QUANTIFYING THE TERRAIN SURFACE ROUGHNESS PERCEIVED BY BLOCKS OF DIFFERENT SIZES

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Numerous rockfall simulation models use artificial surface roughness to be combined with the terrain elevation model. This gives users a lot of freedom, at the expense of the objectivity of the results that can be produced. To quantify and limit the range of values that users should use, we developed a numerical tool that can be used to measure the perceived surface roughness for different samples of terrains. After the method being shortly described, vertical and lateral ranges of deviations encountered for six different terrain surfaces roughness are shown.

Keywords: rockfall, surface, roughness, terrain, simulation, SfM, LiDAR, TLS, ALS

INTRODUCTION

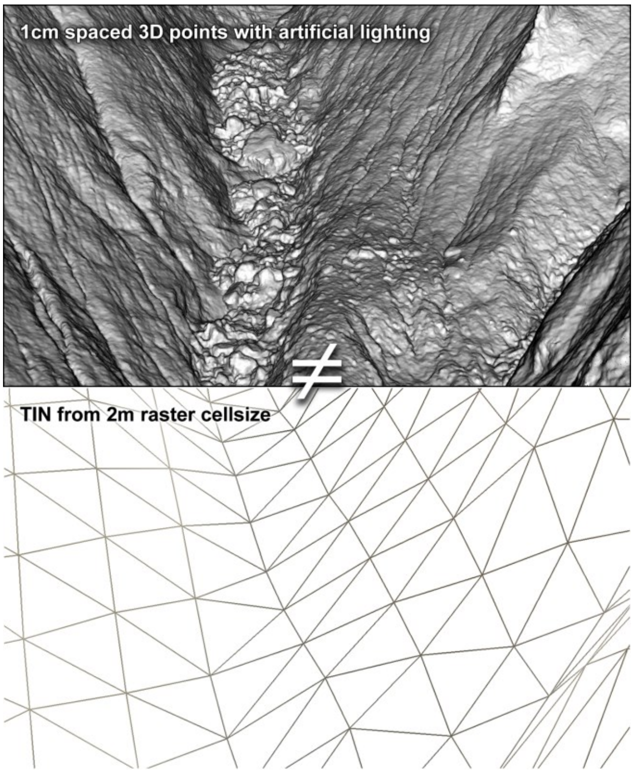

Fig. 1 It is common to lose some surface roughness when representing the terrain with digital elevation model. Here for example, most surface roughness is absent on the triangulated mesh from 2 m raster compared to the same view with 1 cm spaced 3D point cloud.

When representing a site with a 3D terrain model (DTM), some detail of the surface might be lost due to the resolution of the model used (Fig. 1). This may not be always cause for concern depending of the application cases. However, it can affect the results of rockfall simulations [1]. Indeed, many impact models split the input conditions for each impact in two: one related to the tangential and the other related to the normal components of the input velocity with the ground. The problem is that these components are dependent of the terrain orientation and this orientation changes locally with the resolution of the 3D terrain model.

One way of solving this problem is to introduce artificial surface roughness on the DTM, as it is done in numerous existing simulation models (eg. RAMMS::ROCKFALL, Rockyfor3D, RocFall, CRSP-3D, etc.). This is often done subjectively, based on the user's knowledge and experience with the simulation tool used. The simulation results produced can then variate a lot from user to user [2]. To solve this problem, we developed a numerical tool that can be used to measure objectively the perceived surface roughness for different samples of terrains. Its operation is partially described in the methodology section, followed by examples of results produced for 4 different block sizes impacting 6 examples of land surfaces (Fig. 2).

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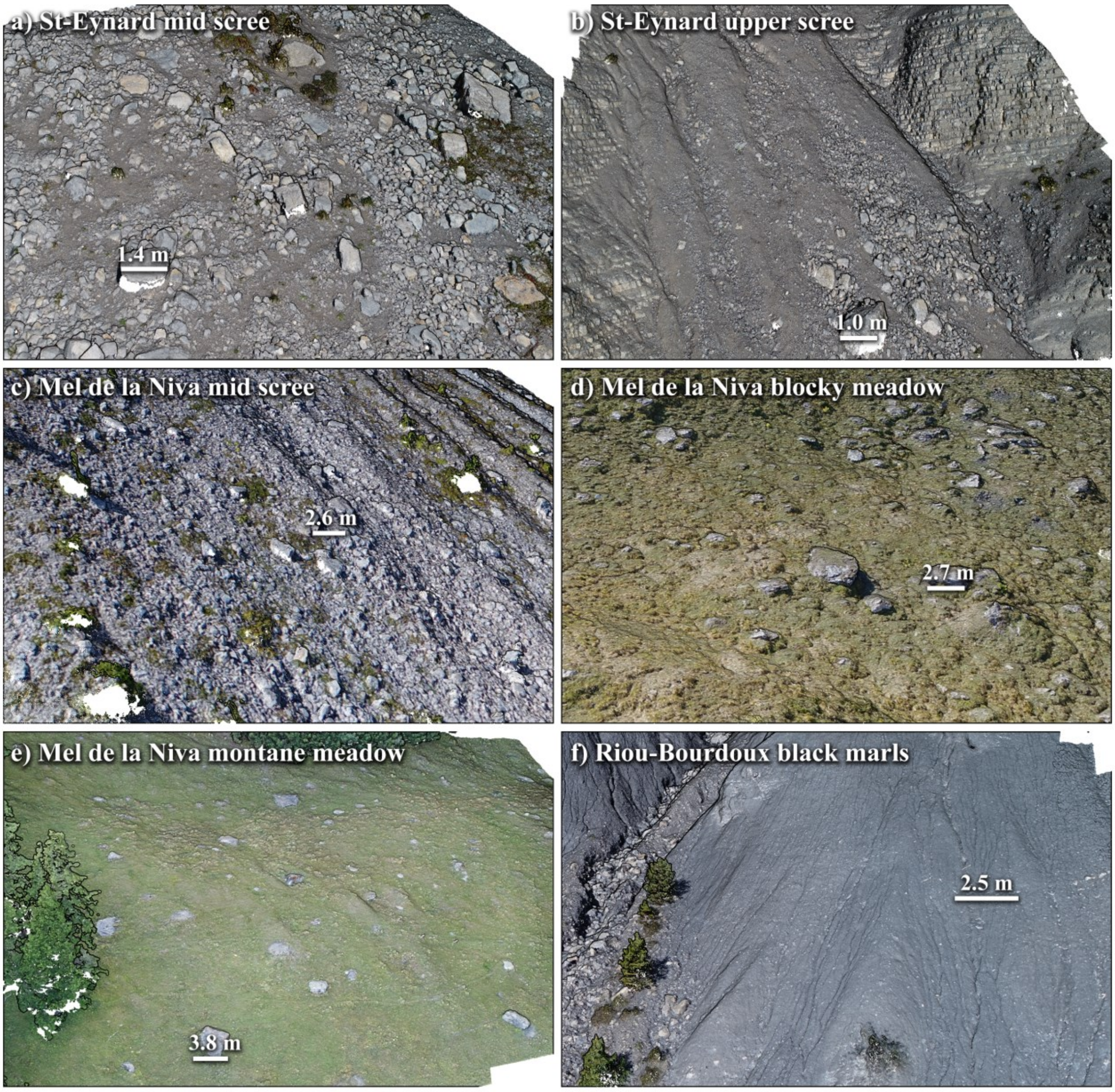

Fig. 2 Six selected sites for their characteristic surface roughness encountered on rockfall prone terrain. The central section of each 3D scene has been isolated to extract its surface roughness. Here, each scene is shown with the 3D SfM model textured and with edges of the foreground elements highlighted using the Eye Dome Lighting filter.

METHODOLOGY

The developed tool simulate about 20 million 3D rockfall impacts on the terrain sample for the chose block size. It uses our developed impact detection algorithm that works on detailed terrain model and consider the block sizes [3]. These simulations are distributed for incident impact angles with the terrain from 5 to 90 ° in 5 ° increments, and with direction from North to South. The terrain samples should correspond to the highly detailed terrain elevation to which the coarse elevation of the DTM is subtracted (DoD), and oriented so the original slope aspect is facing South (because of the simulated impacts coming from N to S). The results are outputted as a distribution of the vertical and lateral deviation angles perceived by the block compared to the terrain orientation it would perceive if the terrain was exempt of any roughness. This process takes from few seconds to about one minute to complete per terrain sample and block size.

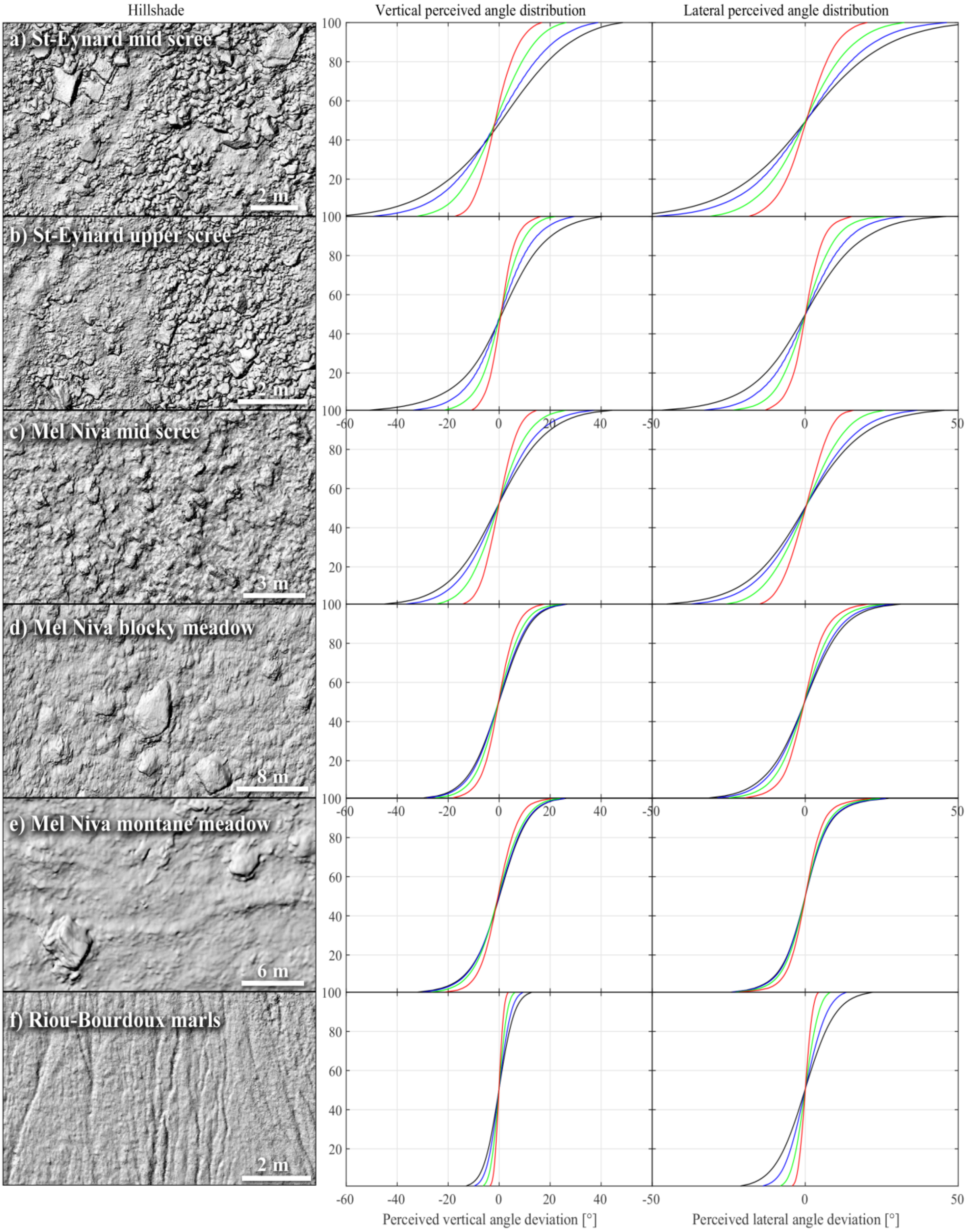

Fig. 3 Vertical and lateral perceived deviation angles for the six tested sites with four different block sizes. The first column shows the surface's shaded top views of the sites. The second column shows the vertical perceived deviation angles. The last column shows the lateral perceived deviation angles. The vertical axis of each graphs corresponds to the centiles. The results for the 0.3, 1.0, 3.0 & 10 m wide blocks are represented respectively with the black, blue, green and red lines.

For this extended abstract, examples of deviation perceived angles are given for 6 selected sites (Fig. 2). Highly detailed 3D models of the sites have been generated using SfM photogrammetry. Their scale and orientation have been adjusted from mobile and fix terrestrial and airborne LiDAR data. The DoDs were generated by subtracting the elevation linearly interpolated from a lowered resolution of the 3D terrain model to the high-resolution terrain samples. Four block sizes were tested for this example, with maximum diameters of: 0.3, 1.0, 3.0 & 10.0 m.

RESULTS & DISCUSSION

The results for the 6 terrain samples are shown at Fig. 3. They cover the straight impacts with incident angle of 90° toward the terrain samples. The other incident angles are not covered here to remain concise, given the four pages restriction. All deviations shown in Fig. 3 seem to follow gaussian distributions. The range covered by the distributions gets wider as the terrain's roughness increase for both vertical and lateral perceived angles.

For the same scree (terrain samples a) & b)), the deviation perceived is more important at mid height than near the top of the scree (foot of the cliff). This is corelated with the granoclassement present where larger deposited blocks are more present toward the bottom of the scree, and smaller ones stopped earlier, near the top of the scree. The effect of the size of the blocks is also well visible, with the 0.3 & 1.0 m particle reaching around ± 40° of deviation compared to the 3.0 & 10.0 m reaching about half of this range. This also partly explains why larger blocks can travel further.

The size of the present roughness also plays a role. For samples d) & e), the deposited blocks from Mel de la Niva mountain on the meadow are quite large. This slightly increase the deviation range perceived by the 10.0 m blocks, and there are few differences in the range of the other block sizes there, because of the lack of smaller surface roughness. The orientation and size of the terrain's features also affect differently the blocks, as it can be seen for the lateral deviations obtained for the samples e) & f). In e), the large deposited blocks and horizontal ridges created by livestock affect all tested sizes in a similar manner compared to the small erosion gullies in f) that makes smaller blocks deviate more than the larger ones.

CONCLUSION

Questions might remain related to how the perceived surface roughness might be affected by the deformation of the terrain under impacts and by the shape of the blocks. However, properly decomposing the impact component objectively, which is made possible thanks to the presented method, is a first step in the right direction. This method used for rockfall simulations will ensure the production of objective results. It has been added to our simulation model under development and will be made available once the related work gets published.

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