

## ***Interactive comment on “Atmospheric influences on the anomalous 2016 Antarctic sea ice decay” by Elisabeth Schlosser et al.***

### **Anonymous Referee #1**

Received and published: 6 November 2017

This paper discusses the atmospheric influences in the anomalously large variation of Antarctic sea ice observed in 2016. It claims that the early and large retreat of Antarctic sea ice was the result of atmospheric flow patterns, predominantly related to a zonal-wave three pattern until October 2016. Thereafter an atmospheric meridional flow during November, consistent with a negative SAM index, resulted in a "large meridional exchange of heat and moisture". It is generally well written with some nice analysis, although there are a number of missing references and citation errors.

The paper is quite descriptive. There is no direct objective analysis of atmospheric heat or moisture and no analysis discounting the influence of ocean surface temperatures playing their role in the 2016 event (as mentioned in line 127 regarding the paper by Stuecker). The analysis of zonal-wave three and SAM is similarly rather descriptive

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and not conclusive. Without an objective analysis I would unfortunately suggest that the paper's claims are not substantiated. That said, I would encourage the authors to complete further analysis and resubmit the paper. More detailed discussion is included below.

Line 23 (and Line 59): "when combined with reduced Arctic SIE" – I don't think this is shown or referenced in the text at all, it just seems to be stated as a fact without proof.

Line 30: It might pay to be cautious in referring to the November 2016 SIE as "extraordinary". The relevance of the apparent sudden variability in net SIE (2014-2016) and the record low monthly SIC for November should perhaps be placed into context with longer term variability (eg the past variability of SIE as shown in Hobbs et al 2016 and Jones et al 2016) in comparison to the relative short period of observations examined within this current paper. Would "...unprecedented low November SIE, based on the post 1979 satellite data." be more appropriate?

Line 51f: "reaching record extents in 2013, 2014 and 2015. . ." This should be "reaching record extents in 2012, 2013 and 2014. . .", and perhaps cite Reid and Massom, 2015 which covers all of 2012 through 2014.

Line 75: Please insert reference for Su 2017.

Line 81f: Please insert reference for Lee et al 2017.

Line 92: "Haumann , 2011" should be "Haumann, 2011".

Line 92: Note that Holland and Kwok's excellent study covers the relationship between wind and SIC trends for the period 1992-2010 and may not necessarily be extrapolated upon without caution. See Kwok et al 2017 for example – as referenced below.

Line 102: Is the term "Usually" based on data since 1979 and your Figure 1? If so then perhaps this should be stated, otherwise please cite some research showing this.

Line 124f: The sentence beginning with "Ross Sea and West. . ." probably needs rewrit-

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ing.

Line 127ff: It probably should be noted that apart from Stuecker 2017, several BAMS State of the Climate sections mention 2016 Antarctic sea ice, please see the references below. In particular, Clem et al decomposes the atmospheric component, while Mazloff et al mention the ocean influence and Reid et al discuss the sea ice in general.

Line 182f: This sentence probably needs rewriting. Paragraph beginning at Line 243: Some of this paragraph confused me. There is mention of, for example, SIE in some regions being close to the long-term average – please see below for direct examples. I think perhaps you are confusing SIE with latitudinal extent, or otherwise could you please make this clearer.

Line 249f: "...with negative anomalies..." – negative anomalies of what?

Line 249f: "Largest negative anomalies". What is this a reference to: SIC, SIA, SIE or latitudinal extent? Note that SIE, as you have defined it, and latitudinal extent are two different things. If this is a reference to SIC or latitudinal extent (the contours on Figure 3?) then perhaps there should be reference to Figure 3a? If this is in reference to SIA or SIE then perhaps this should be shown in another way.

Line 251ff: The sentence beginning "In the Western..." should perhaps be rewritten. There is also some apparent confusion between what is showing "negative deviations" at approximately 130E and SIE – at least I'm confused!

Line 252: "approximately130" should be "approximately 130" – please insert a space.

Line 256: perhaps this should read, "However, in February 2017 the monthly mean SIA..." as otherwise this is a little ambiguous.

Line 267: "Hall and Visbeck should be 2002, not 2001?"

Line 276ff: Other research (Clem et al 2017) has suggested that the SIC anomalies in this region are not necessarily related to atmospheric flow, and that they are re-

lated more to weaker ocean stratification and deeper convection over Maud Rise. The opening of the polynya in this region during August 2016 caused quite a bit of media attention.

Line 307: "This is shown in Figure 6e. . ." should probably be referring to Figure 4e?

Paragraph beginning at Line 314: There is a concluding summary here for section 3.2.1 that is not reflected directly by the analysis, and revolves around the words "strong warm air advection". Not once through the paper is atmospheric temperature directly analysed. There is some nice analysis and discussion within this paper, but much of the analysis that leads to this conclusion is descriptive rather than an objective analysis. Also, a number of papers (and you have cited one) have suggested that the 2016 Antarctic sea ice anomalies were possibly the result of a combination of atmosphere and ocean anomalies. Here you are suggesting the anomalies were the result of a warm atmosphere only, and I don't feel that you have directly shown this. You have not discounted the ocean impacts or objectively shown that a warm atmosphere specifically was responsible for the SIC anomalies. Given your concluding remarks and such a large anomaly in net SIE, surely you would be able to show that there was a large atmospheric temperature anomaly – or ocean surface anomaly?

Line 330: The sentence beginning, "The start of the melt period. . ." probably needs rewriting.

Line 335ff: From Figure 5u it would appear that R7 contributes significantly to the sea ice decay – in contrast to what is said here.

Line 348ff: From, "It shows generally good agreement. ..". Again, this is based on some quite subjective analysis.

Paragraph starting on Line 358: There is discussion here about the first third of the month of November being significant, and there is reference to Figure 4e. But there is no corresponding pattern of sea ice drift for this time period.

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Line 361: "...leading to compaction..." and "...decreasing SIC" are not really consistent. Should you split this discussion into something like and inner and outer ice pack?

Line 374ff: ZW3 plots are given for the years 2013-2016, but with no real explanation as to why these years were chosen. ZW3 is put into perspective with the preceding three years, but there is no suggestion here that an August-October averaged ZW3 index of  $\sim 0.4$  is significant or not. Is this ZW3 value 1, 2 or 3 standard deviations above normal for this time of the year, has it ever happened before and if so what was the consequence on the sea ice? Indeed, it would appear that for August 2014 the ZW3 was considerably well above that of 2016. In fact, looking at Raphael 2004 it would appear that there are long periods of positive ZW3, but there is no mention of the corresponding SIE, SIC for these years.

Line 444: Please reference Schlosser 2015, or should this be Schlosser 2016?

Line 510: There is no citation of Hobbs et al. Please remove or cite within text.

Line 517: There is no citation of Kottmeier and Sellmann 1996. Please remove or cite.

Line 545: Please remove or cite Peng et al.

Line 557: Please remove or cite Schlosser 1988.

Line 566ff: Please remove or cite both Simmonds papers.

Line 576ff: Note that Turner et al 2009 has been referenced twice – please remove one.

Line 581ff: Note that Turner et al 2014 should be Turner et al 2015.

General comments: Is the term Mio, used throughout the text in reference to "million", suitable for this Journal?

I suspect that within the text there are some instances where reference to Figure 3 and

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Figure 4 get confused, or that perhaps that there should be reference to both Figures 3 and 4? For example, Lines 269, 281 and 291 discuss SIC anomalies but both times there are references to the figure showing MSLP (Figure 4).

"Figure" and "Fig" seem to be variously used through the text. Chose one of these that is appropriate for this Journal and be consistent through the text.

Table 1: There appear to be some discrepancies in the longitudes within this table.

Figure 3: What do the coloured contours represent on these figures?

Figure 4: I have some concerns with this figure. Are the arrows hand drawn and coloured – there is no mention in the text or in the figure caption as to how they are derived? They look rather subjective than objective.

Figure 7b: There is no mention of the hatching in this figure.

Suggested References:

Clem, K.R., S. Barreira, and R.L. Fogt, 2017: Atmospheric Circulation [in “State of the Climate in 2016”]. Bull. Amer. Meteor. Soc., 98 (8), S156–S158

Jones et al, 2016 Assessing recent trends in high-latitude Southern Hemisphere surface climate. Nature Climate Change 6, 917–926 (2016)

Kwok, R, et al 2017 Sea ice drift in the Southern Ocean: Regional patterns, variability, and trends. Elem Sci Anth, 5: 32, DOI: <https://doi.org/10.1525/elementa.226>

Mazloff, M.R., Sallée, J.B., Menezes V.V., Macdonald A.M., Meredith, M., Newman, L., Pellichero V., Roquet F., Swart, S., Wahlin, A., 2017, State of the Southern Ocean in 2016, BAMS, 98 (8), S166-S167

Reid, P. & Massom, R. in State of the Climate in 2014 (ed. Blunden, J. & Arndt, D. S.) Spec. Suppl. Bull. .Am. Meteorol. Soc. 96, S163–S164 (2015).

Reid, P., S. Stammerjohn, R. A. Massom, J. L. Lieser, S. Barreira, and T. Scambos,

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2017: Sea ice extent, concentration, and seasonality [in “State of the Climate in 2016”].  
Bull. Amer. Meteor. Soc., 98 (8), S163–S166

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2017-192>, 2017.

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