Effect of data aggregation on crop yields simulated at large scales

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Background and Methodology

Introduction

- Performance of crop models at large scales is uncertain since most of them were developed, parameterized and tested at field scale.
- Here we systematically evaluate effects of climate and soil input data aggregation and model output (simulated yields of winter wheat in Germany)

Data and methods

- Daily weather data for the period 1980-2011 at 1 km resolution was developed based on data derived from the WebWerdis portal of German Meteorological Service (Zhao et al., in press).
- Soil characteristics were derived from the BÜK 1000 N data set (BGR, 2012).
- Input – and output data was aggregated from 1 km resolution to 10 km, 25 km, 50 km, 100 km resolution and to federal state and country level (Figure 1).
- Climate data was aggregated by calculating the mean across cropland.

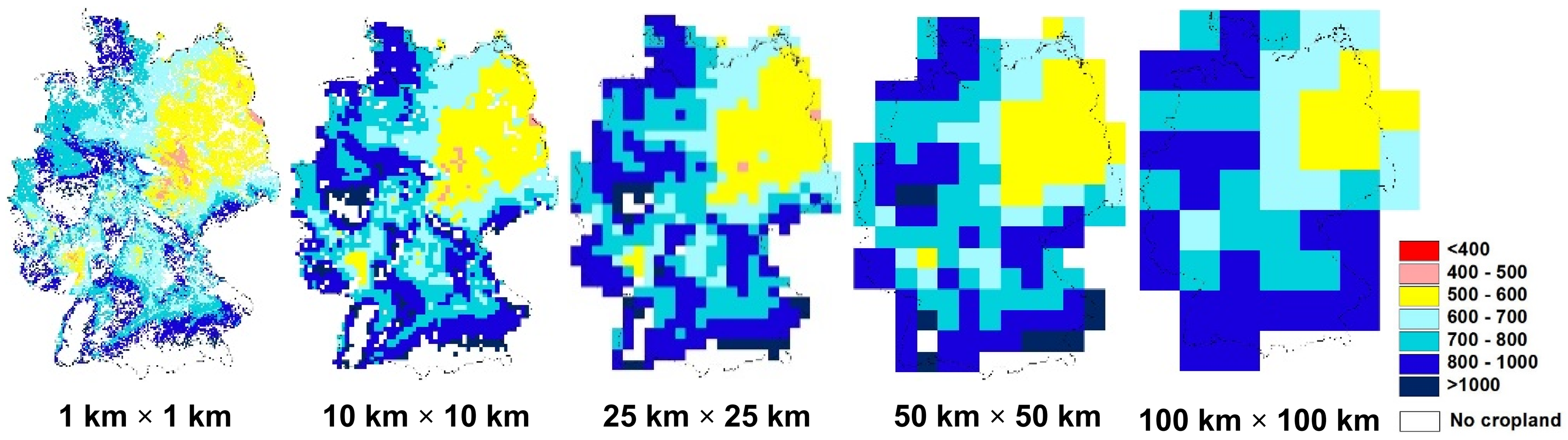

Figure 1. Different aggregation levels of the annual precipitation sum (mm) across Germany.

- The effect of data aggregation was illustrated by input and output data aggregation approaches illustrated (Figure 2).

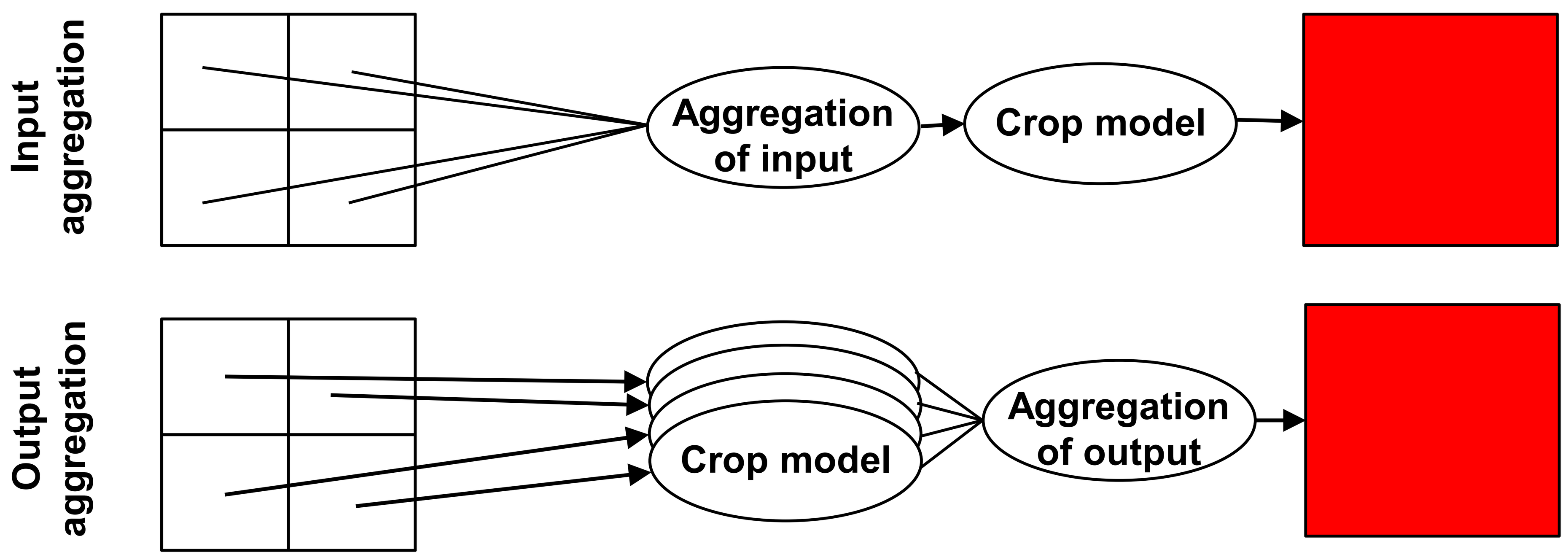

Figure 2. Schematic diagram of input and output aggregation.

Crop model (parameterization and testing)

- The crop model LINTUL-2 (van Oijen and Leffelaar, 2008) has been modified with respect to heat stress and phenology and was applied for winter wheat.
- The model was tested by comparing yields reported by the agricultural statistics at district level (mean 1999-2011) and mean yields simulated for the same period at 50 km resolution (Figure 3).

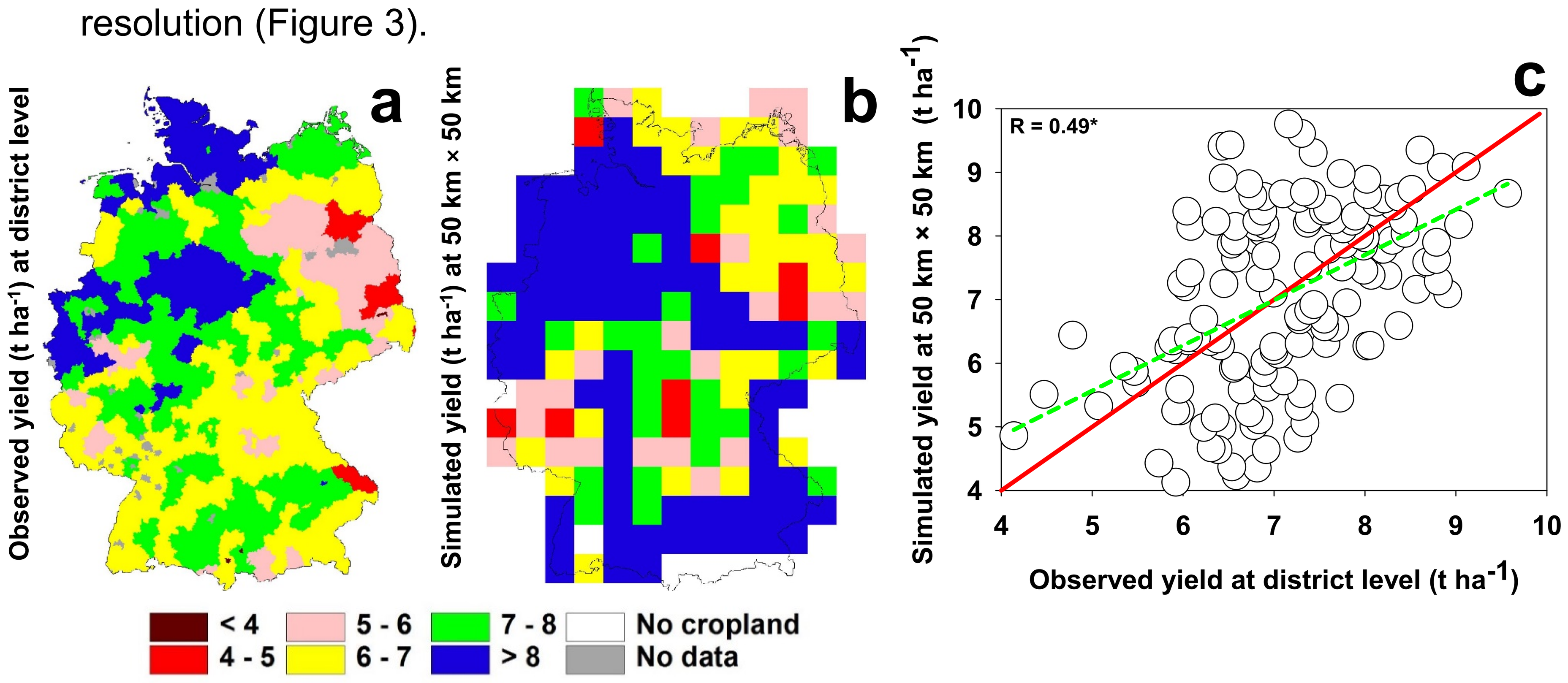

Figure 3. Spatial pattern of mean winter wheat yield observed at district level (a) and simulated at 50 km resolution (b) for the period 1999-2011 and 1:1 plot of simulated and observed yield (c) (at the center of 50 km grid cells).

Conclusion and outlook

Data aggregation resulted in less spatial detail of model results, in particular for regions with high heterogeneity in weather and soil conditions.

Acknowledgements

Research support was provided by the German Research Foundation DFG (grant no. EW 119/5-1).

Results

Effect of data aggregation on weather and soil variables

- Mean and median of daily maximum temperature, annual precipitation sum and total available water capacity in 1 m soil calculated across Germany were not considerably influenced by aggregation (Figure 4a, b).
- Aggregation considerably changed frequency distribution of total available water capacity (Figure 4c)

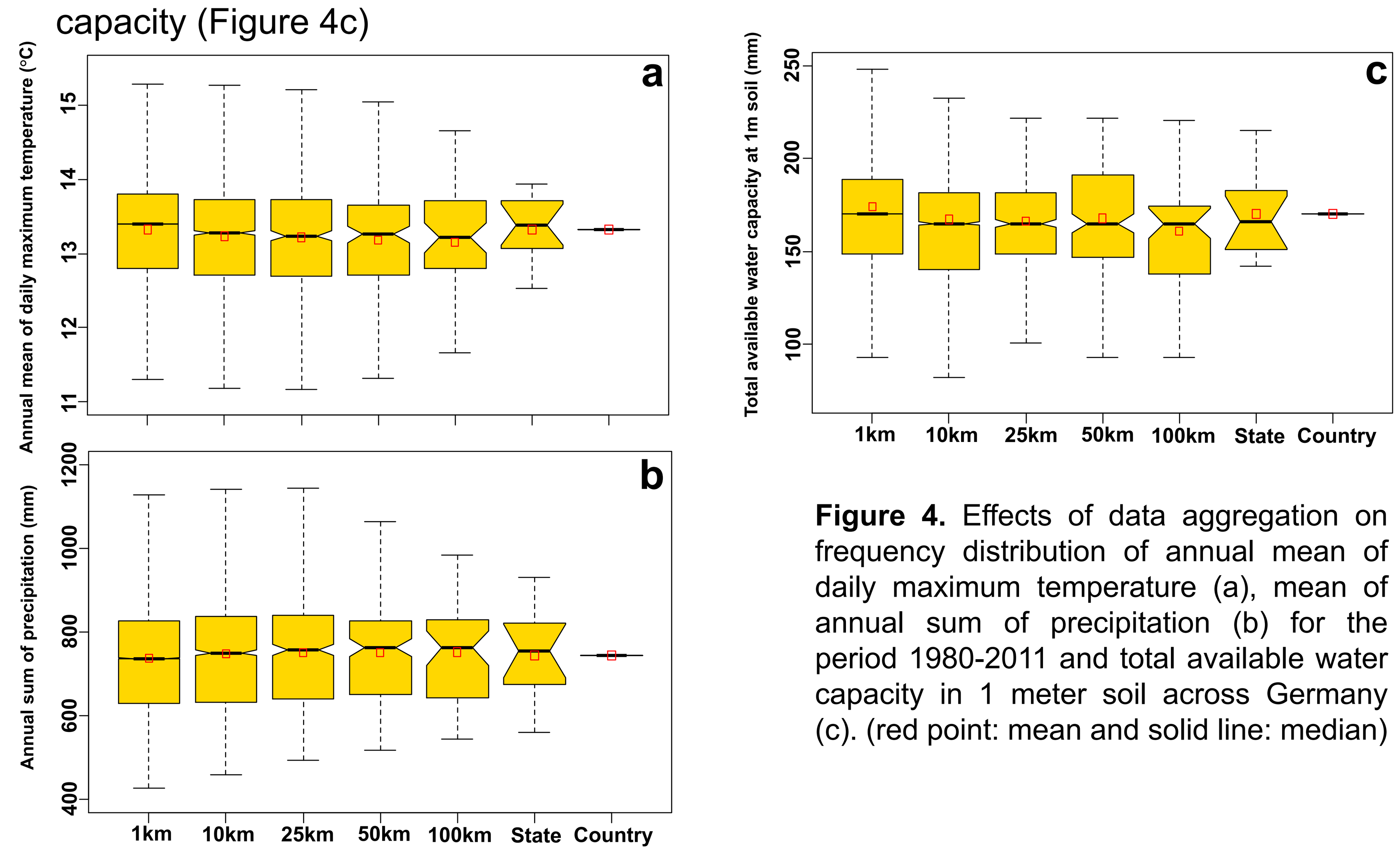

Figure 4. Effects of data aggregation on frequency distribution of annual mean of daily maximum temperature (a), mean of annual sum of precipitation (b) for the period 1980-2011 and total available water capacity in 1 meter soil across Germany (c). (red point: mean and solid line: median)

Effects of input data aggregation compared to effects of output data aggregation

- Aggregation of model input and output data has had only a small impact on simulated mean and median of crop yields at country scale (Figure 5).
- The range of simulated yields considerably decreased by output data aggregation from 1 km to 100 km but, in contrast to yields computed with aggregated input data (Figure 5).

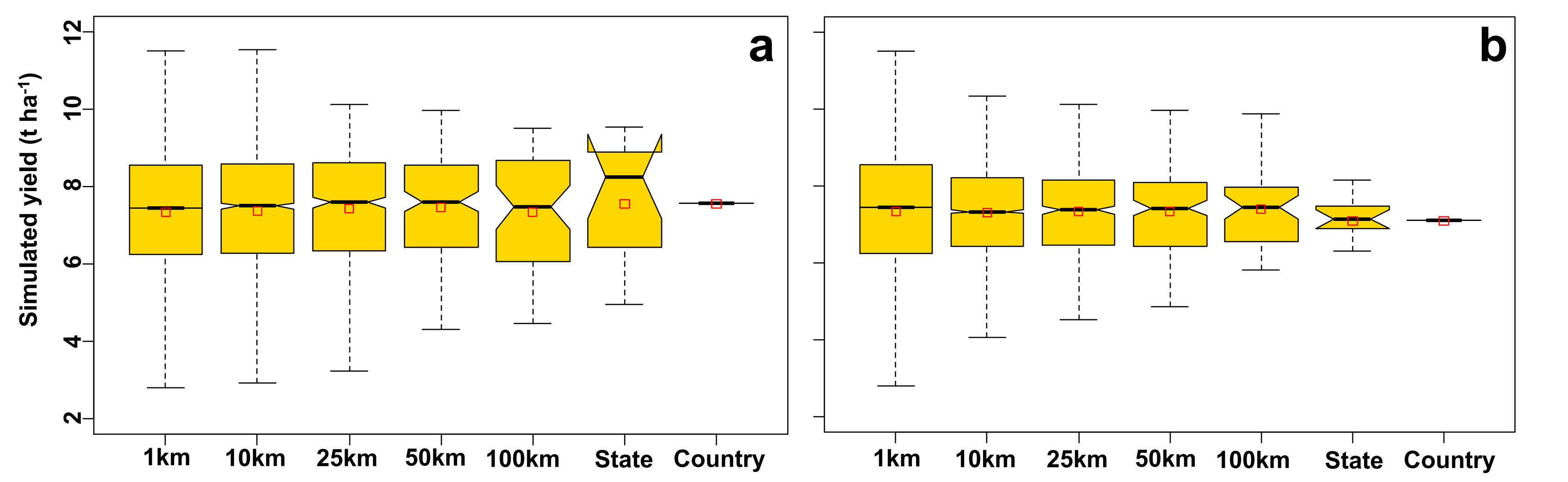

Figure 5. Boxplots of mean crop yields in period 1980-2011 simulated with input (a) and output (b) data aggregation at different aggregation levels across Germany (red point: mean and solid line: median)

- Mean of absolute difference ($\overline{AD}$) between yields simulated with aggregated input data and aggregated yield output increased by increasing of aggregation level to 100 km × 100 km (Figure 6).
- The highest difference between input and output aggregation was obtained for the regions with the lowest yields.

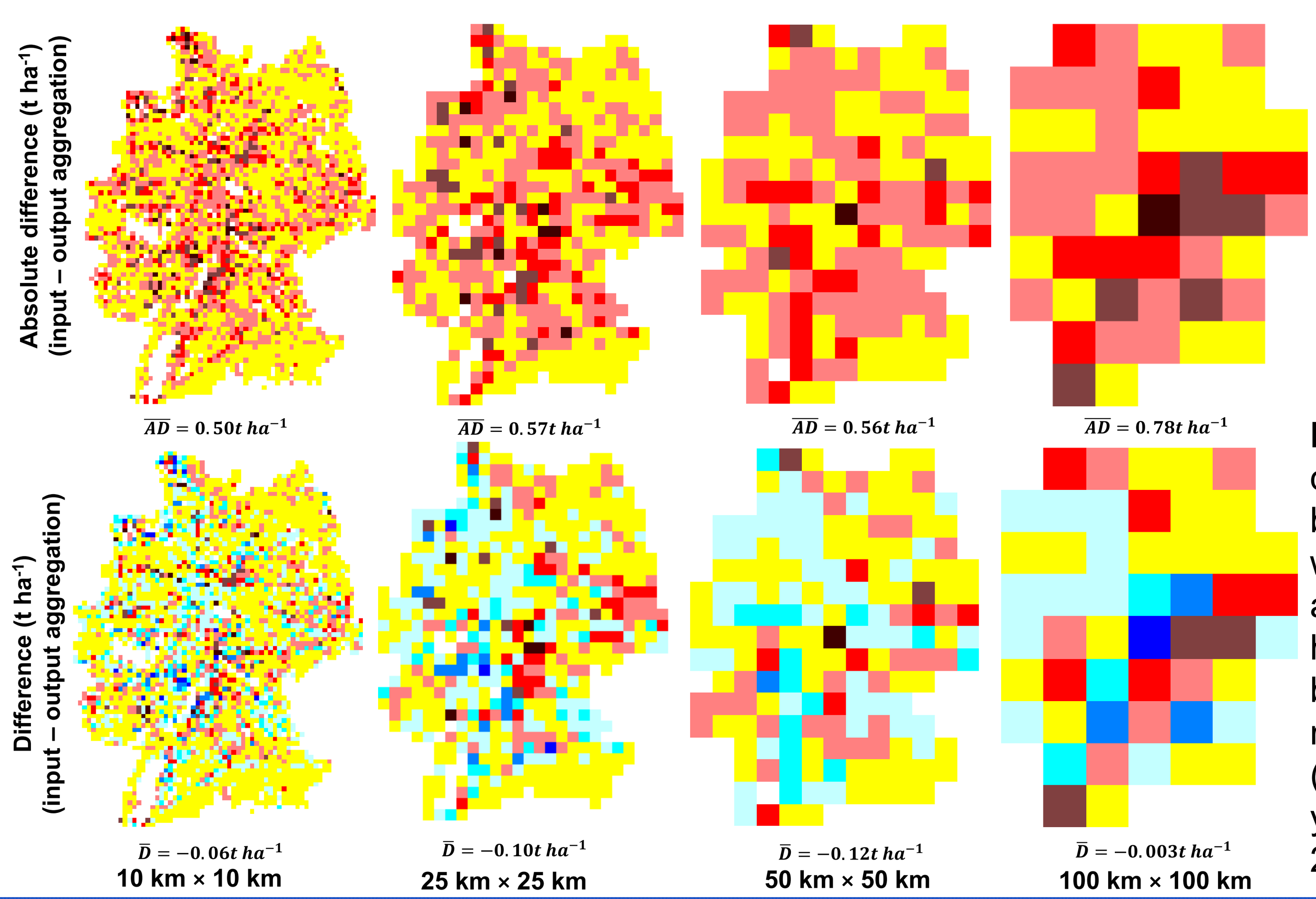

Figure 6. Absolute difference and difference between yields simulated with aggregated input data and yields simulated with high resolution input data but aggregated to coarser resolution afterwards (output aggregation), mean yields for the period 1980-2011 are shown.

References

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