“Seasonal and interannual variability of landfast sea ice in Atka Bay, Weddell Sea, Antarctica” by Stefanie Arndt et al.

Response to Anonymous Referee #2

Received and published: 16 March 2020

The paper summarizes a decade of annual in-situ fast-ice observations in Atka Bay, which is the longest and most continuous time series within the Antarctic Fast Ice Network (AFIN).

The main dataset is a semi-continuous record of fast-ice thickness, snow depth, freeboard, and sub-ice platelet layer thickness that was collected by overwintering teams between 2010 and 2018. In addition to determining the spatio-temporal variability of the fast-ice cover, this data is co-analyzed with meteorological and oceanographic observations in order to determine how snow and platelet ice influence the local fast-ice mass budget.

The discussion at l, 47 p.20 starts with: “In contrast, the relatively thick snow layer on the fast ice in Atka Bay prevents a significant light input to the sea-ice bottom and thus additional biomass production.” This statement is speculative considering the absence of light measurements and associated biological production under the fast ice reported in this study. There is no basis for assuming that the snow cover leads to reduced light and effects on the biological production without specific knowledge of either the light field or the particular organisms that may be, for example, highly shade adapted. Further speculation in subsequent lines that cracks and leads and distance from the ice edge presumes another effect, the increasing light level on the ecosystem. While light may be one component of the algal development in platelet ice, the exchange of seawater with nutrient loads may be even more important for example. As these statements are clearly outside the scope and measurements reported here, I recommend this discussion be deleted.
#The reviewer is correct. We are (obviously) no experts on fast-ice biology, and this is actually exactly the reason we brought aspect this up. The point we wanted to make here is just that there are still so many knowledge gaps with respect to the linkages between the physical platelet-layer system (and fast ice in general) and the uniquely adapted ecosystem, and that these can only be addressed by a multi-disciplinary approach in a handful of accessible ice-shelf influenced fast ice locations. While this has been achieved to some degree in McMurdo Sound in the past decades, the authors have been working towards such an integrative research program in Atka Bay for years, but it is quite hard to get the different groups together and the necessary funding. This paper can be considered as a description of the physical system (which the reviewer also recognized in his statement above), and it should be complemented by an ecosystem study (which is currently not happening unfortunately).

In order to make this intent more clear, we would really like to keep this aspect and changed this paragraph to read

“4.4 Implications for multi-disciplinary research

Such a multi-layered, thick ice cover not only very efficiently separates the atmosphere from the ocean with respect to ice growth, but it also influences the exchange of any fluxes between the two climate system components. Thereby, it also strongly impacts the ice-associated ecosystem, which is particularly unique in sub-ice platelet layers (Arrigo, 2014). From Günther and Dieckmann (1999) it is known that about 99% of the (substantial) total fast-ice biomass in Atka Bay originates from algae being attached to the platelets that congealed to the fast-ice bottom. This is particularly interesting because a thick snow layer as present on the fast ice in Atka Bay prevents a significant light input to the sea ice – ocean

interface, and is usually expected to limit biomass production. While a few studies exist that investigate shade-adaptation in algae and link algal growth to snow depth on McMurdo Sound fast ice (e.g. Sullivan et al., 1985; McGrath Grossi et al., 1987; Robinson et al., 1995), so far still comparably little is known about the adaptation of the ecosystem in the upper ocean to perennial fast-ice conditions and sub-ice platelet layers. These and similar knowledge gaps that exist with respect to ice-shelf influenced fast-ice regimes can only be addressed by integrated, multi-disciplinary research in comparably easy to access locations in coastal Antarctica, one of which was introduced in this study."

In general, the paper represents a good description of the fast ice features within Atka Bay although lacking some important considerations of the work in McMurdo Sound that the other reviewer has provided more details on. With some modification as outlined here and there, I recommend the paper be published.
#We hope that we were able to address all the comments and concerns of the other reviewer to his/her satisfaction. We also hope that these modifications will also be acceptable to this reviewer.

Specific Comments

l.27 Replace images with image
#changed as suggested

l. 92 change "today" to 2018/2019 (here and elsewhere)
#has been changed to read "in particular covering the sea-ice study period from 2010/2011 onwards, and continuing beyond the end of the study period".
Another instance was changed to "so far".

l. 95 delete "a"
#changed as suggested

l.:83 6.2 5m sounds off compared to surrounding values. Is it
0.625 m instead? (See Fig 4 for ATKA11)
#While you are right that this value seems off, this is what was reported by the team in the field. Of course it could be some sort of measurement error, but we do not want to just remove it from the data at this point. This part was modified to read: „The maximum decrease of 6.25 m per month occurred at ATKA11 in 2013 (80th percentile). However, it is highly likely that this is a measurement error."

l.:88-89 sounds confusing: in summer showing sea ice growth rates increasing, or should it be decreasing?
#this has also been mentioned by reviewer 1 and was clarified.

l.05 (105 pg.15?) should decrease be decreases?
#changed as suggested

p.19 l.31 change plate to platelet?
#changed to "platelet layer"

p.20 l.47 change concealed to congealed
#changed as suggested

p.20 l-47-54
Heavy algal formation in platelet ice also observed in McMurdo Sound, many km from the light sources mentioned here(ice edge, cracks etc), so organisms may be instead

very shade adapted. The strong accumulations also suggest continuous supply of nutrients into the platelet layer so the processes of convective overturning (possibly tidal forcing also) may be responsible for the high algal growth rates in the platelet layer. Experiments by Sullivan and colleagues with varying depths of snow artificially placed on or removed from the ice surface showed that growth proceeded best with an optimal snow depth, rather than no snow. Probably delete this discussion since it is not supported by measurements or adequate referencing

#The reviewer is right. The intent was not to provide wild speculations, but rather to highlight the need for a multi-disciplinary research program beyond McMurdo Sound (see above answer).