On Ice with a Twist

August 22, 2010

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On Ice with a Twist

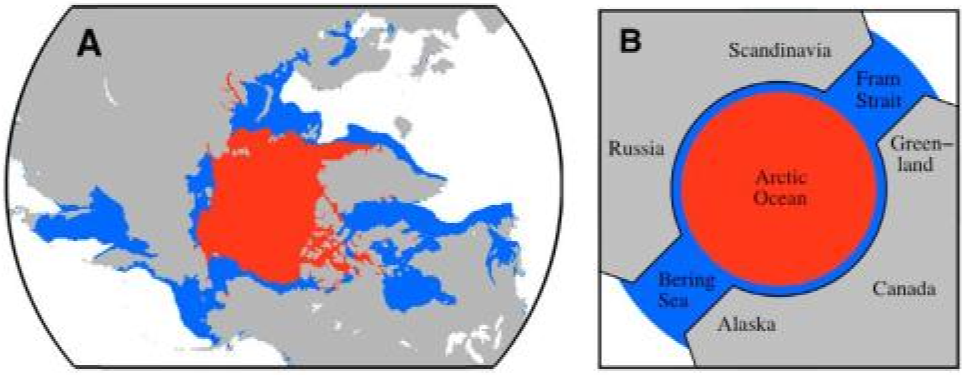
Posted on | 21 Comments

Thanks to reader "DrC" for the tip about a new paper which takes a new view of variations in arctic sea ice. Most of us are familiar with the usual measures of sea ice. Using satellites we can estimate both sea ice *area*, which is the area of the sea which is ice-covered, and ice *extent*, which is the area of ocean which has 15% or more ice cover. Both measures are commonplace, perhaps extent is a bit more commonly reported. It's easy to get daily up-to-date data on arctic ice extent from JAXA, and on arctic ice area from cryosphere today.

Those who study ice extent (or area) data in detail will notice two things. First, the yearly pattern of changes is asymmetric between winter and summer; the winter maximum tends to be more flat-topped while the summer minimum is more pointy. Second, the trend (since satellite observations begin in the late 1970s) is strongly season-dependent; the decline in winter maximum has been much less rapid that of the summer minimum. This has caused much speculation about the reasons for these seasonal asymmetries.

But the new paper by Ian Eisenman (2010, *Geographic muting of changes in the Arctic sea ice cover*, Geophys. Res. Lett., 37, L16501, doi:10.1029/2010GL043741) illustrates that the seasonal differences may be — I'm tempted to say *probably are* — due to geography. During summertime, arctic sea ice has retreated to such high latitudes that it's almost entirely in open ocean. In that case a small move south, i.e. a small change in its latitude extent, corresponds to a large increase in ice area or extent. As ice grows in autumn and winter, of course it extends further and further south. But it soon extends to latitudes where there can't possibly be very much sea ice, simply because there's not that much sea — the arctic ocean is surrounded by land.

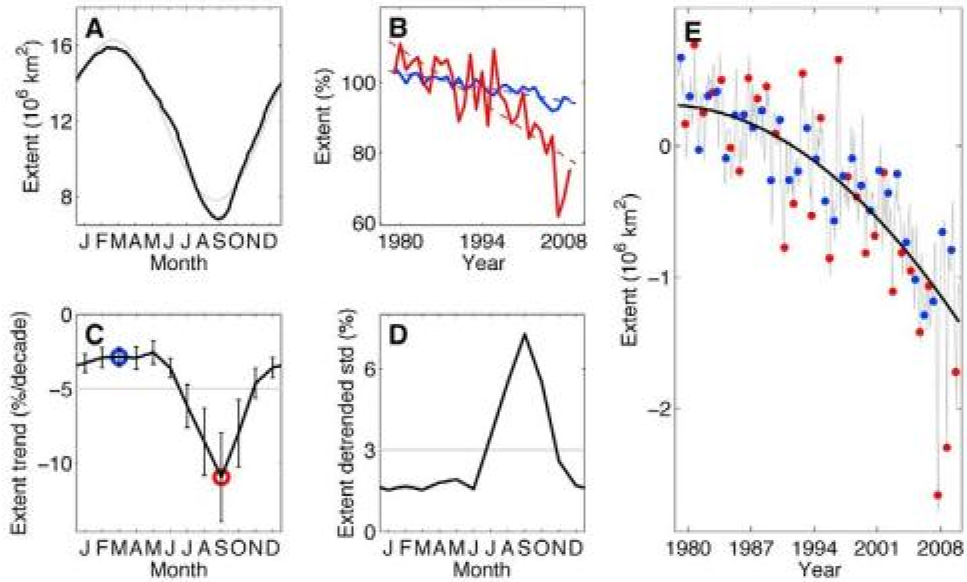
This is illustrated in Eisenman's figure 2, which shows the land masses surrounding the pole in part A and a schematic of the effect in part B. When the ice is beyond the reach of the land masses during summer, a small latitude change covers a lot of ocean, meaning a lot of sea ice area and extent. When the ice reaches the land masses during winter, a small latitude change covers mostly land, which means far less sea ice area and extent.



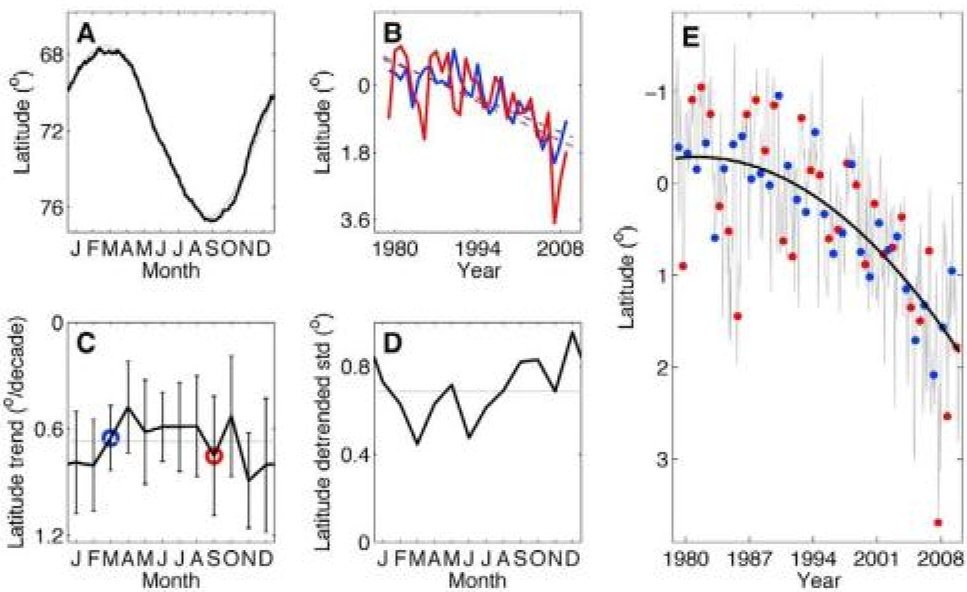
If true, Eisenman's hypothesis means that winter ice extent (and area) is to a large degree limited by geography, i.e., by the placement of the circumpolar land masses. It can still shrink and expand, but not as much as summer ice because there's simply not as much ocean at the "available" latitudes during non-summer seasons.

Eisenman decided to characterize the growth and decay of sea ice, not by its area or extent, but simply by its latitude — how far south, on average, does the ice extend? For each day of satellite data, he estimated the average latitude of the southern border of the ice, but only where it changes from ice to sea — ice that is limited by land masses doesn't figure into the calculation. This gives him the average latitude of the ice/open-ocean boundary. The idea is that perhaps the forces governing change of arctic ice cover determine how far north or south the ice/ocean boundary extends, more directly than they determine how much area is covered by sea ice. You can get Eisenman's latitude data here.

One of the consequences is that even if winter and summer have shown the same trends in latitude change over the last few decades, they'll have shown very different trends in ice extent (or area). In fact winter and summer *have* shown nearly the same trend in latitude change over the last few decades. The trends in extent show dramatic seasonal differences, illustrated in Eisenman's figure 1:

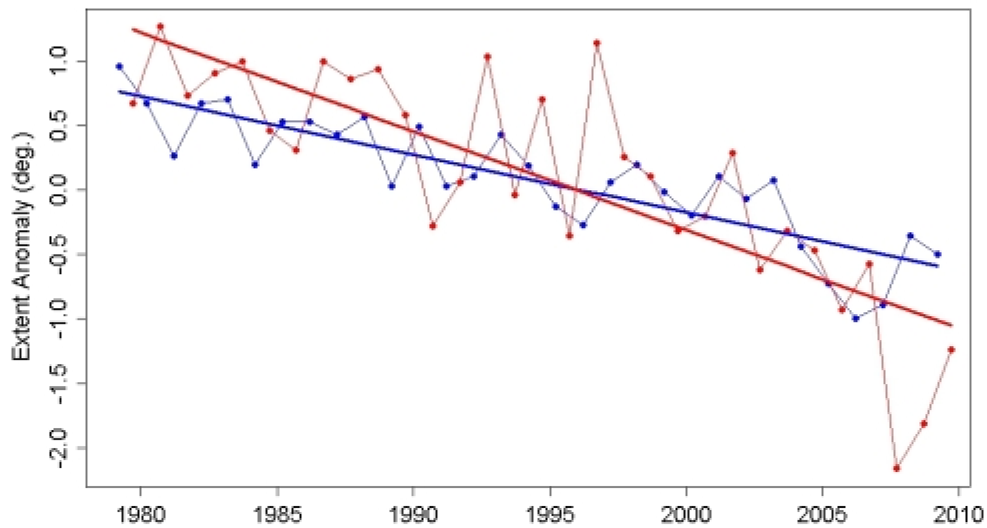


Especially evident is the difference between March and September shown in part B, and the different montly trends shown in part C. In his figure 3 Eisenman shows the same analysis, but in terms of latitude rather than extent:

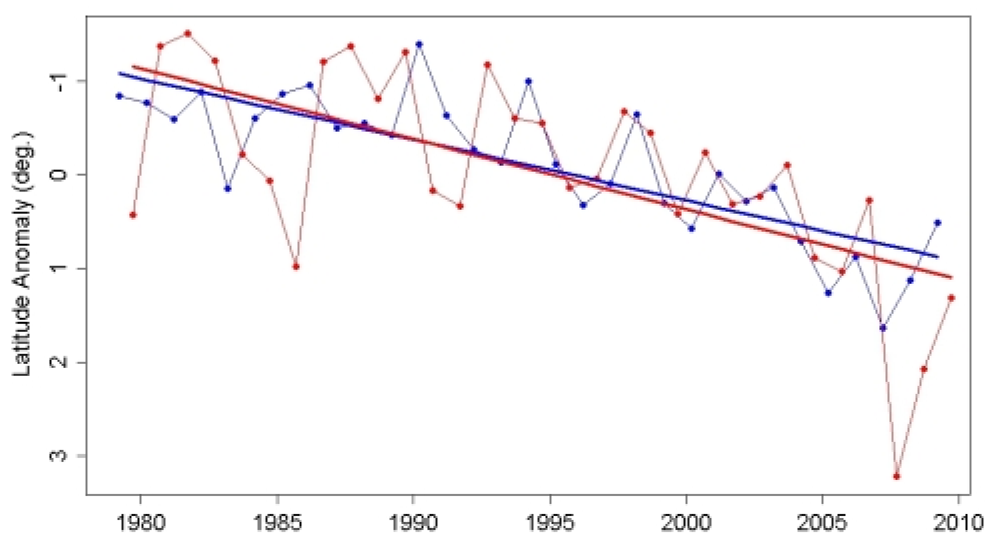


Using this variable, the trends in winter and summer are far more alike, in fact they're more similar than different. During both seasons (and in fact throughout the yearly cycle), the trend in latitude of the ice/open-ocean boundary has been to recede northward about 8 km/yr since satellite observations began.

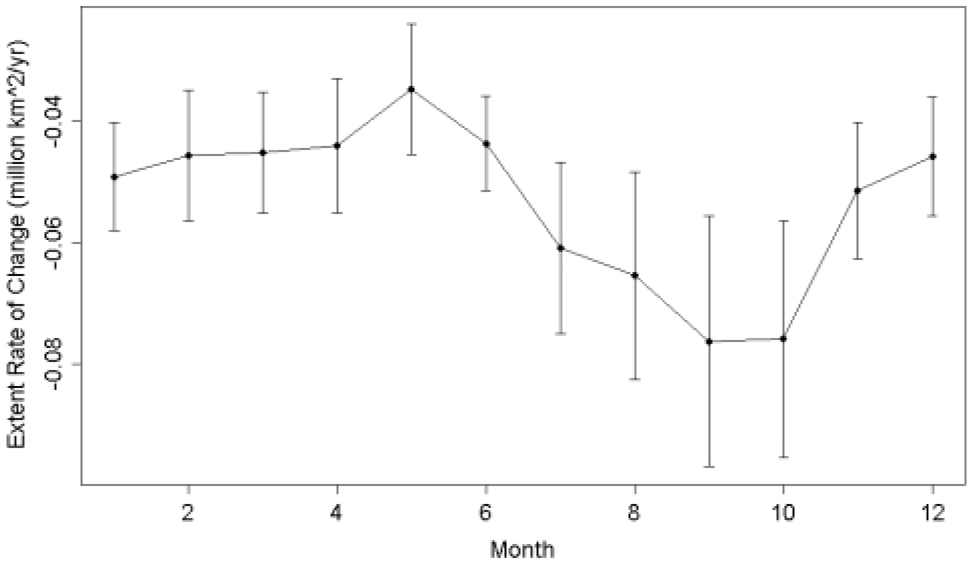
One thing I dislike about Eisenman's analysis is that when analyzing extent, he epresses trends in terms of *percentage* changes rather than absolute (i.e., km^2) changes. This exaggerates the summertime trends compared to winter simply because summer extent is so much lower than winter extent. The difference is not so dramatic when one deals with extent trends in terms of simple areas:



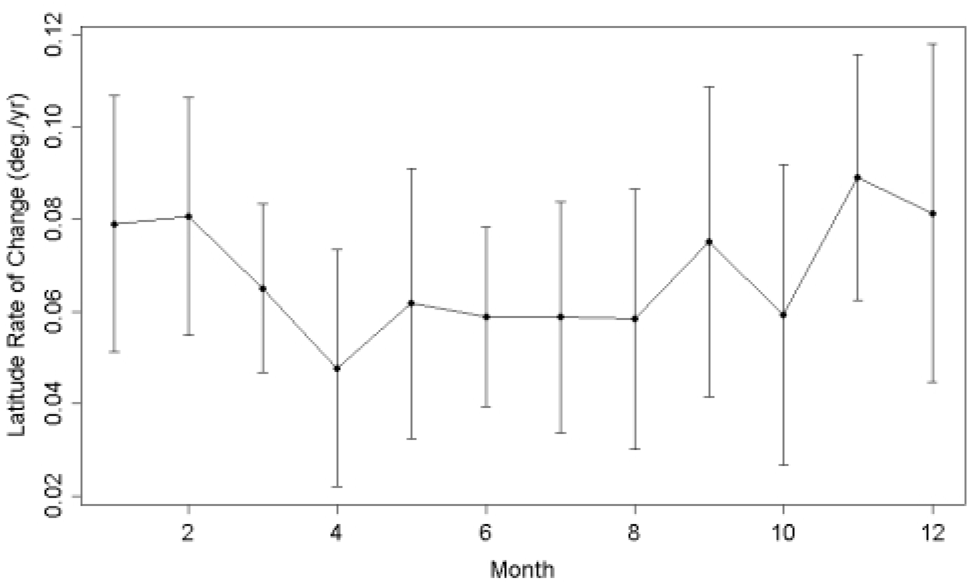
The March anomalies (and trend) are shown in blue, those for September in red (note: the y-axis says the units are “deg” but it should be km^2) But the winter/summer trends, even in terms of area, are still far more different than the winter/summer trends in latitude (again, March in blue and September in red):



Likewise, the rates for all months are not so dramatically different when one deals with extent trends in terms of simple areas rather than percentages:



But again, the monthly trends are *much* more similar in terms of latitude:



In fact, the differences in *latitude* trends between different months are not statistically significant.

Studying the advance and retreat of arctic sea ice in terms of its latitude range rather than area or extent seems to me to make perfect sense, and to compensate for the highly uneven distribution of land mass in the northern hemisphere. In fact it seems to me to be one of those ideas which is obviously the right thing to do — but only **after** someone else has thought of it! My compliments to Eisenman for his insight.

This entry was posted in climate change, Global Warming and tagged Global Warming. Bookmark the permalink.

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21 responses to “On Ice with a Twist”

1. *S2* | August 22, 2010 at 6:54 am |

   It is an interesting approach, but intuitively I think he’s got something wrong.

   Given that the area is (very roughly) πr2, if r is falling linearly then the area should be declining in a parabolic manner, surely?

   I can’t see any evidence for that. Maybe I should go and read the paper, though.

   [*Response: But for small changes in r, when r is not near zero, a parabolic curve is nearly linear.*]

2. *S2* | August 22, 2010 at 7:01 am |

   I guess that WordPress doesn’t like the <sup> tag – it should have been pi r (squared), not πr2.

3. *jyyh* | August 22, 2010 at 7:51 am |

   Interesting paper. Some musings… the wintertime recedence of the ice edge must be a result of greenhouse effect since insolation is having a minimal effect on the conditions there. However I’m not fully convinced of the reasons the summer trend appears to be similar to the wintertime, as the ocean currents and weather patterns have more to say to the conditions. This is because of the sun adds to the energy inherent in the system during summer and produces more unstable weather over the arctic… Now I don’t say these musings on any proven scientific basis, though there might be some meteorological research that has been done over these, so readers take the previous with a grain of salt…

4. *carrot eater* | August 22, 2010 at 3:29 pm |

   I don’t think the idea of geographical constraints is anything new. But I’m not familiar enough with the topic to gauge exactly what insight from this paper is new.

   - *dhogaza* | August 22, 2010 at 5:02 pm |

     No, it’s not, the arctic basin fills every winter and once it’s filled, there are limited places for ice to grow. That’s been mentioned in many places for many years.

     So I imagine it’s the attempt to quantify the effect of geography that’s new, or perhaps the approach towards analysis?

   - *Wayne Johnston* | August 22, 2010 at 5:34 pm |

     The insight would seem to be that there is no seasonal difference in the causes for ice loss. The extent is governed by geographic constraints. The melting is governed by climate warming; the degree of melting is consistent through the seasons. If this holds up, then we have simpler method of measuring ice loss or gain, and can correlate it better with possible causes.

   - *Gareth* | August 22, 2010 at 9:15 pm |

     No, not new. I mentioned it as recently as June, in a slightly different context

5. *William M. Connolley* | August 22, 2010 at 9:51 pm |

   Just to note that the basic idea – of the Arctic ice being geographically limited – certainly isn’t new. It was common currency When I Were A Lad or whatever. But writing it up into a paper may well be new.

6. *Alexander Ač* | August 22, 2010 at 10:37 pm |

   Hello,

   and wot about THIS new paper in Science?

   http://www.sciencemag.org/cgi/content/abstract/329/5994/940

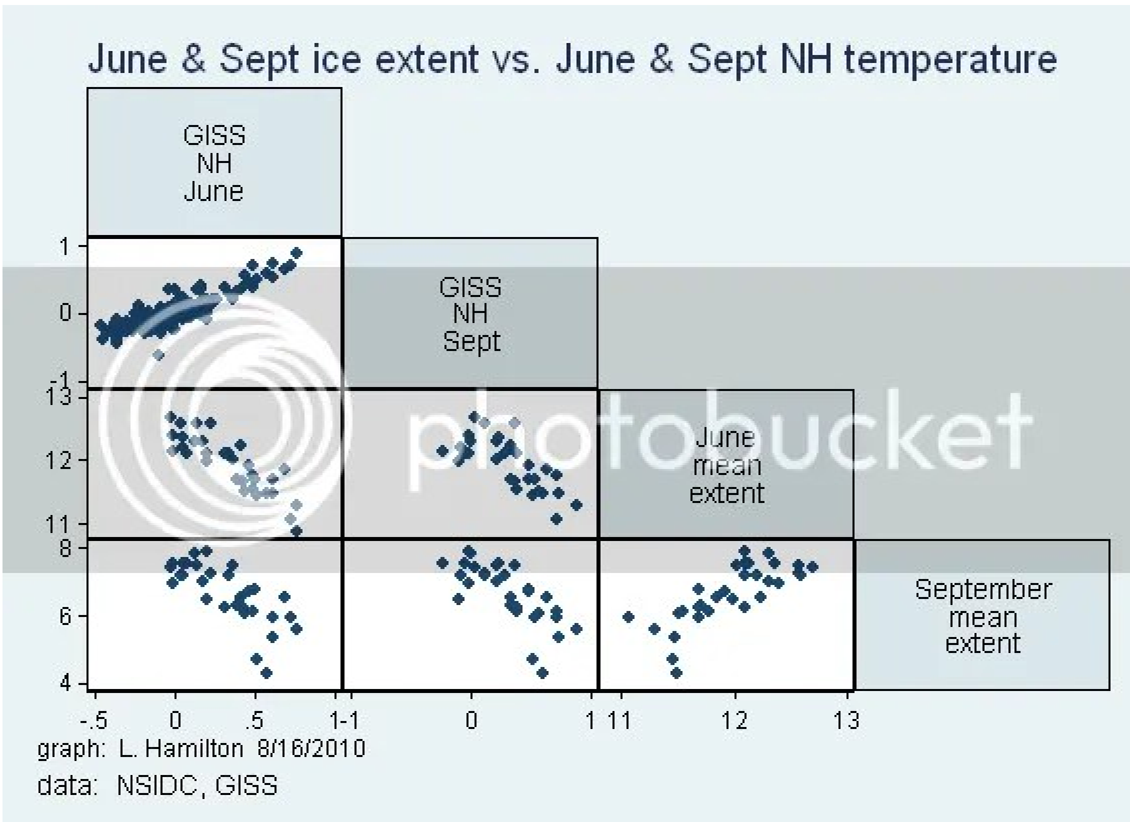
   “Drought-Induced Reduction in Global Terrestrial Net Primary Production from 2000 Through 2009”

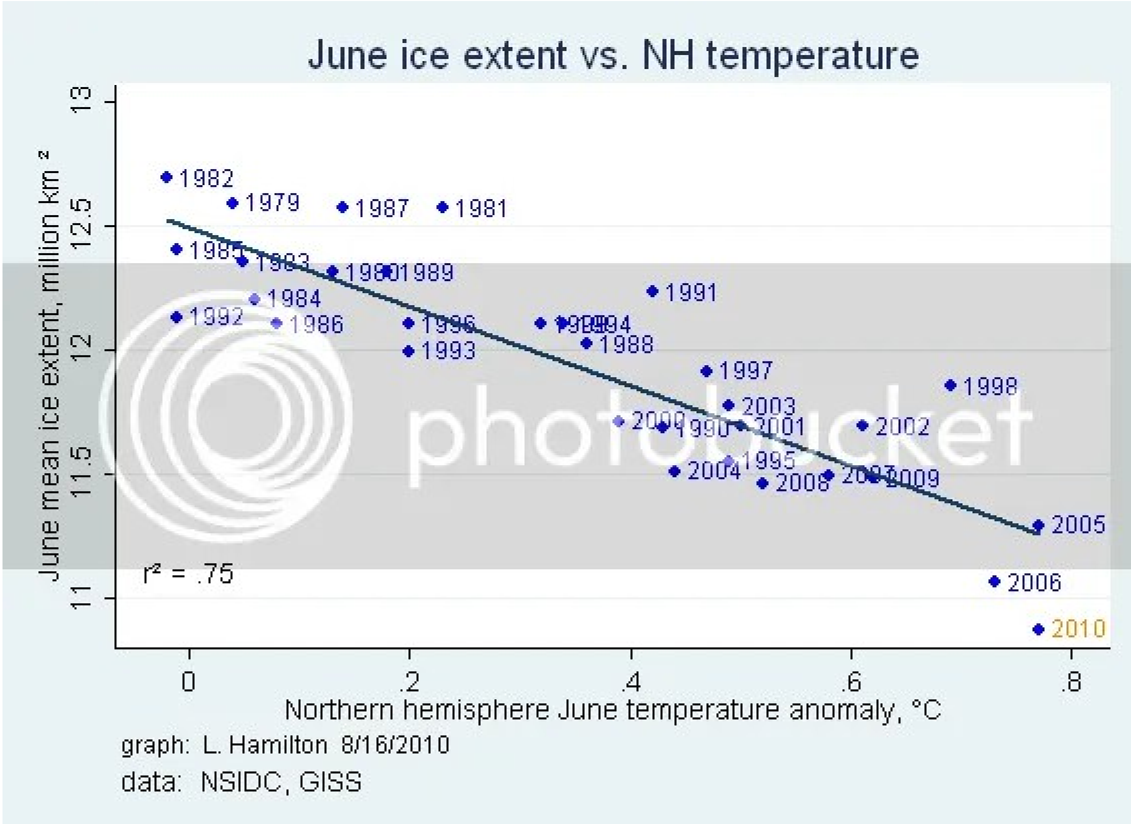
7. *L. Hamilton* | August 22, 2010 at 11:12 pm |

It seems the paper's contribution is introducing a new, observable metric for Arctic ice cover, an alternative to the usual suspects of area and extent.

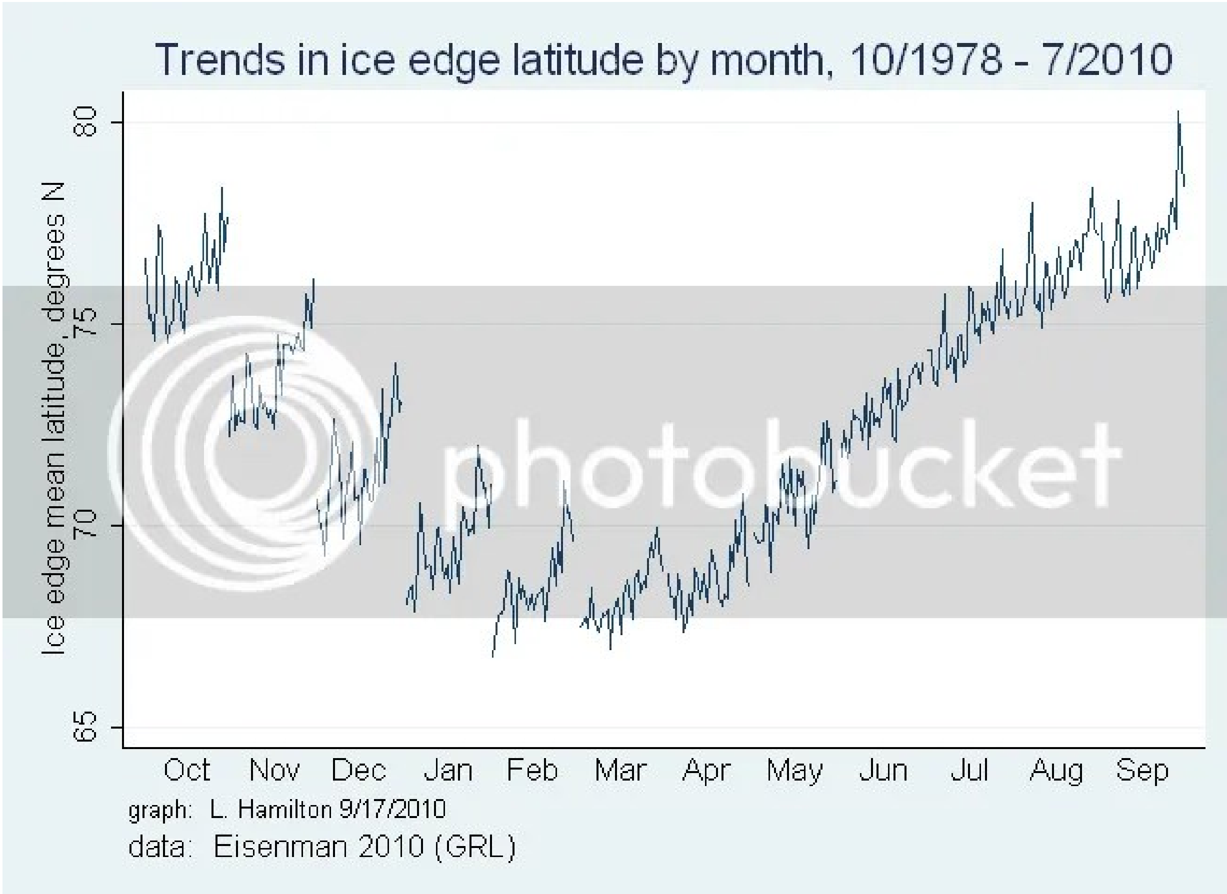
Area and extent have been trending downwards in each month of the year, but most smoothly in June:

June area or extent is surprisingly well predicted (somewhat better than other months) from June's northern hemisphere temperature:

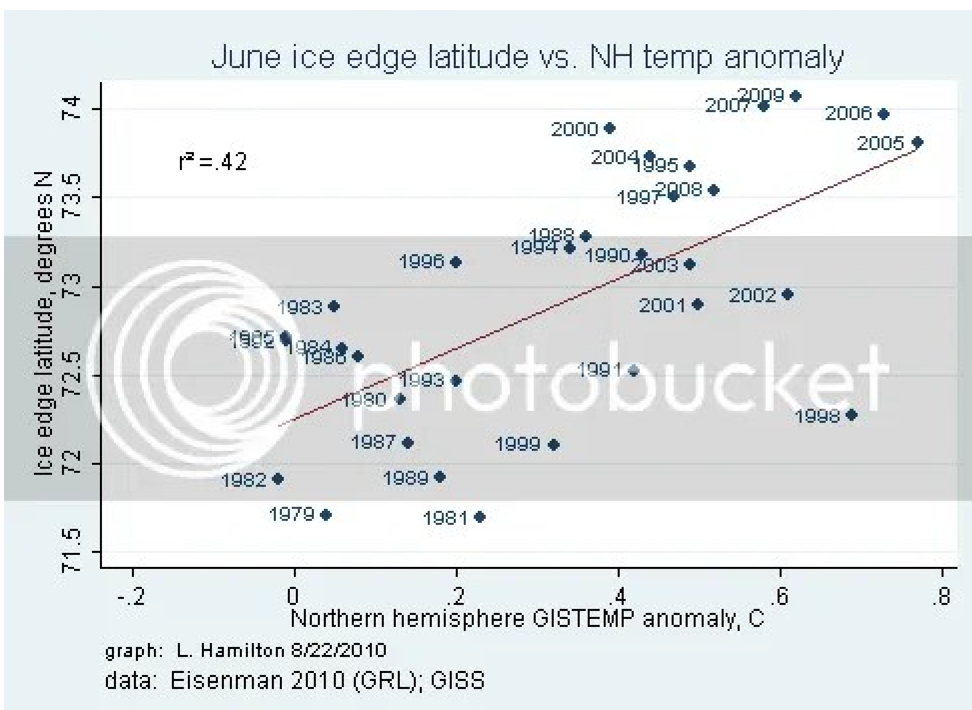




Curious whether the latitude metric would have similar properties, I looked at monthly averages. In ice edge latitude, too, June appears to have a smoother trend than other months:



June NH temperatures also predict June ice edge latitude, but less strongly than they do for June area or extent:



8. *Michael Hauber* | August 22, 2010 at 11:38 pm |

What would be interesting would be to do a similar calculation for the Antarctic ice edge to put the recent growth of Antarctic ice into its proper context.

9. *dhogaza* | August 22, 2010 at 11:54 pm |

> and wot about THIS new paper in Science?

It ain't wot we'd call support for the "CO_2 is plant food, we need more CO_2 in the atmosphere!" argument …

TomG | August 23, 2010 at 3:54 am |

dhog…
Please don't go there.
I've had it up to here with the "CO_2 is plant food" bs.

10. *Robert* | August 23, 2010 at 7:17 am |

Tamino,

Goddard is being himself. Bringing you into it too. Called you a cherry-picker if I believe.

http://wattsupwiththat.com/2010/08/22/picking-carbonated-cherries-in-1975/#comment-464015

11. *GFW* | August 23, 2010 at 5:23 pm |

The linear lattitude-time relation will have to collapse soon. The current relation is about 0.05 angular degrees per year — which would predict that the retreat from 77 deg north to 87 deg north will take 200 years. But I'm thinking 20 years is more likely. (As does the PIOMAS model)

Didactylos | August 23, 2010 at 9:50 pm |

Who said it was linear? Fig 3E says otherwise….

GFW | August 24, 2010 at 5:48 pm |

True. I was reacting to (a) the response to the first comment, and (b) Tamino's figure that is two below Eisenman's fig 3. I'm also not certain where I got 0.05 – it seems 0.07 is closer. Nonetheless, if the PIOMAS predictions for September extent reduction over the next 20 – 30 years are correct, even that parabola in 3E will have to change.

12. *W Scott Lincoln* | August 23, 2010 at 11:23 pm |

"Goddard is being himself. Bringing you into it too. Called you a cherry-picker if I believe."

That isn't all that unusual of a response from someone who just makes stuff up and picks the dates deliberately, without scientific reason, to get the best possible result for the claim he's trying to make. Can't seem to show how his cherry-picked data aligns with anything scientifically realistic in the peer-reviewed literature, because he wont find anything of such to show.
It's quite the defense…. roughly accounting to "takes one to know one."

13. *Hank Roberts* | August 24, 2010 at 3:21 am |

> geographically limited
Not counting the layering of multiyear ice and the ice surges pushing thick sheets of ice up onto coastlines — I wonder how much difference that old multiyear ice used to make? Not much of it left now though.

14.  *mspelto* | August 25, 2010 at 3:42 pm |

I do not find the last line in the abstract a defensible one. Certainly the latitudinal measure as developed here in the limited region it can be applied indicates a somewhat consistent and robust change in sea ice boundaries and has some use. However, sea ice loss is not a simple function of either melting, geography or atmospheric dynamics. Volume nor extent nor latitudinal average will capture all of the important evolutionary changes of an increasingly ice free arctic. The method applied here to spring snow cover extent would be more applicable.

Didactylos | August 25, 2010 at 5:51 pm |

It suggests a change in perspective, not throwing out the baby with the bathwater.

It is clear to me that latitude, as presented here, gives a really surprising perspective on ice conditions. Most of us already knew that sea ice maxima was considerably constrained by geography, but I never suspected that when you subtract the geography, summer and winter are near-identical.

This new measure seems to have much more utility than extent. Concentration and volume, though, are going to remain important.