Sea Ice Outlook - May 2009

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2009 September Extent

Our forecast is 4.92 ± 0.43 Mio. km^2

Methods and Techniques

The estimate is based on a quadratic extrapolation of the measured September sea ice extent time series (Fig. 1)

Physical Rationale

The estimate is based on an assessment of different statistical forecast methods. We investigated three different techniques and a combined method in a hindcast experiment. The different techniques are:

- extrapolation of the september minimum timeseries,
- correlation of previous winter surface air temperature
- correlation of May ice extent anomaly
- a combination of the three methods above.

Extrapolation of the sea ice extent time series

We extended the Cavalieri et al. (2003) dataset with the NSIDC Sea Ice Index (Fetterer et al., 2002) to a homogeneous 37 year long time-series of the sea ice extent. The September minimum was extrapolated using a linear and quadratic fit (Fig. 1). Since the quadratic prediction better represents the observations it was used for the forecast. The 2009 forecast based on this method is 4.92 ± 0.43 Mio. km^2.

Northern hemispheric winter surface air temperature

The surface air temperature was obtained from NCEP reanalysis data. Zonal means of temperature correlated with September minimum showed statistical significant relation in the northern hemisphere from about 27.5N to 90N (Fig. 3). Ice growth during winter has an impact on the amount and extent of ice left after summer melting. The forecast calculated from the average of 27.5N to 90N from December to April air temperature is 6.0 ± 0.4 Mio. km^2.

Correlation of May with September extent

Correlation of the actual extent anomaly with the September anomaly depends on the time of year. The correlation is not significant for the May average extent, but will get better with each month when approaching September. Since the DMSP-F13 SSM/I has serious problems, we extrapolated the daily ice extent data from NSDIC seaice index and obtained three scenarios of the mean may extent: 13.075, 12.925 and 12.825 Mio km^2. Fig.4 shows that this difference does not have a very high impact on the September anomaly. Since there is no significant statistical relation this forecast is not used in the present prediction. The technique will become important in the following months. As you can see in Fig.5 the significance rapidly increases with the start of June and is not significant in previous months. Fig.5 also shows the impact of the 2007 and 2008 extreme minima on the correlation. Statistical significance of correlation coefficients was determined by permutation tests.

Combination of different forecasts

The inverse of the standard error of estimate is used to weight the seperate forecasts and make a combined prediction. The combined forecast $\bar{F}$ is calculated from the seperate forecasts F_k

$$\bar{F} = \frac{1}{S} \sum_{k=1}^{n} \frac{1}{\sigma_k} F_k$$

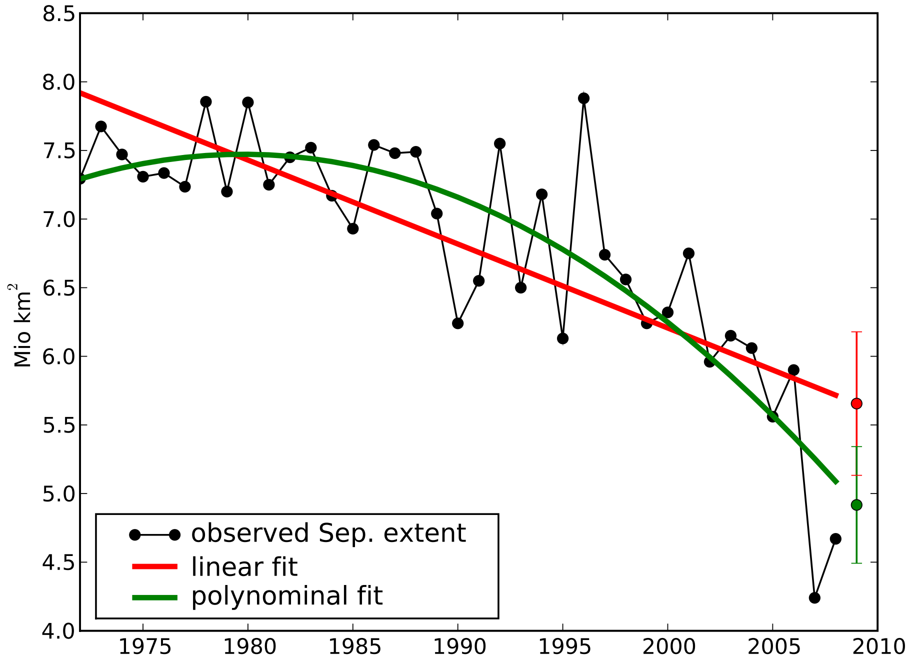

Figure 1: Extrapolation of September time series, correlation coefficients $r_{lin} = 0.78$ and $r_{poly} = 0.86$

with $S = \sum_{k=1}^{n} \frac{1}{\sigma_k}$ being the sum of all weights. The estimated error $\Delta \bar{F}$is calculated using:

$$\Delta \bar{F} = \sum_{k=1}^{n} \frac{\partial \bar{F}}{\partial F_k} \sigma_n$$

The combined forecast is 5.5 ± 0.5 Mio. km^2.

Assessment of the forecast methods

The four different methods are compared in a hindcast experiment (Fig. 6) for the nine years from 2000 to 2008. The total error is smallest for the quadratic extrapolation of the time series. The largest error occurs for the prediction based on the May extent. The combined method yields in average better results than the predictions based on air temperature and on the May extent but also suffers from their larger errors as compared to the extrapolation. Thus, the combined method is not the most suitable approach.

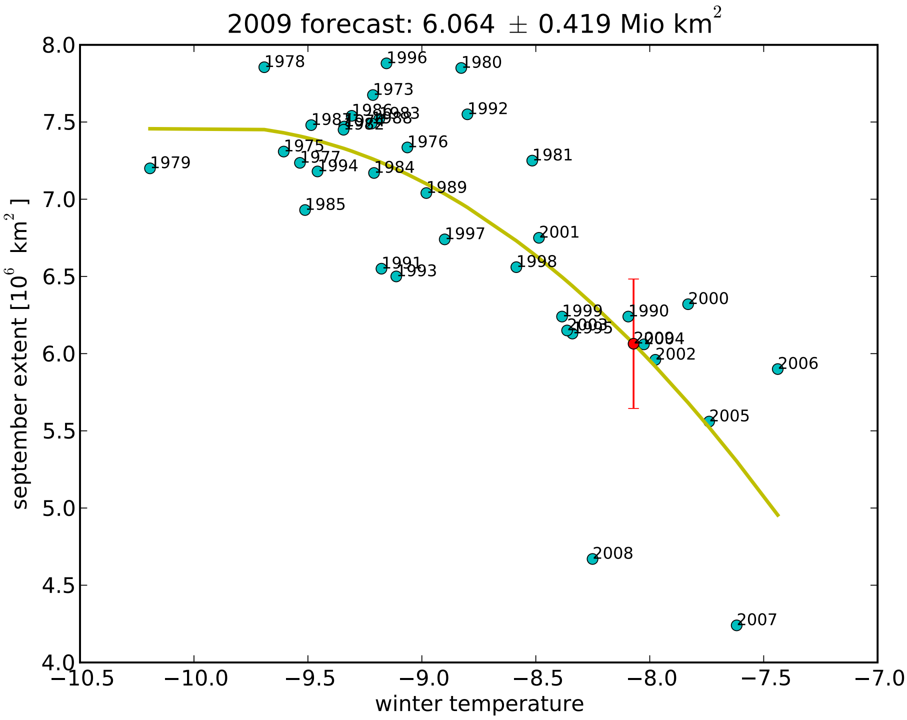

Figure 2: Northern hemispheric winter temperature and September ice extent with 2009 prediction.

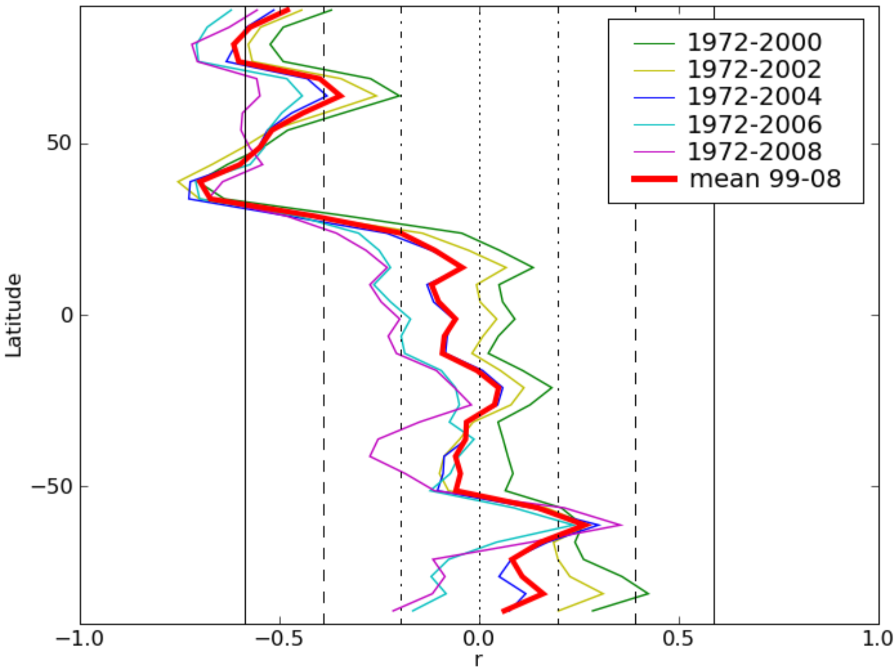

Figure 3: Correlation coefficient r of zonal mean air temperature with September extent; the black lines show 68%, 95% and 99% significance levels

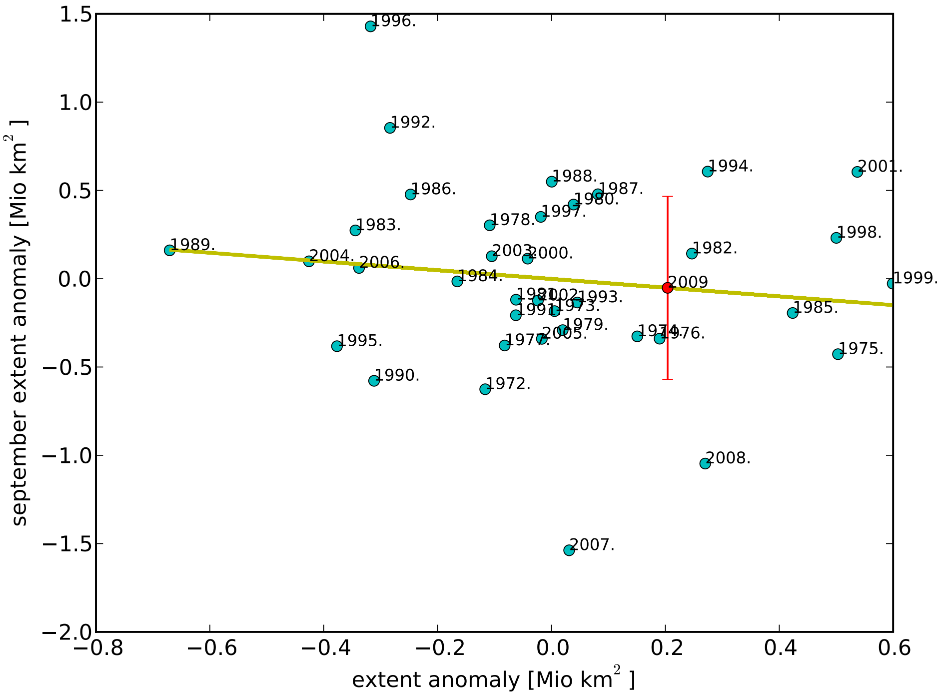

Figure 4: Correlation of May extent anomaly with September extent anomaly, $r = -0.1$

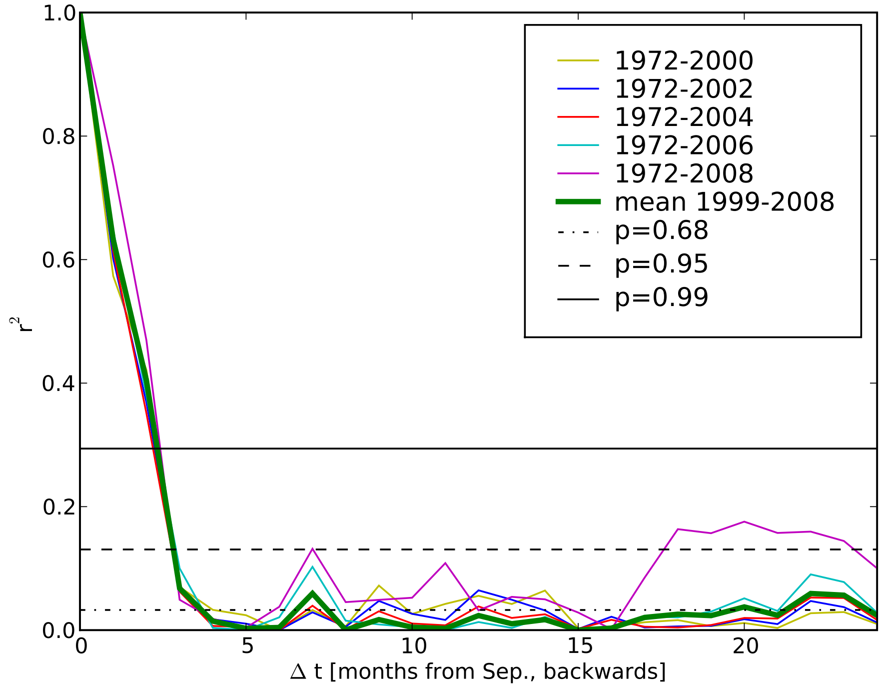

Figure 5: Correlation coefficients of september extent anomaly with previous months, black lines are significance levels, timeseries was cut off in 2-year steps to show the impact of 2007 and 2008 minima

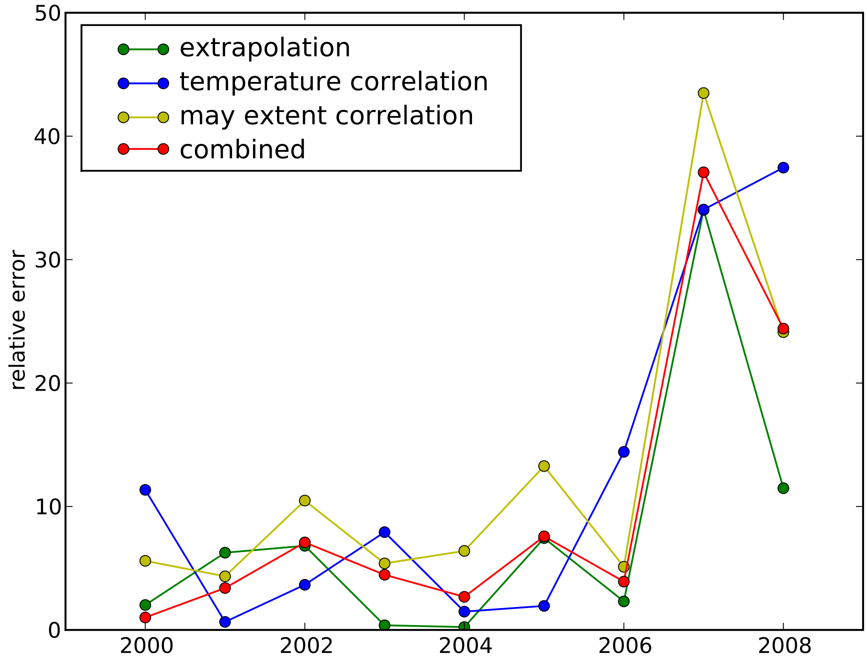

Figure 6: Prediction error hindcast experiment. The methods described in the text are used to predict the September minimum for the years 2000 to 2008. The relative deviation of the prediction to the actual sea ice extent are shown. The averaged errors are 8%, 10%, 12% and 13% for the extrapolation, combined method, correlation with temperature and May extent, respectively.

References

Cavalieri, D., Parkinson, C., and Vinnikov, K.: 30-Year satellite record reveals contrasting Arctic and Antarctic decadal sea ice variability, Geophys. Res. Lett, 30, 1970, 2003.

Fetterer, F., Knowles, K., Meier, W., and Savoie, M.: Sea ice index, National Snow and Ice Data Center, Boulder, CO, USA Digital media (updated 2009), 2002.