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Interactive comment on "Glacier volume estimation as an ill-posed boundary value problem" *by* D. B. Bahr et al.

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I found this to be an interesting paper, and believe it raises an important issue that deserves discussion. Two important conclusions are that (1) scaling methods are best for large-sample aggregate volume assessments, and (2) short-wavelength filtering is needed for numerical inversion methods. The first of these conclusions is certainly true for reasons discussed by Bahr and others elsewhere, related to availability of observational constraints. The focus of this manuscript, however, is the hazard of errors arising from the "ill-posed" problem of using surface observations to infer properties of glaciers at depth. The argument is potentially useful but I found several issues to be

confusing enough that I don't think the paper is ready yet for publication.

I would like to see the authors clarify the following issues:

(1) Page 5410, line 5: "\lambda is the spatial wavelength of any glacier parameter (velocity, stress, etc.)" What does this really mean? Is it the spatial scale of variations in the glacier itself, or the spatial resolution of the observational constraints? If it's the latter, then if there's no systematic error in the observations, don't the errors at neighboring points tend to cancel one another? And wouldn't such cancelling behavior depend on the nature of the model or analysis? I don't really understand what is \lambda.

(2) Page 5410, lines 15+: Surely for global ice-volume calculations, we don't need to think at the small spatial scales of one ice thickness!? Likewise, Page 5411, around lines 15-20: The assertion that "the sum of many short wavelengths can have a surprisingly large macroscopic effect on the spatial distribution of ice thickness..." is not obvious to me. For the example given, a ramp versus an ice fall, the difference in glacier-total volume would be small, wouldn't it? I think this would be clarified well with the addition of a less abstract discussion – examples from a few real glaciers, for example.

(3) Page 5413, line 1+, "shortest acceptable wavelength will be approximately four times the glacier thickness": Just curious whether this is connected in some deep way to the longitudinal coupling length.

(4) Page 5413, Eq. 4, line 10+: Why doesn't this scaling depend on the slope? A group of steep mountain glaciers should scale differently from a group of trunk-valley mountain glaciers. I think Bahr may have talked about this in 1997, but my review is already late and I don't have the time to go back and read those papers.

(5) Eqs. 7, 8, and 9: Maybe I have been drinking too much recently, but I really don't follow the basic math. First, in equation 8, the exponent value should be, using the

following parameters from this paper: b = 1 c = 0.034 pi*r = 3.77/2

the exponent in eq. 8 equals pi * r * c * 1 = 0.064 instead of 0.015.

But in any case, If Eq. 8 is approximately 1, then Eq. 9 should simply be E_b = E_s, with no dependence on S. (Maybe I'm missing something, but I think that exp(a*b) does NOT equal exp(a) * exp(b) as Eqs 7-9 imply.)

(6) Page 5414, line 14: "The wavelength is \lambda = 2 dx". What if the glacier properties are uniform, and the high spatial resolution means that within a short distance errors cancel one another and the mean of observations converges on the true value? Page 5415, lines 20-25, would be a specific example for which this question applies, and lines 25+ of Page 5416 express the importance of the issue: I do not understand why large errors at the 10 to 100 m spatial scale would lead to a large error in the volume estimate for a single large glacier. Doesn't a law of large numbers apply within a glacier itself? This confusion seems to be at the heart of what the authors are trying to teach us. Please clarify for the sake of typical glaciology readers like me.

Interactive comment on The Cryosphere Discuss., 6, 5405, 2012.