Geophysical Research Abstracts
Vol. 16, EGU2014-13582, 2014
EGU General Assembly 2014

Relating photosynthetic activity of BSCs from spectral indices: a first step to upscale BSC role on carbon fluxes

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Arid and semiarid ecosystems are water limited environments where water availability is the main limiting factor controlling vegetation cover, productivity and ecosystem function. However, bare areas of these systems are usually covered by a thin layer of photoautrophic communities of microorganisms comprising cyanobacteria, algae, microfungi, lichens or bryophytes, so called biological soil crusts (BSCs), which may cover up to 70 % of the soil surface in these areas. These BSCs are capable to survive long drought periods, during which their physiological activity ceases, and become active just after rainfall or even after dew or fog events, thus triggering their photosynthetic activity. So, they play an active role in C storage in arid ecosystems, where they are considered the main agent of nutrient input on bare areas. Moreover, the carbon (C) stored in soils covered by BSCs may constitute an important nutrient surplus for soil microbial communities or vegetation. Thus, having accurate continuous information about C stocks and C fluxes in soils covered by BSCs, at ecosystems scale, constitutes a relevant issue for scientists and researchers from many different disciplines, and is crucial for assessing the impacts of increasing atmospheric CO_2 concentration on global environmental change. Remote sensing images and derived vegetation indices are presented as one of the most promising tools to achieve this goal, since they provide spatially explicit information with high temporal resolution. So that, quantifying the photosynthetic activity on BSC areas using remote sensing data constitutes an essential step to advance in the knowledge about the role of arid and semiarid regions in global C balance.

In this study we analyzed the potential of the most widely used vegetation indices to estimate gross photosynthesis (GP) in BSCs. To achieve this objective, GP was calculated, after a rainfall event on different BSCs and on bare field plots, as the sum of net primary production, measured with an IRGA Li-6400 and soil respiration measured with a respirometer EGM-4 (PP Systems). Just after, field spectra measurements were taken with a spectroradiometer, and were used to calculate the most widely used vegetation index: the normalized vegetation index (NDVI), the enhanced vegetation index (EVI) and the photochemical reflectance index (PRI). The applicability of vegetation indices to quantify GP was then evaluated using linear regression analysis. Our results showed an increase in GP, and vegetation indices from bare soil to more developed BSCs. The relations of vegetation indices with the ratio GP/PAR were lower than expected, and only EVI and PRI showed a significant relation with GP/PAR (r2= 0.39 and 0.31 respectively, $p < 0.05$). In spite of the weak relation observed, our results demonstrate the capability of spectral indices to quantify the biological activity of BSCs and the possibility of using remote sensing data for a better quantification of GP at ecosystem scale. This will ultimately used to upscale the effect of BSCs on the global C balance of arid and semiarid ecosystems, and thus to advance in the knowledge about the role of these regions in global C balance.