Geophysical Research Abstracts
Vol. 16, EGU2014-14597, 2014
EGU General Assembly 2014

First 3D thermal mapping of an active volcano using an advanced photogrammetric method

Raphael Antoine (1), David Baratoux (2), Julien Lacogne (3), Teodolina Lopez (4), Cyrille Fauchard (1), Frédéric Bretar (5), Mélanie Arab-Sedze (6), Thomas Staudacher (7), Stéphane Jacquemoud (6), and Marc Pierrot-Deseilligny (8)

(1) CEREMA, DTNC, ERA23, Grand Quevilly, France (raphael.antoine@developpement-durable.gouv.fr), (2) GET, France, (3) CEREMA, DTNC, DADT, Grand Quevilly, France , (4) CESBIO, Toulouse, France, (5) Consulat Général de France, Shanghai, China, (6) IPGP, France, (7) Observatoire volcanologique du Piton de la Fournaise, IPGP, La Reunion Island, (8) LGA, ENSG, Marne La Vallée, France

Thermal infrared data obtained in the [7-14 microns] spectral range are usually used in many Earth Science disciplines. These studies are exclusively based on the analysis of 2D information. In this case, a quantitative analysis of the surface energy budget remains limited, as it may be difficult to estimate the radiative contribution of the topography, the thermal influence of winds on the surface or potential imprints of subsurface flows on the soil without any precise DEM.
The draping of a thermal image on a recent DEM is a common method to obtain a 3D thermal map of a surface. However, this method has many disadvantages i) errors can be significant in the orientation process of the thermal images, due to the lack of tie points between the images and the DEM; ii) the use of a recent DEM implies the use of another remote sensing technique to quantify the topography; iii) finally, the characterization of the evolution of a surface requires the simultaneous acquisition of thermal data and topographic information, which may be expensive in most cases.
The stereophotogrammetry method allows to reconstitute the relief of an object from photos taken from different positions. Recently, substantial progress have been realized in the generation of high spatial resolution topographic surfaces using stereophotogrammetry. However, the presence of shadows, homogeneous textures and/or weak contrasts in the visible spectrum (e.g., flowing lavas, uniform lithologies) may prevent from the use of such method, because of the difficulties to find tie points on each image. Such situations are more favorable in the thermal infrared spectrum, as any variation in the thermal properties or geometric orientation of the surfaces may induce temperature contrasts that are detectable with a thermal camera. This system, usually functioning with a array sensor (Focal Plane Array) and an optical device, have geometric characteristics that are similar to digital cameras. Thus, it may be possible to extract 3D informations from thermal images taken from different positions.
This paper presents the first 3D thermal map of an active volcano (Piton de la Fournaise, La Réunion Island) directly generated from 70 thermal images (so-called "stereothermogrammetric" DEM). The data were obtained above Dolomieu caldera by helicopter just before sunrise, during a clear weather in 2008. They were obtained before the eruptive events occurring within the Dolomieu caldera. We used a 28 mm focal FLIR Thermacam PM695 lent by the Piton de la Fournaise Observatory. The thermal images were acquired automatically every 30 seconds with the helicopter flying around the caldera at low altitude (less than 100 m height above the caldera). This survey led to the acquisition of images with a ground pixel size in the range of 1-3 m. A particular attention has been brought to the obtaining of a high overlap percentage (80 percents) for the localization of the maximum tie points on the image. Finally, the acquisition of 70 images allowed the generation of a 3D thermal model of the caldera containing more than 500000 points. i.e. 1 point each 2 m^2, considering a surface of 10^6 m^2 for the Dolomieu caldera. This model is then compared with a DEM recently obtained with the LIDAR method after the eruptive events occurring within Dolomieu. The comparison of these independent methods leads to the validation of the stereothermogrammetric method. It allows the quantification of the thickness of the lava flows within the Dolomieu collapse in 2008 and 2009, i.e. approximately 80 meters, as estimated by previous studies from field observations.