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Biocrust spectral response as affected by changing climatic conditions

Emilio Rodriguez-Caballero (1), Emilio Guirado (2), Paula Escribano (2), Andres Reyes (2), and Bettina Weber (1)

(1) Max Planck Institute for Chemistry, Multiphase Chemistry, Mainz, Germany (e.rodriguez-caballer@mpic.de), (2) CAESCG - Andalusian Center for the Assessment and Monitoring of Global Change, Almería, Spain

Drylands are characterized by scarce vegetation coverage and low rates of biological activity, both constrained by water scarcity. Under these conditions, biocrusts form key players of ecosystem functioning. They comprise complex poikilohydric communities of cyanobacteria, algae, lichens and bryophytes together with heterotrophic bacteria, archaea and fungi, which cover the uppermost soil layer. Biocrusts can cope with prolonged phases of drought, being rapidly re-activated when water becomes available again. Upon reactivation, biocrusts almost immediately turn green, fixing atmospheric carbon and nitrogen and increasing ecosystem productivity. However, due to their inconspicuous growth they have only rarely been analysed and spatially and temporally continuous information on their response to water pulses is missing. These data are particularly important under changing climatic conditions predicting an increase in aridity and variations in precipitation patterns within most of the dryland regions.

In the present study, we used multi-temporal series of NDVI obtained from LANDSAT images to analyze biocrust and vegetation response to water pulses within the South African Succulent Karoo and we predicted their future response under different climate change scenarios. The results showed that biocrust and vegetation greenness are controlled by aridity, solar radiation and soil water content, showing similar annual patterns, with minimum values during dry periods that increased within the rainy season and decreased again after the onset of drought. However, biocrusts responded faster to water availability and turned green almost immediately after small rains, producing a small NDVI peak only few days after rainfall, whereas more time was needed for vegetation to grow new green tissue. However, once the photosynthetic tissue of vegetation was restored, it caused the highest increase of NDVI values after the rain. Predicted changes in precipitation patterns and aridity within the Succulent Karoo in South Africa comprise a decrease in rainfall events and aridity that finally resulted in higher water availability, especially on days just after rainfall, where biocrust are active. Our calculations suggest that these climatic alterations cause an increase of 30 % in biocrust NDVI by the end of the century, responding far more drastically than vascular plants. As biocrust NDVI is related to biocrust coverage, developmental stage and physiological activity, this will positively affect their contribution to global biogeochemical cycles and their soil-stabilizing effects, partially compensating the negative impacts of climate change on drylands regions. One has to keep in mind, however, that the investigated scenarios considered only climatic and no land use effects and that this study was restricted to a well-confined region. Nevertheless, our data clearly demonstrate that biocrust data need to be incorporated in land use programs and policies to ensure dryland sustainability under global change scenarios.