Soil organic carbon (SOC) is involved in food security, climate change mitigation and other ecosystem services. Assessing SOC dynamics is receiving more and more attention in the context of global changes. SOC consists of organic compounds with a continuum of decomposability and turnover rates which can be divided in conceptual discrete pools that are functionally homogenous. Recently, SOC fractions that correspond to these theoretical pools were isolated through physico-chemical extraction. These fractions are usually based on (de-)stabilization mechanisms that influence SOC dynamics. Our hypothesis is that the evaluation of SOC dynamics across scales could be enhanced by means of SOC fractionation. Thus SOC fractions contribute to the characterization of SOC dynamics in response to anthropogenic forcings in different settings over timescales ranging from years to decades. This thesis aims to:

(i) Evaluate the suitability of organic carbon associated with clay and fine silt as an indicator for SOC decadal evolution under different residue management practices in a long-term experiment in Belgium.
(ii) Evaluate the dynamics of functional soil organic carbon pools during vegetation recovery after land abandonment in Andalucia.
(iii) Evaluate the usefulness of SOC fractions to understand SOC stocks distribution in a hilly catchment after recent conversion to agriculture in southern Brazil.
(iv) Improve the assessment of SOC state and related soil ecosystem functions using SOC fractions in meaningful units for agricultural management in Wallonia.

We used these different study sites as they were selected according to the availability of data and their potential to demonstrate the effect of a single driving factor. We demonstrated that the number of fractions to be distinguished is a function of both the complexity of the system in terms of soil disturbance and the number of samples required to cover the study area.