GEORGE - A new, spatially distributed pesticide leaching model using the PyCatch modelling framework

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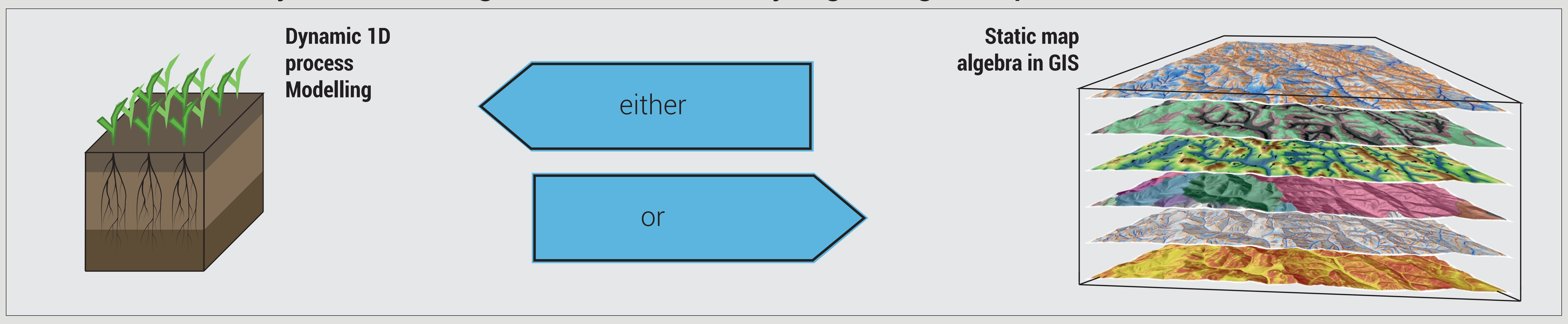
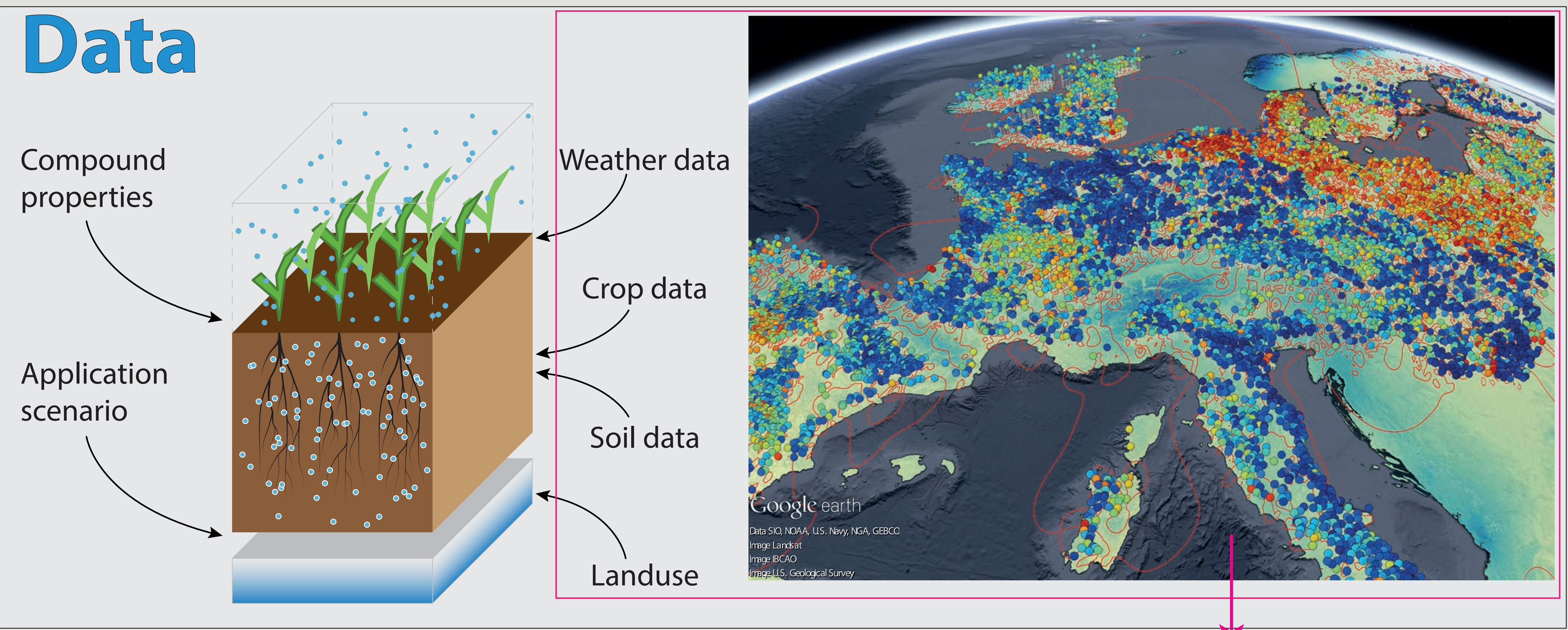
BASF We create chemistry

Motivation: Dynamic & process based leaching model within a GIS

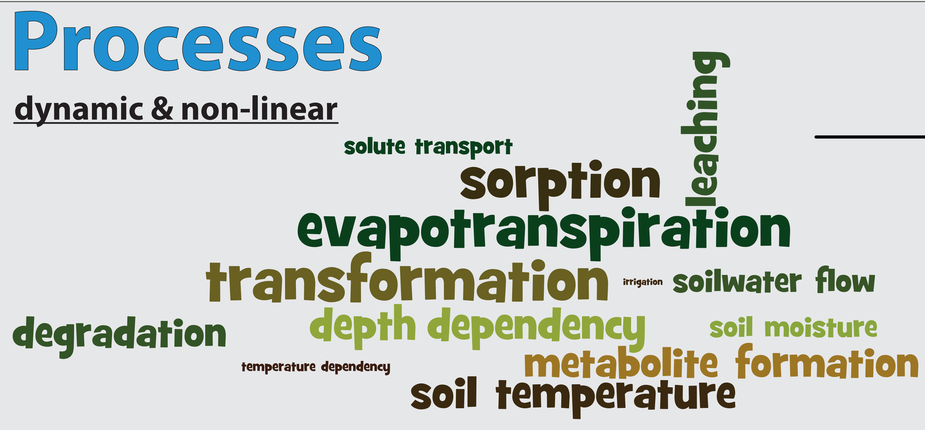
Pesticide leaching models used in European regulatory processes are non-spatial point models (PEARL, PELMO, MACRO, PRZM) with only a few representative soil-climate scenarios to simulate specific worst-case situations (i.e. FOCUS GW scenarios). Spatial modelling is needed for more realistic higher tier approaches such as leaching assessment on regional scales or vulnerability assessment and contextualization of experimental sites. However, the handling of spatial input and output data and interaction with available GIS tools is limited. Apart from that common GIS are not capable to run sophisticated and dynamic processes models. Existing spatial modelling systems are therefore designed to run possible climate-soil-crop combinations outside of the GIS and just display the modelling results with the help of GIS. This limits the flexibility with regard to the modelling area as well as the spatial resolution.
The current work was initiated to overcome these limitations developing a modelling system that completely runs within a GIS system showing maximum flexibility regarding the spatial area and resolution.



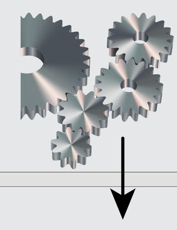
Data



Processes

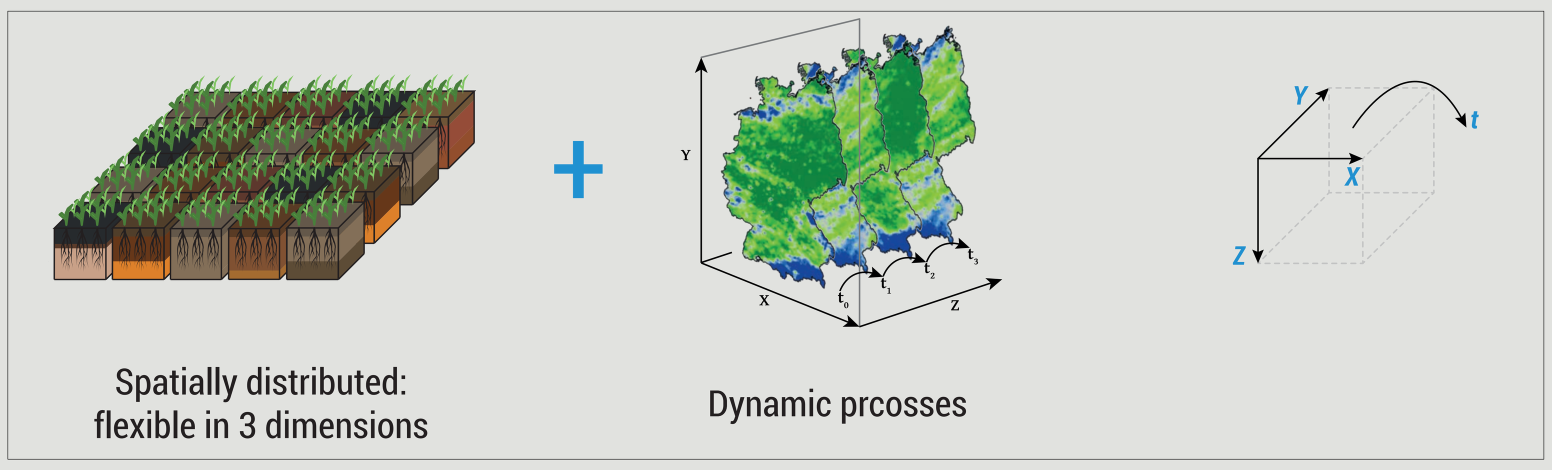


Process-Model



Model output

Our approach: PCRaster modelling framework



We present a new pesticide leaching model developed in PCRaster Python, an environmental modelling framework tailored to the development of spatio-temporal models. The model integrates pesticide leaching processes directly into a spatial modelling framework which is much more flexible, as calculations that are executed directly on spatial data. As the model is not hard-coded on an extensive pre-processing of spatial databases to delineate environmentally homogeneous areas (unique combinations), it is possible to apply the model to various data layers on different spatial scales.

Model Structure

Discretisation

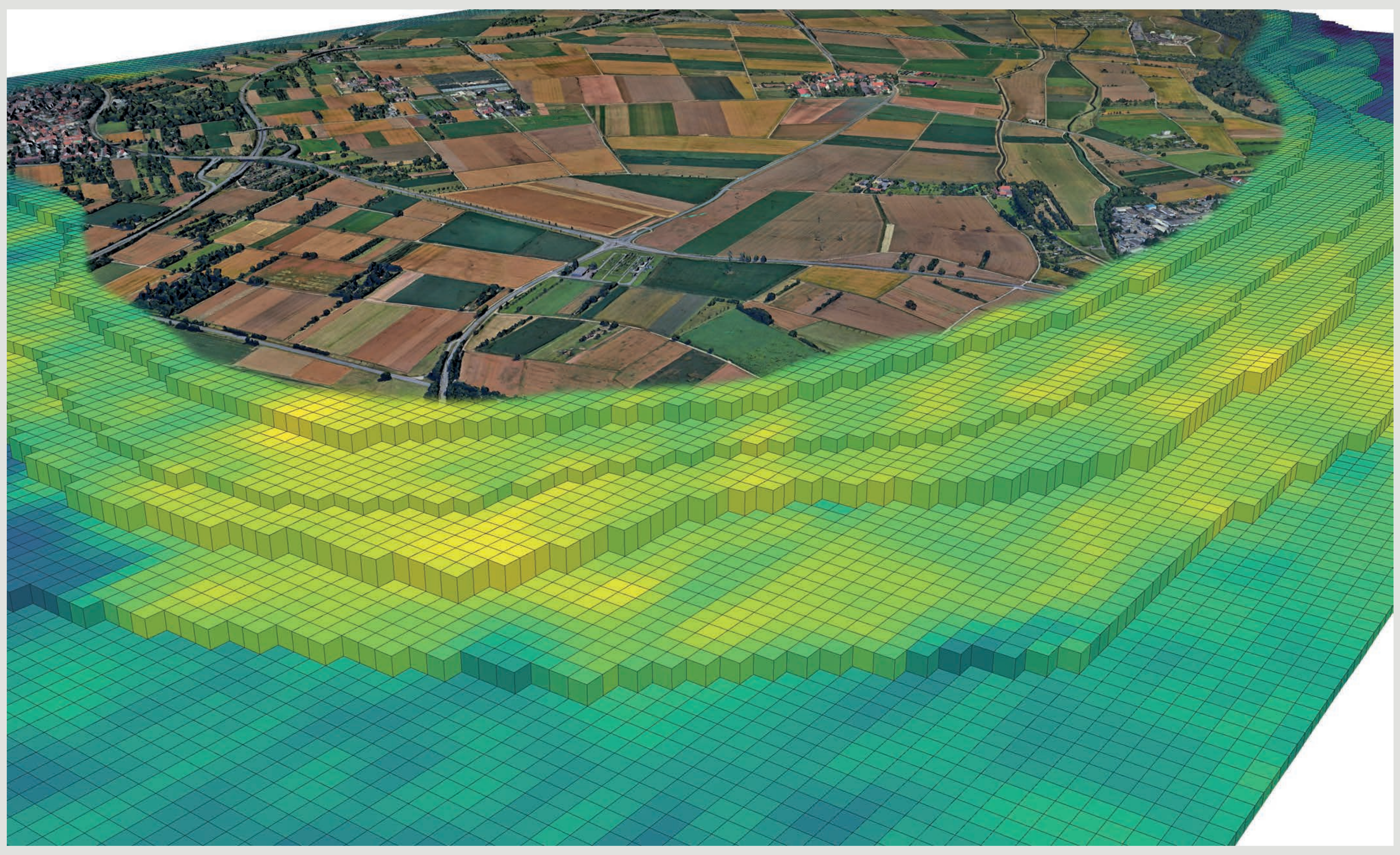
- XY direction: flexible. --> input data (raster cell size)
- Z direction: soil profile is divided into segments (e.g. 5cm)
- Temporal: daily time step.

Soil hydrology

- Water balance capacity model
- Matrix flux
- Evapotranspiration + percolation
- Crop development, root growth
- (runoff and interflow)

Solute transport

- Convection and dispersion
- Non-linear sorption (Freundlich isotherm)
- Degradation (SFO, temperature, moisture, and depth dependent)
- Transformation and fate of metabolites



Results and Discussion

All processes have been implemented into GEORGE and are being validated currently by comparing model outputs to FOCUS PELMO simulations for different FOCUS dummy compounds. The spatio-temporal dynamic of the soil water balance could be simulated nearly identical to PELMO. Also, the comparison of pesticide transport shows promising results, even though small deviations could be observed.
The good agreement between GEORGE and PELMO shows that this new model will have the potential to be used as FOCUS model for higher-tier GW risk assessments and vulnerability analysis in future.

Runtime

Agricultural area Germany

- 1km cell size (262 000 cells)
- daily time step
- 1m soil depth (20 segments)
- 1 CPU
- Linear sorption

15 sec. per timestep ≈1h for 1yr simulation time