National Snow and Ice Data Center
Supporting Cryospheric Research Since 1976

Towards Improving Sea Ice Predictability

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Introduction

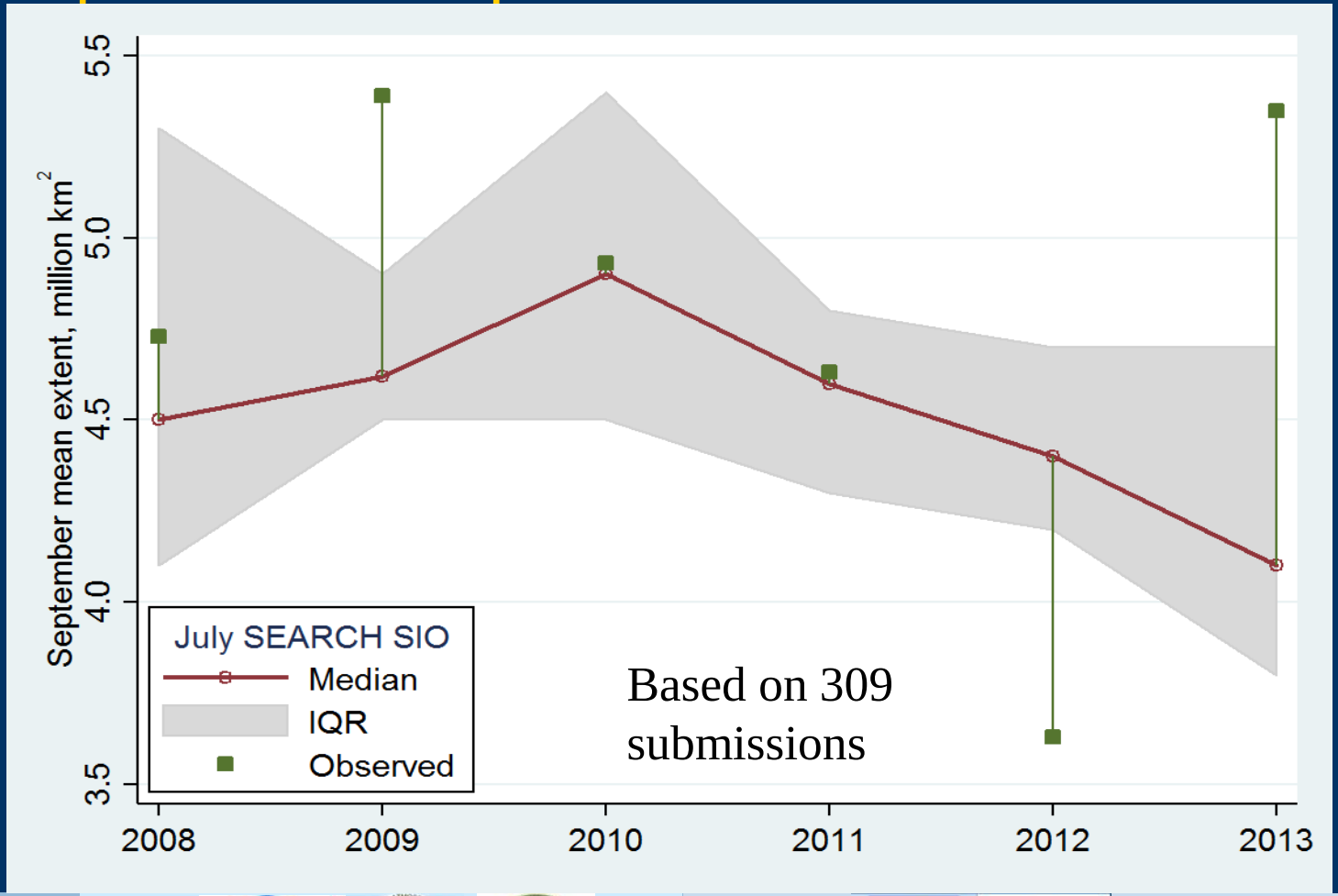
- Predicting Arctic sea ice a few months in advance has become a challenging priority.
- Since 2008 SEARCH has solicited community predictions of the September sea ice extent and disseminated results through the SEARCH Sea Ice Outlook (arcus.org/search-program/seaiceoutlook
- Individuals and teams employ a wide variety of modeling, statistical and heuristic approaches to make these predictions
- This informal network has received a total of 309 contributions for the years 2008 to 2013

Talk Outline

- First we evaluate how well the SIO predictions did over the last 6 years (*Stroeve et al., 2014; GRL*).
- Next we discuss implications for predictability.
- Finally we discuss efforts to turn this informal exercise into a more format network aimed at:
  - **Coordinating** and evaluating seasonal predictions
  - **Integrating, assessing and guiding observations**
  - **Synthesizing predictions and observations**
  - **Disseminating** predictions and engaging key stakeholders

July SIO predictions reveal Bimodal Pattern of Success

Median and interquartile range of July SIO predictions compared with September mean sea ice extent

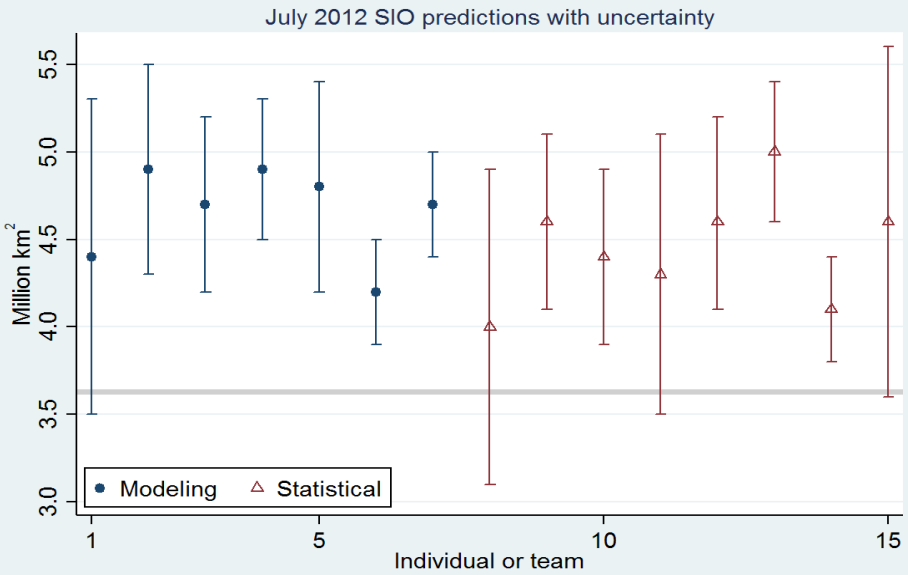


Stroeve et al., 2014

Predictions by method: July 2012

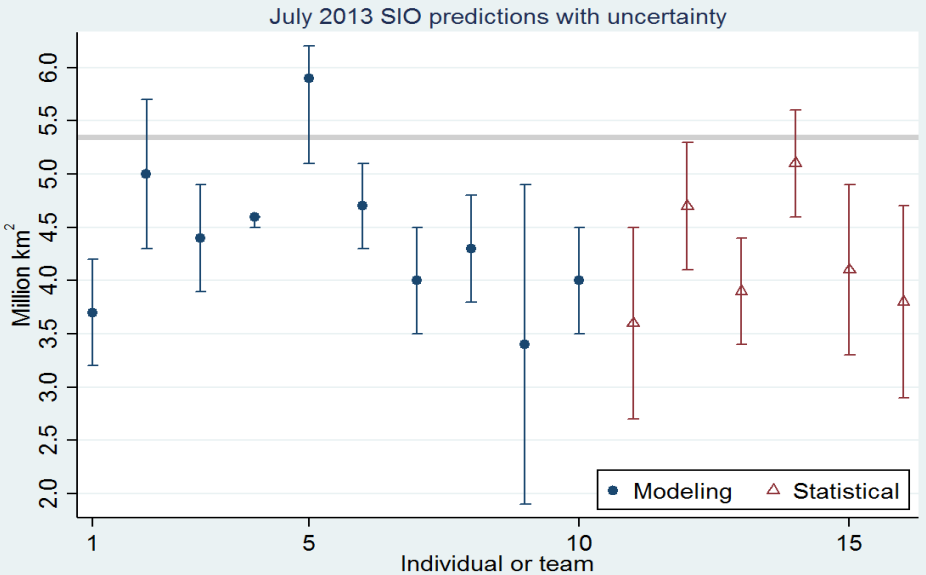
SIO predictions with contributor-supplied uncertainty

2012



Observed extent lies outside the intervals for 11 of 15 predictions, and barely inside the lower limit of 3. As a group, 2012 statistical predictions came closest to the unexpectedly low ice extent.

2013

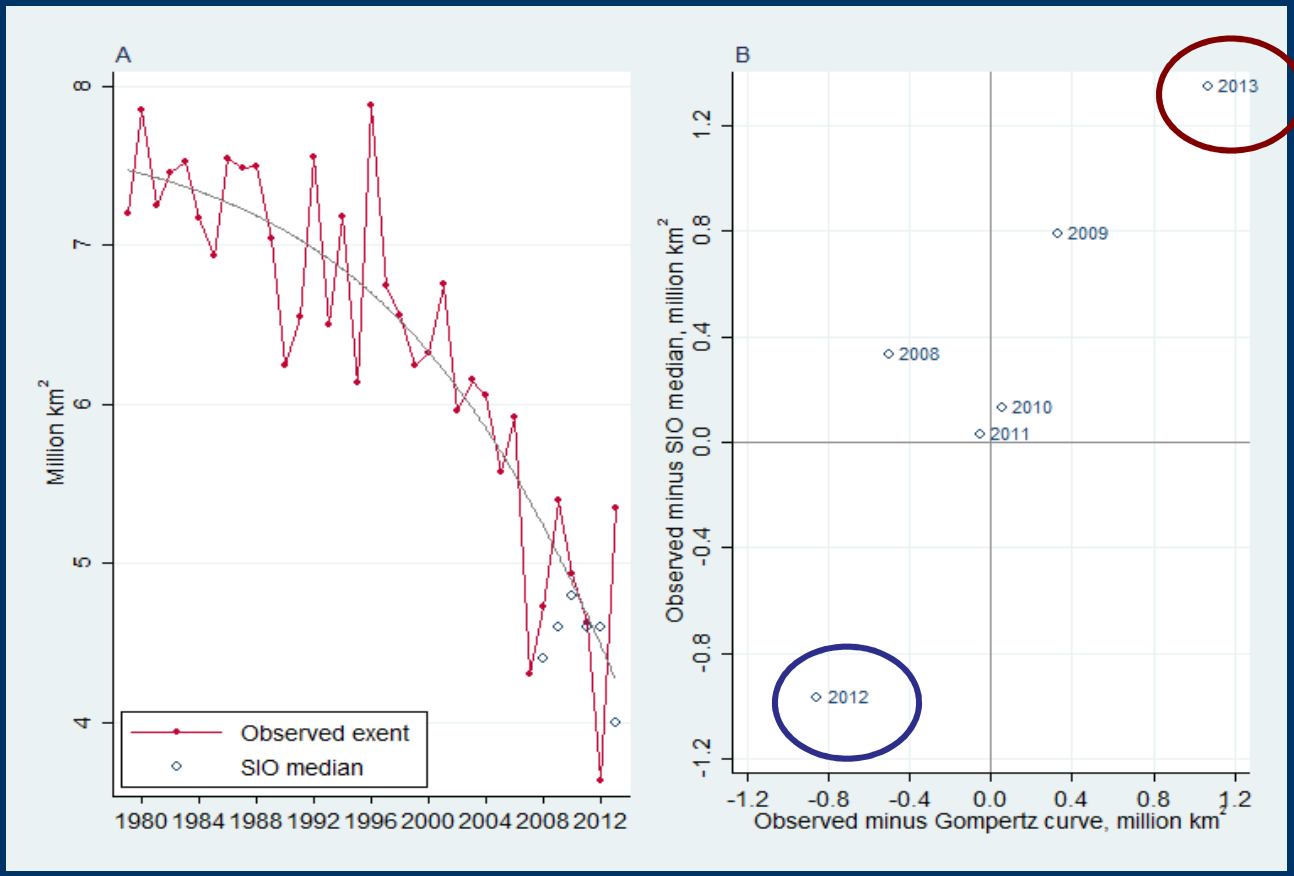


Observed extent lies outside the intervals for 13 of 16 predictions. As a group, 2013 modeling predictions came closest to the ice extent.

Stroeve et al., 2014

SIO Prediction Errors

Observed and Predicted Extent



Prediction Errors

The downward trend is summarized by a Gompertz curve-an asymmetrical S-curve appropriate for the accelerating downward trend.

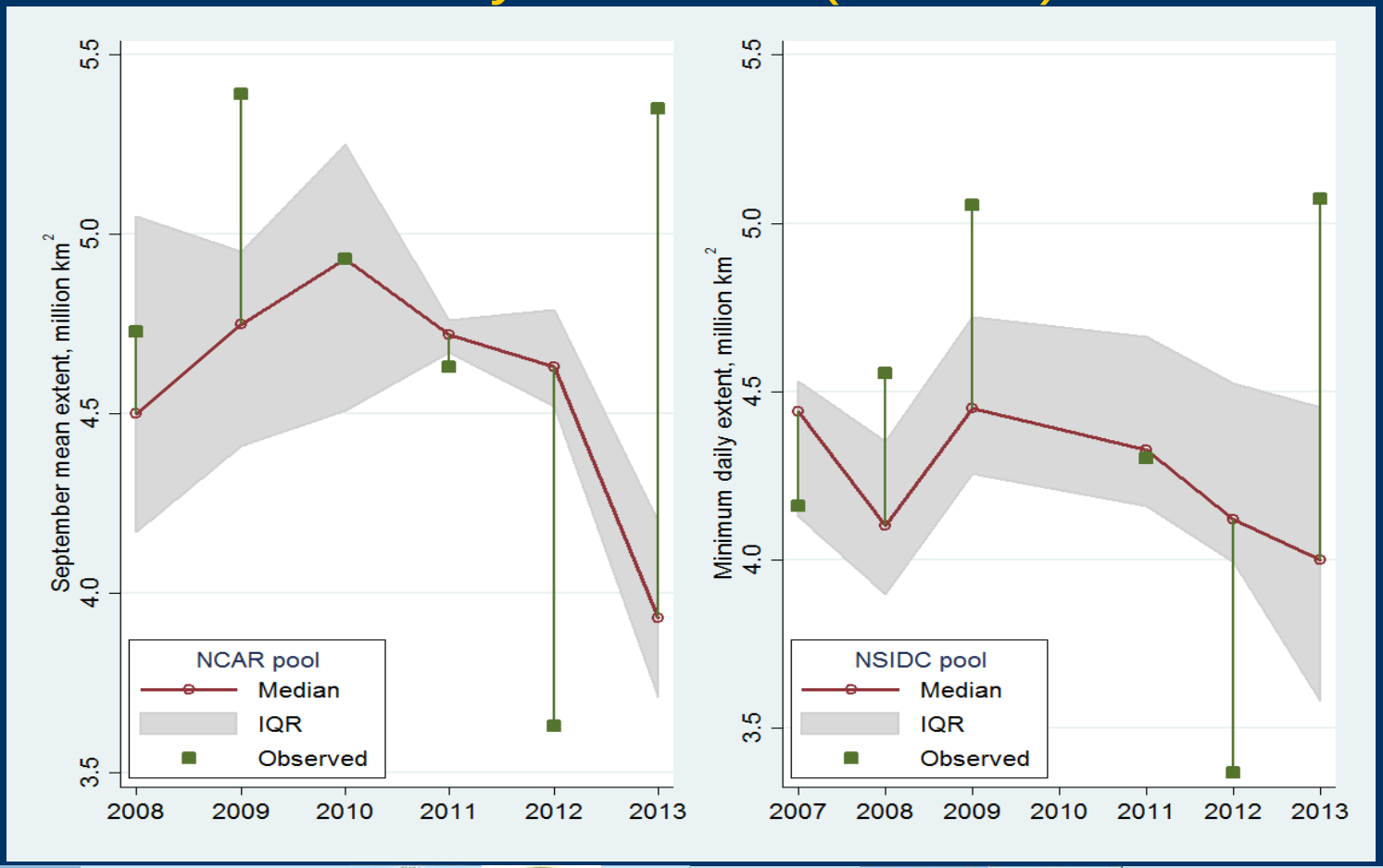
SIO prediction errors and Gompertz curve residuals have a strong positive correlation ($r=0.90$, $p< 0.05$)

MSE of SIO predictions is only slightly better than a series of linear-trend predictions (MSE = 0.58 vs. 0.65)

Stroeve et al., 2014

Same Pattern of Success in Office Pools

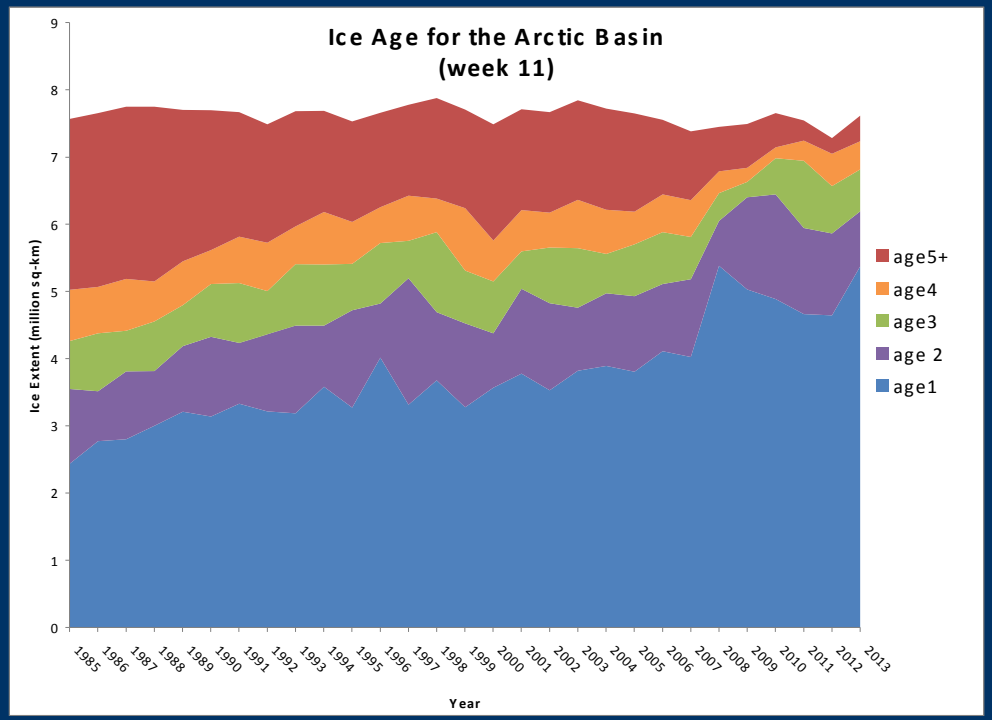
Median and interquartile range of NCAR and NSIDC office pool predictions, compared with September mean (NCAR) or one-day minimum (NSIDC)

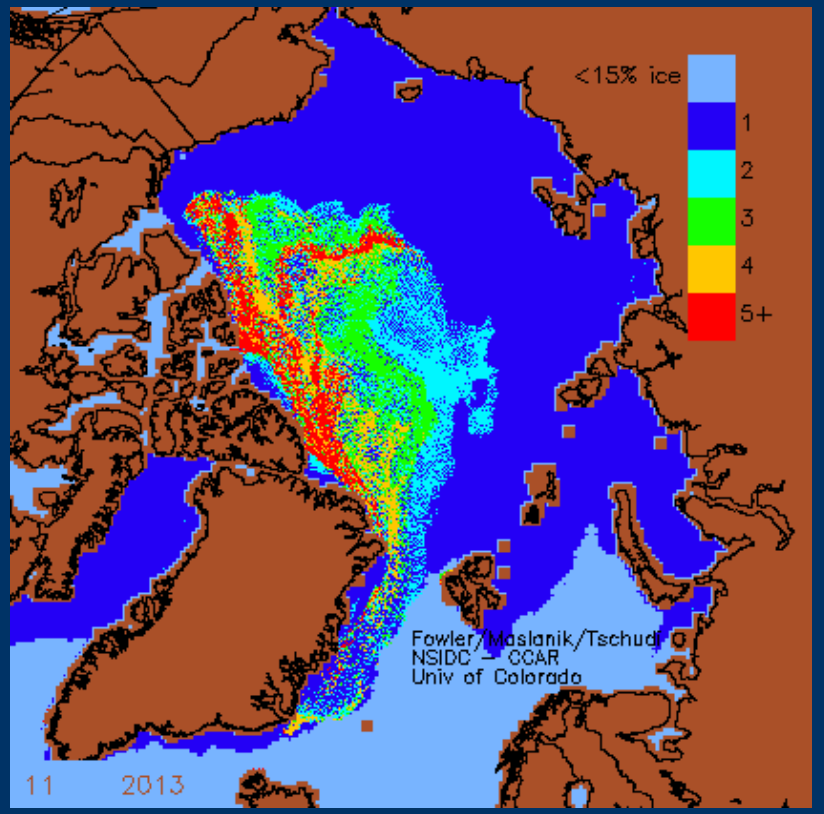


Stroeve et al., 2014

Limits on Predictability

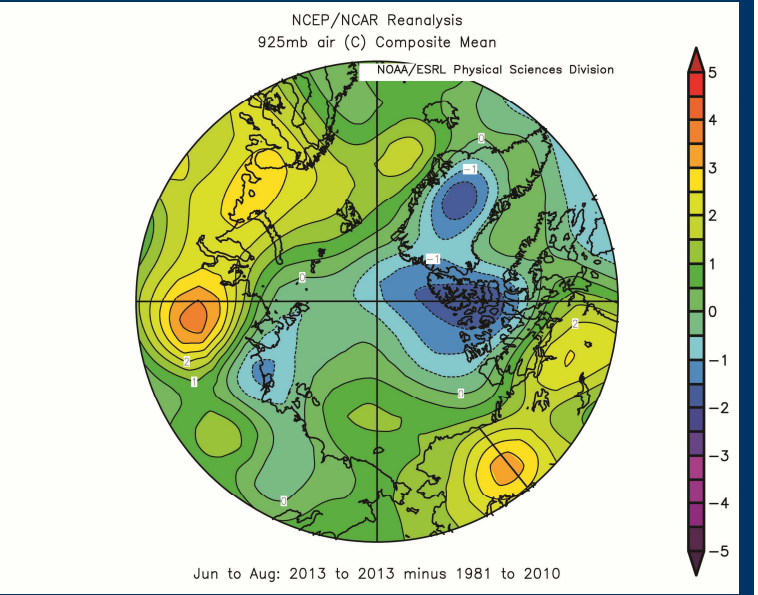
- The largest median error occurred in 2013.
- Yet the summer started out with a large fraction of thin, first-year ice and very little old ice (5+ yr)





Limits on Predictability

- 2013 was characterized by below normal SLP, limiting heat advection from the south, leading to cooler conditions over the Arctic Ocean.
- In this case, despite anomalous spring conditions, summer weather resulted in the September extent not being predictable from a spring initialization.
- On the other hand, some extreme Septembers could be the result of extreme spring preconditioning, which should be predictable to a degree (from a spring initialization with the right ICs and thickness.



JJA 2013 925 mbar temperature anomalies

Limits on Predictability

- Each colored line represents growth in GCM ensemble spread of forecasts for a particular year initialized in May
- Different years can show very different predictability skill
- In some years the summer atmosphere gets rid of all predictability by Sep, in other years there still remains quite a bit of predictability.

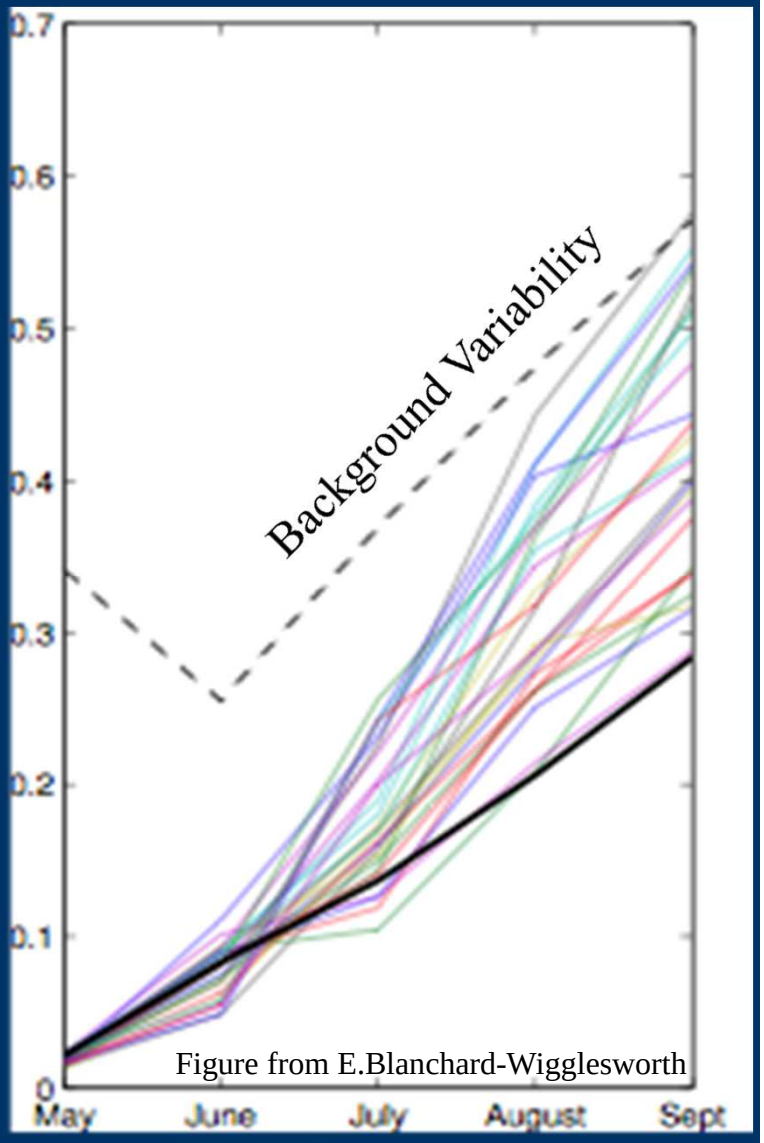


Figure from E.Blanchard-Wigglesworth

Summary of SIO Results

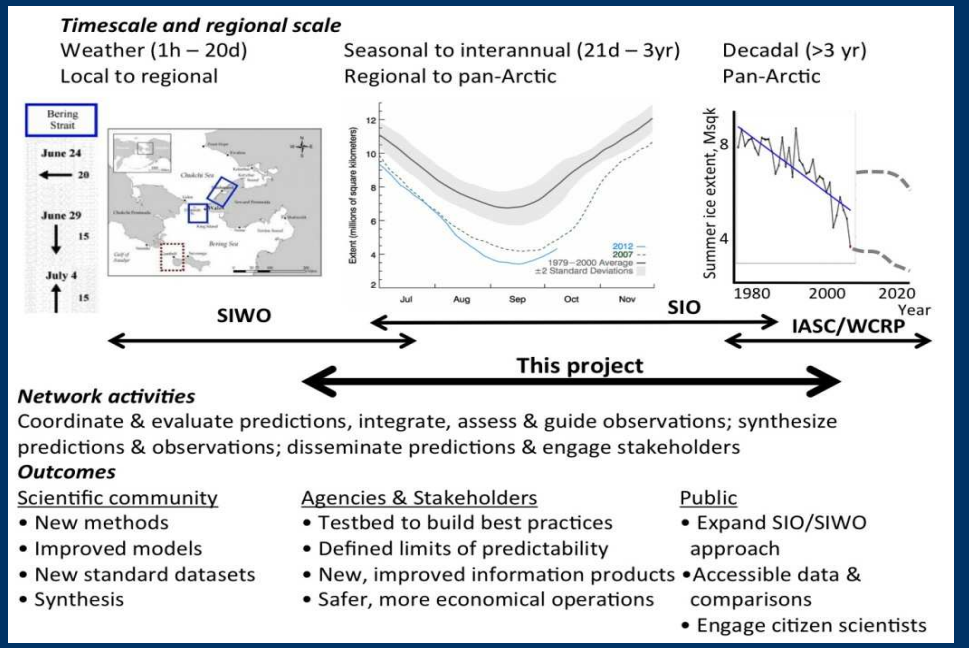
- Analysis of over 300 individual predictions submitted to SIO from 2008 to 2013 show a bimodal pattern of success.
- During years when the sea ice extent departs from the trend, predictions fail despite preconditioning.
- The pattern appears unrelated to the general type of method used, rather year-to-year variability dominates success.
- Predictions do not improve as we get closer to September.
- SIO predictions do beat persistence and climatology.
- While the SIO indicate that extreme years are less predictable than non-extreme years, it is unclear if this is a robust feature of the natural system or result of noise (with only 6 years it's difficult to assess this).

Sea Ice Prediction Network (SIPN)

- SIPN builds on the SEARCH SIO
- Goal of SIPN is to improve sea ice prediction on seasonal to interannual time-scales by developing a network of scientists and stakeholders to advance research on sea ice prediction and communicate sea ice knowledge and tools.
- Observations ⟺ Models
- SIPN team members: *J. Stroeve, C. Bitz, E. Blanchard-Wigglesworth, H. Eicken, L. Hamilton, E. Hunke, J. Hutchings, P. Jones, W. Meier, J. Overland, A. Tivy, M. Wang and H. Wiggins*

Towards a Sea Ice Prediction Network

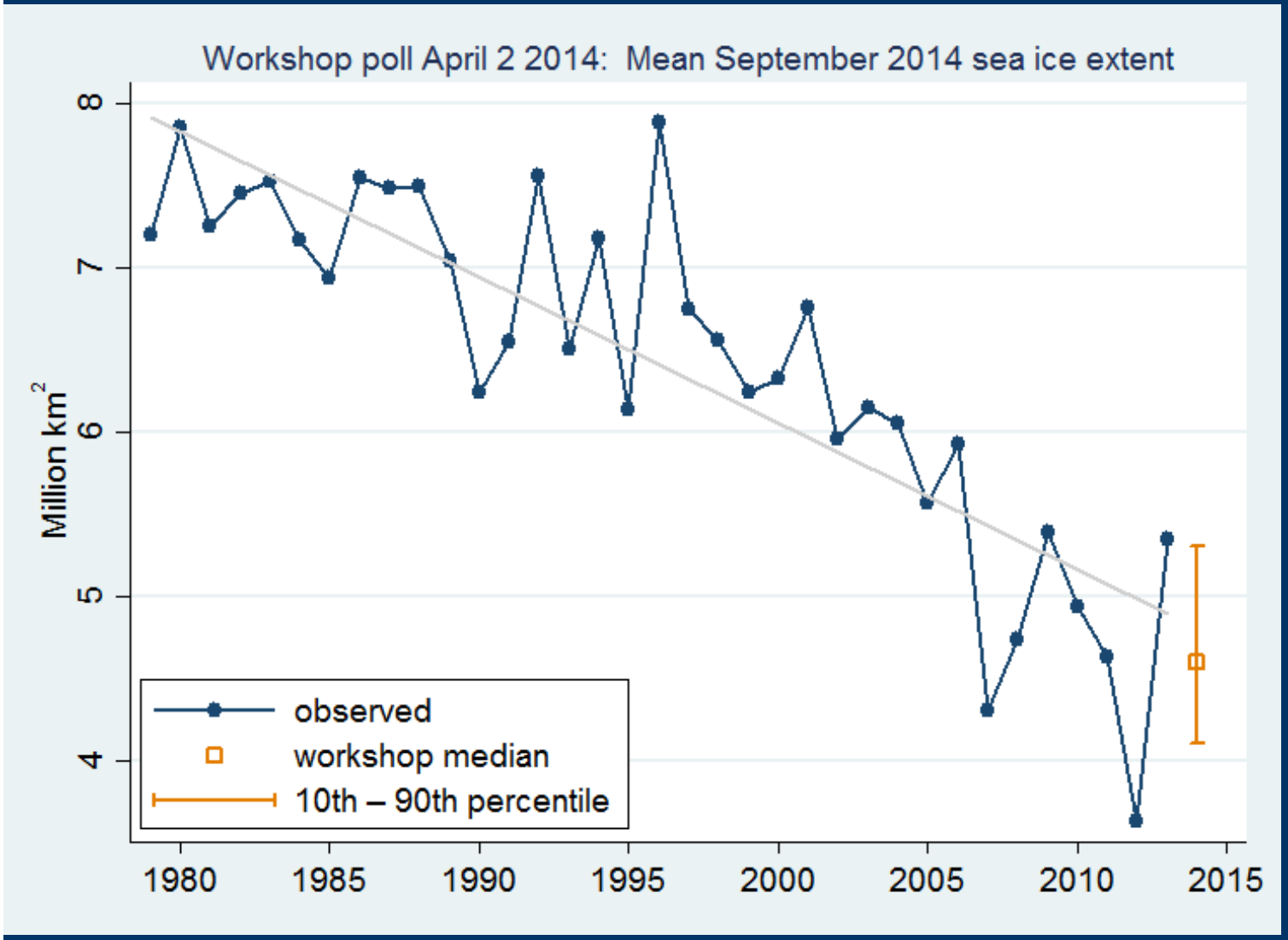
- Coordinate and evaluate predictions (*C. Bitz*)
- Integrate, assess and guide observations (*J. Stroeve*)
- Synthesize predictions and observations (*J. Overland*)
- Disseminate predictions and engage key stakeholders (*L. Hamilton and H. Wiggins*)



SIPN Workshop (1-2 April 2014, Boulder, CO)

- Overall goal was to plan for the 2014 SEARCH SIO
  - Provide sea ice forecasts with uncertainty estimates – move towards probability maps;
  - Expand to include spatial pattern of sea ice;
  - Obtain guidance from the community as to how the SEARCH SIO can improve and become a more robust scientific tool.
- Secondary goal is to advance sea ice prediction by:
  - Coordinating experiments;
  - Defining data sets for initialization and validation;
  - Create better metrics for evaluation.
- In total we had about 67 participants, focused on different aspects of sea ice predictability.
  - Follow on workshop to take place in the UK in April 2015.

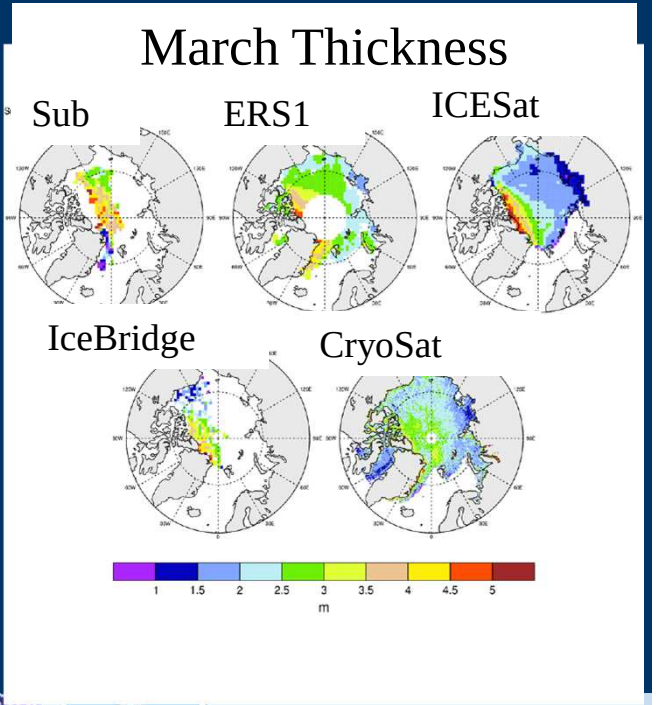
Workshop poll results – 49 "guesses"



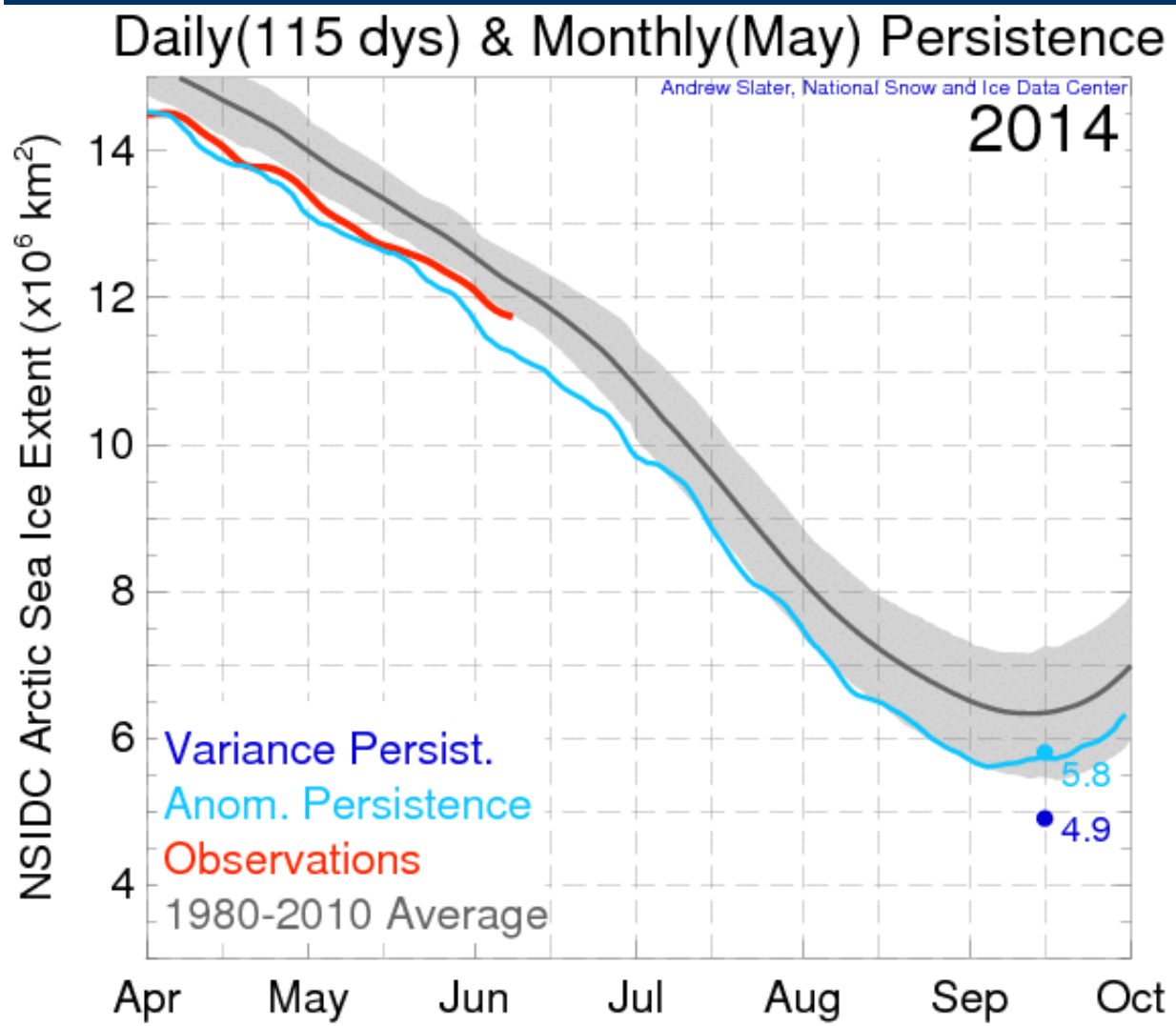
4.68 10^6km^2

New Data Website at NSIDC

- Good knowledge of initial sea ice state is necessary to produce skillful forecasts. New website at NSIDC provides links to sea ice observations at regional and local level (http://nsidc.org/data/sipn/)
  - Goal is to define, assemble and disseminate data sets, particularly sea ice thickness
- Develop integrated data sets
  - Framework and tools for standardized surface-based ship observations (Ice-Watch Program: ASSIST)
- Next Step: Obtain guidance from predictive models on observing strategies, data format requirements



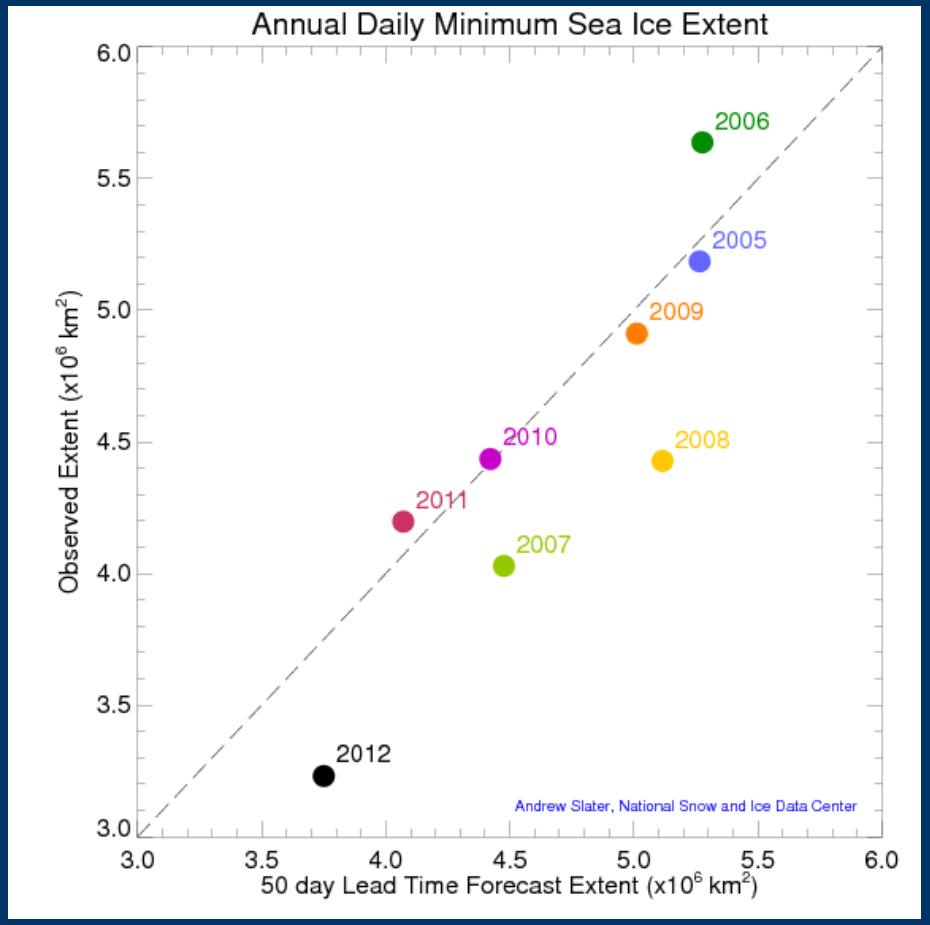
The 2014 SEARCH Sea Ice Outlook



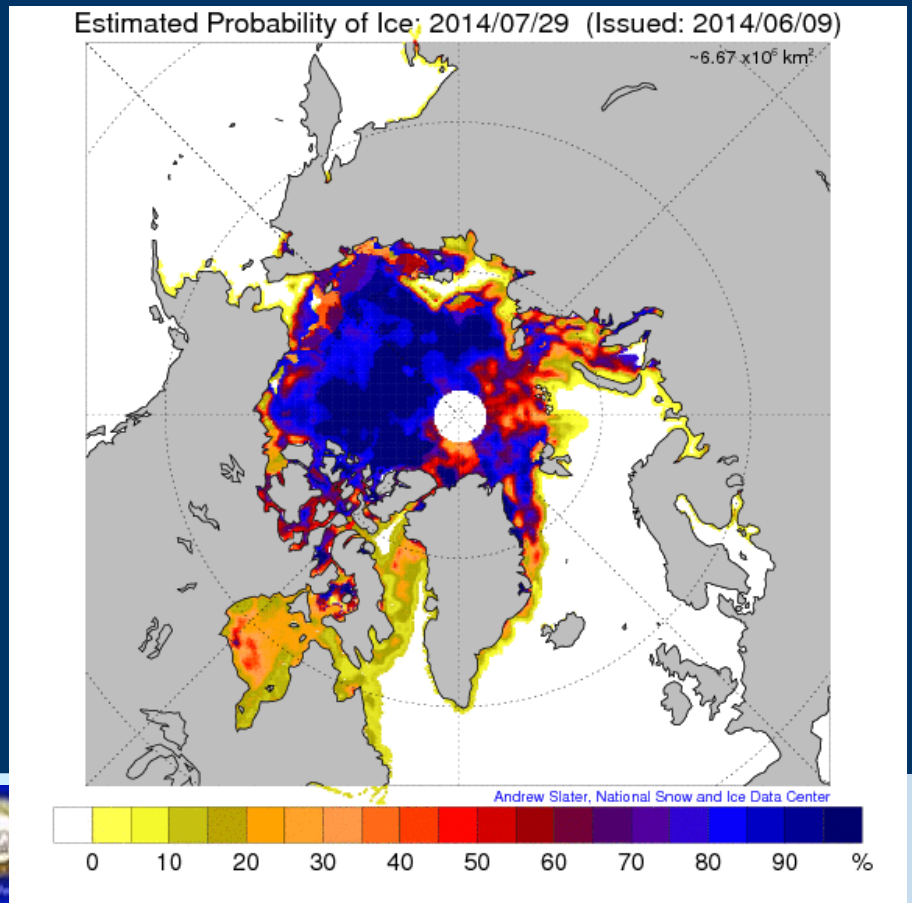
1) Daily anomaly persistence at 115 days lead time -> Sep =5.8
2) Monthly anomaly persistence -> Sep = 5.8
3) Persist the standard normal deviate from May to Sep -> Sep=4.9
All 3 methods have a skill value of less than -1.0 i.e. no skill!

June is a difficult month to forecast with skill.

At shorter lead times, predictive skill improves



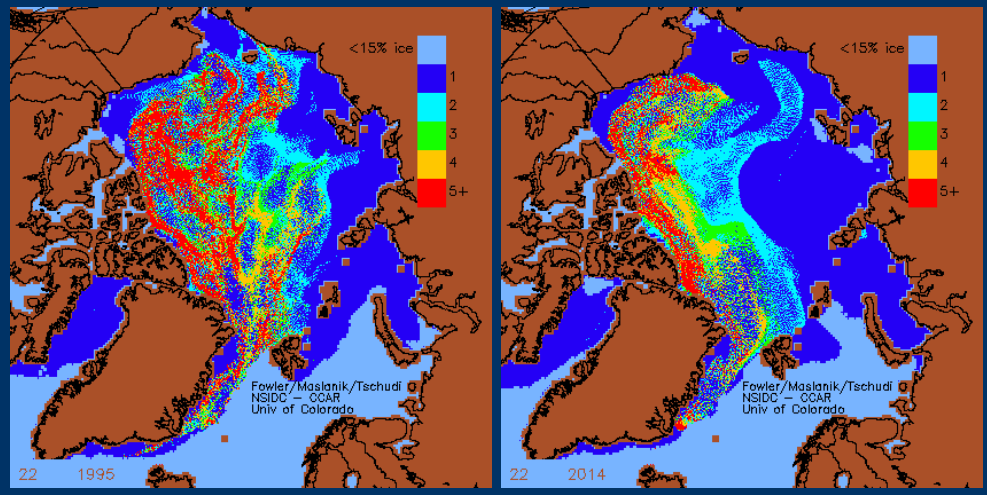
- At 50 day lead time, there appears to be some predictive skill simply using persistence.



Images provided by Drew Slater

Some other predictions

- Based on ice age survivability, predict September minimum of 4.9 $10^6 km^2$.
- Schroeder et al. (based on melt pond fraction in May) predict mean September of 5.4 $10^6 km^2$.
- NOAA CFSv2 coupled forecast system model predict mean September of 6.4 $10^6 km^2$ (i.e. back to conditions in the 1990s!).



Join the Network!

We encourage regional and Arctic-wide predictions

http://arcus.org/sipn

Or email one of the action team leads

- **J. Stroeve – data**
- **C. Bitz – modeling**
- **J. Overland – synthesis**
- **H. Wiggins and L. Hamilton - stakeholders and dissemination**