

# ***Interactive comment on “The growth of shrubs on high Arctic tundra at Bylot Island: impact on snow physical properties and permafrost thermal regime” by Florent Domine et al.***

**Florent Domine et al.**

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Responses to Reviewer 2

We thank the reviewer for his time and useful comments, which allowed to improve the manuscript. The reviewer’s comments are pasted below, labelled as comments (C) with our responses imbedded in the text and labelled as Response (R).

(C) GENERAL COMMENTS

(C) This is an interesting study demonstrating that shrub cover can have a strong effect on snowpack properties, with potentially important impacts on soil temperature regime and permafrost thaw. By focusing on snow-shrub interactions, the study is suitable for

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Biogeosciences and should appeal to its wide readership. However, to be worthy of publication, these issues should be addressed:

(C) 1- The structure needs to be improved, with a sub-section of the Results dedicated to the modelling effort (which is currently presented alongside the discussion). Conversely, there is currently a lot of interpretation incorporated in the results, and many paragraphs could be moved to the discussion.

(R) Agreed. Extensive text reorganization has been done, as discussed in the reply to reviewer 1.

(C) 2- Statistical tests should be used to highlight differences in snow properties among vegetation types (see specific comments for suggestions); if not, the authors should respond as to why this is not feasible.

(R) Statistical test were done in one case. In the other, we believe statistics are not required, as our objective is to understand processes, which statistics cannot perform as efficiently.

(C) 3- The research question(s) should be clearly defined, instead of “This work attempts to contribute to some of these questions” (line 86). In that paragraph, you should define your questions and hypotheses rather than list the measurements you have taken. These research themes could then become subheadings in the next sections (esp. results and discussion), which would greatly enhance the flow and clarity.

(R) This was also a comment by reviewer 1, which we addressed above. The text, and in particular the discussion, has been extensively restructured. The discussion has been organized in 4 subsections.

(C) 4- The presentation of figures should be uniformised (gridlines, text size, plot titles, etc); the clarity of some could be improved (see specific comments)

(R) Changes have been done to Figures, as detailed below.

## (C) SPECIFIC COMMENTS

(C) Results 3.1 and Table 1: Have you tested for significant differences? It does not look like it from your methods and no statistics are reported. At line 169, you write “. . .only that fully covered with willows shows a significantly higher value than the other sites” – which you cannot say unless you have tested for it! You should perform a statistical test that would contrast the effects of vegetation type (polygons, hummocks, shrubs) on snowpack height. Because of the hierarchical nature of your measurements (nested within plots and locations), you could do this with a mixed-effects model, using “plot within location” as nested random effects. Because you have only two years of measurements you should include “year” as a fixed effect, and if you add an interaction with vegetation type it could provide further insight into your discussion of different patterns in different years.

(R) We now show the standard error in Table 1, and this clearly demonstrates that the snow height in the dense willow patch is significantly different from the others. To confirm this, we also performed an ANOVA analysis and a Tukey post-hoc test, but we feel it is not necessary to report that here. The standard errors speak for themselves.

(C) The previous comment applies to Table 2 and comparisons of snow thermal characteristics. Why not perform an ANOVA or a rank-based test (you have even ranked the data already!) to try and highlight differences between vegetation types (Herbs, Willows, Hummocks)?

(R) Our objective here is to understand the impact of shrubs on snow thermal conductivity. Our conclusion is that when melting does not take place, the mean thermal conductivity is decreased in the presence of shrubs, and when melting takes place, it is increased in the presence of shrubs. Statistics do not seem useful to us here. In fact, we wish to show that shrubs can have opposite effects depending on whether they are exposed to radiation or not. We believe a process study, and a detailed understanding of how shrubs, snow and radiation interact are more useful than statistics.

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(C) The paragraph discussing differences in years (starting at line 187) would be more appropriate to the discussion. Same goes for lines 211-227 and 248-255. The results section should focus on comparing values between shrub and herb tundra plots and reporting your model outputs, and then the discussion should be structured as to explain these results based on your understanding of the processes and your additional observations (particularly warm day, recent snowstorm, etc.). In the discussion, you skate over very quickly the potentially opposite effects of shrubs on soil temperature in the summer (line 383). It would be good to see this addressed in more detail so as to nuance your modelling results and general conclusions on permafrost thaw. (I see that the other reviewer has suggested the same thing and suggested references, so I will not expand further here.)

(R) Paragraph starting at line 187 has been moved to discussion. Paragraph in lines 211-227 is essential to understand the description of snow stratigraphy that follows. It definitely belongs here. Otherwise, many sections have been moved to the discussion, as detailed earlier and in our response to reviewer 1. The discussion on summer effect has also been much expanded, as discussed earlier.

(C) Figure 5. It would be worth adding a horizontal line at the height of 25 cm, which is the threshold you mention for shrub effects on snow properties. Please remove the gridlines from the figures.

(R) In fact, the 25 cm height applies to the scattered willows, not the large willow patch of Figure 5. Grid lines have been removed here.

#### (C) TECHNICAL CORRECTIONS

(C) Reference formatting needs to be checked and made consistent throughout; many citations still have brackets when authors' names are used in the active voice (e.g. [. . .] than that measured by (Myers-Smith and Hik,2013), [. . .]). You also need a space after the semi-colon when citing multiple studies.

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(R) End note errors are fixed at type setting.

(C) Latin names of plant species, when referred to for the first time, should be followed by the authority (e.g. *Salix richardsonii* Hook.)

(R) This has been done.

(C) Line 21: *Salix richardsonii* should be italicised

(R) Done

(C) Line 38-39: Incorrect sentence: replace with something like “are also known to be, or suspected of being, modified by shrubs”

(R) Done, thanks

(C) Line 61-76 should be a single paragraph

(R) Sure, done.

(C) Line 93: delete “see map on”

(R) Done

(C) Lines 198 and 201: do not capitalise “Alpine”

(R) Done, thanks.

(C) Table 2: The caption says “the lowest seven values are in bold and the highest 5 values are in italics” – but this is not the case. Again, I think a statistical test would be more appropriate than a qualitative observation of the table.

(R) We apologize, the table was formatted by mistake. We have now restores the bold and italics characters for clarity.

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