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DEM quality assessment and improvement in noise quantification for geomorphic application in steep mountainous terrain

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Spaceborne digital elevation models (DEMs) are fundamental data for mapping and analyzing geomorphic features at regional and continental scale, but are limited by both their spatial resolution and accuracy. Typically, accuracy is measured using point- or profile-based geodetic measurements (e.g., sparse GNSS). We develop new methods to quantify the vertical uncertainty in spaceborne DEMs relevant to geomorphic analysis, focusing on the pixel-to-pixel variability internal to a given DEM, which we term the *inter-pixel consistency*. Importantly, the methods we develop are not based on external, geodetic measurements. Our codes are published open-source (https://github.com/UP-RS-ESP/DEM-Consistency-Metrics), and we particularly highlight a novel sun-angle rotation and hillshade-filtering approach that is based on the visual, qualitative assessment of DEM hillshades. Since our study area is in the arid Central Andes and contains diverse steep (volcano) and flat (salar) features, the environment is ideal for vegetation-free assessments of DEM quality across a range of topographic settings. We compare global 1 arcsec (~30 m) resolution DEMs (SRTM, ASTER, ALOS, TanDEM-X, Copernicus), and find high quality (high inter-pixel consistency) of the newest Copernicus DEM. At higher spatial resolution, we also seek to improve the stereo-processing of 3 m SPOT6 optical DEMs using the open-source AMES Stereo-Pipeline. This includes optimizing key parameters and processing steps, as well as developing metrics for DEM uncertainty masks based on the underlying image texture of the optical satellite scenes used to triangulate elevations. Although higher resolution spaceborne DEMs like SPOT6 are only available for limited spatial areas (depending on funds and processing power), the improvement in geomorphic feature identification and quantification at the hillslope scale is significant compared to 30 m datasets. Improved DEM quality metrics provide useful constraints on hazard assessment and geomorphic analysis for the Earth and other planetary bodies.