Geophysical Research Abstracts
Vol. 16, EGU2014-3773, 2014
EGU General Assembly 2014

Mapping the vegetation colonization on recent lava flows using spectral unmixing of moderate spatial resolution satellite images: Nyamuragira volcano, D. R. Congo

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In volcanic areas, vegetation colonizes recently erupted lava flows and expands over time. The fraction of vegetation is therefore likely to provide information on lava flows' age. Individual lava flows are usually not well resolved on satellite imagery due to the coarse spatial resolution: one pixel on the imagery is a mixture of mainly lava and vegetation. In order to solve the mixed pixel problem, many different methods have been proposed among which linear spectral unmixing is the most widely-used. It assumes that the reflectance of the mixed pixel is the sum of the reflectance of each pure end members multiplied by their proportion in the pixel. It has been frequently used in urban area studies, but no efforts have yet been made to apply it to volcanic areas.

Here, we demonstrate the application of linear spectral unmixing for the lava flows of Nyamuragira volcano, in the Virunga Volcanic province. Nyamuragira is an active volcano, emitting over 30 lava flows in the last 100 years. The limited access to the volcano due to social unrest in D. R. Congo justifies the value of remote sensing techniques. This shield volcano is exposed to tropical climate and thus vegetation colonizes lava flows rapidly. An EO-1 ALI image (Advanced land imager mounted on Earth Observing -1 Satellite) acquired over Nyamuragira on January 3, 2012 at spatial resolution of 30 m was processed with minimum noise fraction transform and end member extraction, and spectrally unmixed by linear mixture modelling technique into two types of lava, and one or two types of vegetation. The three end member model is better in terms of the RMSE and the expected spatial distribution of end members. A 2 m resolution Pleiades image acquired on January 21, 2013 and partly overlapping with the ALI image was taken as the reference image for validation. It was first classified using a supervised pixel-based classification technique and then compared to the proportion image derived from the ALI image. Results show that accuracy depends on the size of moving window of validation samples. We find a best fit (R^2 >0.8) between the two datasets when using a 180 x 180 m^2validation sample. We also find that vegetation proportion have a strong linear correlation with the normalized difference vegetation index (NDVI). When applied to the entire ALI scene, the proportion of vegetation on the recent flows is shown to be mostly controlled by the age of the lava surface and the proximity to the flow boundary. This technique opens the perspective to further characterize the dynamics of vegetation recovery on fresh volcanic surface.