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Systemic modelling of soil functions under the impact of agricultural management

Session SSS6.8; Chat-time Tue 5 May 10:45-12:30

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Content of this display:

- description of a new model to predict soil functions under agricultural management with a focus on a dynamic soil structure
- show case simulations to present some features of the model
- an outlook and discussion on further extensions and possible applications of the model

See next slide for navigating within the display.

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Navigation

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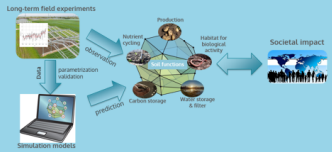
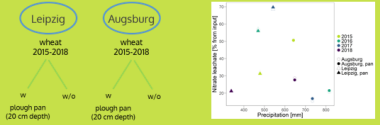
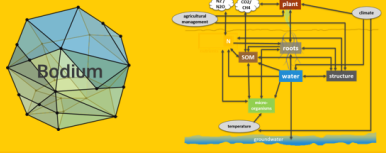
Introduction



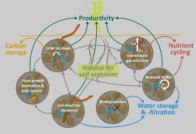
Show case



Model description



Outlook



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Prediction of soil functions in agricultural systems

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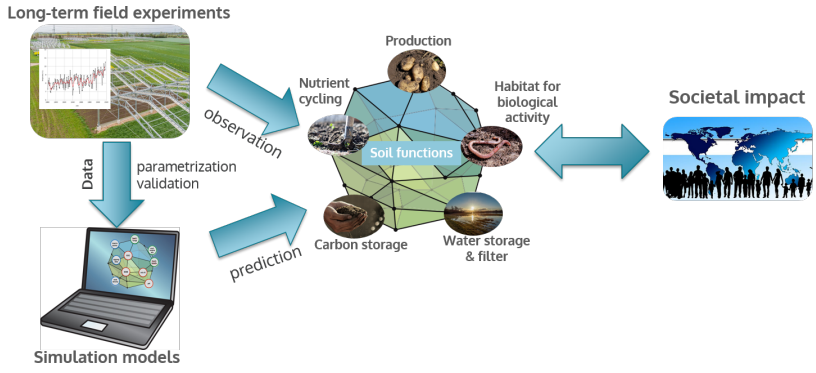
We aim to predict the 5 soil functions

1. Production
2. Habitat for biological activity
3. Water storage & filter
4. Carbon storage
5. Nutrient cycling

by developing a simulation model based on data from long-term field and other experiments and process knowledge received from availabvle sources (e.g. literature) and by learning from the discrepancy between observations and predictions.



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(Soil) modeling of agricultural systems

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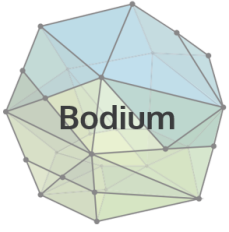
Our model **Bodium**

- aims to predict soil functions under agricultural management
- integrates established model concepts usually focusing on one or two functions and newly developed concepts, and with this
- simulates various soil processes, their feedback and interactions
- captures a dynamic soil structure, which is an important driver for many processes



APSIM next generation

simplace modelling framework

CANDY

expert N

LandscapeDNDC

DAISY SOIL PLANT SYSTEM SIMULATION MODEL

monica

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Challenges

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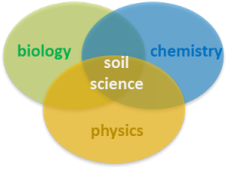
Modellers task:

- Relevant processes at different **temporal & spatial** scales
- Overcome these scaling problems to simulate at **profile scale**



Community task:

- Systemic approach: feedback of soil processes needs to involve different disciplines
- Contribute to data
- Contribute to process knowledge
- Experiments on new research questions required

Socio-economic task:

- Relevance of outcome for the society
- Possible reactions

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BonaRes Data Centre

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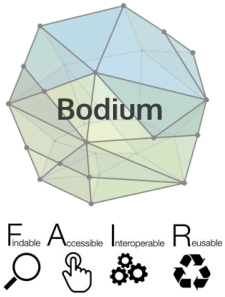

Soil & soil related data from:
- Publicly available sources
- External databases
- Research projects
- Soil profile DB
- ...

Data from scientific community

Do

- Soil
- Environment
- Management
- LTFEs
- ...

Model input

parametrization & validation

Model outcome

biology chemistry soil science physics

BonaRes Repository
- DOI
- License
- ...

Reproduce

Cite

Reuse

More information:
https://datenzentrum.bonares.de/research-data.php

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Our model: Bodium

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written in **C++**
1d soil **profile**, 1 m^2
consisting of list of **nodes**:

- dynamic volume and mass depending on dynamics of
- different components (see next slide)
- process simulation within each node (see next slide)
- communication between nodes

time step: usually 1 day, with higher resolution in specific cases (e.g. rainfall events)

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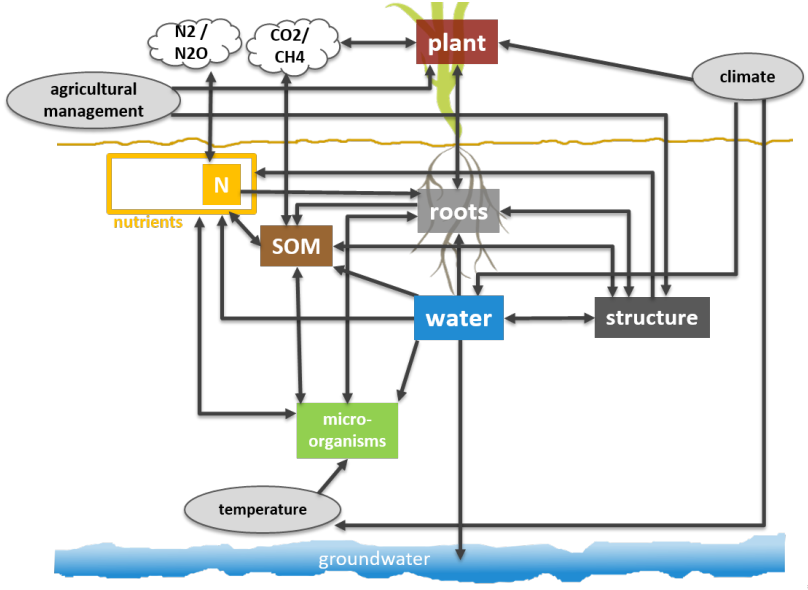
Current version

The current model version involves the components water, SOM & microorganisms, nitrogen, structure, and a plant growth module.

Note that plant and groundwater are not part of the soil nodes, but connected to the top and bottom node, respectively.

See slide 15, for further extensions currently under developement.



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Showcase - overview

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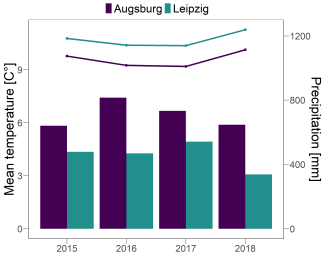
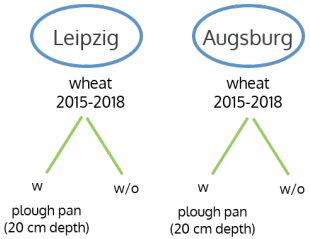
Aim: to test the influence of weather and compaction on soil functions

Used weather data from 2015-2018

- precipitation
- air temperature
- radiation
- evaporation





We simulated wheat growth in four consecutive seasons for two different weathers, each with and without a plough pan in 20 cm depth
⇒ resulting in **4 different scenarios**

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Showcase - productivity

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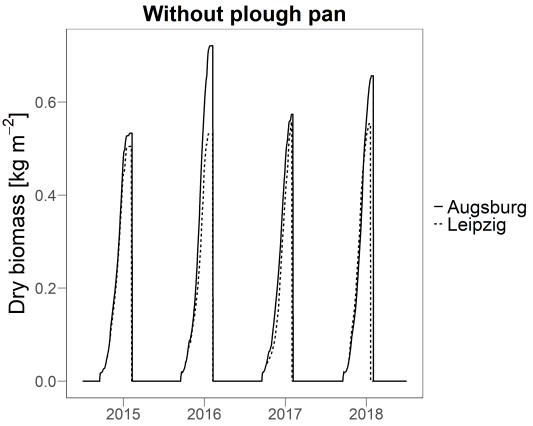

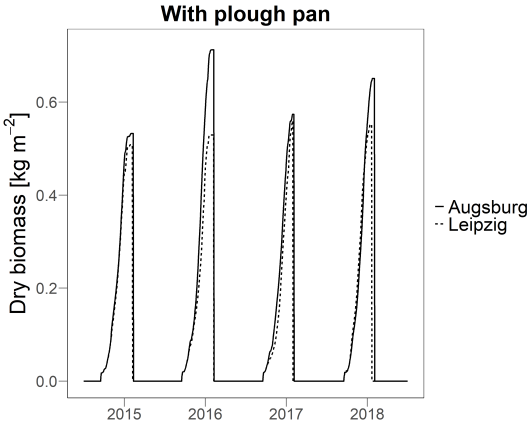

Simulated results show differences in productivity mainly due to **weather conditions**, and only slight differences in scenarios with and without plough pan.

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Showcase - productivity

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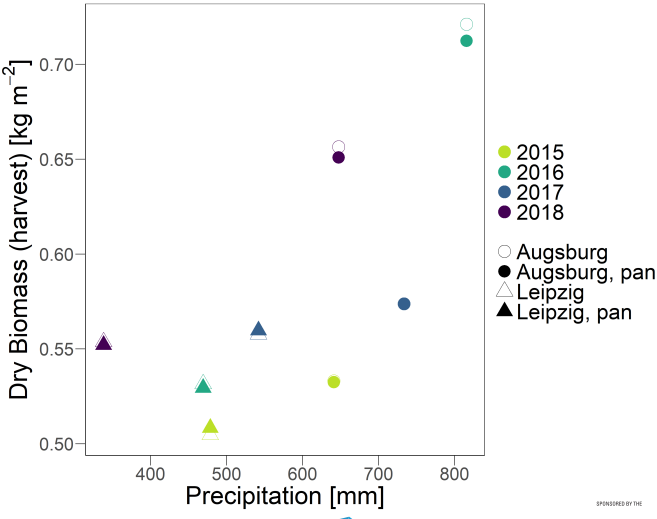
However, there is not a clear relationship between yearly precipitation and simulated yield.
Here, it also depends on the **precipitation regime** and the precipitation of the **previous year**, as our water module is able to capture both effects.
Again, we don't observe a difference in simulated yield for scenarios with and without plough pan (filled & unfilled symbols).



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Showcase - roots and compaction

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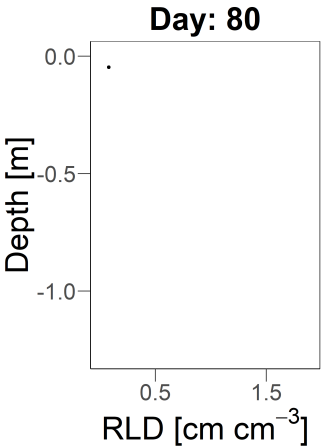
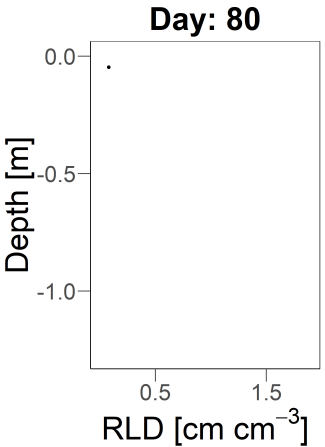
with plough pan (at 0.2m)



without plough pan



But, we clearly observe local effects on root length density (RLD) growth affected by the **compacted horizon**.

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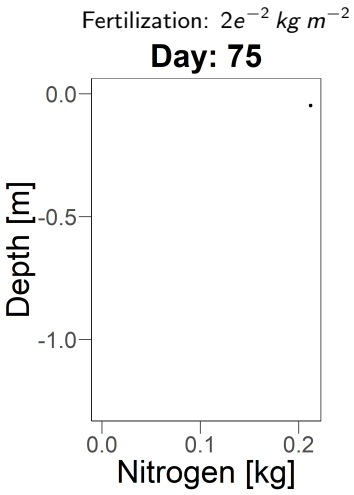
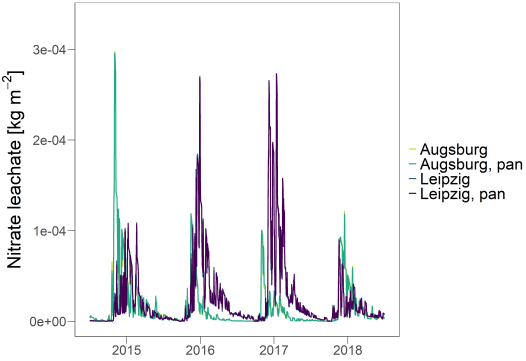
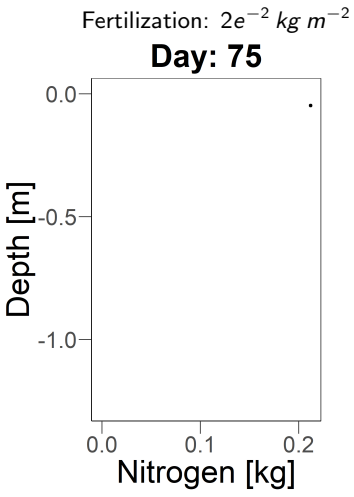
Showcase - nitrogen



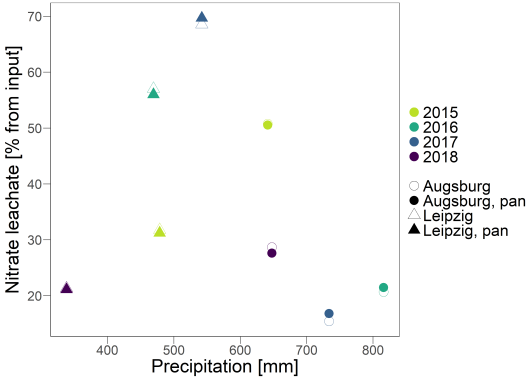
With our model, we can observe the nitrate flow after fertilization and thus also the amount of nitrate leaching into the groundwater. We assume that **nitrate leachate** mainly depends on precipitation.



Showcase - nitrogen



Again, the **precipitation regime** is more important than yearly precipitation. For example, in 2017 in Leipzig (blue triangle) a heavy rainfall event was recorded shortly after fertilization, resulting in the high nitrate leachate for the whole year.



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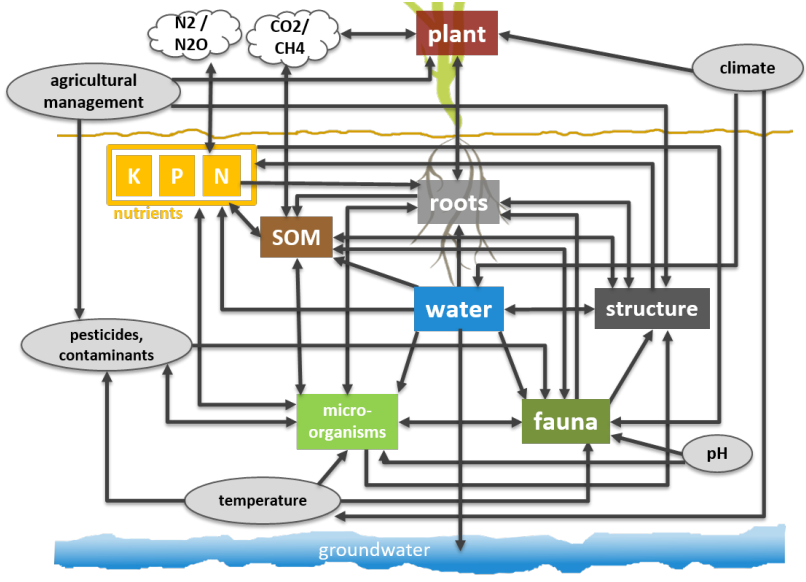
Future extensions

Several extensions of the model are currently in devel-opement.

This includes faunal dynam-ics, K & P cycle, functional microorganism groups, and pH.



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How to represent biological processes in soil models?

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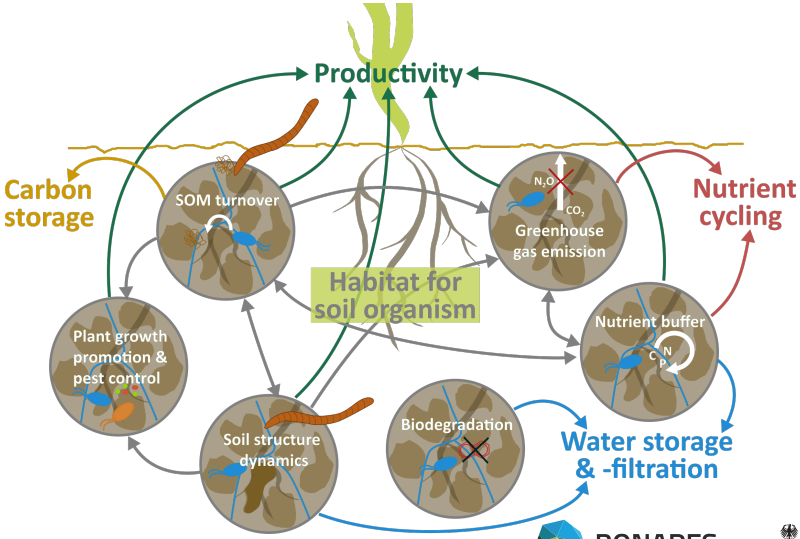
Within the BonaRes community, we are currently discussing how we can best represent **biological processes** in our soil models.

Here, we identified the main biological processes driving the soil functions we are interested in.

This ongoing challenge needs to be tackled as a joint task by **soil biologists and modelers**.



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What to do with Bodium?

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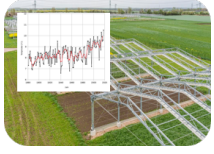
Bodium will be useful for **farmers** -
to evaluate the impact of their soil management on soil functions under their specific soil conditions

Bodium can be used to generate scenarios for **landscapes**



Bodium can be used by **other scientists** -
e.g. to model soil function dynamics which are difficult to measure directly, to explore the impact of individual processes on soil behavior at system level and thus help to complete the systemic view on soils.

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Thanks for your interest!

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