Mapping of Crop Stress Related to Soil Degradation within Rainfed Mediterranean Agricultural Areas using Hyperspectral Optical and Thermal Data

Robert Milewski¹, Thomas Schmid², Paula Escribano³, Eyal Ben-Dor⁴, Marcos Jiménez Michavila⁵, and Sabine Chabrillat¹

¹Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany (milewski@gfz-potsdam.de)
²Centro de Investigaciones Energéticas, Medioambientes y Tecnológicas (CIEMAT), Madrid, Spain
³Andalusian Center for the Monitoring and Assessment of Global Change (CAESCG), University of Almería, Almería, Spain
⁴Department of Geography and Human Environment, Tel Aviv University, Tel Aviv, Israel
⁵Área de Sistemas de Teledetección (INTA), Torrejón de Ardoz, Spain

Hyperspectral data acquired for different seasons provide the means to derive relevant plant biophysical properties during the growing season over agricultural areas, as well as determine soil properties, when the soils are exposed, e.g. during fallow or after harvesting. This combined information can give a detailed insight on the effect of soil degradation on vegetation growth and finally crop yield. In the Mediterranean region, land use practices for crop cultivation have a long history exploiting soils as a natural resource. The soils are an essential factor contributing to agricultural production of rainfed crops such as cereals, olive groves and vineyards. Inadequate land management is endangering soil quality and productivity, and in turn crop quality and productivity are affected. Therefore, the main objective of this work is to map crop stress related to soil degradation and land management practices within a Mediterranean environment focusing on hyperspectral data within the visible, near-infrared, and short-wave infrared (0.4-12 µm) and test the transferability of the methods used to future hyperspectral space-borne sensors such as PRISMA, EnMAP, SHALOM, CHIME and SBG.

In this framework, CASI and AHS hyperspectral imagery have been obtained during the growing season within the Camarena agricultural area located in central Spain. The area is characterized by a Mediterranean climate, a gently undulating relief, evolved soils and traditional rainfed agriculture area. In this environment a combination of tillage erosion as a result of plowing practices, as well as water erosion, has led to the exposure of different soil horizons at the surface with contrasting soil properties. These surface properties have been previously characterized as erosion stages of the same cultivated area in a fallow state. Simultaneous to the airborne acquisitions, intensive field campaigns took place for the characterization of soil and crop variability. This included field spectroradiometry measurements of the different surface covers and vegetation parameters such as Leaf Area Index (LAI), leaf chlorophyll content, plant biomass and grain yield in locations with variable soil erosion and deposition stages from low to very high eroded soils. First results based on random forest modeling between the soil erosion stage
mapping and the AHS/CASI remote sensing imagery of the growing season indicate a strong link between the soil conditions and the spectral properties of the crops. Furthermore, biophysical parameters derived from the imagery in the green season such as Leaf Area Index and Leaf Water Content correlated also well with the soil erosion stages. For selected test sites it could be shown that low crop yields are associated with 1) highly eroded areas, where exposure of the calcite rich bedrock can cause deficiency in nutrient uptake and 2) very sandy accumulation areas that are depleted in nutrients and have low potential for water retention. Whereas highest crop yields are associated with clay and iron rich, moderately to low eroded soils. This study integrates optical VNIR-SWIR-TIR spectral domain and present preliminary results that emphasize the strong influence of soil quality on crop stress and production.