

The Cryosphere Discuss., referee comment RC1
<https://doi.org/10.5194/tc-2021-299-RC1>, 2021
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Comment on tc-2021-299

Adrien Gilbert (Referee)

Referee comment on "Formation of glacier tables caused by differential ice melting: field observation and modelling" by Marceau Hénot et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-299-RC1>, 2021

This paper analyzes the formation of glacier table through the development of an analytical model calibrated on specific observations of table formation. The model is roughly able to explain the growth rate of the tables as a function of the rock geometry. The authors found that the table growing rate is proportional to the surrounding ice melt rate and is a function of mean rock width and thickness. They show the existence of a geometrical threshold determining if the rock will "sink" in the ice or will lead to the formation of a table.

I think that the strength of the paper is to propose an analytical formulation that is able to explain the data and simply determine if a table will form based on simple consideration. The dataset is also pretty good and innovative in glaciology.

However, the paper suffers from too numerous simplifications and approximations that prevent from a reliable physical interpretation of the mechanism playing a role in table formation. This study misses a more physically detailed study to identify what can be neglected or not before proposing the simplifications that would lead to an analytical formulation. While keeping it relatively simple, a more detailed quantitative assessment of the energy flux could be done. Also the manuscript is not very well organized with mixing observation, model description and results. Although it is well written, it is hard to grasp what are all the findings.

I think the study could be published in The Cryosphere after some major revisions listed in my general comments bellow.

General comments

- **Improve the energy balance calculation at the different interfaces**

While keeping the same simple 1D approach, a better assessment of the different energy flux could be done during the period A and B before developing the simplified analytical formulation. It would provide a more robust conclusion about the physical processes involved.

For this purpose, I suggest that:

- You could use LW from Safran reanalysis (Vernay et al., 2021) available at <https://t.co/h0UYFkwIML>. The incoming longwave radiation is strongly depending on humidity and cloudiness so you could get a better estimation of this variable from this reanalysis.
- Humidity data from the same reanalysis can be used to estimate latent heat flux on the ice surface
- You could use a more detailed estimation of the turbulent flux as a function of the surface roughness that can be your tuning parameter. See for example Wagnon et al. (2003).
- You could solve the transient 1D heat diffusion in the rock with a Neuman surface boundary condition given by the surface energy balance and a Dirichlet bottom boundary condition given by the ice temperature (273.15K) to estimate the heat flux at the ice/rock interface. This model could be validated by comparison between modeled and observed rock surface temperature.

A figure summarizing the intensity of the different flux at the different interface (air/ice, air/rock, ice/rock) would then provide a nice material to discuss the physical processes leading to table formation:

Air/Ice : Latent flux, Sensible flux, net shortwave radiation flux, net longwave radiation flux, total surface energy flux balance

Air/Rock : Sensible flux, net shortwave radiation flux, net longwave radiation flux, surface heat flux toward the rock, total surface energy flux balance

Ice/Rock : Heat flux

From this you could clearly identify what is playing a role in the difference between ice/rock flux and air/ice flux. I think this is missing in the study before developing an

analytical approach.

- **The “geometrical effect”**

This effect assumes that the sensible and longwave radiation net flux at the air/rock interface is the same on the horizontal and vertical faces. I don't think this is true for incoming long wave radiation. Is this effect really needed to explain your data? If yes, you should show it by comparing your results with and without this assumption. Otherwise its existence is not really shown by the study.

- **Effect of wind**

I think you overestimate the effect of wind on the energy balance by neglecting the latent flux which is also proportional to wind speed but of opposite sign to the sensible flux. The latent flux should be estimated (see my first general comment).

- **Comparing model and data**

You should compare observed and modeled **cumulated** melt and not reset the comparison every day. This is especially true in this case where this is the cumulated melt that matter to form tables. The performance of the melt model cannot be assessed like this.

- **Manuscript organization**

My last general comment is that the manuscript is not well organized with mixing observation, model, results and discussion. It makes it very complicated to read and to understand all your findings. The manuscript should be re-organized with a clear separation between observation, model and results/discussion.

Specifics Comments:

You will find a list of correction and specific comments embedded in the annotated PDF in attachment. Some are redundant with my general comments but may help to clarify them.

References:

Vernay, M., Lafaysse, M., Monteiro, D., Hagenmuller, P., Nheili, R., Samacoïts, R., Verfaillie, D., and Morin, S.: The S2M meteorological and snow cover reanalysis over the French mountainous areas, description and evaluation (1958–2020), 1–36, <https://doi.org/10.5194/essd-2021-249>, 2021.

Wagnon, P., Sicart, J.-E., Berthier, E., and Chazarin, J.-P.: Wintertime high-altitude surface energy balance of a Bolivian glacier, Illimani, 6340 m above sea level, 108, <https://doi.org/10.1029/2002JD002088>, 2003.

Please also note the supplement to this comment:

<https://tc.copernicus.org/preprints/tc-2021-299/tc-2021-299-RC1-supplement.pdf>