TRANSITION FROM 2D TO 3D ROCKFALL MODELLING: FEEDBACK FROM ENGINEERING USERS

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OBJECTIVES

Since efficient 3D rockfall simulation tools (e.g. hybrid-lumped-mass or rigid-body based) have become available, engineering professionals who have transitioned from 2D to 3D modelling often encountered various issues and questions.

Firstly, the belief that a more accurate, high-resolution digital terrain model (DTM) produces a more realistic simulation still exists. Though counter-intuitive, this assumption is generally untrue. Engineering professionals have often spent decades building their expertise using 2D models for many different geological rock conditions, so they may wish to compare their 3D model results with 2D ones. Experience shows, however, that when modelling rockfalls, restitution coefficients often need to be recalibrated to obtain comparable 2D and 3D modelling results. While this may raise questions or doubts about the relevance of 3D models at first, this apparent discrepancy has a physical explanation that does not affect the validity of 3D models. Next, the question naturally arises as to whether protection should preferably be dimensioned from 2D or 3D models and whether simulation results collected at the protection level can be analyzed statistically with the same accuracy for 3D models as for 2D ones. Finally, unlike 2D modelling, intensive 3D modelling (i.e. with a very large number of blocks, typically 10^5 to 10^8) can result in physical memory issues (RAM paging or overflow) for users. In such cases, adapted computing strategies are required to overcome this physical limit.

MATERIALS AND METHODS

The above points are clarified by analyzing, using both synthetic and realistic examples:

- The negative effects of using an oversampled DTM, and some ways to resolve these issues.
- An explanation of the apparent discrepancy between 2D and 3D soil restitution coefficients.
- Some specific points that users must be aware of when analyzing trajectories at protection level.
- Different paths to solve the RAM issue, bearing in mind that 'we don't get anything for nothing'.

MAIN RESULTS AND CONCLUSIONS

- Mesh resolution should be of a similar order of magnitude to the block size, a resolution of around one meter being usually satisfactory. For TIN-based DTMs, improving the block-soil contact geometry (e.g. via a local length scale) can avoid the drawbacks of high-resolution meshes.
- Careful consideration must be given to performing backward modelling of specific 3D trajectories using 2D models. If the selected 3D trajectories substantially deviate from the slope dip direction, the computed 2D trajectories along the 3D profile will not actually represent the same initial value problem. This explains the apparent discrepancy between the 3D and 2D results.
- At the protection level, there is no fundamental difference between the statistical analyses performed on 2D and 3D models, as the same concepts apply.
- To avoid reaching the physical RAM upper limit, users must strike a balance between computational efficiency and results comprehensiveness by optimizing the model geometry, decimating the mesh, choosing the relevant analysis grid size, and also selecting the most appropriate computation strategy.