Effects of soil and climate input data aggregation on modelling regional crop yields

Hoffmann, Holger*[1]; Zhao, Gang[1]; Constantin, Julie[2]; Raynal, Helene[2]; Wallach, Daniel[2]; Coucheney, Elsa[3]; Sosa, Carmen[3]; Lewan, Elisabet[3]; Eckersten, Henrik[4]; Specka, Xenia[5]; Kersebaum, Kurt-Christian[5]; Nendel, Claas[5]; Grosz, Balasz[6]; Dechow, Rene[6]; Kuhnert, Matthias[7]; Yeluripati, Jagadeesh[8]; Kiese, Ralf[9]; Haas, Edwin[9]; Klatt, Steffen[9]; Teixeira, Edmar[10]; Bindi, Marco[11]; Trombi, Giacomo[11]; Moriondo, Marco[12]; Doro, Luca[13]; Roggero, Pier Paolo[13]; Zhao, Zhigan[14]; Wang, Enli[14]; Vanuytrecht, Eline[15]; Tao, Fulu[16]; Rötter, Reimund[16]; Cammarano, Davide[17], Asseng, Senthold[17]; Weihermüller, Lutz[18]; Siebert, Stefan[1]; Gaiser, Thomas[1]; Ewert, Frank[1]

[1] Crop Science Group, INRES, University of Bonn, Katzenburgweg 5, 53115 Bonn, DE

[2] Equipe MAGE, INRA, 24 Chemin de Borde Rouge – Auzeville CS 5267, 31326 Castanet-Tolosan Cedex, FR

[3] Biogeophysics and water quality, Department of Soil and Environment, Swedish University of Agricultural Sciences, Lennart Hjelms väg 9, 750 07 Uppsala, SE

[4] Department of Crop Production Ecology, Swedish University of Agricultural Sciences, Ulls väg 16, 750 07 Uppsala, SE

[5] Institute of Landscape Systems Analysis, Leibniz Centre for Agricultural Landscape Research, 15374 Müncheberg, DE

[6] Thünen-Institute of Climate-Smart-Agriculture, Bundesallee 50, 38116 Braunschweig, DE

[7] Biological and Environmental Sciences, School of Biological Sciences, University of Aberdeen, 23 St Machar Drive, Aberdeen AB24 3 UU, Scotland, UK

[8] The James Hutton Institute, Craigiebuckler, Aberdeen, AB15 8 QH, UK

[9] Institute of Meteorology and Climate Research – Atmospheric Environmental Research, Karlsruhe Institute of Technology, Kreuzeckbahnstraße 19, 82467 Garmisch-Partenkirchen, DE

[10] Systems Modelling Team (Sustainable Production Group), The New Zealand Institute for Plant and Food Research Limited, Canterbury Agriculture & Science Centre, Gerald St, Lincoln 7608, NZ

[11] Department of Agri-food Production and Environmental Sciences - University of Florence, Piazzale delle Cascine 18, 50144 Firenze, IT

[12] Marco Moriondo, CNR-Ibimet, Via Madonna del Piano 10, 50019 Sesto Fiorentino, Italy

[13] Desertification Research Group, Universitá degli Studi di Sassari, Viale Italia 39, 07100 Sassari, IT

[14] CSIRO Land and Water, Clunies Ross Street, Canberra, ACT, AU

[15] Division Soil & Water Management, KU Leuven, Celestijnenlaan 200E, PO 2411, 3001 Heverlee, BE

[16] Climate Impacts Group, Natural Resources Institute Finland (Luke), 00790 Helsinki, FI

[17] Agricultural & Biological Engineering Department, University of Florida, Frazier Rogers Hall, Gainesville, FL 32611, USA

[18] Institute of Bio- & Geosciences Agrosphere (IBG-3), Forschungszentrum Jülich, 52425 Jülich, DE

*Corresponding author: Tel: (+49) 228 732 047, fax: (+49) 228 73 2870, email: hhoffmann@uni-bonn.de

Climate and soil data at coarse resolution are often used as input for crop models in order to simulate crop yields at larger scales, e.g. at regional or national level, potentially leading to biased yield estimates. While the response to data resolution differs between crop models, it is unknown how the spatial aggregation of different types of input data interacts and contributes to this so-called aggregation effect.

An ensemble of crop models was run with soil and climate input data at different spatial resolutions from 1 to 100 km for the state of North Rhine-Westphalia, Germany. For this purpose, climate time series were averaged spatially and soil data was aggregated by selecting the dominant soil type with a representative soil profile based on a soil map at the scale of 1:50,000. Yields of winter wheat and silage maize were simulated under potential, water-limited and water-nitrogen-limited production conditions. Crop yields from soil and climate aggregation were evaluated separately.

Mean of crop yields of the region and over the simulation period were reasonably reproduced by most models regardless of input data resolution, either using aggregated soil or climate as input. However, larger aggregation effects were observed at higher temporal resolution (e.g. annual yields). Models revealed similar spatial patterns in yield. Being distinct for soil and climate aggregation, these patterns indicate a larger impact of soil aggregation on the spatial distribution of simulated crop yield for this region. Additionally, models differed considerably in their susceptibility to input data aggregation. The results reveal the importance of model ensemble assessments and the relevance of data aggregation when short simulation periods are considered.