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Interactive comment on "Ice-dynamic projections of the Greenland ice sheet in response to atmospheric and oceanic warming" *by* J. J. Fürst et al.

Anonymous Referee #1

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General comments The paper uses numerical modelling to assess the relative contributions of surface mass balance change and accelerated discharge from marine-terminating outlet glaciers to Greenland ice loss during the next three centuries. Overall the paper is interesting and makes a good contribution. However, a couple of elements of the methodology need explaining in more detail, particularly the section linking ice velocities and oceanic forcing. There are a number of small errors in grammar / syntax that should be addressed. I give my detailed comments below.

Specific comments Abstract Line2: specify dates Line 9: What about other potential controls on ice discharge, e.g. hydrofracture causing an increase in calving or loss of sea ice? Line12: Why use only the low emissions scenarios for the longer runs? The

introduction seems unnecessarily long and gives a lot of detail for each example, although the examples themselves are relevant. I suggest restructuring around the idea of oceanic forcing being important (which is the main point), so that the argument is more tightly focused and uses the examples more effectively. P 3853 Line 15: Contradicts the previous sentence. P 3853 Line 19: Add Carr et al 2013. P 3854 Line 13-17 & 25: Needs referencing. P 3854 Line 26: There is only evidence that the water can overtop sills and a few Greenland glaciers (the Straneo paper looks at 6). This implies it over tops all around Greenland, so please re-phrase. P 3854 Line 28: Indicate how the melange cover can impact on glacier retreat/calving. P 3858 Line 13: How were they adjusted? P 3858: Line 21: Peak melt water doesn't necessarily mean peak ice velocities (Schoof, 2010; Sundal et al., 2011; Vieli et al., 2004). Also, the Rignot et al., 2010 paper focuses on submarine melting, rather than seasonal velocities, so I suggest using another reference. P 3859 Line23 & p3860 line 24: How representative are these values for the rest of the ice sheet and how much does the choice of these parameters effect your results? P 3860: Line 15: Why not include these in the calculation of the parameter values? P 3861 Line 1-11: This approach seems a substantial over simplification of the relationship between ocean melt and glacier velocities. First, there is very large variability in the response of individual glaciers to oceanic forcing within each region, which is likely due to localised topography, so we cannot assume that glaciers will respond to future ocean forcing in the same way as they have done in the past (e.g. if they are now on the far side of an overdeepening). It assumes that all changes in velocity are ocean driven and proportional to the forcing applied, which is not necessarily the case. Looking at the south-east in particular, the speed up between 2000-10 consists of acceleration, followed by deceleration, so looking at a decadal scale response could disguise important detail. I also do not understand how / why these are scaled to the entire ice sheet: is the assumption that all areas of the ice sheet respond to ocean temperatures in the same way? To take an extreme example, we cannot say that northern Greenland glaciers (with extensive floating tongues) will respond in the same way as south-western Greenland glaciers. I think this section

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needs better explanation and justification. P 3862 Line 1: Has this distance been used in other modelling studies, e.g. further south on GrIS? P 3863 Line 5: Why were these parameter ranges selected? P 3865 Line 7: Do you see spatial patterns in precipitation, as well as temperature? P 3865 Line 15 onwards: needs references and could be explained more easily by adding these currents and water body names to Fig 4. P 3866 Line 3-6: How representative are these offshore ocean temperatures of what is happening at the glacier front? Is there sufficiently detailed bathymetric data available to identify sills that might block warmer water from entering glacier fjords? Also, how valid is it to use lines of latitude as boundaries for your oceanic units? E.g. using a divider at 70 N means that glaciers located up to $\sim$ 3 degrees north of the Denmark Strait are included in the south-east region. However, it is unlikely that warm water from the Irminger Sea will penetrate this far north and will be much less prevalent than on the south-east coast of Greenland. P 3866 Line 10: How much does your choice of depth averaging influence your results? P 3867 Line 9: Can you quantify 'fairly well'? Some areas look quite different, e.g. north east Greenland. P 3870 Line 12: Why use the two lowest scenarios? Why not do the highest ones as well?

Technical corrections There are a number of minor errors in grammar / syntax and placing of brackets around references throughout the paper, but particularly in the earlier sections. I have highlighted some here, but it would benefit from a detailed proof read. Throughout the paper, 'but' is used at the start of certain sentences. Although this is not technically incorrect, it looks colloquial, so please change. Abstract Line 5: 'with a relative contribution of 40 and 60% respectively'. Line 13: This sentence has grammatical errors and is hard to follow.

P 3853 Line 9: In>During P 3854 Line 18: Petermann Glacier (delete 'the') P 3854 Line 24: with>of P 3856: Line 17: 'Here we include more. . .' P 3856: Line 19: 'with the aim of better assessing. . .' P 3856: Line 20: (RCP) (Moss et al., 2010). P3857 Line 1-3: The model evaluation in the recent past. . .... and the sea level projections for the Greenland ice sheet are presented in Section 5'. P3857Line 19: delete 'representative'. P 3858:

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Line 21: on>of P 3859: Line 2: ‘the annual increase in sliding, relative to the winter reference’. P 3859: Line 13: is preferred> develops. P 3860: Line 2: beyond>above P 3860: Line 7: ‘the mass balance model used here’ P 3862 Line 11: In order to initialise to the... P 3862 Line 13: ....regional surface temperatures, precipitation and sea level. P 3862 Line 14: Although the general approach is unchanged [unchanged from what?].... (Appendix A). P 3863 Line 9: separate these criteria using semicolons for clarity. P 3864 Line 4: as is often done> as in previous studies. P 3864 Line 16: ...to avoid any potential bias associated with the mean states.... P 3864 Line 21: precipitations>precipitation. P 3865 Line 5: For a given latitude, the difference in warming between the east and west of the ice sheet depends strongly on the individual AOGCM. P 3865 Line 14: inspired> based on / determined from P 3869 Line 21: Combine this and the previous sentence and alter to ‘but the AR5 is the first to attempt to quantify....’ P 3869 Line 24: ‘...suffers from including multiple studies that do not have forcing factors or setups that are directly comparable when..... P 3870 Line 8-9: twice as high as other RCPs. P 3870 Line 24: For runs extending to both 210 and 2300, the sensitivity.... P 3871 Line 7: This comprises both directly induced.... P 3872 Line 26: this is because many of the smaller glaciers...

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