Quantification of Mogote Asymmetry: Arecibo, Puerto Rico

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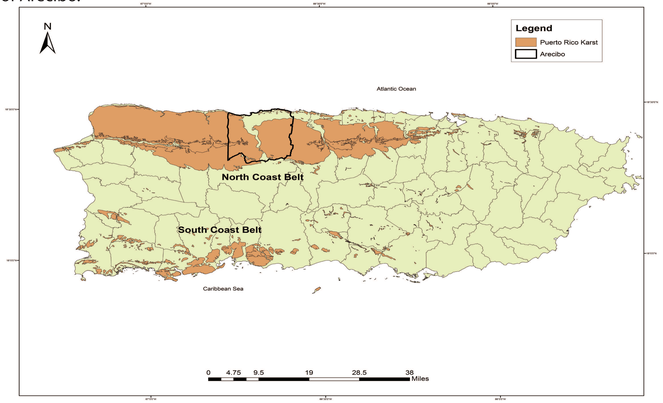
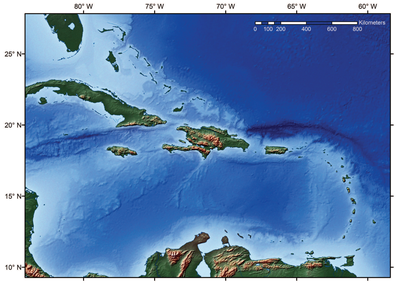
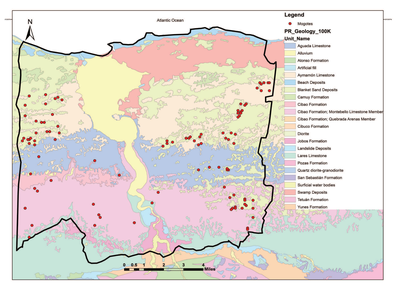
Abstract

Mogotes are dissolution landscape features that are common in the northern karst terrain of Puerto Rico. Their height mostly ranges from 30 to 50 meters, with some over 50 meters. Since the early 20th century, it has been noted that these features tend to have asymmetrical shapes, most commonly with steeper western slopes. Potential causes for the asymmetry of mogotes that have been suggested include differential solution during daily afternoon showers when the western slopes are heated to a higher temperature or action by trade winds which arrive predominantly from the east (Hubbard, 1923; Thorpe 1934). A pilot study conducted in the 1970's using field and photogrammetric data resulted in a slope asymmetry developed in 35% of the mogotes. This asymmetry was related to erosion undermining the mogote slopes causing collapse and subsequent asymmetry (Day, 1978). In order to quantify these anecdotal observations to provide context for local mass wasting hazards, we used a 25 m^2 (DEM) to construct North-South and East-West topographic profiles for solitary mogotes in the pilot study area of the municipality of Arecibo.

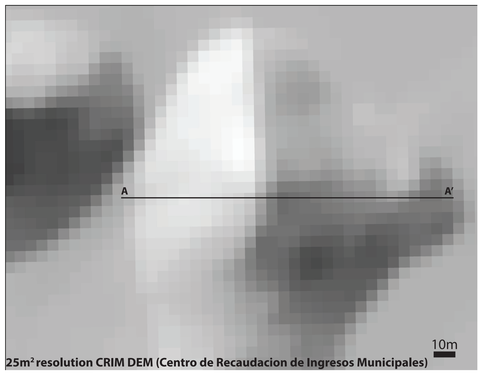


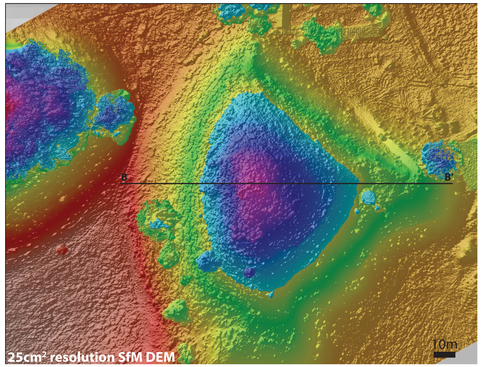
Profiles were generated for 104 mogotes and the resulting metrics show that there is no consistent topographic asymmetry in the data derived from the DEM, regardless of unerdlying geologic unit. However, our field observations indicate that the DEM used is likely too coarse to accurately capture the asymmetry of individual mogotes. To carefully measure the true slope of one target feature, we used the Structure from Motion technique on a mostly unvegetated mogote using over 400 aerial images captured with a drone. The resulting 3D Model was converted to a high-reolution DEM, which was used to construct much more precise topographic profiles. The results of this analysis were compared with the results from the coarse 25 m^2 DEM.

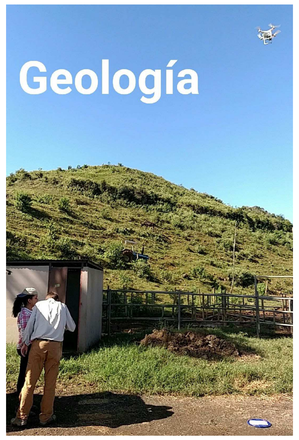


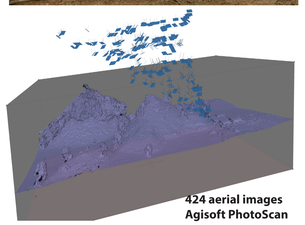


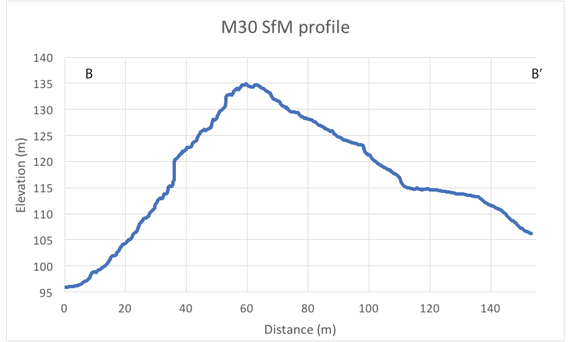
Structure from Motion



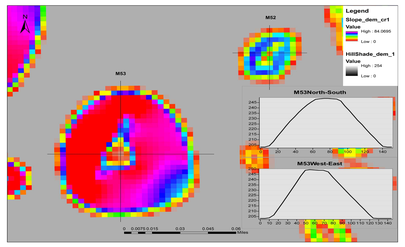




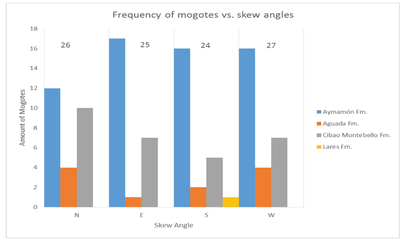




Analytical Procedures



ESRI ArcMap Transects and profiles of West-East and North-South of "mogote 53", showing steeper slope in the West side.



Topographic skew was derived trigonometrically as the azimuth direction between a hypothetical center point (Px-=0.5, Py=0.5) and the actual observed position of (Px, Py).

Conclusion

The results of the analysis of the lower resolution 25 m^2 DEM are mostly inconclusive. Therefore this dataset is not useful in order to determine mass wasting hazards related to mogotes. In order to produce a higher resolution dataset, we targeted a mostly unvegetated mogote and collected over 400 images using a DJI Phantom 3 drone; these images were processed using the AgiSoft PhotoScan software to produce a 25 cm^2 resolution DEM.

The results from this procedure show that this target mogote is definitely asymmetrical, with a steeper western slope as commonly described by early workers (Hubbard, 1923; Thorp, 1934). This study demostrates that the Structure from Motion technique can be used to quantify the asymmetry of solitary mogotes in order to evaluate their possible mass wasting hazards, even in the heavily vegetated tropical landscape of Puerto Rico.

References

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Thorp, J., 1934, The asymmetry of the Pepino hills: of Puerto Rico in relation to the trade winds: The Journal of Chicago Press, v. 42, p. 537-545, doi:136.145.123.144/j.stor.2016.7.04

Day, M.J., 1978, Morphology and distribution of residual limestone hills (mogotes) in the karst of northern Puerto Rico: Geological Society of America Bulletin, v. 89, p. 426-432.