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Hyperspectral remote sensing as a tool for mapping hydrothermal alteration on volcanoes – A case study of Mt Ruapehu (New Zealand)

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Mt Ruapehu is an andesitic to dacitic composite volcano active over the past 250 ky. Prolonged volcanic activity can induce surface and deep-seated hydrothermal alteration that turns primary pyroxene and plagioclase-bearing rocks into secondary clay minerals. Such clay-dominated alteration minerals have unique spectral response in the Near- to Shortwave Infrared (1000 to 2500 nm) of the electromagnetic spectrum. This study utilizes airborne hyperspectral imagery of Mt Ruapehu to map surface hydrothermal alteration zones. The hyperspectral image was acquired with an AisaFENIX full-spectrum (370-2500 nm) push-broom sensor in 2018. The hundreds of narrow spectral bands on this sensor allows detailed discrimination of surface mineralogy on a spatial scale of 1-2 m. The hydrothermal alteration was mapped using band ratios (e.g. bands centred around 2120 nm) and non-parametric supervised image classification approaches, such as support vector machine and random forest with recursive feature elimination. The resulting geological map is validated using existing geological maps and field validation during 2018. The lab-based spectroscopy identified kaolinite and smectite groups as the main mineral phase, using USGS spectral libraries and spectral angle mapper matching algorithm. This is interpreted to be due to shallow surface-related, low-temperature argillic alteration due to meteoric and hydrothermal fluids. The type and distribution of hydrothermal alteration can highlight potential source areas that are structurally weak and might provide material for mass flows (e.g. debris avalanches and landslides). The mapped surface alteration can change at depth, highlighting the limitation of airborne remote sensing approaches. Mt Ruapehu does not have any obvious shallow hydrothermal activity beyond the crater rim; however, older parts of the current volcanic edifice might be altered considerably, causing potential areas of weakness. This can be overcome in the future with the newly acquired aero-magnetic data that allows us to model the sub-surface distribution of hydrothermal alteration through the destruction of magnetite. The mapped source areas will provide inputs for future numerical simulations of mass flows hazards, contributing to long-term land-use planning, volcano monitoring, and natural hazard mitigation at Mt. Ruapehu.