



## Towards a farm-scale digital twin to evaluate trade-offs between ecosystem services for carbon farming

**Felix Maximilian Bauer**, Cosimo Brogi, Michael Herbst, Harry Vereecken, and Johan Alexander Huisman

Institute of Bio- and Geosciences: Agrosphere (IBG-3), Forschungszentrum Jülich GmbH, Jülich, Germany

Carbon farming aims to sequester carbon in agroecosystems by increasing soil organic matter content and reducing greenhouse gas emissions, while also improving soil health. It also affects a range of other ecosystem services, such as water regulation, nutrient cycling, and agricultural productivity. Robust methods are needed to assess the potential and effectiveness of carbon farming approaches and to analyze potential trade-offs between soil carbon sequestration and other ecosystem services. In this context, agroecosystem models that inform and optimize farmer's practices while offering a holistic perspective for the optimization of both agronomic and environmental outcomes in current and future climatic conditions seem a promising tool. This work presents the first steps towards the development of a digital twin for a real-world farm (Damianshof, Rommerskirchen, Germany) using a spatialized version of the agroecosystem model AgroC, which simulates soil water, heat, carbon and nitrogen fluxes. The digital twin is driven by high-resolution soil, climate and farm management data from the year 2010 onwards. This enables the evaluation of different management options to increase soil carbon sequestration, with a particular focus on regenerative management practices such as the use of cover crops and different crop genotypes with more recalcitrant root systems. By simulating and analyzing these scenarios, the digital twin will provide insights for optimizing management decisions while considering multiple ecosystem services. In future studies, the digital twin will serve as a valuable tool for assessing the broader impacts of global change on the ecosystem services and soil health associated with carbon farming.