From point to field scale: How consistent are agro-ecosystem models in terms of changes in soil texture?

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Introduction

Field scale variability of soil texture contributes to the site-specific performance of water dynamics, nitrogen turnover and crop development in the soil-plant-atmosphere system. In agricultural practice, management recommendations that operate on the basis of spatially and temporally variable soil states are rarely considered, even though, having knowledge about it could help to avoid unwanted environmental impact and waste of resources (Fowler et al., 2013). Agro-ecosystem models are able to derive spatially and temporally high resolution state variables considering both, soil and crop processes. To assess selected models for future application in agricultural practice (e.g. precision farming), this study examines the consistency of yield simulation in relation to soil texture changes at the field scale.

Materials and Methods

The data set used in the present study results from intensive mapping and sampling activities at a 20 ha large agricultural field in north western Germany. Data is extensively described in Wallor et al. (2018) and includes three years of on-the-go measured yields and results of soil analysis at 60 sampling points arranged as a regular grid. The soil inventory of the field consists of seven homogeneous soil zones that show increasing clay contents from 5% to 45%. Winter wheat yields of the years 2000 and 2001 show a clear response to these changing soil conditions. We exemplarily tested the models APSIM (AS; Keating et al., 2003), COUP (CO; Jansson, 2012), and HERMES (HE; Kersebaum, 2007) regarding their consistency in yield simulation with respect to changes in clay content and hence, soil water contents. A four-year period is simulated including one spin-up year and one year for model calibration.

Results and Discussion

When comparing the mean deviation of simulated and observed yields with the mean deviation of simulated and observed soil water contents for each model, AS showed highly variable deviations in yield predictions although water deviations were only slightly biased (cf. Figure 1). Especially for sampling points that have less than 25% clay the response of yield formation to soil water is over-predicted. HE produced the most consistent results showing a relative small band of deviations for water and yields, independently from soil texture. CO's simulation was similarly consistent in this sense, but showed larger deviations for yield predictions. The overestimation of yields was accompanied by over-predicted water contents without showing a clear relation to soil texture.

Conclusions

In terms of the highly sufficient depiction of heterogeneous soil water contents, which mainly affect yield performance in this field, the assessed models performed mostly consistent. This suggests that the cause for the deviations between simulation and observation can be found in the model-specific structure and equations, as the influence of model inherent estimation of soil hydrological parameters was excluded before.

Acknowledgements

This work was conducted within the Project I4S which is part of the BonaRes programme funded by the German Federal Ministry of Education and Research (BMBF), Grant Number 031B0513I. It is an in-depth evaluation of a modeling exercise that was carried out within the framework of FACCE JPI MACSUR2. The contributing authors thank the National Ministries and the European Union for funding the projects (grant 0339740 and 031B0039C).

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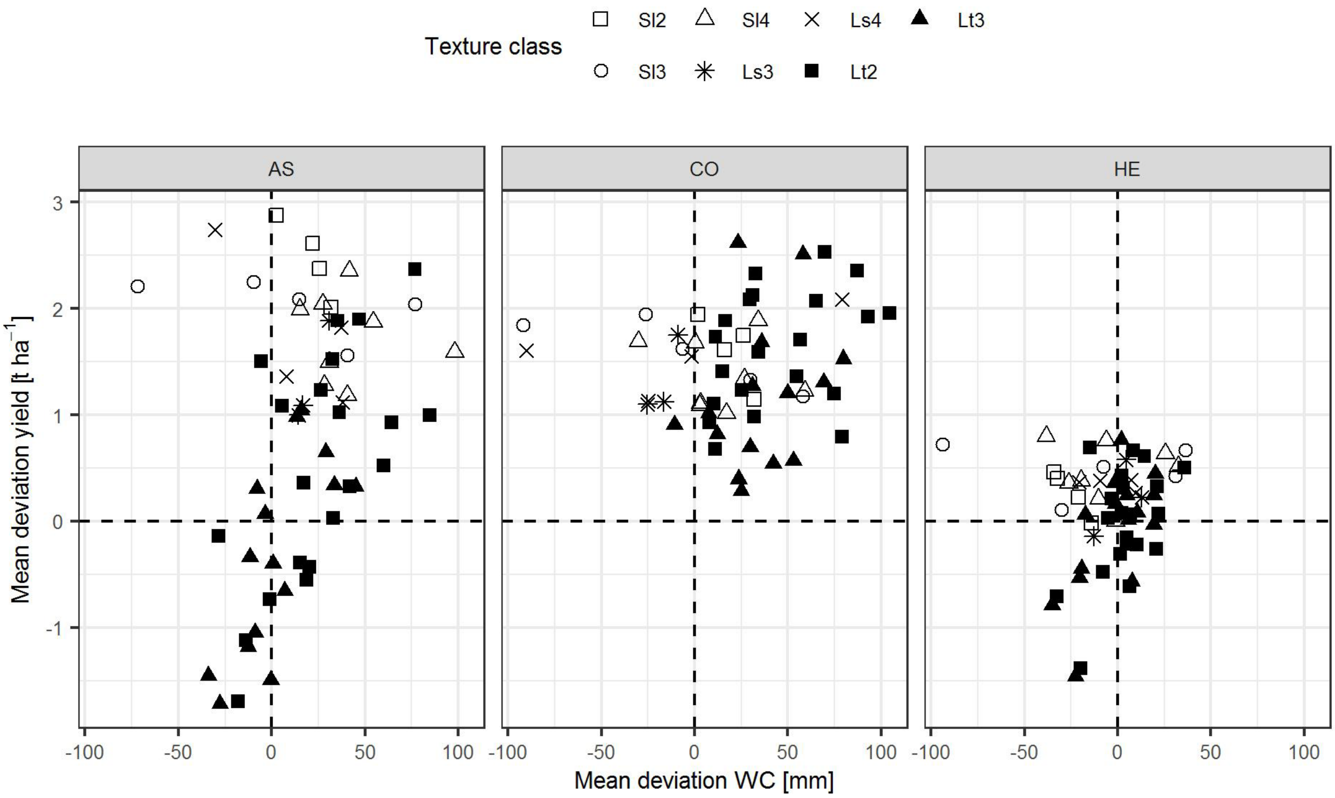

Figure 1. Model-based relation between the mean deviation of simulated and observed yields and the mean deviation of simulated and observed soil water contents (WC) grouped by soil texture class (Sl2, Sl3, Sl4 = 5 to 17% clay; Ls3, Ls4 = 17 to 25% clay; Lt2, Lt3 = 25 to 45% clay); mean deviation was calculated based on all observations per sampling point of the entire simulation period

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