P-048

REMOTE SENSING AND GIS TECHNIQUES TO LANDSLIDE SCARPS DETECTION

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INTRODUCTION

Remote sensing techniques have been widely used from 1990 years in the landslides research. These techniques are generally based on multi-spectral analysis (color compositions, vegetation and other indexes, principal component analysis -PCA- and digital classifications) and textural analysis (textural filters and image segmentations). Other approaches are 3D modeling (from stereoscopic images), lidar and radar interferometry.

GIS techniques are also used to analyze the relations between determinant factors and landslides and to model landslides hazards by means factor layers overlapping.

STUDY ZONE AND SATELLITE IMAGES

The study zone, located Betic Cordilleras (Granada province, Spain), is an area prone to terrain instability, because of a combination of a steep relief and a geological setting susceptible to slope movements.

Medium to high resolution images have been used in this work, correspond to satellites Landsat 7-TM, Spot 5 and Ikonos.

METHODOLOGY

The following techniques have been sequentially used:

1. Pre-processing: Images have been referenced to UTM projection by means control points and a DTM of 10 m resolution. Atmospheric effects have been reduced by Chavez correction.

2. Enhancement: Image bands have been enhanced by lineal, logarithmic or square root stretching. Color compositions including near infrared (NIR) band have been made to distinguish between areas covered or non-covered with vegetation.

3. Several filters have been applied mainly to panchromatic images, particularly textural filters, used to calculate variance between neighboring pixels and to detect irregular morphologies as those in landslides.

4. Transformations: Vegetation indexes are very useful to identify landslides scarps in zones with vegetation cover. PCA bands compositions show a higher variability than the original ones and allow better detection of elements.

5. A supervised classification has been made, discriminating four classes of land-uses and materials: urban/waste lands; vegetation zones (cultivations, grass and forests), soils/brush zones; and, finally, fresh rock outcrops/alluvial deposits. Different types of landslides have been considered as fifth class (figure 1). A separability analysis allow check if it is possible to distinguish between the different landslide types, and between them and stable terrains.

RESULTS AND DISCUSSION

Rock fall zones present mainly lower values of digital number (DN) (darker zones), than mean values of whole image. In the study zone, these values are related to shadow zones, as result of a local effect in the northern slope of a very steep range.

Rock slides have moderate values of the correlation coefficients, probably because of the use of the whole movement and not only the scarps in the analysis. Rock slide zones usually present higher DN values (clearer zones) than mean values in panchromatic images, and lower DN values than mean values in NIR band and NDVI index. It is related with the higher reflectance that presents fresh rock in the visible bands and the lower reflectance in the NIR band regarding to surrounding terrains, due to loss of vegetation.

Debris flows present irregular results and lower correlation coefficients, probably related to its location in ravines o steep zones, affected in an irregular way by solar illumination. In shadow zones, ND values are lower than mean values of the whole image, while in illuminated zones opposite happens.

The observed differences in the behavior of mobilized zones regarding to whole images suggest the utility of digital classification. However, the separability analysis of spectral signatures shows the difficulty to distinguish between landslides and other land uses (figure 2).

This problem leads to combine digital classifications with other approaches. Then, we can observe that in textural filter images, mobilized zones present higher DN values (higher variance) than the mean values of the whole image. In this way, filtered images can be used to discriminate between stable and unstable zones in those cases where classifications are not clear.

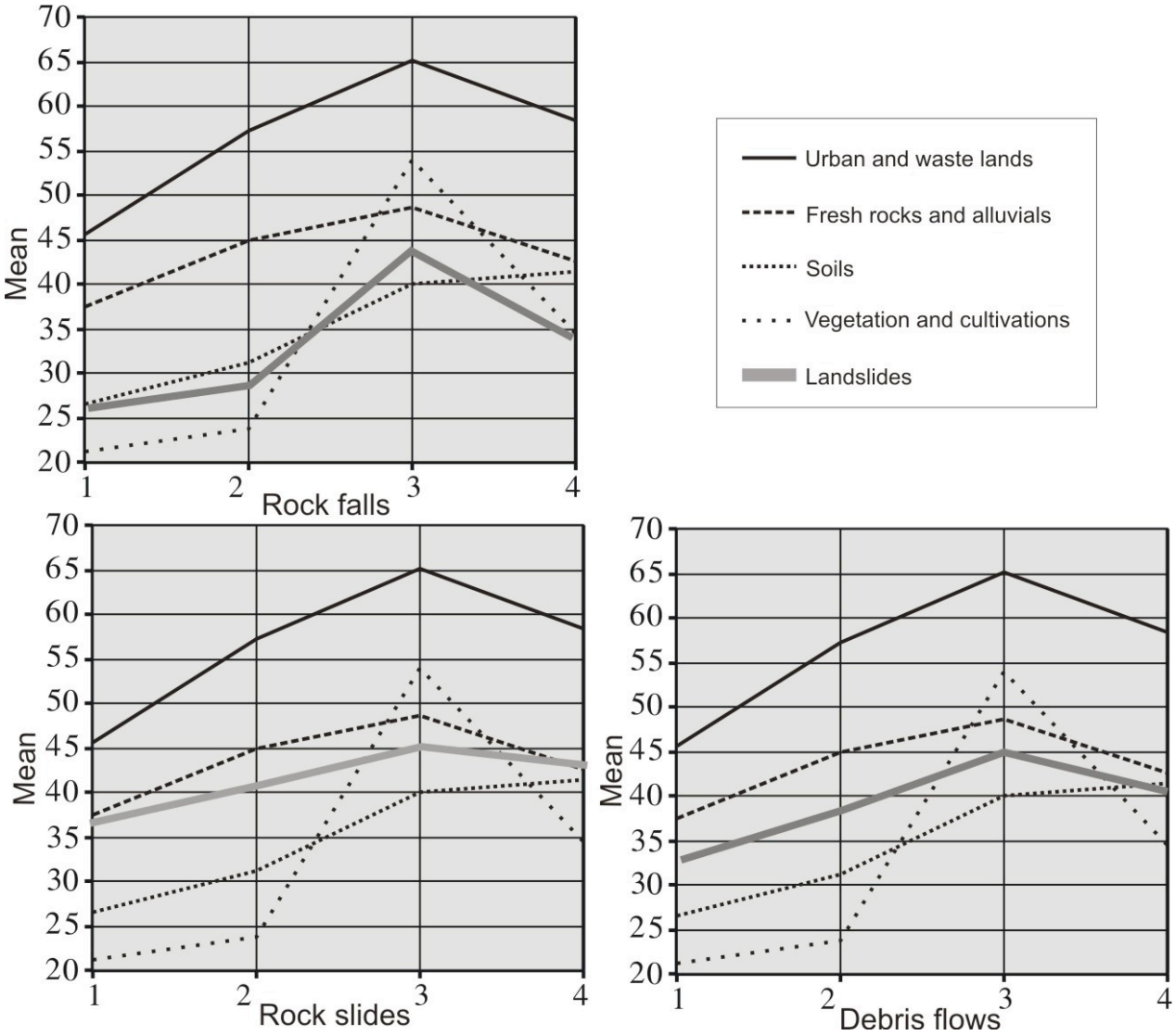

Figure 2. Spectral signatures.

CONCLUSIONS

There are many approaches to the study of landslides by means remote sensing techniques, most of them based on multi-spectral or textural analyses. In this work we combine both approaches, specifically, digital supervised classification and filter of variance.

Previously, a GIS analysis allows determine correlations between the different landslide typologies and satellite images. In this way, rock falls are mainly related to lower DN values (darker zones) while rock slides and debris flows are related to higher DN values (clearer zones) of the images.

Digital classification from multi-spectral images has allowed define a class to each landslide typology; but, this class usually present a certain mixture with other classes. Textural analysis resolves some of these confusions, discriminating the slope movement class from other land uses.

The application of remote sensing techniques are proved again and further researches must to be centered in the improvement of enhancement techniques, in textural analysis and in the combination of these techniques with photogrammetry and field work.