

11 Agriculture (crop modelling)

This section lays out the global output protocol for the agricultural sector’s contribution to ISIMIP. For further details, please contact AgMIP (ag-grid@agmip.org) and ISIMIP (info@isimip.org).

Note that the variable names are chosen to comply with AgMIP conventions, or are harmonized with the conventions used in the ISIMIP water sector (for irrigation water). They are given in lower-case letters only in order to prevent the use of mixed-case names in the file names (see 6.2.1). **Table 30** provides an overview of all experiments to be run in the agriculture (crop modelling) sector in ISIMIP2a. This table is for your reference only; please read chapters 1-5 and this section carefully before beginning with the experiments.

Table 30 Experiment summary for crop models

	Climate Data	Scenario	Management settings	Land use (LU)	Other settings (sens-scenario)	irrigation	# runs
Historical runs	PGMFD v.2 (Princeton)	hist	default (present day) (default)	pure crop run (no LU specifier)	historical CO2 (no co2 specifier)	firr noirr	2
	GSWP3	hist	default (present day) (default)	pure crop run (no LU specifier)	historical CO2 (no co2 specifier)	firr noirr	2
	WATCH (WFD)	hist	default (present day) (default)	pure crop run (no LU specifier)	historical CO2 (no co2 specifier)	firr noirr	2
	WATCH + WFDEI.GPCC	hist	default (present day) (default) fully harmonized (fullharm) harmonized season, no N constraints (harmnon)	pure crop run (no LU specifier)	historical CO2 (no co2 specifier)	firr noirr	6
							12 (per crop)

11.1 Sector-specific input

Some GCMs require inputs on planting dates, crop variety parameters, fertilizer use and possibly other management specifics. While the agreement for the fast-track was to use each model's setting that best represents current management patterns, we'll have specific inputs on planting dates and maturity dates (to allow for spatially-explicit variety parameterization) as well as fertilizer use (N, P, K). Some experiments will be run with harmonized input data (validation and attribution studies), some with default model settings.

Table 31 Crop-model-specific input data

Variable	Source*	Units	Notes
Planting dates	Sacks-2010, Portmann-2010, and environmental-based	Julian days (Jan 1st= 1,...)	Planting dates for primary seasons.
Approximate maturity	Sacks-2010, Portmann-2010, and environmental-based	Days from sowing	Growing season length in days.
Fertilizers and manure	Mueller-2012, Potter-2011, Liu-2010, and Foley-2010	kg ha ⁻¹ yr ⁻¹	Average nitrogen, phosphorus, and potassium application rates in each grid cell, with organic and inorganic amendments aggregated and converted to an "effective inorganic application rate".
Historical [CO₂]	Mauna Loa/RCP historical	ppm	Annual [CO ₂] values from 1900-2013.

11.2 Output data and definitions

Table 32 Crop-model-specific definitions

Definition of time variable	Protocol choice	“growing seasons since YYYY-01-01”	YYYY is just the first year in the file. For a run 1958-2001, YYYY=1958. Values of time are independent of how to map growing season to calendar.
Season Definition	Protocol choice	Definition	AET and PirrWW defined as accumulated over the growing season, not over the calendar year.
Automatic irrigation	Guidance for parameter choices	Definition	Management depth = 40cm / Efficiency = 100% Upper/Lower event trigger threshold = 90/100% Max single AND annual volume = Unlimited
Automatic planting	Guidance for parameters choices	Definition	Min/max soil water at planting (40 cm) = 40/100% Min/max soil temp at planting (10 cm) = 10/40 C

Crop Priority list:

1. Wheat¹¹, maize, soy, rice [whe, mai, soy, ric]
2. All others: Sugarcane, sorghum, millet, rapeseed, sugar beet, barley, rye, oat [sug, sor, mil, rap, sgb, bar, rye, and oat] + managed grass [mgr]¹², field peas [pea], cassava [cas], sunflower [sun], groundnuts [nut], bean [ben], potato [pot], ...
3. Crop rotation

Note that the key diagnostic variables need only be provided for the minimal setting runs.

¹¹ There will be no distinction between winter and spring wheat.

¹² We have decided to include only managed grassland productivity in the fast-track comparison.

Table 33 Output variables for crop models

Variable	Variable name	Resolution	Unit	Comments
Key model outputs				
Crop yields	yield_<crop>	annual (0.5°x0.5°)	dry matter t/ha/yr (t ha ⁻¹ yr ⁻¹)	Crop-specific
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 effective inorganic nitrogen input (ignoring residues).
Actual planting dates	plant-day_<crop>	annual (0.5°x0.5°)	Day of year	
Anthesis dates	anth-day_<crop>	annual (0.5°x0.5°)	Days from planting date	
Maturity dates	maty-day_<crop>	annual (0.5°x0.5°)	Days from planting date	
Additional output variables (optional)				

Biomass yields	biom_<crop>	annual (0.5°x0.5°)	Dry matter t/ha/yr (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 N2O-N ha-1	Ideally should be modeled with realistic land-use history and initial carbon pools. Subject to extra study.

11.3 Experiments

11.3.1 Historic runs and validation experiment

Specification of the historical run

Simulations for the historical period should be provided as pure crop runs (i.e. assuming the crop growing all over the world), based on the climate input described in section 4.1. For each crop there should be a full irrigation run (firr) and a no-irrigation run (noirr), as already specified for the Fast Track. In contrast to the Fast Track simulations, however, within ISIMIP2 we ask for historical runs with three different degrees of harmonization as given in **Table 34**.

Table 34: Scenario settings for crop model simulations

Simulation	Comments
Default	Model should use their individual “best representation” of the historical period with regard to sowing dates, harvesting dates, fertilizer application rates and crop varieties.
fully harmonized	Simulations based on prescribed “present day” fertilization rates (available for download) and fixed planting and harvesting dates (also available for download). Modelers should have planting as closely as possible to these dates, but it may be admissible to use these dates as indicators for planting windows (depending on model

	specifics).
Harmonized seasons with no N constraints	<p>For models with an explicit description of the nitrogen cycle: Harmonized simulations should be run with nitrogen stress turned off completely or (if that's not possible) with very high N application rates to make model results comparable between those GCMs that have explicit N dynamics and those that do not.</p> <p>For models without the nitrogen cycle: harmonized and fullharm simulations are the same and do not need to be duplicated.</p>

Each of these three variants should be combined with a no-irrigation and full irrigation assumption, resulting (for the models with an explicit representation of the nitrogen cycle) in 6 runs for the respective climate input data set (cf. **Table 30**).

Specification of the validation procedure

For the validation task the pure crop simulations should

- 1) be masked by the following LU patterns: "Dynamic MIRCA" (reconstruction of historical LU based on HYDE and MIRCA2000, see section 4.1.3.
- 2) averaging and aggregation will be performed in the post-processing and depending on what data we compare to. It could include de-trending (to compare with possibly de-trended observations).

11.3.2 Fast track runs for new models

Please consult the fast track protocol Section 7 for those runs and related information. It is available at www.ISIMIP.org/ under ISIMIP Fast Track -> Simulation Protocol. In case of any questions please contact Info@isimip.org. Please note that aside from harmonized climate and socio-economic input the default settings of your model should be used. Also note that for output data files the file name (as specified in Section 5.2 of the fast track protocol) everything is lower case!