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"Towards multi-functional agro-ecosystems
promoting climate resilient futures"

A novel digital twin system combining earth observation, field monitoring and artificial intelligence for maize production in south Africa

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Abstract

The rapidly growing global population, together with climate variability and resource constraints, is intensifying the demand for higher and more resilient food production systems. Maize production is central to South Africa's food security and is facing increasing pressure from climate extremes and sub-optimal management. Digital technologies, in particular, digital twins offer near-reality frameworks needed to integrate heterogeneous data and enhance the understanding of agricultural landscape conditions.

We present a new project (SAI-Crop) in the frame of the newly established South Africa-German collaboration on artificial intelligence for societal transformation (ZADE-AI). The project integrates crop modelling, data assimilation, Earth Observation (EO) and artificial intelligence to improve agricultural data acquisition, evaluate crop conditions, and assess the viability of alternative agronomic management strategies.

The system combines multiple-source datasets, including EO data, drone-based imagery, meteorological datasets from station observations and reanalysis products data, and *in situ* crop characteristics and soil conditions. These inputs are assimilated into process-based models and enhanced through machine learning algorithms to enable continuous monitoring, yield estimation, stress detection, and scenario analysis. The digital twin is implemented in the Free State province, South Africa's primary maize-producing region, serving as a living lab prototype designed for transferability to diverse agroecological regions across the country. Additionally, the project will deploy an information delivery platform to guide farmers' management decisions across South Africa's maize-growing regions. The SAI-Crop project represents the first holistic operational digital twin for maize production in South Africa. Consequently, the system aims to improve maize productivity, climate resilience and sustainable agricultural management in the region.

Keywords: Artificial intelligence, crop modelling, digital twin, maize production, precision agriculture

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