Effects of spatial resolution on slope and aspect derivation for regional-scale analysis

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Abstract— **When performing a regional-scale geomorphometric analysis, one might face a decision on whether to derive morphometric data from a low-resolution DEM or to calculate basic derivatives from a higher resolution dataset and average these data afterwards. This paper investigates differences between morphometric parameters (slope and aspect) derived from a resampled DEM and resampled morphometric data derived from a medium resolution DEM, with examples for three study areas in South America. Using a low resolution DEM for regional scale morphometric analysis is not an optimal choice, since slope attenuation will strongly affect the distribution of calculated values. Unless bounded by computational constraints, one should choose to derive basic morphometric parameters from higher resolution data, and resample it to a coarser resolution as needed.**

INTRODUCTION

The widespread availability of medium to high resolution Digital Elevation Models (DEMs) has grown exponentially in the last years. While ASTER GDEM [1] and SRTM [2] provide a global or near-global coverage at medium spatial resolution (30 to 90 m), the forthcoming TanDEM-X will deliver a global dataset with a resolution of 12 m [3] and the Open Topography initiative [4] aim to centralize the distribution of high-resolution (usually less than 5 m) elevation data derived from airborne or ground-based LiDAR.

In the case of a regional-scale analysis, when areas as large as entire continents can be studied [5][6], use of medium/high resolution data may impose computational constraints in processing time, available memory or even software capability to handle large amounts of data.

One common alternative is to use coarser resolution DEMs (such as SRTM30_PLUS [7], with spatial resolution of about 1 kilometer) to derive morphometric data. Another option would be to use medium/high resolution DEMs to derive morphometric parameters and then resample these parameters to a coarser resolution [8-13].

This paper intents to investigate the differences between morphometric parameters (slope and aspect) derived from a resampled DEM and resampled morphometric data derived from a medium resolution DEM. Examples are presented for three study areas in South America (Fig. 1), one in the Amazon region (gentle, flat topography), one in southeastern Brazil (Minas Gerais State - mixed topography with hills and ranges) and one in the Andes Chain (mountainous relief).

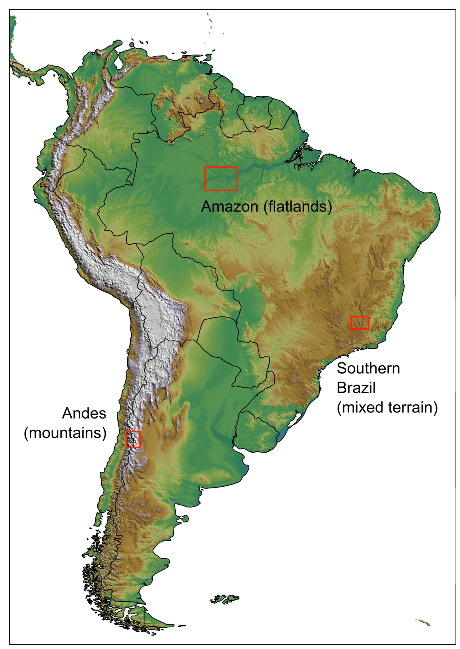

Figure 1. Location of study areas in South America

METHODS

DEM preparation

SRTM V4 elevation data was downloaded from CIAT-CSI website [14] and processed in GRASS-GIS [9]. After merging the data tiles for each area, a bilinear interpolation was performed at the original resolution of 3 arcsec to avoid artifacts in derived parameters, and slope and aspect were calculated using Horn's formula [16].

Parameters derived from a resampled DEM

For each study area, the base DEM was resampled (averaged) at resolutions of 0º0'10", 0º0'15", 0º0'20", 0º0'25", 0º0'30", 0º0'35", 0º0'40", 0º0'45", 0º0'50" and 0º01'. Slope and aspect were calculated and aspect values were converted from cartesian to azimuth angles [17].

Resampled parameters from a base DEM

In this case, original values of slope and aspect (calculated at 0º0'03" resolution) were resampled at resolutions of 0º0'10", 0º0'15", 0º0'20", 0º0'25", 0º0'30", 0º0'35", 0º0'40", 0º0'45", 0º0'50" and 0º01'. Slope was taken as the average of values and aspect was calculated as a vector mean.

Analysis

The differences between both methods of obtaining aspect and slope values in a coarser resolution was done by comparing: a) density plots [18] of all calculated maps and (Fig. 2) b) plots of the correlation coefficient (R-square) between the original parameter (0º0'03" resolution) and resampled values (Fig. 3).

RESULTS

Fig. 2 shows density plots of the calculated parameters. Shades of green are used for parameters derived from a resampled DEM and shades of blue for resampled morphometric parameters.

Resampling the DEM prior to calculating derivatives will attenuate relief and slope will systematically reduce as the resolution becomes coarser [8,11,12,18]. In all study areas, the density curve's mode shifts towards the y-axis (Fig. 2 A, C) and in the Andes area (mountainous relief), the distribution looses its bimodal character (Fig. 2 E). Resampled slopes do not vary much from the original values, without a significant shift of the mode and maintaining the bimodal character in the Andes area.

Aspect presents a consistent behavior for values calculated from a resampled DEM and for averaged aspect values. In the Amazon area (flat terrain) and in Southeastern Brazil area (mixed terrain), differences between density curves for both methods is easily noticed, while in mountainous terrain the differences are less distinct.

Correlation plots (Fig. 3) shows that data obtained from averaging the original morphometric parameter (blue lines) has a higher correlation with the original parameter than parameters calculated from an averaged DEM (green lines).

CONCLUSIONS

The data presented in this paper suggests that using a low resolution DEM for regional scale morphometric analysis is not an optimal choice, since slope attenuation will strongly affect the distribution of calculated values.

Unless bounded by computational constraints, one should choose to derive basic morphometric parameters from higher resolution data, and resample it to a coarser resolution as needed.

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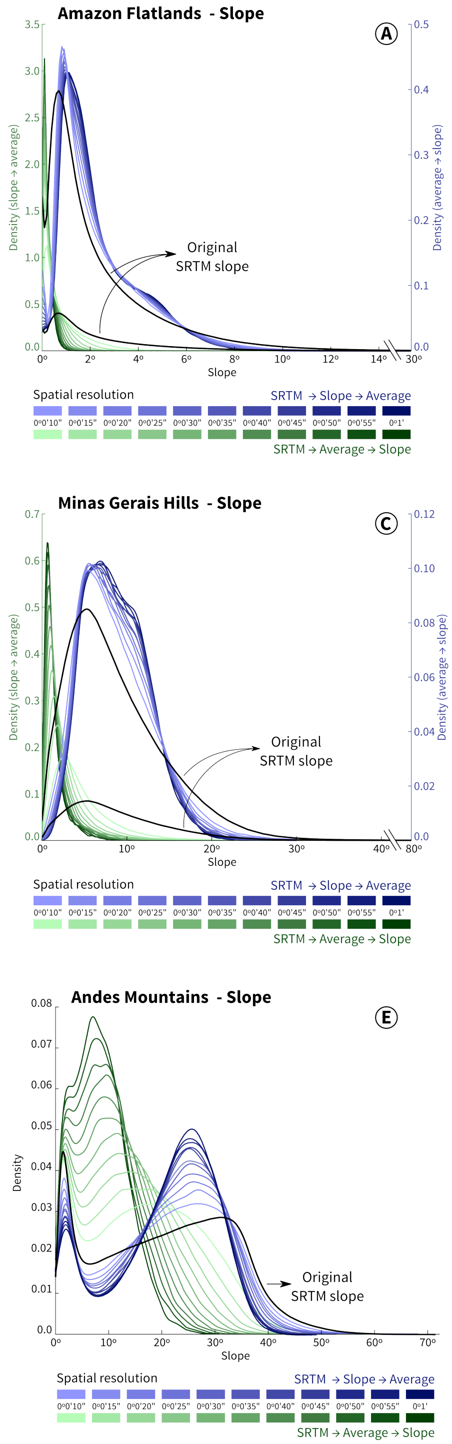

Figure 2. Density plots for slope and aspect derived from a resampled DEM (shades of green) and resampled slope and aspect derived from a base DEM (shades of blue)

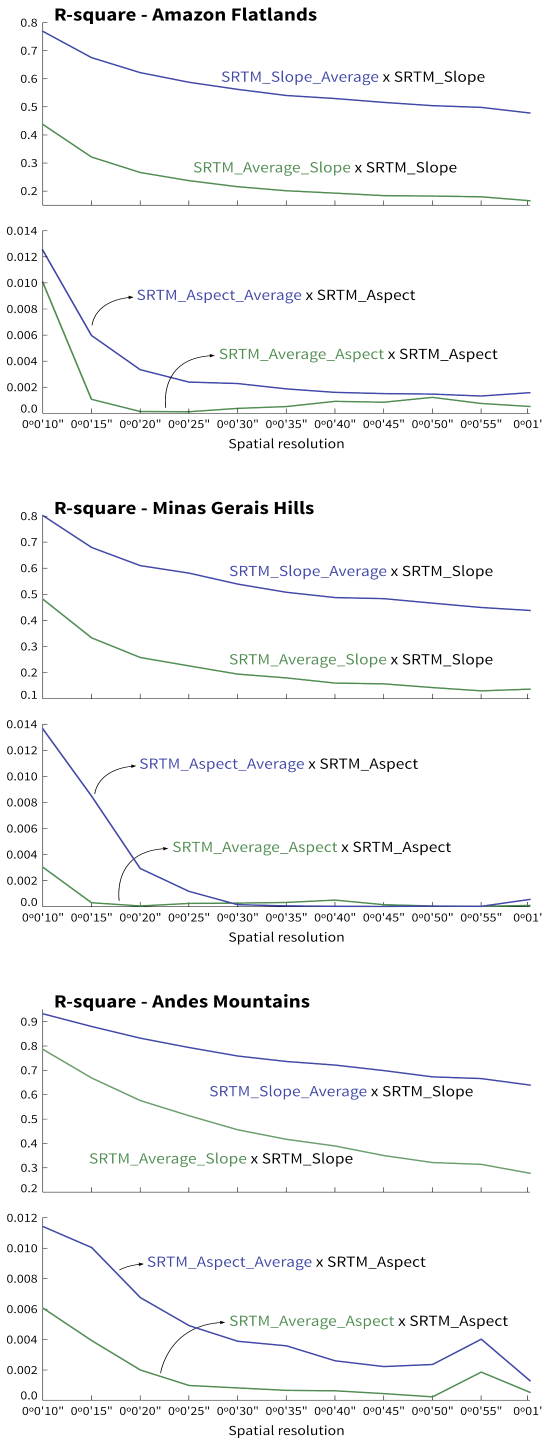

Figure 3. Plots of correlation (R-square) between the original morphometric parameter (0º0'03" resolution) and resampled values

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