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Geoscientific
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Discussions

# *Interactive comment on* "The Gravitational Process Path (GPP) model (v1.0) – a GIS-based simulation framework for gravitational processes" *by* Volker Wichmann

**Anonymous Referee #2**

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General comments

In his manuscript, V. Wichmann presents a GIS-based simulation framework for gravitational processes, i.e. a compilation of model components and their software implementation. It includes various well-known as well as recently developed approaches that conceptually or semi-physically represent displacement processes (but not initiation processes). This simulation framework can be of great interest and value to a broad range of academic, government and corporate users especially since its open-source implementation facilitates access and encourages customization.

While this paper is, in principle, worthy of publication in GMD, in my view the manuscript should still be substantially improved:



- The introductory section currently does not provide a general scientific background and motivation.

- The cited references are too narrowly focused on work by Wichmann and Heckmann, including non-refereed publications. The chosen methods / model components and general modelling approach needs to be situated in the broader context of (physically-based, conceptual and empirical) models of gravitational mass movements.

- The Discussion lacks depth. In particular, limitations are not discussed, and comparisons with similar models and software (including commercial products) are missing.

- The presentation of model structure and components in sections 2 and 3 should be partly re-arranged and re-written as it is often hard to follow (see detailed comments below).

I hope that the author will find these general comments as well as the following detailed comments useful in improving their manuscript.

Detailed comments

P1L12 This paper will attract the interest of a broader audience if it starts with a paragraph introducing the motivation for this work and the broader context, e.g. scientific and societal relevance and need for this kind of model and software implementation

P1L17 what is 2.5D in this context? perhaps too much detail for an introduction

P1L18 Rather than presenting what the author's GPP model is capable of, the author should first provide a brief overview of state-of-the-art modelling approaches for gravitational mass movements (including suitable references to the literature) and then indicate which of these approaches were chosen for / included in GPP and why

P1L20-21 A reference should be included to support this statement. 'simple' may be more appropriate than 'simplistic'

P1L23-P2L2 - Some of the Wichmann / Heckmann references are published in less accessible journals and conference proceedings which may overlap in content with some of the peer-reviewed publications by the same authors? A better selection from this set of papers plus additional relevant references to the work of other authors may be more appropriate here. As far as hazard susceptibility modelling is concerned, I noticed that statistical and machine-learning methods (e.g. logistic regression, generalized additive model, support vector machine), which are tremendously popular in this field, aren't mentioned.

P2L33 'the plugging of a channel' - check wording; perhaps 'clogged stream channels'?

P3L5-9 This information is too detailed for a 'general model structure' section. Focus on broad concepts and structures, and explain the general modelling approach. E.g. is the proposed model based on principles of physics or is this a more heuristic GIS-based approach, could it perhaps be referred to as a cellular automata model? The processing steps descript in P3L12-15 appear to suggest a more heuristic approach that certainly ensures mass preservation but is not capable of accommodating the physical (sliding / flowing) behaviour of solid to liquid mixtures of rock, soil, water, snow etc. that may be present in the various types of gravitational mass movements considered here. Such a simple approach may not necessarily be a bad thing, but the methodology should be contrasted appropriately with other possible modelling approaches, in particular physically based ones. In this context it appears to me that the approach presented here is similar to the cellular-automata model proposed by Guthrie et al. (2008) in Landslides in the narrower context of landslide modelling.

'particle' - In general, I have the feeling that this word may be misleading; at the very least, its meaning in the context of this model should be properly defined. To me the word 'particle' suggests that the model works with some elementary units of mass, e.g. 1 $m^3$ blocks, that are either passed on or deposited. Does the model really operate on such discrete elementary units, or does it determine amounts of material (e.g. 1.432 $m^3$, i.e. real values not multiples of discrete units)? - (In P4L8 particles are referred to as "start cells", which adds to the confusion, since a grid cell does not change its



location but particles are presumably passed along.)

P4L10-19 - What's the rationale behind these three strategies? What geomechanical process characteristics are they based on?

Figs. 1-3 - Are all three figures necessary, or does figure 3 contain all necessary information? Diamond shapes are used for decisions; while "sink" and "stop" may be (nearly) self-explanatory, I am having difficulties understanding why "Material" or "Deposition Model" would involve a yes/no decision. E.g. if the material "stops" (Stop: Yes), then it will be deposited in full - what additional decisions are necessary? Perhaps some re-wording might help, or slightly more detailed labelling of boxes.

P6, Equation (2): This equation is a bit hard to read at first because of the unusual use of a conditional statement within a set, i.e. two opening curly braces of same size. Also, n_i should just be i, the cell identifier; n_i has not been defined. Perhaps to separate equations (2a) and (2b) should be given for N for gamma_max <= 1 and gamma_max > 1. A less technical and more direct way of expressing this condition would be to say that all beta_i are smaller or equal beta_thres and that at least one adjacent grid cell is steeper than beta_thres, respectively. Perhaps a brief explanation should be given as to what process or principle this equation is based on. It seems that this explanation is provided in lines P724-30 - why not here, before entering into technical details?

P7L9 "only steep neighbors are allowed" - what is the physical meaning of this? Does this restriction represent a real dynamic process or is this an arbitrary modelling decision?

P7L11 "which is missing [in] the modeling approaches developed for hydrological processes" - insert "in"; provide reference

In Eq. (4), upper branch (i' \in N), it seems necessary to include the persistence factor p in the denominator, i.e. \sum_j{p tan\beta_j} rather than \sum_j{tan\beta}. In the numerator, placing the factor p before tan\beta_j would be preferable. With this, the scaling mentioned in L19 seems avoidable as they would already add up to 1.

P7L18 "this property (Markov chain)" - the described property, which tries to represent inertia, doesn't seem to be related to the Markov property of stochastic processes.

P7L29-30 These statements concerning the dynamics properties of various types of mass movements should be supported with suitable references.

P7L33-38 run-out length calculated with geometric gradient approach - approach not introduced previously. In general, referring to section 3.2.1, how does this fit into the previously described framework that processes mass movements on a cell-by-cell basis while the run-out length approaches look at vectors from initiation points to potential run-out locations?

P8L15 This statement needs to be supported by a reference. The assumptions underlying the estimates presented in this paragraph should be outlined at least briefly.

P12 Eq. (16) The exponent \beta_i shouldn't be in superscript when using the exponential function exp; just write exp\beta_i instead of exp^\beta_i

Section 5 needs to discuss limitations of the presented model(s). E.g. this conceptual modelling approach is not entirely physically based; it builds upon basic principles such as mass preservation and tries to mimic typical macroscopic behaviours of various types of mass movements (e.g., divergence) without modelling the actual internal geomechanical dynamics (e.g. viscous flow etc. as applicable).

Run-up of material on the opposite valley slope doesn't seem to be possible in the GPP model since material is only transferred to lower-elevation neighbouring cells as mentioned in P6L27.

P21L14 "impact of ... immediately obvious" - This is not a result of this study. The authors should avoid claims that are neither based on their findings nor on the cited literature. It may be appropriate to state that the proposed model can be used to assess the potential effectiveness of such forests (provided that the relevant processes are



adequately represented by this model and its parameters).

A very brief section outlining implementation details should be included. E.g. which programming language; parallelized implementation? how parallelized, e.g. different Monte Carlo repetitions executed in parallel, ...?

Is it correct that this model implementation only provides forward modelling capabilities, i.e. modelling possible outcomes based on prescribed model parameters? Or is it also capable of estimating model parameters such as the persistence parameter based on observed runout distributions? Are there any capabilities for validating the model based on observed runout distributions, or does the user have to do this outside the GPP module? I am thinking AUROC estimation based on observed historical events as commonly done in the statistical landslide susceptibility modelling literature.

The presented model and its implementation should be contrasted against other models and software, including commercial products, at least at a general level.

If I understand correctly the present model does not implement scouring (erosion) along the path as implemented by other similar models such as Guthrie et al. (2008) in Landslides.

P21 Section 6 - This shouldn't be a separate section (unless required by journal policy)

Technical comments

P1L7 "practicability" -> applicability or feasibility

P1L8-9 "first ... re-written" seems contradictory; it can't be first if it has been re-written, extended and improved

P1 'large-coverage...' -> 'regional-scale'

P2L26 'disposition modelling ' - susceptibility or slope stability modelling?

P7L21 "like" -> "as"

P7L24 "iterations" -> "repetition"

P7L29 "fixation" - re-word

P9L9 (i.e. first line) and elsewhere: "encoded" - re-word

P20L15 "proven" - re-word

P21L9 "pure" -> "purely"

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