



Thermal remote sensing, unmanned imagery, and their joint application to monitoring of different volcanic hazards

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This study reviews the development of thermal infrared remote sensing, and its application to volcano monitoring. Thermal imagery has been utilized to calculate various eruptive properties, such as lava effusion rates, lava flow dynamics and structures, heat fluxes, emission velocities, and activity styles. We explain the methods of remote sensing of volcanic activity, through ground-based, air-borne, and satellite-borne recording instruments. With a focus on ground-based and UAV remote sensing, we describe how previous studies have applied thermal imagery to Strombolian eruptions at Stromboli (Italy), lava flows at Kilauea (Hawaii), lava dome growth at Santiaguito (Guatemala), degassing vents at Villarrica (Chile), and lava lakes at Erta 'Ale (Ethiopia). Ground-based applications have the highest potential in monitoring volcanoes, as they provide high spatial and temporal resolution data, and are continuously improving as camera technology advances. With the continuing development in drone technology, the use of UAVs would help relevant governments to assess risk and damage to areas affected by geohazards in an efficient and effective manner.