The Cryosphere Discuss.,
doi:10.5194/tc-2016-132-RC1, 2016

The Cryosphere Discussions

Interactive comment on "Modelling rock wall permafrost degradation in the Mont Blanc massif from the LIA to the end of the 21st century" *by* Florence Magnin et al.

Anonymous Referee #1

Received and published: 13 October 2016

This paper investigates the rock wall permafrost evolution from 1850 (Little Ice Age) to 2100 in Mont Blanc massif. Applying a simple 2D numerical model based on heat conduction equation and latent heat transfer, this study shows the possible ongoing degradation of permafrost at representative selected locations according to two climatic scenarii. The results outline local topographical control on the patterns of permafrost changes, and evidenced a general trend to increased permafrost degradation at high altitude.

I found this paper very clear and well written. The purpose of the work is well articulated and methodology adapted. The collected data (temperature and ERT) in such harsh environmental conditions are impressive and are well used to evaluate model

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Discussion paper

performance. Although simple, the applied numerical model appears to be quite efficient to simulate the long term temperature evolution within the three selected rock walls. The discussion section honestly presents the model limits.The scientific results and conclusions are presented in a clear, concise, and well-structured way. Therefore I will have only few comments.

However, I am not convinced this study constitutes a substantial progress in current scientific understanding: Although the results try to quantify and map the recent and future changes of rock wall temperatures (according to climatic scenarii based only on temperature), the conclusions are of no surprise considering initial assumptions and model limitations. I was unable to find really new insights on permafrost study. Although authors claim this study provides insights for retrospective stability analyses of rock walls (which appears to be the main motivation of the paper), they never give a way to tackle this very important problem (for example characterizing temperature gradient within rock wall, linking fracture dynamics to temperature changes, quantifying effect of saturation on temperature changes,...). Moreover, as rock wall stability might be essentially driven by rapid external/internal changes (solid/liquid precipitation, air temperature, permafrost evolution, fracture propagation, previous rockfalls,...), I doubt this long term approach would help for stability assessment (as this approach cannot "debate on short-time scale" and on 3D effects due to limitation in the modelling approach).

General comments:

This study only accounts for possible temperature changes, not for the solid/liquid precipitation changes. Even if the model do not consider precipitations (snow or rain), precipitations might really influence the global permafrost pattern - presence of snow patches, liquid precipitation percolating into surface fractures,... Even if total annual precipitations might not evolve drastically in the future, a change in seasonality might occur, leading to a different ratio between solid and liquid precipitations. Even if this effect is marginal, this might be mentioned in introduction section and in section 5.1.2

The model section could be slightly reorganised: After exposing modelling strategy, I was expecting the description of the core of the model, i.e. the heat transfers. I suggest to first describe how heat transfers are modelled before describing boundary conditions and transient simulations (as both refer to heat transfer computations).

The description of the numerical approach is not clear:
1. Equation 1 refers to conservation of energy WITHOUT phase transition (heat capacity). The presence of a phase transition might introduce a discontinuity. How exactly is the phase transition treated? Please provide additional explanations.
2. How/why exactly is used the freezing function (eq. 3)? The definition is clear but the use in the calculation is not clearly define. Is this relation directly given by the model, or empirical? Is it meant to define the amount of ice formed during the phase transition? Where is latent heat in your model?

Specific comments:

In abstract:
page 1 line 12: define LIA in abstract.
p. 1, l. 16: describe briefly the model used (2D Finite Element Model accounting for heat conduction and latent heat transfer).

p. 3, l. 12: again describe a bit the model.
p. 4, l. 9: mechanics? please develop (is it not fracture kinematics?).
p. 4, l. 12 and in the following: abbreviation *c.*: I though such abbreviation was used only for dates.
p. 5, l. 19 and l. 29: I would suggest to redefine here RST and MARST for readers convenience.
p. 9, l. 25-29: Not clear: adaptable thermal properties of ice? configurable latent

heat??? This should be constant, please elaborate.
p. 10, l. 6: Is this 5% value constant in the whole domain? Why not setting high porosity near the surface to somehow represent the presence of fractures and a smaller one in the interior of the wall?

Figure 2: < -5 in colormap caption. Add (a) detailed MARST and (b) topographical situation.

Fig. 6: I would suggest to take another kind of marker (circle and bullet are too similar, and sometimes cannot be distinguished).

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