DATA Aggregation effects in regional yield simulations

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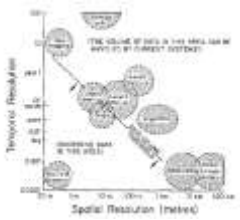
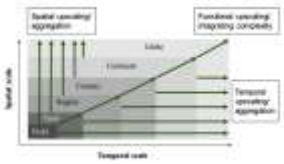
Data Aggregation Effects in Regional Yield Simulations

Holger Hoffmann, Kurt-Christian Kersebaum, Gang Zhao, Senthold Asseng, Senthold; Marco Bindi, Davide Cammarano, Julie Constantin, Elsa Coucheney, Rene Dechow, Luca Doro, Henrik Eckersten, Thomas Gaiser, Balázs Grosz, Edwin Haas, Belay Kassie, Ralf Kiese, Steffen Klatt, Matthias Kuhnert, Elisabet Lewan, Marco Moriondo, Claas Nendel, Helene Raynal, Pier P. Roggero, Reimund Rötter, Stefan Siebert, Carmen Sosa, Xenia Specka, Fulu Tao, Edmar Teixeira, Giacomo Trombi, Jagadeesh Yeluripati, Eline Vanuytrecht, Daniel Wallach, Enli Wang, Lutz Weihermüller, Zhigan Zhao, Frank Ewert

Introduction | Scale and resolution

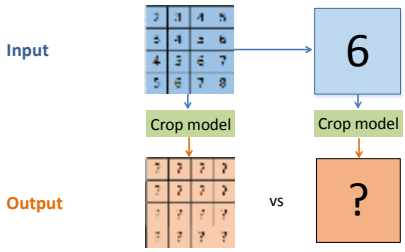


Meentemeyer 1989, after Townsend 1987



Ewert et al. 2006, 2011

Introduction | The aggregation effect



Zhao et al. 2015a (modified)

Introduction | Current literature: 14 examples

Region	Data	Method	Resolution	Model type (no.)	Response variable	Error	Reference
NRW (DE)	climate	average	≤100 km	crop (13)	maize / wheat yield	Bias ≤ 3.5 [%] RMSE ≤ 4.5 [%]	Hoffmann / Zhao et al. 2015a
DE, FR	climate	average	≤50 km	crop (1)	maize / wheat yield	RMSE ≤ 4.7 [%]	De Wit et al. 2005
US	climate, soil, land-use	average, majority, other	≤45 km	crop (1)	maize yield	Bias ≤ 2.3 [%]	Folberth et al. 2012
FI	climate	average	≤100 km	crop (4)	barley yield	Bias ≤ 1.5 [%]	Angulo et al. 2013
NRW, (DE)	soil	maps	≤1:10^6	crop (4)	wheat yield	Bias ≤ 2.9 [%]	Angulo et al. 2014
DE	climate, management	average	≤100 km	crop (1)	wheat phenology	RMSE ≤ 4.4 [%]	Van Bussel et al. 2011
DE	climate, soil, phenology	average, majority	≤100 km	crop (1)	wheat heat stress	Bias = 0.003 ^{b} [-]	Rezaei et al. 2015
W US	climate, soil, topography, vegetation	average	≤110 km	ecosystem (1)	NPP	Bias = 18 [%]	Pierce et al. 1995
S-E AU	climate RS ^{f}	average	≤0.96 km	energy balance (1)	ETa	Bias ≤ 15 [%]	Ershadi et al. 2013
N-E DE	soil	maps ^{e}	≤1:10^5	crop (1)	nitrogen leaching	Bias ≤ 8.6 [%]	Kersebaum & Wenkel
DE	climate	average	≤100 km	crop (1)	wheat yield	RMSE ≤ 5 [%] (approx.)	Zhao et al. 2015b
DK	climate, soil	various	various	crop (1)	wheat yield	Bias ≤ 14 %	Olesen et al. 2000
US	climate, soil	various	≤2.8°	crop, (1)	maize / wheat yield	MAE ≤0.29 (ww), ≤0.7 t ha^{-1} (gm)	Easterling et al. 1998

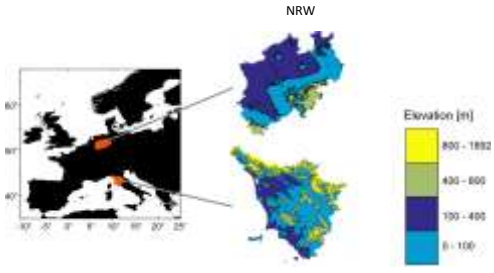
Motivation

To what extent are crop model outputs affected by spatial data resolution and aggregation of the model input data?

How does this depend on the data and aggregation method?

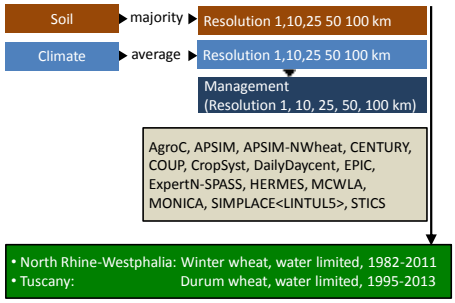
How does this depend on the region?

Methods | Regional focus

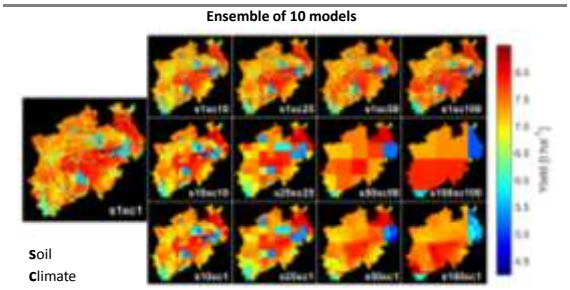


Tuscany

Methods | Aggregation and simulations

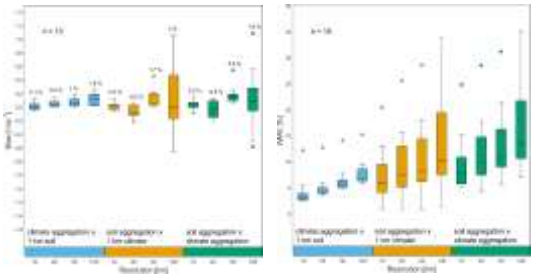


NRW winter wheat grain yield (average 1982-2011)

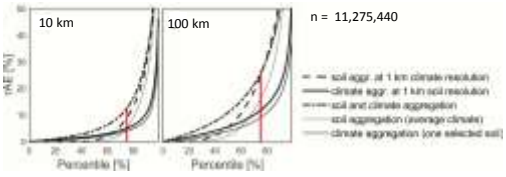


Hoffmann et al. 2016

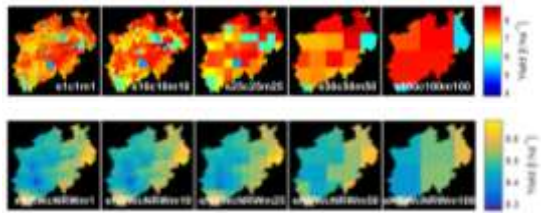
NRW Winter wheat grain yield bias, rMAE



NRW Winter wheat grain yield rAE

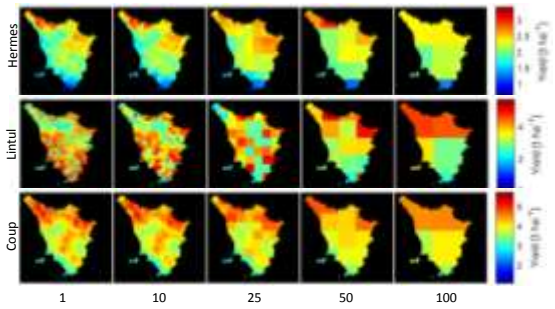


NRW winter wheat grain yield (average 1982-2011)
→ management

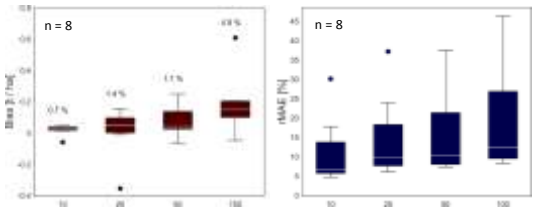


Soil
Climate
management

Tuscany durum wheat grain yield (average 1995-2013)



Tuscany durum wheat grain yield (average 1995-2013)



Soil, climate resolution [km]

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Discussion & outlook

1. aggregation effects…
   - are generally smaller (bias) than other sources of yield variability
   - are partially larger (rMAE) depending on data and aggregation method
   - soil matters
   - management as defined here neglectable
   - results comparable across regions

2. known unknowns
   - spatial patchiness, spatial range, spatial variance, no. of spatial clusters
   - model linking (data – model interactions need to be analyzed)?
   - management, crop rotation (temporal vs. spatial effects)?
   - generalization of effects (mathem. rules/models)?
   - aggregation vs. other scaling methods (e.g. sampling)?
   - correction for aggregation errors?
   - …

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