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Surface changes in the Atacama Desert due to two extreme rainfall events: Insights from IrMAD processing in LANDSAT imagery and unsupervised classification

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The Atacama Desert in northern Chile is the driest place in the world. Nevertheless, it has experienced some rare, extreme rainfall events that have caused landscape changes. Rain events of March 2015 and July 1991 caused extensive damage in some locations. Attempts at spatially comprehensive detection of areas that change due to rainfall include use of InSAR after the March 2015 rain event in Antofagasta Province, Chile (Scott et al., 2017). In this work, we employ a new method to delimit the areas of important change in the physical characteristics of the surface using LANDSAT imagery; one of the cases allows comparison to the InSAR approach. The process is an easy, semiautomatic, and reproducible methodology that has the potential to identify the types of surface change. The method is based on a succession of filters that constrain the area of change due to extreme rain, while deleting areas of human activities and of shadow change.

The filter sequence starts with the identification of areas of human activity using two different information sources: a map of historical mine disturbances based on visual inspection of optical satellite images, and the extreme differences between two before-rain LANDSAT scenes. The latter are identified using the extreme Chi-square values produced using IrMAD (Nielsen and Morton, 2011), an unsupervised change-detection procedure which is also able to characterize the degree of change. The two products are merged into one Human Activity polygon (HA). Areas with high degrees of change in shadows are identified using simple hillshades (Shadow Changes polygon, SC). Then, we combine HA and SC to form a non-rain effect area (Non-Rain polygon, NR). Finally, with the NR polygon masked, we extract the high-value IrMAD results from a set of images for dates before and after a rain event (Second Chi-Square polygon, SCS) to define the area of true rain influence.

Using the area of true change as a mask of the MAD (multivariate alteration determination) rasters, which corresponds to the variance in every spot in different wavelength of the six bands (1,2,3,4,5,7 for the 1991 rain event and 2,3,4,5,6,7 for the 2015 event), we performed an unsupervised classification in ArcGIS software, selecting 10 classes.

The unsupervised classification shows great potential for delimiting categories of change – erosion, deposition or moisture content - in the playa-lakes and channels. One class correlate strongly to alluvial fans and colluvium-covered hillslopes. However, it is ambiguous whether the hillslope changes result from non-filtered shadow changes or real soil surface changes. Additionally, there are some classes that mainly show cloud change and LANDSAT misdetection areas.

Nielsen, A. A, and Morton, C. J., 2011, A Method for Unsupervised Change Detection and Automatic Radiometric Normalization in Multispectral Data: 34th International Symposium on Remote Sensing of Environment (Sydney, Australia: ISPRS, 2011).

Scott, C., Lohman, R., and Jordan, T.E., 2017, InSAR constraints on soil moisture evolution after the March 2015 extreme precipitation event in Chile: Scientific Reports, 7(4903), 10.1038/s41598-017-05123-4.2.