Response to reviewer 1 of manuscript "What controls the isotopic composition of Greenland surface snow"

We thank reviewer 1 for valuable suggestions, which has improved the manuscript. We have below answered the individual comments using Green text.

Anonymous Referee #1

This is a well written and well presented MS. The writing style is concise and the figures are of good quality. The science is original and important. My comments listed below are all relatively minor.

Minor comments For accuracy, please use 'near-surface' instead of 'surface' when you refer to measurements performed in the near-surface air (temperatuDriesc,uswsioantser vapor). For instance, p. 6037, l. 12 you use '...surface vapor d18O and air temperature...' suggesting two different levels, while in reality I assume water vapor and temperature were sampled/measured at the same (atmospheric) level. Along the same lines, also be specific about 'surface' (as modelled with CROCUS and measured by MODIS) vs. 'near-surface air' (as measured in the air) temperature, these are two very different things.
We agree with the comment and have corrected the text accordingly.

Why are not 2012 precipitation values included? Please explain.
We do not have the isotopic data for the precipitation from 2012 but only 2011.

Unexpectedly, sublimation as simulated by CROCUS is largest during precipitation events. During these events, surface to air temperature and humidity gradients are normally expected to be small, so we would expect small sublimation rates. As CROCUS is forced using ERA-Interim, have you checked that precipitation events are well represented (magnitude/timing) by the latter dataset? Unfortunately, as MODIS does not see the surface when clouds are present, CROCUS evaluation of skin temperature is not possible during precipitation.
Based on the comment we looked more into the simulated mass flux and found that it was not always such that the sublimation was larger during precipitation event. We notice for example that for 2011 day 212 show the largest mass flux despite being outside a precipitation event. On day 193 we find a similar large sublimation flux also outside a precipitation event. For 2012 we see that day 164, 196, and 198 is similarly very large despite them all being in between precipitation event.
We notice that for these days of high sublimation, which are in between precipitation events, it a common feature is lack of diurnal variability in temperature. This corresponds to cloudy days.
We investigated this observation more in details in the CROCUS model outputs and found that in general the skin surface temperature is found to be larger than 2-meter air temperature during cloudy days and no inversion is formed during the night. This is a result of a typical summer polar situation when both high LW down and SW down is occurring.
It was documented in Steen-Larsen et al. 2011 that precipitation events and strong wind often occurred during the same period. This is also observed in the forcing of CROCUS.

Stronger winds enhance the sublimation. This is particularly the cause for the high sublimation during the 2012 period from day 171 to 177.

Specific comments
p. 6038, l. 4: directly -> direct
Corrected
p. 6039, l. 29: this sentence is unclear, please reformulate.
Corrected
p. 6041, l. 20: remove one 'altogether'.
Corrected
p. 6042, l. 19: if the standard deviation is 5 C (which comes across as a very large number) then the summers of 2011 and 2012, being four degrees warmer than average, are not 'significantly warmer'.
We agree that this is not very clear. The 5C standard deviation are referring to the 3-hourly observations for the period 2006-2011 during June-August. The 1 standard deviation for the mean summer variations 2006-2011 are however just ~1C which makes especially 2012 significantly warmer. We have therefore updated the text such that it now reads:
"
The estimated mean summer (JJA) temperature at NEEM is $\sim -11 \pm 5$\,\unit{{\degree}C} ($1\sigma $ based on 3-hourly observations during the summers 2006--2011, the 1-σ on the mean summer temperatures 2006--2011 is ~ 1\,\unit{{\degree}C}), but the summer of 2012 was found to be significantly warmer (~ -7.5\,\unit{{\degree}C}) than average.
"
p, 6043, l. 5: '...from THE nearest building...'
Corrected
p, 6043, l. 16: '...in THE beginning...'
Corrected
p, 6043, l. 25: '...the 3 m level WAS measured...', also line 25
Corrected
p. 6044, l. 23: previous -> previously
Corrected
p. 6044, sentence starting at l. 23: unclear, please reformulate.
Corrected
p. 6046, l. 17: ' Its inputs are snowfall and frost and its outputs are melt, sublimation and calving.' This is unclear; by input and output you mean mass fluxes towards and away from the surface; please specify that this is not model in/output. How is calving defined here, a word normally used for the production of icebergs?
Yes we agree that this is unclear.
By input and output we mean the mass flux – this is now corrected in the text. The values are calculated by the LMDZiso model.
We do acknowledge that 'calving' is a word normally used for production of icebergs. However we do describe in the text what we mean by calving

“‘Calving’ occurs whenever the snow height exceeds a~maximum capacity of 3\,\unit{m}”
We have updated the text such that we describe ‘Calving’ as “Forced removal” in parenthesis. We have also written ‘Calving’ instead of just Calving to indicate that we are not referring to icebergs calving.

p. 6048, l. 13: ’ to occur (indicated on Fig. 1 with grey band)’; confusing, as grey band indicates precipitation events in Fig. 1.
This was a mistake. We have indicated this on Figure 1 with text boxes.

p. 6048, l. 15: remove ’been’
Corrected

P. 6049, l. 19: ’ We do not investigate further the comparison between LMDZiso and our data, as this will be the focus of a separate multi-model – data paper currently under preparation.’ In that case consider to remove the LMDZiso results from Fig. 1, as they do not add anything to the discussion that follows.
We do unfortunately not agree here. We use the LMDZiso model to show that the observed near-surface water vapor isotope variations are caused by synoptic variations and not induced by surface-snow changes.

“As shown for summer 2010 (Steen-Larsen et~al.,
2013), the day-to-day variability of temperature and
\chem{\delta^{18}O_v} is well captured by LMDZiso (Fig.~1). This
confirms that such changes in d\chem{^{18}O_v} are driven by changes
in large-scale circulation, since only the large-scale winds are
nudged in this simulation.”

p. 6050, l. 4: show all -> all show
Corrected

p. 6053, l. 17: add ’is foud’.
Corrected

p. 6055, l. 12: lead TO changes
We would like to not include “TO” here as it will change the meaning of the sentence. Instead to make it more clear we introduce a “The” instead.

l. 6057, l. 7: condensation referes to the phase change between vapor and liquid; rime formation (riming) would be a more appropriate term here.
Corrected

p. 6060, l. 11: (ii) -> (iii)
Corrected

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