

Interactive comment on “Climate change threatens archeologically significant ice patches: insights into their age, internal structure, mass balance and climate sensitivity” by R. S. Ødegård et al.

Anonymous Referee #1

Received and published: 3 July 2016

This paper provides an interesting analysis of the physical characteristics and recent mass balance of an ice patch in northern Norway, and provides information about a topic which has been little investigated in the past. The results are certainly interesting, but the paper is currently quite simplistic and underdeveloped compared to the rich datasets that are available for analysis. The paper basically lists the different characteristics of the ice patch, but does little to integrate them and to really explore the different processes that might be driving its temporal and spatial changes. For example, wind is stated to be an important factor in the ice patch development, but no proper analysis of the wind dataset and its connections to air temperatures and surface melt rates is

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made. Similarly, no calculations are made of likely internal deformation rates for the observed ice thicknesses and surface slope. There is a considerable glaciological literature that could help with these kinds of calculations, but this is little referenced at the moment. These kinds of analyses could lift the paper from its current simplistic form to one that could really provide useful long-term insights into the factors that control ice patch growth and decline.

There is considerable duplication between the latter sections, with the Conclusions basically just providing a bulleted list of what's already been said in the Discussion and Results. The paper would also benefit from a thorough read by a native English speaker; there are currently many (generally minor) typos and language issues, some of which I detail below, but several others that I don't. Finally, several of the figures and tables could do with improvement, as detailed below.

Here are a list of comments by line number:

P2, L20: for a reader who may be unfamiliar with Otzi, please indicate where he was found

P3, L6: it would be good to add some more details about the finds at other ice patches around the world, such as the clothing associated with Otzi, spears in Yukon ice patches, etc.

P3, L13: 'differed' should be 'differentiated'

P3, L18: to help with the differentiation between glaciers and ice patches it would be useful to specify the ice thickness needed to cause ice motion (i.e., ~40 m according to most textbooks)

P4, L6: change 'was excavated' to 'were excavated'. Also need to specify where the ice patch was that was investigated: from this para it's not even obvious that it's in Norway!

P4, L29: it would be useful to state what the ELA is on the nearby glaciers

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P5, L6 (and elsewhere): there should be a space after every semi-colon. At the moment the references run into each other due to this space being missing.

P5, L19: where exactly 'in the area' were these boreholes and air temp measurements installed? I also think that you mean 'temperature sensors' rather than 'temperature measurements'

P6, L9: change 'Totally' to 'A total of'

P6, L11: please provide more information about these measurements: e.g., what was the flight altitude above the ground, what was the name of the instrument, what data was used for positioning?

P6, L18/19: some words are missing from this sentence: I think that you need to say 'were made following standard...'

P7, L1: please provide information on how the GNSS data was processed (e.g., using a base station, using precise point positioning?)

P7, L6: please add a label to Fig. 2 to show the location of this station

P7, L18: delete extra bracket from end of this sentence

P7, L22: it would be useful to provide some information about how the tunnels were excavated. E.g., using chainsaws? Did the excavation cause any disturbance to the surrounding ice?

P9, L5: later in the paper (P15, L8) you say that 'there are several organic/debris layers' observed within the ice tunnels. These seem to be just as likely, or perhaps more likely, to explain the layering observed in the GPR profiles.

P10, L14: this sentence makes it sound as if the ice patch almost doubled in size between 2014 and 2015 (0.101 to 0.186 km²), but based on the presence of an asterisk in Table 1 it appears that this growth was entirely due to the presence of temporary snow rather than ice. This should be made clearer in the text, and I don't believe that

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it's fair to include temporary snow in the calculation of the ice patch area.

P10, L27: please state here as to what defines a 'strong breeze', and how that value was chosen

P11, L1: change 'peaks out' to 'stands out'

P11, L3-L6: there is no data presented to back up the statements in this para, so either the para should be deleted or the data should be provided.

P11, L13: I haven't heard the term abrasion used much in relation to snow events; 'wind scouring' is a more commonly used term, and would seem to be a better descriptor here.

P11, L13: change 'not take' to 'don't take'

P12, L1-4: please indicate the depth of the winter cold wave. Also please explain why the heat flow into the ice would gradually decrease during the melt season. And approximately how much superimposed ice forms each year?

P13, L1: change 'obtained results' to 'results obtained'

P13, L19: it's not clear from the text as to why 'increased accumulation towards the front of the ice patch... is probably a response to increased melt'. Please explain.

P13, L26-29: please provide information to back up these statements. You have the wind, temperature and ablation data, so you need to provide specific data that shows the patterns that you are arguing for.

P14, L1-3: if you make comparisons with recent major Greenland melt events you have to persuade the reader that the same conditions prevail at Juvfonne as they did in Greenland, but this isn't done at the moment.

P14, L8-9: delete 'One'. Also provide the specific date that you're referring to in this sentence (I presume that it's the storm that occurred around Feb. 5 in Fig. 11?)

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P14, L10: I'm unclear as to what event you're referring to here. Please provide a specific date so that it can be connected to the patterns shown in Fig. 11

P14, L23-24: if you say that the ice patches have a similar thermal regime to nearby glaciers, then please describe what the thermal regime of the nearby glaciers actually is

P14, L29: state the ice thickness used to determine this basal shear stress

P15: L1-3: please provide reference to previously published studies that indicate the shear stress required for ice deformation to occur. There are several laboratory studies that have investigated this, so this could provide insight into the likely amount of deformation that is currently occurring, and that occurred in the past.

P15, L5: change 'theses layer' to 'these layers'

P15, L13-L16: I don't understand what the point of this para is. What are you trying to say?

P15, L21: I don't understand what 'environmental treats' are. Please define.

P16, L5: it would be good if this photo could be incorporated into this study, as it would really help to extend the timeline provided in Table 1

P17, L16: delete 'One'

Table 2: this table is poorly organized and difficult to follow, with inconsistent placing of columns between different part of the table. For example, some parts of the table have a 'Comments' column, others have a 'Dated material' column, while others have neither of these. Some sample ages are only given with 1 sigma, others are with 2 sigma. Some ages are given in relation to 1950, others are BCE. The table needs completely reworking and tidying up to make it consistent throughout.

Table 3: I don't see the value in including this table. For the (limited) information it provides it seems that it could just be incorporated into the text

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Table 4: this table makes little sense by itself as from the caption it's not even possible to know what it relates to, and none of the data given in the table are really described or evaluated in the text. It should either be deleted or better described and better integrated into the manuscript.

Figure 1: this map is pretty poor quality and is missing basic information such as a scale or elevations. If you can't find better quality vector data it would be better to use something like a Landsat 8 image for the base map.

Figure 2: provide date of photo, and the direction in which the photo was taken. Also add labels to show where the P30 and P31 boreholes are located.

Figure 3: this figure needs a scale bar. Also change 'ortofoto' to 'orthophoto' in caption Figure 6/7 (and check elsewhere): use a, b, etc. to label figure parts rather than terms such as upper, lower, left and right

Figure 8: the base of the bars for 2010 and 2013 are cut off, so it's not clear what the bs values are for these years

Figures 12/13: it's very difficult to distinguish between the black lines then they cross each other. Please use a different colour (or different shade of the same colour) for each line.

Figure 14: very nice picture!

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