9 Agriculture (crop modelling)

9.1 Scenarios

Crop-model simulations should be provided as pure crop runs (i.e. assuming that each crop grows everywhere), so that future LU patterns can be applied in post-processing ensuring maximum flexibility. Simulations should be provided for the four major crops (wheat, maize, soy, and rice). For each crop there should be a full irrigation run (firr) and a no-irrigation run (noirr).

Those models that cannot simulate time varying management/human impacts/fertilizer input should keep these fixed at year 2005 levels throughout the simulations ("2005soc" scenario in Group 1 (dashed line in **Figure 1**) and "2005soc" scenario in Group 2). They only need to run the first preindustrial period of Experiment I (1661-1860). Group 3 runs only refer to models that are able to represent future changes in human management (varying crop varieties or fertilizer input).

To resolve potential double harvests within one year, crop yields should be reported per growing and not per calendar year. The unit of the time dimension of the NetCDF v4 output file is thus "growing seasons since YYYY-01-01 00:00:00". Cumulative growing season variables as, e.g., actual evapotranspiration or precipitation are to be accumulated over the growing season. The first season in the file (with value time=1) is then the first complete growing season of the time period provided by the input data without any assumed spin-up data, which equates to the growing season with the first planting after this date. To ensure that data can be matched to individual years in post-processing, it is essential to also provide the actual planting dates (as day of the year), actual planting years (year), anthesis dates (as day of the year), year of anthesis (year), maturity dates (day of the year), and year of maturity (year). This procedure is identical to the GGCMI convention (Elliott et al. 2015: The Global Gridded Crop Model intercomparison: data and modeling protocols for Phase 1).

Climate & CO_2 scenarios	
picontrol	Pre-industrial climate and 286ppm CO_2 concentration. The climate data for the entire period (1661-2299) are unique – no (or little) recycling of data has taken place.
historical	Historical climate and CO_2 concentration.
rcp26	Future climate and CO_2 concentration from RCP2.6.
rcp60	Future climate and CO_2 concentration from RCP6.0.
rcp85	Future climate and CO_2 concentration from RCP8.5.
2005co2	Fixed year 2005 levels of CO_2 at 378.81ppm.
Human influence & land-use scenarios	

1860soc	Pre-industrial levels of fertilizer input.
histsoc	Varying historical fertilizer input.
2005soc	Fixed year 2005 management
rcp26soc	Varying level of fertilizer input and varying varieties of the same crop associated with SSP2 and RCP2.6
rcp60soc	Varying level of fertilizer input and varying varieties of the same crop associated with SSP2 and RCP6.0
2100rcp26soc	Fertilizer input and varieties of the same crop fixed at year 2100.

Table 25 ISIMIP2b scenarios for global crop simulations. *Option 2 only if option 1 not possible. **If you can only run simulations with 2005soc, then it is sufficient 200 years worth of picontrol climate (1661-1860).

	Experiment	Input	Pre-industrial 1661-1860	Historical 1861-2005	Future 2006-2099	Extended future 2100-2299
I	no climate change, pre-industrial CO_2	Climate & CO_2	**picontrol**	**picontrol**	**picontrol**	**picontrol**
	varying management until 2005, then fixed at 2005 levels thereafter	Human & LU	Option 1*: **1860soc**	Option 1*: **histsoc**	**2005soc**	**2005soc**
			Option 2*: **2005soc**	Option 2*: **2005soc****	**2005soc****	**2005soc****
II	RCP2.6 climate & CO_2	Climate & CO_2	Experiment I	**historical**	**rcp26**	**rcp26**
	varying management until 2005, then fixed at 2005 levels thereafter	Human & LU		Option 1*: **histsoc**	**2005soc**	**2005soc**
				Option 2*: **2005soc**		
IIa	RCP2.6 climate, CO_2 after 2005 fixed at 2005 levels	Climate	Experiment I	Experiment II	**rcp26, 2005co2**	**rcp26, 2005co2**

	varying management until 2005, then fixed at 2005 levels thereafter	Human & LU			**2005soc**	**2005soc**
III	RCP6.0 climate & CO_2	Climate & CO_2	Experiment I	Experiment II	**rcp60**	not simulated
	varying management until 2005, then fixed at 2005 levels thereafter	Human & LU			**2005soc**	
IV	no climate change, pre-industrial CO_2	Climate & CO_2	Experiment I	Experiment I	**picontrol**	**picontrol**
	varying management up to 2100 (RCP2.6), then fixed at 2100 levels thereafter	Human & LU			**rcp26soc**	**2100rcp26soc**
V	no climate change, pre-industrial CO_2	Climate & CO_2	Experiment I	Experiment I	**picontrol**	not simulated
	varying management (RCP6.0)	Human & LU			**rcp60soc**	
VI	RCP2.6 climate & CO_2	Climate & CO_2	Experiment I	Experiment II	**rcp26**	**rcp26**
	varying management up to 2100 (RCP2.6), then fixed at 2100 levels thereafter	Human & LU			**rcp26soc**	**2100rcp26soc**
VII	RCP6.0 climate & CO_2	Climate & CO_2	Experiment I	Experiment II	**rcp60**	
	varying management (RCP6.0)	Human & LU			**rcp60soc**	
VIII	RCP8.5 climate & CO_2	Climate & CO_2	Experiment I	Experiment II	**rcp85**	not simulated
	management fixed at 2005 levels	Human & LU			**2005soc**	

9.2 Output data

Table 26 Variables to be reported by crop models

Variable (long name)	Variable name	Unit (NetCDF format)	Resolution	Comments
Key model outputs				
Crop yields	yield-<crop>-<irrigation setting>	dry matter (t ha-1 per growing season)	per growing season (0.5°x0.5°)	
Irrigation water withdrawal (assuming unlimited water supply)	pirrw-<crop>-<irrigation setting>	mm per growing season	per growing season (0.5°x0.5°)	*Irrigation water withdrawn in case of optimal irrigation (in addition to rainfall), assuming no losses in conveyance and application.*
Key diagnostic variables				
Actual evapotranspiration	aet-<crop>-<irrigation setting>	mm per growing season	per growing season (0.5°x0.5°)	portion of all water (including rain) that is evapo-transpired, the water amount should be accumulated over the entire growing period (**not** the calendar year)
Nitrogen application rate	initr-<crop>-<irrigation setting>	kg ha-1 per growing season	per growing season (0.5°x0.5°)	Total nitrogen application rate. If organic and inorganic amendments are applied, rate should be reported as inorganic nitrogen equivalent (ignoring residues).
Actual planting dates	plantday-<crop>-<irrigation setting>	Day of year	per growing season (0.5°x0.5°)	Julian dates
Actual planting year	plantyear-<crop>-<irrigation setting>	Year of planting	per growing season (0.5°x0.5°)	Attention: This is an additional output compared to the ISIMIP2a reporting. It allows for clear identification of planting that is also easy to follow for potential users from outside the project.

Anthesis dates	anthday-<crop>-<irrigation setting>	Day of year of anthesis	per growing season (0.5°x0.5°)	Attention: This has changed compared to the ISIMIP2a reporting where we asked for the "day from planting date". Together with the year of anthesis added to the list of outputs (see below) it allows for clear identification of anthesis that is also easy to follow for potential users from outside the project.
Year of anthesis	anthyear-<crop>-<irrigation setting>	year of anthesis	per growing season (0.5°x0.5°)	Attention: This is an additional output compared to the ISIMIP2a reporting. It allows for clear identification of anthesis that is also easy to follow for potential users from outside the project.
Maturity dates	matyday-<crop>-<irrigation setting>	Day of year of maturity	per growing season (0.5°x0.5°)	Attention: This has changed compared to the ISIMIP2a reporting where we asked for the "day from planting date". Together with the year of maturity added to the list of outputs (see below) it allows for clear identification of maturity that is also easy to follow for potential users from outside the project.
Year of maturity	matyyear-<crop>-<irrigation setting>	year of maturity	per growing season (0.5°x0.5°)	Attention: This is an additional output compared to the ISIMIP2a reporting. It allows for clear identification of maturity that is also easy to follow for potential users from outside the project.
Additional output variables (optional)				
Biomass yields	biom-<crop>-<irrigation setting>	Dry matter (t ha-1 per growing season)	per growing season (0.5°x0.5°)	
Soil carbon emissions	sco2-<crop>-<irrigation setting>	kg C ha-1	per growing season (0.5°x0.5°)	Ideally should be modeled with realistic land-use history and initial carbon pools. Subject to extra study.
Nitrous oxide emissions	sn2o-<crop>-<irrigation setting>	kg N2O-N ha-1	per growing season (0.5°x0.5°)	Ideally should be modeled with realistic land-use history and initial carbon pools. Subject to extra study.

Total N uptake (total growing season sum)	tnup-<crop>-<irrigation setting>	kg ha -1 yr -1	monthly (0.5°x0.5°)	Nitrogen balance: uptake
Total N inputs (total growing season sum)	tnin-<crop>-<irrigation setting>	kg ha -1 yr -1	monthly (0.5°x0.5°)	Nitrogen balance: inputs
Total N losses (total growing season sum)	tnloss-<crop>-<irrigation setting>	kg ha -1 yr -1	monthly (0.5°x0.5°)	Nitrogen balance: losses