Soil Spectroscopy: From The Lab to The Sky

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Abstract:

Soil is an essential component in the environment and is vital for food security. It provides ecosystem services, filters water, supplies nutrients to plants, provides us with food, stores carbon, regulates greenhouse gases emissions and it affects our climate.

Traditional soil survey methodologies are complicated, expensive, and time-consuming. Visible and infrared spectroscopy can effectively characterize soil properties. Spectroscopic measurements are rapid, precise and inexpensive. The spectra contain information about soil properties, which comprises minerals, organic compounds and water.

The objective of this study is to conduct a research that will find the optimal way to exploit several soil spectral libraries (SSLs) for practical utilization of hyperspectral sensors from both air and orbit domains.

To that end, we are suggesting to find the spectrum-based connection between laboratory and field sensors using deep-learning methods. This procedure will combine soil spectral signatures acquired in the laboratory with those obtained through hyperspectral sensors (at the same location in the field using a new optical apparatus that simulates the sun's radiation while minimizing atmospheric attenuation). The importance of this study lies in the number of SSLs that are evolving worldwide and are available to users, but have not yet been reliably exploited for field utilization in either the air or space domains. This is because SSLs

are mainly used at the laboratory level and cannot be directly utilized in the other domains.

Spectral information from the same soil in the laboratory and in the field may be affected by the sampling method. The surface of the soils brought to the laboratory is disturbed by the sampling, whereas the surface of field-measured soils remains undisturbed and well represents the remote sensing view.

A massive work conducts today worldwide to establish a SSL that can be used as a training dataset for machine learning methods that will benefit precision agriculture activity for better management food production. Nonetheless, as SSL are created under laboratory conditions it is not clear if it can be used to infer field conditions in situ and/or from the sky. Thus, study the relationship between remote sensing (RS), field spectroscopy and the laboratory measurements of soil is very important.

Accordingly, this study postulates that traditional SSLs don't simulate the real spectral signatures in the field that both satellite and airborne hyperspectral sensors measure as well, because they are affected by factors that are not an integral part of the soil, such as: moisture, litter, human and animal activity, plow, grass, dung, waste, etc… In laboratory conditions these factors are usually removed for the preparation of SSLs.

Thus, given the several SSLs available in the web, it is necessary to evaluate the protocols that were used in these SSLs. For this end, chemical parameters and the spectra of one dataset that will not be used for the calibration of the models, will be used to test all the others SSLs.

Then, this project will provide methods that will correct these SSLs in order to improve the estimation of soil properties from the sky using machine learning methods like Partial Least Squared (PLS) Regression.

For this, we will carry out field experiments with airborne and UAV platforms in order to validate our methods and our conclusions.