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Earth Surface Dynamics Discussions

Interactive comment on "Creative computing with Landlab: an open-source toolkit for building, coupling, and exploring two-dimensional numerical models of Earth-surface dynamics" *by* Daniel E. J. Hobley et al.

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Summary

Hobley and co-authors present Landlab, a toolkit that is poised to significantly change the face of Earth-surface modeling. I expect their framework to easily build and integrate models of the evolving Earth's surface to enable the community to improve – possibly rapidly – the state of our knowledge and theory of Earth-surface dynamics. On a personal note, I have followed the development of Landlab since its inception,

and offer my enthusiastic support of the publication of this article that makes this comprehensive modeling infrastructure easy to follow in a way that mirrors the clean and well-written code base.

I recommend that the article be accepted for publication after some very minor technical corrections. As the article is, in my opinion, ready for publication, this review contains both technical notes and copyedits as a result of a very thorough read.

Main text

General: Many geomorphic models are run in 1 dimension. Is Landlab capable of solving 1-D problems? As I understand from my reading, it is designed for 2-D solutions, but it would be helpful to have a comment on this to clarify.

Page 4, line 9: I second Wolfgang Schwanghart's comment regarding open-source modules written in closed-source languages. Here, the algorithm may be known even if it cannot be run without the closed-source core programming language.

Page 6, line 9: Strong agreement regarding rapid prototyping. Based on reading the article, and having never used Landlab before (though having some familiarity with it), I was able to assemble a simple program for a class exercise in 1-2 hours.

Page 9, lines 6-10: Easy to note that this is standard right-hand-rule, if you think this is helpful.

Page 10, *"get" and "create" methods*: I have seen "get" commands, such as "mg.get_grid_ydimension", that are exposed to the end user and have no underscore. So I must guess that there are two types of "get" commands, or... ?

Page 11, section 3.1.4: More a comment: the single set of boundaries implies to me

that you have intended the model for discretization of only first and second derivatives.

Page 12, line 16: Missing a noun between “ID” and “of”.

Page 12, line 24: “Pairwise Transition Automata” appears, on Google and Google Scholar, only in this article, and its meaning is unknown to me. Could you elaborate?

Page 13, line 20: What is “syntactic sugar”?

Page 13, line 28: Missing hyphen for steady-state (modifies “solutions”)

Page 15, line 18: Suggest replacing “However” with “While these are focused on Earth’s surface” (or “While these are Earth-surface focused”, if you like some dislike using the vestigial English genitive in scientific writing.

Page 16, line 4: Having not thought about it before, it is not clear to me how you would combine a set of Jacobian matrices to, presumably, simultaneously solve an arbitrary number of coupled processes. It is probably just my ignorance, but I would like to see a bit of explanation and/or a reference.

Page 16, line 9: changes $\rightarrow$ change; the word “data” is plural.

Page 17, line 19: Are “known correct solutions” all analytical solutions, or do you include solutions that go beyond this limited class of solutions? And/or, is “solutions” meant more generally – as in, is this also just making sure that general functions that you have programmed that may not be generating mathematical solutions are functioning as expected? As I type, I’m starting to think it must be the latter...

Page 18, line 26: uplifting $\rightarrow$ uplift

Page 20, line 15: More general question: Your method implies central differencing.

How do you ensure that numerical diffusion is minimized and/or is not large enough to be important?

Page 21, line 8: Would this be the depth-integrated flux, as “flux” generally means [quantity/[area time]], so volumetric flux is L/t and therefore depth-integrated would become L^2/t? Of course, Earth-system modelers use “flux” more liberally, but in a mathematics (and fluid mechanics), this is the use that I know, and I think it’s best to be precise with language – especially considering how much you are in general.

Page 21, line 11: Again, more general question: if you are using the CFL condition, I am guessing that this is referring to something that is Euler forward. How would you choose time steps internally while using some of your implicit methods?

Page 22, Equation 9. Note $\geq$ is possible ($\geq$) in LaTeX. There are also options to use curly brackets to make the conditional part of the equation clearer; see http://tex.stackexchange.com/questions/47170/how-to-write-conditional-equations-with-one-sided-curly-brackets.

Page 22, line 22. Near m/n, you may mention that this is the channel concavity. Perhaps, “m/n, i.e., channel concavity, ≈ 0.5.

Page 22, line 26. Remove “possible” (repeated later)

Page 23, line 2: Remove “performs as order-n, and as expected”: redundant. You could keep “as expected” if you like.

Page 23, lines 3-4: “Broadly linearly” sounds strange: two dimension terms, the first metaphorical. How about “approximately”, or even just no modifier (it is so close to linear)?

Page 23, lines 17-19: “based on...2001b).” is a repeat of text at the start of section 5.2

(p. 22, l. 2-6).

Page 23, line 20: “storm depth” to “stormwater depth” (or something like this)?

Page 23, lines 24-25: “looped upon” to “called within the loop”, and remove “until...cease”. If I understand you here, this is a simpler way of writing this.

Page 23, line 28: “and where it only rains” to “with rainfall occurring” for better parallel structure

Page 25, line 5: remove comma after “region”

Page 25, line 6: remove “using” after “by”: unnecessary

Page 25, line 6: did you just write that stormwater depth is given by a gamma function? Also, “storm depth” should be turned into something like “stormwater depth” that makes more sense, per the above comment.

Page 25, line 9: Does Bras’ model incorporate latitude, integration over a day, etc.? And is it simple incident radiation (i.e. no diffuse or reflected)? I think that the latter is true from what you have written, but not sure about the former.

Page 25, line 21: “and also” $\rightarrow$ “and”

Page 25, line 29: “shrubs cluster as they...”

Page 26, line 12: “shallow” is ambiguous since you are writing about flow depth and slopes. I would write “low-slope” instead. Also, did you mean a different word than “urban”?

Page 26, line 29: “a uniform rainfall rate”. Also, this is by filling the pits with water, I

presume.

Page 28, line 4: You haven’t mentioned visualization except for one reference to ParaView that you didn’t follow up and a passing reference to matplotlib. Not actually a problem, but a note.

Tables

Table 1b: What about raster D8?

Table 2: Should rectilinear have rectangular cells, not “quasi-rectangular”?

Table 4: More of a comment: based on all boundaries being inactive, a 1D model in Landlab would have to have $3 \times (N + 2)$ nodes. So it really isn’t optimized for 1D, it seems.

Table 5: A nice set of modules... but at risk of sounding ungrateful of the large amount of work that this was, it would be really great to see a depositional components for Landlab appear... in case this isn’t obvious, this is not a criticism of the paper, but more a comment on where this work could lead.

Figures

Figure 3: Please ask copyeditors to ensure that this appears on the same page as Table 1.

Figure 4: Are patches numbered in order of min(max(surrounding nodes or links))? (Question inspired by (b)(ii).)

Figure 7: Include line numbers. Also, flux → discharge, per our discussions? In addition, for this and the other figures with code, I am not sure if »> and . . . are needed or are distracting... they are more the latter for me, I guess. But your decision in the end on style.

Figure 8: You use both “base level” and ”baselevel”; check for consistency (2x/each).

Figure 9: Why not combine this with Figure 8, if they make the same plot?

Figure 10: Please tell us how many cells you computed over to help readers gauge their own compute times.

Figure 14: (b) Vertical axis: PFT is more precise than plant type? Although this is clear from everything else. Legend: shown in parts (b) and (c) of this figure.

Supplement

No concerns.

Testing

During the review process, I took advantage of the fact that I am teaching a geomorphology class to test Landlab. In our modeling lab, the students, most of whom have little experience in programming, were all able to install and run Landlab. In some cases, differences between computers and Python versions caused a little confusion, but the code itself worked well. The students are currently working using it with a simple coupled channel–hillslope model to (1) find relationships between hillslope diffusivity, the stream power coefficient, and the drainage area of the hillslope–channel transition, (2) investigate which factors lead to changes in the time it takes to reach

steady-state conditions in a landscape, and (3) explore the effects of changing grids, uplift patterns, stream-power exponents, and more on the model results. The overall reception was very positive in this mixed undergraduate–graduate class, with students realizing through the model how real landscapes form and evolve. The code that I used, modified from one of those supplied in the paper, is attached below. I intend to teach the lab again.

One issue that I had while running this code on Linux within iPython is that the plotting tools would not release control of the shell to me (i.e. after plotting, I could not type anything more into the terminal, even after closing all of the graphical windows). This of course is not an issue to preclude publication, but I will add it as a ticket on GitHub.

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