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Compact Thermal Infrared Hyperspectral Imaging Solution: Application to Volcanology monitoring.

Stephane Boubanga Tombet, Frederick Marcotte, Eric Guyot, and Martin Chamberland
Telops, Research, France (stephane.boubanga@telops.com)

Research activities on volcanoes are very challenging due to their unpredictable behavior and the life-threatening situations they may create. Volcanic emissions contain great proportions of water vapor (H_2O) and carbon dioxide (CO_2). Depending on the type of volcano, emissions may contain variable proportions of toxic/corrosive gases such as sulfur dioxide (SO_2), hydrogen chloride (HCl), hydrogen fluoride (HF) and silicon tetrafluoride (SiF4). Ash is also omnipresent in volcanic emissions. During volcanic eruptions, lava (molten rock) and ash are expelled in the atmosphere at high velocity by hot gases under high pressure. Since these circumstances represent destructive conditions for most scientific instruments, sampling techniques and close-range analysis are not viable investigation approaches. Therefore, instrumentation solutions using remote sensing techniques like UV and/or infrared (IR) imaging provide considerable benefits in volcanology.
Broadband thermal infrared imaging has been extensively used for characterizing volcanic environments. However, the lack of spectral information makes it impossible to identify and quantify the gases emanating from the volcano. Open-path Fourier Transform (FT)-IR have given interesting insights about the chemical content of vents and fumaroles. However, the lack of spatial information and the geometrical constraints of this technique limits its applicability. The use of passive single-pixel FT-IR scanning systems for investigating volcanic emissions has also been explored. However, the time required for scanning the whole volcano's plume area somewhat limits the use of this approach to steady-state conditions, such as passive degassing.
Thermal infrared (TIR) hyperspectral imaging solutions including high spectral and temporal resolutions appear to a good suit for volcanology studies. Telops recently released thier newly designed compact, light and robust TIR hyperspectral module of less than 10 kg with about 50W of power consumption. The new module can be operated as a stand-alone imager with applications such as 360˚ Hyperspectral surveillance and monitoring. Integration in complete, highly flexible UAV based, infrared hyperspectral imaging solutions, such as airborne real-time gas detection, identification and quantification is also possible. The UAVs based TIR remote sensing technology offers many benefits over traditional systems as it allows safely monitoring and imaging the volcano several hundreds of meters away. Beside the newly designed compact and light TIR hyperspectral module, Telops have also developed in-scene atmospheric correction solutions based on MODTRAN to conduct Temperature-Emissivity Separation and unveil the spectral features associated with each gas from TIR measurements along with solutions for real time gas detection and identification and tools.
In this communication we will discuss application of these solutions on volcanic plumes from an elevated point (altitude of about 800 m) of the Stromboli volcano in Italy. The selectivity provided by our solutions allowed identification, quantitatively mapping and tracking of both SO_2 and SiF4 before, during and after an eruption. The results provide unique insights into the characterization of volcanic eruptions.