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In this paper, we synthesize the main outcomes of a collaborative project (2009-2014) initiated at the UCL (Belgium). The main objective of the project was to increase our understanding of soil organic matter dynamics in complex landscapes and use this to improve predictions of regional scale soil carbon balances. In a first phase, the project characterized the emergent spatial variability in soil organic matter storage and key soil properties at the regional scale. Based on the integration of remote sensing, geomorphological and soil analysis techniques, we quantified the temporal and spatial variability of soil carbon stock and pool distribution at the local and regional scales. This work showed a linkage between lateral fluxes of C in relation with sediment transport and the spatial variation in carbon storage at multiple spatial scales. In a second phase, the project focused on characterizing key controlling factors and process interactions at the catena scale. In-situ experiments of soil CO_2 respiration showed that the soil carbon response at the catena scale was spatially heterogeneous and was mainly controlled by the catenary variation of soil physical attributes (soil moisture, temperature, C quality). The hillslope scale characterization relied on advanced hydrogeophysical techniques such as GPR (Ground Penetrating Radar), EMI (Electromagnetic induction), ERT (Electrical Resistivity Tomography), and geophysical inversion and data mining tools. Finally, we report on the integration of these insights into a coupled and spatially explicit model and its application. Simulations showed that C stocks and redistribution of mass and energy fluxes are closely coupled, they induce structured spatial and temporal patterns with non negligible attached uncertainties. We discuss the main outcomes of these activities in relation to sink-source behavior and relevance of erosion processes for larger-scale C budgets.