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Evaluation of the potential of Sentinel-1 and Sentinel-1 data for clay content mapping

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Soil texture is a key parameter in agricultural processes and an important measure for agricultural prediction, water cycle, filtering of pollutants and carbon storage. Besides, its estimation is essential for agronomists, hydrologists, geologists and environmentalists and for modeling in these application areas. Several studies have been based on understanding and modeling the biological, physical and chemical processes in the soil. Regarding the texture of the soil, few researches propose soil texture spatialization, and are generally based on ground measurements. Among other things, field observations or laboratory analyzes are very expensive and are not very representative. Indeed, the soil texture presents a strong heterogeneity even at the scale of a field. It is then necessary to use precise and spatialized information on soils.

These methods are generally based on remote sensing data and particularly optical data to restore soil component. However, these techniques are strongly affected by atmospheric conditions. This constraint is not valid for Radar sensors (Radio Detection And Ranging). Radar data are mainly sensitive to soil moisture and soil roughness, and has also been evaluated for its ability to perform texture measurements.

The aim of this study is evaluate the potential of these techniques based on optical and radar data for soil texture estimation. By its composition, its structure, its texture and its porosity, soil moisture is strongly influenced by the soil nature. With the arrival of Sentinel-1 (S-1) and Sentinel-2 (S-2) ESA spatial missions, data are acquired with high spatial and temporal resolution between July and early December 2017, on a semi-arid area in central Tunisia. This study is therefore conducted using S-2 SWIR (Short-Wave Infrared) bands (B11 and B12, most sensitive to clay) and soil moisture products derived from radar data. And algorithms based on the support vector machine (SVM) and random forest (RF) methods are proposed for the classification and mapping of clay content.

In order to evaluate the approach and determine the adequate data (between optical and radar data) allowing to precisely characterize the clay content, a cross-validation was used. The SWIR bands lead to less satisfactory outcomes compared to soil moisture. With an overall accuracy of approximately 65%, soil moisture achieved the best performance for estimating soil texture. The results also showed that RF and SVM are robust classifiers for texture estimation despite the small number of training data. However, RF displays greater accuracy and speed of simulation compared to SVM.

Keywords: Sentinel-1, Sentinel-2, soil moisture, clay content, classification, SVM, RF.