

## 5 Water (hydrological models)

### 5.1 Scenarios

Climate & CO <sub>2</sub> concentration scenarios	
<b>picontrol</b>	Pre-industrial climate and 286ppm CO <sub>2</sub> concentration. The climate data for the entire period (1661-2299) are unique – no (or little) recycling of data has taken place.
<b>historical</b>	Historical climate and CO <sub>2</sub> concentration.
<b>rcp26</b>	Future climate and CO <sub>2</sub> concentration from RCP2.6
<b>rcp60</b>	Future climate and CO <sub>2</sub> concentration from RCP6.0
Human influence and land-use scenarios	
<b>1860soc</b>	Pre-industrial land use and other human influences. Given the small effect of dams & reservoirs before 1900, modellers may apply the 1901 dam/reservoir configuration during the pre-industrial period and the 1861-1900 part of the historical period if that is significantly easier than applying the 1861 configuration.
<b>histoc</b>	Varying historical land use and other human influences.
<b>2005soc</b>	Fixed year-2005 land use and other human influences.
<b>rcp26soc</b>	Varying land use, water abstraction and other human influences according to SSP2 and RCP2.6; fixed year-2005 dams and reservoirs. For models using fixed LU types, varying irrigation areas can also be considered as varying land use.
<b>rcp60soc</b>	Varying land use, water abstraction and other human influences according to SSP2 and RCP6.0, fixed year-2005 dams and reservoirs. For models using fixed LU types, varying irrigation areas can also be considered as varying land use.
<b>2100rcp26soc</b>	Land use and other human influences fixed at year 2100 levels according to RCP2.6.

For the historical period, groups that have limited computational capacities may choose to report only part of the full period, but including at least 1961-2005. All other periods should be reported completely. For those models that do not represent *changes* in human influences, those influences should be held fixed at 2005 levels throughout all Group 1 (cf. **2005soc** marked as dashed blue lines in Fig. 1) and Group 2 simulations. Group 3 will be identical to Group 2 for these models and thus does not require additional simulations. Models that do not include human influences *at all* should

nevertheless run the Group 1 and Group 2 simulation, since these simulations will still allow for an exploration of the effects of climate change compare to pre-industrial climate, and will also allow for a better assessment of the relative importance of human impacts versus climate impacts. These runs should be named as **nosoc** simulations.

5 The regional-scale simulations are performed for 12 large river basins. In six river basins (Tagus, Niger, Blue Nile, Ganges, Upper Yangtze and Darling) water management (dams/reservoirs, water abstraction) will be implemented. In the other six river basins, human influences such as LU changes, dams and reservoirs, and water abstraction is not relevant (Upper Yellow, Upper Amazon) or negligible (Rhine, Lena, Upper Mississippi), and can be ignored. Apart from this, regional water simulations should follow the global water simulations to allow for a cross-scale comparison of the simulations. The focus lakes for the local lake models are located within the focus river basins and listed in section 5.2.

**Table 9** ISIMIP2b scenarios for global and regional water simulations. Option 2\* only if option 1 not possible.

Experiment	Input	pre-industrial	historical	future	extended future	
		1661-1860	1861-2005	2006-2099	2100-2299	
<b>I</b>	no climate change, pre-industrial CO <sub>2</sub>	Climate & CO <sub>2</sub>	<b>picontrol</b>	<b>picontrol</b>	<b>picontrol</b>	<b>picontrol</b>
	varying LU & human influences up to 2005, then fixed at 2005 levels thereafter	Human & LU	Option 1: <b>1860soc</b>	Option 1: <b>histsoc</b>	<b>2005soc</b>	<b>2005soc</b>
		Option 2*: <b>2005soc</b>	Option 2*: <b>2005soc</b>			
<b>II</b>	RCP2.6 climate & CO <sub>2</sub>	Climate & CO <sub>2</sub>	Experiment I	<b>historical</b>	<b>rcp26</b>	<b>rcp26</b>
	varying LU & human influences up to 2005, then fixed at 2005 levels thereafter	Human & LU		Option 1: <b>histsoc</b>	<b>2005soc</b>	<b>2005soc</b>
		Option 2*: <b>2005soc</b>				
<b>III</b>	RCP6.0 climate & CO <sub>2</sub>	Climate & CO <sub>2</sub>	Experiment I	Experiment II	<b>rcp60</b>	not simulated
	varying LU & human influences up to 2005, then fixed at 2005 levels thereafter	Human & LU			<b>2005soc</b>	
<b>IV</b>	no climate change, pre-industrial CO <sub>2</sub>	Climate & CO <sub>2</sub>	Experiment I	Experiment I	<b>picontrol</b>	<b>picontrol</b>

	varying human influences & LU up to 2100 (RCP2.6), then fixed at 2100 levels thereafter	Human & LU			rcp26soc	2100rcp26soc
<b>V</b>	no climate change, pre-industrial CO <sub>2</sub>	Climate & CO <sub>2</sub>	Experiment I	Experiment I	picontrol	not simulated
	varying human influences & LU (RCP6.0)	Human & LU			rcp60soc	
<b>VI</b>	RCP2.6 climate & CO <sub>2</sub>	Climate & CO <sub>2</sub>	Experiment I	Experiment II	rcp26	rcp26
	varying human influences & LU up to 2100 (RCP2.6), then fixed at 2100 levels thereafter	Human & LU			rcp26soc	2100rcp26soc
<b>VII</b>	RCP6.0 climate & CO <sub>2</sub>	Climate & CO <sub>2</sub>	Experiment I	Experiment II	rcp60	not simulated
	varying human influences & LU (RCP6.0)	Human & LU			rcp60soc	

## 5.2 Global and regional hydrological models

Variable names are chosen to comply, where feasible, with the ALMA convention ([www.lmd.jussieu.fr/~polcher/ALMA/convention\\_output\\_3.html](http://www.lmd.jussieu.fr/~polcher/ALMA/convention_output_3.html)) and the names used in WATCH/WaterMIP. All variables are to be reported as time-averages with the indicated resolution; do not report instantaneous values ('snapshots'). Exceptions are **maxdis** and **mindis**, which are the maximum and minimum daily-average discharge in a given month, respectively, to be reported on a monthly basis (see below).

### 5.2.1 Output data

**Table 10** Output variables to be reported by water sector models. Variables highlighted in orange are requested from both global and regional models; discharge at gauge level (highlighted in purple) is requested only from regional models; other variables are requested only from global models. Variables marked by \* are also relevant for the permafrost sector and also listed there. Variables marked by \*\* are **only** relevant for the permafrost sector.

Variable (long name)	Variable name	Resolution	Unit (NetCDF format)	Comments
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Hydrological Variables				
*Runoff	Qtot	daily (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	total (surface + subsurface) runoff (qtot = qs + qsb). If daily resolution not possible, please provide monthly.
Surface runoff	Qs	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	Water that leaves the surface layer (top soil layer) e.g. as overland flow / fast runoff
Subsurface runoff	Qsb	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	Sum of water that flows out from subsurface layer(s) including the groundwater layer (if present). Equals qg in case of a groundwater layer below only one soil layer
Groundwater recharge	Qr	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	Water that percolates through the soil layer(s) into the groundwater layer. In case seepage is simulated but no groundwater layer is present, report seepage as qr and qg.
Groundwater runoff	Qg	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	Water that leaves the groundwater layer. In case seepage is simulated but no groundwater layer is present, report seepage as qr and qg.
Discharge (gridded)	Dis	daily (0.5°x0.5°)	m <sup>3</sup> s <sup>-1</sup>	If daily resolution not possible, please provide monthly
Discharge (gauge level)	Dis	daily (see website for gauge locations)	m <sup>3</sup> s <sup>-1</sup>	If daily resolution not possible, please provide monthly
Monthly maximum of daily discharge	Maxdis	monthly (0.5°x0.5°)	m <sup>3</sup> s <sup>-1</sup>	Reporting this variable is not mandatory, but desirable particularly if daily discharge data is unfeasible
Monthly minimum of daily discharge	Mindis	monthly (0.5°x0.5°)	m <sup>3</sup> s <sup>-1</sup>	Reporting this variable is not mandatory, but desirable particularly if daily discharge data is unfeasible
Evapotranspiration	Evap	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	Sum of transpiration, evaporation, interception losses, and sublimation.

Potential Evapotranspiration	Potevap	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	as for <i>evap</i> , but with all resistances set to zero, except the aerodynamic resistance.
*Soil moisture	soilmoist	monthly (0.5°x0.5°)	kg m <sup>-2</sup>	provide soil moisture for all depth layers (i.e. 3D-field), and indicate depth in m.
Soil moisture, root zone	rootmoist	monthly (0.5°x0.5°)	kg m <sup>-2</sup>	Total simulated soil moisture available for evapotranspiration. If simulated by the model. Please indicate the depth of the root zone for each vegetation type in your model
**Frozen soil moisture for each layer	soilmoistfroz	monthly (0.5°x0.5°)	kg m <sup>-2</sup>	water content of frozen soil
**Temperature of Soil	Tsl	daily (0.5°x0.5°)	K	Temperature of each soil layer. Reported as "missing" for grid cells occupied entirely by "sea". Also need depths in meters. Daily would be great, but otherwise monthly would work. **if daily resolution not possible, please provide monthly
**Snow depth	Snd	monthly (0.5°x0.5°)	m	Grid cell mean depth of snowpack.
*Snow water equivalent	Swe	monthly (0.5°x0.5°)	kg m <sup>-2</sup>	Total water mass of the snowpack (liquid or frozen), averaged over a grid cell.
Total water storage	TwS	monthly (0.5°x0.5°)	kg m <sup>-2</sup>	Mean monthly water storage in all compartments. Please indicate in the netcdf metadata which storage compartments are considered.
*Annual maximum daily thaw depth	thawdepth	annual (0.5°x0.5°)	m	calculated from daily thaw depths, which do not need to be submitted themselves.
Rainfall	Rainf	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	These variables are required for test purposes only. If you need to reduce output data volumes, please provide these variables only once, with the first (test)

Snowfall	Snowf	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	data set you submit, e.g. for the first decade of each experiment. NOTE: rainf + snowf = total precipitation
Water management variables (for models that consider water management/human impacts)				
<b>NOTE:</b> Models that cannot differentiate between water-use sectors may report the respective totals and include the first letter of each sector included in the filenames. E.g. combined potential water withdrawal in the irrigation and livestock sectors would be “pi $\_$ lww”; combined actual water consumption in the irrigation, domestic, manufacturing, electricity, and livestock sectors would be “ai $\_$ dme $\_$ luse” (see section 2.6 for the latest naming convention regarding file names).				
Irrigation water demand (=potential irrigation water Withdrawal)	Pirrww	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	Irrigation water withdrawal, assuming unlimited water supply
Actual irrigation water withdrawal	Airrrww	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	Irrigation water withdrawal, taking water availability into account; please provide if computed
Potential irrigation water consumption	Pirrruse	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	portion of withdrawal that is evapo-transpired, assuming unlimited water supply
Actual irrigation water consumption	Airrruse	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	portion of withdrawal that is evapotranspired, taking water availability into account; if computed
Actual green water consumption on irrigated cropland	airrrusegreen	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	actual evapotranspiration from rain water over irrigated cropland; if computed
Potential green water consumption on irrigated cropland	pirrrusegreen	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	potential evapotranspiration from rain water over irrigated cropland; if computed and different from airrrusegreen
Actual green water consumption on rainfed cropland	airrainf $\_$ usegreen	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	actual evapotranspiration from rain water over rainfed cropland; if computed
Actual domestic water withdrawal	adomww	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	if computed

Actual domestic water consumption	adomuse	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	if computed
Actual manufacturing water withdrawal	Amanww	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	if computed
Actual Manufacturing water consumption	amanuse	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	if computed
Actual electricity water withdrawal	Aelecww	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	if computed
Actual electricity water consumption	Aelecuse	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	if computed
Actual livestock water withdrawal	Aliveww	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	if computed
Actual livestock water consumption	Aliveuse	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	if computed
Total (all sectors) actual water consumption	Atotuse	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	Sum of actual water consumption from all sectors in case it is not possible to provide this information sector-specific.
Total (all sectors) actual water withdrawal	Atotww	monthly (0.5°x0.5°)	kg m <sup>-2</sup> s <sup>-1</sup>	Sum of actual water withdrawal from all sectors in case it is not possible to provide this information sector-specific
Static output				

Soil types	Soil	static (0.5°x0.5°)		Soil types or texture classes as used by your model. Please include a description of each type or class, especially if these are different from the standard HSWD and GSWP3 soil types. Please also include a description of the parameters and values associated with these soil types (parameter values could be submitted as spatial fields where appropriate).
Leaf Area Index	lai	static (0.5°x0.5°) or monthly (0.5°x0.5°) where appropriate	1	if used by, or computed by the model