Pan Arctic Outlook

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Public outlook, statistical method

1. **Extent Projection** 4.438 + (End of July CT area - 4.383) * 0.9176 m km^2
   = 4.3 m km^2 +/- 95% confidence interval of 0.8 m

2. **Method** – single linear, single non-linear regression

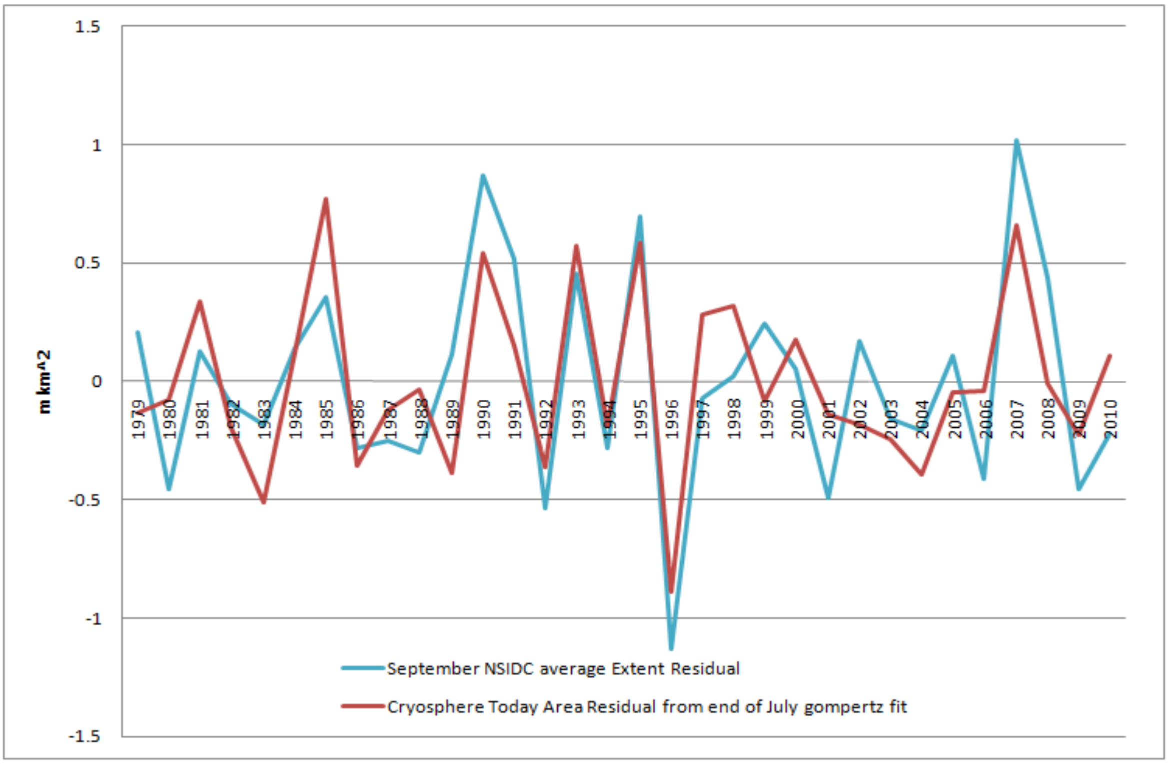
   A gompertz fit of the NSIDC September extent figures is used as a starting point.

   Linear regression is then used to predict the residual from the Gompertz fit using the residual of the end of July 2011 Cryosphere Today area number from a gompertz fit of end of July area numbers.

3. **Rationale**

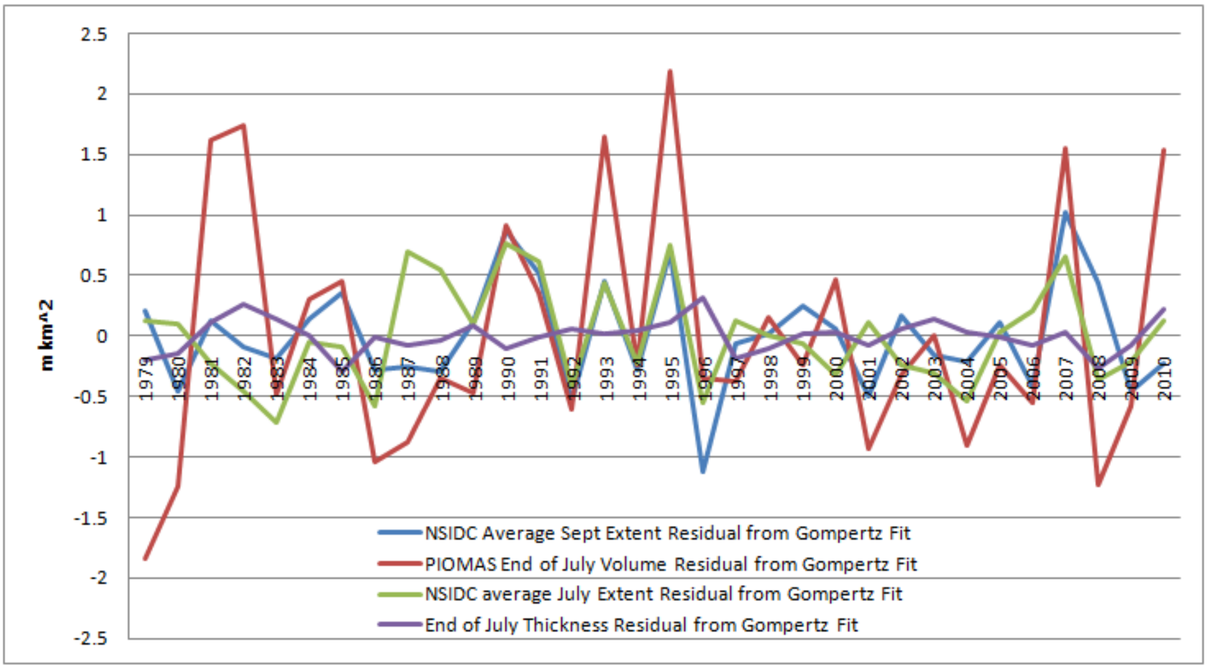
   Several contributors have used multiple linear regression. This felt inadequate when there appears to be a curved shape that other contributors have used quadratic, exponential, logistic or gompertz fits to approximate.

   For the July outlook I used both area and volume data to predict the residual. For this outlook, PIOMAS volume data does not appear to improve prediction of the residual significantly and has been dropped.

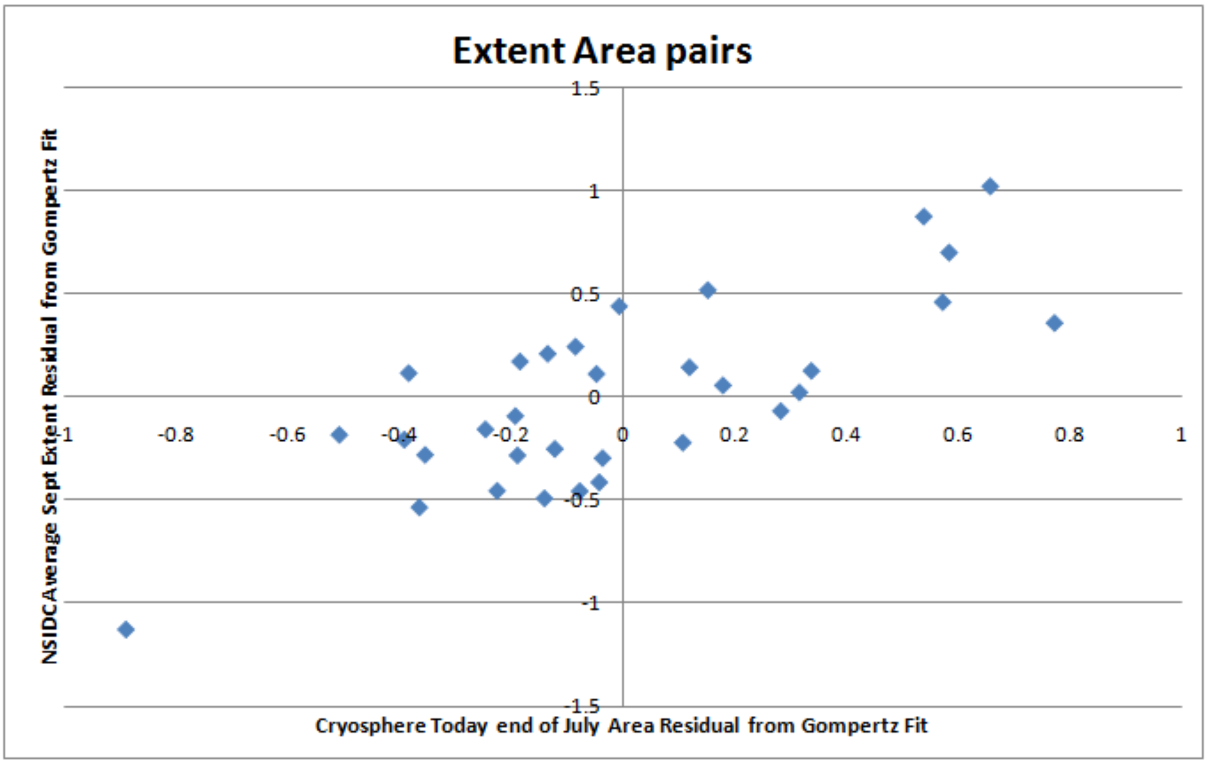


Other predictor variables may well exist to further reduce the error but I have not found any significantly useful data sets. Area that has a thickness that could be melted is one obvious likely improvement over just using PIOMAS volume numbers and Lindsay and Zhang use such data.

The following did not appear to be significantly useful:



A scatter plot suggests a fairly linear response to area residuals:



Hamilton's Contribution used a gompertz fit and yielded an estimate of 4.438m km^2. This prediction updates that prediction with an area based prediction. Area is .112 m km^2 below the gompertz fit value of 4.383 for the data labelled with year-fraction .5781. Extent is predicted to be the regression factor of 0.9176 times the difference of .112 m below the September extent gompertz fit of 4.438 to make a prediction of 4.3 m km^2.

This method makes no attempt at evaluating impact of likely weather over next six weeks which appears capable of causing substantial variation in the loss of extent between 31 July and the minimum.

I have not seen anyone attempting any sort of multiple non-linear regression and this approach which de-trends the extent and area data in a non-linear manner prior to a linear regression to predict the residual in the extent that we are trying to estimate appears to be one way to do that.

4. Executive Summary

The data appears to have a curved shape which it appears advantageous to recognise and adapt multiple linear regression to predicting the residuals from the curved shape which has been approximated using a Gompertz fit. – See Hamilton's Contribution. This model yields an average September extent prediction of 4.3 m km^2 with a 95% confidence interval in the region of +/- 0.8m (though RMSE is as low as 0.28m).

5. Estimate of Forecast Skill

A 95% confidence interval of +/- 0.8 m is calculated though there are mixed indicators over whether this might understate the uncertainty. This estimate is higher than the inappropriately tuned RMSE figures of as low as 0.28m.

The RMSE of estimates reduces as follows:
Linear regression of September average extent =0.508 m
Gompertz fit of September average extent = 0.438 m

Gompertz fit then linear regression prediction of residual with CT area residual from gompertz fit = 0.282 m

Note however that these RMSE numbers are likely to underestimate the likely error as they have the advantage of the method being tuned with data that cannot be available at the time of making a true prediction.

Removing that advantage

Year	Gompertz	Adjusted Gompertz	Actual	Error
1991	6.8956	6.8076	6.55	-0.2576
1992	6.7332	6.9470	7.55	0.6030
1993	6.8981	6.4133	6.5	0.0867
1994	6.7476	7.1558	7.18	0.0242
1995	6.8010	6.3916	6.13	-0.2616
1996	6.5989	7.6012	7.88	0.2788
1997	6.8246	6.4639	6.74	0.2761
1998	6.7712	6.4440	6.56	0.1160
1999	6.6921	6.7547	6.24	-0.5147
2000	6.4976	6.2863	6.32	0.0337
2001	6.3397	6.4042	6.75	0.3458
2002	6.4390	6.5182	5.96	-0.5582
2003	6.1693	6.2445	6.15	-0.0945
2004	6.0600	6.2112	6.05	-0.1612
2005	5.9505	5.7487	5.57	-0.1787
2006	5.6486	5.4538	5.92	0.4662
2007	5.6232	4.8907	4.3	-0.5907
2008	4.7365	4.8002	4.68	-0.1202
2009	4.3707	4.5991	5.36	0.7609
2010	4.5460	4.3898	4.9	0.5102

Average absolute error	0.312 m
RMSE without tuning to unavailable data	0.378 m

A 95% confidence interval is calculated at +/- 0.8 m. All 20 errors are less than this suggesting that 0.8 m may be more than necessary.

However, the average of the absolute errors for the first 10 year is only 0.245 m whereas the average in the last 10 years is higher at 0.378 m. So there may be some growth in the expected size of errors and therefore a 95% credible interval may need to be higher than +/- 0.8 m.

Using exponential fits instead of Gompertz fits yielded a minor improvement in the fits giving a RMSE of 0.2814 instead of 0.282 but I prefer to stick with the Gompertz fit in case this is needed for a levelling off in the rate of decrease which could occur.

In the format

	A	B	C	D	E	F
1	m_n	m_{n-1}	...	m_2	m_1	b
2	se_n	se_{n-1}	...	se_2	se_1	se_b
3	r_2	se_y				
4	F	d_f				
5	ss_{reg}	ss_{resid}				

The regression factors and data are

Multiple Regression Factors – Area

0.917599	0.00023
0.140987	0.051496
0.585401	0.291307
42.35909	30
3.594582	2.545792

6. Projection based on August data

Unless improvements are found, Average September Extent projection =

= 4.438+(IJIS JAXA End Aug Extent–4.824)*.9083+(End Aug CT Area–3.124)*0.3785

m km^2 +/- unfairly tuned RMSE of 0.14 m.

The IJIS JAXA daily extent record is only short starting in 2002. Thanks to Lucia and blog readers the NASA GFSC daily extent record here was made known to me. I have attempted to create a homogenous daily extent record by applying a step change to the GFSC data. The data and calculations are made available here. This appears to work well and is a better guide to NSIDC average extent than CT daily area at the end of August. At the end of July, both CT area and GFSC-JAXA daily extent are significant but CT area is a better guide than this daily extent record. There is a large overlap of information between these two as using both only performed better than area and 8 out of 10 sets of random numbers. So there does not appear to be a significant advantage to using this GFSC-JAXA daily extent record at 31 July and it has not been used.

7. Invitation to discuss

Comments on this method or the error estimate or comparing different methods or error estimates between different contributions are welcome. I suggest such discussion could be useful be done at Neven's blog. The latest appropriate post being http://neven1.typepad.com/blog/2011/07/august-search-outlook-contribution.html