

Answers to the comments by reviewer RC2:

General comments:

1) My main issue with this manuscript has to do with its readability. There are numerous grammatical errors throughout, some of which are pointed out below. A native English speaker should edit the paper before resubmission.

This is now done. The authors are grateful for the thorough review also concerning the language.

2) The authors tend to make some broad sweeping conclusions based on trends that are only significant across a small fraction of the total study region. I would like to see more discussion of the full picture (like Figure 9). Pg 10 L2 and Pg11 L5 are two instances where the discussion is too narrow in focus.

The authors have now extended the mentioned discussions (sections 3.1.1, 3.1.3 and 3.3.) as requested. The systematic signal of change is not as dramatic in Finland as in some areas, because of the large variation of winter weather. Especially the sea ice extent of Baltic Sea affects largely the Finnish winter weather. If the Gulf of Finland and Gulf of Bothnia freeze completely the Finnish climate is almost continental in winter even on the coast. We added a comment about the hemispherical study published recently, where we studied the effect of weather parameters on the observed changes in larger areas.

Section 3.1.1 main addition:

Especially variable melt onset timing is in the coastal regions (Southwestern Finland and Southern Ostrobothnia) and in the Lake district. For those regions the standard deviation values of the melt onset day are 14.3, 14.7 and 14.6, respectively. For the Northern Fjeld Lapland the vicinity of the Barents Sea obviously causes also higher a standard deviation (13.4) of the melt onset day. So large part of Finland is coastal that changes in air temperature or precipitation preceding melt onset are not that directly dominating as in some regions of the northern hemisphere (Anttila et al., 2018), but the sea ice extent of the Baltic Sea has a large effect as well. When using 10 year moving averages for the trend analysis based on albedo data, a negative trend ($R^2 > 0.5$) of melt onset day was detected in Northern Karelia – Kainuu, Southwestern Lapland, Ostrobothnia, Kuusamo district and Lake district. Although the time series of 34 years is not really long enough for using 10 year averages, the results, however, confirm the intuitive impression that the snow melt starts earlier than it used to do in the past, as the two distinct areal trends showed.

Section 3.1.3 addition:

For the length of the melting season the standard deviation during 1982-2015 was on the average, naturally, even larger than for the melt onset day the value being as high as 16 days. The largest values occurred again in Southwestern Finland (20.3), Southern Ostrobothnia (17.5), Lake district. (17.1) and Northern Fjeld Lapland (20.0). When using 10 year moving averages in the trend analysis, the result was that the melting season length increased in Northern Karelia – Kainuu, Kuusamo district, Southwestern Lapland and North Ostrobothnia and decreased in Northern Fjeld Lapland.

Section 3.3. addition:

It is obvious also that meaningful trends ($R^2 > 0.5$) for five year average albedo values were obtained only when the fraction of forested area exceeded 0.7 and the stem volume was smaller than 75 m³/ha. For those areas (Southern Lapland, Kainuu, Northern Ostrobothnia, Lapland and North Karelia) the albedo trend is negative. It is well known that the winter time albedo depends strongly on the LAI (and thus stem volume of a larger area), when the LAI is relatively small (Manninen and Stenberg, 2009). For larger LAI values the albedo more or less saturates and a further increase of LAI does not show up markedly.

Specific comments:

L25-27: Confusing sentence - reword.

Edited as requested.

L27: "Change in albedo" to "albedo change". Also, albedo change isn't really a mechanism, but a result of changing forest/snow cover/properties.
[Edited as requested.](#)

L30 and Pg2 L2: "enhances the climate change" – remove the
[Edited as requested.](#)

Pg2 L8: Remove "The forest management changes albedo and carbon sequestration".
[Edited as requested.](#)

L11: remove second "in"
[Edited as requested.](#)

L14: change water to rain
[Edited as requested.](#)

L15: Change to "On average, the precipitation changes..."
[Edited as requested.](#)

L19: Change "snow precipitation" to "snowfall"
[Edited as requested.](#)

L19: "The Arctic warming has resulted in decline of the Arctic Ocean ice cover" Awkward wording, change to this or similar: Arctic warming has caused Arctic sea ice cover to decline rapidly.
[Edited as requested.](#)

L20: Change "such decline" to "such a decline"
[Edited as requested.](#)

L24: since 2005
[Edited as requested.](#)

L26: Based on the prior paragraphs, the authors should mention how well models represent recent changes in snow cover (e.g., Derksen and Brown, 2012, GRL; Thackeray et al., 2016, J Climate).
[These mentioned essential references are now added, thanks for suggesting.](#)

Pg3 L23-26: This sentence should be reworded.
[This sentence is split in two to clarify the text.](#)

Pg4 L5: Change "the spatial resolution" to "a spatial resolution".
[Edited as requested.](#)

L10: remove second "of Finland" here.
[Edited as requested, although now it is implicitly expected to be understood that they don't survey forests abroad.](#)

L11: change "forest associated variables"
[Edited.](#)

L17-19: Confusing sentence, reword.
[Edited.](#)

Pg5 L19: Change to "if the forest floor"
[Edited as requested.](#)

L21: Confused by "15-20 FSC %-units".
[They are just percentages. Edited accordingly.](#)

L23: Confusing first sentence, reword.

The authors did not grasp what is confusing, but tried to clarify this sentence.

Pg7 L17-23: This paragraph seems as though it would be a better introduction to this section.

The paragraph is moved to the beginning of section 2.2.2.

Pg8 L4: Change “composes” to “is composed”

Edited as requested.

L22: This sentence is poorly worded. Do the authors mean to say that Snow melt-off day is derived from FSC maps?

Yes. The first sentence is now removed altogether as the later text explains, how the snow melt-off day is derived.

L23: Change “however ignoring” to “but ignores”

Edited as requested.

Pg9 L25: Change to “Seasonal snowmelt timing” or similar?

Edited as requested.

Pg10 L1: Since these changes are so small across many regions, I recommend changing the units from days per year to days per decade (Table 3,4,5, etc).

Tables 3, 4, 5 and 6 are edited as requested. The corresponding change has been made also in the text part, where numbers appear (abstract and conclusions).

L2: What about the other eight vegetation zones?

The other vegetation zones did not show distinct trends. This information is added in the text on page 10, lines 14-15.

L20: Change “The land ecosystem model results” to “Results from JSBACH”

Edited as requested.

L21-22: Awkward sentence, reword.

Edited as requested.

L33: Not clear what this means: “the southeastern -northwestern zones of equal timing are obvious”.

The snow melt contours in Finland are more or less in the southeast-northwest direction. The sentence is edited (page 11, line 16).

Pg11 L5: What about the two regions with a decreasing melting period length of a similar magnitude?

The coefficients of determination for those areas are markedly smaller than 0.5, so that the value of the slope does not signify, not even its sign.

L6: Change to “Start of the Growing Season”

Edited as requested. Also elsewhere in the manuscript we now use the term start of the growing season.

L9: should be “on the forest floor”

Edited as requested.

L27: Remove “the” to start the sentence and change “quality” to “type”.

Edited as requested.

L29: Remove “as form of snow or water”

Edited as requested.

L29: Capitalize arctic

Edited as requested.

Combine Tables 3, 4 and 5 into one to save space?

The tables 3 and 4 are combined, because the significant trends of melt onset and melting season length appear in the same regions (shown in bold fonts). Table 5 (now 4) is kept separate, because the albedo trends are significant in other regions than those of the melt onset and melting season length. Besides, table 5 (now 4) will be compared more with table 6 (now 5).

Table 3-5: state in the caption why some entries are bold.

Edited as requested.

Figure 1, 6, 8: Use white background with black outlines. Include latitude/longitude gridlines.

The background and outlines are updated as requested. The region maps are given in the national metric coordinate system, not in latitudes/longitudes. In order to avoid conversion errors we carried out the analysis in the original coordinates. The latitude/longitude information is now added to the caption of Figure 1. As all figures cover the same area, it is sufficient to give it once.

Figure 7: remove "out[161]=" from plot

Edited as requested.

Figure 8: Include a panel showing the explicit albedo change from the 1982-1986 panel to the 2011-2015 panel. This will make it easier for the reader to comprehend the change.

The authors agree that this is a good idea and added the requested panel.

Figure 9: Narrow the y-axis on these plots to make the interannual variability and change more apparent (10 or 20 to 60%).

Updated as requested.

One co-author from the FMI model team should be added:

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