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Arid land characterisation with EO-1 Hyperion hyperspectral data

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ABSTRACT

The low spectral resolution of multispectral satellite imagery limits its capability for extracting information in arid environments with sparse vegetation cover. The higher spectral resolution of hyperspectral imagery may improve discrimination of different vegetation types, even with low cover. The aim of this study was to evaluate the potential of Earth Observing 1 (EO-1) Hyperion hyperspectral data to discriminate arid landscape components in the southern rangelands of South Australia. Hyperion imagery was analysed with spectral mixture analysis to discriminate spectrally distinct land cover components. Five distinct end-members were extracted: two associated with vegetation cover and the remaining three associated with different soils and surface gravel and stone. The end-members were characterised with field spectra collected by ASD Fieldspec Pro spectrometer. To confirm the identity of the end-members we also investigated relationships between their abundance and field cover data collected at 54 sample sites using a step-point technique. One vegetation end-member was significantly correlated with Cottonbush (*Maireanaaphylla*) vegetation cover ($R^2 = 0.89$) that was distributed as patches throughout the study area. The second vegetation end-member mapped green and grey-green perennial shrubs (e.g. Mulga, *Acacia aneura*) and was significantly correlated with total vegetation cover ($R^2 = 0.68$). The soil and surface gravel and stone were not significantly correlated with the field estimates of these physical components. Despite the high spectral resolution of the Hyperion scene, spectral mixture analysis was unable to identify more than five meaningful spectral end-members in this arid environment. This may be the result of low vegetation cover of the region (28%), the lack of spectral contrast in arid vegetation types, and the ground resolution of Hyperion (900 m^2) that reduced the ability to identify spectrally pure end-members to represent different land cover components.

1. Introduction

Arid environments are characterised by sparse vegetation cover, with exposed soils dominating the landscape. Remote sensing techniques such as vegetation indices have been used widely for assessing and monitoring vegetation cover (Bannari et al., 1995). It is well known that estimating vegetation cover from vegetation indices is often strongly influenced by soil background effects. Huete et al. (1985), for example, found that most of the slope-based vegetation indices (e.g. NDVI) and distance-based vegetation indices (e.g. Perpendicular Vegetation Index (PVI)) overestimate the amount of vegetation cover on darker and brighter soils, respectively.

Spectral mixture analysis (SMA) may overcome the limitations of vegetation indices by decomposing all the ground cover components within a sensor's ground resolution or pixel (Smith et al., 1990). It makes full use of all spectral bands in an image, rather than relying on combinations of a few selected bands to discriminate particular cover types. Known also as linear mixture analysis, linear unmixing and end-member analysis, SMA aims to map the relative abundances of different components present within a pixel. The general assumption in SMA is that the reflectance recorded for each ground resolution element is a linear mixture of the reflectance of different ground cover components, mixed in proportion to their relative abundances. This occurs when the radiation interacts with only one material type on its path between the earth surface and sensor (Campbell, 1996).

SMA has been used in numerous environmental studies including land cover assessment and monitoring, land degradation assessment, mineral and fire mapping and urban assessments (Pu et al., 2008; Veraverbeke et al., 2012; Wu, 2009) and several studies have shown that unmixed vegetation and soil components and their variations in space and time can be used as indicators of land condition or degradation (Harris and Asner, 2003; Hostert et al., 2003; Metternicht and Fermont, 1998; Tromp and Epema, 1999). SMA has been shown to be a superior method to widely-used vegetation indices in arid and semi-arid environments (Elmore et al., 2000; Smith et al., 1990). Elmore et al. (2000) found, for example,

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