

10 Global crop simulations

10.1 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 GGCM1 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
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.

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		
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		
Ila	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	

10.2 Output data

Table 26 Variables to be reported by crop models

Variable	Variable name	Resolution	Unit	Comments
Key model outputs				
Crop yields	yield_<crop>	annual (0.5°x0.5°)	dry matter (t ha ⁻¹ yr ⁻¹)	
Irrigation water withdrawal (assuming unlimited water supply)	pirrww_<crop>	annual (0.5°x0.5°)	mm yr ⁻¹	<i>Irrigation water withdrawn in case of optimal irrigation (in addition to rainfall), assuming no losses in conveyance and application.</i>
Key diagnostic variables				

Actual evapotranspiration	aet_<crop>	annual (0.5°x0.5°)	mm yr ⁻¹	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>	annual (0.5°x0.5°)	kg ha ⁻¹ yr ⁻¹	Total nitrogen application rate. If organic and inorganic amendments are applied, rate should be reported as inorganic nitrogen equivalent (ignoring residues).
Actual planting dates	plant-day_<crop>	annual (0.5°x0.5°)	Day of year	Julian dates
Actual planting year	plant-year_<crop>	annual (0.5°x0.5°)	Year of planting	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	anth-day_<crop>	annual (0.5°x0.5°)	Day of year of anthesis	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	anth-year_<crop>	annual (0.5°x0.5°)	year of anthesis	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	maty-day_<crop>	annual (0.5°x0.5°)	Day of year of maturity	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	maty-year_<crop>	annual (0.5°x0.5°)	year of maturity	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>	annual (0.5°x0.5°)	Dry matter (t ha ⁻¹ yr ⁻¹)	
Soil carbon emissions	sco2_<crop>	annual (0.5°x0.5°)	kg C ha ⁻¹	Ideally should be modeled with realistic land-use history and initial carbon pools. Subject to extra study.
Nitrous oxide emissions	sn2o_<crop>	annual (0.5°x0.5°)	kg N ₂ O-N ha ⁻¹	Ideally should be modeled with realistic land-use history and initial carbon pools. Subject to extra study.