Geophysical Research Abstracts
Vol. 18, EGU2016-13659, 2016
EGU General Assembly 2016

Potential of EnMAP spaceborne imaging spectroscopy for the prediction of common surface soil properties and expected accuracy

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There is a renewed awareness of the finite nature of the world's soil resources, growing concern about soil security, and significant uncertainties about the carrying capacity of the planet. As a consequence, soil scientists are being challenged to provide regular assessments of soil conditions from local through to global scales. However, only a few countries have the necessary survey and monitoring programs to meet these new needs and existing global data sets are out-of-date. A particular issue is the clear demand for a new area-wide regional to global coverage with accurate, up-to-date, and spatially referenced soil information as expressed by the modeling scientific community, farmers and land users, and policy and decision makers.

Soil spectroscopy from remote sensing observations based on studies from the laboratory scale to the airborne scale has been shown to be a proven method for the quantitative prediction of key soil surface properties in local areas for exposed soils in appropriate surface conditions such as low vegetation cover and low water content. With the upcoming launch of the next generation of hyperspectral satellite sensors in the next 3 to 5 years (EnMAP, HISUI, PRISMA, SHALOM), a great potential for the global mapping and monitoring of soil properties is appearing. Nevertheless, the capabilities to extend the soil properties current spectral modeling from local to regional scales are still to be demonstrated using robust methods. In particular, three central questions are at the forefront of research nowadays: a) methodological developments toward improved algorithms and operational tools for the extraction of soil properties, b) up scaling from the laboratory into space domain, and c) demonstration of the potential of upcoming satellite systems and expected accuracy of soil maps.

In this study, airborne imaging spectroscopy data from several test sites are used to simulate EnMAP satellite images at 30 m scale. Then, different soil algorithms are examined based on the analyses of chemical-physical features from the soil spectral reflectance and/or multivariate established techniques such as Partial-Least Squares PLS, Support-Vector Machine SVM, to determine common surface soil properties, in particular soil organic carbon (SOC), clay and iron oxide content. Results show that EnMAP is able to predict clay, free iron oxide, and SOC with an RV2 between 0.53 and 0.67 compared to airborne imagery with RV2 between 0.64 and 0.74. The correlation between EnMAP and airborne imagery prediction results is high (Pearson coefficients between 0.84 and 0.91). Furthermore, spatial distribution is coherent between the airborne mapping and simulated EnMAP mapping as shown with a spatial structure analysis. In general, this paper demonstrates the high potential of upcoming spaceborne hyperspectral missions for soil science studies but also shows the need for future adapted strategies to fulfill the entire potential of soil spectroscopy for orbital utilization.