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Selection of HyspIRI optimal band positions for the earth compositional mapping using HyTES data

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ABSTRACT

The National Aeronautics and Space Administration (NASA) has proposed the launch of a new space-borne sensor called HyspIRI (Hyperspectral and Infrared Imager) which will cover the spectral range from 0.4–12 μm. Two instruments will be mounted on HyspIRI platform: 1) a hyperspectral instrument which can sense earth surface between 0.4 and 2.5 μm at 10 nm intervals and 2) a multispectral infrared sensor will acquire images between 3 and 12 μm in eight spectral bands (one in Mid infrared (MIR) and seven in Thermal Infrared (TIR)). The TIR spectral wavebands will be positioned based on their importance in various applications. This study aimed to identify HyspIRI optimal TIR wavebands position for earth compositional mapping. A Genetic Algorithm coupled with the Spectral Angle Mapper (GA-SAM) was used as a spectral bands selector. High dimensional HyTES (Hyperspectral Thermal Emission Spectrometer) emissivity spectra comprised of 202 spectral bands of Cuprite and Death Valley regions were used to select meaningful subsets of bands for earth compositional mapping. The GA-SAM was trained for fifteen mineral classes and the algorithms were run iteratively 50 times. High calibration (> 95%) and validation (> 90%) accuracies were achieved with a limited number (seven) of spectral bands selected by GA-SAM. The knowledge of important band positions will help the scientists of the HyspIRI group to place spectral bands in regions where accuracies of earth compositional mapping can be enhanced.

1. Introduction

For the next decade and beyond, the National Research Council's (NRC) recommended the development of a new suite of space-borne sensors to answer critical Earth science questions (NRC, 2007). In this regard, NASA-Jet Propulsion Laboratory (JPL) proposed the launch of a new space-borne sensor called HyspIRI (Hyperspectral and Infrared Imager) for the next Decadal Survey (Lee et al., 2015; Roberts et al., 2012). HyspIRI will carry two imaging sensors onboard: 1) a hyperspectral sensor which can image the earth surface between 0.4 μm and 2.5 μm with 10 nm intervals and, 2) a multispectral infrared sensor which will acquire images between 3 and 12.0 μm in eight spectral bands (one in mid infrared (MIR) and seven in thermal infrared (TIR)) (Meerdink et al., 2016). The thermal infrared (TIR) band positions of HyspIRI are not yet final and will be determined based on the outcome of research driven by pertinent science questions that HyspIRI mission will address (Ramsey et al., 2012). The prime science questions are to detect natural hazards and precursor activities associated with earthquake and volcanic eruptions. Another important application of the HyspIRI TIR sensor is to map the mineralogical composition of the natural and urban landscapes. To answer these and other related questions, the placement of seven spectral bands in thermal infrared (TIR) are critical for the success of the HyspIRI mission (Ramsey et al., 2012). To harness maximum benefits by placing HyspIRI's TIR bands at meaningful locations, a number of researchers are exploring TIR data at laboratory, airborne and space-borne levels. This study aims to find

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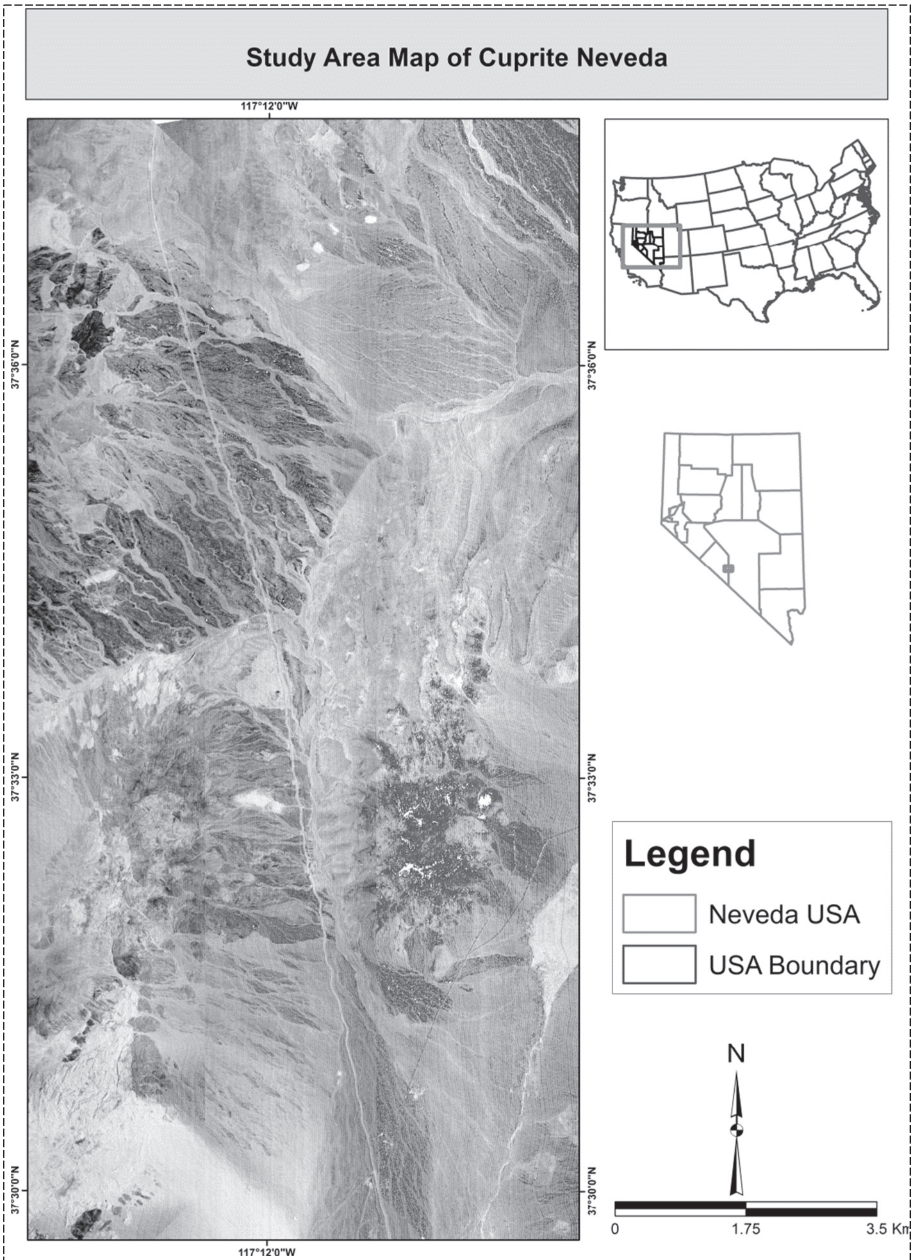

Fig. 1. Map of Cuprite Hills.

HyspIRI optimal wavebands position in the TIR for mapping mineral resources and earth composition.

Remote sensing is considered an effective tool for geological analysis, especially in arid and semi-arid regions (where geologic structures are sparsely covered by vegetation) of the earth's surface (Khan and Mahmood, 2008). Compared to conventional geological surveys and exhaustive laboratory analysis, remote sensing provides a quick and cheap solution to map mineral distribution. Remotely sensed mapping of mineral resources demands less man power and can image otherwise inaccessible regions. In the past, minerals have been mapped worldwide using multispectral and hyperspectral images (Liu et al., 2013; Vaughan et al., 2005; Vicente and de Souza Filho, 2011). While mapping mineral resources using multispectral data, the narrow absorption features associated with mineral composition are masked due to broad band-width and make it difficult to precisely quantify a resource (Ramsey et al., 2012). Hyperspectral sensors have confirmed to be a valuable tool for mapping earth composition (Ramsey et al., 2012) because of their high spectral details over adjacent narrow bands. The hyperspectral data in the VNIR (Visible-Near InfraRed: 0.4–1.0 μm) and SWIR (Short-Wave InfraRed: 1.0–2.5 μm) have been widely used for characterizing transition metals minerals (i.e., Cu, Fe, Ni, Cr, Mn, etc.) and mapping alteration (where absorption features are associated with Al-OH and Mg-OH bonds) minerals (Abrams and Hook, 1995; Abrams et al., 1977; Clark et al., 1993; Clark and Swayze, 1996; Hook et al., 2005; Hook and Rast, 1990). Although hyperspectral data in the reflective domain (i.e.,0.4–2.5 μm) have been found invaluable for mapping alteration minerals, from a geological stand point, mapping rock-forming-silicates are more important because they comprise the bulk of the earth surface lithology (Black et al., 2016). For mapping and identifying silicates minerals, the VNIR-SWIR data are insufficient as their diagnostic absorption features rests in TIR (8–14 μm) region of the electromagnetic spectrum (Vaughan et al., 2003; Vaughan et al., 2005). Earth surfaces and lithological units abundant in clay, carbonate, sulfate, silicate and felsic minerals can be quantified more effectively using hyperspectral TIR data (Hecker et al., 2012; Hecker et al., 2010; Vaughan et al., 2003; Vaughan et al., 2005).

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