Geophysical Research Abstracts
Vol. 20, EGU2018-16319, 2018
EGU General Assembly 2018

Semi-arid ecosystem monitoring using thermal and hyperspectral data

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Biocrusts, communities formed by mosses, lichens, liverworts, algae and cyanobacteria, play a vital role in maintaining the structure and functioning of dryland ecosystems worldwide. We examined the potential of hyperspectral and thermal data for characterizing biocrust distribution and activity by using a spectral index and their thermal emission, which are in both cases sensitive to changes in biocrust activity and wetness. We related the activity of samples to their water content both in the field and in the laboratory. Biocrust samples with different compositions (i.e. dominated by lichens, mosses and cyanobacteria) and samples from bare ground areas without biocrusts were obtained from a semi-arid ecosystem in Central Spain (40°01'57.7"N-3°32'53.7"W). Their optical properties were measured in the laboratory by means of a hyperspectral imaging spectrometer covering the VIS-NIR spectrum. We applied the continuum removal algorithm to the hyperspectral reflectances to quantify the absorption features related to the pigment composition of biocrusts and vascular vegetation constituents (i.e. chlorophyll, carotenoid and phycobilins). Biocrusts apparent temperature was measured using thermal cameras both in the laboratory (using the camera in a fixed position) and in field, carrying it on a UAV. The temperature was used to monitor the effect that water has on the studied ecosystem component activity.
The continuum removal algorithm allowed to identify the absorption features related to the pigment content of biocrusts, and to monitor their change from dry to wet. The apparent temperature allowed to differentiate between areas dominated by biocrusts, shrubs and bare soil patches. All the vegetation surveyed showed absorption peaks at 500 nm, typical of carotenoid/phycoerythrin, and at 685 nm, typical of chlorophyll a. However, they showed different absorption depths, probably related to different pigment compositions. Immediately after wetting, these absorption features increased, while the overall reflectance decreased due to soil moisture. The change of absorption from dry to wet was related to an increase of light absorption that should be linked to the activation of biocrusts. The temperature changed depending on the biological component, since they retain more water due to a more complex biological structure.
The methodology applied shows that pigment absorption depth calculated with the continuum removal algorithm is a robust index to monitor spatial and temporal changes in biocrust activity in semi-arid ecosystems. This methodology also shows how thermal information could be used to differentiate vegetation at landscape scales and to improve its mapping. Further developments are foreseen in linking the absorption depth to pigment content. At the same time, more improvements in the mapping are expected, with the aim of couple the hyperspectral information and the apparent temperature of the constituents of the ecosystem, and to increase the scale of study, using different platforms and sensors.