Review

Laboratory observations on meltwater meandering rivulets on ice

by

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The paper presents observations in a laboratory experiment by the authors, in which a flow of warm water generates meandering channels on a block of ice. The authors find two types of channels. Major ones are a few centimeters wide, while smaller rivulets spontaneously form as the ice thaws. They compare the geometry of these channels to field observations, either on ice or in entirely different settings (alluvial rivers, bedrock rivers, karst). The experimental value of most of the quantities used to characterize the morphology of the channels, such as sinuosity, skewness, etc., are comparable to those measured in the field.

The paper is carefully written, and the text is easy to follow, despite the systematic use of the passive form, which often confuses the reader about whose experiment or observation the authors are referring to.

The major channels indeed exhibit many features that also exist in natural systems, and the authors present those in details. I must say, however, that I find the shape of the smaller channels more striking (Figure 3c). To me, these spontaneous, millimeter-scale channels resemble natural meanders more than the larger ones. I agree with the authors when they suggest that the former are probably closer to the thermal equilibrium than the latter, and I would think this closeness to equilibrium is essential to their developing a well-defined, single-wavelength instability. Based on this observation, I would be much interested to see what the major channels would look like were they fed with water barely above 0°C, and the experiment run for a long time.

The above suggestion, of course, is beyond the scope of the present manuscript which, I believe, can be published in E-Surf after the authors have addressed the minor points listed below.

Writing and minor points

- Page 4: “sometimes possess double-valued planforms” what does this mean? Why is sinuosity the only parameter that’s mathematically defined? How about “fatness” and “skewness”? Please provide their mathematical definition.
- Figure 7: The legend says “(b) Concordia, Pakistan. Flow direction unknown.”, but an arrow shows the flow direction on the picture nonetheless.
- Page 6: “It is likely that the neck cutoff produced a knickpoint”: This could be argued for based on the amplitude of the knickpoint, the river’s slope and the length of the loop before cutoff.
- Figure 10: The fatness seems not much different from zero, given the variability in measurements. This seems at odds with the pictures previously shown.
- Page 7: “[...] 2.01 whereas the latter have a median value of 1.36”: How are these values “very different from each other” when the variability is about 25%?
- Figure 11: How come runs 3 and 4 are so similar their planform curves appear to match almost perfectly?
- Page 7: How do you measure the wavelength of the planform? There seem to be many wavelengths in the planforms of figure 11.
- Page 9, lines 12 and 24: “temperature gradient” → “temperature difference”
- Page 9, line 20: How do you make the migration speed dimensionless?
- Page 11, Please define mathematically the Bond and Weber numbers when they appear in the text. “The lack of flow velocity measurements”: this is at odds with the previous estimation of a Reynolds number.
- The text about surface tension is confusing. Capillary rivulets on a solid surface are fixed in place by the hysteresis of the contact angle, a mechanism related to, be different from, surface tension. In the present experiment, surface tension most likely affects the shape of the water surface. This, however, doesn’t mean that it is directly related to the (unknown) process by which the meandering instability occurs.
- Page 11: “Laminar river analogs have 1.5-2.5 higher slopes”: some might, but there is no rule here. It is about 0.1 in some experiments [1] and 10^{-3} in others [2]. Similarly, there is no typical value for the slope of an alluvial river, since it scales like the inverse square root of its discharge, which varies over many orders of magnitude [3, 4].
- Page 11: “It is also likely that the mm-scale meanders did have similar values”: Indeed, they are probably much closer to the thermal equilibrium, and their shape resemble natural meanders more strikingly. I believe this is a good reason to maintain the main channels as close to equilibrium as possible.

References

[1] P Delorme, O Devauchelle, L Barrier, and F Métivier. Growth and shape of a laboratory alluvial fan. *Physical Review E*, 98(1):012907, 2018.

[2] A Abramian, O Devauchelle, and E Lajeunesse. Laboratory rivers adjust their shape to sediment transport. *Physical Review E*, 102(5):053101, 2020.

[3] O. Devauchelle, A. P. Petroff, A. E. Lobkovsky, and D. H. Rothman. Longitudinal profile of channels cut by springs. *Journal of Fluid Mechanics*, 667:38–47, 2011. doi: 10.1017/S0022112010005264.

[4] F. Métivier, O. Devauchelle, H. Chauvet, E. Lajeunesse, P. Meunier, K. Blanckaert, P. Ashmore, Zh. Zhang, Y. Fan, Y. Liu, et al. Geometry of meandering and braided gravel-bed threads from the Bayanbulak Grassland, Tianshan, PR China. *Earth Surface Dynamics*, 4(1):273–283, 2016.