

1 Review of “Exploring the decision-making process in model development: focus on the  
2 Arctic snowpack” by Menard et al.

3 We thank the Reviewer for taking the time to review our manuscript. Please find our  
4 answers in blue font.

5 This is a somewhat unusual manuscript, submitted as a “Research article” for consideration  
6 in The Cryosphere. The “unusual” aspect is that, where most research articles focus on  
7 measurement data and/or simulations, this study reports on interviews conducted with  
8 experts in the field of Arctic snow, [L96-97] *“to understand why decisions made by modellers  
9 all over the world and over the past decades have not led to more (or is it “any”?) progress in  
10 Arctic snowpack modelling, ...”*

11 It is true that *“[quantitative] research articles focus on measurement data and/or  
12 simulations”*. However, qualitative research does not. Indeed, it is *“unusual”* for a  
13 manuscript using qualitative methodologies to be submitted to a journal that predominantly  
14 publishes research using quantitative methodologies. For this reason, we contacted the TC  
15 editorial board prior to submission to check whether a manuscript using qualitative  
16 methodologies to investigate decision-making in snow modelling could be considered for  
17 peer-review. The editorial board confirmed that qualitative methodologies as applied to  
18 cryosphere topics are within the remit of the journal.

19 We suspect that the many comments in this review questioning the methodological  
20 soundness of our study may stem from Reviewer 1's unfamiliarity with qualitative  
21 methodologies. We did expect that some TC readers would be unfamiliar with qualitative  
22 research, which is why we did explain our process throughout the manuscript, but now  
23 realise more information will be needed. For example, we described our approach in the  
24 Methods section and referenced a number of papers examining the qualitative  
25 methodologies we used in our manuscript (e.g. Braun and Clark, 2006; DiCicco-Bloom and  
26 Crabtree, 2006; Lincoln 1995; Rapley, 2011). We as well mentioned in the Introduction and  
27 Conclusion that our approach was borrowed from Science and Technology studies (L99 and  
28 L563-568).

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30 Nevertheless, the comments from Reviewer 1 made us realize that, in our revised version,  
31 we will need to provide more information about our methodology and stress in greater  
32 depth the value and complementarity of qualitative research. We will for example quote  
33 Fossey (2002) in the introduction to set the tone of our work: *“Restricting oneself to any  
34 single paradigm or way of knowing can result in a limitation to the range of knowledge and  
35 the depth of understanding that can be applied to a given problem situation’. (...) Thus,  
36 research needs to draw on different perspectives, methodologies and techniques to generate  
37 breadth of knowledge and depth of understanding. Qualitative research is a broad umbrella  
38 term for research methodologies that describe and explain persons’ experiences, behaviours,  
39 interactions and social contexts without the use of statistical procedures or quantification.  
40 (...) One of the major criticisms is that within the positivist paradigm [i.e. scientific research  
41 based on quantitative methodologies] it is assumed that an objective reality, or truth, exists  
42 independent of those undertaking the inquiry and the inquiry context. Two research  
43 paradigms that inform qualitative research methodologies, namely the interpretive and*

44 *critical research paradigms, place emphasis on seeking understanding of the meanings of*  
45 *human actions and experiences, and on generating accounts of their meaning from the*  
46 *viewpoints of those involved”*

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48 Here, issues identified are the somewhat troublesome transferability of modeling  
49 approaches between lower latitudes and polar regions, limited data availability from the  
50 arctic suitable for model development, parameterization development, and calibration and  
51 validation. Other issues are the historical underrepresentation of arctic snow in snow model  
52 development environments, lack of attention and (thus) funding for the problem, and  
53 inadequate approaches.

54 Major comments:

55 1. I think it is an interesting concept to access knowledge that is normally not finding its  
56 way to the broader community in the form of manuscripts. However, I think there are  
57 some methodological problems that devalue this manuscript from a “Research article”  
58 to only an opinion piece.

59 1. First of all, the selection of participants was seemingly done very subjectively,  
60 and is not transparent for the reader. The only procedural aspect mentioned  
61 here is [L118] *“CM, SR and IM compiled a shortlist of participants”*. I wish that  
62 there would have been some objective criteria, for example a random pick of  
63 first authors on papers that mention “snow”, “arctic” and “modeling” in the  
64 abstract that were published over the last ten years, based on a database like  
65 Scopus, ISI knowledge or google scholar.

66 *Participant selection abided with qualitative methodologies: “Quantitative*  
67 *research requires standardization of procedures and random selection of*  
68 *participants to remove the potential influence of external variables and ensure*  
69 *generalizability of results. In contrast, subject selection in qualitative research is*  
70 *purposeful; participants are selected who can best inform the research*  
71 *questions and enhance understanding of the phenomenon under study (...)*  
72 *Decisions regarding selection are based on the research questions, theoretical*  
73 *perspectives, and evidence informing the study.” (Sargeant, 2012)*

74 Based on this, we explained our reasoning for selection in the introduction L96-  
75 104: *“The aim of this study is to understand why decisions made by modellers all*  
76 *over the world and over the past decades have not led to more (or is it “any”?)*  
77 *progress in Arctic snowpack modelling (...)* *Therefore, to address our aim, we will*  
78 *investigate the construction of snow models through interviews with the*  
79 *individuals who shape their content and present the results of this investigation*  
80 *in their own words”*. Nevertheless, we recognise that TC readers may welcome  
81 more information about our selection process, which we will provide in the  
82 revised version in the Methods section.

83 For completeness, we note that that the quoted sentence was truncated. The  
84 full sentence is “CM, SR and IM compiled a shortlist of participants, both within  
85 and outside CHARTER, who consider the snowpack structure important for their  
86 research”.

87 2. Second, the manuscript relies heavily on quotes from the interviews. The full  
88 interview transcripts are, understandably, not released. Thus this could  
89 potentially result in heavy cherry-picking of quotes by the first three authors.  
90 Apparently, the interview transcripts have been coded using NVivo, but it is not  
91 clear how this has further been used. It is not clear what attempts were made  
92 for objective analysis of the interview transcripts.

93 Information about our methods is found between L152:156: “*The transcripts*  
94 *were analysed by conducting a thematic analysis (Braun and Clark, 2006;*  
95 *Rapley, 2011), which consists in identifying codes (semantic content or latent*  
96 *features in interviews) and collating them into overarching themes. Iterative*  
97 *coding was conducted in NVivo, a qualitative data analysis software that*  
98 *facilitates the classification and analysis of unstructured data. Three iterations*  
99 *were necessary to identify all codes and to classify codes into themes”*. We  
100 recognise that the TC readership may welcome more information about  
101 thematic analysis and will provide more information in the revised manuscript;  
102 readers particularly interested in the methodology are invited to consult the  
103 two papers cited above. Until then and briefly: The questions asked during the  
104 interviews were to understand the decision-making process of the participants.  
105 Following the interviews and using the transcripts, one or multiple codes (or  
106 “labels”) were attributed to each statement by CM. Codes were then merged  
107 and grouped into themes. This process was repeated three times to ensure  
108 thorough codification. These themes were then addressed separately in each  
109 subsection in Sections 3. The quotes that best illustrated the themes were then  
110 included in the manuscript.

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112 3. Third, I’m concerned that quotes from the interviewed scientist are published,  
113 without fact-checking if this is true. This results in a few false statements, for  
114 example that “*CROCUS is an avalanche model*” [L237], or that [L282-  
115 283] “*[Models] are limiting the number of [snow] layers for computational*  
116 *stability and efficiency*”, which for Crocus or SNOWPACK, for example, would be  
117 trivially easy to adjust. [L373-375] “*In my sense, large scale climate modellers*  
118 *aren't sufficiently aware of snow. (...) There are so many people who don't care*  
119 *about that*“. The first part of this statement is an opinion. The second part is  
120 stated as a fact. “*There are so many people who don't care about that*“. I would  
121 like to see evidence for that.

122 We had attempted to explain the nature and purpose of the quotes L173-177 in  
123 the manuscript: “*The working title of this study in the participant information*  
124 *sheet was “A multi-perspective approach to snow model developments”, thus*  
125 *implicitly alluding to the fact that, by approaching a single issue from multiple*  
126 *angles, this study sought to elicit diverse responses. This certainly turned out to*

127 *be the case. Most significantly, no opinion was unanimous; every statement*  
128 *made by each participant was contradicted by a statement made by another*  
129 *participant.” We also addressed the fact that we were eliciting opinions “By*  
130 *opting for the semi-structured interview format, our aim was to use a medium,*  
131 *the conversation, in which using “I” was natural. While all participants provided*  
132 *important information related to their field – information that is presented in*  
133 *Section 3.1– they also ventured where few scientists do, at least in their*  
134 *publications: they offered opinions”. Reviewer 1’s comment makes us realize*  
135 *that the nature of the statements may not be clear to all readers and we will*  
136 *therefore clarify in the next version of the manuscript that all quotes are*  
137 *opinions and that as some quotes contradict each other, none of the quotes are*  
138 *endorsed by all authors and, consequently, readers will inevitably disagree with*  
139 *some quotes.*

140 Regarding “fact-checking” and “truth”, as explained in the manuscript and  
141 above, what we are interested in is how the opinion of decision-makers - in  
142 other words their truth based on their experience, expertise and perspective -  
143 inform their decisions. We also stress that the word “fact” is loaded in social  
144 sciences, including Science and Technology studies (we refer Reviewer 1 to  
145 Fleck, 1935, referenced L565), which understands facts as being constructed.

146 Regarding the Crocus quote, we invite Reviewer 1 to read the full paragraph in  
147 which it figures to understand the context in which it is cited: *“Issues of scale*  
148 *are further complicated by the fact that some models are being repurposed and*  
149 *operate at scales that they were not intended to. Examples include context-*  
150 *specific models being used at large scale (‘a lot of snow models are being used*  
151 *now in land surface schemes as broadly applicable snow models for all snow*  
152 *climate classes. But, I mean Crocus, it’s an avalanche model, right?’)”. We hope*  
153 *that, as we will be more explicit about quotes expressing opinions in the revised*  
154 *version, there will be no more room for misinterpretation. We will also revise*  
155 *this paragraph e.g. “some participants believed that some models were being*  
156 *repurposed and operated at scales that they were not initially intended to”;*  
157 *this will help the reader understand that the quote means that the participant does*  
158 *not think that a model initially developed as an avalanche forecasting model*  
159 *(Brun et al., 1989) should not be broadly applied for all snow climate classes.*

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161 • *“[Models] are limiting the number of [snow] layers for computational stability*  
162 *and efficiency”, which for Crocus or SNOWPACK, for example, would be trivially*  
163 *easy to adjust. [L373-375].*

164 As mentioned above L134-139, we will clarify that all quotes are opinions. We  
165 also invite Reviewer 1 to review the context in which this quote is cited: *“Ten*  
166 *participants began the interview by providing some background about snow*  
167 *model developments, using this as a historical justification for Arctic snowpack*  
168 *properties not being included in snow models”.*

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170 • *“In my sense, large scale climate modellers aren’t sufficiently aware of snow. (...)*  
171 *There are so many people who don’t care about that”.* The first part of this

172 statement is an opinion. The second part is stated as a fact. *“There are so many*  
173 *people who don't care about that”*. I would like to see evidence for that.  
174 As mentioned above L134-139, we will clarify that all quotes are opinions.  
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176 4. Lastly, the Interview consent form states: *“Access to the interview transcript will*  
177 *be limited to the research team: Dr Menard, University of Edinburgh; Dr Sirpa*  
178 *Rasmus, University of Lapland; Dr Ioanna Merkouriadi, Finnish Meteorological*  
179 *Institute.”* Yet the list of co-authors further encompasses the majority of  
180 interviewed scientists. I cannot see how this can be objective. I think  
181 interviewees have the right to review their quotes, such that they can verify  
182 that no misunderstandings or misrepresentations have occurred. But I fail to  
183 understand how the interviewees can also be co-author. On the one hand, they  
184 have no access to the other interview transcripts, thus cannot reliably judge if  
185 this was a proper reporting of what was said in the interviews, but more  
186 importantly, as author they have direct impact on which quotes from them are  
187 selected, and how they are presented. That means that this manuscript  
188 basically has become a vehicle to get their own opinions across, which I think  
189 doesn't align with what is expected for a “Research article”. On top of that, they  
190 obviously have full access to their own interview, but not to the other  
191 interviews. I cannot see how this can properly result in a good co-authorship,  
192 when the majority of underlying data is inaccessible to the co-author. I cannot  
193 see a scenario where this leads to proper scientific conduct for a peer-reviewed  
194 “Research article”. Unfortunately, I don't see how these methodological flaws  
195 can be corrected, and I think the manuscript should be rejected as a peer-  
196 reviewed “Research article”. It may find an outlet as an opinion piece.

197 i) This quote from Reviewer 1 *“as author they have direct impact on which*  
198 *quotes from them are selected, and how they are presented. That means*  
199 *that this manuscript basically has become a vehicle to get their own*  
200 *opinions across”* somewhat contradicts this one in their epilogue:  
201 *“Maybe the interviewees expressed themselves somewhat awkwardly*  
202 *because they also felt like they were in an informal private conversation.*  
203 *It is also very possible that context or tone went missing in the*  
204 *transcription and the quote selection for the manuscript”*. If the  
205 participants “expressed themselves somewhat awkwardly” during the  
206 interviews, but then could turn the manuscript into a “vehicle to get  
207 their opinions across”, would the participants/co-authors not have, in  
208 that case, removed any “awkward” quotes?  
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210 In addition, the participants were well aware that the interviews were  
211 not “informal private conversations”. As mentioned L130-131 in the  
212 manuscript *“participants were emailed with a request for participation*  
213 *that included a participant information sheet and consent form”*. All  
214 participants had to return the signed consent form prior to being  
215 interviewed. The consent form states that the interviews were recorded  
216 and transcribed and that quotes from the interviews may be used in  
217 future publications.

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ii) As mentioned in the participant information sheet (PIS) and the interview consent form, the methodology used in this study was approved by the University of Edinburgh School of GeoSciences (where CM is based) Research Ethics & Integrity Committee. The Committee consulted the PIS in which it is stated that the participants “*will be given the choice to remain confidential, to be named as a participant or to be a co-author in publications stemming from this study*”. The Committee, therefore, concluded that inviting participants to become co-authors did constitute “proper scientific conduct”, perhaps because committee members are familiar with qualitative methodologies and knew that it is becoming increasingly customary to invite participants to co-author the research they participated in (e.g. see Given, 2008; Pope, 2020; Farbotko et al, 2021; Doering et al., 2022; Warman et al., 2024)

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2. I also struggled with understanding the modeling environment that the authors were considering. I found that the manuscript paints a picture of this environment that simply didn't resonate with me. For example, when I read: [L549-553] “*Yet, models are a product of one or multiple modelers' vision. This was reflected in the interviews during which many participants often mentioned the name of the model creator or lead developer instead of, or as well as, the model's name. The research identity of many modellers is, whether they want it or not, intertwined with their model; inviting authors to reflect about their positionality would allow modelers to regain control over their own narrative and research identity.*” My personal experience is completely different. Thinking about the snow model I work with most, and which is widely used and recognized in various cryosphere communities, basically all major model developments in the last 15 years were done by PhD students and PostDocs, most of whom have since moved on. So their “research identities” stretch way beyond “their model”. I think when asked, very few of the PhD students would describe the model as “their model”. In fact, even though they contributed most significantly to model developments, I doubt they will describe their role as a “modeller”. The model I'm mostly familiar with, has almost no dedicated, long-term model developers or code maintainers. The large majority of recent code changes (last 15 years) has been done by people with contracts lasting shorter than a few years. The original “model creators”, in the meantime, have taken up different research fields, retired or have taken up other roles in academia. For the model I work with most, no “lead developer” can be identified. Thus, I struggle to agree with this proposed narrative of “model creators” or “lead developers” as well as supposedly the concept of “their model” at face value. It needs to be supported by data and analysis. For example by analyzing model code repositories and investigating how many people contributed how much to the code, and in what role. That would give the necessary underpinning of this narrative. I'm now curious if the model ecosystem I work with is the exception, or the rule. It could also signal a bias in the selection of participants for the interviews.

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- We are glad that the manuscript is making Reviewer 1 reflect on their own experience because it suggests that we have reached one of our goals stated in the Conclusion: the novelty in this paper is that “*it is a reflective exercise which, we hope, will be the start rather than the end point of the conversation*”.

264 However, while Reviewer 1's experience could contribute future conversations  
265 and similar research studies, it does not mean that it cancels the participants'  
266 experience. When participants talked about a snow model, they did often  
267 mention the name of the model's creator e.g. Glen's or the Liston model  
268 (SnowModel), Richard's model (FSM), Marie's model (Ivori), or Dave Lawrence  
269 when mentioning CLM; these are the (qualitative) data we base our analysis on.  
270 The exception was Crocus; although some of its developers were named, no one  
271 was singled out and it was generally referred to as "simply" Crocus.

272 • "For example by analyzing model code repositories and investigating how many  
273 people contributed how much to the code, and in what role." This would be  
274 assuming that all model code repositories exist, are well maintained and that  
275 protocols about comments were instigated since the birth of the investigated  
276 models and have been respected since. Based on Menard et al. (2021) who  
277 found that up-to-date and well-maintained model documentation was rare, we  
278 would be reluctant to conduct such an analysis.

279 3. Further, it is written: [L96-97] "*The aim of this study is to understand why decisions*  
280 *made by modellers all over the world and over the past decades have not led to more*  
281 *(or is it "any"?) progress in Arctic snowpack modelling, ...*". Given that my personal  
282 experience is that most development is done by researchers on PhD or other short-  
283 term contracts, I think a lot of issues were mentioned that they have no control over,  
284 like funding or the historical legacy of models. In contrast, very little was reported on  
285 the experiences and choices made by PhD students or other short-term contracted  
286 researchers over the course of their model development efforts. I think it plays a role  
287 here that those researchers seem to be absent from the pool of interviewees.

288 Thank you for this comment. It is exactly because PhD students and casualised  
289 researchers have no control on funding or the historical legacies of the models that  
290 they were not interviewed. The aim of our study was to interview those who decide or  
291 influence model developments. This is what we meant when we wrote: "*we will*  
292 *investigate the construction of snow models through interviews with the individuals*  
293 *who shape their content*". We recognise that what we meant needs clarifying and will  
294 revise the wording for the next version of the manuscript.

295 4. I found that the manuscript was lacking context. It feels like it is assumed that the  
296 readers understand the problems with snow models in the Arctic. There is very little  
297 substantiation of these problems (basically restricted to L86-95).

298 We kept this part of the introduction short because we wanted the participants to  
299 explain, in their own words, what *they* thought were the problems with modelling the  
300 Arctic snowpack. We (CM, SR and IM) did not want to dominate the narrative by  
301 explaining in detail what *we* thought were the problems. We will make this clearer in  
302 the introduction, but also ensure that sufficient information is provided for the reader  
303 to have enough context.

304 In my opinion, it fails to properly introduce the problems to the reader. Furthermore, I  
305 found context lacking in what the past decades have seen in model development and

306 projects focusing on Arctic snowpacks. In modern-day science, which is highly project-  
307 driven, national funding agencies are one of the major sources of funding for model  
308 development. There is a lot of emphasis in the manuscript on lack of funding, lack of  
309 long-term perspective, focus on other regions than the Arctic, as well as a strong  
310 sentiment that these “modellers” supposedly live in their own world.

311 We find this interpretation misleading and incorrect. We particularly refer Reviewer 1  
312 to 3.2.2 Adaptability e.g. *“Although much literature argues that there is a conflict*  
313 *between academic freedom and solution-based or applied science (e.g. Henkel, 2005;*  
314 *Winter, 2009; Skea, 2019 etc), we found instead that adaptability and shifting priorities*  
315 *was integral to the participants” or “interdisciplinary collaborations were the key*  
316 *motivation for model development, demonstrating the participants' adaptability”*. For  
317 clarity, we will replace “participants” with “modellers” in the above sentence.

318 I would have expected to read much more about efforts undertaken by the Arctic snow  
319 community to support model development. How many proposals did they submit?  
320 How many were funded? How much of these funds was allocated for model  
321 development? I would have expected to see more hard data on this. Also more  
322 concrete information about decision making. I.e., if a proposal contains a modeling  
323 component, what model is selected and why? How is decided where to focus energy  
324 on model development?

325 Please see L93-110 above to see how the themes and sections in the manuscript  
326 address our aim. Some of these questions were addressed during the interviews, but  
327 not all answers are in the manuscript and, when they are, the information is scattered  
328 throughout the manuscript and, therefore, may be difficult to decrypt. We will be  
329 clearer in the revised version of the manuscript. We also wish to highlight that, while  
330 mixing quantitative and qualitative research methods can provide important  
331 information, this study is qualitative and therefore the interview transcripts are our  
332 “hard data” and quantitative answers were not specifically sought during the  
333 interviews

334 Right now, the manuscript comes across as a lot of complaining and finger-pointing.

335 The manuscript does not aim to complain or finger-point. It simply describes the  
336 research environment in which the participants evolve and which shapes and - given,  
337 amongst others, limited data availability and limited funding opportunities - constrains  
338 their decision-making. Many quotes reflect a much more collaborative environment  
339 than Reviewer 1 believes we describe (e.g. Section 3.2.2, L299-301, L380-385), but we  
340 agree that they can seem isolated and lost. We will ensure that explanatory text is  
341 clearer.

342 , but a bit more reporting on one’s own activities, including some concrete and  
343 objective data on funding, money spent, etc., would be expected given the goal set  
344 forth by the authors. Here, for example: [L116-118] *“In these discussions, it became*  
345 *clear that the current snow models fell short in representing all the Arctic snowpack*



346 *processes needed by project collaborators.” We will provide more detail about what*  
347 *was needed in CHARTER.*

348 and then expect there to be a free, open-source model that fits one's needs, with  
349 proper documentation and an email address that you can send all your questions to  
350 with efficient response times. That is just an unrealistic expectation. *These “unrealistic*  
351 *expectations” are not described in the manuscript and Reviewer 1’s comment is*  
352 *somewhat misleading.* In my opinion “modeling” should be an undertaking done by the  
353 community as a whole, where everyone contributes knowledge, expertise, skills, data,  
354 etc.

355 5. [L182] *“I’m sick of modelers who think the world is a computer screen”* This quote is a  
356 confirmation for me about the big problem of accessibility to fieldwork, combined with  
357 the “hero”-status attached to fieldwork (Nash et al, 2019). Many research positions  
358 including fieldwork ask for previous fieldwork experience, or, alternatively, “outdoor  
359 experience”. Particularly back-country skiers, (alpine) climbers, and hikers have an  
360 edge in securing snow-related fieldwork. And we know that “the outdoors” notoriously  
361 lacks diversity (e.g., Winter et al., 2020, Ho and Chang, 2022). Fieldwork is mostly  
362 accessible for PhD students, or senior scientists with previous fieldwork experience.  
363 Model developers often lack access to participating in fieldwork, and people without  
364 access to fieldwork mostly concentrate on doing modeling work. It’s important to note  
365 here that even when possibilities arise, fieldwork is not a safe environment for  
366 everyone (Marín-Spiotta et al., 2020), and that could be prohibitive for participation.  
367 The fact of the matter is that many researchers will never go to the field for a variety of  
368 reasons, which may require rethinking of the status of fieldwork (e.g., Bruun et al.,  
369 2023).

370 This quote was taken from a conversation during which I (CM) told the participant that  
371 some large-scale modellers had told me anecdotally (i.e. prior to the interviews  
372 conducted for this research) that improving the representation of snow in ESMs was  
373 much less important than improving clouds. The quote was a manifestation of the  
374 participant’s frustration with such claims. We will either provide more context or  
375 remove the quote.

376 We are well aware of the accessibility issues and of the much-needed enormous  
377 progress to make field work more accessible, diverse and inclusive. Had this theme  
378 emerged in our data analysis, we would have addressed it, but it did not. Undertones  
379 of endorsing the hero status did emerge in one conversation and were coded as such,  
380 but in order for codes to be included in the final themes, they had to be identified in  
381 multiple conversations, which, in this instance, was not the case. We will provide this  
382 methodological information in the Methods section in the revised manuscript.

383 The message delivered in this manuscript is mostly one-directional: [L96-97] *“The aim*  
384 *of this study is to understand why decisions made by modellers all over the world and*  
385 *over the past decades have not led to more (or is it “any”?) progress in Arctic snowpack*  
386 *modelling”,* combined with the statement *“I’m sick of modelers who think the world is a*  
387 *computer screen”.* There are more than 80 quotes in the manuscript and it is

388 misleading of Reviewer 1 to isolate one quote and to claim that this is our message.  
389 Reviewer 1 expects “proper scientific conduct” (L193 above) to be adopted by the  
390 authors; we expect the same from the reviewers.

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392 6. I so wish the authors would have written “by the Arctic snow community” instead of  
393 “by modellers”. I found this diversity, equity and inclusion aspect overwhelmingly  
394 missing from the manuscript. I will further detail my sentiments here in the “Epilogue”  
395 below. We will reword our aim or/and provide clarification regarding the different uses  
396 of “modeller”, aligning with Reviewer 1’s Minor comment #3.

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398 Minor comments:

399 1. Several statements and wordings are vague.

400 ○ [L96-97] *“The aim of this study is to understand why decisions made by*  
401 *modellers all over the world and over the past decades have not led to more*  
402 *(or is it “any”?) progress in Arctic snowpack modelling.”* See also my major  
403 concern #3. I think more effort is needed to document and quantify the  
404 progress that has been made, such that it can be objectively concluded  
405 whether or not this constitutes “progress”. As it stands, this statement  
406 carries little weight. In fact, the problems with snow modeling in the Arctic  
407 are poorly introduced in the manuscript. Only L88-95 discuss this aspect, but  
408 only very marginally.

409 This was already answered. See L292-297 above and L561-567 below of this  
410 reply.

411 ○ [L294-296] *“When I speak to large scale modellers about rain on snow, the*  
412 *feedback is usually ‘we are aware that something needs to be done, but we*  
413 *have other priorities and we don’t have resources for this’. It’s not*  
414 *straightforward.”*

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416 I think I understand what this is about because of my expertise, but for  
417 reaching a broader audience, it should be made explicit. Please specify what  
418 the issues with rain-on-snow are. Is it the precipitation phase separation rain  
419 vs snow, is it the runoff from a snowpack, is it the formation of ice lenses?  
420 Also, academia is almost fully project driven, so why not write a proposal or  
421 provide funding otherwise for a model developer to work on improving the  
422 “rain-on-snow” problems in a model? I think this also relates to my major  
423 concern #3, listed above, regarding missing context.

424 We will clarify.

425 ○ [L372-373] *“the first thing it would do is alert the modelers to the difficulties*  
426 *that they have in the Arctic that, in the absence of these evaluations, they*  
427 *wouldn't even know about...”* Please provide examples. The statement

428 suggests that the interviewee knows about difficulties that the modelers  
429 supposedly don't know about. I deem it inadequate to publish a paper with  
430 statements like that, without sufficient backing up of examples, preferably  
431 using peer-reviewed literature. As mentioned previously, we are interested in  
432 how the opinion of decision-makers - in other words their truth based on  
433 their experience, expertise and perspective - inform their decisions. This  
434 quote is about the need to implement a Tundra-SnowMIP and is consistent  
435 with one of the aims of the previous SnowMIP i.e. ESM-SnowMIP, which was  
436 to "identifying previously unrecognized weaknesses in these models"  
437 (Krinner et al., 2018)

- 438 ○ [L310-311] *"I mean, the idea that you're going to create an arctic snow model*  
439 *in a PhD is...?!"*

440 This is an incomplete sentence, and I'm not sure what I need to fill in at the  
441 "...?!". Please add some explanation here.

442 We will.

- 443 ○ [L537-538] *"Some users of [our model], they probably don't know what*  
444 *they're doing, and sometimes a paper comes where I say ???"*

445  
446 Please fill in the "???" here. With my social background, I think I understand  
447 what "???" and "?!" is supposed to indicate, but for non-native English  
448 speakers, I think there is a risk here that they don't get the implicit message.

449 We will.

- 450 2. There were a few quotes that I think are wrong, and I wonder if there should not be an  
451 editorial comment that the statement is deemed inaccurate.

- 452 ○ For example, looking at the publications involving Crocus over the last 10 years,  
453 I don't think the statement [L237] "But, I mean Crocus, it's an avalanche model,  
454 right?" is accurate.

- 455 ○ Similarly, [L282-L284] *"[Models] are limiting the number of [snow] layers for*  
456 *computational stability and efficiency so they are not respecting the way in*  
457 *which the snow pack is actually built up i.e. in episodic snowfall events, which*  
458 *will form different layers (...)"*. For models like Crocus and SNOWPACK, it is  
459 trivially easy to avoid a limiting number of snow layers. I think it is important to  
460 make an editorial remark, since otherwise, false information gets propagated.

461 This was already answered. See L122-159 above.

- 462 3. Extensive use of the term "Modeller": I'm not sure the word "modeler" is meaningful.  
463 Even the authors seem to have an ambivalent definition, defining it both as "model  
464 developer" [L127] as well as "with expertise in modeling" [L128]. I think there is a  
465 substantial difference between both. Note that in L132, both SPM and LSM "modelers"  
466 are defined as "model developers". Personally, I think labeling someone as a "modeler"  
467 often attaches an identity to an individual, where this is not justified. It also has unclear  
468 meaning. Is it someone who uses the model, or someone who develops for the model,  
469 or is it someone who maintains the model code? Is someone who has used a model

470 once in their research career already a “modeler”, or is it someone who uses models in  
471 more than, let’s say, 50% of their research? I would rather like to see more exact  
472 wording being used, specifically focusing on the role someone has. Like “model user”,  
473 “model developer” or “model maintainer”. I think IPCC rightfully avoids the word  
474 modeler (referring to L546). But thinking about roles avoids attaching an identity to a  
475 researcher, while allowing to encapsulate the common situation where researchers can  
476 take up different roles during their career, or even within a single project.

477 We will provide more exact wording.

478 4. [L427-428]: “We argue that efforts to represent Arctic snowpack processes would pave  
479 the way in the research areas highlighted below for new interdisciplinary  
480 collaborations”. What follows are three rather specific research directions. Not that I  
481 want to argue about their relevance, it is just missing context why those three are  
482 listed, who has set these priorities? Did this come out of the interviews as well?

483 They did. We will clarify.

484

485 Epilogue

486 I also would like to stress that the manuscript contained quite some material that to me  
487 came across as somewhat “aggressive”. I would like to make the authors aware that it left  
488 me with the impression of a poorly working field, with a lack of communication,  
489 collaboration and a missing cooperative mindset.

490 We note Reviewer 1’s concern.

491 Below, Reviewer 1 expressed concerns about the manuscript not fostering a healthy,  
492 welcoming, open environment and objects to specific quotes being used. Reviewer 1 also  
493 accuses us of “heavy cherry-picking”, of making up data (“these sorts of things apparently  
494 have been said in the interviews”), of misleading the participants (“Maybe the interviewees  
495 expressed themselves somewhat awkwardly because they also felt like they were in an  
496 informal private conversation”), of having no consideration for equ(al)ity, diversity and  
497 inclusion. These are very strong accusations of data falsification, manipulation and selection  
498 i.e. of instances of research misconduct. We hope that Reviewer 1 understands that they  
499 were mistaken, now that we have clarified that (1) these quotes are not presented as  
500 “truths” but as opinions that contribute to informing decisions, (2) these quotes illustrate  
501 the themes that were identified during the thematic analysis, (3) that the themes are about  
502 decision making and therefore serve to answer our research question, and (4) qualitative  
503 data (here the quotes) are data and that this is a research paper which followed established  
504 methodologies. As mentioned above, we will revise the manuscript to ensure that this  
505 process is clear to all readers.

506 We would also like to mention that the review process is not an “open” environment either.  
507 While Copernicus publications are leaders in the peer-review process and have dramatically  
508 improved reviewing by making it open-access, reviewers still can, as is the case for Reviewer

509 1, remain anonymous; a choice we, of course, respect. Nevertheless, there is a power  
510 imbalance in single-blinded reviews (see e.g. Manchikanti et al., 2015; Parmanne et al.,  
511 2023) and with power comes responsibility. We trust that this responsibility includes not  
512 accusing authors of misconduct until having given them the opportunity to prove otherwise.

513 Examples:

514 [L182] *"I'm sick of modelers who think the world is a computer screen"*

515

516 In fact, many scientists have no other choice but to focus on modeling, since fieldwork in  
517 polar regions is generally poorly accessible (Nash et al., 2019, Karplus et al., 2022). I know  
518 scientists who would give an arm and a leg to go to the field just once, and probably doing  
519 so would increase the quality of their model development efforts considerably. The phrasing  
520 of this statement suggests that the scientist never considered that they could have made an  
521 effort to bring the *"modelers who think the world is a computer screen"* in closer contact  
522 with the real world, instead of saying that they are "sick" of them. [This was already](#)  
523 [addressed L366-378 of this reply.](#)

524 [L184-185] *"The[se] models spend so much time doing things that aren't very important for*  
525 *lots of applications that they're kind of worthless"*

526

527 Claiming that work done by fellow scientists is worthless, because it doesn't fit one's own  
528 needs, is detrimental to a healthy, open and welcoming academic atmosphere I think.

529 We wish to clarify that almost half of the quotes used in this manuscript are from modellers  
530 reflecting on their own practice and community (hence L569 *"the novelty here is that it is an*  
531 *insider's job. It is a reflective exercise"*). As mentioned L159 in the manuscript, we decided  
532 not to indicate which quotes came from which group unless necessary to improve  
533 understanding of the context within which they were cited. We understand thanks to  
534 Reviewer 1's comments that we must revise this decision and be clearer about which group  
535 the quotes came from. We hope that it will make it clearer that the manuscript is not a  
536 criticism of modellers, but a reflective process that includes modellers and other members  
537 of the Arctic snow community.

538

539

540 [L537-538] *"Some users of [our model], they probably don't know what they're doing, and*  
541 *sometimes a paper comes where I say ???"*

542

543 First of all, I'm not really sure what I have to fill in at the "???", but I assume it is some  
544 negative sentiment. In these cases, reaching out to those users can be of great help to the  
545 users, and would foster exchange of knowledge, and, again, an open and welcoming  
546 academic environment.

547 We make it clear in Section 3.2.2 Adaptability that modellers do collaborate extensively.  
548 Reviewer 1's comment proposes a solution to an issue that our manuscript identified. As we  
549 wrote in the Conclusion, *we hope that this reflective exercise will be the start rather than the*  
550 *end point of the conversation.* For example, the EDI issues in fieldwork that Reviewer 1

551 highlighted are only starting to be tackled because recent papers have exposed these issues  
552 and those who want to change the system now have academic papers to back their  
553 initiatives. As highlighted in the Conclusion, we argue that our manuscript serves a similar  
554 purpose. It addresses issues that are well-known but have remained hidden in the literature.  
555 Visibility is key to changing practices and our manuscript contributes to making some of the  
556 issues more visible in order to address them.

557 [L374-375] *"In my sense, large scale climate modellers aren't sufficiently aware of snow. (...)*  
558 *There are so many people who don't care about that"*

559

560 I find this quite the accusation that those people don't care. Please provide evidence that  
561 they don't care, for example from reviews of proposals and/or manuscripts. Did papers in  
562 fact get rejected, because reviewers claim that snow is irrelevant? See L532-538 in the  
563 manuscript for examples provided by other participants of how snow is treated in some  
564 manuscript using large scale models. I'm skeptical that that is the case.

565 [L96-97] *"The aim of this study is to understand why decisions made by modellers all over*  
566 *the world and over the past decades have not led to more (or is it "any"?) progress in Arctic*  
567 *snowpack modelling, ..."*

568

569 I understand that the phrasing "(or is it "any"?)" is catchy, but it comes across a bit as  
570 dismissive towards publications from, let's say, the last 10 to 20 years, documenting  
571 improvements in modeling approaches, some of which are cited in the manuscript. I would  
572 strongly encourage more precise wording. We agree. As mentioned, L384-385 of this reply,  
573 the aim will be reworded.

574 Which objective has not been achieved (yet)? The statement that directly precedes *"The*  
575 *aim of this study etc"* answers this question *"No ESM, so far, simulates these Arctic*  
576 *snowpack processes"*. As already stated above, we will ensure that sufficient information is  
577 provided for the reader to have enough context, but we maintain this statement to be  
578 accurate with regards to the representation of the snow profile of Arctic snowpacks, vapour  
579 fluxes and ice crust formation in ESMs. We welcome references from Reviewer 1 that could  
580 inform us otherwise.

581

582 All the points below have already been made by Reviewer 1 and addressed by the authors  
583 multiple times. There will, therefore, be no further comments.

584 Also, this phrasing implies that "modelers" are to blame for the supposedly slow progress. In  
585 fact, the manuscript discusses very few decisions made by "modelers" (interpreted by me  
586 here as model developers). And also in light of the sentences I have listed above, I think this  
587 is unfair. There seems to be a lack of healthy collaboration in the field. I am also aware that  
588 there is also a big issue with accessibility (diversity and inclusion) to fieldwork, that in my  
589 opinion plays a role here.

590 There are also funding agencies, and hiring decisions that I think are to blame for a lack of  
591 resources for model development. Some of those are addressed in the manuscript, some of

592 those are not. But it would have been better to phrase the aim of the study as: “The aim of  
593 this study is to understand why decisions made by the Arctic snow community all over the  
594 world and over the past decades have not led to more progress in Arctic snowpack  
595 modelling, ...”

596 I put this feedback as “Epilogue”, because for me, it is not relevant to whether or not the  
597 manuscript could be published as a scientific research article, but I hope the authors  
598 become aware that including statements like these, unfortunately left me with the  
599 impression that the field of Arctic snow is a somewhat unhealthy environment, with some  
600 missing collaborative mindset. In a way, I think it’s already a problem that these sorts of  
601 things apparently have been said in the interviews, but maybe this was simply the heat of  
602 the moment. Maybe the interviewees expressed themselves somewhat awkwardly because  
603 they also felt like they were in an informal private conversation. It is also very possible that  
604 context or tone went missing in the transcription and the quote selection for the  
605 manuscript.

606 One could argue that it may be important to report about such sentiments in the field, since  
607 it can signal problems hindering progress. However, it would require proper context,  
608 including identifying this as a problem, and proposing pathways forward to resolve such  
609 conflicts. I think that the authors should seriously consider the purpose, and effect, of  
610 including statements like these in the manuscript.

611 In my opinion, it doesn’t reflect well on the Arctic snow community, and I refuse to believe  
612 that this is the message the authors wanted to get across.

613

614

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659

660 All other references can be found in the manuscript.

661