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Influence of Crop Rotation Design for Biomethane Production on Soil Moisture Regime – Scenario Simulations for Different Sites in Germany

background & objectives

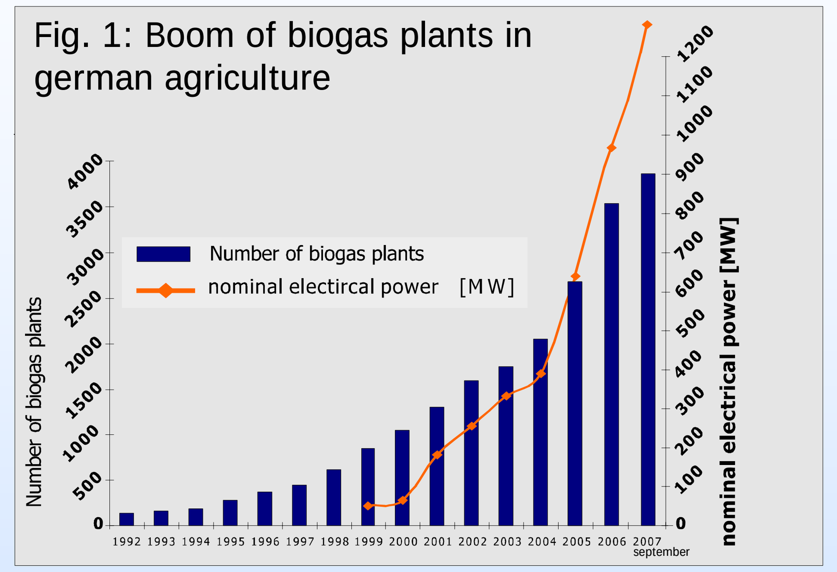


Fig. 1: Boom of biogas plants in german agriculture

Influenced by the energy policy of Germany the number of biogas plants and its nominal power is increasing (Fig. 1).

Regional "hot spots" are found in northwestern and southern Germany (see Fig. 2).

As substrat for fermentation energy crop production (in particular maize and wheat) became important.

Because of this development an aggregation of nutrients (energy) in the neighbourhood of biogas plants is expected.

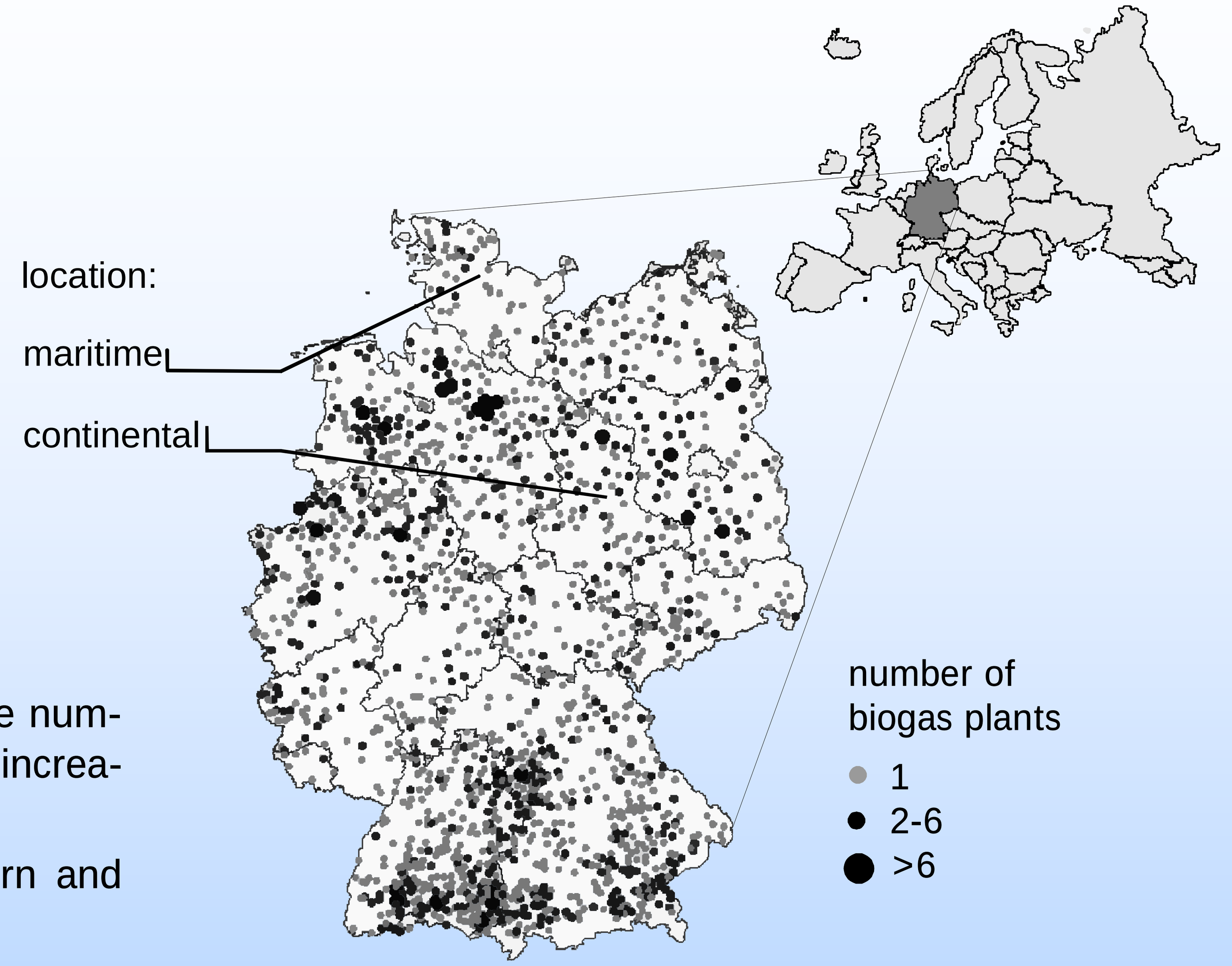
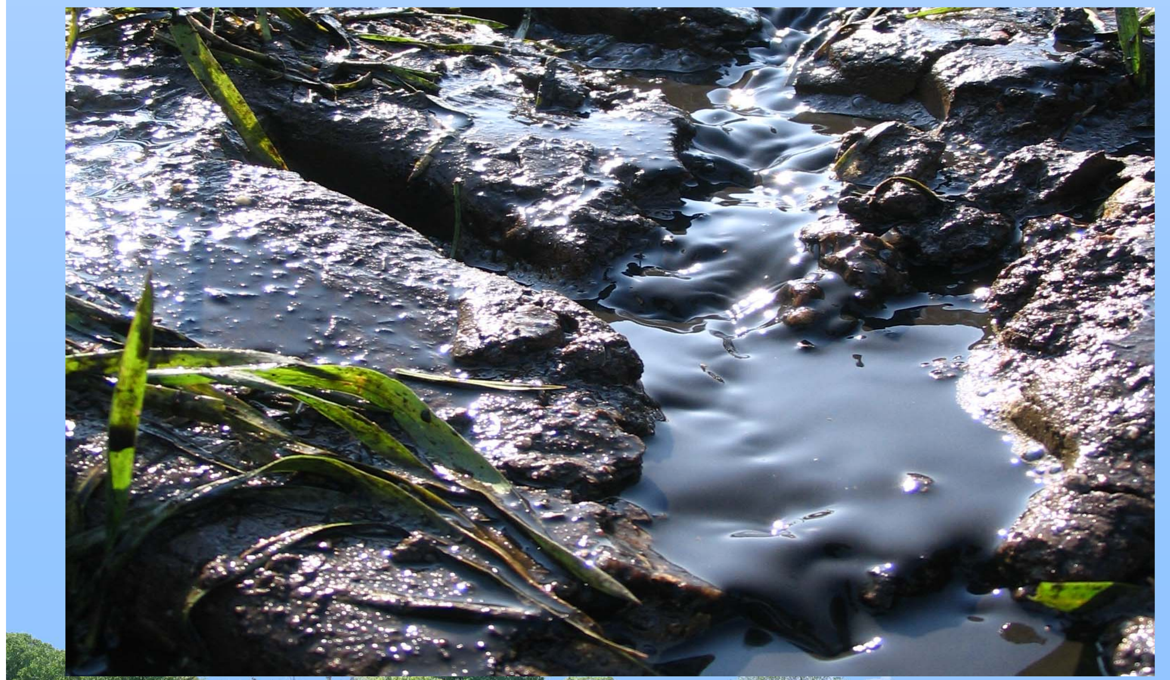


Fig. 2: Location and number of biogas plants 2006 in Germany



To avoid the risk of nitrogen leaching the following hypotheses are formulated:

- Maize grown in monoculture causes more leachate.
- High productive energy crop rotations lead to increased water stress and thus less leaching compared to maize grown in monoculture and permanent grassland, especially under continental conditions.
- Regional environmental conditions (continental vs. maritime) have to be taken into account when optimizing energy crop rotations.

materials & methods

The HUME/FOPROQ models were applied to simulate energy crop production systems and were checked upon their plausibility.

A long-term simulation study (1970-2006) compares a permanent grassland with monocropped maize and an energy crop rotation (wheat-grass-maize).

Included are two locations, differing in climatic conditions: a maritime and a continental one.

Impact of energy crop production on water balance was quantified by soil water content and drainage.

For calculating the plant available soil water the maximum root depth was used.

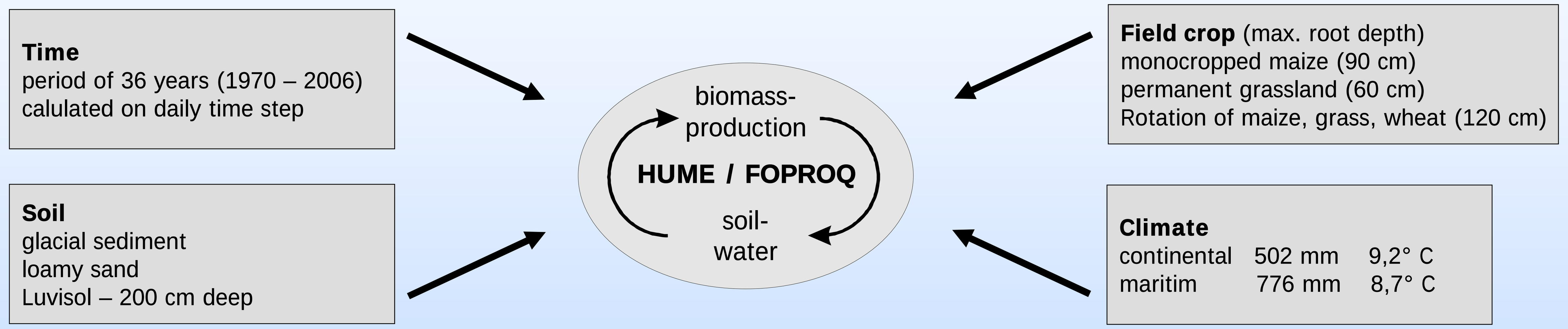


Fig.3: Design of the long-term simulation study

results & discussion

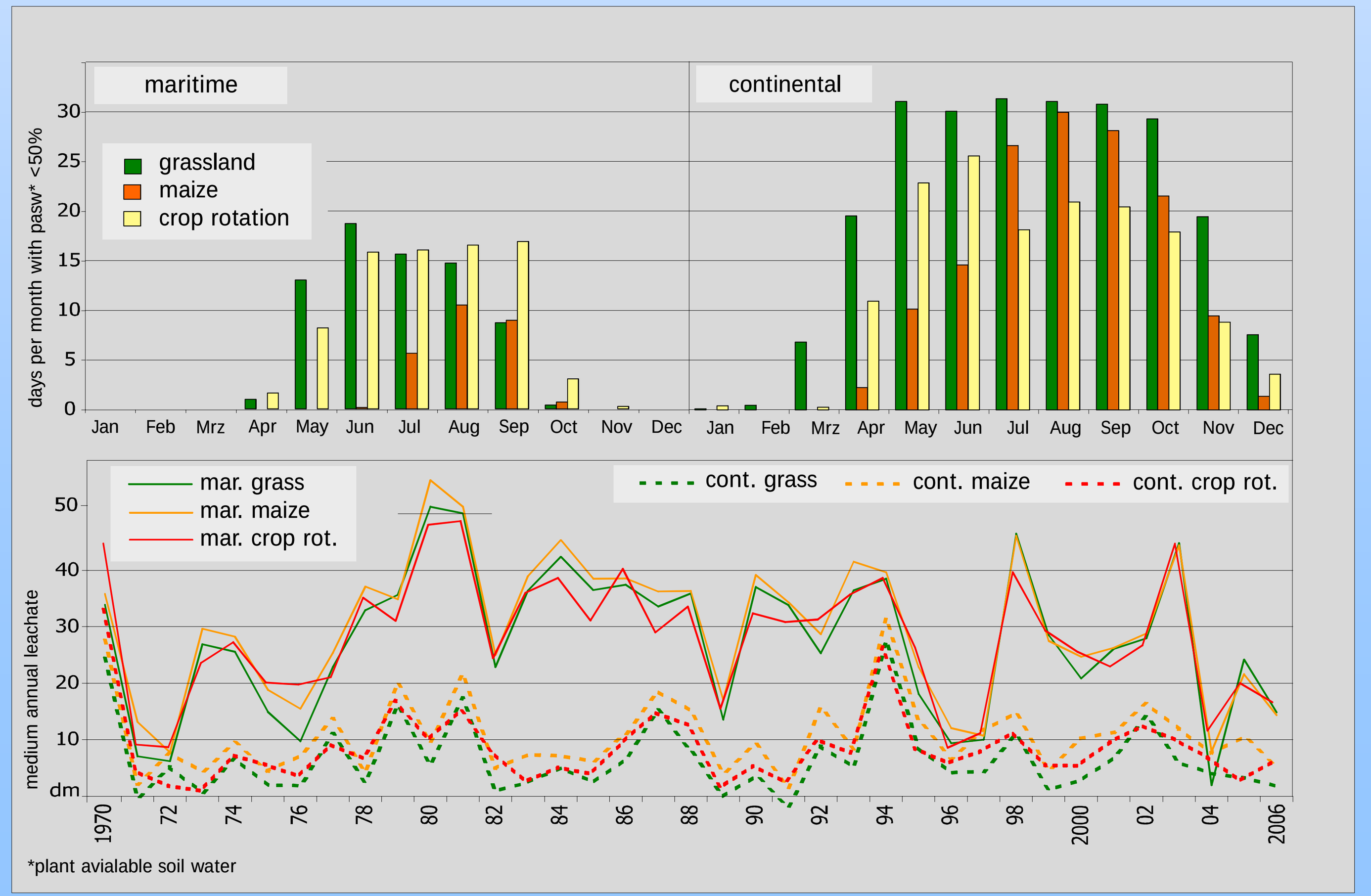


Fig. 4: Simulated soil water content and amount of leachate for the different energy production systems, averaged over 36 years.

The amount of plant available soil water and leachate was considerably influenced by the energy crop production system (Fig. 4, Tab. 1)

Tab. 1. Simulated amount of leachate (mm) and evapotranspiration (mm)

	Drain	Evapotrans-piration	
crop rotation	87	405	continental
maize	114	388	
grass	72	413	
crop rotation	289	465	maritim
maize	308	454	
grass	286	460	

In the maritime climate the crop rotation caused the soilwater buffer to deplete more often between July and October, while under continental conditions permanent grassland and maize resulted in low soil water contents.

The different effects of energy crop production systems on the soil water balance cannot be explained in total. For instance, a drop in water stress (June/July) in the crop rotation was observed only under continental conditions.

Generally more leachate was found under maritime conditions and in monocropped maize. Grassland and the crop rotation showed similar effects on leachate in both environments.

The leaching effects were caused by different climate regimes, different duration of canopy and a better WUE of maize. In contrast to maize, grassland as well as crop rotation covered the ground nearly all the year.

conclusions & perspective

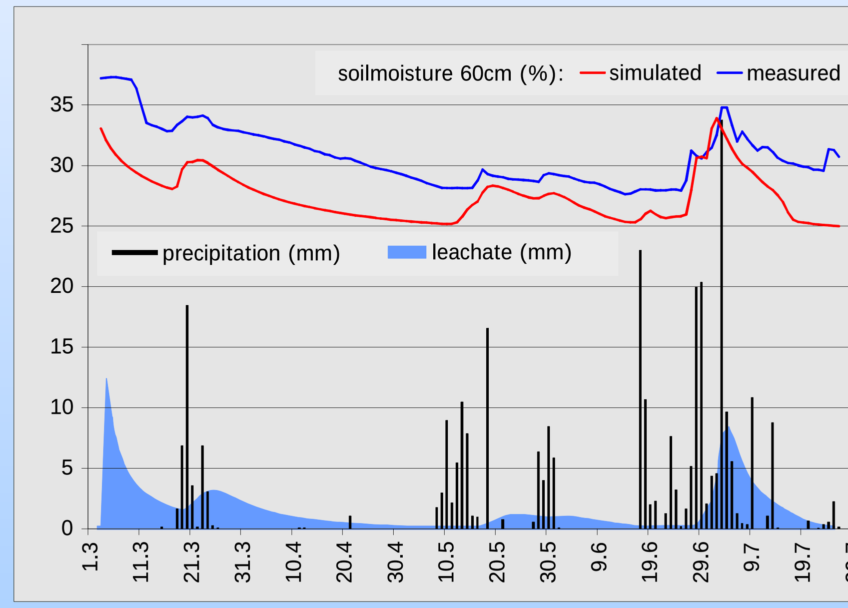


Fig. 5: Model validation 2007: comparing measured and simulated data

The time course of the observed soil moisture content was satisfactorily reproduced by the model.

The peaks in soil moisture and leachate were plausible with the precipitation.

Some discrepancies, that were observed with respect to the total amount of soil water, will probably be dispelled when empiric model parameters are available.

The applied models allowed to quantify the soil moisture and to calculate the amount of leachate under the given conditions.

Not all hypotheses could be confirmed.

Some effects of the energy crop production system concerning the soil water balance may slightly change when improved model parameters are used.

Future model development will include an optimization of model parameters based on experimental data and the extension to different climatic and soil conditions.

The model will be able to calculate the N-leachate of biogas production systems under the special conditions of northern Germany.

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