Geosci. Model Dev. Discuss.,
doi:10.5194/gmd-2016-277-AC2, 2017

Geoscientific Model Development Discussions
Open Access

Interactive comment on "The Landlab OverlandFlow component: a Python library for computing shallow-water flow across watersheds" *by* Jordan M. Adams et al.

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Received and published: 5 February 2017

Dear Dr. Yu,

Thank you for taking the time to review our manuscript. We appreciate the detail you have put into your comments and believe your suggestions have strengthened the manuscript. Below we have replied to each comment, addressing the concerns regarding the original manuscript.

Many thanks again,

Jordan (on behalf of all authors)

I enjoyed reading the article. It reproduced a 2D inertial based flow routing algorithm within an earth surface dynamics modelling package. I made quite a few comments/inquires in the document attached but the major comments are summarized below. I didn't comment on the sediment transport bits very much as I don't have the expertise in that area.

We thank Dr. Yu for his comments.

General comments

1. The writing needs to be improved. It is unclear at the first read in many places. A lot of polish is needed to make the texts more concise and remove the unnecessary bits. This needs quite a bit of work in my opinion.

We appreciate the time you have taken reviewing the document. We carefully reviewed all of the comments in the PDF supplement, addressed them and have commented in more depth below.

2. Structure can be improved to follow the typical/classic way of journal paper writing. In particular, background sections within the two test cases should be incorporated into the introduction so readers can get a sense of the overall context of the work you undertook.

We have restructured the paper per this suggestion, moving the two application "background" sections into the introduction. The introduction was then edited to improve the flow.

3. The design of the tests is rather unstructured and in many ways rather random, often un- or not justified properly. A few sentences here and there are needed to justify the choice of rainfall intensity and design of tests.For example, why 5 mm/h storm - is this based on real events? Why two catchments with different shapes and how the relief is designed?

The assumptions regarding infiltration and precipitation have been added to the text.

These assumptions were used to keep the tests simple and replicable, as the codes are made publicly available so readers may test the component on their own. The test design was also explained more clearly in the text. Regarding the storm durations and intensities, these events were selected based on real data. For example, a 1-yr, 60-min precipitation event in semi-arid climate in central Colorado has a total depth of approximately 12 mm. To simplify, a 10 mm storm depth was used. This storm depth was held constant so that results could be easily compared, but was then applied across different durations to test for differences in hydrograph shape and incision depth. Finally, the basin shape was changed to see if hydrograph shape changes with basin organization. This is mentioned in the introduction and is also clearly explained in section 7 and subsections, where the model set-up for the synthetic landscapes application is outlined.

4. Sensitivity to resolution and roughness needs to be investigated. Whether changing mesh resolution will change the hydrograph shape? What are the impacts of roughness? I suggest simulations to be designed and a graph or two to be included for test case 1 where the authors demonstrate the model's response to these two parameters.

This was an excellent suggestion. We more clearly stated how the existing analytical solution (now Fig. 7) can be used to analyze model sensitivity to roughness. We also clarified the range of Manning's n values used in that test, to illustrate how it captures a range of natural roughness values from urban landscapes to more heavily forested watersheds. A new figure (Fig. 6) and section (5.1) were added to outline how sensitive the model is to changes in grid resolution, following the solution in Bates et al., 2010.

5. It is rather disappointing that test 1 is not chosen in a site where real rainfall records and flow gauging records are available. Surely there are plenty of such datasets. As such the model is not validated in a robust way although patterns of hydrographs at the outlet look reasonable. A comment on this somewhere would be useful. Also perhaps highlight this for future studies?

The model was not calibrated using real rainfall records or flow data. The current model is not meant to be a predictive hydrologic model, and does not include the many other processes found in existing hydrologic models. This submission was designed to merely illustrate the capabilities of the model. We have also added a sentence about the rationale for using the Spring Creek watershed for our model runs, in section 6.

Specific comments

[1.6] This sentence should be before the last one as it tells the readers what is Landlab

The abstract has been reworded and Landlab is now properly introduced before any other reference is made to it.

[2.2] Many more recent papers on urban flood modelling from various are available. I suggest including a few to recognize the recent developments in the field.

Good suggestion. We have added new references about overland flow modeling in urban landscapes.

[2.9] not all the references therein are relevant. This can be removed.

Removed.

[2.13] Make it specific - computational mainly and solving the equations

This sentence has been clarified to state complexity comes from solving the equations.

[2.31] change “may never” to “can rarely”

Changed.

[4.19] I found this is hard to follow but the figure is very useful. State clearly an open boundary is where inflow is taken into the system (I assume). Active nodes are those receiving water. Rainfall can be used as I read on... so on and so forth.

We have updated the text to state clearly how the model behaves on different grid elements, per their boundary condition (e.g. rainfall is applied on core nodes, fluxes are calculated on active links).

[5.3] not for the 1D case which is fast. It is only when it becomes 2D what states here applies.

Clarified to specifically state the 2D case.

[6.28] This was not mentioned earlier on - mentioned afterwards so need to bring it in earlier or here..

We have added a reference to the steep_slopes flag much earlier in this section.

[7.7] and its

Changed.

[7.28] LisFlood-FP reads in ASCII files as far as I know. So I think this is an overstatement - I don't think Landlab simplifies this as both are doing the same - i.e. reading in ASCII files, which need to be prepared for the simulation site.

Reworded, and removed text that implied Landlab simplified this process.

[8.7] Can there be multiple outlets? In urban applications, this may well be the case.

We first specified that the set_watershed_boundary_condition method can only operate on a watershed with a single outlet. Added specific reference to the type of situation mentioned here: multiple outlets. This new text states that if a user requires multiple outlets, they can set those boundary statuses manually.

[9.1] Will there only be incision? Will there be deposition? No expert in this field but assume this happens during land evolution? The model described here only looks at incision, no deposition. This is not unreasonable compared to existing landscape evolution models.

The OverlandFlow component can be coupled with sediment transport (erosion and deposition) in other applications, as described in the Future Applications section 8.

This was also more clearly stated in the text, section 3.2.

[9.3] Also need to mention the sensitivity to resolution from previous studies. I assume this study agrees.

We have added a new section (5.1) and figure (Fig. 6) which address the sensitivity of the model to grid resolution.

[9.3] How does the time steps compare with the published studies?

We have added text to compare minimum time steps in the analytical solution runs to the values provided in published studies of Bates et al., (2010) and de Almeida et al., (2012).

[9.16] 0.1 is high for a natural landscape... according to Chow.

While 0.1 is high, it is within the range given by Chow. 0.1 can be a representative roughness for landscapes with “very weedy reaches, deep pools or floodways with a heavy stand of timber” or channels with “dense brush”. These types of landscapes could be of interest to geomorphologists, which is why the high value was included. Additionally, using a range of 0.01 to 0.1 demonstrates how the model behaves across a range of nearly all Manning’s n values, from quite low (0.01) to quite high (0.1). The analytical solutions show the model is capable of handling all types of terrain roughness values. The text has been updated to reflect that these two tested n values capture a range of landscape types.

[9.27] This should be moved to the introduction.

This has been moved to the introduction, and the text there has been modified to accommodate the the new sections.

[10.12] Is this used in the model?

This is calculated manually in the Landlab driver file. Data can be plotted to explore the different grain sizes that can be transported by the OverlandFlow flood wave. (Fig.

8d)

[10.14] should be water surface slope

Changed

[10.16] This can be kept here

This transition paragraph was now put at the end of section 6, as the “Background” section in the previous draft was integrated into the Introduction (See General Comment #2).

[10.29] This is not exactly what D4 does. There are depressions in the landscape which won’t be removed by this I think? Can the authors explain>

This has been clarified to state that the Landlab SinkFiller component actually fills the depressions, allowing for D4 flow routing.

[10.34] unclear to me: is this uniform rainfall across the catchment? If so, why not use a more realistic or even real event with the typical shape of a rainfall episode?

All references to rainfall events have now included the assumptions about spatial distribution. Uniform rainfall was applied for simplicity. It is possible to instantiate temporally and spatially variable rainfall, but the point of this paper is to focus on demonstrating the capabilities of this software.

[11.1] Why only at the peak? Does the peak depth reach for all points at the same time - unlikely? If not, sheer stress recorded this way may not represent the maximum transport capacity.

This is an excellent point. We have updated Fig. 8 and the corresponding caption to reflect the changes to the figure. The new figure shows the maximum shear stress which occurs at each point in the domain. This can account for differences in the time to peak.

[11.11] Do we need such details here as these are known facts?

Good suggestion. Extra details were removed to keep the paragraph concise.

[11.4] Did the authors undertake sensitivity analysis to roughness and mesh resolution? This is typically required for this sort of modelling

The analytical solution section has been updated to discuss the sensitivity of the model to surface roughness (section 5.2 and Fig. 7). A new section has been added within the analytical solution section to discuss the sensitivity of the model to grid resolution (section 5.1. and Fig. 6).

[11.7] Timings of the upstream and midstream point depth profiles are very similar. Why there is no delay for the midstream point?

While they are somewhat similar, the midstream point hydrograph does reach the peak value several minutes before the upstream-most point. In plotting the entire hydrograph, this delay is less apparent. Text was added to the figure caption to make this delay clearer.

[11.22] It would be interesting to see how this can be validated. A real event with gauging data at the outlet would be highly recommended.

As we stated in response to an earlier comment, this paper was designed to demonstrate different use-cases of the OverlandFlow component. The model is not meant to be predictive in its current form, as it still lacks processes and variables (e.g. infiltration, vegetation dynamics) that are generally considered in predictive hydrology models. Additionally, parameter tuning, model calibration to field data could constitute an entire manuscript, and were too extensive to be explored in a model description paper.

[11.28] Similar to the above section, this can be incorporated into the introduction and the last paragraph can be moved to discussion.

Background information was moved to the introduction section.

[12.28] Are the synthetic rainfall based on any particular event?

As stated before, we used simplistic cases for reproducibility and to keep the results easy to understand. As part of the model description paper, we are demonstrating use cases. The rainfall depths are not out of the ordinary for semi-arid climates like those in central Colorado, draw from NOAA data (cited now in the paper).

[13.13] So assuming 50 storms per year?

Additional text has been added to state the assumption for the base storm is 50 storms per modeled year, and 25 storms per modeled year in the higher intensity and longer duration storms.

[13.21] depth at all point

Changed.

[14.22] Isn't this expected? Don't think this is a finding.

Added a few extra words to clarify that these results were as expected.

[15.2] Not clear to me. What does this refer to? This was not mentioned in the introduction and came rather abruptly.

The Future Applications section (8) was updated to include more examples, and have softened the transition from previous sections.

[Figure 5] should be 0.4, as stated in the text?

We have double checked all labels and in text references to (now) Figure 7.

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