

## ***Interactive comment on “Glacier-like forms on Mars” by B. Hubbard et al.***

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The paper “Glacier-like forms on Mars” (GLFs) provides a summary of, and new work on, the distribution and geomorphology of these martian features, and also a forward looking summary describing potential research directions. To my mind, the paper falls between being a review and a “research” article. The literature about GLFs is not enormous, and these authors are responsible for much of it. Hence, this combination of their latest data, and a review of the field, is not a bad thing. It does seem to represent a good summary of the state of the art.

The only major question I have is whether the case studies provided are sufficient, in and of themselves, to support a research article. This lack of weight is seen in the summary, in which most of the bullet points reference “review” aspects. However, having said that, the forward looking part of summary is extremely useful, and so with

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a bit of 'beefing up' of this section the paper would be improved.

Specific points P 2959 line24. What types of images were examined? What percentage of the global surface area was observed?

P 2960, line 1-3. Distribution of GLFs. Were these numbers normalised by (1) total area observed (i.e. is the coverage the same in both hemispheres (2) by surface area (i.e. higher latitudes have small surface area in a given latitude band)? If not, can this be done? This is specifically important for the discussion of clustering – does this reflect true clustering, or just a concentration of images? Without such normalisation, the results are not so compelling.

#### Specific Comments

P 2960 Line 19. How do we know the regolith is dust-rich?

P 2961 Line 9-11. According to the Laskar model results, (Laskar, J., A.C.M. Correia, M. Gastineau, F. Joutel., B. Levrard, and P. Robutel. 'Long Term Evolution and Chaotic Diffusion of the Insolation Quantities of Mars'. *Icarus* 170, no. 2 (2004): 343–64.) mean obliquity decreased about 5 Ma BP and has been stable at around 25 ° for ~ 3 Ma. There have been numerous cyclic obliquity excursions since then, which might have triggered 'ice ages'. In the time period specified here, the obliquity was much more variable than in the preceding 0.5Ma, changing from nearly 15 to nearly 35 degrees on very short (~100ka) timescales. As written, this section appears to mix up these two concepts.

P2965 Line 6. Is the Smooth Terrain type related at all to GLFs?

P2965 Line 17. The MLRs are all contained within each other. Does this lack of transgression tell us anything? Do any MLRs record transgressions across a terminal moraine by more recent glacier activity?

Page 2967 Line 1. Does this 'model restriction' to 2 dimensions make any difference? This is the sort of thing where planetary science can really learn from terrestrial exper-

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tise. Can the authors expand on what the benefits (if any) are of using a more complex model?

Page 2968 Line 12. Does it have to be exposed by excavation, it could be caused by a lack of regolith deposition in this area?

Page 2971 Line 1. Why is the erosional headwall similar to a depositional lateral moraine? This needs to be explained more fully.

Page 2973, line 10. It would be relatively simple to estimate the error on this velocity, or at least provide a realistic range in which the actual number would sit. This should be done. Without the acknowledgment that this is not a precise measure, this number could end up being used in future models etc without question.

Page 2973 Line 11-15. These are great observations, revealed clearly in the mapping figure.

Section 3.1.1. The evidence presented for these channels is the weakest part of the paper. It is very hard to differentiate between the background pattern of fractures and potential channel-like forms. In the sketch elements of fig 10, perhaps only the most convincing ones should be shown, and the matching features marked with arrows in the image? Also, use of the term “strongly indicate” seems to be overly confident.

Section 3.2. Could the authors discuss possible evidence for possible pro-glacial channels systems too? Do any GLFs have channels ‘downstream’ of them?

Section 4. The ‘current unknown aspects’ part of the paper is very important, and the authors have identified some useful points. I think that they could expand upon each point to say which aspects could be determined using current (or planned future) data, and how. Thus, rather than just being a ‘wish list’, this part of the paper would read more like a roadmap.

Minor points

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Page 2958, Abstract, line 2. “visually similar... being composed of...”. Referencing ‘visual similarity’ and ‘composition’ makes the sentence confusing as written, just needs a tweak in structure

Page 2960 Line 13. How were the mean bearing calculated?

Page 2964 Line 1. “much-contested sinuous ridges”. Presumably, this means that their formation mechanism is still hotly debated. If so, more detail is needed to explain what the debate consists of. Alternatively, this could be deleted as it doesn’t add much here anyway.

Page 2967 Line 6. “relatively unambiguous, universal diagnostic indicator” is a contradiction.

Fig 7b. The contrast could be improved on this figure, and arrows added to show the features of interest. The same applies to several other figures, where features should be identified with arrows or labelled in some other way.

Page 2973 Line 18. The idea that mars was both significantly warmer and significantly wetter in the past is still debated. Suggest toning down this statement, or add reference to the alternative point of view.

Page 2973 Line 23. Earlier, more fundamental RSL papers than Stillman (2014) exist. Suggest these should be cited too/instead.

Page 2974 Line 1. Is there a reference for the gullies eroded into pro-GLF material?

Note: I am not in favour of single-blind anonymous reviewing. I therefore wish to make my name known to the authors

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Interactive comment on The Cryosphere Discuss., 8, 2957, 2014.

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