Dear Editor:

Thank you for your kind letter of “TC-2022-27 (author) - file upload for peer-review completion” on May 25, 2022. We have revised the manuscript “Wind Conditions for Snow Cornice Formation in a Wind Tunnel” in accordance with the reviewers’ comments and carefully proofread the manuscript to minimize grammatical and bibliographical errors during the last two months. Below is our revision description according to the reviewers’ comments. The font color of the comments is black, the responses in blue, and the revisions in red.

Point-By-Point Reply to Editor's Comments

1. Thank you for your extensive and detailed response to the reviewer comments, which is really helpful. The main issue is the dissertation on this topic, which you indicate is sufficiently different from your study for a variety of reasons. Please could you go ahead and amend your paper as you suggest with extra attention paid to the comparison between this study and the dissertation.

Response: We are grateful to the editor for her encouraging comments and constructive suggestions. We appreciate she gave us the opportunity to resubmit the revised manuscript and the chance to make a comparison between our work and the Japanese dissertation of Naito and Kobayashi (1986) (abbreviated as N&K86 below). Here we highlight our differences:

(1) So far, there are few laboratory experiments on cornice formation, except for the work of N&K86. However, due to the language gap, few researchers have noticed this non-peer-reviewed Japanese dissertation. Our work can not only enhance the reliability of N&K86 by reproducing their results but also attract more researchers’ attention to the snow cornice topic through full peer review and open discussions, which is still valuable.

(2) We recorded the whole cornice formation by implementing a state-of-art technology: the shadowgraphy method, which allowed us to present more details on snow cornice formation. For example, we quantitively measured the whole growth process of snow cornice. We recorded the time series of cornice growth rates in length and thickness and particle mass flux in the air, etc. These experimental data are fundamental for further conceptual investigation of cornice formation.

(3) We proposed a conceptual model to explain the length and thickness growth of snow cornice based on the mass balance conservation and the experimental results, which have a good consistent with the field observation results in Gruvefjellet, Svalbard, Norway (Vogel et al., 2012; Hancock et al., 2020).

(4) We also tested the factors of the air temperature and grain shape on the snow cornice formation. However, these effects are not dominant as the wind speed. Thus, in this manuscript, we mainly focused on the wind effects and didn’t mention these results.

More details can be seen in the revised manuscript. For example, we summarized their work and pointed out the open scientific questions in lines 30-31: “Naito and Kobayashi (1986) measured the suitable wind speed for cornice formation is between

4 m s^{-1} to 8 m s^{-1}, at 1 m above the snow surface in the field and at the center (0.5 m height) in the wind tunnel." and lines 46-53: "There are few laboratory experiments on cornice formation except Naruse (1985) and Naito and Kobayashi (1986). Naito and Kobayashi (1986) carried out experiments both in the wind tunnel and in the field, observing the process of snow cornice. They described the snow cornice formation as a process that snow particles adhere one after another at the leeward edge, in the form of a thin slab of snow elongating leeward, then the slab hangs down under its weight, depositing drifted snow particles on it. However, quantitative descriptions of this process have not been reported. Their results show that the cornice growth under suitable conditions of the air temperature is between -20 ºC to 0 ºC, the wind speed is between 4 m s^{-1} to 8 m s^{-1}, and fresh snow with an irregular dendritic shape. However, further quantitative analysis of experiments has not been carried out."

In section 3.2, we added the comparison results of our collection rates value in lines 165-169:

"A non-dimensional wind speed $\tilde{u} = \frac{u}{u_t}$ is defined here to compare with the experimental results of Naito and Kobayashi (1986). In this definition, u_t is the threshold wind speed which can be considered as the lower limit wind speed value for cornice growth. As is shown in Fig. 5, the mass collection efficiency in both experiments decreases with the increasing wind speed and the corresponding drift rate. Our experimental results are much larger than that in N&K86, which is mainly due to the different wind tunnel sizes."

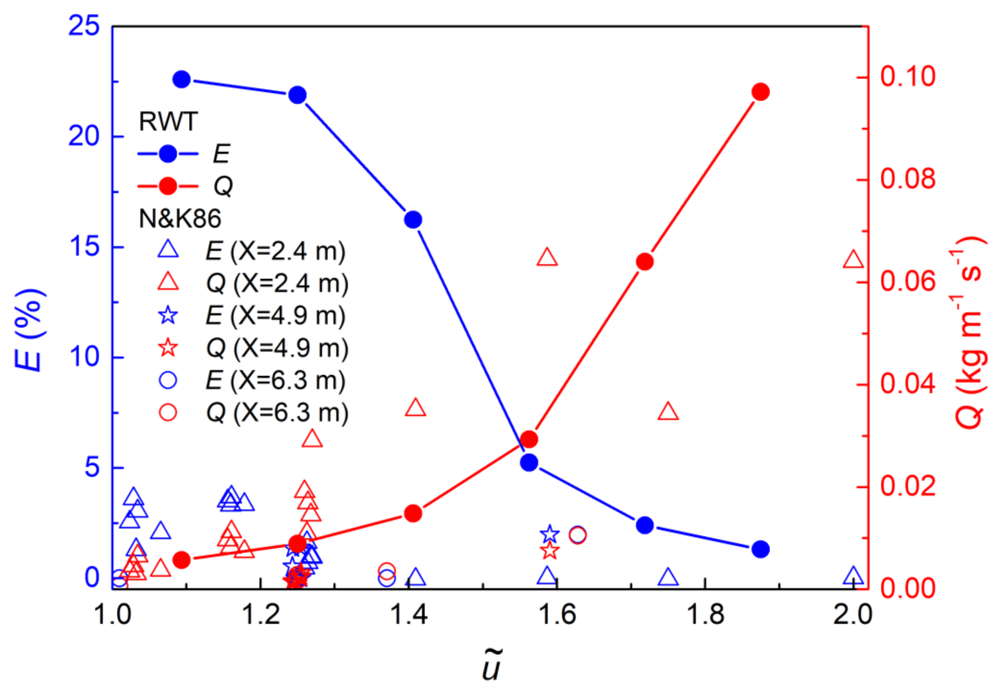

Fig. 5 Collection efficiency E (in blue) and snow transport rate Q (in red) under different non-dimensional wind speeds $\tilde{u}$. X represents the distance from the snow particle feeding point to the mass collection pits where the cornice grows. Lines are for ring

wind-tunnel experiments, hollow scatters are for N&K86. N&K86 represents the experiment results of (Naito and Kobayashi, 1986).

2. I recommend one further change to remove the word 'testing' from your new proposed title so that it reads 'Wind Conditions for Snow Cornice Formation in a Wind Tunnel'.

Response: Thanks for your insightful suggestion. We have revised the title to:
"Wind Conditions for Snow Cornice Formation in a Wind Tunnel".

Point-By-Point Reply to Referee #1's Comments

1. Investigations of snow cornice development is worthwhile since its collapse is strongly related to the snow avalanche release; I cannot agree with you more. In this study, the leading-edge technology including the closed-circuit wind tunnel and the shadow graph imaging technologies. I appreciate very much for the efforts by authors.

Response: We thank the reviewer for a positive view on the importance of the subject covered by our submission.

2. However, that is all. Similar experiments in the wind tunnel were carried out more than 35 years ago by a master student as shown below and much more meaningful outcomes were obtained.

Naitou, A. and Kobayashi, D., Experimental Study on the Generation of a Snow Cornice, Low temperature science. Series A, Physical sciences, 44, 91-101, 1986.

https://eprints.lib.hokudai.ac.jp/dspace/bitstream/2115/18521/1/44_p91-101.pdf

Unfortunately, the text is written in Japanese. However, it cannot be an excuse, since English summary is attached, in which the wind speed of 4 to 8 m/s is suitable for the cornice formation, and the capture coefficient of drifting snow is also referred. Incidentally, I suppose some of the authors can recognize Chinese characters and are understandable what is mentioned in the test as well more or less. Please read through carefully.

Response: We are sorry that we didn't find this thesis before. Many thanks for mentioning this paper, and we have tried our best to translate and strive to understand the content correctly. In the revised manuscript, we highlighted the innovations of our work and the progress compared to this paper. We have introduced this work in the introduction section, in lines 46-53: "There are few laboratory experiments on cornice formation except Naruse (1985) and Naito and Kobayashi (1986). Naito and Kobayashi (1986) carried out experiments both in the wind tunnel and in the field, observing the process of snow cornice. They described the snow cornice formation as a process that snow particles adhere one after another at the leeward edge, in the form of a thin slab of snow elongating leeward, then the slab hangs down under its weight, depositing drifted snow particles on it. However, quantitative descriptions of this process have not been reported. Their results show that the cornice growth under suitable conditions of the air temperature is between -20 °C to 0 °C, the wind speed is between 4 m s^{-1} to 8 m s^{-1}, and fresh snow with an irregular dendritic shape. However, further quantitative analysis of experiments has not been carried out."

And in section 3.2, we added the comparison results of our collection rates value in lines 165-169: "A non-dimensional wind speed $\tilde{u} = \frac{u}{u_t}$ is defined here to compare with the experimental results of Naito and Kobayashi (1986). In this definition, u_t is the threshold wind speed which can be considered as the lower limit wind speed value for cornice growth. As is shown in Fig. 5, the mass collection efficiency in both experiments decreases with the increasing wind speed and the corresponding drift rate. Our experimental results are much larger than that in N&K86, which is mainly due to the different wind tunnel sizes."

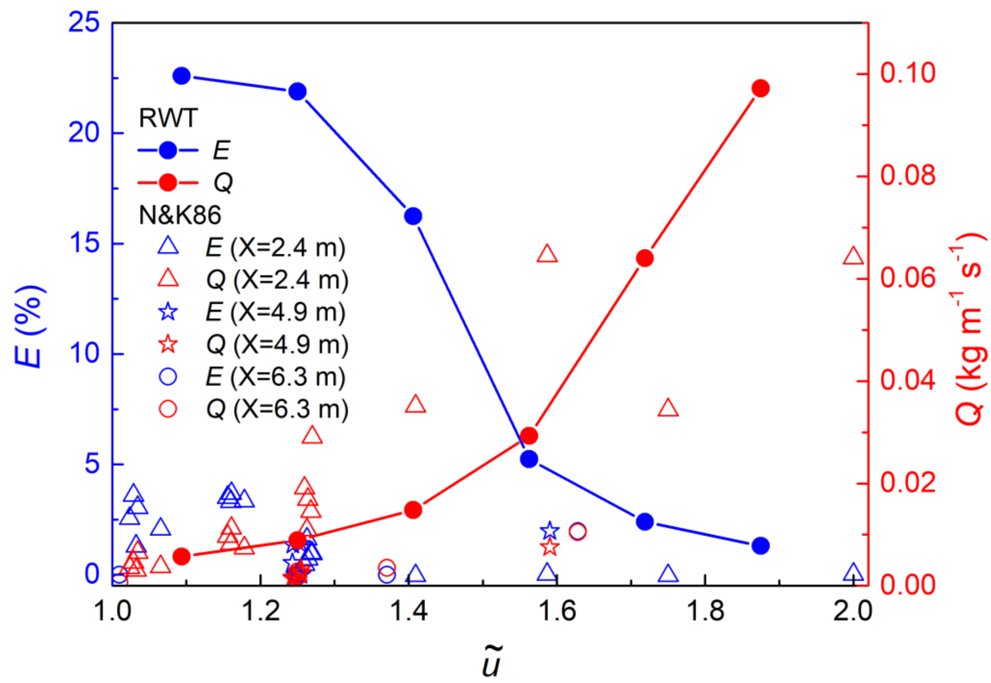

Fig. 5 Collection efficiency *E* (in blue) and snow transport rate *Q* (in red) under different non-dimensional wind speeds $\tilde{u}$. X represents the distance from the snow particle feeding point to the mass collection pits where the cornice grows. Lines are for ring wind-tunnel experiments, hollow scatters are for N&K86. N&K86 represents the experiment results of (Naito and Kobayashi, 1986).

3. Dependencies on not only the air temperature but also crystal shape, which are listed as the future work in the submitted manuscript, have been already studied. Thus, from my point of view, nothing looks new and no findings which deepen our understandings of the snow cornice formation mechanism are introduced in the submitted manuscript.

Response: We disagree that our paper does not present any new insights. No more relevant experimental work has been published except N&K86's work as the reviewer mentioned. Considering this, we think there are still many open scientific questions on cornice formation. In N&K86's paper, which has not gone through peer review, potential factors such as wind speed, air temperature, crystal shape, and mass flux have been investigated with respect to the phenomenon of cornice growth. However, the effects are still not fully understood with solid evidence and data from our point of view. In all, for cornice formation research, more detailed physical mechanism explanations and solid scientifical evidence are still lacking. A detailed comparison of four aspects is presented in reply to Editor.

In summary, compared to N&K86's work, we obtained the following new results, which deepens the understanding of the snow cornice formation mechanism by quantitative analysis of the macro variables:

1) Offering an explanation of the cornices only growing at suitable wind speeds. From the macro view, cornice growth is the dynamic mass balance between deposition and erosion. The wind speed range is limited by the comprehensive effects of drifting snow

deposition and erosion on the edge of the ridge. The lower limit wind speed for cornice growth is approximately equal to the threshold wind speed for transport. The upper limit of wind speed is when the erosion rate is over the pure deposition rate.

2) Finding the cornice growth process has two stages: In the first stage, a thin slab grows and overhangs at the edge. In the second stage, cornice thickness and length both increase simultaneously.

3) The cornice only grows at a moderate wind speed range (1-2.03 $\tilde{u}$). The length growth rate gets maximum at the wind speed is 40 % over the threshold.

4) Finding that the collection rates of snow cornice growth decrease with increasing wind speed, and it cannot directly reflect the cornice growth characteristics. Instead, the pure deposition rates, the erosion rates, and the growth rates both in length and thickness were analyzed separately for all wind conditions. From the results, we can conclude that in all wind conditions, the cornice starts to grow when the wind speed exceeds the threshold value and starts to scour when the erosion rate is over the pure deposition rate.

5) Setting up a conceptual model to estimate the suitable wind speed range for cornice growth and the length growth rate of a cornice. The estimation results are in good consistency with the field observation results.

4. Further, the discussions, in which authors argue the similarities between the wind tunnel experiments and the observations in the fields, look odd. As is common for the researchers working on blowing/drifting snow, the blowing threshold wind speed in nature is around 5 m/s at 2 to 3 m high (not 11 m/s!), which roughly corresponds to the friction velocity of 0.2 to 0.3 m/s. If you assume, Ut 0.4m=3.2 m/s in the wind tunnel corresponds to Ut2.8m=11m/s in the field, friction velocity and the roughness length will be calculated extremely large (roughly u*=2.4 m/s, z0=0.235m !!; in usual former should be 0.3 to 0.4 m/s and the latter the order of 10-4 m). Thus, discussions below line 175 in this manuscript sound meaningless.

Response: Sorry for the misunderstanding we have caused. 0.4 m and 2.8 m are the heights of the wind speed sensors. However, both in our experiment and in the field the sensors are not directly over the ridge. For our experiment, the wind velocity is measured by a MiniAir sensor installed at the entrance of S2, while the cornice study area is 0.5 m downward, with a height of 0.125 m. For the field observation, the wind speed data comes from an automatic weather station - Gruvefjellet meteorological station (464 m a.s.l.), located centrally on the plateau, 300 m from the study site, where the cornice study site is along the edge of the plateau mountain Gruvefjellet (~460 m a.s.l.). Thus, the logarithmic wind profiles are not directly available in this situation. Meanwhile, we observed that the cornice grew since the drifting snow started our experiment. Thus, we defined the threshold wind speed u_t as the wind speed when drifting snow starts, namely the wind speed that a cornice starts to grow.

We used the **nondimensionalization method** to unify the wind speed range between field studies and our laboratory works by using u_t. In our experiments, the cornice accretion starts after the wind speed exceeds 3.2 m s^{-1} with enough snow supply, and no cornice formation when the wind speed is below it (e.g., 3.0 m s^{-1}). In field observation, Vogel et al. (2012) surmised that cornice accretion proceeded during both entire snow seasons (46 h in 2008/2009, 54 h in 2009/2010), when hourly maximum wind speed is averaged of 12 m s^{-1}, with a minimum of at least **10 m s^{-1}**, marking the lower limit of the cornice accretion. Eckerstorfer et al. (2012) measured that the initial cornice accretion started along the plateau edge during the first snowfall (10-12, Oct. 2010) with a maximum wind speed of **11 m s^{-1}**. We found that the corresponding averaged wind speed is about 7.37± 0.97 m s^{-1} when the maximum wind speed is in the range of 10.5~11.5 m s^{-1}, by analyzing the time series of wind speed data from Gruvefjellet meteo station (http://158.39.149.183/Gruvefjellet/index.html), and the friction velocity is about 0.288 m s^{-1} by using $z_0 = 10^{-4}$ m. Considering the harder snow surface in Gruvefjellet (Eckerstorfer et al., 2012), this wind speed value is comparable to the threshold wind speed in previous literature. Considering the wind in the field is gustier and more turbulent compared to the wind tunnel, the actual threshold wind speed value for cornice growth in the non-dimensional calculation should equal the maximum value of the threshold wind speed measured in the field, according to the study of Li et al. (2020, DOI: 10.1029/2019GL086574). Thus, we chose the maximum wind speed value of 10 m s^{-1} as the threshold wind velocity.

To avoid misunderstanding, we set up a new conceptual model for interpreting the inner mechanism of cornice growth and compared the estimation cornice growth rate with the field observation in section 4 Discussion.

5. Preferably, missing link between the 4 cm long and 5 mm thick cornice observed in the wind tunnel and the several-meter scale of cornice formed leeside of the mountain ridge should be also referred to answer the motivation in the introduction part.

Response: Thanks for this insightful suggestion. In the field, snow cornices form in snowstorms that can last a few hours and can have multiple growth periods during the snow season, which leads to a much larger scale. The shape and the size of the cornices are indeed an interesting topic, but our experiment here is not mainly focused on it. Due to the limitation of the field of view of the camera, our experiment didn't last until the final state of the snow cornice growth. In this work, we mainly focused on the laws of growth rates in the initial state and relevant physical explanations.

In the revised manuscript, we added the link in the introduction section from lines 58-60:

"Therefore, wind tunnel experiments with controlled environmental conditions and quantitative descriptions of the individual cornice formation process as a pathway to improve the understanding of cornice dynamics in the field, particularly on the wind effects on cornice formation, are essential."

And in the results section from lines 202-204:

"The presented framework for characterizing cornice accretion may provide a basis for future field and laboratory studies under different conditions."

Moreover, based on the experimental results, we proposed a conceptual model (in the discussion section) that can explain the mechanism for cornice growth in length and thickness. We estimated the suitable wind speed range and the growth rate of the cornice in the field and compared the results with the field observations from Vogel et al. (2012) and Hancock et al. (2020), which are in the good consistent.

Point-By-Point Reply to Referee #2's Comments

General comments:

1. I appreciate the opportunity to review the manuscript entitled "Environmental Conditions for Snow Cornice Formation tested in a Wind Tunnel." In this study, the authors seek to improve the process understanding of snow cornice formation by conducting wind tunnel experiments in a cold laboratory. Specifically, the authors simulate cornice development in the wind tunnel by forcing snow particles made by a snowmaker over a small "ridge" of compacted snow at various wind speeds. Cross-sectional photographs of the model ridge and associated cornices taken with high temporal resolution help illustrate cornice development under different wind speeds. The manuscript in its current form is generally well-written, with few grammatical errors and clear language. The authors describe their methodology such that future work can easily repeat, and thus build upon, the present experiments. Figures are relevant, clear, and appropriately described. I found the combination of the repeatable methodology and associated results to be a relevant basis for future field studies and would like to complement the authors on their work.

Relatively few, to my knowledge, studies in the last couple decades have addressed cornice formation in laboratory settings. I think such laboratory studies offer a compelling avenue to improve our understanding of cornice processes and refine conclusions derived from field data. The methods employed by the authors in the current study therefore have the potential to augment recent field investigations by better constraining the environmental conditions influencing various processes of cornice dynamics (e.g. wind speeds leading to cornice accretion). Such work falls within the scope of *The Cryosphere* and will be of interest to an audience of snow researchers and practitioners working with cornice-related avalanche problems.

Response: We thank the reviewer for the positive feedback on the general aspects of our work. We really appreciate your efforts in reviewing this manuscript. In the following, we respond point by point to your comments.

2. In this context, although the manuscript provides a decent overview of some previous work and general cornice-related concepts, the current introduction does not, in my opinion, adequately address the scientific framework for the current study. Specifically, the introduction fails to effectively link the referenced field studies to the "macroscopic view" mentioned in the abstract and laboratory methods presented in the current work. The authors should, in my opinion, considerably expand the introduction to better introduce and justify the laboratory methods employed in this work as pathway to improve the understanding of cornice dynamics in the field.

Response: Thanks for your insightful suggestion. We linked the fieldwork with the experimental research by pointing out the constraints from the field observation and wind tunnel experiment as the pathway to improving our understanding of the cornice dynamics. In the revised manuscript, we added the link in the introduction section from lines 58-60:

"Therefore, wind tunnel experiments with controlled environmental conditions and quantitative descriptions of the individual cornice formation process as a pathway to improve the understanding of cornice dynamics in the field, particularly on the wind effects on cornice formation, are essential."

And in the results section from lines 201-203:

"The presented framework for characterizing cornice accretion may provide a basis for future field and laboratory studies under different conditions."

3. In such an expanded introduction, the authors would have an opportunity to cite the Naitou and Kobayashi paper referenced by reviewer #1 (which, to be fair, I also had not read previously) in addition to other laboratory experiments serving as a basis for the presented work.

Response: Thanks for your advice. We have introduced the work of Naito and Kobayashi in the revised manuscript, in lines 46-53: "There are few laboratory experiments on cornice formation except Naruse (1985) and Naito and Kobayashi (1986). Naito and Kobayashi (1986) carried out experiments both in the wind tunnel and in the field, observing the process of snow cornice. They described the snow cornice formation as a process that snow particles adhere one after another at the leeward edge, in the form of a thin slab of snow elongating leeward, then the slab hangs down under its weight, depositing drifted snow particles on it. However, quantitative descriptions of this process have not been reported. Their results show that the cornice growth under suitable conditions of the air temperature is between -20 °C to 0 °C, the wind speed is between 4 m s^{-1} to 8 m s^{-1}, and fresh snow with an irregular dendritic shape. However, further quantitative analysis of experiments has not been carried out."

4. Additionally, the authors could help guide the reader by more specifically stating which aspects or processes of cornice formation they sought to investigate with their wind tunnel experiments – e.g., explicitly state what processes currently unresolved by field studies you hope to address in the laboratory. See also the specific comments related to content in the introduction.

Response: Thank you for this valuable suggestion. We have rewritten the section introduction by directly pointing out these open questions currently unresolved by the field studies, and we investigated them in the RWT experiments. In the introduction, we pointed out the open questions in lines 36-37: "However, to our best knowledge, this discrepancy and the conditions under which certain wind speed ranges apply have not been investigated." lines 43-46: "Due to the compromise of these field observations, continuous observations on individual cornice accretion and failure events are hard to achieve (Hancock et al., 2020). Specifically, measuring the horizontal growth of snow cornice (Vogel et al., 2012) and recording dynamic details of snow mass transport simultaneously is hard to achieve." lines 52-56: "However, further quantitative analysis of experiments has not been carried out. Mott et al. (2010) have indicated that snow cornice formation is mainly through snow distribution processes driven by saltation. However, due to the lack of physical mechanism of snow cornice formation, cornice characteristic features could not be reproduced in numerical simulation of snow distribution in mountain areas (Gauer2001). Thus, there is still no snow cornice prediction model that could be used in avalanche prevention so far."

5. My other major concern with the manuscript in its current form stems from the results

and discussion in Section 3.2. In general, I think splitting the combined results and discussion section here could help with clarity (e.g. split the calculations and numerical results into a results section and the associated discussion into its own section).

Response: Thanks for your suggestion. We have split the result section into two parts. Now the result section is only for the presentation of the experimental data of cornice formation, such as length growth rate. The discussion section proposed a conceptual model based on the experimental results, as well as its application in the field. Please see more details in the revised manuscript.

6. However, the main issue stems from the selection of the appropriate wind speed range for cornice growth in the field. The authors cite our 2020 paper as stating the wind speed range for cornice growth in the field is 12-30 m s^{-1}.

Unfortunately, this is a mischaracterization of the results from that paper. Vogel et al. (2012) determined cornice accretion occurred during periods with hourly maximum wind speeds of 12 m s^{-1} and observed cornice scouring when maximum hourly wind speeds were as low as 15 m s^{-1}. In our 2020 work, the temporal constraints on our TLS measurements of cornice accretion were relatively poor and did not allow us to effectively determine a lower threshold wind speed for which cornice accretion begins to occur. Instead – and admittedly this is a weakness in that study – we simply used 5 m s^{-1} as a conservative lower threshold for snow transport (and therefore, we assumed, cornice accretion) derived from the literature. Accordingly, although the comparison between the authors' experiments and field studies from lines 172 – 202 is interesting and relevant for this work, I think the authors should redo their calculations with a more appropriate $U_{t2.8}$ value.

My suggestion here would be to consider that field studies often struggle to determine the threshold wind speeds for cornice accretion and/or scouring due to temporal or spatial constraints on data acquisition. Laboratory experiments such as the current study can help better determine these thresholds, and therefore one option would be to extrapolate a "field" $U_{t2.8}$ based on your measured $U_{t0.4}$ and a logarithmic wind profile. This would then allow the authors to discuss how their results can help address gaps in field studies (e.g. more specifically constrain the wind speeds at which cornice accretion happens, with the wind speeds expressed for the height at which standard meteorological observations occur). In the conclusions, however, I would appreciate a link between your measurements (e.g. cornice growth occurs between 3.5 and 6 m s^{-1}) and the corresponding "field" wind speeds which will be more relevant, especially, for practitioners interested in your work.

Response: Sorry for our misleading expressions using $U_{t0.4}$ and $U_{t2.8}$. Here, it is not suitable for us to use the logarithmic wind profile to link the laboratory experiments and field observations for the following reasons:

1) A well-developed boundary layer cannot be generated in the ring wind tunnel.

2) The wind speed sensor is installed at the height of 0.4 m in the inlet of section S2, 0.5 m upstream of the ridge edge, which is not the real wind speed over the cornice (0.125 m in height), while the field observation station is located 400 m upstream of the cornice study site that contains a 220 m plateau ridgeline, which is also not the real wind speed over the cornice, moreover there is a height difference between the field observation station (Gruvefjellet met station, 464 m a.s.l.) and the cornice study site (about 460 m a.s.l., Figure 2 in the paper of Vogel et al. 2012).

Thus, we used the nondimensionalization method to unify the wind speed range between field studies and our laboratory works, using the threshold speed. In our experiments, the cornice accretion starts after the wind speed exceeds the threshold wind speed (3.2 m s^{-1}) with enough snow supply, and no cornice formation when the wind speed is below it (e.g., 3.0 m s^{-1}). In field observation, Vogel et al. (2012) surmised that cornice accretion proceeded during both entire snow seasons (46h in 2008/2009, 54h in 2009/2010), when wind speeds averaged 12 m s^{-1}, with a minimum of at least **10 m s^{-1}**, marking the lower limit of the cornice accretion; Eckerstorfer et al. (2012) measured that the initial cornice accretion started along the plateau edge during the first snowfall (10-12, Oct. 2010) with maximum wind speeds of **11 m s^{-1}**, which is lower than the observation result of Vogel et al. (2012). Thus, by analyzing the time series of wind speed data from Gruvefjellet meteo station (http://158.39.149.183/Gruvefjellet/index.html), we can conclude that the corresponding averaged wind speed is about 7.37$\pm$ 0.97 m s^{-1} (and mean friction velocity is about 0.288 m s^{-1} using z_0 = 10^{-4} m) when the maximum wind speed is in the range of 10.5~11.5 m s^{-1}. Considering the harder snow surface in Gruvefjellet (Eckerstorfer et al., 2012), this wind speed value is comparable to the threshold wind speed in previous literature. For the wind in the field is gustier and more turbulent compared to the wind tunnel, the actual threshold wind speed value for cornice growth in the non-dimensional calculation should equal the maximum value of the threshold wind speed measured in the field, according to the study of Li et al. (2020, DOI: 10.1029/2019GL086574). Thus, we chose the maximum wind speed value 11 m s^{-1} as the comparison value with the threshold wind speed in our laboratory experiment where the wind condition is stable and steady. The nondimensional velocity is then defined as: $\tilde{u} = \frac{u_{ref}}{u_{t\_ref}} = \frac{u_*}{u_{*t}}$, in which u_{ref}, u_* are the wind speed at the measurement height and friction velocity, respectively, and u_{t_ref}, u_{*t} are the corresponding threshold wind speed at the measurement height and threshold friction velocity, respectively.

To better explain the reason for the cornice formation in drifting snow, we set up a new conceptual model on the basis of granular snow continuously interacting with the wind during transportation, as shown in Section 4 Discussion. We then used the model to estimate the length growth rate in the field and compared the results with the filed observations. The estimated suitable wind speeds are consistent with the observation results from the field, and the estimated length growth rates are comparable with the TLS data.

Specific comments:

1. Title – I wonder if the title could be more specific than “environmental conditions” – would wind conditions be more appropriate?

Response: Thank you for the suggestion. We will revise the title to “Wind Conditions for Snow Cornice Formation in a Wind Tunnel”.

2. Line 16 – please clarify what the percentages refer to, or consider omitting the percentages altogether.

Response: The percentages refer to the contribution of different types that causes secondary snow avalanche in the snow seasons 2006-2009 in Longyearbyen. For clarity, we have omitted the percentages in the revised manuscript.

3. Lines 27-31 – consider splitting this long sentence for clarity and readability

Response: Thank you for pointing this out, we revised it as shown in lines 38-41: "Indirect evidence was presented by van Herwijnen and Fierz (2014) that snow cornices only grow under the moderate to strong wind, during or soon after the snowfall. The cornice width from observation is in remarkable agreement with the wind drift index calculated by the snow cover model SNOWPACK (Lehning and Fierz, 2008), which indicates that snow transport plays an important role in cornice formation."

4. Lines 36-38 – please revise this sentence, I don't understand what widely accepted hypothesis is referred to here

Response: We have deleted this sentence which might lead to misunderstanding: "Particles, which follow the changing wind direction locally as the flow passes the ridge will stick to the growing cornice front at the mountain ridge is a widely accepted hypothesis."

5. Lines 39-40 – which assumptions have no supporting evidence?

Response: In here, we mean these assumptions of the vortex and the electric fields lack supporting experimental evidence. In the revised manuscript, we have deleted this sentence.

6. Lines 41-42 – this sentence needs to be revised in lieu of the existence of the Naitou and Kobayashi work. I am unable to read Japanese so cannot specifically comment on the methodological and content overlap between this work and the Naitou and Kobayashi study. I would suggest attempting to determine how your work differs from this previous work and adjusting the intro/results as needed.

Response: Thank you very much for the suggestion. Our differences are listed below:

(1) So far, there are few laboratory experiments on cornice formation, except for the work of N&K86. However, due to the language gap, few researchers have noticed this non-peer-reviewed Japanese dissertation. Our work can not only enhance the reliability of N&K86 by reproducing their results but also attract more researchers' attention to the snow cornice topic through full peer review and open discussions, which is still valuable.

(2) We recorded the whole cornice formation by implementing a state-of-art technology: the shadowgraphy method, which allowed us to present more details on snow cornice formation. For example, we quantitively measured the whole growth process of snow cornice. We recorded the time series of cornice growth rates in length and thickness and particle mass flux in the air, etc. These experimental data are fundamental for further conceptual investigation of cornice formation.

(3) We proposed a conceptual model to explain the length and thickness growth of snow cornice based on the mass balance conservation and the experimental results, which have a good consistent with the field observation results in Gruvefjellet, Svalbard, Norway (Vogel et al., 2012; Hancock et al., 2020).

(4) We also tested the factors of the air temperature and grain shape on the snow cornice formation. However, these effects are not dominant as the wind speed. Thus, in this manuscript, we mainly focused on the wind effects and didn't mention these results.

More details can be seen in the revised manuscript. For example, we summarized their work and pointed out the open scientific questions in lines 30-31: "Naito and Kobayashi (1986) measured the suitable wind speed for cornice formation is between 4 m s^{-1} to 8 m s^{-1}, at 1 m above the snow surface in the field and at the center (0.5 m height) in the wind tunnel." and lines 46-53: "There are few laboratory experiments on cornice formation except Naruse (1985) and Naito and Kobayashi (1986). Naito and Kobayashi (1986) carried out experiments both in the wind tunnel and in the field, observing the process of snow cornice. They described the snow cornice formation as a process that snow particles adhere one after another at the leeward edge, in the form of a thin slab of snow elongating leeward, then the slab hangs down under its weight, depositing drifted snow particles on it. However, quantitative descriptions of this process have not been reported. Their results show that the cornice growth under suitable conditions of the air temperature is between -20 ºC to 0 ºC, the wind speed is between 4 m s^{-1} to 8 m s^{-1}, and fresh snow with an irregular dendritic shape. However, further quantitative analysis of experiments has not been carried out."

In section 3.2, we added the comparison results of our collection rates value in lines 165-169:

"A non-dimensional wind speed $\tilde{u} = \frac{u}{u_t}$ is defined here to compare with the experimental results of Naito and Kobayashi (1986). In this definition, u_t is the threshold wind speed which can be considered as the lower limit wind speed value for cornice growth. As is shown in Fig. 5, the mass collection efficiency in both experiments decreases with the increasing wind speed and the corresponding drift rate. Our experimental results are much larger than that in N&K86, which is mainly due to the different wind tunnel sizes."

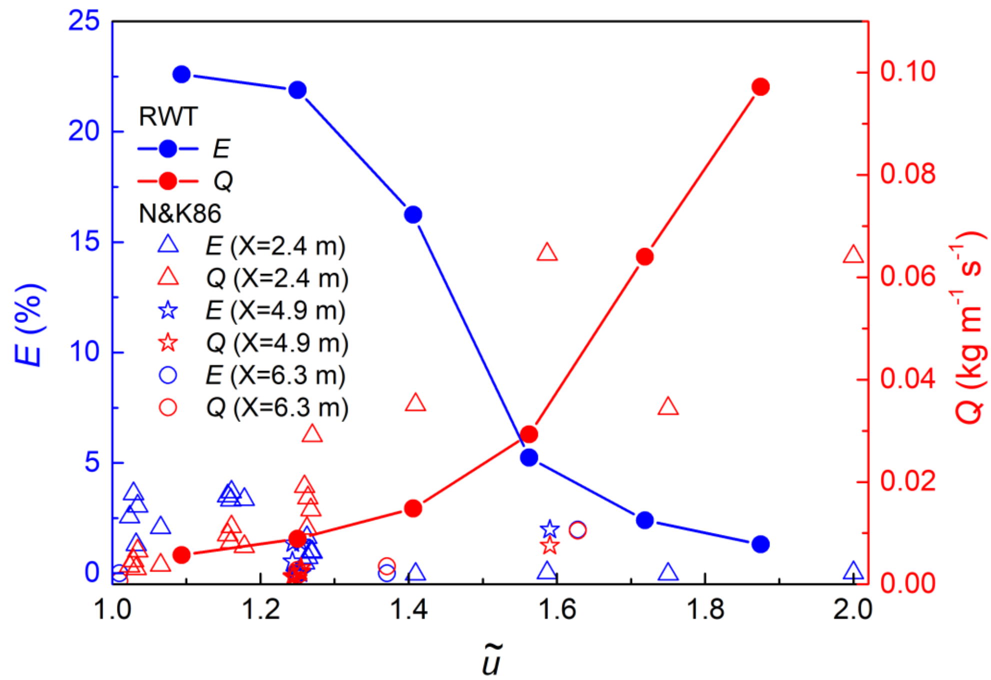

Fig. 5 Collection efficiency *E* (in blue) and snow transport rate *Q* (in red) under different

non-dimensional wind speeds $\tilde{u}$. X represents the distance from the snow particle feeding point to the mass collection pits where the cornice grows. Lines are for ring wind-tunnel experiments, hollow scatters are for N&K86. N&K86 represents the experiment results of (Naito and Kobayashi, 1986).

7. Line 53 – is 7 m s^{-1} the maximum wind speed this device can generate?
Response: The maximum wind speed can reach 8 m s^{-1}. However, in our experiment, we only use the range of 3 - 7 m s^{-1} for there is no cornice when $U \leq 3$ m s^{-1} and $U \geq 6.5$ m s^{-1}.
8. Lines 108-113 – Super cool! Thanks for this.
Response: Thanks for your field observation data.
9. Figure 3 caption – I think the cornice length growth rate and cornice thickness growth rate are represented with Xs, not triangles.
Response: Thank you for pointing this out, we will correct the caption to "cornice length growth rate (light blue crosses), cornice thickness growth rate (grey crosses)".
10. Line 144 – by crackdown do you mean cornice collapse or failure?
Response: Thank you for pointing this out, we will change the word "crackdown" to "collapse" for precise expression in the revision.
11. Line 145-146 – Is this because higher wind speeds form a cornice with a smaller angle?
Response: Yes, cornices form at a higher wind speed with a smaller angle.
12. Lines 175-185 – I am struggling to follow these calculations here, which may partially be due to my inexperience with such work. Is it possible to more explicitly define your terms somewhere (e.g. in a table) in the manuscript to help along readers such as myself? Also, to what are you referencing the Leonard et al. (2012) study here?
Response: Thanks for your comment, we will add a notation with physical definitions and units of all the symbols in the manuscript.
For Leonard et al. (2012) study, we were referencing the threshold friction velocity. However, we deleted the sentence "where u_{*t} = 0.25 m s^{-1} is the threshold friction velocity Leonard et al. (2012)" to avoid misunderstanding.
13. Line 204 – please revise this sentence in lieu of Naitou and Kobayashi.
Response: We have deleted the word "first" in this sentence.
14. Lines 205 – 215 – specifically here I think this work would really benefit from explicitly linking your results to field meteorological measurements (e.g. Ut2.8) for increased utility of your results and work.
Response: Thanks for this valuable suggestion. We have reorganized it by splitting the linking wind tunnel results to field meteorological measurements as a separate section of the Discussion.
15. Technical corrections:
Line 28 – that snow cornices only grow
Line 135 – there are no more chances for slabs to form on the model edge because of…
Line 137 – gets smaller
Line 202 – the newly formed cornice
Response: Thank you for pointing these out. We have revised them in the manuscript.