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Analyses of the soil surface dynamic of South African Kalahari salt pans based on hyperspectral and multitemporal data

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The consequences of climate change represent a major threat to sustainable development and growth in Southern Africa. Understanding the impact on the geo- and biosphere is therefore of great importance in this particular region. In this context the Kalahari salt pans (also known as playas or sabkhas) and their peripheral saline and alkaline habitats are an ecosystem of major interest. They are very sensitive to environmental conditions, and as thus hydrological, mineralogical and ecological responses to climatic variations can be analysed. Up to now the soil composition of salt pans in this area have been only assessed mono-temporally and on a coarse regional scale. Furthermore, the dynamic of the salt pans, especially the formation of evaporites, is still uncertain and poorly understood. High spectral resolution remote sensing can estimate evaporite content and mineralogy of soils based on the analyses of the surface reflectance properties within the Visible-Near InfraRed (VNIR 400-1000 nm) and Short-Wave InfraRed (SWIR 1000-2500 nm) regions. In these wavelength regions major chemical components of the soil interact with the electromagnetic radiation and produce characteristic absorption features that can be used to derive the properties of interest. Although such techniques are well established for the laboratory and field scale, the potential of current (Hyperion) and upcoming spaceborne sensors such as EnMAP for quantitative mineralogical and salt spectral mapping is still to be demonstrated. Combined with hyperspectral methods, multitemporal remote sensing techniques allow us to derive the recent dynamic of these salt pans and link the mineralogical analysis of the pan surface to major physical processes in these dryland environments.

In this study we focus on the analyses of the Namibian Omongwa salt pans based on satellite hyperspectral imagery and multispectral time-series data. First, a change detection analysis is applied using the Iterative-reweighted Multivariate Alteration Detection (iMAD) method to identify and investigate surface changes based on Landsat archive imagery covering the period 1984-2015. For the complete Landsat time series, a total of 130 bi-temporal change maps have been derived and are compiled to produce a change magnitude map, which indicates different regions of activity and stability of the pan surface. Then radiometric geometric and atmospheric correction of Hyperion data were performed using the pre-processing chain of Rogass et al. (2014). Based on field spectroscopy and XRD analysis of soil samples, one of the main evaporite minerals of the pan soil could be identified as gypsum. Different approaches based on spectral features were tested and validated against reference samples to find the most suitable approach for estimating the gypsum content from the Hyperion data. Major challenges were the influence of water vapour absorption bands close to major gypsum absorption feature as well as low signal-to-noise ratio of Hyperion in the SWIR wavelength. A best method was determined that allow to determine Gypsum content with R^2 of 0.7 and relative RMSE of 0.14. Results reveal a variable spatial distribution of different mineralogy and in particular gypsum content within the pan, which seems to be associated with varying dynamic of the pan surface.