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Interactive comment on "Fram Strait spring ice export and September Arctic sea ice" *by* M. H. Halvorsen et al.

M. H. Halvorsen et al.

mari.halvorsen@gfi.uib.no

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Dear Anonymous Reviewer #3

We are glad you find the topic interesting and took the time to review our paper. We are also glad you acknowledge that the role sea ice export has played for the recent sea ice area and volume loss is under discussion, and we certainly agree that we need to better quantify the relative importance of thermodynamic versus dynamic processes. We are far from supplying all the answers here, but we hope we supply some new and important information.

There are a number of critical questions in your review. Many of these questions are based in good physical reasoning, and you are obviously well informed about the many

processes ongoing in the Arctic today. Nevertheless there is certain hostility in your writing, and you seem not to have much trust in our results. All these particular questions brought up this quote from Alfred North Whitehead in our minds

"The aims of scientific thought are to see the general in the particular and the eternal in the transitory." In short – you seem to be more interested in the particular details, and on high temporal and spatial resolution, than in the general picture that we try to present. Here are a couple of examples:

1) The calculated ice drift from mSLP (1979 – 2003).

This is a time series you think "could artificially amplify trends, which would influence the validity of the merged time series before 2004." Yet – you also state that you would not be so suspicious if our results were comparable to earlier results (Kwok 2013). Then you say that "the two time series differ most during the recent years where you merged your SAR based ice drift". So – our estimated ice drift from mSLP is not causing the difference, the recent SAR values are, and the whole exercise with the mSLP is not critical. We did mention these similar values already before 2003 (Page 4213, line 26). In the resubmitted version we will have a look into the trends using only mSLP estimated ice drift, and see what it brings.

2) Convergence of sea ice inside the Arctic Basin.

You state that "the authors completely neglect any other area changes caused by ice dynamics like convergence". This is indeed not what we have stated. We state that 30% of the September SIE can be attributed to ice area export variability. The rest, 70%, is caused by other factors, like divergence, radiative change, a higher ocean heat transport etc. We specifically discussed convergence on page 4215 (line 28, onwards). We also state that there are a number of other factors contributing to the 70% on page 4219 (Line 1, onwards). Additionally we apply a fully coupled climate model with decent sea ice rheology. The model simulates convergence and divergence and when a similar response is seen to the ice export, it suggests that changes in ice dynamics

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are not dominating the response. We also acknowledged that change in internal ice stress is a likely or possible effect of the thinning, but noted that the seasonal thickness change would not improve the regression towards the mSLP seasonal cycle (Page 4211, line12, onwards). This is also true for a long-term change; if the ice was moving slower for a similar wind during the 80's the increasing overall trend is larger, not smaller, than our estimate. This is a possibility, and a new paper in TCD seems to indicate that the increase in Fram Strait area transport is larger than what we estimate here. The increase is based on the "standard" passive satellite data at NSIDC: (See Figure 7)

Krumpen et al (2015) Recent summer sea ice thickness surveys in the Fram Strait and associated volume fluxes: http://www.the-cryosphere-discuss.net/9/5171/2015/tcd-9-5171-2015.html

We are happy to cite more papers stating that the convergence is important, two good ones are: Ogi et al (2008) (Summer retreat of Arctic sea ice: Role of summer winds, Geophys. Res. Lett., 35, L24701, doi:10.1029/2008GL035672) or Ogi and Wallace (2012) (The role of summer surface wind anomalies in the summer Arctic sea ice extent in 2010 and 2011, Geophys. Res. Lett., 39, L09704, doi:10.1029/2012GL051330). But this was not the main focus here, and we wanted to focus on the general effect of the export. We are happy also to read and cite the new Kwok (2015) about convergence north of Greenland.

3) The bigger picture – Arctic Natural variability.

You state that we should both cite the IPCC report, and that we should not trust the IPCC models. In our minds is the IPCC report itself not a source of new information, because it draws on other published scientific papers, that should be cited instead. But we certainly acknowledge the efforts of the CMIP5 models, and the global climate models in general. They are our only source for future projections, and although they do not perform perfectly in many areas, they provide a physically consistent system

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that supply valuable insight into both the mean state, natural variability and individual processes. We are well aware that the CMIP models do not capture the increasing speed inside the Arctic Basin (Rampal 2009), and that they overestimate the sea ice area export (Langehaug et al 2013). Anyway - over 1000 papers have now been published using CMIP5 simulations (http://cmip.llnl.gov/cmip5/publications/allpublications), mMany published papers onof them discussing Arctic sea ice processeschanges have used CMIP models, so they clearly have value despite not simulating nature perfectly. The GFDL model has great value because it has a reasonable mean state, and such a large number of simulated years available. A relationship that appears over 3600 years is certainly not a coincident, and there is no problem to calculate trends and correlations with 99% confidence. For 30 years of observations that is quite different, as we all know. The model greatly strengthens our confidence in the proposed relations, and provides a good basis for claiming that the increased ice export we have seen the last decade can be viewed as natural climate variability.

4) Figure 1- the sea ice speed.

You state that Figure 1 gives the wrong impression of ice area transport, because there is "basically no export east of 0°. First we have confidence in our audience, this is a scientific journal, and we think that the reader knows that area transport is the product of ice area and ice speed. In addition there is ice as far east as 5°E. While it is correct that the export mostly occurs between 1°E-11°W (>2% of the export, see Smedsrud et al 2011, Figure 7), there is about 40% sea ice concentration at 0°, decreasing to about 5% at 5°E, even in summer (Smedsrud et al 2011, Figure 1). All these numbers are NSIDC concentrations that you seem to think that we would not like to use.

We will answer the more detailed questions when we have prepared our new version of the paper and are ready to re-submit.

Best regards Lars H. Smedsrud, Mari H. Halvorsen, Rong Zhang and Kjell Kloster

Interactive comment on The Cryosphere Discuss., 9, 4205, 2015.