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Processing, validating, and comparing DEMs for geomorphic application on the Puna de Atacama Plateau, northwest Argentina

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This study analyzes multiple topographic datasets derived from various remote-sensing methods from the Pocitos Basin of the central Puna Plateau in northwest Argentina at the border to Chile. Here, the arid climate and clear atmospheric conditions and lack of vegetation provide ideal conditions for remote sensing and Digital Elevation Model (DEM) comparison. We compare the following freely available DEMs: SRTM-X (spatial resolution of ∼30 m), SRTM-C v4.1 (90 m), and ASTER GDEM2 (30 m). Additional DEMs for comparison are generated from optical and radar datasets acquired freely (ASTER Level 1B stereo pairs and Sentinal-1A radar), through research agreements (RapidEye Level 1B scenes, ALOS radar, and ENVISAT radar), and through commercial sources (TerraSAR-X / TanDEM-X radar). DEMs from ASTER (spatial resolution of 15 m) and RapidEye (∼5-10 m) optical datasets are produced by standard photogrammetric techniques and have been post-processed for validation and alignment purposes. Because RapidEye scenes are captured at a low incidence angle (<20º) and stereo pairs are unavailable, merging and averaging methods of two to four overlapping scenes is explored for effective DEM generation. Sentinal-1A, TerraSAR-X / TanDEM-X, ALOS, and ENVISAT radar data is processed through interferometry resulting in DEMs with spatial resolutions ranging from 5 to 30 meters. The SRTM-X dataset serves as a control in the creation of further DEMs, as it is widely used in the geosciences and represents the highest-quality DEM currently available. All DEMs are validated against over 400,000 differential GPS (dGPS) measurements gathered during four field campaigns in 2012 and 2014 to 2016. Of these points, more than 250,000 lie within the Pocitos Basin with average vertical and horizontal accuracies of 0.95 m and 0.69 m, respectively. Dataset accuracy is judged by the lowest standard deviations of elevation compared with the dGPS data and with the SRTM-X control DEM. Of particular interest in the field of quantitative geomorphology are topometrics (e.g., relief, channel steepness, and hillslope concavity) derived from the DEMs. The accuracy of these metrics is partly dependent on the overall DEM accuracy, but also on the accuracy of the depiction of the river network (a small areal fraction of the DEM). In addition, several topometrics depend on the first and second derivative of elevation (slope and curvature), which are affected by DEM accuracy and noise. In light of these issues, topometrics are compared across the DEM datasets in order to assess their quality for specific geomorphic applications.