ISIMIP2b Simulation Protocol

Published on 31 January 2021

The simulation protocol describes the simulation scenarios, input data sets and output variables necessary to participate in the ISIMIP2b simulation round. The scientific rationale and more detailed information about the pre-processing of input data can be found in the accompanying description paper Frieler et al. 2017 *Assessing the impacts of 1.5°C global warming – simulation protocol of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b)*, Geoscientific Model Development. 10, 4321–4345 doi.org/10.5194/gmd-10-4321-2017.

Contents

1 Scenario design

The simulation scenarios are divided into three groups, depicted in **Figure 1** and **Figure 2**, directed at addressing distinct scientific questions:

- Quantification of pure climate-change effects of the historical warming compared to pre-industrial reference levels (Group 1).
- Future impact projections accounting for low (RCP2.6) and high (RCP6.0) greenhouse gas emissions assuming present day socio-economic conditions (Group 2).
- Future impact projections accounting for low (RCP2.6) and high (RCP6.0) greenhouse gas emissions assuming dynamic future socio-economic conditions according to SSP2 (Group 3).

In the sector-specific sections below, we provide a more detailed description of the sector-specific simulations. The grey, red, and blue background colours of the different entries in the tables there indicate Group 1, 2, 3 runs, respectively. Runs marked in violet represent additional sector-specific sensitivity experiments. Each simulation run has a name (Experiment I to VII) that is consistent across sectors, i.e. runs from the individual experiments could be combined for a consistent cross-sectoral analysis. Since human influences represented in individual sectors may depend on the RCPs (such as land-use changes), while human influences relevant for other sectors may only depend on the SSP, the number of experiments differs from sector to sector.

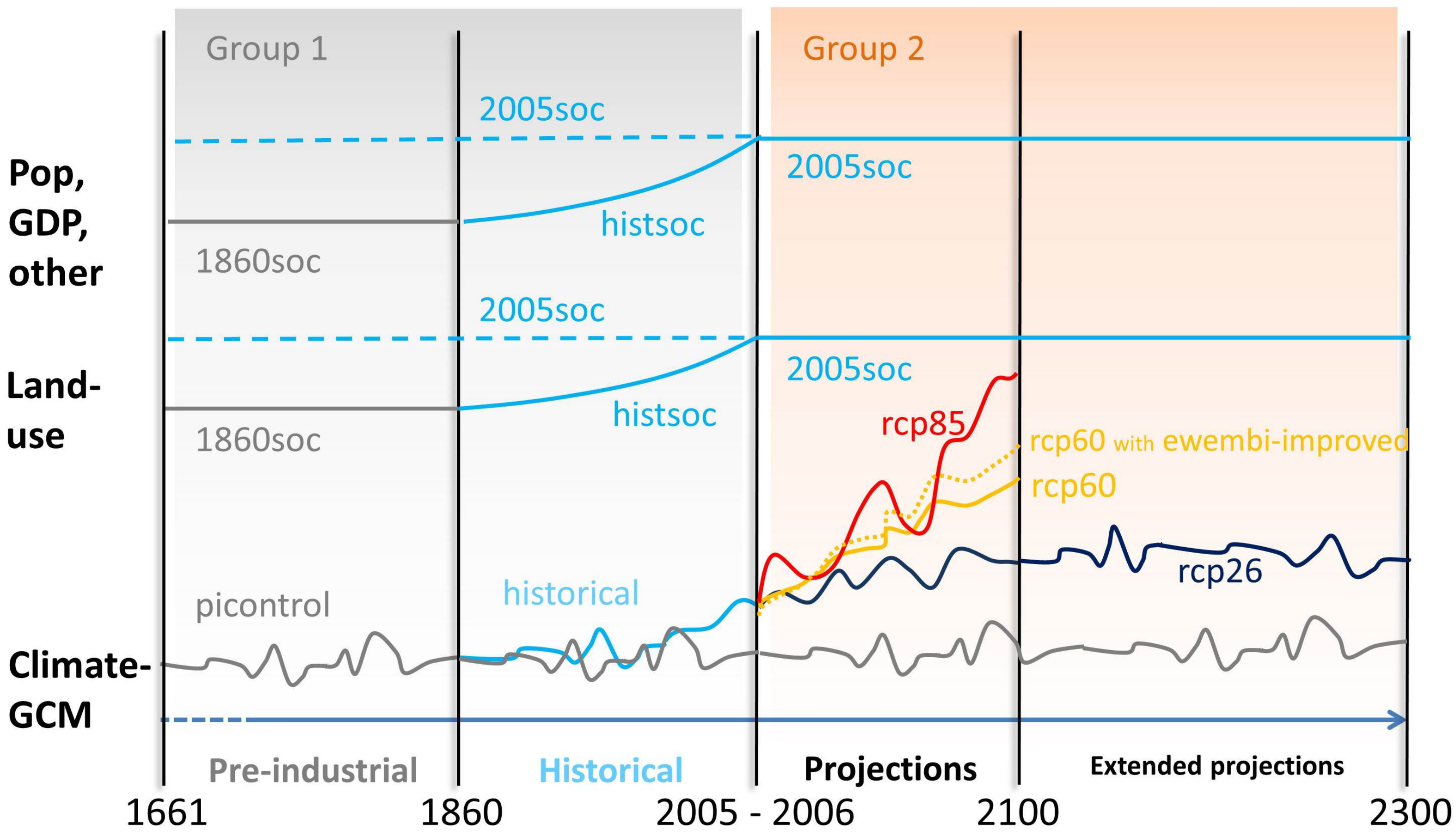

Figure 1 Schematic representation of the scenario design for ISIMIP2b **Group 1** and **Group 2** runs. “Other” includes other non-climatic anthropogenic forcing factors and management, such as irrigation, fertilizer input, selection of crop varieties, flood protection levels, dams and reservoirs, water abstraction for human use, fishing effort, atmospheric nitrogen deposition, etc. **Group 1** consists of model runs to separate the pure effect of the historical climate change from other human influences. Models that cannot account for changes in a particular forcing factor are asked to hold that forcing factor at 2005 levels (2005soc, dashed lines). **Group 2** consists of model runs to estimate the pure effect of the future climate change assuming fixed year 2005 levels of population, economic development, land use and management (2005soc). The yellow dashed line represents an optional sensitivity run with RCP6.0 climate forcing using statistical downscaling and improved bias-correction (ewembi-isimip3basd). This run, as well as the RCP8.5 run (red line) were introduced in February 2019.

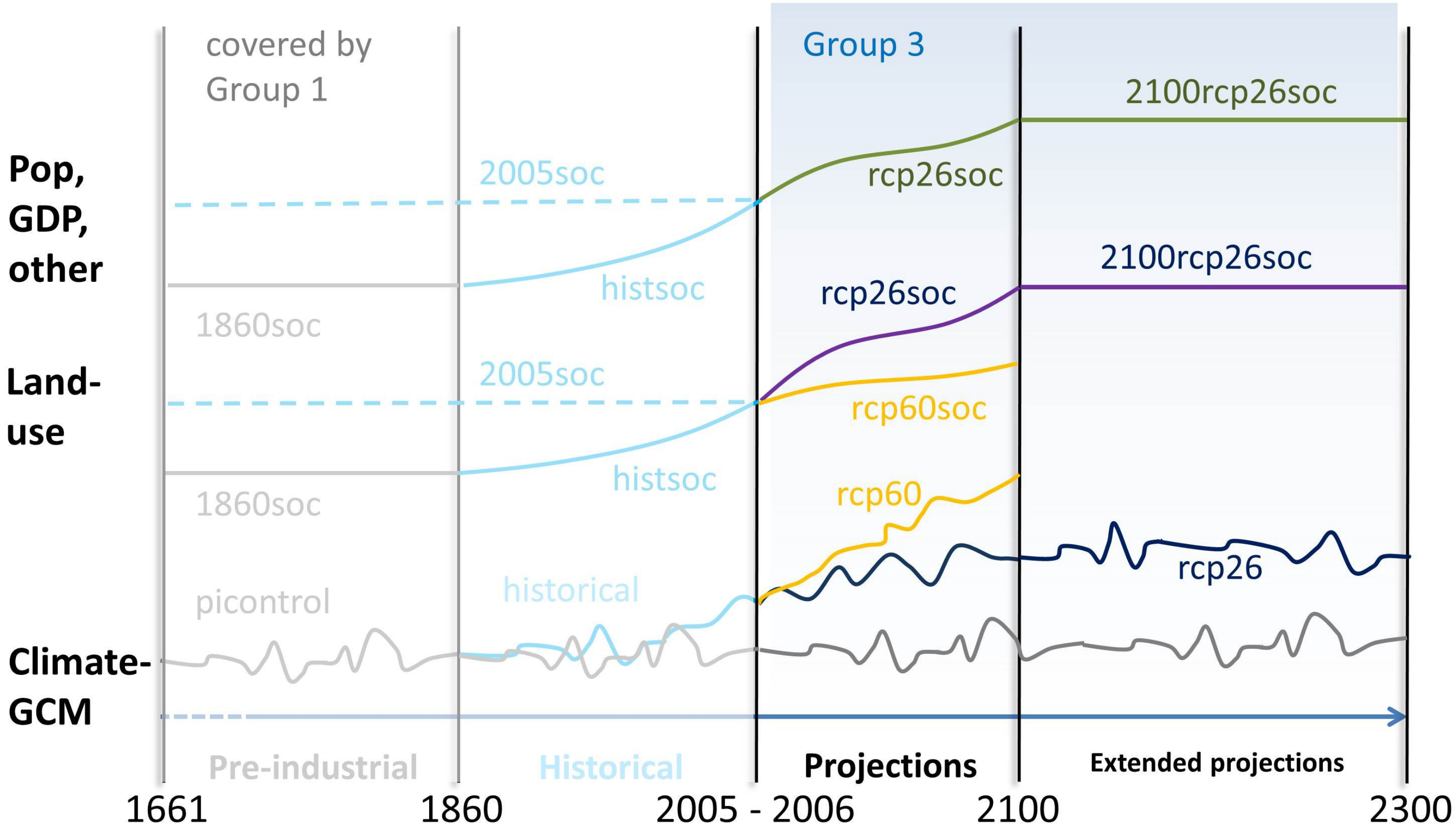

Figure 2 Schematic representation of the scenario design for **Group 3** runs. Group 3 consists of model runs to quantify the effects of the land use changes, and changes in population, GDP, and management from 2005 onwards associated with RCP6.0 (no mitigation scenario under SSP2) and RCP2.6 (strong mitigation scenario under SSP2). Forcing factors for which no future scenarios exist (e.g. dams/reservoirs) are held constant after 2005.

2 Input data

- Information about how to access ISIMIP Input Data can be found here: https://www.isimip.org/gettingstarted/data-access/
- A full list of ISIMIP input-data sets can be found here: http://www.isimip.org/gettingstarted/input-data-bias-correction

2.1 Climate input data

- Bias-corrected to the EWEMBI data set at daily temporal and 0.5° horizontal resolution using an updated version of the Fast-Track methods. The updated method was applied to climate model output data that was first spatially interpolated to 0.5° spatial resolution. This method is described in Frieler et al. (2017, doi:10.5194/gmd-10-4321-2017, section 3). For some locations, additional climate input data is available where climate model data was bias-corrected to local weather station data (see sector-specific chapters).
- Daily time step, 0.5° horizontal resolution
- Pre-industrial (1661-1860), historical (1861-2005) and future (RCP2.6, RCP6.0 and RCP8.5) conditions provided based on CMIP5 output of GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR and MIROC5. Output from two GCMs (GFDL-ESM2M and IPSL-CM5A-LR) includes the physical and biogeochemical ocean data required by the marine ecosystem sector of ISIMIP (see FISH-MIP, https://www.isimip.org/gettingstarted/marine-ecosystems-fisheries/).
- For some GCMs, it was necessary to recycle pre-industrial control climate data in order to fill the entire 1661-2299 period (for more information see, Frieler et al. 2017).
- Priorization of climate models (from highest to lowest):
    1. IPSL-CM5A-LR
    2. GFDL-ESM2M
    3. MIROC5
    4. HadGEM2-ES
- For the lakes sector, bias-corrected meteorological forcing data is available on the DKRZ input data repository. At the global scale, at /work/bb0820/ISIMIP/ISIMIP2b/InputData/OBS_atmosphere/global/EWEMBI/historical, and at the local scale, at /work/bb0820/ISIMIP/ISIMIP2b/InputData/OBS_atmosphere/local_lakes/EWEMBI/historical.
- For the water sector, at the regional scale, we also provide bias-corrected meteorological forcing data on our DKRZ input data repository, at /work/bb0820/ISIMIP/ISIMIP2b/InputData/OBS_atmosphere/regional_water/EWEMBI/historical.

Table 1 Bias-corrected climate variables.

Variable	Short name	Unit
Near-Surface Relative Humidity	hurs	%
Near-Surface Specific Humidity	huss	kg kg^{-1}

Precipitation (rainfall + snowfall)	pr	kg m^{-2} s^{-1}
Snowfall Flux	prsn	kg m^{-2} s^{-1}
Surface Air Air Pressure	ps	Pa
Sea-level Pressure	psl	Pa
Surface Downwelling Longwave Radiation	rlds	W m^{-2}
Surface Downwelling Shortwave Radiation	rsds	W m^{-2}
Near-Surface Wind Speed	sfcWind	m s^{-1}
Near-Surface Air Temperature	tas	K
Daily Maximum Near-Surface Air Temperature	tasmax	K
Daily Minimum Near-Surface Air Temperature	tasmin	K

Table 2 Variables provided without bias correction.

Variable	Short name	Unit	Temporal resolution
Ocean variables (for marine ecosystems & fisheries sector)			
Sea Water X Velocity	uo	m s^{-1}	monthly
Sea Water Y Velocity	vo	m s^{-1}	monthly
Sea Water Z Velocity	wo	m s^{-1}	monthly
Sea Water Temperature	to	K	monthly
Dissolved Oxygen Concentration	o2	mol m^{-3}	monthly
Total Primary Organic Carbon Production (by all types of phytoplankton) [calculated as sum of lpp + spp (IPSL) or sum of lpp + spp + dpp (GFDL)]	intpp	mol C m^{-2} s^{-1}	monthly
Small Phytoplankton Productivity	spp	mol C m^{-3} s^{-1}	monthly
Large Phytoplankton Productivity	lpp	mol C m^{-3} s^{-1}	monthly
Diazotroph Primary Productivity	dpp	mol C m^{-3} s^{-1}	monthly
Total Phytoplankton Carbon Concentration [sum of lphy + sphy (IPSL) or lphy + sphy + dphy (GFDL)]	phy	mol C m^{-3}	monthly
Small Phytoplankton Carbon Concentration	sphy	mol C m^{-3}	monthly
Large Phytoplankton Carbon Concentration	lphy	mol C m^{-3}	monthly

Diazotroph Carbon Concentration	dphy [diaz]	mol C m^{-3}	monthly
Total Zooplankton Carbon Concentration [sum of lzoo + szoo]	zooc	mol C m^{-3}	monthly
Small Zooplankton Carbon Concentration	szoo	mol C m^{-3}	monthly
Large Zooplankton Carbon Concentration	lzoo	mol C m^{-3}	monthly
pH	ph	1	monthly
Sea Water Salinity	so	psu	monthly
Sea Ice Fraction	sic	%	monthly
Large size-class particulate organic carbon pool	goc	mmol C m^{-3}	monthly
Photosynthetically-active radiation	Par	Einstein m^{-2} day^{-1}	monthly
Ocean variables (for tropical cyclones)			
Depth-resolved monthly mean Sea Water Potential Temperature	thetao	K	monthly
Sea Surface Temperature	tos	K	monthly
Atmospheric variables (for tropical cyclones)			
Air Temperature at all atmospheric model levels	ta	K	monthly
Specific Humidity at all atmospheric model levels	hus	kg kg^{-1}	monthly
Eastward Wind at 250 and 850 hPa levels	ua	m s^{-1}	daily
Northward Wind at 250 and 850 hPa levels	va	m s^{-1}	daily
Atmospheric variables (for coastal systems)			
Sea Level Pressure	psl	Pa	3-hourly
Eastward Near-Surface Wind	uas	m s^{-1}	3-hourly
Northward Near-Surface Wind	vas	m s^{-1}	3-hourly

2.2 Ocean input data

We provide global ocean data (see **Table 2**) that has been provided by the ocean models CESM1-BEC, GFDL-ESM2M and IPSL-CM5A-LR, on our DKRZ input data repository, at /work/bb0820/ISIMIP/ISIMIP2b/InputData/ocean. **IMPORTANT:** These data are situated on a different grid than most of the other ISIMIP data. The ocean grids have a resolution of 1° instead of 0.5°, and the western boundary is located at the 0° meridian.

On top of these global data sets we also provide data for focus regions, see **Table 7** and **Figure 6**. Most of these data come from IPSL-CM5A-LR (med-nw is also provided by GFDL-ESM2M).

The data are provided on different vertical layers. Files containing "_zall_" give data for all ocean layers, "_zb_" resp. "_zs_" give the bottom resp. the surface layer, and "_zint_" integrates the data over the whole ocean column.

2.3 Land-use patterns

The following land-use data are provided and described in detail in **Table 4**:

- Historical land-use (LU) changes from the HYDE3.2 data (Klein Goldewijk et al., 2017) (see **Figure 3**). Three, consistently generated disaggregation levels are provided:
    - Rainfed crop land, irrigated crop land, pastures and total crop land (the sum of rainfed and irrigated) – filename includes "landuse-totals";
    - As above, with crop land divided into 5 functional crop types (LUH2) – filename includes "landuse-5crops";
    - As above, with crop land divided into 15 individual crops or crop groups (based on (Monfreda et al., 2008)) – filename includes "landuse-15crops";
- Transient, future LU patterns generated by the LU model MAgPIE (Popp et al., 2014; Stevanović et al., 2016), assuming population growth and economic development as described in SSP2, for climate-change scenarios using RCP2.6 and RCP6.0 (see **Figure 3**). These scenarios should be referred to as "landuse_ISIMIP2b_ssp2_rcp26" and "landuse_ISIMIP2b_ssp2_rcp60" respectively. Note that while these data sets cover the period 2006-2100, the period 2006-2014 are taken from historical data.

The transition from historical to future LU patterns requires a harmonisation between the land-use classes and areas between the different data sets.

Table 3 Agricultural land-use categories

Land-use type	Historical reconstruction	Future projections	Disaggregation into functional crop types (LUH2)	Individual crops or crop groups
Irrigated crops	HYDE	MAgPIE	Total cropland disaggregated into: C_3 annual, C_3 nitrogen-fixing, C_3 perennial, C_4 annual, C_4 perennial (contains only sugarcane)	C_3 annual disaggregated into: rapeseed, rice, temperate cereals, temperate roots, tropical roots, sunflower, others C_3 annual C_3 perennial: (no further disaggregation) C_3 nitrogen-fixing disaggregated into: groundnut, pulses, soybean, others C_3 nitrogen-fixing C_4 annual disaggregated into: maize, tropical cereals C_4 perennial: sugarcane
Rainfed crops	HYDE	MAgPIE	Total cropland disaggregated into:	C_3 annual disaggregated into: rapeseed, rice,

			C_3 annual, C_3 nitrogen-fixing, C_3 perennial, C_4 annual, C_4 perennial (contains only sugarcane)	temperate cereals, temperate roots, tropical roots, sunflower, others C_3 annual C_3 perennial: (no further disaggregation) C3 nitrogen-fixing disaggregated into: groundnut, pulses, soybean, others C_3 nitrogen-fixing C_4 annual disaggregated into: maize, tropical cereals C_4 perennial: sugarcane
Pastures	HYDE	MAgPIE	Total pastures are provided.	In addition, pastures are split into managed pastures and (natural) rangelands
Bioenergy production (rainfed grass)	-	MAgPIE		e.g., miscanthus (if you use a different bioenergy crop, please indicate this in the model description)
Bioenergy production (rainfed trees)	-	MAgPIE		e.g., poplar (temperate), eucalyptus (tropical) (if you use a different bioenergy crop, please indicate this in the model description)
Urban	HYDE	constant (HYDE)		
Other (natural vegetation etc.)	1 - everything else	1 - everything else	The LUH2 data set includes additional natural land classes, which are consistent with the historical LU data provided here, and could be provided upon request.	(to be specified)

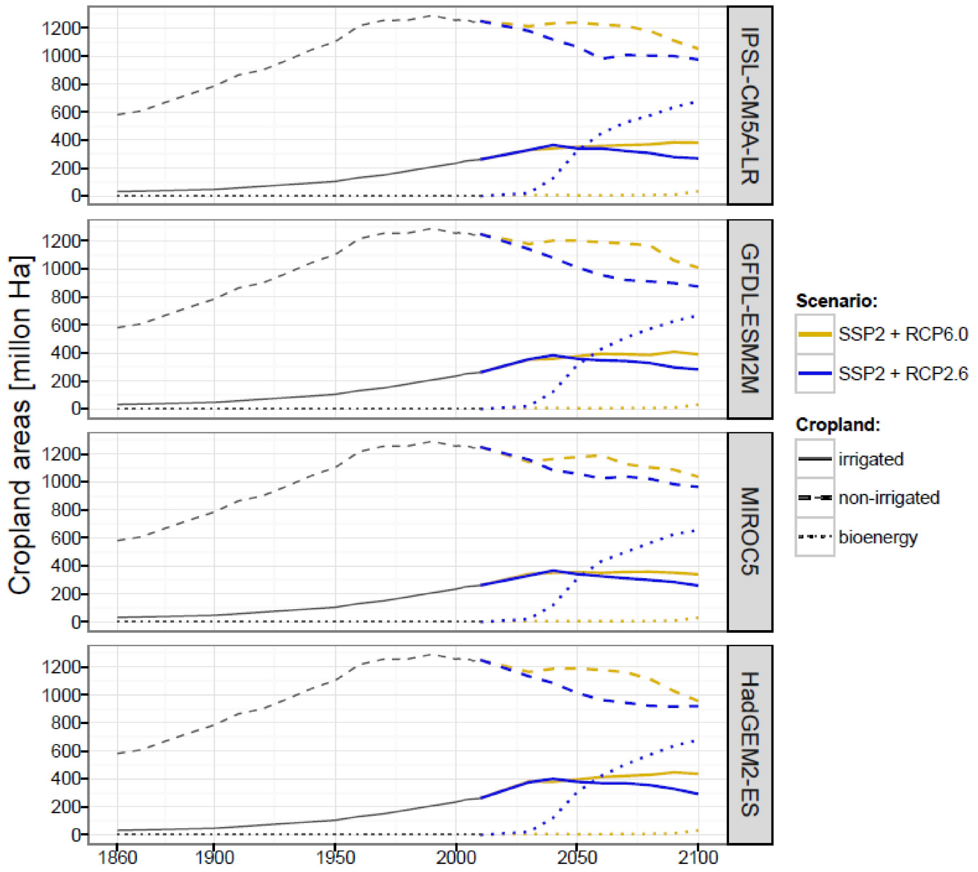

Figure 3 Time series of total crop land (irrigated (solid lines) and non-irrigated (dashed lines)) as reconstructed for the historical period (1860 - 2015) based on HYDE3.2 (Klein Goldewijk et al., 2017) and projected under SSP2 (2016-2100) assuming no explicit mitigation of greenhouse gas emissions (RCP6.0, yellow line) and strong mitigation (RCP2.6, dark blue line) as suggested by MAgPIE. Future projections also include land areas for second generation bioenergy production (not included in “total crop land”) for the demand generated from the Integrated Assessment Modelling Framework REMIND/MAgPIE, as implemented in the SSP exercise (dotted lines). Global data were linearly interpolated between the historical data set and the projections.

2.4 Sea-level rise patterns

Table 4 Information on sea-level-rise data.

Driver	Historical reconstruction	Future projections	Long-term projections
Sea-level rise	Observed time series up to 2000	From 2000 onwards, spatial patterns derived from GCMs. Regional variation of sea-level rise from glaciers and the large ice sheets are scaled from their respective gravitational patterns.	Constrained extrapolations have been extended to 2299.

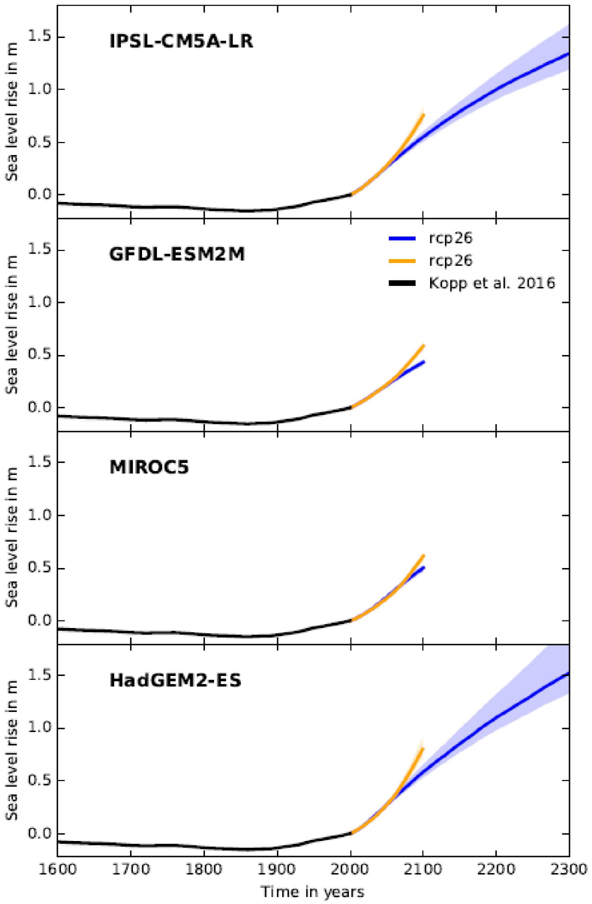

Figure 4 Time series of global total sea-level rise based on observations (Kopp et al., 2016, black line) until year 2000 and global-mean-temperature change from IPSL-CM5A-LR (panel 1), GFDL-ESM2M (panel 2), MIROC5 (panel 3) and HadGEM2-ES (panel 4) after year 2000: solid lines: Median projections, shaded areas: uncertainty range between the 5th and 95th percentile of the uncertainty distribution associated with the ice components. Blue: RCP2.6, yellow: RCP6.0. All timeseries relative to year 2000. Non-climate-driven contribution from glaciers and land water storage are added to the projections.

2.5 Population patterns and economic output (Gross Domestic Product, GDP)

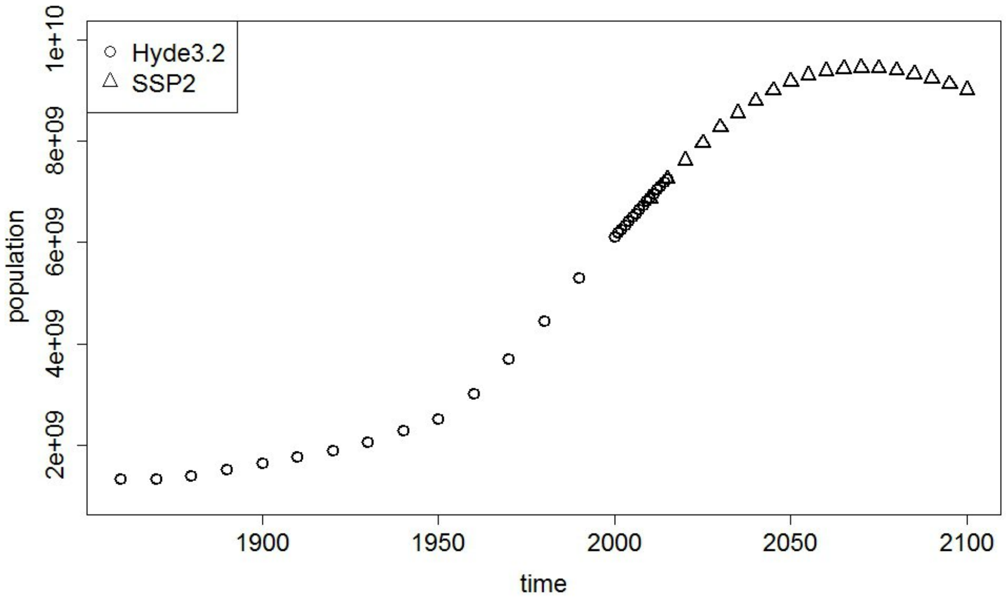

Figure 5 Time series of global population for the historical period (dots) and future projections following the SSP2 storyline (triangles).

Table 5 Socio-economic input data corresponding to SSP2.

Driver	Historical reconstruction	Future projections
GDP	• Annual country-level data derived from the Maddison project (Bolt and van Zanden, 2014, http://www.ggdc.net/maddison/maddison-project/home.htm) and extended by Penn World Tables 9.0 and World Development Indicators (1861-2005). • Annual data on 0.5° grid corresponding to SSP2 (1861-2005).	• Annual country-level data based on OECD projections from the SSP database (Dellink et al., 2015, https://secure.iiasa.ac.at/web-apps/ene/SspDb/) corresponding to SSP2 (2006-2299). • Annual data on 0.5° grid based on downscaling of country-level data (Murakami and Yamagata, 2016) (2006-2299).
Population	• Annual data on a 0.5° and 5'grid based on the HYDE3.2 database (Klein Goldewijk et al., 2017) (1861-2005). • Annual country-level, age-specific population data based on the HYDE3.2 database (Klein Goldewijk et al., 2017) (1861-2005).	• Annual data on a 0.5° grid based on the national SSP2 population projections as described in Samir and Lutz, (2014) (2006-2299). • Annual country-level, age-specific data in 5-year age groups and all-age mortality rates in 5-year time (2006-2299). Also includes rural/urban division.

2.6 Other human influences

For all of these input variables, we describe reconstructions to be used for the historical **histsoc** simulations (see **Table 6**). For models that do not allow for time-varying human influences across the historical period, human influences should be fixed at present-day (**2005soc**) levels (see dashed line in **Figure 1**, Group 1). Beyond 2005 all human influences should be held constant (Group 2) or varied according to SSP2 if associated projections are available (**Figure 2**, Group 3). As ISIMIP2b Group 3 only considers SSP2 and no other socio-economic storylines, the SSP scenario is not explicitly mentioned in the file names, although the changes in land-use patterns, etc. certainly not only depend on the RCP (due to the accounting for associated climate impacts of, e.g., crop yields), but also on the SSP. Within ISIMIP2b projections are provided for future irrigation-water extraction, fertilizer application rates and nitrogen deposition (see **Table 6**).¶

Table 6 Data sets representing "other human influences" for the historical simulations (**histsoc**, Group 1) and the future projections accounting for changes in socio-economic drivers (**rcp26soc**/**rcp60soc**, Group 3).

Driver	Historical reconstruction	Future projections
Reservoirs & dams • **location** • **upstream area** • **capacity** • **construction/commissioning year**	Global data on 0.5° grid based on GranD database and the DDm30 routing network. Documentation: http://www.gwsp.org/products/grand-database.html **Note**: Simple interpolation can result in inconsistencies between the GranD database and the DDM30 routing network (wrong upstream area due to misaligned dam/reservoir location). A file is provided with locations of all larger dams/reservoirs adapted to DDM30 so as to best match reported upstream areas.	No future data sets are provided. Held fixed at year 2005 levels in all simulations.
Water abstraction for domestic and industrial uses	Generated by each modelling group individually (e.g., following the varsoc scenario in ISIMIP2a). For modelling groups that do not have their own representation, we provide files containing the multi-model mean domestic and industrial water withdrawal and consumption generated from the ISIMIP2a varsoc runs of WaterGAP, PCR-GLOBWB, and H08. This data is available from 1901 until 2005.	Generated by each modelling group individually. For modelling groups that do not have their own representation, we provide files containing the multi-model mean (from the global water models WaterGAP, PCRGLOBWB, and H08) domestic and industrial water withdrawal and consumption under SSP2 from the Water Futures and Solutions (WFaS) (Wada et al., 2016) project. This data is available from 2006 until 2050. The values should be kept constant from 2050 onwards.

		The data provided for rcp26soc and rcp60soc are identical and both are taken from simulations based on RCP6.0. The combination SSP2–RCP2.6 was not considered in WFaS; the difference is expected to be small since the choice of RCP only affects cooling water demand in one of the three models.
Irrigation water abstraction	Individually derived from the land-use and irrigation patterns provided. Water directly used for livestock (e.g. animal husbandry and drinking), except for indirect uses by irrigation of feed crops, is expected to be very low (Müller Schmied et al., 2016) and could be set to zero if not directly represented in the individual models.	Derived from future land-use and irrigation patterns provided based on output from the MAgPIE model (see section 0). Land-use projections are provided for: • SSP2+RCP6.0 • SSP2+RCP2.6 Direct water use for livestock should be ignored (i.e., can be set to zero).
N fertilizer use (kg per ha of cropland)	Annual crop-specific input per ha of crop land for C_3 and C_4 annual, C_3 and C_4 perennial and C_3 Nitrogen fixing. This data set is part of the LUH2 dataset developed for CMIP6 (Hurtt et al., 2020) based on HYDE3.2.	Crop group-specific inorganic N fertilizer use per area of cropland provided by the LUH2-ISIMIP2b dataset, which differs for SSP2CRCP2.6 and SSP2CRCP6.0. To allow for the all-crops model set-up this information is extrapolated to all land cells using a nearest neighbour algorithm.
Nitrogen (NH_X and NO_Y) deposition	Annual and monthly, 0.5° gridded data for 1850-2005 derived by taking the average of three atmospheric chemistry models (GISS-E2-R, CCSM-CAM3.5, and GFDL-AM3) in the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP) (0.5° x 0.5°) (Lamarque et al., 2013a, 2013b). GISS-E2-R provided monthly data; CCSM-CAM3.5 provided monthly data in each decade from 1850s to the 2000s; and GFDL-AM3 provided monthly data for 1850-1860, 1871-1950, 1961-1980, 1991-2000 and 2001-2010. Annual deposition rates calculated by aggregating the monthly data, and deposition rates in years without model output were calculated according to spline interpolation (CCSM-CAM3.5) or linear interpolation (for GFDL). The original deposition data was downscaled to spatial resolution of half degree (90° N to 90° S, 180° W to 180° E) by applying the nearest interpolation.	As per historical reconstruction for 2006-2099 following RCP2.6 and RCP6.0.

Fishing intensity	Depending on model construction, one of: Fishing effort from the Sea Around Us Project (SAUP); catch data from the Regional Fisheries Management Organizations (RFMOs) local fisheries agencies; exponential fishing technology increase and SAUP economic reconstructions. Given that the SAUP historical reconstruction starts in 1950, fishing effort should be held at a constant 1950 value from 1860-1950.	Held constant after 2005 (**2005soc**)
Forest management	Based on observed stem numbers (see **Table 16-Table 17**)	Based on generic future management practices (see **Table 16-Table 17**)

2.7 Focus Regions

Simulation data are welcome for all world regions. Even single model simulations for specific sites will help to generate a more comprehensive picture of climate change impacts and potentially allow for constraining global models. However, to allow for model intercomparisons simulations should also be provided for the sector specific focus regions shown in **Figure 6** and defined in **Table 7**, if feasible with your model. For regions not defined in the protocol, please contact the ISIMIP Team to agree on appropriate naming and define the location of the region in the metadata of your output files.

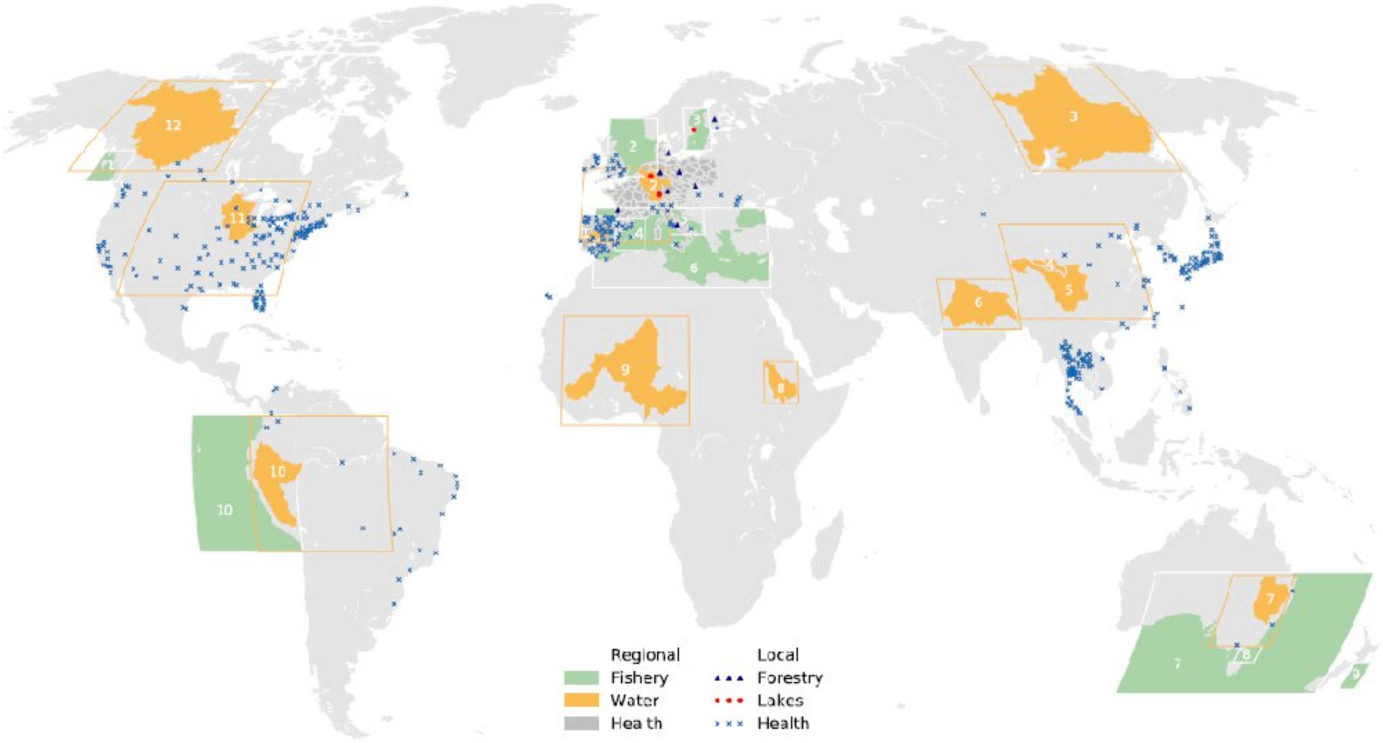

Figure 6 ISIMIP focus regions. See **Table 7** for region definitions.

2.8 Lake specifications

Grid-scale lake fraction is provided based on the Global Lake Data Base version 1 (GLDBv1; Kourzeneva, 2009; 2010)~~and Wetland Database (GLWD; Lehner and Döll, 2004)~~ and available on the DKRZ input data repository (/work/bb0820/ISIMIP/ISIMIP2b/InputData/lakes/pctlake.nc4; Subin et al., 2012).

Since a 0.5°x0.5° pixel potentially contains multiple lakes with different characteristics (e.g., in terms of bathymetry, transparency, fetch), it is not possible to fully represent this subgrid-scale heterogeneity. Instead, the global-scale lake simulations should represent a 'representative lake' for a given pixel. Consequently, no stringent requirement is imposed with respect to lake depth, light extinction coefficient or initial conditions. However, lake depth, modellers are encouraged to use the data from the Global Lake Data Base (GLDB). A regridded lake-depth field based on GLDBv1 (Kourzeneva, 2010) is available at 0.5°x0.5° resolution on the DKRZ input data repository (/work/bb0820/ISIMIP/ISIMIP2b/InputData/lakes/lakedepth.nc4); this field was aggregated from 30 arc sec to 1.9°x2.5° and then interpolated again to 0.5°x0.5°; Subin et al., 2012). Alternatively, modellers may choose to use the more recent GLDBv2 available at 30 arc sec (http://www.flake.igb-berlin.de/ep-data.shtml, Choulga et al., 2014).

An up-to-date list of lakes that are analysed in the ISIMIP Lake sector can be found under https://docs.google.com/spreadsheets/d/1UY_KSR02o7LtmNoOs6jOgOxdcFEKrf7MmhR2BYDlm-Q/edit#gid=555498854.

Table 7 List of ISIMIP focus regions as shown in **Figure 6**.

Focus region (shortname) **Number refers to Figure 6**	**Zonal extent (longitude)**	**Meridional extent (latitude)**	**River basin(s) or Region (shortname).**
Regional water simulations			
North America (11) (nam)	114°0'W– 77°30'W	28°30'N–50°0'N	Mississippi (Mississippi)
Western Europe (1, 2) (weu)	9°30'W–12°0'E	38°30'N–52°30'N	Tagus und Rhine (rhine)
West Africa (9) (waf)	12°0'W–16°0'E	4°0'N–24°30'N	Niger (niger)
South Asia (6) (sas)	73°0'E–90°30'E	22°0'N–31°30'N	Ganges (ganges)
China (4, 5) (chi)	90°30'E–120°30'E	24°0'N–42°0'N	Yellow (yellow), Yangtze (Yangtze)
Australia (7) (aus)	138°30'E–152°30'E	38°0'S –24°30'S	Murray Darling (murrydarling)
Amazon (10) (ama)	80°0'W–50°0'W	20°0'S–5°30'N	Amazon (amazon)
Blue Nile (8) (blu)	32°30'E–40°0'E	8°0'N–16°0'N	Blue Nile (bluenile)
Lena (3) (len)	103°0'E–141°30'E	52°0'N–72°0'N	Lena (lena)
Canada (12)	140°0'W– 103°0'W	52°0'N–69°0'N	Mackenzie (mackenzie)

Regional forest simulations			
bily-kriz	18.32	49.300	-
collelongo	13.588	41.849	
soro	11.645	55.486	
hyytiala	24.295	61.848	
kroof	11.400	48.250	
solling-beech	9.570	51.770	
solling-spruce	9.570	51.770	
peitz	14.350	51.917	
le-bray	-0.769	44.717	
Ocean regions			
North-west Pacific (1) (pacific-nw)	134°30’W–125°30’W	49°30’N–56°30’N	
North Sea (2) (north-sea)	4°30’W–9°30’E	50°30’N–62°30’N	
Baltic Sea (3)	15°30’E–23°30’E	55°30’N–64°30’N	
North-west Meditteranean (4) (med-nw)	1°30’W–6°30’E	36°30’N–43°30’N	
Adriatic Sea (5) (adriatic-sea)	11°30’E–20°30’E	39°30’N–45°30’N	
Meditteranean Sea (6) (med-glob)	6°30’W–35°30’E	29°30’N–45°30’N	
Australia (7) (australia)	120°30’E–170°30’E	47°30’S–23°30’S	
Eastern Bass Strait (8) (eastern-bass-strait)	145°30’E–151°30’E	41°30’S–37°30’S	
Cook Strait (9) (cook-strait)	174°30’E–179°30’E	46°30’S–40°30’S	
(10) (psp)	90°30’W–30°30’E	48°30’N–70°30’N	
(11) (mat)	90°30’W–30°30’E	35°30’N–49°30’N	
(12) (med-atl)	90°30’W–30°30’E	17°30’N–36°30’N	
(13) (tst)	90°30’W–30°30’E	0°30’S–18°30’N	
North Humboldt Sea (14) (Humboldt-n)	93°30’W–69°30’W	20°30’S–6°30’N	

3 Conventions for File Names and Formats

3.1 General Notes

It is important that you comply precisely with the formatting specified below, in order to facilitate the analysis of your simulation results in the ISIMIP framework. Incorrect formatting can seriously delay the analysis. The ISIMIP Team will be glad to assist with the preparation of these files if necessary.
For questions or clarifications, please contact info@isimip.org or the data manager directly (buechner@pik-potsdam.de) before submitting files.

3.1.1 Time slices for individual files

For time slices holding global daily data, files should cover 10 years starting in the second year of a decade and end in the first year of the next decade (e.g., 1991-2000). If the time period starts after the second year of the decade or ends before the first year of the new decade, the start or end year of the time period should be used as the start or end year of the file respectively. Data on a lower than daily temporal resolution or non-global data should be submitted for the entire simulation period in single files per variable.

Examples of time slices for individual files with global daily data:
Pre-industrial: 1661_1670, 1671_1680, ..., 1851_1860
Historical: 1861_1870, 1871_1880, ..., 2001_2005
Future: 2006_2010, 2011_2020, ..., 2081_2090, 2091_2099
Extended future: 2100_2100, 2101_2110, ..., 2281_2290, 2291_2299
Examples of time slices for individual files with non-global or non-daily data:
Pre-industrial: 1661_1860
Historical: 1861_2005
Future: 2006_2099
Extended future: 2100_2299

3.1.2 File names

File names consist of a series of identifiers, separated by underscores; see examples below. Things to note:

- Report **one** variable per file
- In filenames, use **lowercase** letters only
- Use underscore (“_”) to separate identifiers
- Variable names consist of a single word without hyphens or underscores
- Use hyphens (”-“) to separate strings within an identifier, e.g. in a model name
- NetCDF file extension is .nc4

The file name format is:

<modelname>_<gcm>_<bias-correction>_<climate-scenario>_<soc-scenario>_<co2sens-scenarios>_<variable>_<region>_<timestep>_<start-year>_<end-year>.nc4

The identifiers in brackets should be replaced with the appropriate identifiers from **Table 8**. Identifiers may be dependent on the sector. The identifiers <variable> might also contain information about the plant functional type (in the biomes and permafrost sectors). The pft naming is model-specific and hence has to be reported in the impact-model database entries for each model (https://www.isimip.org/impactmodels/). In the forest sector, the identifier <variable> might contain information about the tree species. The species names codes are listed in **Table 38**.

Examples:

lpjml_ipsl-cm5a-lr_ewembi_historical_histsoc_co2_qtot_global_annual_1861_1870.nc4
lpjml_ipsl-cm5a-lr_ewembi_rcp26_rcp26soc_2005co2_yield-mai-noirr_global_annual_2006_2010.nc4

Table 8 Identifiers for file naming convention.

Item	Possible identifiers	Description
<model-name>		Model name
<gcm>	hadgem2-es, ipsl-cm5a-lr, miroc5, gfdl-esm2m	Name of the General Circulation Model (global climate model) from which climate-forcing data was used.
<bias-correction>	nobc, localbc, ewembi, ewembi-isimip3basd	The target observed climate data used for the bias correction. “nobc” Indicates that no bias correction was performed on the climate data (e.g., ocean data). “localbc" refers to local data from weather stations used for the bias-correction in e.g., the forest sector. “ewembi” refers to EWEMBI data used for the bias-correction globally on a 0.5° grid. “ewembi-isimip3basd” refers to EWEMBI data used for the bias-correction globally on a 0.5° grid, using improved bias-correction methods (Lange 2018, doi: 10.5194/esd-9-627-2018), and with statistical downscaling (instead of interpolation) of GCM data to the 0.5° grid prior to bias-correction.
<climate-scenario>	picontrol, historical, rcp26, rcp60, rcp85	Climate & CO2 concentration scenario (RCP). **Note:** even though “picontrol” uses fixed co2-levels, it should come with the <co2sens-scenario> qualifier “co2” (see below)
<soc -scenario>	nosoc, 1860soc, histsoc, 2005soc, rcp26soc, rcp60soc, 2100rcp26soc	Scenario describing other human influences, such as land use and land management.

<co2sens-scenario>	co2, 2005co2	“co2” for all experiments other than the sensitivity experiments for which “2005co2” is explicitly written. Note: even models in which CO2 has no effect should use the co2 identifier relevant to the experiment.
<variable>		Output variable names – see sector-specific tables.
<region>	global, [region/basin/sites]	Region, basin or site names given in Section 2.6. Where simulations are provided for a single station within a river basin, the tag should have the format [basin]-[station].
<timestep>	3hr, daily, monthly, annual, 5-year, 30year-mean, growing-season	The temporal resolution of your output data files.
<start-year>_<end-year>	e.g. 1861_1870	Daily, global files should be uploaded in 10-year pieces. For the transition from the historical to the future period (2005-2006), files should be separated, i.e. the identifiers would be 2001_2005 and 2006_2010. For non-daily, non-global files, no time slices are needed, and files should cover the entire simulation period. For the forest simulations, no time slices are needed, and the full simulation period can be covered in one file.

For further instructions on file naming and formatting, please also refer to our website: https://www.isimip.org/protocol/preparing-simulation-files/#file-formats-and-meta-data.

15 References

Bolt, J. and van Zanden, J. L.: The Maddison Project: collaborative research on historical national accounts, Econ. Hist. Rev., 67(3), 627–651, 2014.

Choulga, M., Kourzeneva, E., Zakharova, E. and Doganovsky, A.: Estimation of the mean depth of boreal lakes for use in numerical weather prediction and climate modelling, Tellus A Dyn. Meteorol. Oceanogr., 66(1), 21295, doi:10.3402/tellusa.v66.21295, 2014.

Dellink, R., Chateau, J., Lanzi, E. and Magné, B.: Long-term economic growth projections in the Shared Socioeconomic Pathways, Glob. Environ. Chang., doi:10.1016/j.gloenvcha.2015.06.004, 2015.¶

Elliott, J. and Müller, C. and Deryng, D. and Chryssanthacopoulos, J. and Boote, K. J. and Büuchner, M. and Foster, I. and Glotter, M. and Heinke, J. and Iizumi, T. and Izaurralde, R. C. and Mueller, N. D. and Ray, D. K. and Rosenzweig, C. and Ruane, A. C. and Sheffield, J.: The Global Gridded Crop Model Intercomparison: data and modeling protocols for Phase 1 (v1.0), Geosci. Model Dev., 8, 261–277, https://doi.org/10.5194/gmd-8-261-2015, 2015.

Frieler, K., Lange, S., Piontek, F., Reyer, C. P. O., Schewe, J., Warszawski, L., Zhao, F., Chini, L., Denvil, S., Emanuel, K., Geiger, T., Halladay, K., Hurtt, G., Mengel, M., Murakami, D., Ostberg, S., Popp, A., Riva, R., Stevanovic, M., Suzuki, T., Volkholz, J., Burke, E., Ciais, P., Ebi, K., Eddy, T. D., Elliott, J., Galbraith, E., Gosling, S. N., Hattermann, F., Hickler, T., Hinkel, J., Hof, C., Huber, V., Jägermeyr, J., Krysanova, V., Marcé, R., Müller Schmied, H., Mouratiadou, I., Pierson, D., Tittensor, D. P., Vautard, R., van Vliet, M., Biber, M. F., Betts, R. A., Bodirsky, B. L., Deryng, D., Frolking, S., Jones, C. D., Lotze, H. K., Lotze-Campen, H., Sahajpal, R., Thonicke, K., Tian, H., and Yamagata, Y.: Assessing the impacts of 1.5 °C global warming – simulation protocol of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b), Geosci. Model Dev., 10, 4321-4345, https://doi.org/10.5194/gmd-10-4321-2017, 2017.

Gasparrini A, Leone M. Attributable risk from distributed lag models. BMC Med Res Methodol. 2014 Apr 23;14:55. doi: 10.1186/1471-2288-14-55. PMID: 24758509; PMCID: PMC4021419.¶

Haith, D. A. and Shoemaker., L. L.: Generalized Watershed Loading Functions for stream flow nutrients, Water Resour. Bull., 23, 471–478, 1987.

Håkanson, L. Models to predict Secchi depth in small glacial lakes. *Aquatic Science* **57**, 31–53 (1995). https://doi.org/10.1007/BF00878025¶

Hinkel, Jochen and Lincke, Daniel and Vafeidis, Athanasios T. and Perrette, Mahé and Nicholls, Robert James and Tol, Richard S. J. and Marzeion, Ben and Fettweis, Xavier and Ionescu, Cezar and Levermann, Anders: Coastal flood damage and adaptation costs under 21st century sea-level rise, Proceedings of the National Academy of Sciences, 111 (9): 3292-3297; DOI: 10.1073/pnas.1222469111, 2014.¶

Hurtt, G. C., L. Chini, R. Sahajpal, S. Frolking, B. L. Bodirsky, K. Calvin, J. C. Doelman, J. Fisk, S. Fujimori, K. K. Goldewijk, T. Hasegawa, P. Havlik, A. Heinimann, F. Humpenöder, J. Jungclaus, Jed Kaplan, J. Kennedy, T. Kristzin, D. Lawrence, P. Lawrence, L. Ma, O. Mertz, J. Pongratz, A. Popp, B. Poulter, K. Riahi, E. Shevliakova, E. Stehfest, P. Thornton, F. N. Tubiello, D. P. van Vuuren, X. Zhang (2020). Harmonization of Global Land-Use Change and Management for the Period 850-2100 (LUH2) for CMIP6.Geoscientifc Model Development Discussions. https://doi.org/10.5194/gmd-2019-360

Klein Goldewijk, K., Beusen, A., Doelman, J., and Stehfest, E.: Anthropogenic land use estimates for the Holocene – HYDE 3.2, Earth Syst. Sci. Data, 9, 927-953, https://doi.org/10.5194/essd-9-927-2017, 2017. ¶

Kopp, Robert E. and Horton, Radley M. and Little, Christopher M. and Mitrovica, Jerry X. and Oppenheimer, Michael and Rasmussen, D. J. and Strauss, Benjamin H. and Tebaldi, Claudia: Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites, Earth's Future, 2 (8): 383-406, https://doi.org/10.1002/2014EF000239, 2014.¶

Kopp, Robert E. and Kemp, Andrew C. and Bittermann, Klaus and Horton, Benjamin P. and Donnelly, Jeffrey P. and Gehrels, W. Roland and Hay, Carling C. and Mitrovica, Jerry X. and Morrow, Eric D. and Rahmstorf, Stefan: Temperature-driven global sea-level variability in the Common Era, Proceedings of the National Academy of Sciences, 113 (11): E1434--E1441, doi:10.1073/pnas.1517056113, 2016.¶

Kourzeneva, E. 2009. Global dataset for the parameterization of lakes in numerical weather prediction and climate modelling. ALADIN Newsletter. 37, July_December, (eds. F. Bouttier and C. Fischer), Meteo-France, Toulouse, France, 46_53.

Kourzeneva, E.: External data for lake parameterization in Numerical Weather Prediction and climate modeling, Boreal Environ. Res., 15(2), 165–177, 2010.

Lange, S.: Bias correction of surface downwelling longwave and shortwave radiation for the EWEMBI dataset, Earth Syst. Dynam., 9, 627–645, https://doi.org/10.5194/esd-9-627-2018, 2018.¶

Lamarque, J. F., Dentener, F., McConnell, J., Ro, C. U., Shaw, M., Vet, R., Bergmann, D., Cameron-Smith, P., Dalsoren, S., Doherty, R., Faluvegi, G., Ghan, S. J., Josse, B., Lee, Y. H., Mackenzie, I. a., Plummer, D., Shindell, D. T., Skeie, R. B., Stevenson, D. S., Strode, S., Zeng, G., Curran, M., Dahl-Jensen, D., Das, S., Fritzsche, D. and Nolan, M.: Multi-model mean nitrogen and sulfur deposition from the atmospheric chemistry and climate model intercomparison project (ACCMIP): Evaluation of historical and projected future changes, Atmos. Chem. Phys., 13(16), 7997–8018, doi:10.5194/acp-13-7997-2013, 2013a.

Lamarque, J. F., Shindell, D. T., Josse, B., Young, P. J., Cionni, I., Eyring, V., Bergmann, D., Cameron-Smith, P., Collins, W. J., Doherty, R., Dalsoren, S., Faluvegi, G., Folberth, G., Ghan, S. J., Horowitz, L. W., Lee, Y. H., MacKenzie, I. a., Nagashima, T., Naik, V., Plummer, D., Righi, M., Rumbold, S. T., Schulz, M., Skeie, R. B., Stevenson, D. S., Strode, S., Sudo, K., Szopa, S., Voulgarakis, a. and Zeng, G.: The atmospheric chemistry and climate model intercomparison Project (ACCMIP): Overview and description of models, simulations and climate diagnostics, Geosci. Model Dev., 6(1), 179–206, doi:10.5194/gmd-6-179-2013, 2013b.

De Lary, R.: Massif des Landes de Gascogne. II – ETAT DES CONNAISSANCES TECHNIQUES, Bourdeaux., 2015.

Lehner, B. and Döll, P.: Development and validation of a global database of lakes, reservoirs and wetlands, J. Hydrol., 296(1–4), 1–22, doi:10.1016/J.JHYDROL.2004.03.028, 2004.

Millero FJ & Poisson A: International one-atmosphere equation of state of seawater. Deep-Sea Research, 28, 625–629, 1981.

Monfreda, C., Ramankutty, N. and Foley, J. A.: Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000, Glob. Biogeochem. Cycles, 22(GB1022), doi:10.1029/2007GB002947., 2008.

Müller Schmied, H., Adam, L., Eisner, S., Fink, G., Flörke, M., Kim, H., Oki, T., Portmann, F. T., Reinecke, R., Riedel, C., Song, Q., Zhang, J. and Döll, P.: Impact of climate forcing uncertainty and human water use on global and continental water balance components, Proc. Int. Assoc. Hydrol. Sci., 93, doi:10.5194/piahs-93-1-2016, 2016.

Murakami, D. and Yamagata, Y.: Estimation of gridded population and GDP scenarios with spatially explicit statistical downscaling, [online] Available from: http://arxiv.org/abs/1610.09041 (Accessed 29 May 2017), 2016.

Popp, A., Humpenöder, F., Weindl, I., Bodirsky, B. L., Bonsch, M., Lotze-Campen, H., Müller, C., Biewald, A., Rolinski, S., Stevanovic, M. and Dietrich, J. P.: Land-use protection for climate change mitigation, Nat. Clim. Chang., 4(December), 2–5, doi:10.1038/nclimate2444, 2014.

Reyer, C. P. O., Silveyra Gonzalez, R., Dolos, K., Hartig, F., Hauf, Y., Noack, M., Lasch-Born, P., Rötzer, T., Pretzsch, H., Meesenburg, H., Fleck, S., Wagner, M., Bolte, A., Sanders, T. G. M., Kolari, P., Mäkelä, A., Vesala, T., Mammarella, I., Pumpanen, J., Collalti, A., Trotta, C., Matteucci, G., D'Andrea, E., Foltýnová, L., Krejza, J., Ibrom, A., Pilegaard, K., Loustau, D., Bonnefond, J.-M., Berbigier, P., Picart, D., Lafont, S., Dietze, M., Cameron, D., Vieno, M., Tian, H., Palacios-Orueta, A., Cicuendez, V., Recuero, L., Wiese, K., Büchner, M., Lange, S., Volkholz, J., Kim, H., Horemans, J. A., Bohn, F., Steinkamp, J., Chikalanov, A., Weedon, G. P., Sheffield, J., Babst, F., Vega del Valle, I., Suckow, F., Martel, S., Mahnken, M., Gutsch, M., and Frieler, K.: The PROFOUND Database for evaluating vegetation models and simulating climate impacts on European forests, Earth Syst. Sci. Data, 12, 1295–1320, https://doi.org/10.5194/essd-12-1295-2020, 2020. ¶

Samir, C. and Lutz, W.: The human core of the shared socioeconomic pathways: Population scenarios by age, sex and level of education for all countries to 2100, Glob. Environ. Chang., doi:10.1016/j.gloenvcha.2014.06.004, 2014.

Schneiderman, E. M., Pierson, D. C., Lounsbury, D. G. and Zion, M. S.: Modeling the hydrochemistry of the Cannonsville watershed with Generalized Watershed Loading Functions (GWLF), J. Am. Water Resour. Assoc., 38, 1323–1347, 2002.¶

Shatwell (unpubl.)

Stevanović, M., Popp, A., Lotze-Campen, H., Dietrich, J. P., Müller, C., Bonsch, M., Schmitz, C., Bodirsky, B., Humpenöder, F. and Weindl, I.: High-end climate change impacts on agricultural welfare, Sci. Adv., 2016.

Subin, Z. M., Riley, W. J. and Mironov, D.: An improved lake model for climate simulations: Model structure, evaluation, and sensitivity analyses in CESM1, J. Adv. Model. Earth Syst., 4(1), M02001, doi:10.1029/2011MS000072, 2012.

Wada, Y., Flörke, M., Hanasaki, N., Eisner, S., Fischer, G., Tramberend, S., Satoh, Y., Van Vliet, M. T. H., Yillia, P., Ringler, C., Burek, P. and Wiberg, D.: Modeling global water use for the 21st century: The Water Futures and Solutions (WFaS) initiative and its approaches, Geosci. Model Dev., 9(1), 175–222, doi:10.5194/gmd-9-175-2016, 2016.¶