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The Cryosphere Discussions

Interactive comment on "Recent extreme light sea ice years in the Canadian Arctic Archipelago: 2011 and 2012 eclipse 1998 and 2007" *by* S. E. L. Howell et al.

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This is a nicely structured paper that addresses the drivers of the extreme ice loss in the Canadian Archipelago in recent years. The topic is certainly timely, given the fact that five of the six most extreme minima of ice coverage have occurred in the last six years. In addition, the loss of summer sea ice on a pan-Arctic scale has attracted huge attention, with increased shipping opportunities being seen as a potential opportunity. In this regard, the present paper complements the "look forward" to shipping opportunities in the CAA by Smith and Stephenson (2013, Proc. Nat. Acad. Sci.) – a paper that should be cited here.

The study spans a 45-year period, 1968-2012, which provides temporal context beyond the usual post-1978 period of passive microwave satellite coverage. While the longer timeframe is good for perspective, there have been changes in the available information sources, e.g., the recent availability of RADARSAT, IceSAT, IceBridge, in addition to coverage by satellite passive microwave sensors. The heterogeneity of available information has less impact on the study than could have been the case, however, because the four minimum-ice years of greatest focus have all occurred in the most recent 15 years (1998 onward).

The authors do a commendable job of sorting out the dynamical drivers and the thermodynamic drivers. The computed dynamical transport into (or out of) the key CAA passages is a strength of the paper. However, the paper is somewhat murky (i.e., non-quantitative) about the effect of thermodynamic forcing anomalies. The uncertainty enters through the amount of ice loss that can occur via melt during a summer season. Specifically, how much thickness can be lost by melt in a single melt season? The conventional wisdom seems to have been 1 to 2 meters in the central Arctic, with the greater amounts near in the marginal ice zone. On p. 1328, for example, the authors the authors say that "the imported MYI subsequently melted" in 2012. The MYI thickness in 2012 was 3.7 m, which sounds like a lot of ice to melt. If 3.7 m could melt in 2012, how about the 5.2 m of MYI in 2007? Is there a limit to the thickness that can be lost by melt in one summer? More generally, it would be helpful to address the thermodynamic impacts of the air temperature anomalies reported here. How much additional melt results from a 2°C air temperature anomaly (Fig. 7) over the course of a four-month melt season? (Empirical rules based on thawing-degree days could be used for back-of-the-envelope calculations, although I suppose the picture is complicated by variable amounts of open water and associated heat absorption). In a similar vein, how much additional melt occurs when there is a lengthening of the melt season by a week? A related question is: How does one distinguish loss of MYI by melt from loss of MYI by ice export?

Because of the availability of some information (particularly RADARSAT), there was some subjectivity in the choice of the four "heavy" years. According to p. 1318, 1997 (5th heaviest) and 2004 (6th heaviest) were used instead of 1978 (3rd heaviest) and 1986 (4th heaviest) because the additional information was available for the more recent years. Would the conclusions have been the same if the four "heavy" ice years had been the four heaviest? There is certainly air temperature and sea level pressure (wind) information available for the earlier heavy years.

Figure 2 shows some interesting changes over time in the FYI/MYI area ratio. The ratio has become much larger in June and smaller in September. Is this evolution a manifestation of thinner FYI, in addition to the reduction of MYI area in early summer?

A few additional suggestions:

It would be nice to include a plot of fast ice thickness by year (to accompany the trend values in Table 2).

P. 1329 (lines 19-26): The inferences about inflow and outflow for 1972 and 1979 vis-à-vis the SLP patterns (Fig. 13) seem unclear because the discussion does not include explicit mention of wind directions. It would be helpful to clarify which wind directions create inflow for McLure Strait and the QEI region. Can MYI enter the QEI region from the east as well as the northwest?

P. 1316 (also p. 1335): The more precise statement would be "5 of the 6 lightest years in the CAA since 1968 have occurred in the last 6 years".

p. 1328: Related to my first main point, it seems that pre-existing MYI (not just imported MYI) may also have melted.

P. 1333, lines 13-15: "The only other time period the northern route experienced a longer navigation season was from 1998-2000...". Longer than what? According to Fig. 16, the navigation season lengths of 1998-2000 were not longer than the past several years.

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/7/C419/2013/tcd-7-C419-2013-supplement.pdf

Interactive comment on The Cryosphere Discuss., 7, 1313, 2013.