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Mapping tillage operations over peri-urban croplands using a synchronous SPOT4/ASAR ENVISAT pair and soil roughness measurements

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Tillage operations (TOs) affect nutrient uptake, carbon sequestration, water and CO_2 exchanges in soil, and therefore impact soil ecology together with biophysical processes such as soil erosion, leaching, run-off and infiltration. They are critical for parameterizing complex dynamic models of carbon and nitrogen. This study done in the framework of the Prostock-Gessol3 project presents an approach for mapping TOs of bare agricultural fields over a peri-urban area characterized by conventional tillage system in the western suburbs of Paris (France), combining synchronous SPOT4 and ENVISAT/ASAR images (HH and HV polarizations).

Spatial modeling relied on 57 reference within-field areas named “reference zones” (RZs) homogeneous for their soil properties, constructed in the vicinity of 57 roughness measurement locations and spread across 20 agricultural fields for which TOs were known. Soil roughness expressed as the standard deviation of surface height (Hrms) was estimated on the ground with a fully automatic photogrammetric method based on the processing of a set of overlapping pictures taken from different viewpoints from a simple digital camera all around a rectangular frame. The relationship was studied between the mean backscattering coefficient of the ASAR image and Hrms choosing a limited set of 28 RZs, on which successive random selections of training/validating RZs were then performed; the remaining 29 RZs were kept for validating the final map results.

Six supervised per-pixel classifiers were used in order to map 2 TOs classes (seedbed&harrowed and late winter plough) in addition to 4 landuse classes (forest, urban,crops and grass, water bodies): support vector machine with polynomial kernel (pSVM), SVM with radial basis kernel (rSVM), artificial neural network (ANN), Maximum Likelihood (ML), regression tree (RT), and random forests (RF). All 6 classifiers were implemented in a bootstrapping approach in order to assess the uncertainty of map results.

The best results were obtained with pSVM for the SPOT4/ASAR pair with producer’s and user’s mean validation accuracies of 91.7%/89.8% and 73.2%/73.3% for seedbed&harrowed and late winter plough conditions, respectively. Whatever classifier, the SPOT4/ASAR pair appeared to perform better than each of the single images, particularly for late winter plough: producer’s and user’s mean validation accuracies were 61.6%/53.0% for the single SPOT4 image; 0%/6% for the single ASAR image. About 73% of the validation agricultural fields (79% of the RZs) were correctly predicted in terms of TOs in the best pSVM-derived final map. Final map results could be improved through masking non-agricultural areas with land use identification system layer prior to classifying images. These results show promises for further monitoring of TOs within a crop production campaign, in the perspective of the ESA Sentinel-1/2 time series. Such knowledge of cultural operations is likely to facilitate the mapping of agricultural systems which otherwise proceed from time-consuming surveys to farmers.