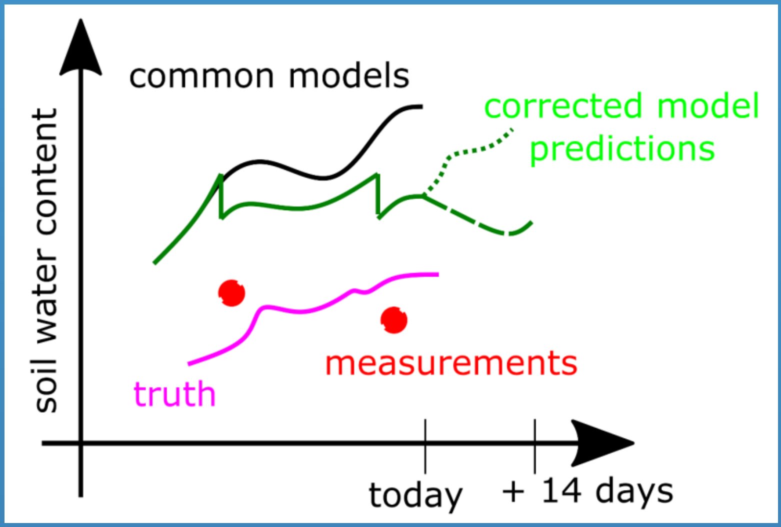
# FACTSHEET

## DATA ASSIMILATION SYSTEM




## Key information

In data assimilation, on-line field observations are communicated to a mathematical model to improve its performance to provide more accurate predictions on e.g. soil water content. The set-up presented here provides forecasts at plot and regional scale for the next 14 days. The approach can be used to predict crop yield and soil water content for climate resilient agriculture and to optimize irrigation schedules

Target audiences: Advisory Services, Farmers, Decision Maker, General Public

This project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement No 858735.

## A. Brief Introduction:

The data assimilation system is designed to provide the best possible predictions of crop and soil conditions (e.g., soil water content, groundwater levels) at the plot and regional scale for the next 14 days. Simulations of integrated terrestrial system models are combined with measurements to reduce model uncertainty. The innovation of the data assimilation system is to support near real-time decision making in agricultural watersheds. The system, i.e., the code, can be used by advisory services to provide long-term quantitative support to farmers and decision makers. Results, such as estimates of conditions for agricultural fields or watersheds, e.g., predictions of soil water content, groundwater levels, crop biomass trends, and expected yields, can be provided by the advisory services online in form of maps, tables, and graphics. Farmers and the general public could then in turn use this information to optimize irrigation schedules, for example.

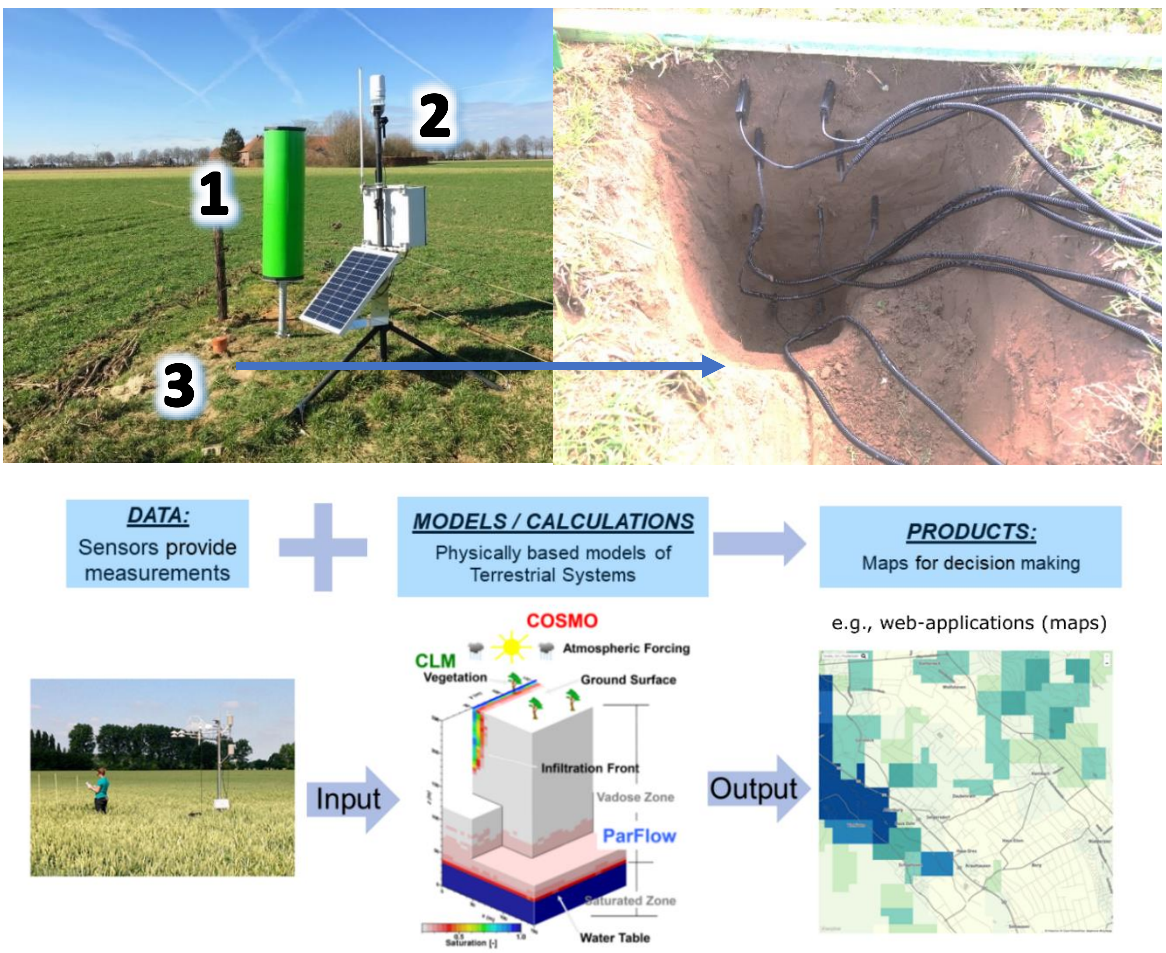



**Fig. 1:** From real-time observations to model predictions and visual products. (A) Instruments on an agricultural plot. 1: Cosmic Ray Neutron Sensor, 2: All in one Weather station (ATMOS-41), 3: Sensors in different depth of the soil. (B) Soil water and temperature sensors installed in different depths. (C) Workflow: On-site measurements are the input data for physically based models. The simulation output will be used to support decision making in agricultural business.

## B. Design concept:

Spatially varying inputs such as precipitation, land use, crop types, meteorological conditions and hydro(geo)logical properties are used to numerically calculate the water, energy, carbon and nitrogen cycle of the terrestrial systems of interest. Weather data are measured directly in the field, e.g., on an agricultural plot, stored in a geodatabase, and harmonized in near real-time. Short- to medium-term weather forecasts are used to predict hydrologic, crop, carbon, and nitrogen conditions and fluxes for selected crop types for the next two weeks. The simulated states of terrestrial systems, e.g., soil water content, are corrected by observations of soil water content in near real time via data assimilation. This continuous combination of simulations with observations reduces the prediction uncertainty. Prediction of variables important for decision making, such as soil water content, crop conditions, and groundwater levels, can be provided via a cloud interface, including their uncertainty.

## C. Technical information:

A meteorological station is needed to measure the variables that drive the physically based models. This can be, for example, an eddy covariance station that measures land-atmosphere exchange fluxes, soil heat fluxes, and typical meteorological variables at best 10-minute (at least 1 day) resolution. Soil moisture and soil temperature should ideally be measured at different depths, e.g., 0.01 m, 0.05 m, 0.20 m, 0.5 m and 1.0 m A wireless sensor network would allow collection of relevant information in near real time. Trained experts take care of the design of the integrated terrestrial systems model, the model maintenance (including hardware and software maintenance) and the visualization of the results. The integrated models for e.g., agricultural plots or regions, can be built with open source (e.g., Community Land Model/ParFlow) or commercial (e.g., HydroGeoSphere) codes/modeling software.

## D. Costs and Benefits:

Costs include the infrastructure needed to collect plot-specific or local data for modeling and to run a terrestrial model continuously. The instruments, e.g., an eddy-covariance station and a wireless sensor network should be continuously maintained by a technician. Collected data must be checked for completeness and realism. Instruments may stop operating in the field, e.g., due to intrinsic failures or external conditions (weather, damage). Periods without measurements (gaps) must be filled with information from neighboring weather stations, which can increase costs. In addition, there are costs for the development of the terrestrial system model by a specialist and the necessary access to computer resources. Clearly, the benefit to stakeholders, particularly advisory services, is the option to provide forecasts for specific agricultural areas with a high spatial resolution. Model outputs can also be adapted to local needs, making the outputs more reliable and providing quantitative and long-term decision support to farmers.

## E. Challenges and opportunities

The nature of the meteorological variables (atmospheric forcings) limits the possible forecast period, i.e., the time span for which forecasts can be made with reasonable reliability. For example, weather forecasts can only describe a general trend for the next 10 days and are relatively reliable only for the next 5 days. Therefore, extending the forecast period beyond 14 days with reasonable reliability (seasonal forecasts) is only possible to a limited extent, but soil moisture contents and groundwater levels have a longer memory which opens the doors to also make predictions for longer time scales. The data assimilation system is based on a stochastic modeling approach that clearly allows predictions with lower uncertainty for the next 14 days and, in turn, to increase the handling time in agricultural operations. These predictions can be useful, for example, to start optimizing irrigation schedules ahead in time. Costs and possible yield loss during drier periods can be reduced and precision agriculture is an option.

## F. Reference and demonstration:

*Websites:*

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