook
June Report based on May Data

Xingren Wu
Robert Grumbine
National Oceanographic and Atmospheric Administration

Wu and Grumbine:

Model Prediction for September 2010 average ice extent:
5.13 million km2, standard deviation 0.25 million km2

This prediction is based on the coupled Air-Sea-Ice Climate Forecast System (CFS) at NCEP. These predictions are based on the CFS Reanalysis and Reforecast model, the improved CFS version which will be implemented in operations later this year. The CFSRR is currently only up to December, 2009, so the prediction is based on a forecast from that period. An ensemble of 24 forecasts were made to provide estimates of mean and model variability. At this lead time, the model shows a consistent high bias in its forecasts of September ice extent. We have, therefore, attempted bias correction. One method is to subtract the extent bias observed from the prediction of September 2009 from December 2008. This lead to an estimate of 5.16 million km2. The second is to consider the model's bias as being excessive thickness, and then find the thickness greater than which the extent in September would match observed. This lead to an estimate of 5.11 million km2. We then averaged these two predictors.

Grumbine and Wu:

Statistical: 4.78 million km2, 0.45 million km2 sdev

This prediction continues the statistical approach used by Grumbine in 2009. The approach is to consider the growth of open water as proceeding according to a population growth (positive feedback of more open water leading to more open water) with a constraint. The constraint is that the open water area cannot exceed the original area of ice. The resultant curve for growth of open water is logistic curve -- exponential growth of open water in the early phase, exponential approach to zero ice extent in the later phase. Using the data for 1979 through 2009, the absolute best fitting parameter set (K, P0, r) predicted extent for September 2010 is 4.59 million km2. The standard error in this fit is 0.45 million km2 to date. The best fit logistic curve paramaters are K = 7.43 million km2, P0 = 0.074 million km2, and r = 0.133 per year. On the other hand, there are many parameter sets which are unbiased (bias less than 0.01 million km2) and have rms error less than 0.5 million km2. For our prediction, we are taking the average prediction from all these high quality logistic curves. That gives a prediction of 4.78 million km2.

Sea ice outlook 2010

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[2]Jet Propulsion Laboratory, California Institute of Technology
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June 12, 2010

1 Extent Projection

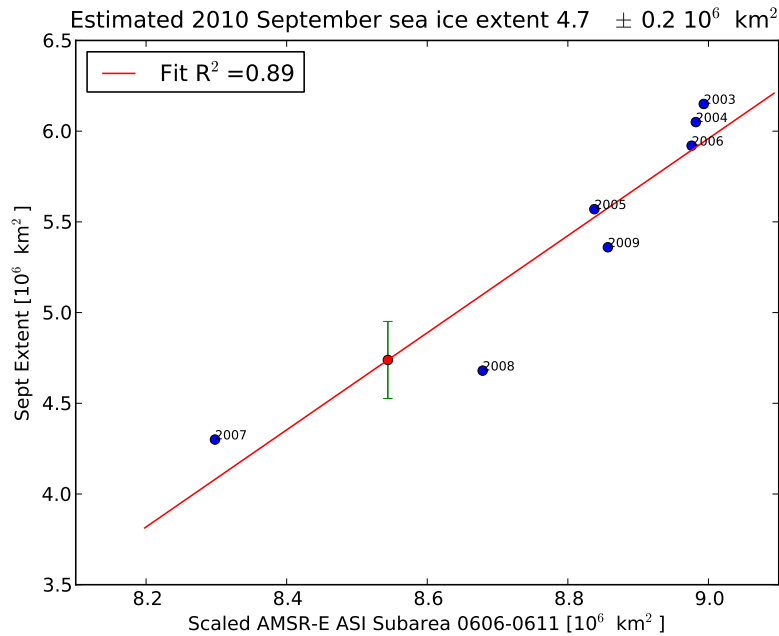We estimate a September 2010 monthly mean extent of **4.7 ± 0.2 million square kilometers**.

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
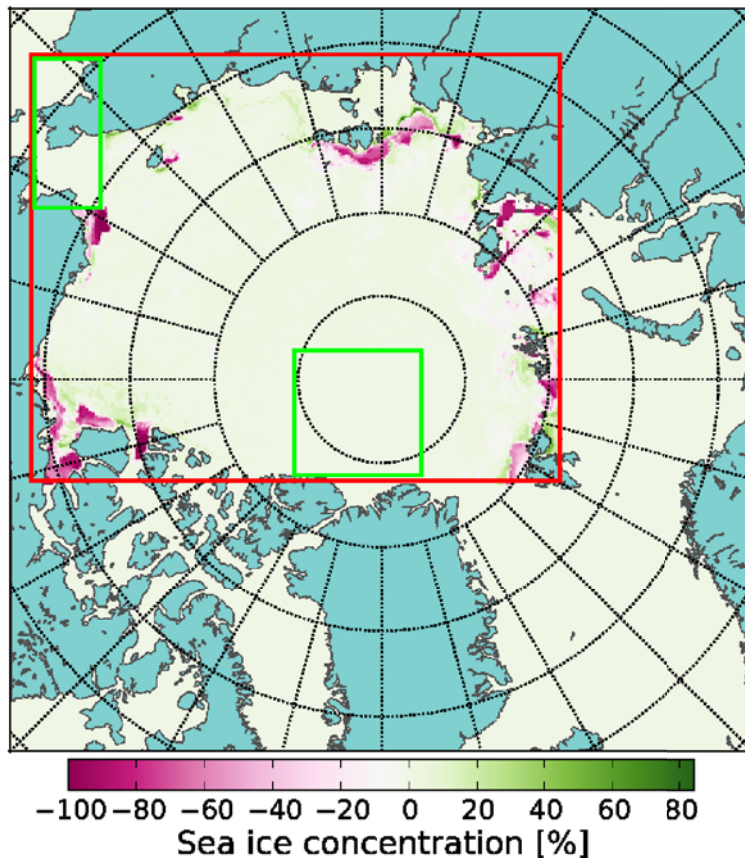
Figure 2: 2010 sea ice concentration anomaly derived from AMSR-E ASI data. The anomaly is calculated with respect to the years 2003–2009. The red rectangle indicates the subset for calculation of the ASI AMSR-E sea ice area. The green rectangles indicates areas that are not taken into account.
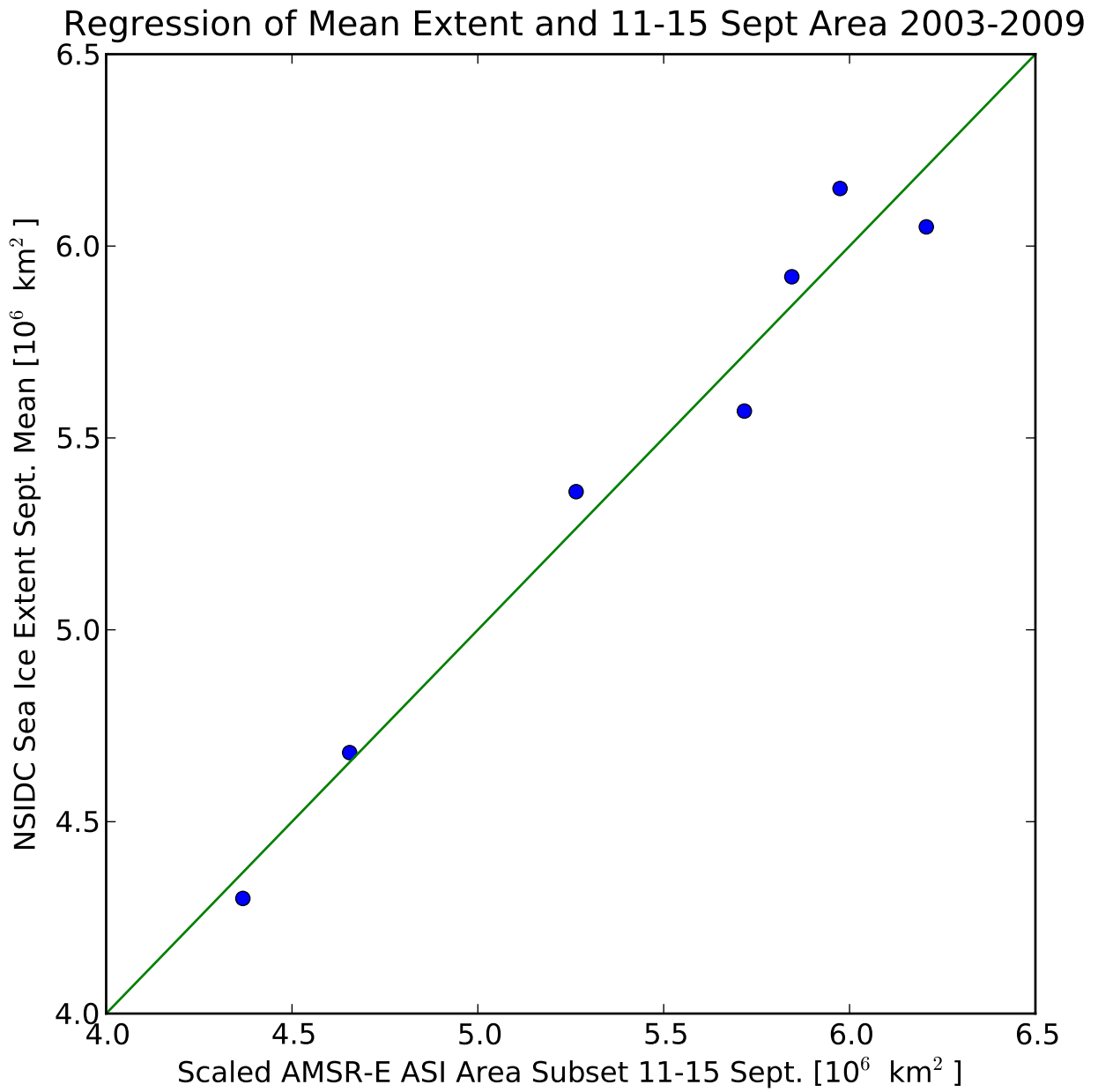
Figure 3: Regression of regional (region shown in Fig. 2) five-day median filtered AMSR-E ASI area and total NSIDC September mean extent.
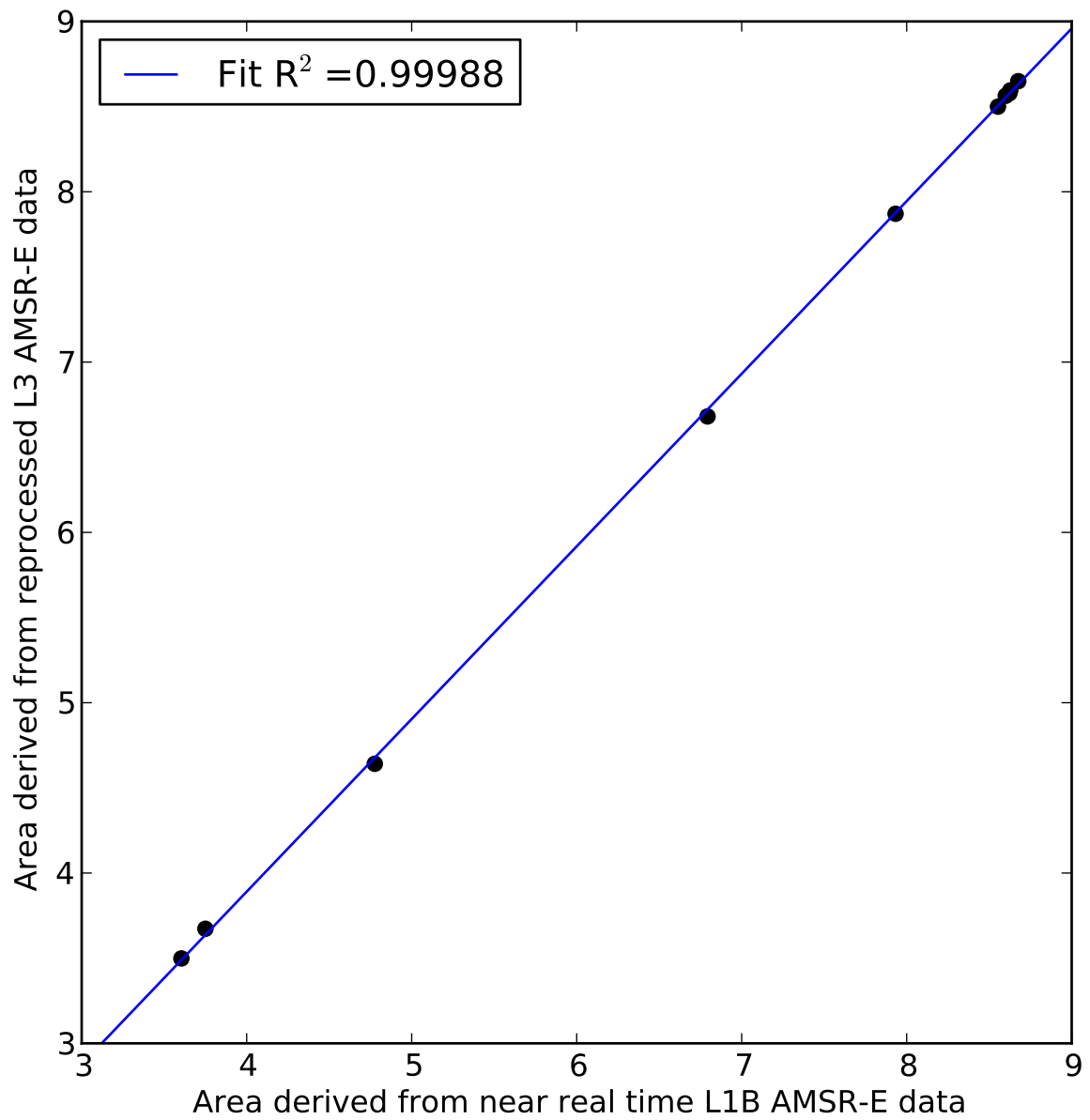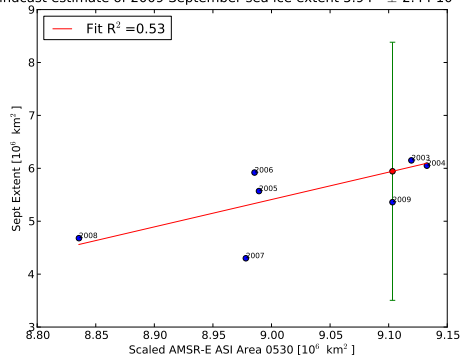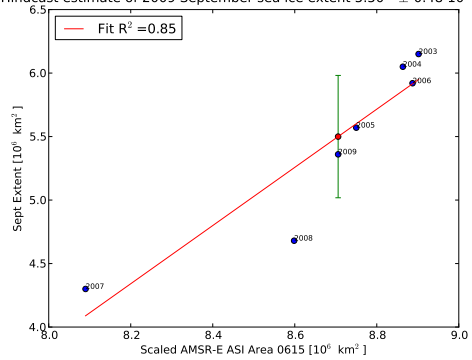
Figure 4: Regression of near real time and reprocessed data.
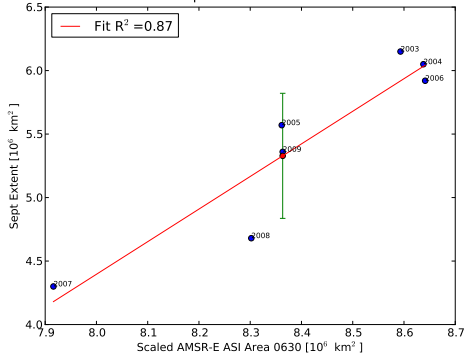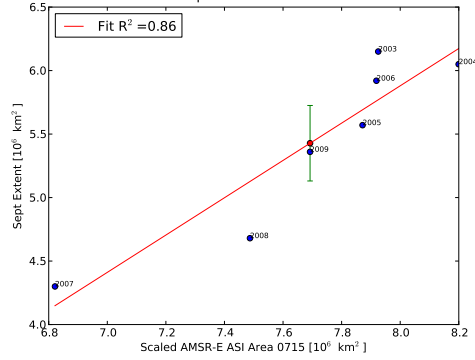
Figure 5: Hindcast prediction for September 2009.

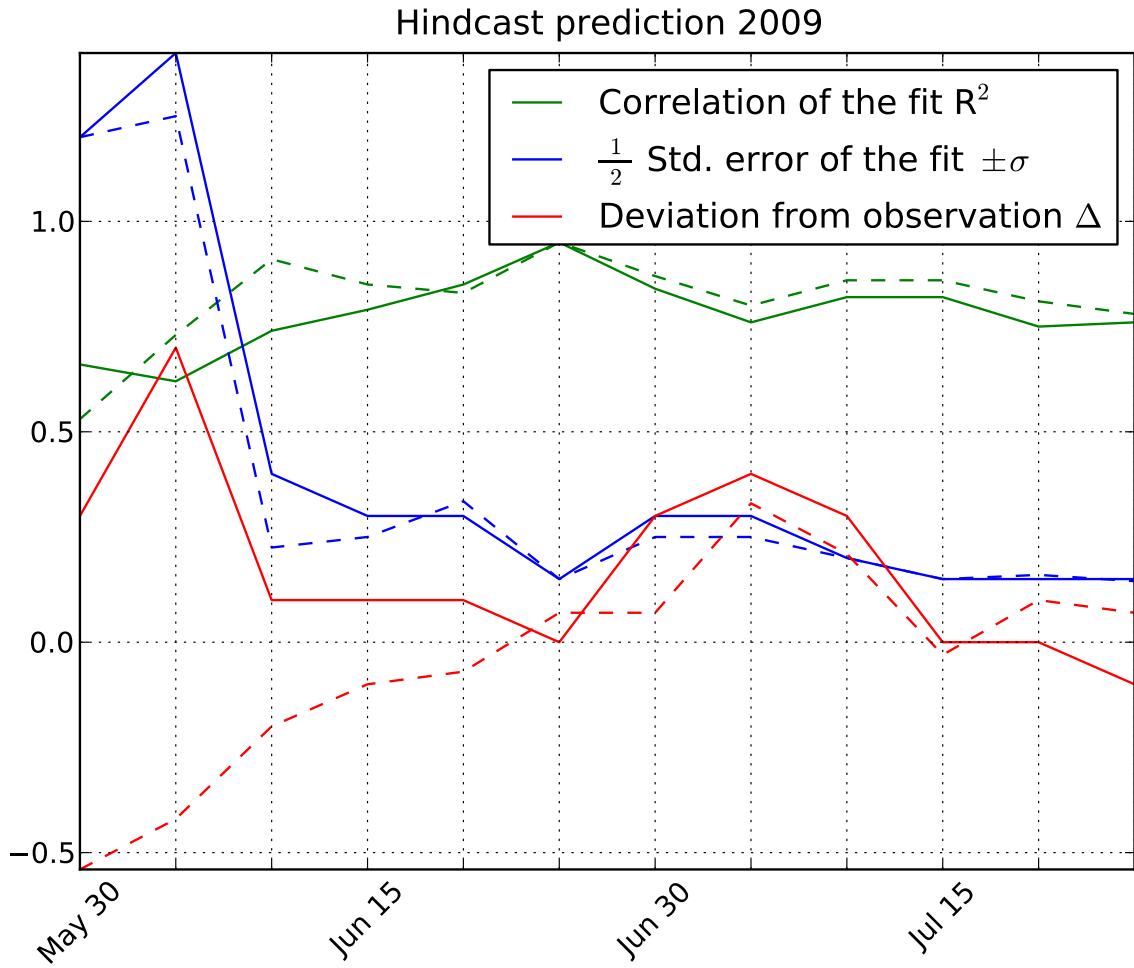Figure 6: Hindcast prediction for September 2009. The results for the solid and dashed lines are for different training areas (see 2).

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

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June, 2010

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[c] FastOpt, Hamburg, Germany

As for the SIO 2009 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 May 28nd 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 May 28nd 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 2009 two ensemble experiments with different initial conditions on May 28nd 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 28nd May 2010.

Ensemble II starts from an optimised state derived by NAOSIMDAS with an assimilation window from March 2010 to May 28th 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 May 28th 2010.

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

Figure 1 displays the modeled ice concentration on May 28th 2010 for the "free" run and the run with data assimilation. Differences can be mainly seen next to the ice margin especially in the Barents Sea. We have not expected large differences this early in the melting season because we know that NAOSIM is able to simulate the ice concentration during the winter season with some accuracy. We expect that the benefit of the data assimilation will become more obvious in the July and August outlooks. The ice thickness on May 28th 2010 (Fig. 2) exhibits some differences at the ice edge but also some minor differences in the Canadian basin. We assume that this is driven by a slight weakening of the Beaufort gyre in case of data assimilation as illustrated by the mean March 2010 ice drift and it's difference with the "free" run (Fig. 3).
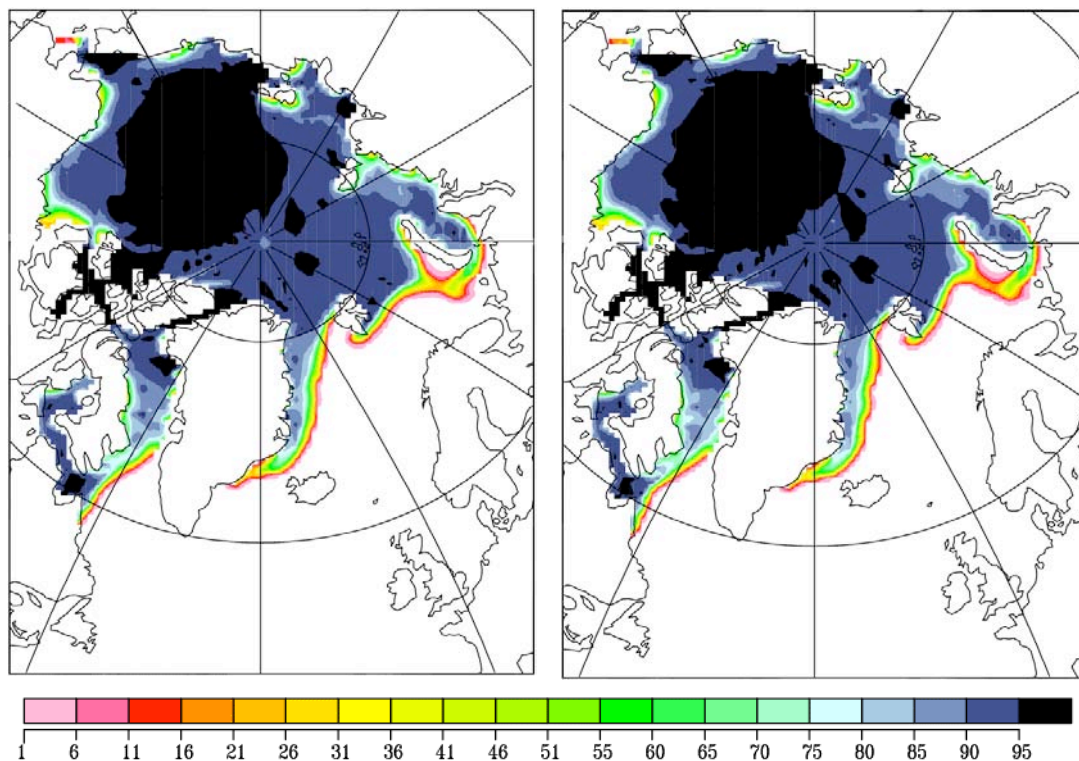

Fig. 1: The ice concentration [%] at the 28th of May 2010 in case of the "free" run (left) and in case with data assimilation (right).
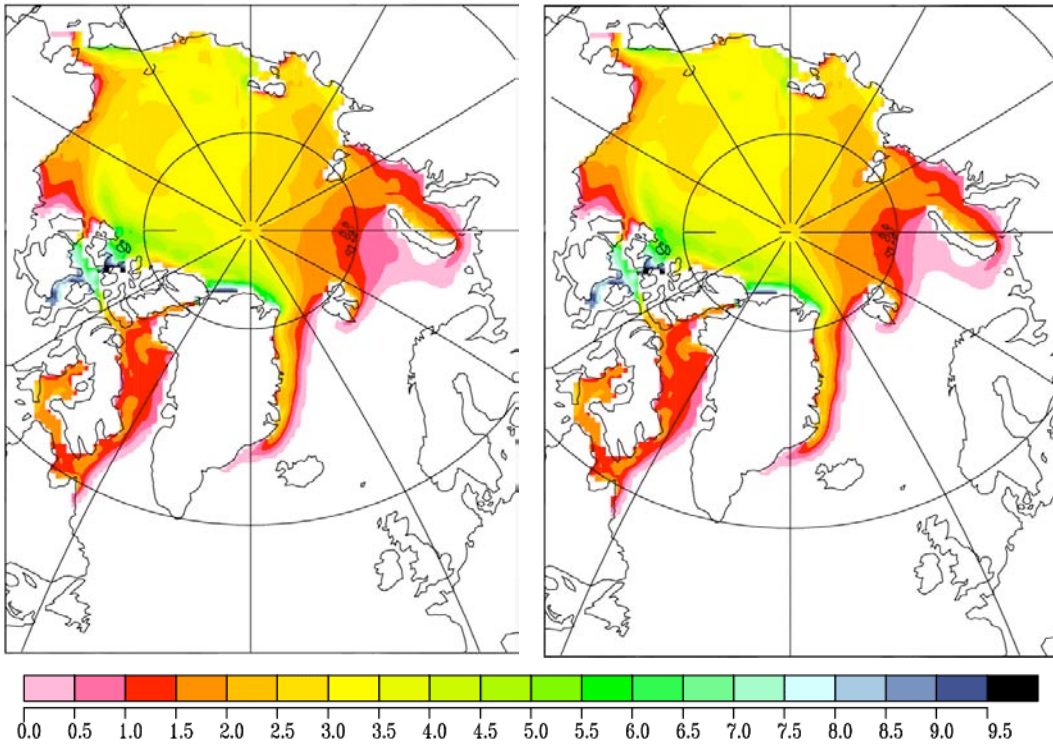
Fig. 2: The ice thickness [m] at the 28th of May 2010 in case of the "free" run (left) and in case with data assimilation (right).
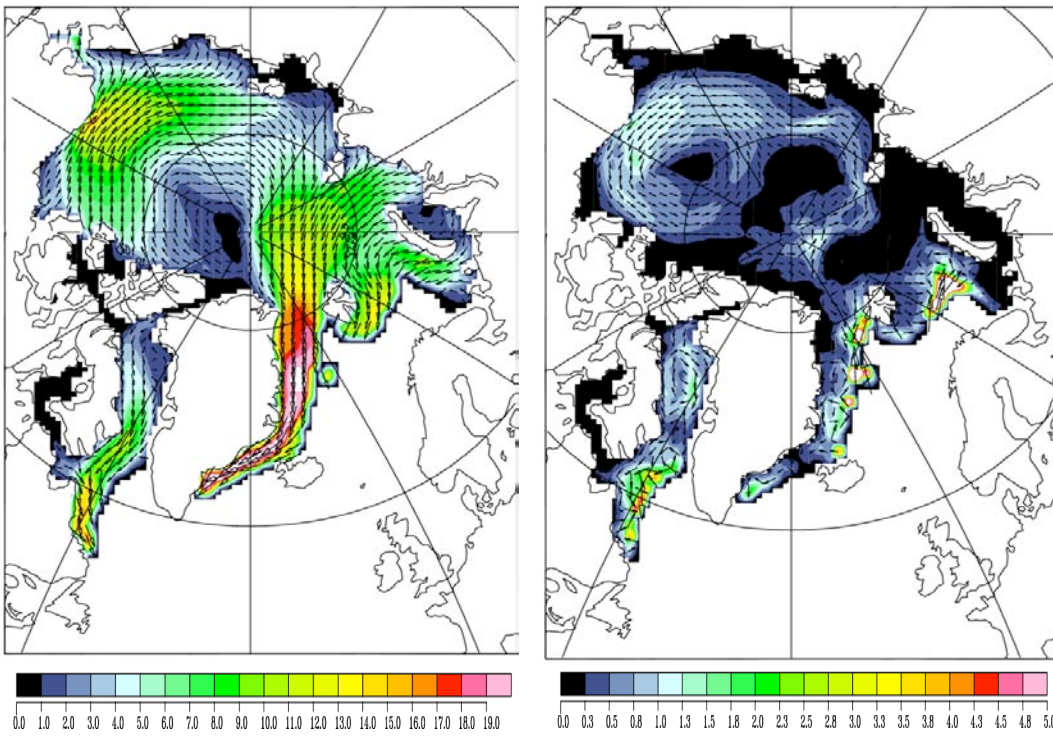

Fig. 3: The mean March 2010 ice drift [cm/s] in case of data assimilation (left) and the difference to the "free" run (right).

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 4. 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 systematic bias to the results of Ensemble I. We are not able to say whether the bias is caused by a imperfect sea ice-ocean model or by imperfect initial or boundary conditions. Fig. 5 shows the mean September ice extent for 1989 to 2009 for hindcasts performed with the same model but with three different sets of surface boundary conditions. Black bars denote the hindcast performed with the NCEP/NCAR reanalysis (Kalnay et al., 1996), green bars the hindcast driven with JRA25 (Onogi et al., 2007), and blue bars the hindcast driven by the ERA interim (Berrisford et. al, 2009) reanalysis. To eliminate effects associated with the cold start the JRA-25 experiment was initialized with fields from the NCEP/NCAR driven experiment on 1st of January 1979 and the ERA interim experiment was initialized with fields from the NCEP/NCAR driven experiment on 1st of January 1989.
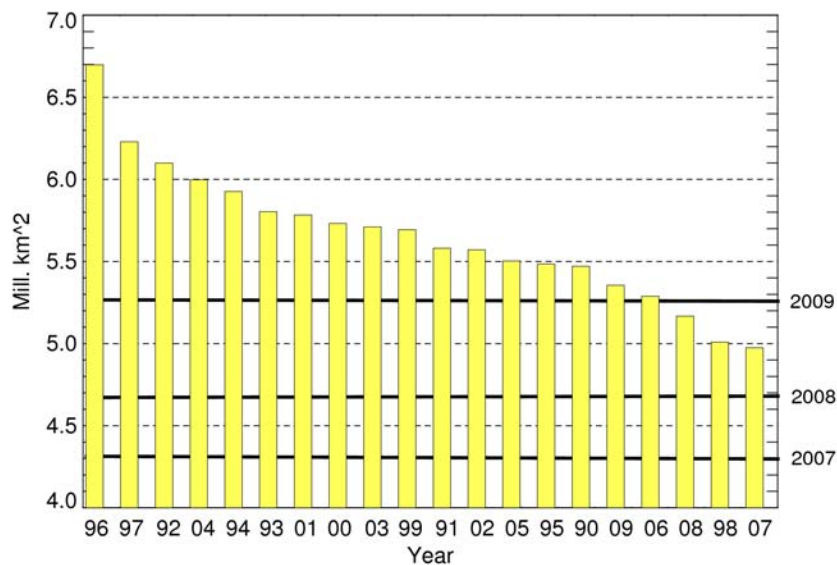

*Figure 4: **Ensemble I** - Simulated mean September ice extent in 2010 [million km^2] when forced with atmospheric data from 1990 to 2009 (initial state on May 28nd 2010). Model derived ice extents have been adjusted assuming a systematic bias (see text). The thick black horizontal lines display the minimum ice extent observed in 2007, 2008 and 2009.*

The results of the NCEP/NCAR experiment and the JRA-25 experiment are similar (especially for 2007, 2008, and 2009) but both underestimate the ice extent. The ERA interim experiment, on the other hand, overestimates the extent by about a million km^2. The reasons for this mismatch are unclear and currently being investigated. This demonstrates that errors in the surface boundary conditions are one possible origin of the bias. The 4DVar data assimilation used for ensemble II includes the surface boundary conditions in the set of control variables, i.e. the set of variables to be adapted to match the observations.
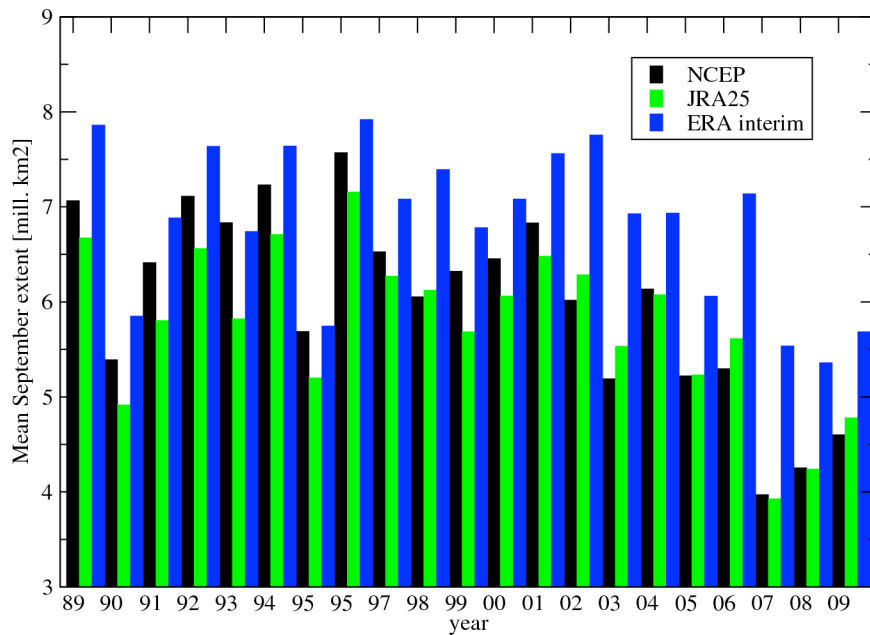
Fig 5: The mean September ice extent [million km^2] as simulated with the NCEP reanalysis (black bars), the Japanese (green bars) and the ERA interim reanalysis (blue bars).

The Ensemble I mean value is 5.61 million km² (bias included). The standard deviation of Ensemble I is 0.41 million km^2 (2008: 0.55; 2009: 0.40). 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 27%.

With a probability of 80% the mean September ice extent in 2010 will be in the range between 5.1 and 6.1 million km^2.

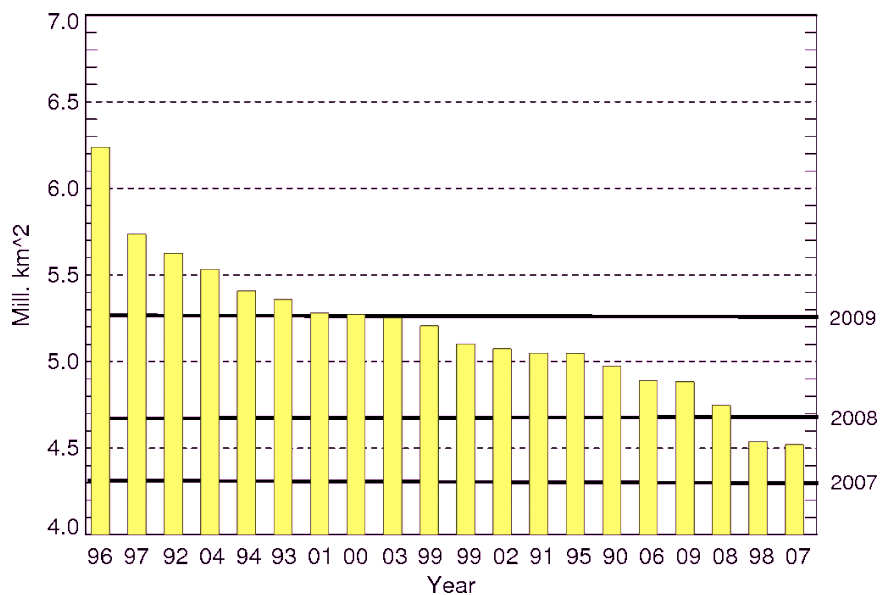**Ensemble II (initial state from data assimilation)**

The mean September sea ice extent for all 20 realizations starting from optimized initial conditions is shown in Figure 6. 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. We expect the observations to have a larger impact in the upcoming outlooks.

The Ensemble II mean of 5.19 million km^2 is somewhat lower than the mean of Ensemble I (note that the optimization increases the predicted mean by about 0.07 million km² compared to the uncorrected Ensemble I mean of 5.12 million km^2). As for Ensemble I the standard deviation of Ensemble II is 0.41 million km^2.

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

probability to fall below 2007 (record minimum)   is about 1%,
probability to fall below 2008 (second lowest)   is about 10%,
probability to fall below 2009 (third lowest)   is about 72%.

With a probability of 80% the mean September ice extent in 2010 will be in the range between 4.67 and 5.71 million km^2.

*Figure 6: **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 May 28th 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 ensemble I prediction of September 2010 looks similar to the situation before 2007.

In previous analyses we showed the importance of the initial ice thickness distribution for the ensemble prediction. A comparison of the modeled ice thickness on June 1st 2007, 2008, and 2009, and the initial ice thickness on May 28th 2010 reveals considerably larger ice thickness mainly in the East Siberian Sea, north of the East Siberian Sea, and in the vicinity of the North Pole in 2010 compared to the years 2007 to 2009 (Fig. 7).

An adjoint sensitivity analysis (Kauker et al., 2009) of the causes of the modeled difference in ice area in September 2007 and September 2005 pointed out the importance of wind stress anomalies which redistributed the ice in the inner Arctic. May and June wind stress anomalies were found to cause about

50% of the September difference between 2007 and 2005 of about 1 million km². Therefore we calculated the March to May mean ice drift for the years 2007 to 2010 (Fig. 8).
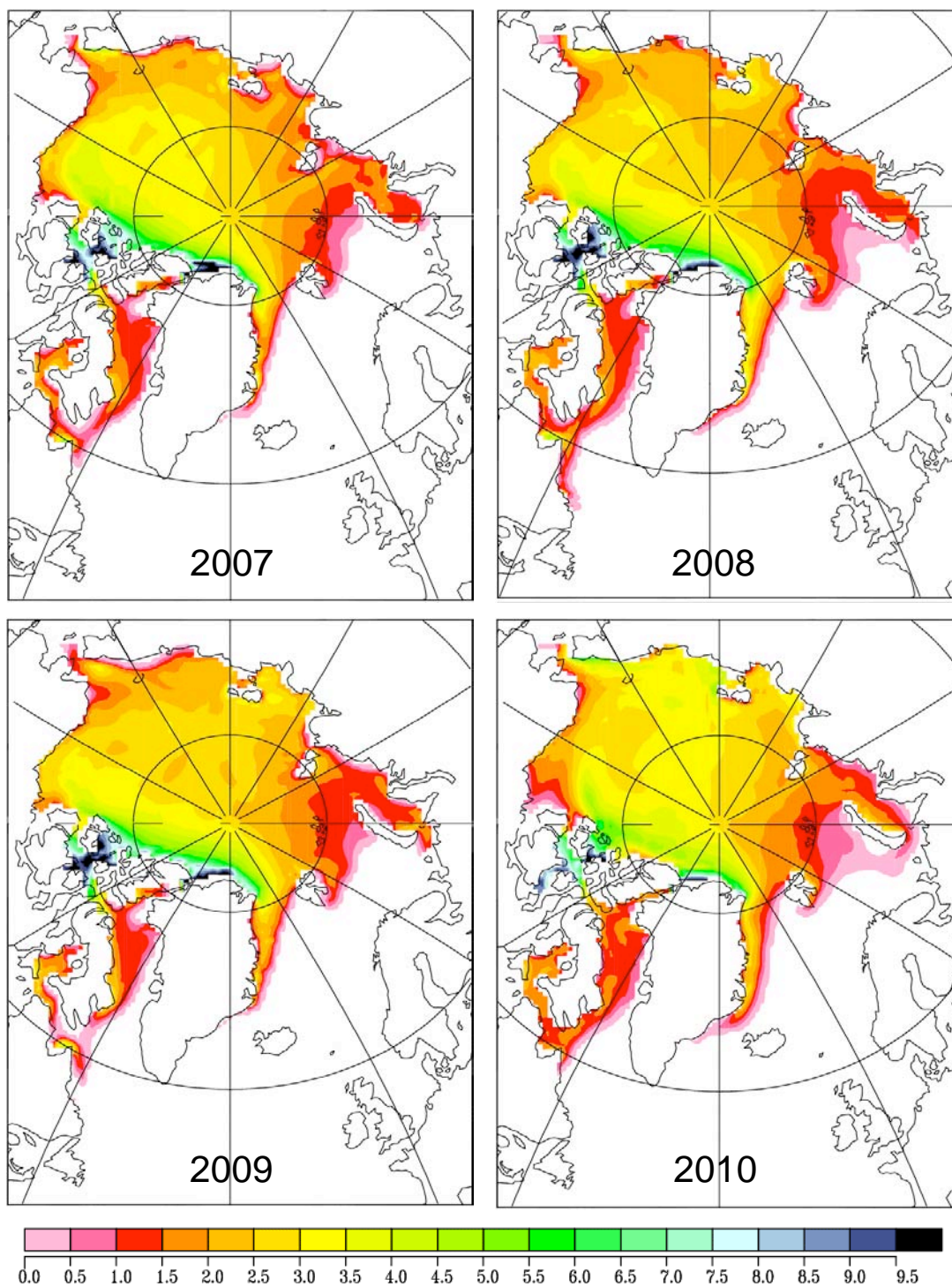

Figure 7: The ice thickness [m] at end of May 2007, 2008, 2009, and at the 28ᵗʰ of May 2010 (equal to Fig. 2 left).

Figure 8: The mean March to end of May ice drift [cm/s] of 2007, 2008, 2009, and 2010 (until 28th of May).
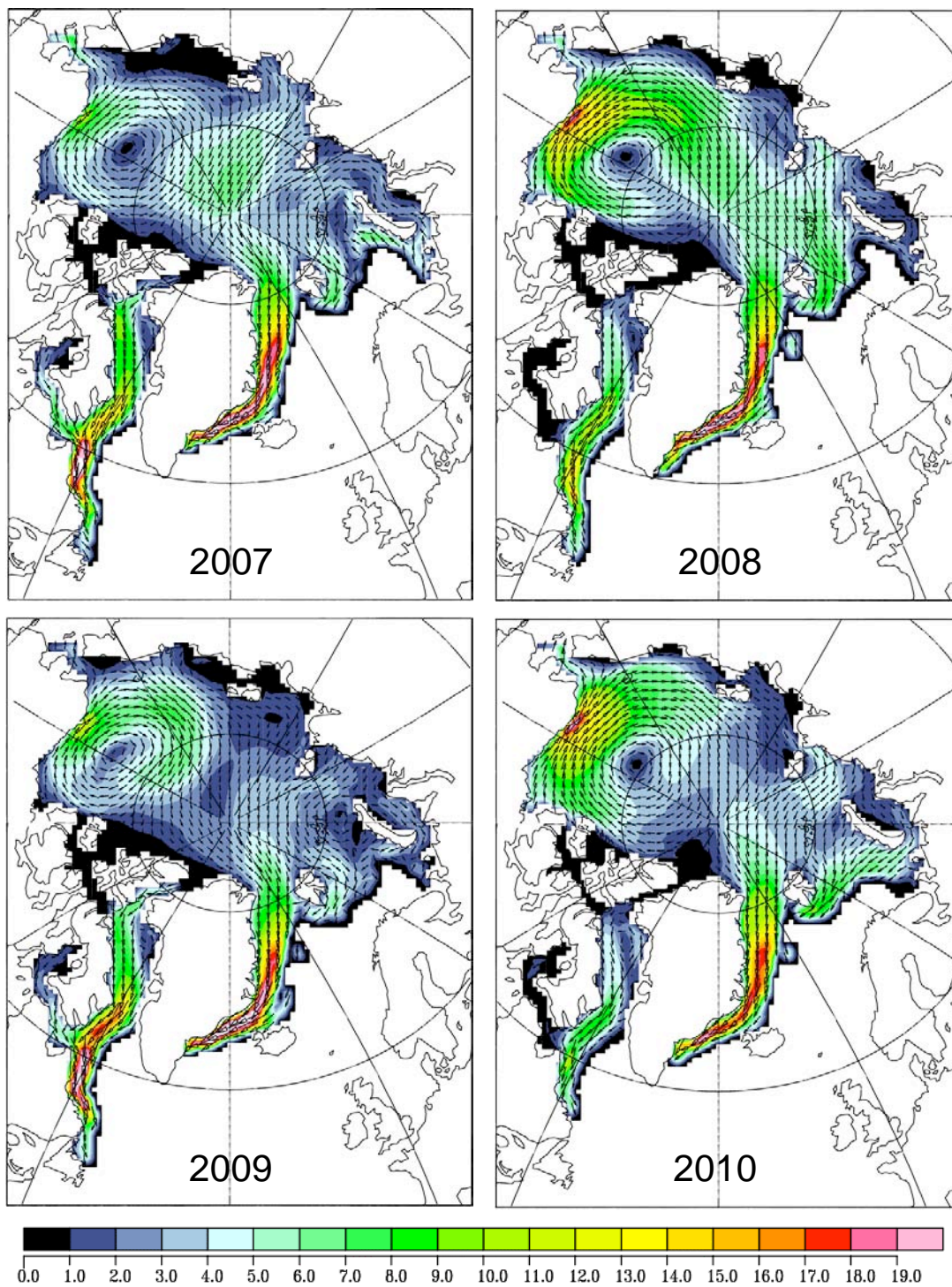
Figure 8: The mean March to end of May ice drift [cm/s] of 2007, 2008, 2009, and 2010 (until 28th of May).

In contrast to the years 2007 and 2009 which showed a relatively weak Beaufort gyre, in 2009 and in 2010 a strong Beaufort gyre is present. While in 2009 also the Transpolar Drift was strong, in 2010 the Transpolar Drift is weak. This suggests that the strong Beaufort gyre and the weak Transpolar Drift are at least partly responsible for the large ice thickness in the Beaufort Sea and north of it through anomalous ice advection. This hypothesis is supported by ice age observations. Fig. 9 displays the ice age distribution estimated by satellite data for end of April 2009 and 2010. In 2010 a much stronger Beaufort gyre is suggested. However, no multi-year ice is visible in the east Siberian Sea at the end of April 2010.
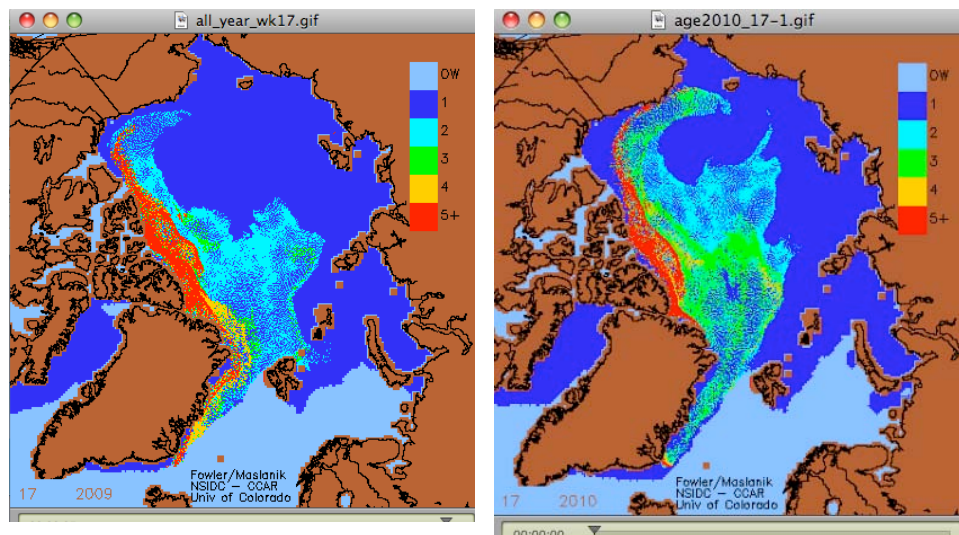

Figure 9: The observed ice age distribution at end of April 2009 (left) and end of April 2010 (right) (taken from the presentation of J. Overland at the final DAMOCLES GA in Tromso, Norway, 27th of May, 2010; courtesy Chuck Fowler and Jim Maslanik).

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Berrisford, P., D. Dee, K. Fielding, M. Fuentes, P. Kallberg, S. Kobayashi and S. Uppala (2009), The ERA-Interim archive, Technical Report, ERA Report Series, 1, Shinfield Park, Reading.
Kalnay et al. (1996), The NCEP/NCAR 40-year reanalysis project, Bull. Amer. Meteor. Soc., 77, 437-470.
Kauker, F., T. Kaminski, M. Karcher, R. Giering, R. Gerdes, and M. Voßbeck (2009), Adjoint analysis of the 2007 all time Arctic sea-ice minimum, *Geophys. Res. Lett.*, 36, L03707, doi:10.1029/2008GL036323.
Onogi, K., J. Tsutsui, H. Koide, M. Sakamoto, S. Kobayashi, H. Hatsushika, T. Matsumoto, N. Yamazaki, H. Kamahori, K. Takahashi, S. Kadokura, K. Wada, K. Kato, R. Oyama, T. Ose, N. Mannoji and R. Taira (2007), The JRA-25 Reanalysis. J. Meteor. Soc. Japan, 85, 369-432.

2010 Sea Ice Outlook
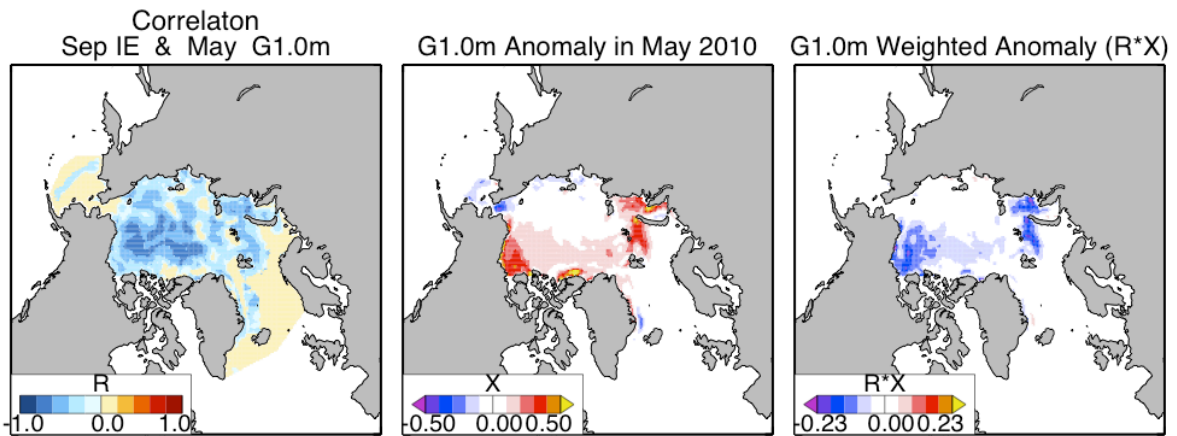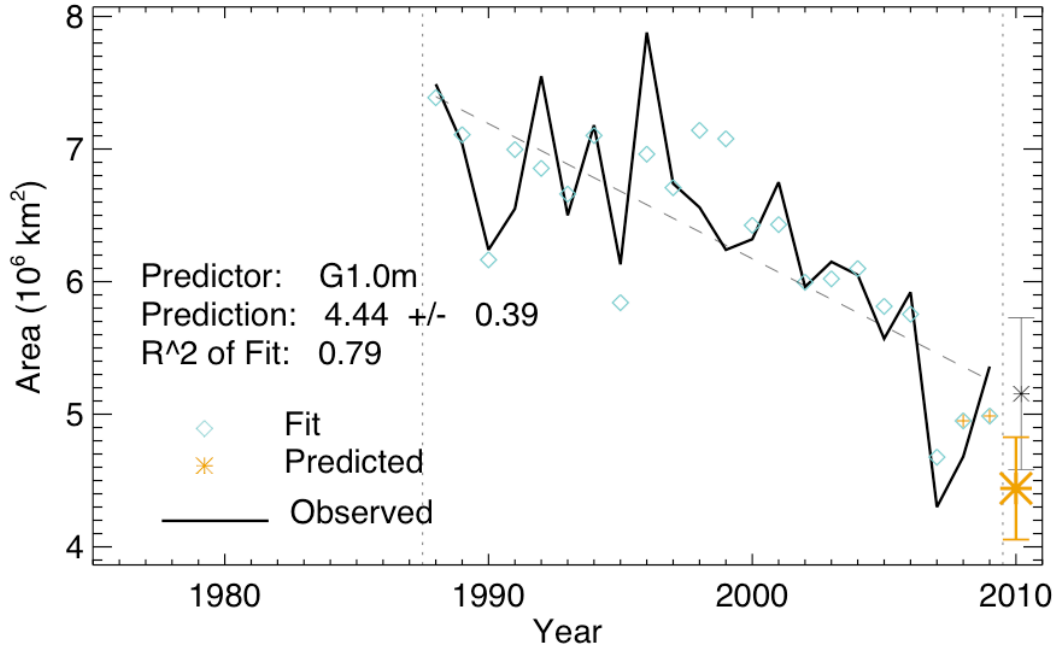# June Report based on May Data

Ron Lindsay and Jinlun Zhang
Applied Physics Laboratory, University of Washington

End of May 2010: Our prediction is made with model data from the end of May 2010. We are using May data for the 22 years 1988 through 2009 to fit the regression model and then the ice conditions for 2010 to make the predictions. The best single predictor is the fraction of the area with open water or ice less than 1.0 m thick, G1.0. This predictor explains 79% of the variance. **The predicted extent in September is 4.44 +/- 0.39 million square kilometers.** This is much lower than what was observed last September, however the error bars are still quite large, though smaller than that of the trend line prediction over the same years (5.15 +/- 0.57 milion sq km). The one-standard-deviation error bar includes the record low of 2007. The regions most influential in making the prediction are in the Beaufort Sea, the Barents Sea, and the Kara Sea (right map in the figure). All of these regions have greater than normal fractions of thin ice (middle map) and the G1.0 variable in these regions have a significant correlation with the September ice extent (left map). The figure shows the time series of the observed September ice extent (solid line), the predictions of the model for past years (cyan diamonds), and the prediction for this year (orange star and error bars). The error bars are the standard deviation of the error in the fit of the regression. The trend line (dashed) and the prediction of the trend line (black star) are also shown.

The mean ice thickness predicts more ice but the error is larger, 4.76 +/- 0.51 m sq km ($R2 = 0.63$). The region most influential in the prediction is the thin ice in the Beaufort Sea and along the Canadian Archipelego to Fram Strait. The ice concentration is a poor predictor this time of year. The prediction using ice concentartion is lower than that from the G1.0 predictor and gives 4.37 +/- 0.47 m sq km ($R2 = 0.69$) and the regions most influential are small places in the Kara and Barents Seas.

Predictions for September 2010 from May

Observed and Predicted Ice Extent from the Sea Ice Index

Predictor: G1.0m
Prediction: 4.44 +/- 0.39
R^2 of Fit: 0.79

◇ Fit
✳ Predicted
— Observed

Correlaton
Sep IE & May G1.0m

G1.0m Anomaly in May 2010

G1.0m Weighted Anomaly (R*X)

2010 Sea Ice Outlook
June Report based on May Data

J. Maslanik
University of Colorado

The following is based on consideration of the U. of Colorado satellite-derived (Lagrangian drift) sea ice age in the context of conditions in previous years (see attached figure) along with review of atmospheric fields and a variety of other data sets.

A. Regional outlook for Beaufort and Chukchi seas

(1) A prominent feature is the lobe of old ice extending through the Beaufort Sea and into the Chukchi Sea at the end of April (top-left panel in Figure 1). Based on our age data, the strip of ice on the southern edge of this area is 5+ year-old ice (red), which is likely to be particularly thick and strong. One might expect it and the 3+ year-old ice to survive well into the melt period, at fairly high ice concentrations. Our data and other data we have examined suggest that the floes are large but with some separation by first-year ice. Given the likelihood of 3+ year-old ice being present, then some residual and perhaps quite small multiyear ice floes may well survive into autumn, with the associated potential hazards they pose for shipping, etc. These surviving floes may end up relatively close to the coast and therefore might be entrained into new land-fast ice, thus helping stabilize the fast ice. Note that our ice age product uses a 40% ice concentration cut-off, so it is possible and even likely that some old ice extends beyond the bounds we show, and particularly so at the westernmost tip of the old ice lobe.

(2) Wind patterns during most of May have continued to push this ice to the west, placing more ice into the Chukchi Sea and keeping the ice further south than in recent years. Given the extent of melt over the past several years and the southern location of this old ice, we expect that it will completely melt out (excluding some residual floes) from the central Beaufort and Chukchi seas. Some of the oldest ice may survive melt in the Banks Island area, but unlike most other years, the multiyear ice is shifted toward the west, leaving a fairly large area of first-year ice between it and the eastern Beaufort Sea area to the south.

(3) There is little reason to expect that first-year ice in these areas will survive melt. While the lobe of multiyear ice will persist later into the melt season, the first-year ice to the north will melt out earlier, yielding a "semi polynya" of open water/low concentration ice partially surrounded by multiyear ice into late summer.

B. Overall outlook for minimum sea ice extent

Our best guess at this point for end-of-summer ice extent ranges from 4.5×10^6 km^2 at the high end to 3.8×10^6 km^2 at the low end.

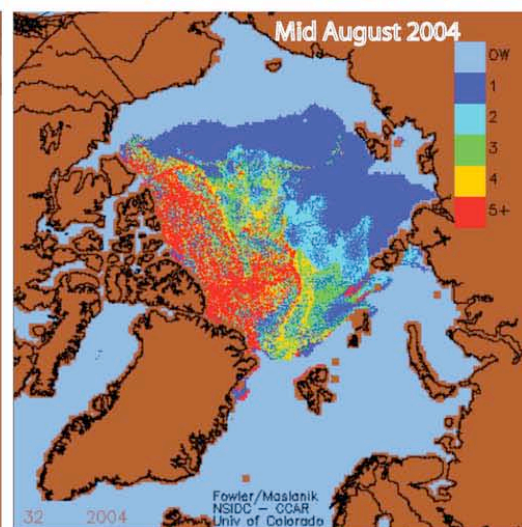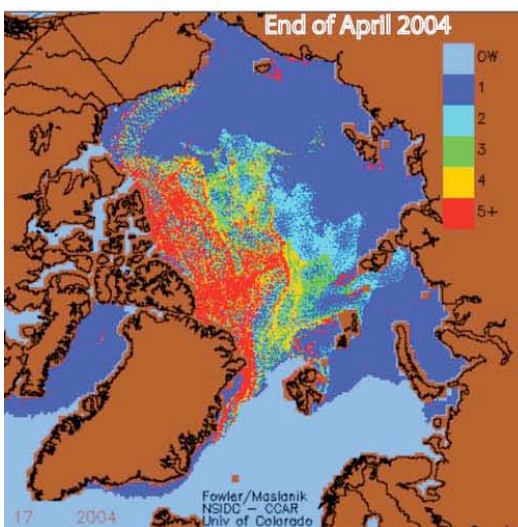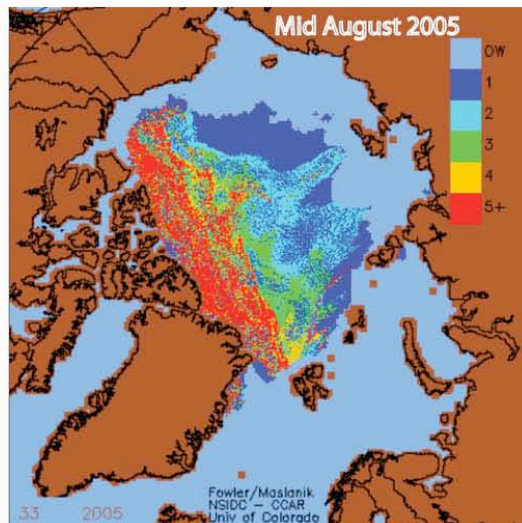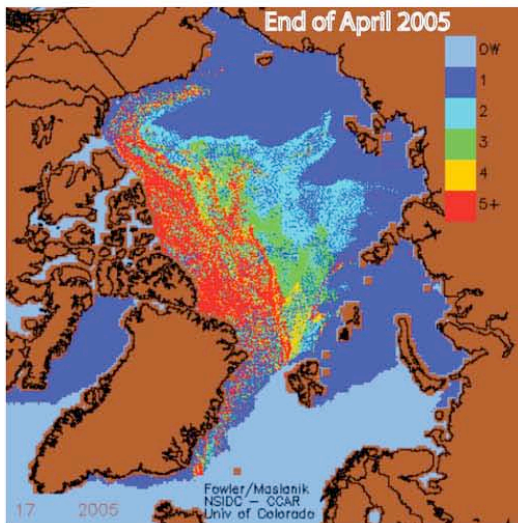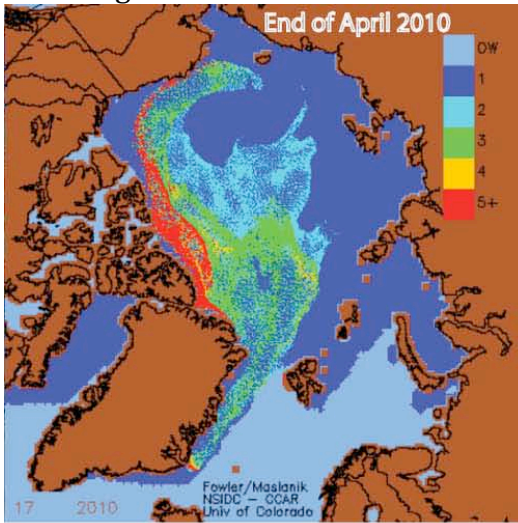Figure 1. Estimated ice age at the end of April (left-hand panels) for 2010 (top), 2005 (center) and 2004 (bottom). Panels on the right are age coverages for mid-August 2005 and 2004. Warmer colors indicate older ice.

2010 Sea Ice Outlook
June Report based on May Data

Oleg Pokrovsky
Main Geophysical Observatory (RosHydroMet)

1. Extent Projection
Sea ice projection for the September monthly mean arctic sea
ice extent – 5.5-5.6 (in million square kilometers)

2. Methods / Techniques
Statistical analysis of the AMO, PDO and AO time series based on specific regression model

3. Rationale
There are three major climate factors impacted on the Arctic sea ice extent (SIE): AMO, PDO and AO.
PDO (fig.1) as an oscillation between positive and negative values shows no long-term trend, while temperature shows a long term warming trend. When the PDO last switched to a cool phase, global temperatures were about 0.4C cooler than currently. E.g., in 1905, PDO switched to a warm phase as global warming began. In 1946, PDO switched to a cool phase as temperatures cool mid-century. In 1977, PDO switched to a warm phase around the same time as the modern global warming period. First of all, PDO impacts on the regime of atmospheric circulation in North Pacific and in Pacific sector of Arctic, secondary- on the SST anomaly in Bering and Chukcha Seas. This year is a cold one in this region due to the north wind domination (fig.2). That explains that the SIE in Pacific sector of Arctic exceeds climate (20-th century) magnitudes (fig.3).
The AMO (fig.4) determines the temperatures of inflow waters in Arctic Ocean and thus it impacts on the SIE values in Atlantic sector of Arctic. Primarily, I mean Russian margin seas (Barents, Kara Seas and others). AMO entered into negative phase since 2003. But this spring SST attained small positive values in North-East Atlantic (fig.5). That explains that now in the eastern part of Barents Sea there is a significant area of the sea surface free of ice (fig.3).
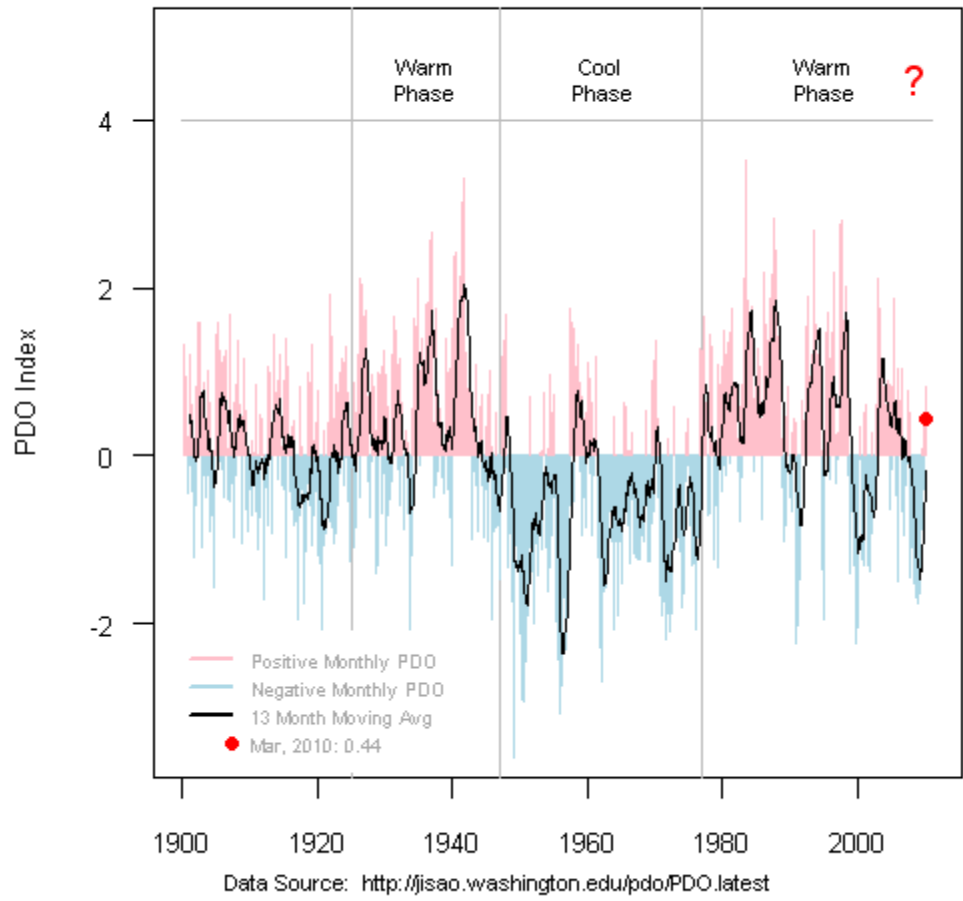The "high index" of the Arctic Oscillation (AO) is defined as periods of below normal Arctic SLP, enhanced surface westerlies in the north Atlantic, and warmer and wetter than normal conditions in northern Europe. This is depicted as the "warm phase" in the following figure. "Low index" AO conditions are described in the "cool phase" panel. The outflow of broken ice masses from these seas to North Atlantic are regulated by Arctic Oscillation (pattern of atmospheric circulation in Artic). This spring AO values (after negative phase in past year (fig.6)) are close to zero and so there is probability that outflow mechanism will be weak. Above let us to say that September SIE anomaly should demonstrate tendencies in more ice in Pacific and lesser ice in Atlantic sectors. But, in general SIE should attain higher value than in past year.

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.
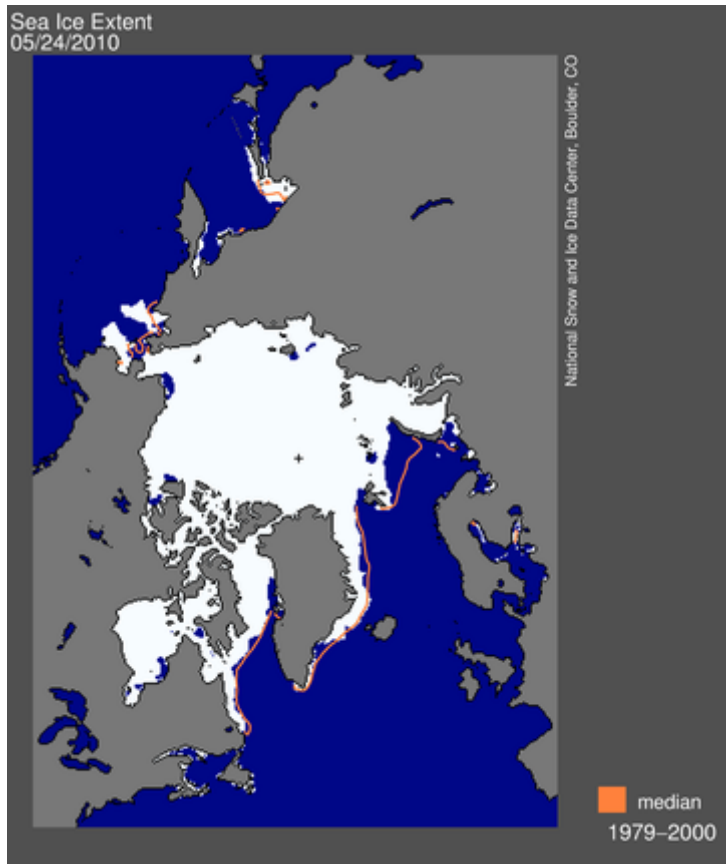
Figure 1.

Figure 2.

Figure 3.

Atlantic Multidecadal Oscillation
ESRL AMO, ERSST.v3b (0-70N, 78W-10E)
Jan 1978 to Feb 2009

Figure 4.

NOAA OI SST
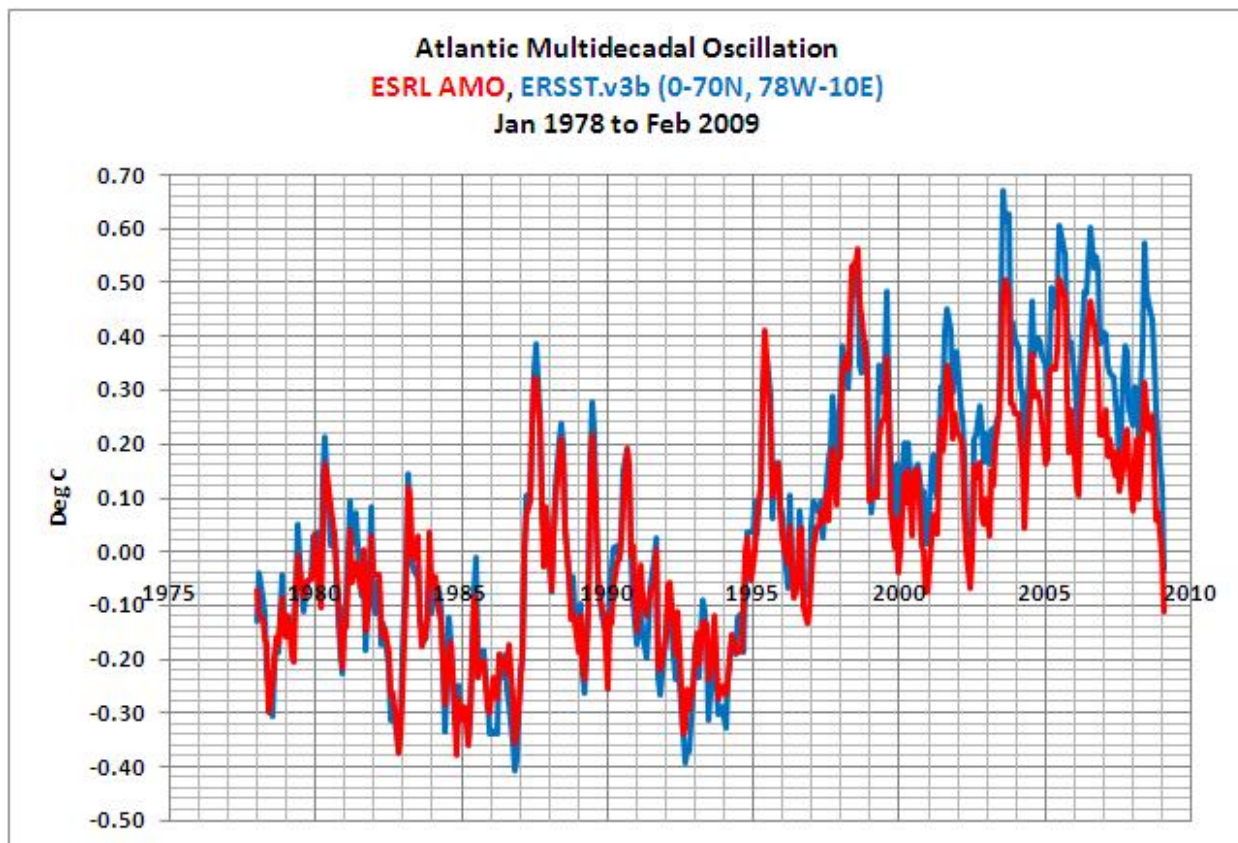Surface SST (C) Composite Anomaly 1971-200 climo

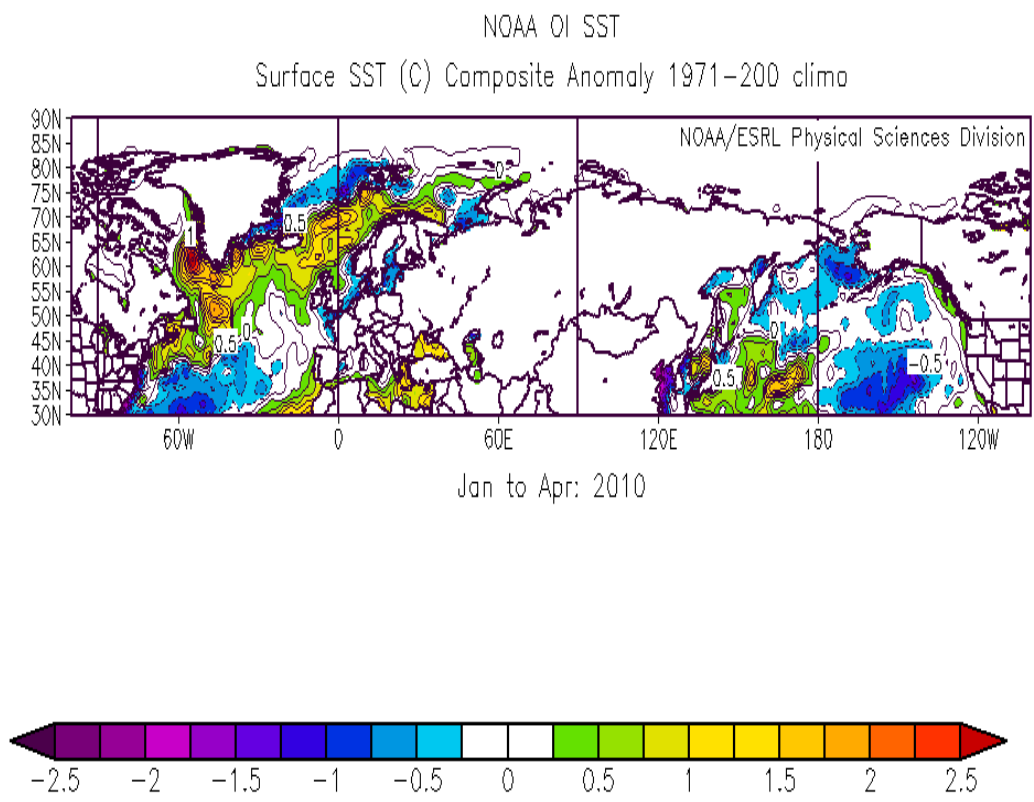NOAA/ESRL Physical Sciences Division

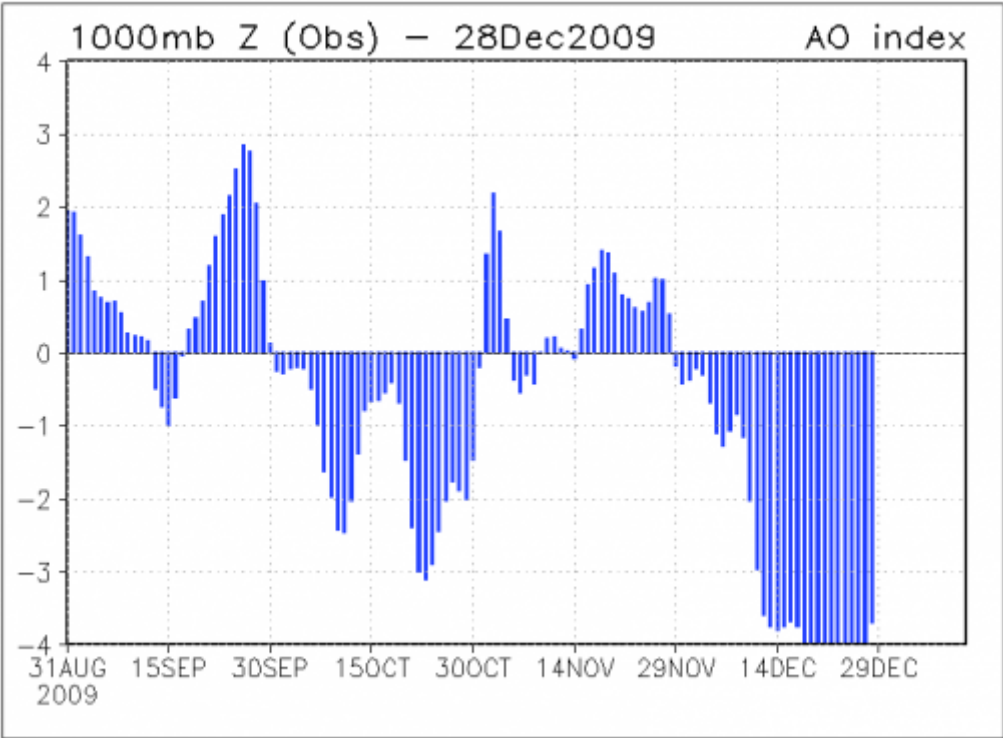Jan to Apr: 2010
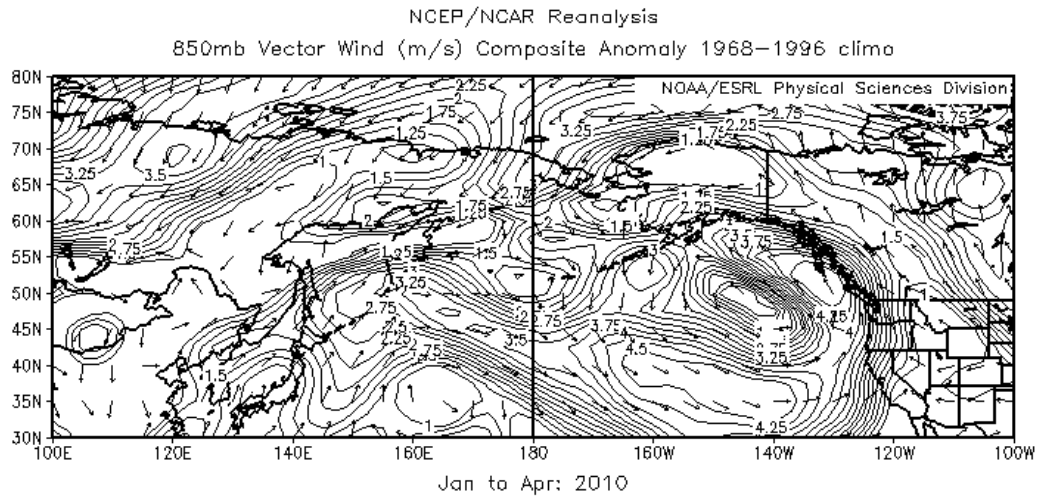
Figure 5.

Figure 6.

Sea Ice Outlook for September 2010 from the Polar Science Weekend

The Polar Science Weekend is an annual event at the Seattle Pacific Science Center organized by the Pacific Science Center and the University of Washington Polar Science Center. 15 to 20 displays are created by various groups in the Seattle area to engage the general public in an outreach effort (http://psc.apl.washington.edu/psw/ … don't miss the photo album). Several thousand visitors visit the Science Center during our four-day event. This year the event took place from February 25th to the 28th. In order to stimulate discussions with the public about sea ice, how it has a strong annual cycle, and how the summer minimum has a strong downward trend, a small activity was organized to allow members of the public to consider sea ice extent and guess at the magnitude of the extent this next September. Maps of the ice extent last September and January were displayed. This poster was a good starting point for discussions:
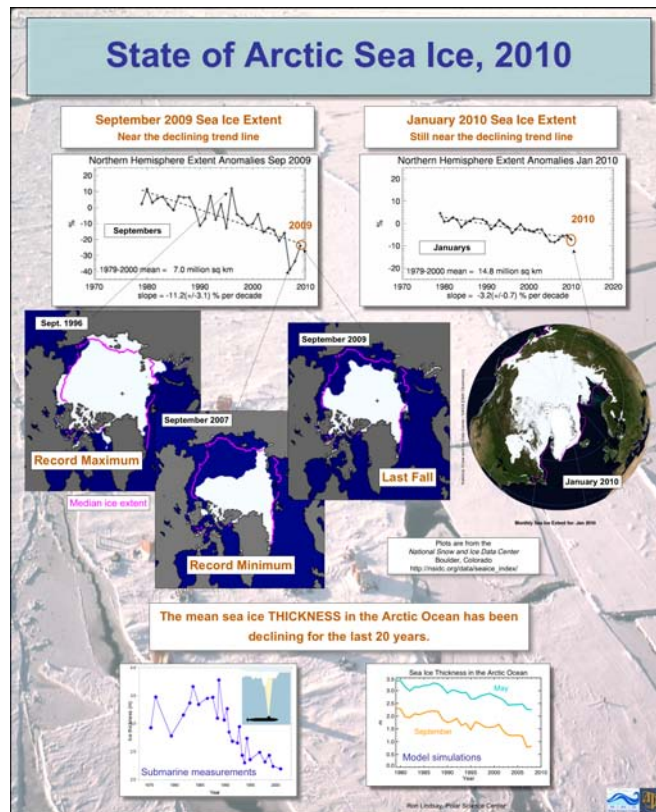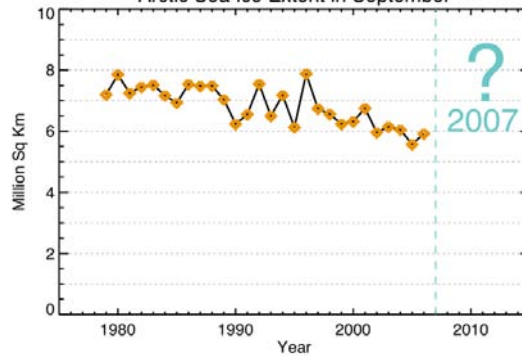

Members of the public were invited to make a prediction for next September in a two step process, first a practice prediction was made for 2007 using this graph:

Practice Prediction

What's YOUR Sea Ice Prediction for September 2007?
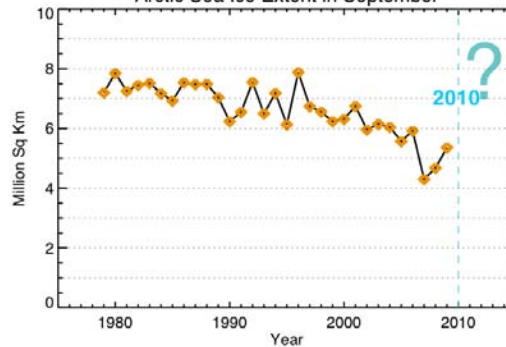
Arctic Sea Ice Extent in September

How many million square kilometers were there in September 2007? _____

and of course we could show them the actual answer in the display maps. Then they were offered a chance to guess for 2010 using this ballot:

Prediction Ballot

What's YOUR Sea Ice Prediction for next September?

Arctic Sea Ice Extent in September

How many million square kilometers will there be September 2010? _____

They were then given a card with the 2010 ballot where they could write their guess and a web site address as provided where they can check in the fall to see what actually happened.

Results:
We had a total of **N = 60** guesses from about 6 hours of discussions.
The mean was 5.11 million sq km and the standard deviation was 2.15 million sq km. The mean is quite near that predicted by the trend line (5.15 +/- 0.57 milion sq km) but the spread is greater.

The best part of the exercise was the opportunity to engage a number of people in interesting discussions about the fate of sea ice in a changing climate.

Sea Ice Outlook for September 2010 (Based on May Data)

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.

Figures
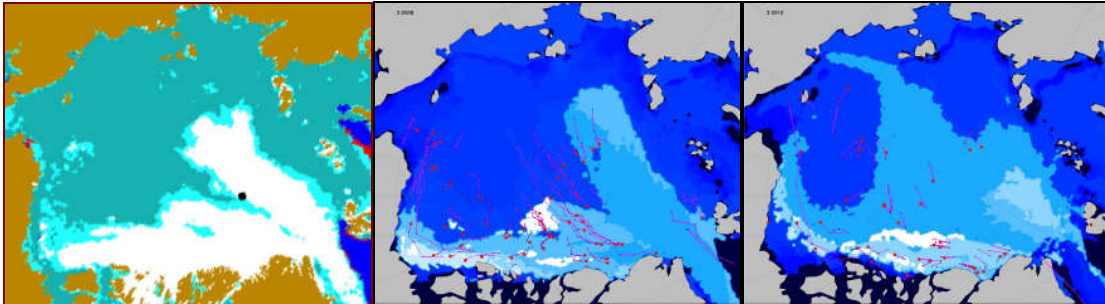
Figure 1. Maps of Arctic sea ice distribution based on QuikSCAT (QS) for March 2009 (left), and the age of sea ice based on the Drift-Age Model (DM) for each March 2009 and March 2010 (middle and right). The colors on the QS map shows perennial ice (white), mixed ice (aqua), seasonal ice (teal). The 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.
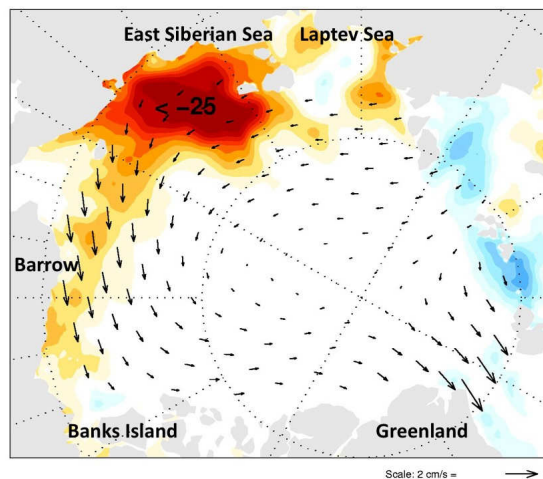
Figure 2. Regression map of summer sea ice concentration and prior winter sea ice motion on the prior winter Arctic Oscillation index. After low AO winters, the reds imply that sea ice concentrations should be higher I these areas, while blues imply lower that normal sea ice concentrations during the following summer. Based on Rigor et al. 2002.

Acknowledgment

NSIDC Sea Ice Outlook Contribution, 16 June 2010

Julienne Stroeve, Walt Meier, Mark Serreze, Ted Scambos

Summary

NSIDC is using the same approach as last year: applying the survival fraction of ice of different ages determined from past seasons to the observed distribution of ice ages at the beginning of the melt season. Ice age fields are provided by Chuck Fowler and Jim Maslanik (Univ. Colorado, Boulder; see Fowler et al., 2004 and Maslanik et al., 2007).

Computing survival rates of the different ice age classes for each year, together with the observed ice age distribution from March 2010 and the "extra" ice not mapped by the ice age data during March 2010 gives the results shown in **Figure 1** based on survival rates for 1985-2009. Shown also are the minimum September extents for the last 3 years (horizontal lines). From this analysis it appears that a new record low will not be reached this year if the 2010 survival rates are within the range of historical ice survival rates. This is in part because there is more 2nd and 3rd year ice at the start of 2010 than has been seen the last few years. Also, winter extent was larger in 2010 than in previous years. If the 2010 survival rates are similar to 2007, however, the September 2010 extent will rival what was observed in 2007 (4.31 versus 4.13 million km^2).
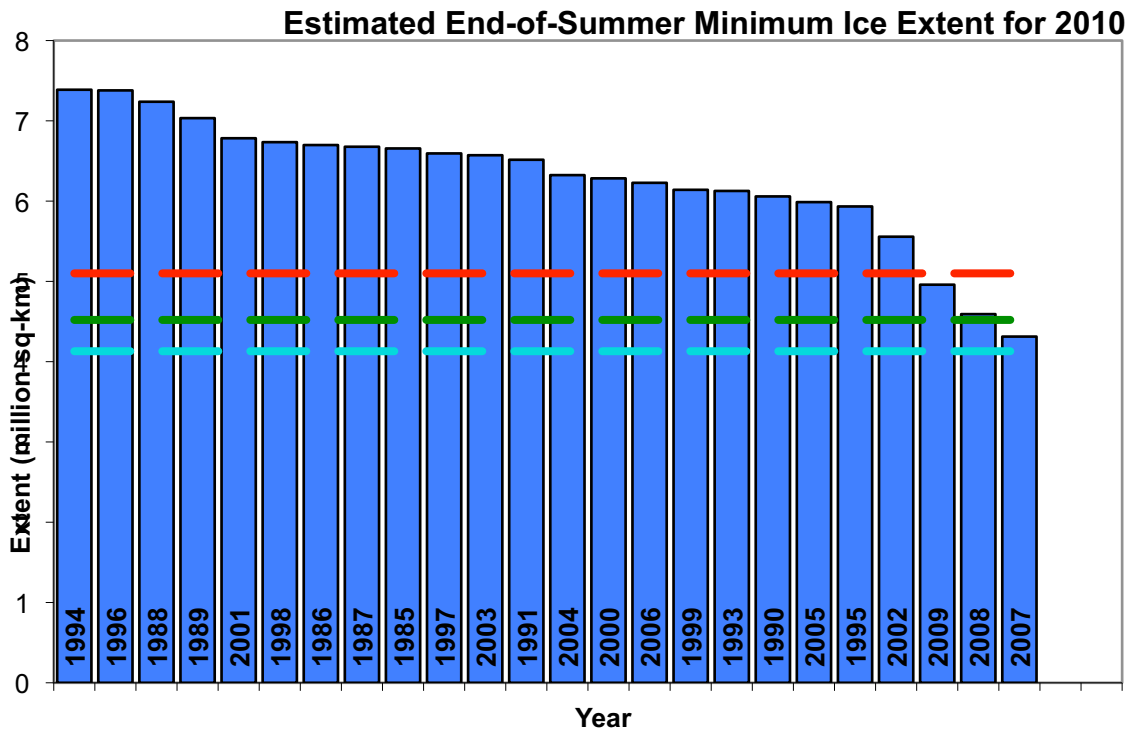
Figure 1. Estimated 2010 minimum extent based on ice age survival rates from previous years (1985-2007). Dashed lines are actual minimum extents for the past three years (red = 2009; green = 2008; blue = 2007).

Details

Because most of the summer ice loss is due to first-year ice (FYI), the survival of FYI is an important component of the end-of-summer minimum extent. How much FYI survives the summer melt season depends on a number of factors, e.g., the amount of FYI at the start of the melt season, the location of the FYI within the Arctic, advection of FYI ice (within and out of the Arctic basin), and of course the evolution of summer atmospheric and oceanic conditions. Though less of a percentage than FYI, some older multiyear ice (MYI) also does not survive the melt season due to the same factors. Thus, at any time of the year, the total sea ice area (SI) can be defined as the sum of the areas of FYI and MYI, or breaking it into the individual ice age classes:

$$SI = F_1 + F_2 + F_3 + \ldots + F_n$$

Where F_1 is the area fraction of first-year ice, F_2 is the fraction of second year ice, etc. The amount of ice left over at the end of summer (SI_{sep}) then depends on the survivability of the winter ice cover (SI_{mar}) which can be defined as the survivability of the ice of different ice age classes, i.e. s_1 equals the survivability of the winter first-year ice fraction (F_{mar_1}) such that $s_1 = F_{sep\_1}/F_{mar\_1}$. In this way, SI_{sep} equals:

$$SI_{sep} = s_1{}^*F_{mar\_1} + s_2{}^*F_{mar\_2} + \ldots + s_n{}^*F_{mar\_n}$$

As we did last year, we account for survival rates at different latitude bands to compensate for the fact that over the past few years' first-year ice has been found at much higher latitudes than has been typical during previous years and this more northerly first-year ice likely has a better chance of surviving summer melt than more southerly located first-year ice. Breaking up the analysis into 2 degree latitude bands, the total September ice area is then the sum of all survival rates for each ice age category and for each latitude band

$$SI_{sep} = \Sigma_{lat} (s_1{}^*F_{mar\_1} + s_2{}^*F_{mar\_2} + \ldots + s_n{}^*F_{mar\_n})$$

Thus the equation above gives the September minimum as defined by the ice age data.

However, the ice age data does not cover the entire Arctic, nor does the ice edge as defined by the ice age data match that provided by the SMMR and SSM/I time-series of ice extent archived and distributed by NSIDC. This is because the ice age product uses a 40% threshold for the ice edge whereas NSIDC uses a threshold of 15%. The higher threshold is required for accurate ice motion tracking, which is the basis for the age determination. On average the March winter extent from NSIDC is 5.07 ($\pm$0.37) million km^2 larger than that from the ice age product. Similarly, during September, the ice age September minimum is underestimated on average by 1.56 ($\pm$0.21) million km^2. Nearly all of the extra ice in the NSIDC extent is first-year ice at low latitude, and therefore unlikely to survive. For September, we anticipate that almost all of the ice

remaining at the end of the melt season – including that not mapped by the ice age grid -- will survive, although we do not know the age of the extra ice in the NSIDC minimum extent.

In order to account for the area of Arctic ice not covered by the ice age data, we additionally compute another survival rate for each year based on the extent bias between the two data sets, i.e.

$$s_{extra} = offset_{sep}/offset_{mar}$$

where $offset_{sep}$ = September ice extent from NSIDC minus that from the ice age data. The same is true for March. Since the majority of this ice is likely first-year ice (except for the Canadian Archipelago) and located in a relatively southerly location, the latitudinal dependence of survival of this "extra" ice is not considered. Including the "extra" ice, the final equation can be written as:

$$SI_{sep} = ?_{lat} (s_1 {*} F_{mar\_1} + s_2 {*} F_{mar\_2} + \ldots + s_n {*} F_{mar\_n}) + s_{extra} {*} offset_{mar}$$

This represents a correction to the algorithm from the last two years, where we did not properly account for the offset of ice area between the ice age determination and the NSIDC ice extent. Computing this for every year, using each year's survival rates together with the ice age distribution from March 2010 and the "extra" ice not mapped by the ice age data during March 2010 gives the results shown in **Figure 1** based on survival rates for 1985-2009.

Historically, different summers have had substantially different survival rates. If we assume that conditions during the forthcoming summer will fall somewhere between the extremes of the historical period between 1985 and 2009, we provide a reasonable range of potential minimum extent based on the range of survival rates through previous summers. However, it is clear from this analysis that survival rates have changed in recent years. For example, if we use an average of survival rates for 2000-2010, then the prediction for 2010 would be for a September minimum of 5.76 million km^2. If instead an average from the last 5 years is used, the prediction would be for 5.21 million km^2 (just above the 5.10 million km^2 observed last summer). While using average survival rates can be useful, it is clear that these rates have been changing in recent years, which may in part reflect thinning of the ice in different age classes, warming atmospheric and ocean temperatures and changes in wind patterns that impact on summer ice survival.

This year presents an interesting challenge. A significant amount of high-latitude FY ice was retained at the end of the previous two summers, which has since aged and thickened into 2nd and 3rd year ice [**Figure 2**]. A tongue of this relatively older ice was advected westward to the northern coast of Alaska due to a strong Beaufort Gyre through the winter (a result of the high negative AO phase this year). This offshore Alaskan ice is relatively far south and largely in shallow shelf regions that will likely receive considerable heating from both the ocean and

atmosphere. It is quite possible that this ice will melt out completely by September. However, during the melt season (and possibly even at the end in September) we forecast that the MYI will melt more slowly, possibly leading to a situation similar to 2006, where thinner ice north of MYI melted earlier, forming a large polynya-like feature at high latitude in the Beaufort. The fate of this thicker older ice is a bit of a wildcard in our estimates because if much of this ice does melt out completely, our estimates for older ice survival will be too high.

On the other hand, because of the retention of 2nd of 3rd year ice within the Arctic, FYI is mostly found at more typical latitudes closer to the coasts. Thus, FYI retention estimates may be more accurate this year compared to the past two years.

The NSIDC sea ice group forecasts are:

5.76 million square km based on the mean age- and latitude- corrected ice survival rates for 2000-2009;

5.21 million square km based on the mean age- and latitude- corrected ice survival rates for 2005-2009.
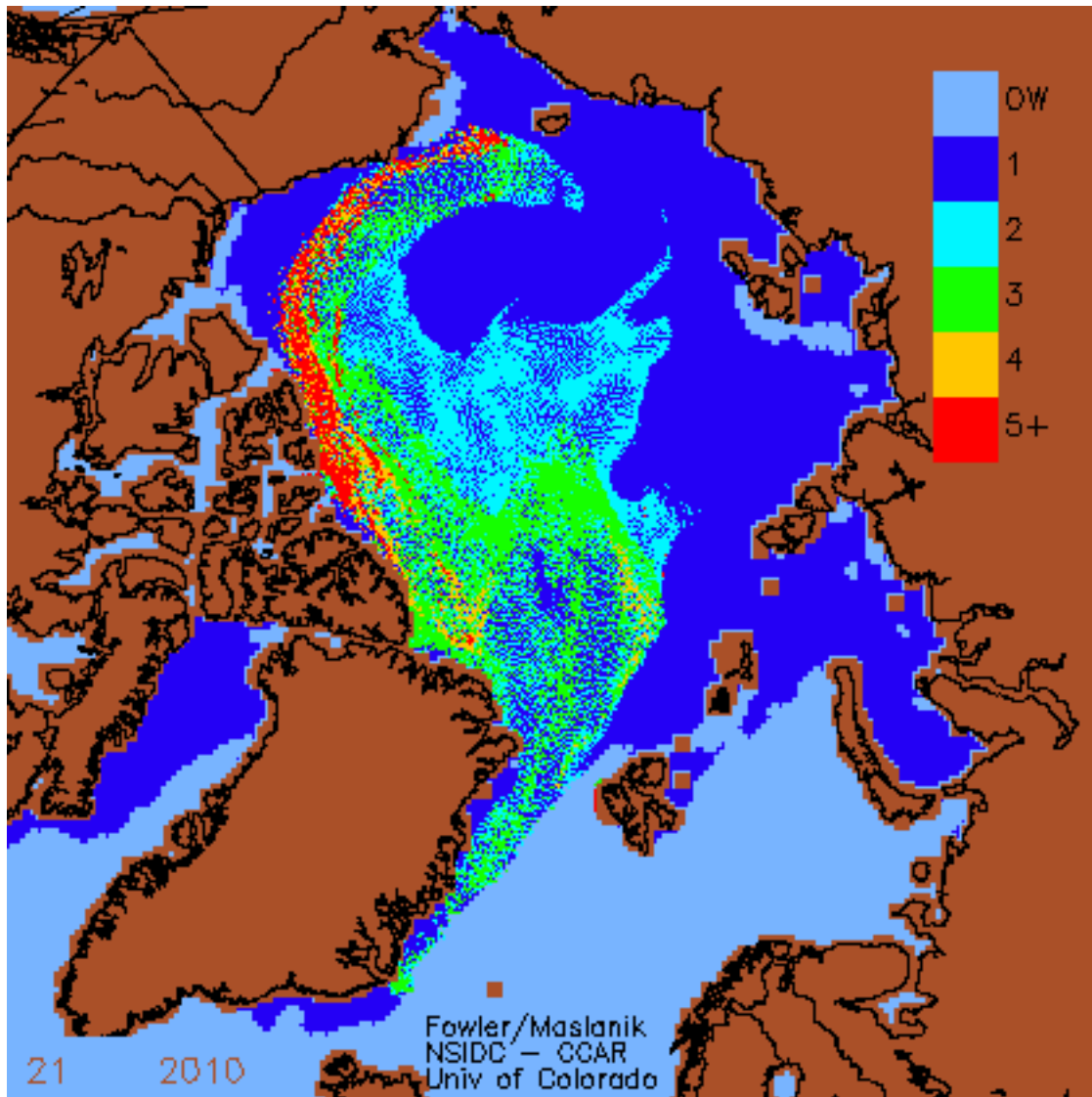
Figure 2. Ice age distribution from early May 2010 showing the substantial amount of 2nd and 3rd ice around the pole and the tongue of older ice stretching into the Beaufort Sea. Data/image provided by Chuck Fowler and Jim Maslanik, University of Colorado at Boulder.

2010 Sea Ice Outlook
June Report based on May Data

Adrienne Tivy
International Arctic Research Center, University of Alaska Fairbanks

Prediction - 5.7 million sq km

The prediction is statistical, it is based on a simple regression where the predictor is the previous summer (May-June-July) sea surface temperature in the North Atlantic and North Pacific oceans near the marginal ice zone. Warmer (colder) than normal SST is associated with a reduction (increase) in ice extent.

2010 Sea Ice Outlook
June Report based on May Data

Greg Wellman
Princeton Consultants

1. Extent   5.1 Million Square km for the Sept average.

2. Method   (barely) statistical - aka amateur guesswork

3. Rationale   My baseline is simply the NSIDC linear regression through past Sept averages. That would predict about 5.3. Beyond that are many competing factors.

Factors that lower the estimate:
1. The May melt has been the fastest in the satellite record.
2. May ended in a near tie for lowest extent at that time of year in the satellite record. Thus, albedo feedback in the period around the solstice should be as high as it has ever been
3. Warmer than average North Atlantic.
4. PIOMAS volume estimates are very low.

Factors that increase the estimate:
1. Arctic oscillation has tended towards a state with lower than average ice export through Fram Strait - but that may be moderating
2. Colder than average Bering Sea

4. Summary

The long term decline will continue. The most important factor in interannual variability will continue to be export through Fram Strait, but earlier fragmentation north of the strait will tend to increase that export. Earlier fragmentation will be driven by warmer winter temperatures leading to thinner new ice.

2010 Sea Ice Outlook
June Report based on May Data

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. This comes from a simple Statistical comparison - - Ice VOLUME CHANGE times the relative strength of the years' El Nino (warm spot in the Pacific).
2007 was a Vast change & so I IGNORE the small Progressive Changes for simplicity, & look at the really this year's strong El Nino (4th strongest in 60 years).

6000 cubic km (ICESAT figure for September 2007)
- 4000 cubic Km (ICESAT's number for 2007's reduction from Previous year Volume)
x (times) El Nino rating = 1.8 (2009-2010 El Nino)) /(divided by)/ 1.1 (2006-2007's peak ONI rating)

= - 545 cubic km (a negative number)

= ZERO ... further, it will melt off EARLY. If I used the 2009 PIOMAS estimate of 5800 km3, it would be negative 745.

3. Discussion:
 2007's El Nino did 3 things to melt off 40% of Ice Volume relative to 2006:

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)
 (these are figures from the Satellite (uah) Lower Troposphere breakout for N. Polar OCEAN)

b. Winds pushed Ice ... though this will be critical mainly in July, the 2 years: 2007 & 2010, are unique in breaking the Nares Ice Dam – and 2010 broke it MUCH worse.

c. Cloudiness was 16% Less than Norm – If I am wrong, it will be here.

 - - -

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) BUT:

These "IF" s cut the probability to 1-in-4

or perhaps 1-in-8, as:

> SHUTDOWN was feared when salinity flipped around 2000. But currents move for Both salinity & temperature reasons (an Open Arctic, EARLY, means the 24-hour-a-day sun at the Pole will run temps well above the area South of it, thus an EARLY melt = the "warmth - conveying" reason for the current "conveyor" reverses)

 - - - I suspect it needs BOTH salinity & temperature to be reversed, for the current to reverse:

 = 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 high-altitude 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.

5. Is it Happening ?:

The Piomas model at the Polar Science Center is now 1200 km3 BELOW 2007's anomaly, and FALLING FAST. It actually ran off the bottom of the Chart, leading to a 20-day gap in Updates (people noticed, too).

Yet it often jumps up & down -- a month ago it was well above the worst 2007 anomaly.
 PIOMAS did match ICESAT's numbers almost perfectly except once -- in late 2007. So, IF the Central Arctic Ocean melts, PIOMAS will understate the loss (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. Alas, since Cryosat 2 launched, instead of providing more complete coverage than PIOMAS, its' Science team has embargoed the "Quick Look" feature, wishing to preserve "Scientific Priority of Publication'" until they publish

 - - in about 18 months. So what good is a "Quick Look" if it is SECRET for over a year?

 ONI ratings are at:
 http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml Also see:
uah Arctic Ocean air temp (last 5 months' anomaly: + 3.2 December, 1.6, 2.92, 2.53, 2.68 degrees C.) http://vortex.nsstc.uah.edu/data/msu/t2lt/uahncdc.lt

# Outlook of 9/2010 Arctic sea ice from 6/1/2010

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

The predicted September 2010 ice extent is **4.7 million square kilometers**. This is based on ensemble predictions starting on 6/1/2010. 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 6/1/2010. 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.
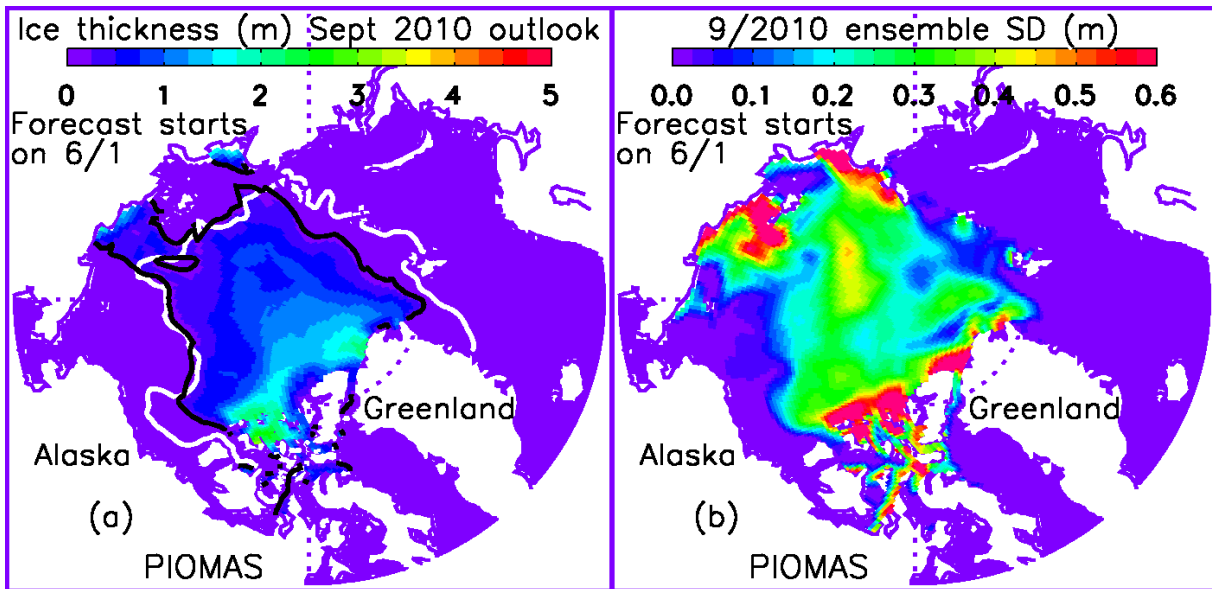
Figure 1. (a) Ensemble prediction of September 2010 sea ice thickness and (b) ensemble standard deviation (SD) of ice thickness which shows the uncertainty of the prediction. The white line represents satellite observed September 2009 ice edge defined as of 0.15 ice concentration, while the black line model predicted September 2010 ice edge.
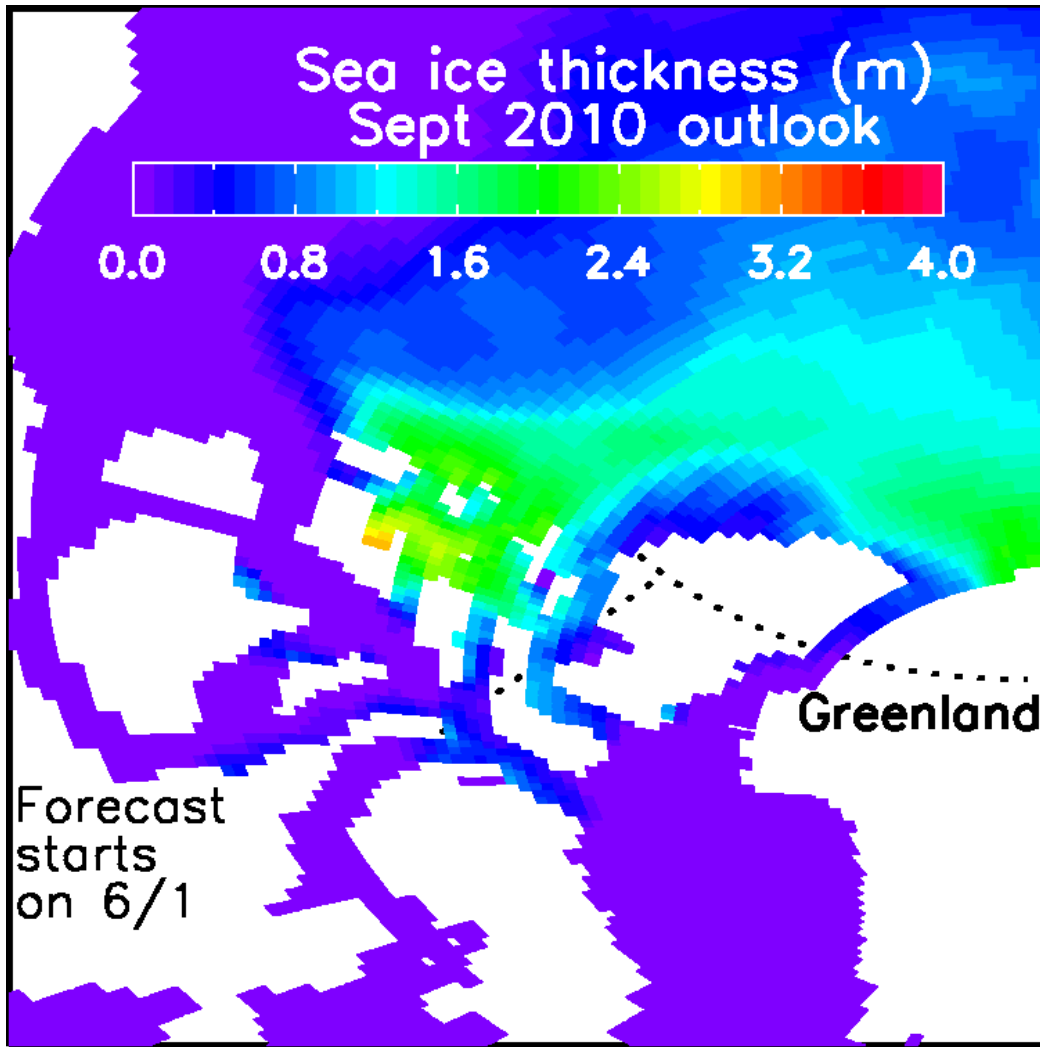
Figure 2. Ensemble prediction of September 2010 sea ice thickness in the Northwest Passage (NWP) region.