Comments to the Authors on 'New observations indicate the presence of permafrost in North Africa (Djebel Toubkal, High Atlas, Morocco)' by G. Vieira, C. Mora and A. Faleh.

Dear Authors,

The paper has been improved but I feel it requires some major revisions for the following reasons. The two reviewers proposed a series of useful revisions, many of which were not carried out – for example with the rather unconvincing argument that 'a larger project is envisaged in future'. As the data basis presented is extremely meagre and was measured over a very short time period, as was underlined by Reviewer 2, I would have expected more of the Reviewers' suggestions to have been carried out to substantiate the existing observations and data – and to underline that future research would be of relevance in this area of North Africa.

Prof. E. Serrano (Reviewer 1) commented that the analysis of the landforms was poor - and although you describe some of them, it is impossible for the reader to locate these, as there is no overview of them. A simple geomorphological map, an aerial photograph or even an excerpt from Google Earth with labelled landforms would be useful. This is particularly important in this setting, because the distribution of possible permafrost does not appear to be linked to an elevational gradient – but rather to morphological terrain characteristics. The process of ice genesis at the base of steep slopes due to mass wasting (avalanches, rockfall) needs to be discussed further and will be mentioned again below.

Dr. B. Staub (Reviewer 2) suggested carrying out a GIS analysis to investigate potential solar radiation, slope angles and terrain curvature. This would allow interesting comparisons with GIS analyses carried out in other mountain regions, e.g. (Kenner and Magnusson, 2017) and would help to determine whether the presence of permafrost is possible or not. From a purely morphological point of view, a simple GIS analysis would allow to determine locations where snow avalanches and rock fall can be deposited – thus pointing towards potential locations of buried ice at the foot of slopes (where air temperature regimes, solar radiation and GST have less influence on the distribution of permafrost than the presence of massive ice buried under a layer of rock debris).

Reviewer 2 also suggested including freezing and thawing degree-days – this would be a further interesting way of comparing the GST regime at the 4 sites and of making first steps towards the development of High Atlas-specific GST indices – if they have any relation to permafrost distribution at all here. You state that you have these values and I suggest you include them. The extremely high summer GSTs at site T3 and the low ones in winter indicating possible permafrost at this site are worth further reflection and discussion.

Although you adapted your previous statements and analyses regarding the comparisons of weather data measured at Menara and on Toubkal, you did not attempt any of the other approaches suggested by Reviewer 2, such as land surface temperature data analysis, which would provide an interesting comparison with your point data and should at least be mentioned in the outlook.

As mentioned above, an important point I suggest you include and discuss is the potential distribution of avalanche snow and of rock fall debris (see Figure 11 for example), based on slope angles. Buried avalanche deposits may be the main / only type of permafrost remaining in this region

– independent of elevation but dependent on slope angle and snow / rock debris availability. The ice may be very old. Current avalanche deposits give clues to where snow may have been buried in the past. In the Swiss Alps we have for example observed excess ice at the base of slopes at low elevations (and hence not included on the Swiss permafrost distribution map), and buried under a thick layer of talus (see e.g. www.permos.ch – the Flüelapass site is one of these). Lambiel & Pieracci (2008) and (Scapozza et al., 2011) also provide such examples. You observed creeping features, lobate deposits and ridges/furrows at T3, which is at the base of a steep slope. These indicate that there is/was ice buried here – and if it is still present, it is a much more likely explanation for the low GSTs in winter than intra-talus ventilation. You should carefully consider what effects buried ground ice would have on the ground thermal regime. The presence of buried ice would also be of interest regarding future water resources in the High Atlas – an important aspect for further research in this arid area.

Some open questions: Did you notice any cold air fluxes at the base of the slope during very hot days in summer (pointing towards ventilation)? Are there any springs emanating from the lobes at T3 or elsewhere? Were spring temperatures measured? Have the local guides noticed a change in the occurrence of mass wasting?

Further details:

Title: I suggest you add '…the **possible** presence of permafrost…'

p. 3, line 17: is the atmosphere-soil interaction the major controlling factor on the ground thermal regime here? It may be one of the controlling factors – but has less relevance if you consider the presence of buried ice.

Study area: mention present/past snow avalanche activity

Methods: how were the temperature loggers calibrated? Ice-water mixture? Active layer zero-curtain?

Methods: remove the last sentence (iButtons would for example have been a cheap and practical solution – and why would there be a higher probability of disappearance at high altitude sites??)

3.2, p. 6, line 5: define the difference between 'snow' and 'significant snow' – and how is it determined?

Figure 4: where is the extrapolated data for D. Toubkal? (Figure 12?)

Figure 9: please label the axes in English (months)

What are your thoughts on the usefulness and quality of the remote sensing snow cover data?

Conclusions: please make these more concise and add a separate section: Outlook.

The study area is of great interest and in future the use of more measurement devices and different investigation techniques may well allow to gain a better insight on the presence and distribution of

permafrost here. However, at present there is very little data available and so any existing clues from other sources of information must be used to explain this data and to provide convincing arguments for the paper – and also to justify future research. The points mentioned above therefore need to be taken into account and addressed before your paper can be reconsidered for publication in the special issue of The Cryosphere.

References

Kenner, R., Magnusson, J., 2017. Estimating the Effect of Different Influencing Factors on Rock Glacier Development in Two Regions in the Swiss Alps. Permafrost and Periglacial Processes, 28(1), 195-208. DOI: 10.1002/ppp.1910

Scapozza, C., Lambiel, C., Baron, L., Marescot, L., Reynard, E., 2011. Internal structure and permafrost distribution in two alpine periglacial talus slopes, Valais, Swiss Alps. Geomorphology, 132(3–4), 208-221. DOI: http://dx.doi.org/10.1016/j.geomorph.2011.05.010