Review of: "The importance of accurate glacier albedo for estimates of surface mass balance on Vatnajökull: Evaluating the surface energy budget in a Regional Climate Model with automatic weather station observations ", by *L. Steffensen Schmidt et al.*, submitted to *The Cryosphere*.

General comments

This manuscript is a sound evaluation of the surface mass balance (SMB) and energy balance (SEB) simulated by the regional climate model HIRHAM5 over Vatnajökull ice cap, Iceland. Here HIRHAM5 is run at 5.5 km resolution for the period 1981-2014, using an updated albedo scheme that calculates snow albedo as a function of surface temperature and snow ageing, and prescribes ice albedo from MODIS records. Comparison of HIRHAM5 output with SMB measurements (1995-2014), meteorological data, and observed radiative and turbulent heat fluxes (2001-2014) collected at 5 automatic weather stations (AWS) shows good agreement. However, the authors find a winter mass balance overestimation in the ablation zone, resulting from overestimated surface albedo in HIRHAM5. This is attributed to both the formation of a too thick snow layer covering the ice in winter and the fact that snow darkening from dust events or volcanic eruptions is not accounted for in the model.

This study investigates the climate of an Icelandic ice cap, for which little research has been conducted. Through model evaluation, the authors highlight the importance of well representing impurities deposition, e.g. from dust and volcanic ashes, to realistically capture snow/ice albedo and hence accurately model SMB changes. They also present a 1981-2014 SMB data set that will be valuable for forthcoming studies. However, further clarifications, shortening, and copy editing are necessary to improve the manuscript readability (see ***Point Comments***). I judge that **minor revisions** are required before acceptance in The Cryosphere.

Substantive Comments

a) The authors use multiple terminologies for surface mass balance (SMB), which is confusing. For consistency, the authors should refer to "winter or summer mass balance" and "SMB or net SMB".

b) In the abstract and conclusions, the authors introduce results that are not discussed in the main manuscript. Examples can be found at **L14-15** of page 1 and **L3-10** of page 17. As the paper focuses on model evaluation, I would advise to remove these lines.

c) Ice albedo records from AWS stations are sometimes extremely low, e.g. 0.03 (L12 of page 10) and 0.01 (L26 of page 10). Are these measurements valid, i.e. deposition of dust or ashes darkening the surface, or do they result from AWS malfunction, e.g. low solar zenith angle, riming of the sensors, …? Could the authors provide references for such low albedo records or verify that all measurements used in this study are valid?

d) In Section 4.5, the authors should describe the "total energy balance" using an equation:

E = LWnet + SWnet + Hs+l + Gh

Where LWnet and SWnet are the net short/lonwave radiation, Hs+l are the turbulent heat fluxes and Gh is the ground heat flux. I would advise to refer to "melt energy" instead of "energy balance" in the discussion.

Point Comments

Page 1
L1: "carried out" instead of "made".
L2-3: I would suggest "[…] of the glacier surface mass balance (SMB). This simulation uses a new snow albedo parameterization that describes the albedo using an exponential […] surface temperature depend**e**nt".
L6: "in situ SMB measurements". See also my ***Substantive Comment*** a).
L6: "The model agrees well with observations at the AWS sites […]".
L5-6: "for 2001-2014" and "for 199**5-**2014".
L9: "[…] and not taking the surface darkening from dirt and […]".
L10-14: "balance for the whole of Vatnajökull (1995-2014) […], with a small mass balance underestimation of […] on average, whereas the winter mass balance is overestimated by 0.5 m w. eq. due to too large precipitation […] the ice cap. A simple correction […].".
L14-18: I would reformulate as "Here, we use HIRHAM5 to simulate the evolution of the SMB of Vatnajökull for the period 1981-2014, and show the importance […] ice albedo to model realistic SMB and that processes such as dust storms, currently not accounted for in RCMs, are an important […].". See also my ***Substantive Comment*** b).

Page 2
L5: "contribute to rise the sea level by 1 cm".
L6: You should move the following sentence here "Runoff from Vatna. ice cap is economically important for hydropower […] and future surface mass balance (SMB) changes are thus of keen interest.".
L9: "However, to carry out reliable future projections, or reconstruct the past climate, it is important to evaluate how well models simulate the present climate.".
L11-14: You could also refer to the work of Fettweis et al. 2017 (The Cryosphere Discussion) after Langen et al. 2016 at L13.
L16-22: I would suggest "Therefore, Icelandic glaciers are excellent candidates for evaluating modelled meteorological and SMB components. Compared to Greenland, observations are recorded in a relatively small area, offering a good […] HIRHAM5 model on a regional scale. As albedo in Iceland is significantly different from that of […], model evaluation over Iceland provides important […] on the glacier energy balance."
L23-26: I would suggest: "Here we present a 1981-2014 SMB data set of the Vatna. ice cap modelled by HIRHAM5 at 5.5 km resolution. HIRHAM5 is a state-of-the-art, high resolution RCM that has been well validated over Greenland (e.g. …). In this study, HIRHAM5 incorporates an updated albedo scheme, using a background MODIS ice albedo field, in the aim of capturing the effect of dust and tephra on ice albedo in the ablation zone. Model simulations results […]"
L30: This sentence can be removed.

Page 3
L5: Could you mention the period of observation in brackets?
L13: I would suggest: "The turbulent fluxes, combining sensible and latent heat fluxes, and […].".
L25: "weigh**t**ing"
L27: Remove "the" before 1995.
L30-: As the MODIS ice albedo product is described in this Section, the authors should move **L14-22** of page 6 here. The authors do not mention the period over which minimum autumn MODIS albedo is averaged nor the range of values obtained. This should be clarified.
L30: Replace "domain" by "spectrum".
L32: Replace "have been shown t be" by "are".

Page 4
L6: Replace "has implemented" by "implements".
L18: Replace "calculated results" by "calculated turbulent fluxes".

Page 5
L18: For consistency, I would suggest to refer to "dry regime" instead "cold regime", to match the regime names at **L25**.
L19: "In a dry regime, […]".

L30: "Refreshment of the snow albedo to its minimum value […]. A partial refreshment is possible as the snow albedo is only reset to the […]".

Page 6
L1: Replace "value" by "threshold".
L9: I would suggest: "In the case of shallow snow cover, […]".
L18: I suggest: "Additional tephra or dust deposition will […]".
L19: Washed off by runoff or wind? Could you provide a reference here?
L26: Move "(equivalent to ~5.5 km)" after "0.05º". Insert "for the period 1981-2014" after "rotated pole grid".

Page 7
L9: Could you provide a reference in which this previous HIRHAM5 data set is used?
L11: You could remove the sentence "Running the model […] cost of the model".
L12: You should insert **L19-24** here.
L14: "effect on upward short and longwave radiation ".
L30: What do the authors mean by "four surrounding", do they mean the four closest grid-cells?
L32: For consistency, temperature should be expressed in ºC.
L32: "Pressure is corrected using Eq. 1 decreasing the bias down to 0.1 to 0.5 hPa".
L33: Replace "[…] , it is not large […]" by "[…], and the resulting differences are not large […]".

Page 8
L12: Replace "made by AWSs" by "collected at AWSs".
L14: Do you mean "bi-linearly interpolating"?
L16: Replace "given in this study" by "listed in Tables 2-4".

Section 4.1: Here you could include scatterplots of the 4 meteorological variables to highlight how HIRHAM5 performs on a daily basis.
L20-21: You could remove the sentence "Before validating […] are simulated in the model.".
L22: "2 m temperature".
L25: I suggest "The comparison of modelled and observed mean daily […] from 2001-2014 is shown in Table 2.".
L27: You could remove "is generally forecast with a high degree of skill;"
L27-29: I would suggest "At each station […] correlation ($r > 0.9$) between modelled and estimated pressure (Eq. 1), for the entire time series and for each individual year.".
L31: "by 0.8 ºC overall.".

Page 9
L1: Replace "remaining" by "other" and "but with less than 0.6 K" by "by at most 0.6 ºC".
L2: Insert "($r \sim 0.9$)" after "all five stations".
L17-21: I would suggest "As a result, a similar underestimation of incoming longwave radiation is obtained at all five stations, with the largest difference occurring at the BAB station (Fig. 2). The average percentage […] (see Table 3), and falls well within the 10 % […]. However, Fig. 2a also shows that 25-30 % of the simulated days have larger errors than 10 %.".
L28: "[…] reproduces the daily values well ($r \sim$ …).".
L30: Replace "and only" by "combined with".
L31: I would suggest "[…] at all AWS locations (-7.9Wm-2)."

Page 10
L10-11: I suggest: "[…] in the model, while snow cover persists longer in reality. One exception occurs in 2001, where the modelled albedo never drops down to the ice value, whereas observations […]".
L14: Which period? I also suggest: "which contributes to delay the albedo drop […]".
L15: "[…] a too thick snow cover in winter is also the cause […]".
L15: You could move **L20-23** here, followed by "As a result, the ice surface is never exposed […] any of the modelled years […] during all but two years, i.e. … and … . During these two years, the simulated albedo fits well […]".
L19-20: You could remove these sentences.

L20: Comparisons with mass balance […] at this station. An overestimation of the snow thickness […] fluxes, lead to persistent snow cover at the end of summer.".
L26: See my ***Substantive Comment*** c).
L29-30: I suggest "Close to the equilibrium line, the albedo is highly […] spatially, e.g. there is a large […]".
L33: "meaning that".

Page 11
L3: I suggest "The smallest difference between modelled and observed albedo is found […]".
L5: "An exception to this is found in 2010 […]".
L8: I would suggest "For instance, the very low albedo values obtained at the TAC station (Fig. 3b) are due to tephra deposition […]".
L12: I suggest "Such discrepancy could be explained by dust events, advancing or delaying the drop in surface albedo. Dragosics et al. (2016) investigated […]".
L15: "[…] all events and showed that the dust storms have a […]".
L16: Remove ", of course,".
L21-25: I would suggest "As both the incoming and outgoing SW radiation are underestimated at most stations, the net SW shows a negative bias of ~ -6 to 12 Wm-2 at stations AB and ELA, and of -22 and -28 Wm-2 at the two AC stations. The resulting average model error at all five stations is -15.5 Wm-2.".
L27: I suggest "As HIRHAM5 underestimates meteorological variables at all stations, similar underestimation is obtained for the turbulent fluxes (Table 3 and Fig. 4). The two AC stations […] between the AWS estimate and […].".

Page 12: See my ***Substantive Comment*** d)
L5: "inaccurate cloud representation cannot be the only […] error. Errors in the interaction of clouds and radiation, e.g. error in the optical thickness of the clouds, or in the clear sky fluxes, could partly explain these discrepancies.".
L10: I suggest "Since the simulated outgoing […] a small negative bias, the deviation in net LW radiation is governed by the incoming radiation. Errors in the simulated albedo mean […] the deviation in net SW radiation. These errors can be partly attributed to […] storms, which are not taken into account in HIRHAM5. In addition, errors in the simulated albedo also stem from snow cover that disappears too slowly compared to AWS records in the ablation zone. As a result, modelled albedo drops […]".
L16: I suggest "of the net SW and LW radiation and the turbulent fluxes leads to underestimated melt energy, which contributes to overestimate the modelled snow thickness.".
L21: "the mean difference between modelled and observed energy components […] is shown for each station (Fig. 5)".
L25: "net SW radiation".
L26-28: These explanations are unclear to me, could you reformulate?
L32: "Modelled longwave radiation is consistently underestimated by 10 Wm-2.".
L34: "the albedo comparison. Depending on […] the albedo is generally […]".

Page 13
L6: "As previously discussed, this albedo bias, and hence underestimated SW radiation, occurs […] proximity of the equilibrium line. An underestimation of the incoming […]".
L19: Replace "offers an evaluation" by "allows to evaluate".
L20: Here the authors could mention the specific year.

Page 14
L2: "SMB is also measured at 25-120 non-AWS sites, depending on the year (Fig. 1b).".
L8: "receives a large amount of precipitation. However, since HIRHAM5 […]".
L13: Replace "particularly significant process" by "key process".
L15: I would suggest "Removing this location from the comparison, the total difference drops to one-third […]".
L16-18: This sentence is difficult to read, could you reformulate?
L26: I would suggest "HIRHAM is used to estimate the mean SMB of Vatna. for 1981-2014. The winter, summer and net mass balances […]."
L29: "manually interpolating", what do the authors mean by this? Please clarify.

L31: "The largest deviations are obtained in 1995, where ablation is overestimated in the simulation […] 2010-2012, where ablation is underestimated […]".

Page 15
L16-18: I would advise to swap Fig. 10 and Fig. 9, and to discuss these mass balance maps earlier in this Section.
L21: "a previous run using a constant ice albedo of 0.3.".
L26: Replace "appears to be on the" by "are found on the".
L27: "are located in areas".
L28: "The TAB station is located in the ablation area, where the ice surface is never exposed in the model due to an overestimation of the winter accumulation.".

Page 16: Present tense should be used in the conclusions.
L1: "[…] ice cap allows us to evaluate the model performance.".
L21: "[…] into the model is to implement a stochastic […]".
L31: "by 0.06 m".

Page 17
L3-10: See my ***Substantive Comment*** a).
L10: "HIRHAM5 is therefore a useful tool to expand […]".
L15: "[…] lateral boundary, e.g. output of a general circulation model.".

Figures and Tables

Tables 2-4: I would advise to show average observations at the AWS stations instead of HIRHAM values in the second column.
Table 2: For consistency, temperature should be expressed in ºC.
Figure 1a: Could you rename the different stations so that they match the labels used in the main manuscript, e.g. T acc. → T-AC.
Figures 2-4: Could you use similar symbols for both locations (B and T stations), the large crosses you use make the deviations appear larger than they really are.
Figure 4: Remove the last sentence in the caption and insert a similar legend (symbols) as in Figs. 2 and 3
Figure 5: In the legend, could you write "Hs+l" instead of "Hs + Hl"?
Figure 6 caption: I suggest: "Comparison of the winter […] 2014 between the mass […]".
Figure 7 caption: "see Fig. 1b".
Figure 10 caption: Replace "placement" by "location".
Figure 11 caption: "Difference in a) mean albedo, and b) mean SMB in m w. eq. for 2001-2014 between two runs with […].".