Hydrological model comparison

WULCA Project, Stress sub-group

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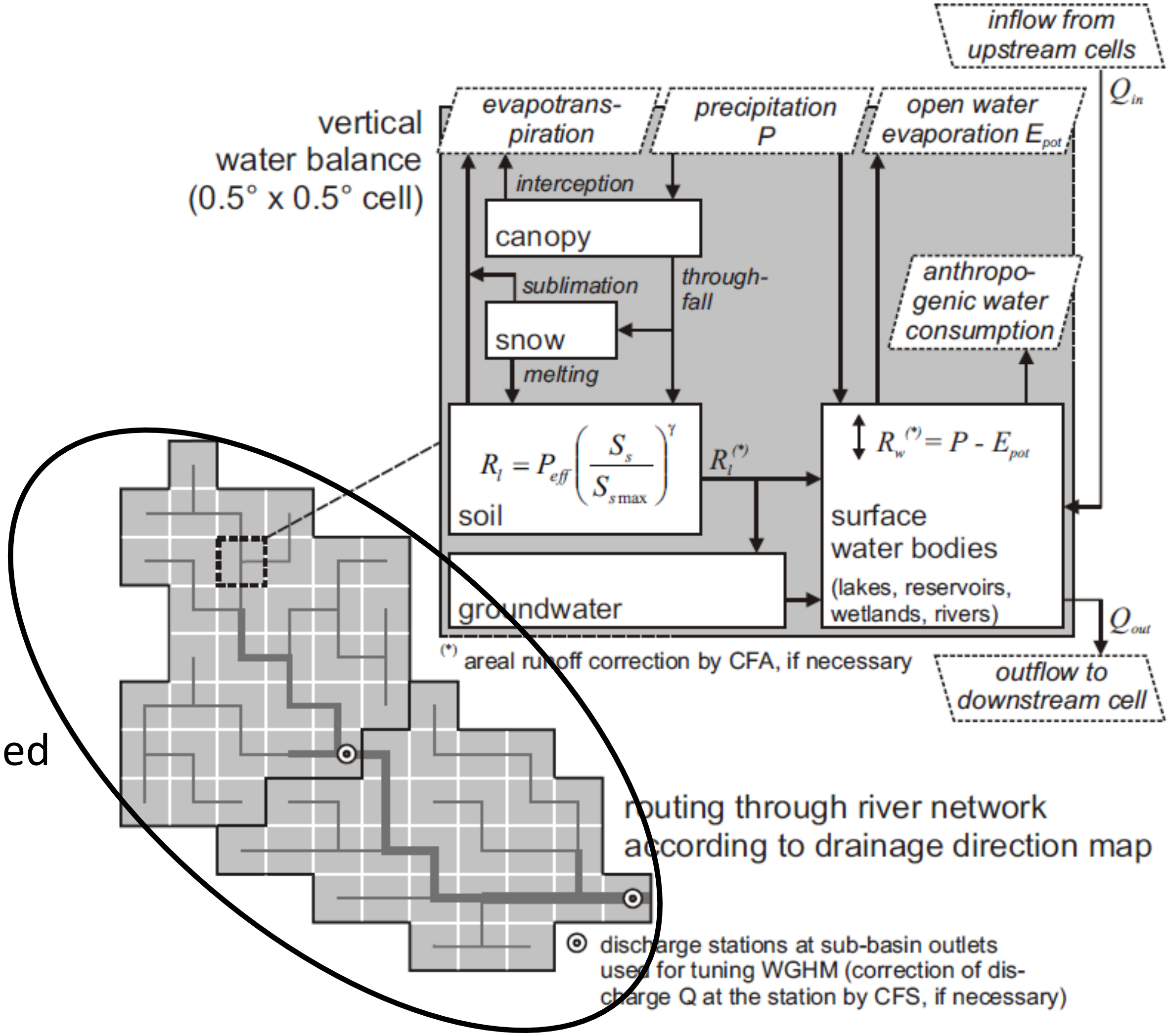
General concept of global hydrological models

Watershed divided in grids
For each grid compute:

- Stocks of compartments
- Flows (water/energy)



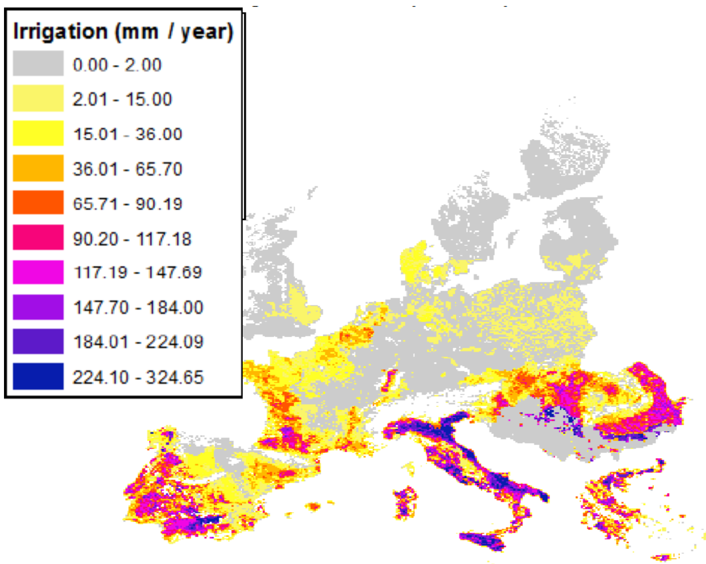
Watersheed

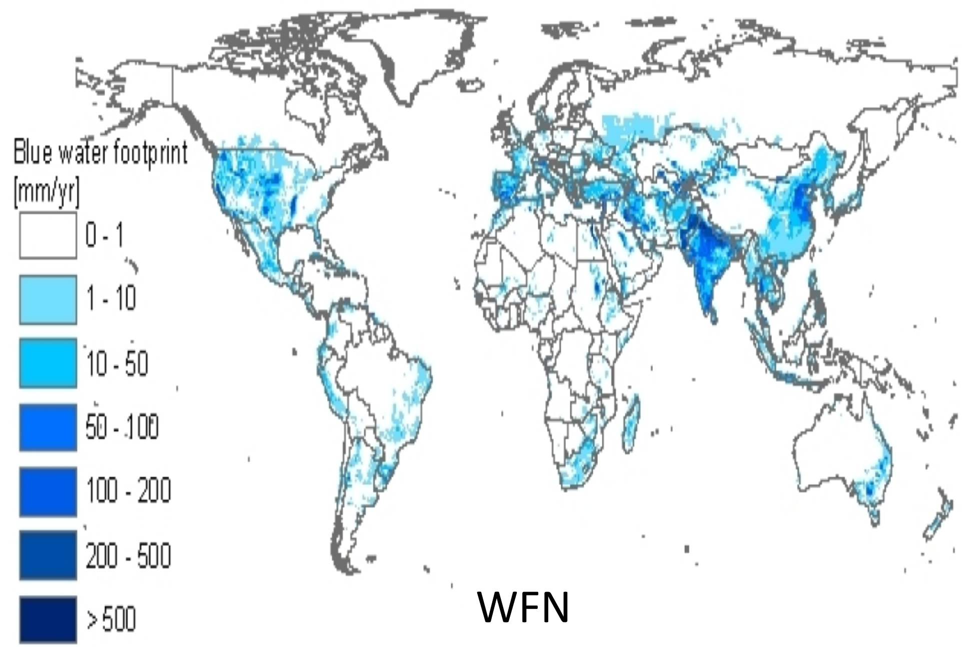
1. Withdrawal/consumption by human activities
2. Hydrological processes

Human water withdrawals and consumption

	Users (color represent the level of complexity, from simple (purple) to refined (green))					Resolution	Temporal Resolution of irrigation
	Agriculture		Industry		Domestic		
WaterGap	Irrigation model (CROPWAT), 2 types of crop	**Livestock Farming**: Number of animals per grid cell * water requirements. **10 different livestock types**.	**Manufacturing industries**: Country scale statistics, downscaled with urban population.	**Thermal power plants** : 14 combinations of plant type and cooling systems, plant location and electricity production stat.	National domestic water uses per country, downscaled with population density.	0.5°	Daily
WRI	National values (FAO extrapolated to 2010), downscaled with global irrigation map		National value reported by FAO (extrapolated to 2010), downscaled with Nighttime lights maps and power plants location.		National values (FAO, extrapolated to 2010), downscaled with population density	2.5' population 5' irrigation	Annual
LPJmL	Dynamic Irrigation model, 13 irrigated crop types.	Provided by WaterGap	Provided by WaterGap		Provided by WaterGap	0.5° grid	Daily
WFN	Irrigation model similar to WaterGap. 24 major crops.	Not included in "blue water scarcity"	FAO Aquastat (**5% consumed**), downscaled with population density.		National values (FAO, extrapolated to 2010), downscaled with population density (10% of withdrawal consumed)	5' grids	Monthly
H08	Irrigation model (plant growth). Maintain soil moisture at 75% (100% for paddy rice). 18 Crop types	No	FAO Aquastat country data downscaled with **urban population**. (**15% evaporation rate**)		National values (FAO, extrapolated to 2010), downscaled with population density (10% of withdrawal consumed)	1°	Daily
PCR-GLOBWB	Irrigation model to reach potential transpiration for 26 crops	Number of animals per grid cell * water requirements. **6 different livestock.**	Country stat data downscaled with urban population, several evaporation rates depending on country development		Only monthly model depending on temperature per month, based on annual values for countries, distributed with population density	0,5°	Daily
JRC	Irrigation water requirement with growth model, 5 crops.	Number of animals per grid cell * water requirements, corrected with T° function	**Manufacturing:** country scale statistics, downscaled with industrial areas maps.	**Thermal power plants**: national statistics downscaled with power plan location	National values downscaled with population and tourist density.		Daily

Example of irrigation consumption maps





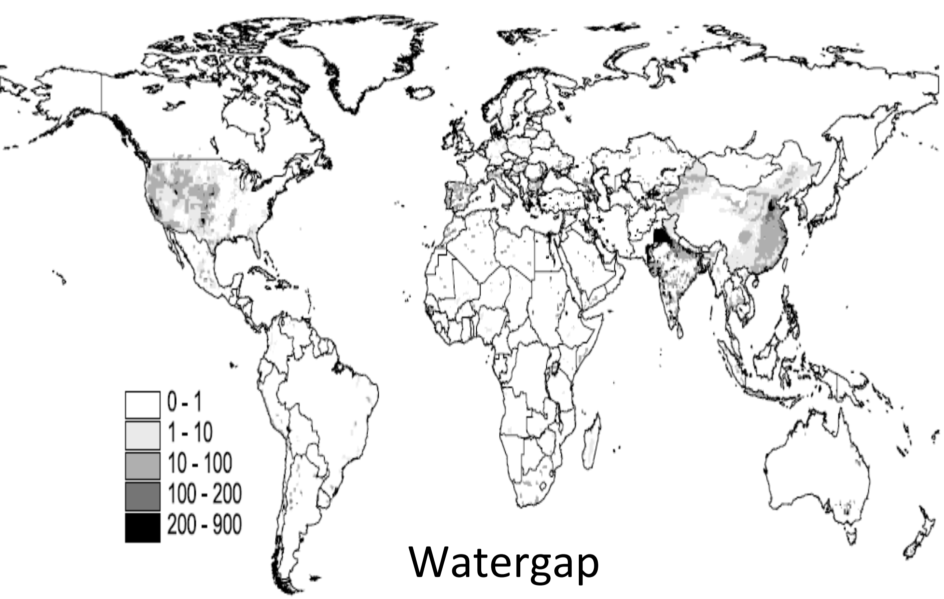
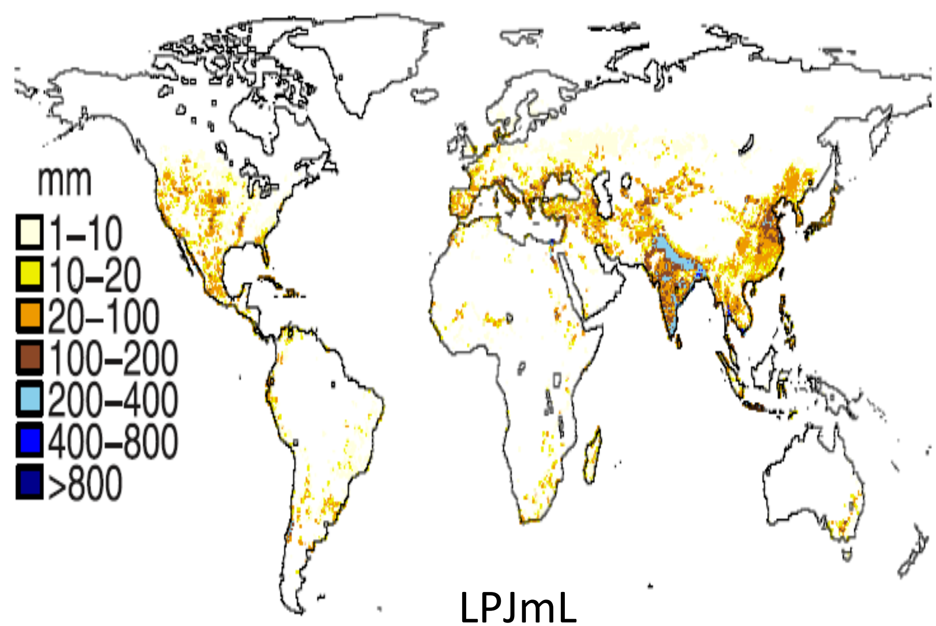


Figure 5. Net irrigation requirement per unit cell area, in mm/yr, under average climatic conditions (1961–1990), in grid cells with irrigated areas in 1995.



Hydrological models overview

	WaterGap	Composite Runoff (WFN)	H08	LPJmL	GLDAS-2 (Aqueduct)	PCR-GLOBWB
Spatial res.	0.5°	0.5°	1°	0.5°	1° (0.25° available)	0.5°
Timestep	Daily	Daily	Daily	Daily	3 hour or monthly	Daily
Model structure	<u>Vertical water balance:</u> • Canopy • Snow • Soil • Subsurface <u>Horizontal balance :</u> Runoff as an increased function of soil moisture • Rivers • Lakes • Wetlands • Reservoirs (algorithm inspired by H08)	Water balance model, focus on soil moisture excess and empirical soil drying function depending on vegetation	<u>Surface energy and water module</u>: • Albedo • Sensible and latent heat • Energy balance • Snow and soil water balance <u>River rooting module (without lakes or weetlands) :</u> Excess moisture runoff scheme <u>Reservoir operation module</u>	<u>Mainly focused on vegetation dynamics:</u> • "Canopy" • Snow • Soil • Subsurface Excess moisture runoff scheme <u>Recently completed with water rooting:</u> • Rivers • Lakes • Reservoirs	<u>Surface energy and water module :</u> • Canopy • Multilayer Snow • Multilayer Soil • Subsurface <u>Water rooting?</u>	<u>Vertical:</u> • Canopy • Snow melt • 2 soils layer • Subsurface <u>Horizontal:</u> • River • Lakes • Reservoirs
Climate period	1901-2009	1963-2002	1986-1995	1901-1998	1950-2008	1958-2001
Availability type	Observed	Observed	Observed[1]	Observed ?	Natural ?	Natural and observed[1]
Calibration	Calibration of the runoff exponent coefficient by watershed to fit mean annual observed discharge	Calibration of the runoff with a correction factor by watershed	Adjustment of subsurface runoff shape and time constant parameters, by climate zone	No calibration	??	No calibration

[1]Water consumption is explicitly abstracted from runoff, for each cell and is propagated downstream
[2]Water consumption is not explicitly included, but run-off are fitted to observed discharge

Hydrological models, first impressions

Model	Strengths	Weaknesses
WaterGap	• Evolving model. • Extensive set of publication • Transparency. • Evolved horizontal rooting	• No energy balance • Simple crop model (2 crops, but is it bad ?)
Composite Runoff (WFN)	• Simple water balance (but hard to find an explicit documentation)	• No explicit withdrawal/consumption modeling.
H08	• Clear documentation • Energy balance	• Spatial resolution (1°)
LPJmL	• Dynamic crop model	• Water rooting scheme poorly documented
GLDAS-2 (Aqueduct)	• Most physically based ?	• Lack of transparency. • No explicit modelling of consumption
PCR-GLOBWB	• Evolved vertical water balance	

Suggestions

- Selecting one model ?
  - *Dig into a short list of 2-3 models, extended description and compare results ?*

- Multimodel approach ?
  - *The range of results from model represent a distribution of possibles*
  - *Feasible ?*