Dear all,

I want to kick off a discussion on the extrapolation of observed and generation of hypothetical crop rotations. In a nutshell:

We want to turn from one-crop-covers-all simulations to the simulation of complete and realistic, however simplified, crop rotations, especially for the simulation of long-term soil organic matter dynamics over large areas. From IACS data sets we have long-term crop rotation information for some regions in Germany (2005-2020), from remote sensing we have complete coverage for some years (2017-2019). We have sets of agronomic rules that are currently incorporated in software products (e.g. ROTOR), and we have a fine-scale soil map with profile data (1:200.000) and 1km² weather data. The task would be to predict the following crop in a rotation, and to develop long-term sequences into the future (2100). While for a baseline we can just extrapolate observed patterns, an additional challenge comes with the target crop share may be different than the current one (output of economic models), so that gradual changes need to be implemented into the generated sequences (+ the introduction of new crops). The spatial crop patterns may also reveal regional peculiarities, e.g. clustering of certain crops around a processing plant.

This task serves a milestone publication in crop modelling, but could also feed into DAKIS as a side effect. Not clear yet who can do what, but this is to be found out.

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Dear all,

this is just an update to the data preparations for the crop rotation genesis activity

1) The Czech colleagues Monika and Vojtek are almost finished with the data set for the Czech Republic. We expect a 10m ASCII grid with time series for a reduced set of crop types (harmonized with the German crop type map from remote sensing) and individual references to soil profiles and weather data by Mid May

2) Clemens is currently producing a 5m ASCII grid for Germany with time series for the same set of crop types from IACS and EO sources. Matching this with the BÜK250 soil data and the 1km² weather data product is still to be done then. I hope that this will be available also by Mid May.

3) Tomorrow we will have an internal kick-off for the KlimErtrag project, in which will introduce Diana Seserman as new co-worker in this activity, and welcome Clemens Jänicke and Stefan Ernst to the team.

I have attached a tentative work program for the next months, for orientation. It may need adjustment as we are all also involved in other duties, but Diana and Clemens have only a limited time frame due to funding.

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Dear Masahiro, Dear Claas,

Background: It’s been a month-long journey since we last spoke about the crop rotation predictor applied to German data and I apologise for that. I kept on making progress in the hopes I will update you with graphs attached and then I experienced drawbacks and then progress and then some more drawbacks. But as a whole:

- I received from Clemens data from 7 federal states pertaining to crop choice per year from 2005 to 2020 and their respective weather (radiation, temperature, precipitation) and soil (soil type, elevation, slope) data amounting to 4.23 Mil. values x several variables (crop and soil) and 358k values x several variables (weather);

- The obvious thing I tried to do was to cluster observations given a “closeness” criterion. I spent 2 weeks trying to work with the raster R package, but we didn’t get along well J and so I returned to QGIS and intersected our observations with municipalities of Germany, i.e. a total of 11,302 municipalities / Gemeinde;

- From now on I had x and y coordinates intersected with GID (7,717 Gemeinde belonging to only 7 federal states) and CELLID (IDs given to weather and soil observations only);

- The variables in crop and weather are set as columns, so when reshaping (so that we have one variable against year), the data frame for crops has a size of 67.62 Mil. x 7 variables and the data frame for temperature (here the temperature was given as monthly values per year, i.e. 12 x 16, but I have extracted 3 variables per year, i.e. TempAvg, TempAprilMay, TempJuneJuly) has a size of 210.90 Mil. x 4 variables;

- As you can surely presume, my working data storage is not high enough to handle this, but Ehsan might be able to help by borrowing me his computer for a little while.

Questions: Still, I am looking for ways (and hence asking you as well for ideas and advice):

- To handle this amount of data as well as possible without losing information;

- To maybe change the requirements and / or the input size of the model Masahiro and I worked on a month ago so that my computer can cope with the calculations in a relatively timely fashion (<10h per run is what I would call perfect right now J).

Financial Variable: Of course, there is also the financial variable per year per crop, but its size is neglectable compared to what else we have. However, I would have a question: what is better to use, LCU/tonne, SLC/tonne, USD/tonne, or a price index?

Tasks: Regarding the tasks broadly envisioned by Claas in April I have the following updates:

Task 2: Extrapolate the simplified rotations for each field of the Czech Republic to a baseline 30-year time slice (1991-2020) (Masahiro & Stefan, May/June 2021) – I am waiting for an answer from CZ because the problems I presented above would be nothing compared to what came from CZ as a whole. Good news is still that once we handle the above-mentioned, we would be closer to checking this task off. May/June 2021 might become October/November 2021.

Task 4: Develop an algorithm that expands each crop rotation under consideration of climate and soil suitability, agronomic crop rotation rules and regional preference (e.g. processing chains, market opportunities) (Masahiro & Stefan S., June 2021) – Done, using data from Hohenheim, but it shall work the same for more locations.

Task 5: Develop an algorithm that alters crop rotations based on given crop share trends under consideration of climate and soil suitability, crop rotation rules, regional preference, allowing for scenarios with different future crop shares as produced by economic models. (Masahiro & Stefan S., Summer 2021) – If this refers to CZ data, see above at Task 2, else see Task 9. Summer 2021 might become October/November 2021.

Task 9: Repeat 1-6 for Germany based on available IACS data sets for some federal states and EO data sets for whole Germany (2017-2021) (Masahiro & Stefan, Summer 2021) – My E-mail refers to this Task, but with data from 2005 to 2020. Summer 2021 might still be achieved if we consider the autumn solstice on 22nd of September 2021 J.

Thank you in advance and I am looking forward to your opinions on this!

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**Research gap**

Large-area assessments of future agricultural ecosystem services and productivity are currently based on highly aggregated and uncertain input information and a range of rough assumptions. Economic simulations project future changes of crop shares, but how the change in production of these crops is distributed in space and how this translates into consistent crop rotations is unclear. This step is needed to assess the consequences of crop share changes in large-area simulations for future productivity and related agricultural ecosystem services.

Research questions

Given that we have a short snippet (~ five years) of which crop rotation is grown on each field across a large region, how can we

1. simplify each rotation to arrive at a portfolio of crops that can be simulated with an agroecosystem model,
2. extrapolate these rotations for each field to a baseline 30-year time slice (1991-2020) despite the current trends in the crop shares and
3. extrapolate these rotations for each field to any time in the future under a given target crop share, under consideration of climate and soil suitability, agronomic crop rotation rules and regional preferences

Objectives

1. Produce a 1991-2020 baseline for simplified crop rotations across an example region
2. Produce crop rotation expansions into the future that reflect scenarios of future crop shares
3. Simulate baseline and future crop yields and agroecosystem services across the example region using the developed crop rotations and the best high-resolution input data that is available

Tasks

1. Screen the crops that appear in the IACS data set of the Czech Republic (2015-2020), identify crops of minor importance and suggest substitutes (together with Czech agronomists) for which a well-tested parameter set is available (**Monika & Vojtek, Early May 2021**)
2. Extrapolate the simplified rotations for each field of the Czech Republic to a baseline 30-year time slice (1991-2020) (**Masahiro & Stefan, May/June 2021**)
3. Define a set of crop rotation rules for the Czech Republic (see ROTOR - Bachinger and Zander, and check with Czech agronomists) (**Diana, June 2021**)
4. Develop an algorithm that expands each crop rotation under consideration of climate and soil suitability, agronomic crop rotation rules and regional preference (e.g. processing chains, market opportunities) (**Masahiro & Stefan S., June 2021**)
5. Develop an algorithm that alters crop rotations based on given crop share trends under consideration of climate and soil suitability, crop rotation rules, regional preference, allowing for scenarios with different future crop shares as produced by economic models. (**Masahiro & Stefan S., Summer 2021**)
6. Produce a crop rotation for each field of the Czech Republic from 1991 to 2060 (2100) for GLOBIOM crop share scenarios (**Diana & Juliana, September 2021**)
7. Simulate crop yields for the eight most important crops in the Czech Republic for 2031-2060 and 2071-2100 at the resolution of 1ha using MONICA, future climate projections for the Czech Republic, and the developed crop rotations (**Diana, October 2021**)
8. Write a scientific article that presents these results: “Future yield projections for major crops in the Czech Republic based on spatially explicit crop rotations and economic scenarios” for Nature Climate Change (**Diana, Clemens & Claas, November 2021**)
9. Repeat 1-6 for Germany based on available IACS data sets for some federal states and EO data sets for whole Germany (2017-2021) (**Masahiro & Stefan, Summer 2021**)
10. Produce a map of irrigated fields for Germany (with Vienna University of Technology, Zappa/Schlaffer/Dourigo) as input into the simulations (**Gohar, September 2021**).
11. Test MONICA against field-scale yield data (yield maps) (**Clemens & Ehsan, October 2021**)
12. Create a set of future climate scenarios based on a weather generator (CzechGlobe, Martin Dubrovský) and compare the projections with the DWD future scenario products (**Ehsan & Martin, Mai – October 2021**)
13. Introduce a sowing and harvest date product for Germany if already available (**Gohar, December 2021**)
14. Simulate crop yields and soil organic matter trends for the eight most important crops in Germany for 2031-2060 and 2071-2100 at the resolution of 1ha using MONICA, future climate projections for Germany, and the developed crop rotations (**Diana, Clemens, Ehsan, January 2022**)
15. Write a scientific article that presents the simulations results: “Future trends for soil organic matter in agricultural soils across Germany” for Global Change Biology (**Diana, Clemens, Ehsan, February 2022**)
16. Write a scientific article that presents the results for the different climate projections: “A comparison of future climate scenarios for Germany generated by different methods” for Climate Research (**Ehsan & Martin, April 2022**)
17. Write a scientific article that presents simulations of irrigation water use: “Future trends of water demand for irrigation in Germany” for European Journal of Agronomy **(Claas, Ehsan & Gohar, April 2022)**