Volcanic deposit mapping using surface roughness textures

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Spectral remote sensing is well suited for differentiating regions based on chemistry and mineralogy. The addition of quantitative morphologic analyses augments spectral interpretations as compositionally identical materials can have quite distinct morphologies. This is especially relevant for volcano remote sensing where vastly different emplacement mechanisms can produce deposits with the same mineralogy. For example: effusive lava flows and explosive pyroclastic flow and fall deposits all of the same composition are common at stratovolcanoes.

Here, LiDAR and radar data are used to quantitatively differentiate volcanic facies based on patterns in surface roughness. Roughness elements consist of primary volcanic features and clasts (e.g., pumice-lobes, blocks, and bombs) as well as erosional features (e.g., remnant mounds and channels). The distribution of these features produce roughness textures (i.e., patterns) that depend on the local depositional and erosional history.

At Mount St. Helens (46.251, -122.202), roughness textures are derived from a ∼2 m spaced LiDAR point cloud, acquired in 2004 by the USGS, Puget Sound LiDAR consortium, and NASA. Point data covering the ´Pumice Plain´are processed in ITT- ENVI to produce roughness rasters with 5 m resolution. In Southeast Asia, roughness is derived from 5-15 m resolution space-borne radar backscatter images of active and potentially active volcanoes (i.e., Mayon (13.257, 123.685), Barren Island (12.278, 093.858), Doro Maria (-08.4833, 118.9) and Sengeang Api (-08.2, 119.067)). In all cases, textural statistics (e.g., Entropy (ENT), and Homogeneity (HOM)) are calculated from roughness rasters to produce maps of roughness textures.

Roughness textures are based on statistical measures of the distribution of roughness elements on the surface of volcanic deposits, within discrete geomorphic units. These include: primary eruptive deposits (lava flows, domes, debris avalanche deposits, pyroclastic fans, and pumice lobes), modified volcaniclastics (e.g., lithic rich lobes, lithic armored pumice lobes, and steep walled channels), and landforms (e.g., collapse scars and craters). Each geomorphic unit has a unique set of roughness textures that are a result of the depositional conditions and erosion. Textural segmentation of roughness maps is demonstrated to be a useful tool for volcanic deposit mapping using both radar and LiDAR data. A similar approach could be used in many other applications (volcanic or non-volcanic) to differentiate geomorphic units and quantify the degree of modification from erosion.