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Supplement of

Graphical representation of global water models

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Table S1: Overview of actions of the progress and temporal context.

Date	Action
Jun 2016	HMS joined SG coordinating the global water sector
Nov 2016	Submission of ISIpedia proposal to ERA4CS (lead: Katja Frieler, PIK) with one key idea to support sectoral coordinators with funded staff to encourage modelling teams to participate in ISIMIP2 (for model simulations and assessments), HMS involved with a sub-project
Mar 2017	ISIpedia was funded, a 0.5 FTE position at GU Frankfurt was opened to work on the global water topic
Apr 2017	Ted Veldkamp presented at EGU 2017 a multi-model validation study based on ISIMIP2 and included in the presentation a collection of schematic diagrams from various GHMs. However, the different diagram types make it impossible to connect differences of model outputs to model components. The seed for a torough model review and a standardized diagram of the global water models was set.
2017	CET started to work on reviewing the global water models and creating diagrams
Oct 2017	Presentation of the general ideas for such a joint effort to describe the ISIMIP2b global water models by common diagram / documentation style at the ISIpedia kick-off workshop
Nov 2017	First structure and abstract about a model comparsion paper sent to Geoscientific Model Development (GMD) executive editors to ask if the idea would fit into the journal as a review paper
Dec 2017	Agreement of GMD executive editors that such a manuscript is in scope of GMD and that review is the suitable manuscript type
Dec 2017	SNG, HMS, CET were exchanging ideas for hosting a paper writing workshop, email SNG: "It would also be a great chance to discuss the global water model description paper we are currently preparing, which is working towards creating a central, published resource, which includes process diagrams for all the global water models participating in ISIMIP."
Jan 2018	CET started creating a list and tables of water storages and fluxes with the aim to get an overview but also to find icons for each component of the hydrological cycle to create a puzzle out of it to form a diagram
Feb 2018	ISIMIP coordinators opened a call for workshop proposals to boost collaboration and outcome production; joint submission of a proposal (SNG, HMS, CET) for a paper writing workshop in Frankfurt in July/August 2018 where the model review is one of the papers to be discussed
Mar 2018	CET presented the general idea and the "puzzle" approach to design a diagram to the working group Hydrology at GU Frankfurt. Also a, "draw a model diagram" exercise for the participants have been conducted with 3 defined rules: 1. Use all pre-defind hyrological processes, 2. decide how to represent each component of the water cycle, 3. write 3-5 ideas / recommendations of how to draw a Water Cycle.
Apr-May 2018	Discussion and modification of different versions of the water cycle components and diagram drafts between CET, HMS, Tim Trautmann, Claudia Herbert and SNG
May 2018	Mail to global water sector modelling teams with a draft of the model diagram and a paper outline with tables of fluxes & storages that builds mainly on the WaterGAP model (with whom HMS is very familiar) and invite to collaborate; received positive feedback from modelling teams
Aug 2018	Sectoral and inter-sectoral discussion about scope, audience, presentation, diagram drafts at the paper writing workshop Frankfurt. The in-person meeting was very important to exchange content but also to build trust and get-to-know each other
Sep 2018	Email to modelling teams with the feedback of the paper writing workshop, a draft of the resulting matrix diagram and upates of the tables; with mixed/reserved feedback about the matrix design.
Sep 2018	Presentation of workshop results at ISIMIP workshop with regards to the model review to the broader ISIMIP community to report on the current progres and get feedback
Oct 2018	Preparation of material for the ISIpedia workshop Krakow, in particular to define the audience of the diagrams
Nov 2018	Request to WaterGAP team (HMS, Tim Trautmann) to fill out the Tables (fluxes, storages, water use) for this model

Table S1 continued from previous page

Date	Action
Nov 2018	Next round of diagram drafts, realizing that drawing a diagram with the hydrological cycle requires a certain level of abstraction, which is in particular difficult for specific processes (e.g. link between canopy and soil, interaction with groundwater) and how these process is considered can differ between the models
Nov 2018	New idea of diagram structure: 1 conceptual diagram to represent the water cycle, 2 modelling diagram what happens in each model in a block scheme and 3 also including the definition of a mathematical notation of each component
Nov 2018	Presentation at ISIpedia stakeholder workshop and discussion to test the general idea and the standard diagram with a survey. Result: stakeholders did not understand the 3D format of the diagram and the symbols on it and suggested a format with full words on it (instead of mathematical notation)
Dec 2018	Documents to modelling teams sent around with detailed requests to fill in for each model; also with a definition of all variables for a common understanding
Dec 2019	Submission of EGU2019 abstract for first presentation of the idea to the broad scientific audience
Jan-Feb 2019	Preparing material for the ISIpedia stakeholder workshop in Burkina Faso
Mar-Apr 2019	The process to prepare around 100 tables (each flux within each storage) and a verbal description of each component as well as a mathematical symbol is coming to an end; Mail to modelling teams to collect the equations for snow and canopy send out
Jun 2019	Email to modelling teams to collect information for soil, glacier, groundwater, river, lake, wetland and reservoir storage
Jul 2019	Decision to split the model review into two parts: 1) the description & tables with equations for fluxes and storages and 2) the diagrams and focus on part 1
Jul 2019	Submission of AGU2019 abstract
Aug 2019	Email to modelling teams to collect information about the water use sectors
Oct 2019	Decision to work collaboratively in overleaf instead of Word to collect and homogenize the equations for each model, with support from Sam Rabin (fire-mip activity)
Nov 2019	Sending around filled out canopy and snow equation tables to the modelling teams for review. Decision to put the equation tables as a supplement to the paper for length and technical reasons
Jan 2020	Submission of EGU2020 abstract and of JpGU-AGU2020 abstract
Feb 2020	Email to modelling teams to review and correct the equations (except water use)
Apr 2020	Email to modelling teams to review and correct the equations for water use
Jun 2020	First draft of the paper sent to co-authors
Aug 2020	Second draft of the paper sent to co-authors
Oct 2020	Third draft of the paper sent to co-authors
Nov 2020	Submission of paper to GMD
Jan 2021	CET & HMS exchange ideas to continue with the model diagram part and agreed to: 1. to send the current draft to modellers for feedback and agreement, 2. to find a graphics desinger to produce a professional version of the diagram, 3. to draw 16 individual diagrams, 4. to write a paper; email to modelling teams sent out with intended structure and workplan
Jan 2021	WT suggested to contact Marlo Garnsworthy as graphics designer; we got into contact and arranged work relations
Mar 2021	Email to modelling teams to inform about the continued efford and for having a joint virtual meeting (modelling teams and graphics designer); deciding that we would like tho show an "optimal ISIMIP2b model" and 16 individual models in the similar style
Apr 2021	First diagram version of the vertical water balance
May 2021	GMD accepted the model review paper
May 2021	First diagram version of surface water body storages
Jun 2021	Model review paper has been published in GMD
Jul 2021	Second diagram version from vertical water balance
Jul 2021	First diagram version of the Main water cycle
Jul 2021	Email to modelling teams with first drafts of the diagrams and a paper outline and ask for feedback. Idea to have a "best model representation" and individual model diagrams where only those processes are drawn that are represented; a "Main" diagram, the vertical water balance and the lateral water balance.

Table S1 continued from previous page

Date	Action
Sep 2021	Email to co-authors with the collected feedback and invite for a virtual meeting
Oct 2021	Virtual meeting modelling teams, with decicions to not continuing with the horizontal water balance part and also further discussions e.g. how to draw groundwater to avoid misconception
Nov 2021	Email to graphics designer with result of the modelling team discussion and wishes for modification of the diagrams
Dec 2021	Recieving next drafts of the diagrams
Dec 2021	Email to co-authors with the next iteration of the diagrams and ask for feedback; recieving lots of detailled feedback & suggestions
Feb 2022	CET left the leading role, HMS took over the lead
Feb 2022	Consolidation of feedback from co-authors on the diagram and send modification requests to the graphics designer
Feb 2022	Discussion between HMS and SNG about paper outline and about the idea to grey out the parts that are not represented in the individual models
Mar 2022	Next iterations of the diagrams, including the WaterGAP with grey-outs as a proof of concept
Apr 2022	Setting up overleaf document for the paper; HMS identified the components of the review paper from the individual models that should be greyed out
Apr 2022	Email to co-authors to review the revised standard diagram and to review the individual models with the intended greying out parts and to answer model-specific questions for clarification
Apr - Jun 2022	subsequent individual interactions with the modelling teams to clarify remaining questions
Jun 2022	Invite for a paper writing workshop in Frankfurt to discuss (among other papers) about the model diagram paper
Aug 2022	Email to the graphics designer with the collected feedback to draw the individual diagrams with the greyed out components
Sep 2022	Discussion about the individual diagrams and the paper outline at the paper writing workshop Frankfurt
Jan 2023	Email to co-authors to recieve a final check of the standard diagram and the individual model diagrams as well as a feedback on the paper outline
Jan 2023	HMS developed the idea of a script-based generation of the individual model diagrams based on binary information about each model (represented or not) and asking the graphics designer for the individual signatures and background images to test the script
Nov 2023	First draft of paper circulated in the core writing team (HMS, SNG, LM)
Dec 2023	Email to the co-authors with abstract for EGU2024 and information that a manuscript draft is in development
Jan 2024	Extraction of the single elements and backround from the graphics designer for developing the Python script to automatize diagram generation
Jan 2024	Next iteration of the paper draft within the core writing team
Jan 2024	Further development of the python script to create the model diagrams and decision to use this as the source for the figures in the paper
Jan 2024	Email to co-authors with the paper draft, to insert/condense information in an online spreadsheet to clarify which flux/storage is included in the model or not (basis for the information to create the individual diagrams)
Mar 2024	Discussion of next paper draft within core writing team
Mar 2024	Discussion of the paper at the paper writing workshop in Mainz
Apr 2024	Email to the co-authors with the next version of the paper draft, approval
May 2024	Submission of the manuscript to GMD

Table S2: Conferences and title of presentation where the content of the topic was presented and discussed.

Conference	**Description**
Apr 2019, EGU	12.4.2019: EGU2019-6212 Understanding each other's models: a standard representation of global water models to support intercomparison, development, and communication by Camelia Eliza Telteu et al.
Dec 2019, AGU	10.12.2019: H21O-1958 Co-design of a Water Cycle Diagram to Discover Similarities and Differences among Global Water Impact Models by Camelia Eliza Telteu et al.
May 2019, EGU	7.5.2019: EGU2020-7549 Similarities and differences among fifteen global water models in simulating the vertical water balance by Camelia-Eliza Telteu et al.
Jul 2020, JpGU-AGU	12.-14.7.2020: AHW30-P05 Similarities and differences among ten global water models in modelling water use by Camelia Eliza Telteu
Apr 2024 EGU	18.4.2024: EGU24-6462 Graphical representation of global water models participating in the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b) by Hannes Müller Schmied et al.

Table S3: Workshops and title of presentation where the content of the topic was presented and discussed.

Date	Workshop
Oct 2017	9.-10.10.2017: ISIMIP/ISIpedia workshop; Camelia Telteu: Ideas for a joint effort to describe the ISIMIP2b global water models by common diagram /documentation style
Jul 2018	30.7.-1.8.2018: ISIMIP global water sector paper writing workshop, Frankfurt; 3 h presentation and discussion time: Description of the hydrological cycle through 11 models included in the global water sector of the Inter-Sectoral Impact Model Intercomparison Project phase 2b (ISIMIIP2b)
Sep 2018	24.9.2018: ISIMIP Strategy Group Meeting, Potsdam
Jun 2019	14.6.2019: cross-sectoral ISIMIP workshop, Paris; Camelia Telteu: Understanding each other's models: a standard representation of global water models to support intercomparison, development, and communication
Jun 2020	15.-18.6.2020: cross-sectoral ISIMIP online Workshop, Camelia Telteu: Understanding each other's models: a standard representation of global water models to support intercomparison, development, and communication
Sep 2022	21.-22.9.2022: ISIMIP global water sector paper writing workshop, Frankfurt, Hannes Müller Schmied: Visualization of ISIMIP2b global water models
Mar 2024	18.-20.3.2024: ISIMIP joint-sectorial paper-writing workshop, Mainz; Hannes Müller Schmied & Simon Gosling: Graphical representation of global water models participating in the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b)
Apr 2024	22.-26.4.2024: cross-sectoral ISIMIP and PROCLIAS Workshop, Hannes Müller Schmied: Graphical representation of global water models participating in the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b)

Table S4: ISIpedia stakeholder interaction workshops and participants.

Date	Description
Nov 2018	Krakow, Poland with 14 stakeholders from 10 countries, 4 modellers
Feb 2019	Ouagadougou, Burkina Faso with 41 stakeholders from 15 countries, 4 modellers

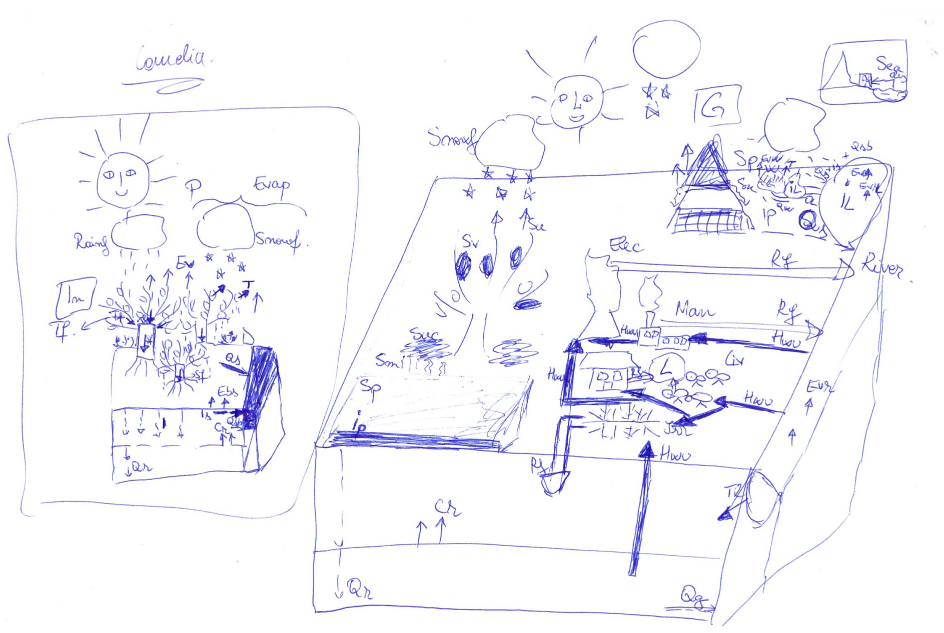

Figure S1. Draft of a water cycle, created within a meeting of members of working group hydrology, Goethe University Frankfurt in March 2018. After an introduction to the idea, the task was to draw a water cycle with a pen and paper. The collected drawings have been the basis for understanding what a drawing could look like. Creator: CET.

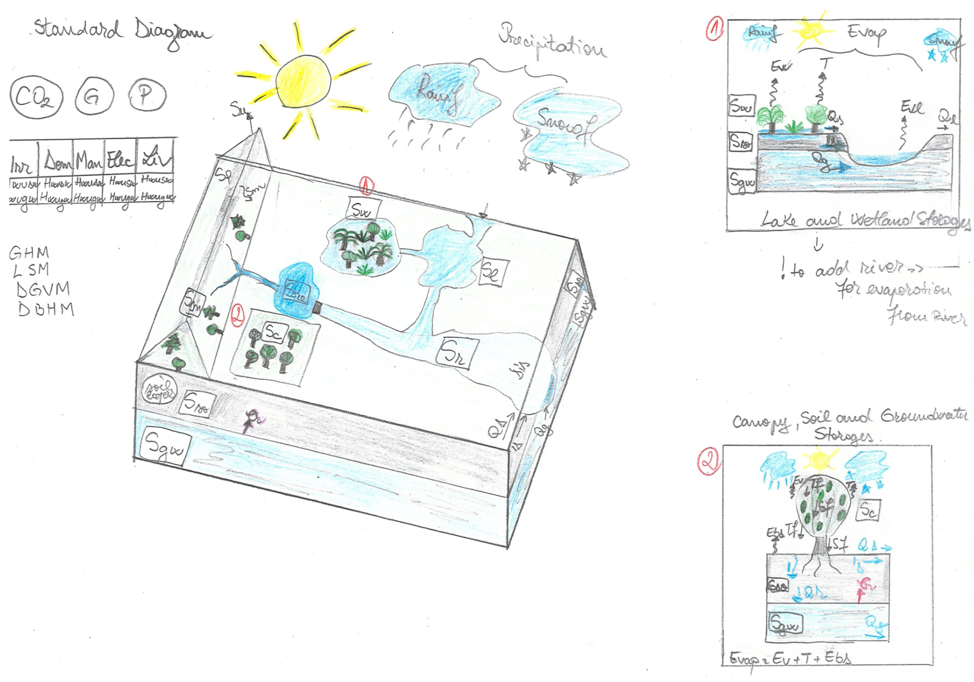

Figure S2. This version of the water cycle diagram from May 2018 was sent around to the modelling teams in order to visualize the idea and to invite for joining this effort. Creator: CET.

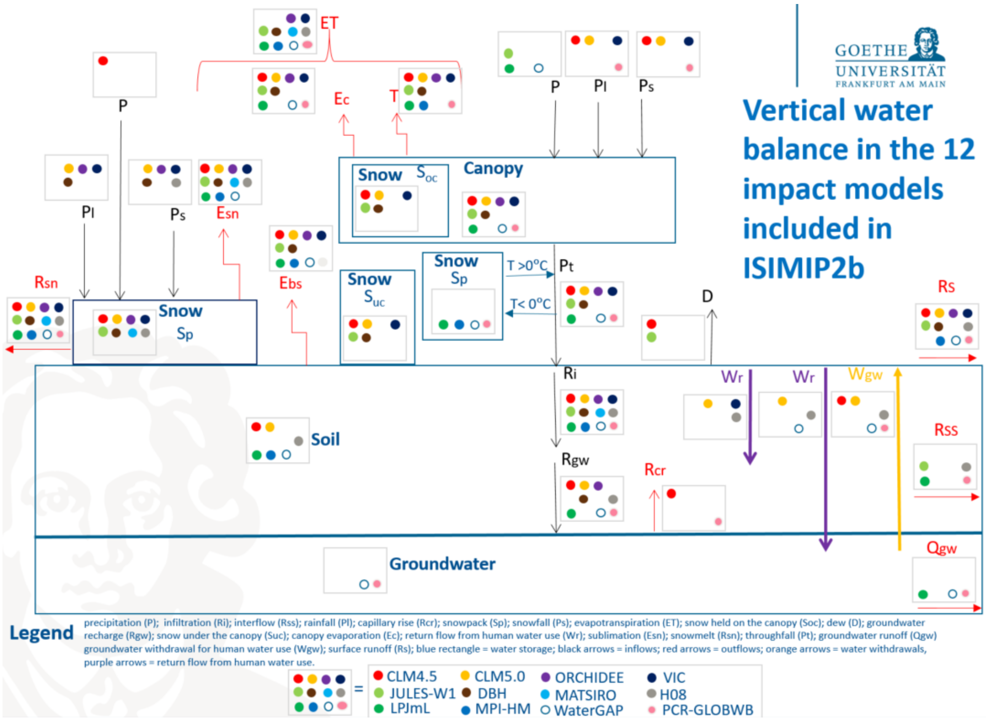

Figure S3. In the paper writing workshop Frankfurt, we thought on trying for a more abstract, schematic drawing (September 2018). The draft here shows, which models represent certain components of the water cycle. However this way was perceived as not very intuitive to understand from both, audience of a ISIMIP workshop presentation but also for the modelling teams and was thus not continued. Creator: CET.

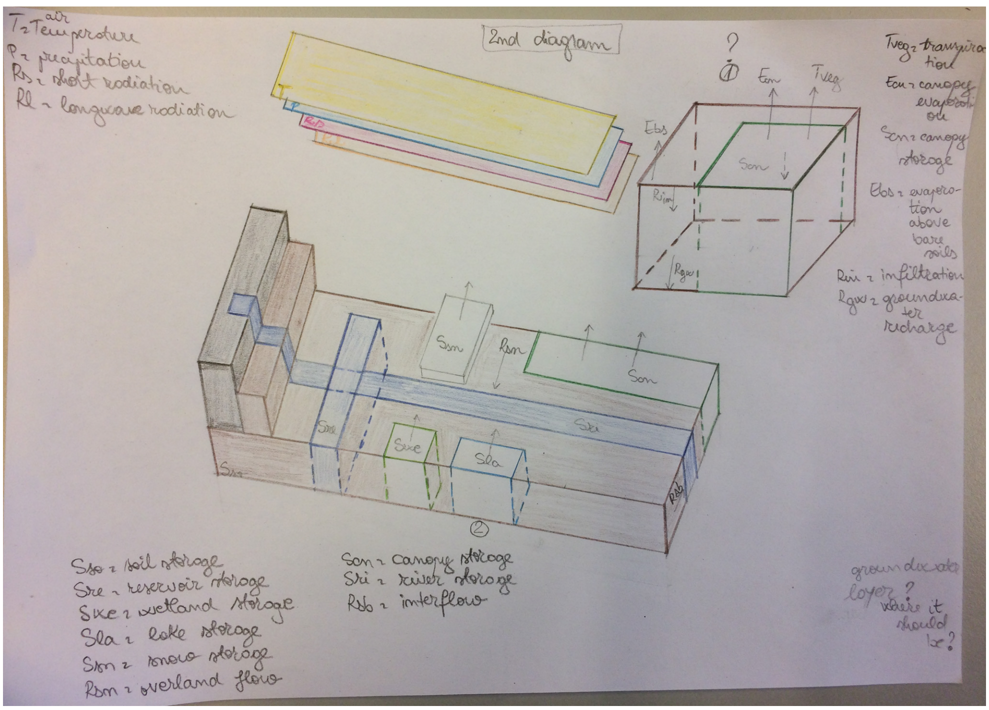

Figure S4. Still following the idea of a schematic representation of the water cyce, this figure (created November 2018) was shown jointly with Fig. S2 and Fig. S5 as potential way to visualize the global water cycle as represented by the models. The intention fo these diagrams was to imitate the schematic and abstract way of representing the real world in a model. However, also here, the level of abstraction was perceived as too high as feedback from the ISIpedia stakeholder workshop and thus not continued. Creator: CET

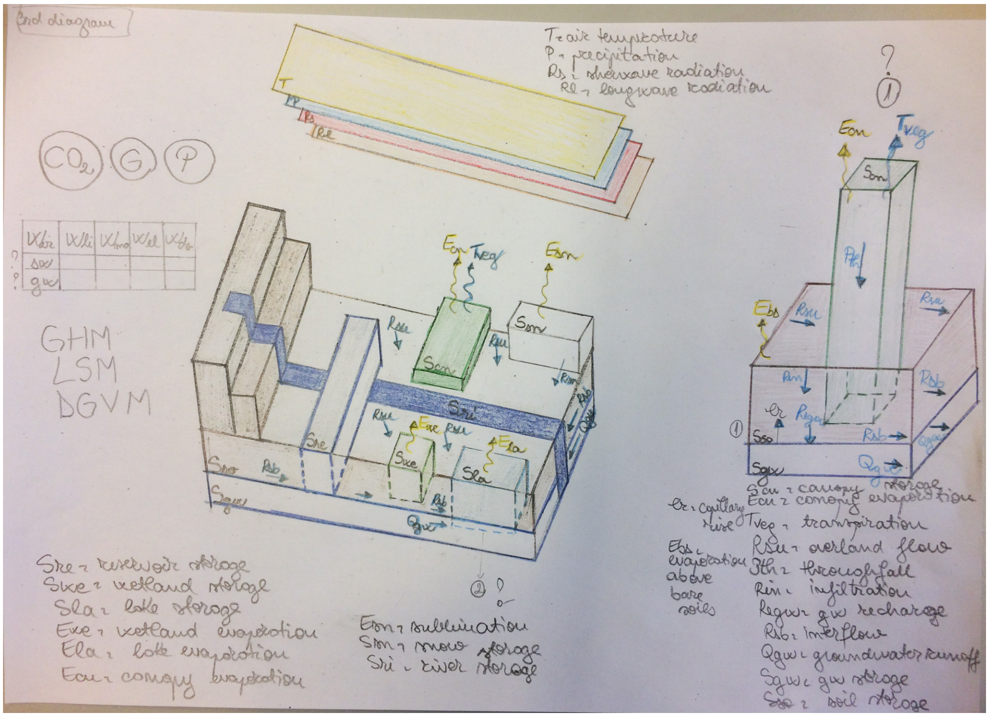

Figure S5. As for Fig., S4 but with more mathematical symbols included - intended to serve better understanding but workshop participants were not convinced. Creator: CET

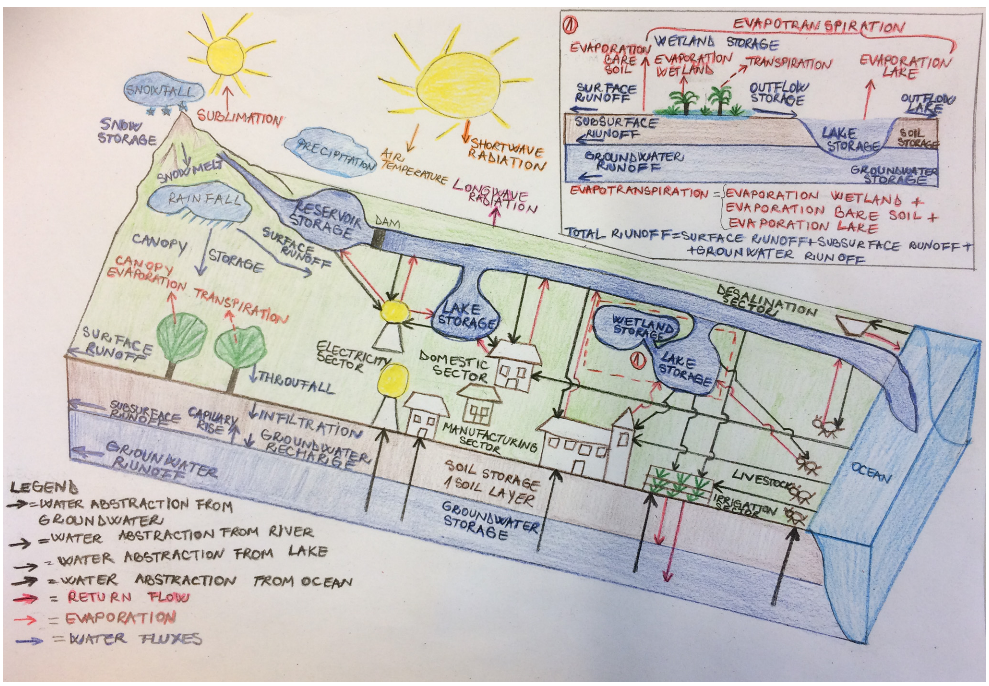

Figure S6. Diagram from Feb 2019 as a result of both, the interactions in the first ISIpedia stakeholder workshop but also with the modelling teams. A more realistic diagram with written out descriptions. Used as input for the second ISIpedia stakeholder workshop. Creator: CET

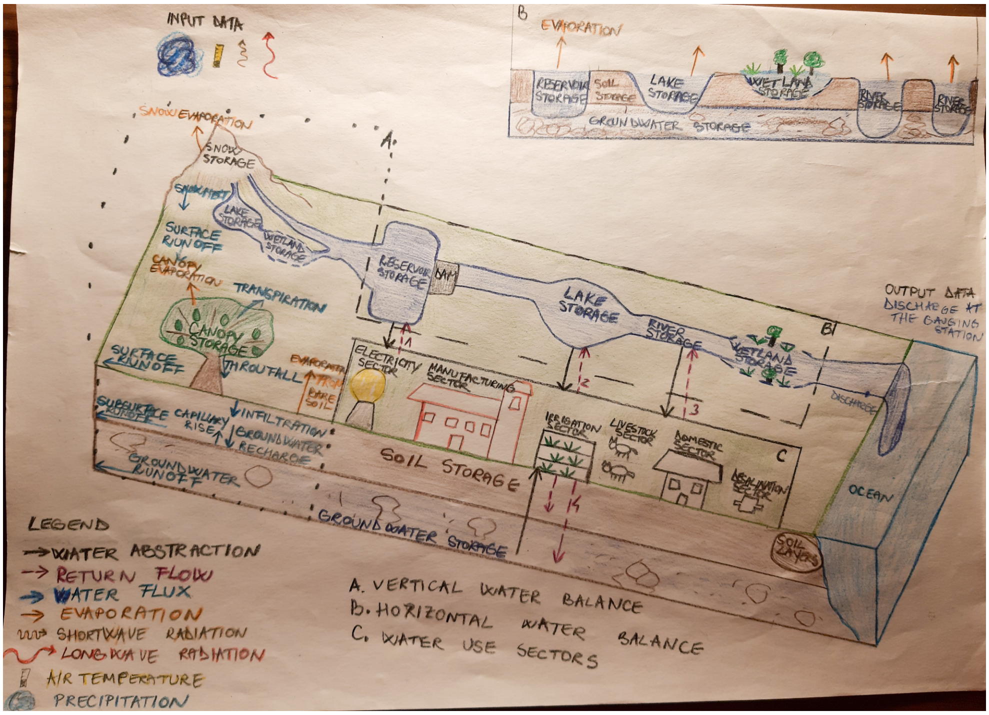

Figure S7. Draft of a diagram from Jan 2021 which was a result of the ongoing discussion within the modelling teams. Here, we focused on showing the main water cycle but also sections of vertical and lateral water balance components as well as the human water use sectors. Creator: CET

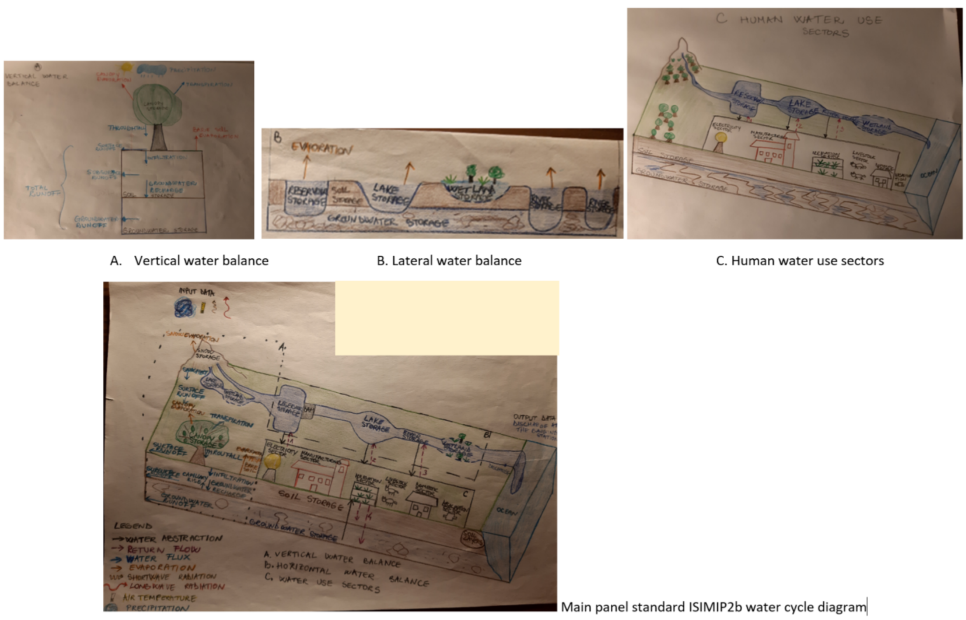

Figure S8. These diagrams from March 2021 served as input for the graphics designer. At this stage, the idea was to provide the main diagram (bottom) and join it with subfigures that show the vertical and lateral water balance but also specificly the human water use sectors. Within the following discussion and on basis of the professional designed diagrams, we agreed to include the lateral water balance and human water use sectors into the main diagram and to show only the vertical water balance as a subfigure. Creator: CET

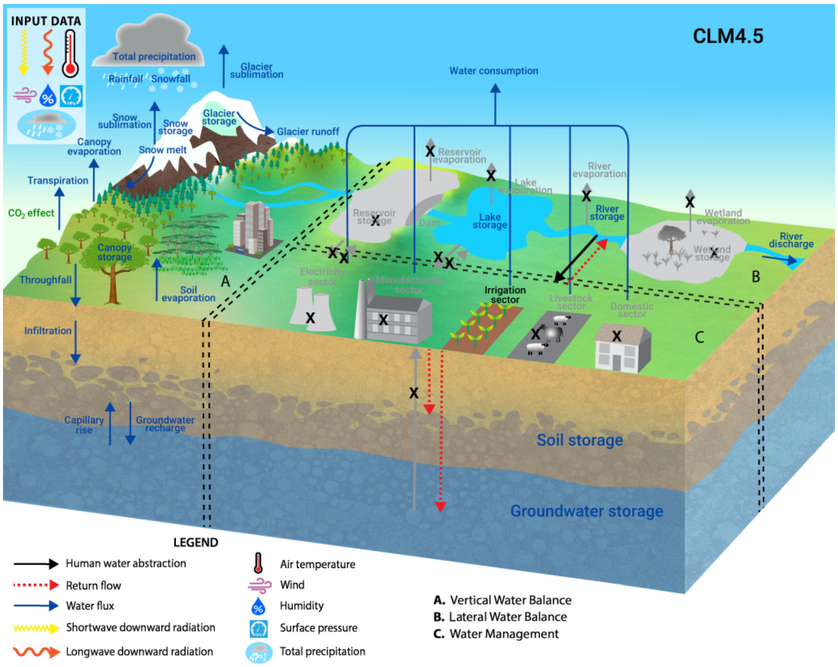

Figure S9. The "CLM4.5" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey). Please note that lake evaporation is computed in terms of the surface energy balance as the latent heat flux. But it does not affect the lake water balance as it is deliberately counteracted by an equally large flux with opposite sign, to avoid drifting lake levels. River storage and river discharge is calculated by MOSART. The irrigation module from CLM is taking the water from the river storage, the irrigation flux is transferred between both models through the coupler.

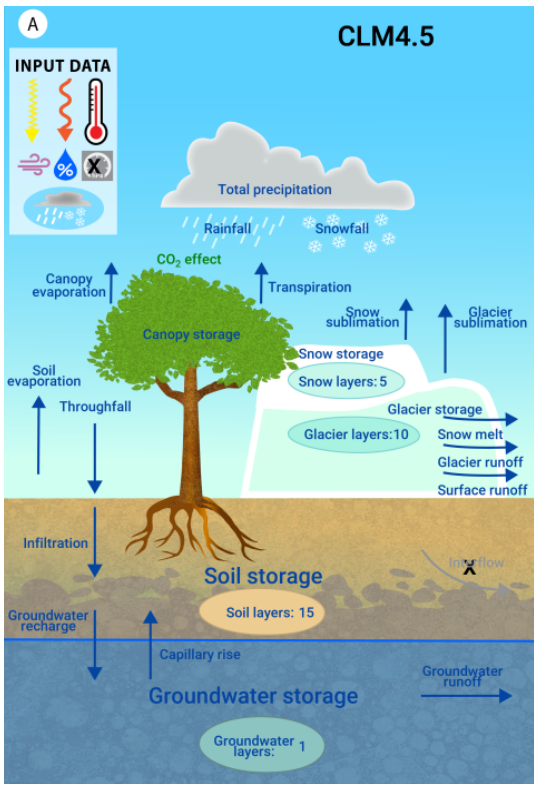

Figure S10. The "CLM4.5" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

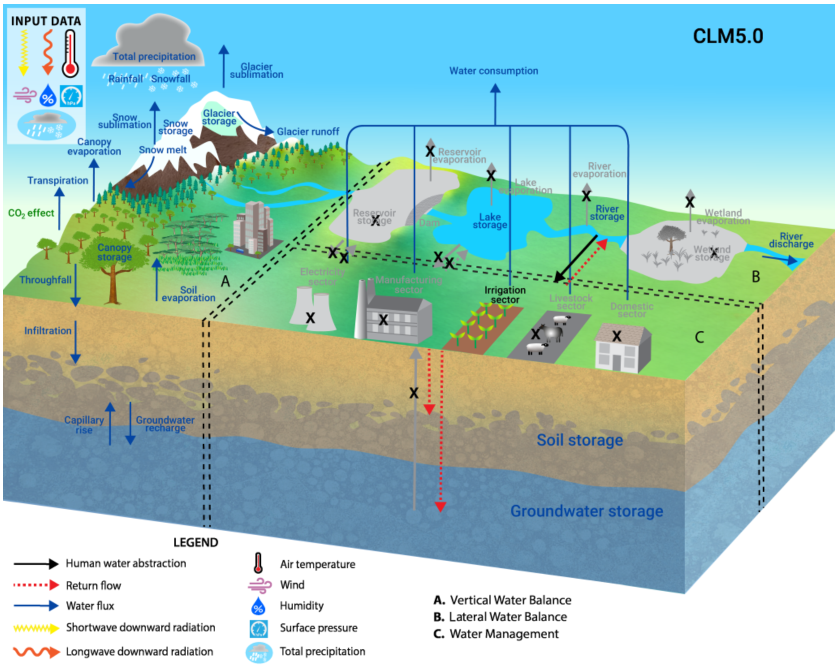

Figure S11. The "CLM5.0" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey). Please note that lake evaporation is computed in terms of the surface energy balance as the latent heat flux. But it does not affect the lake water balance as it is deliberately counteracted by an equally large flux with opposite sign, to avoid drifting lake levels. River storage and river discharge is calculated by MOSART. The irrigation module from CLM is taking the water from the river storage, the irrigation flux is transferred between both models through the coupler.

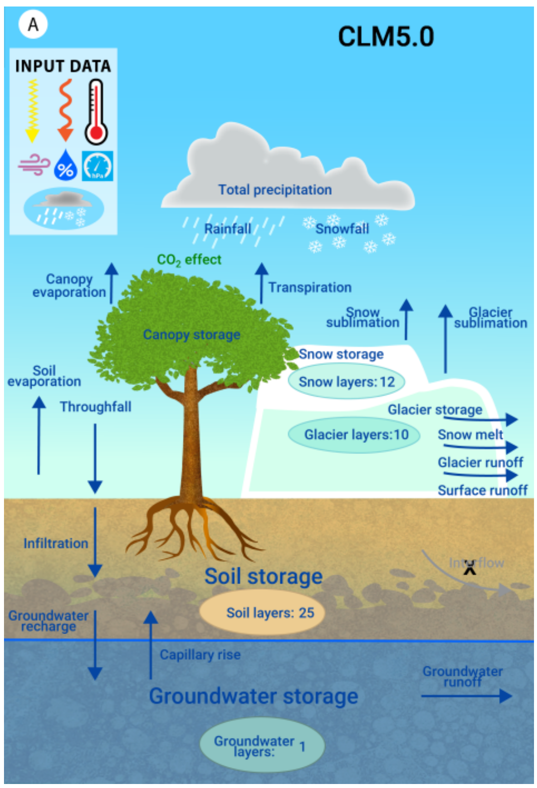

Figure S12. The "CLM5.0" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

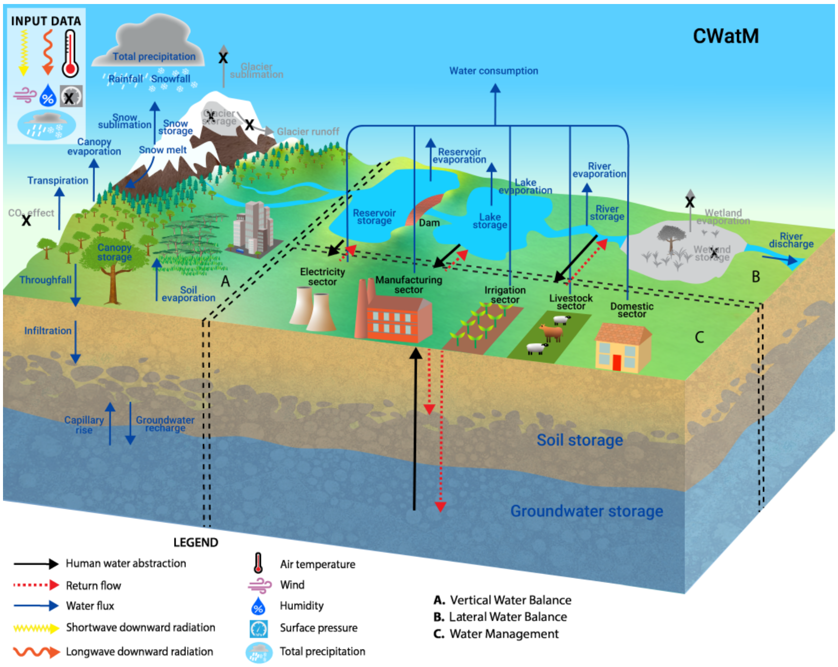

Figure S13. The "CWatM" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

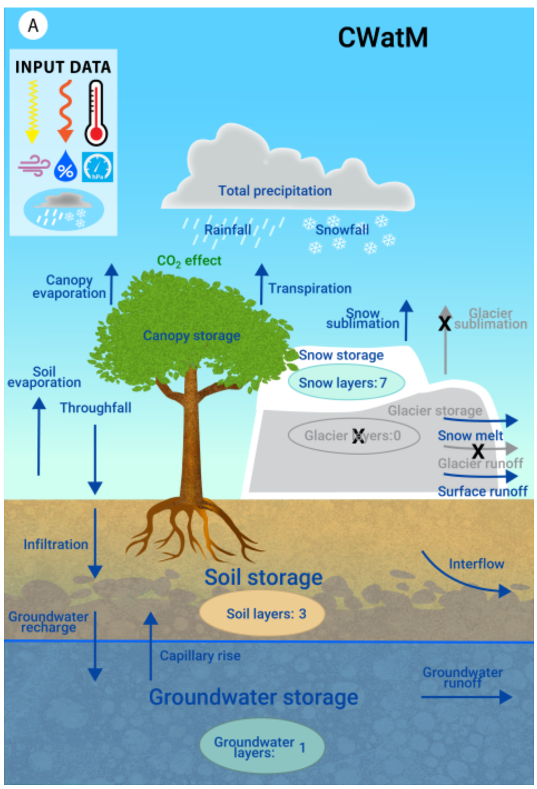

Figure S14. The "CWatM" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

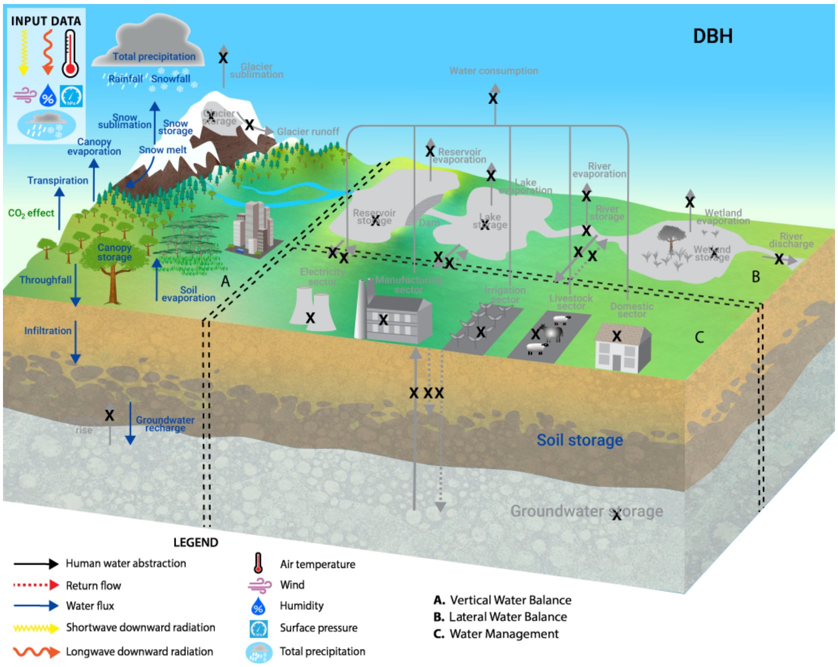

Figure S15. The "DBH" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

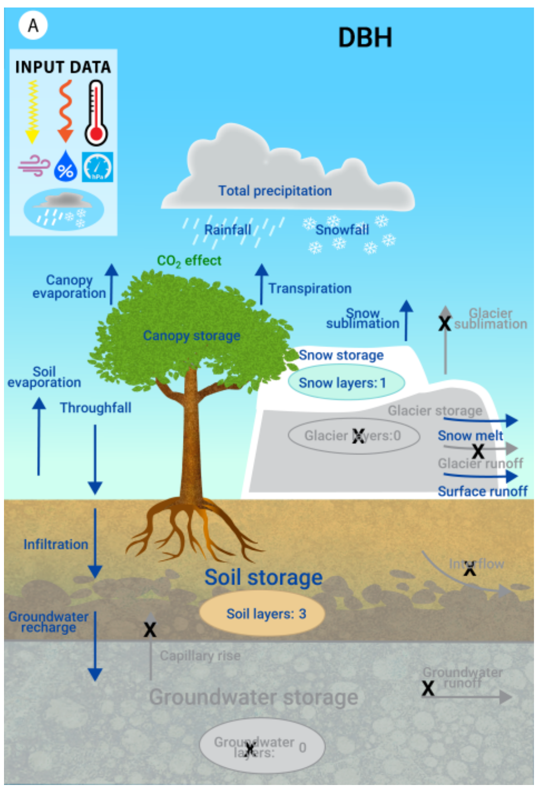

Figure S16. The "DBH" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

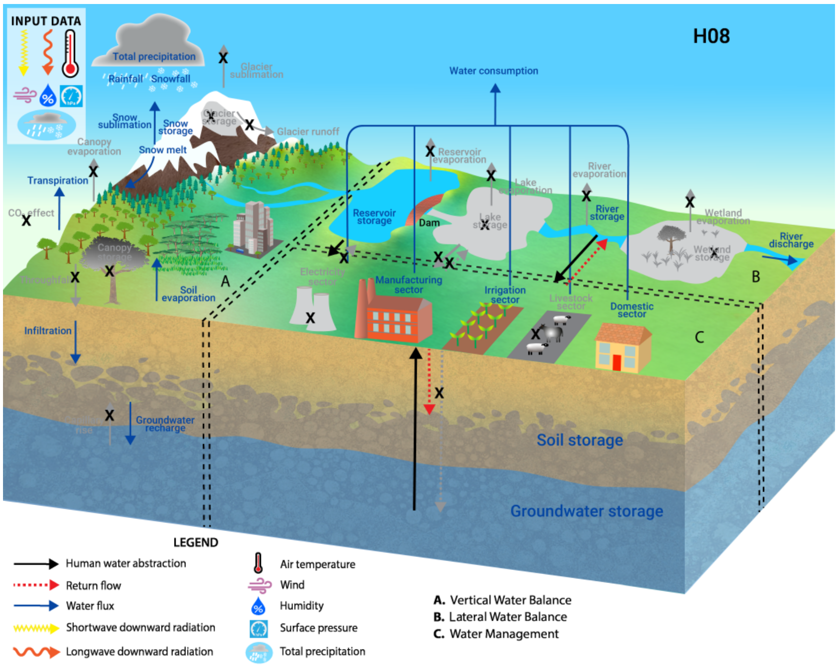

Figure S17. The "H08" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

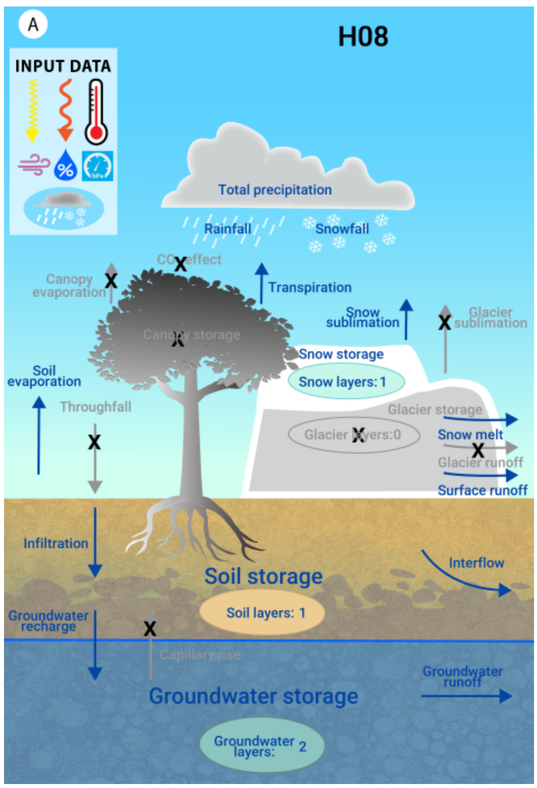

Figure S18. The "H08" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

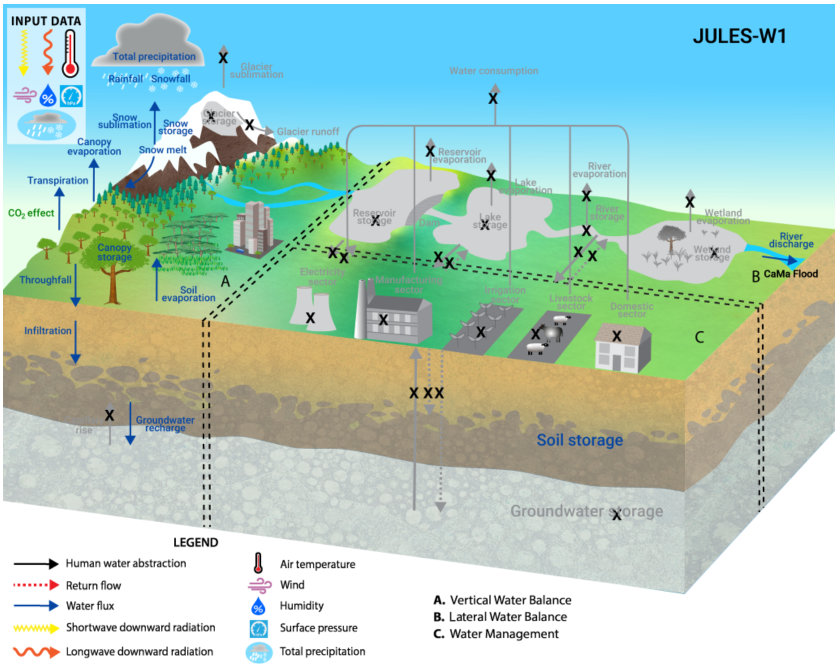

Figure S19. The "JULES-W1" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

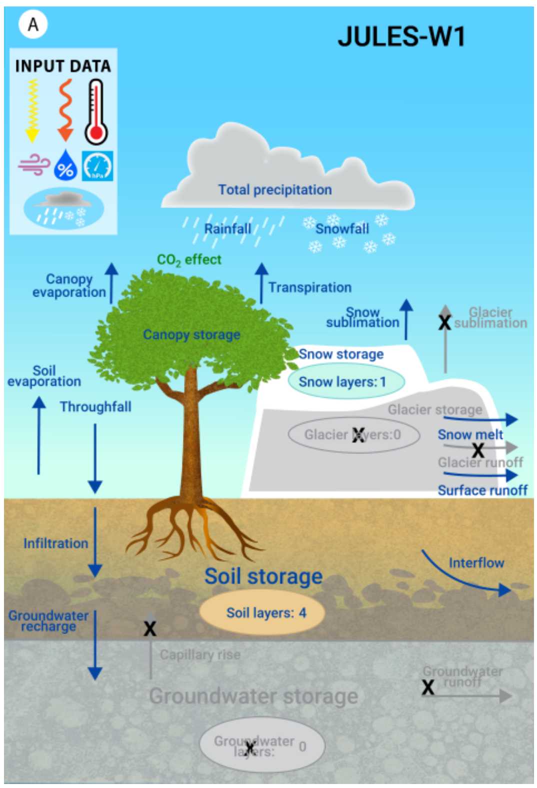

Figure S20. The "JULES-W1" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

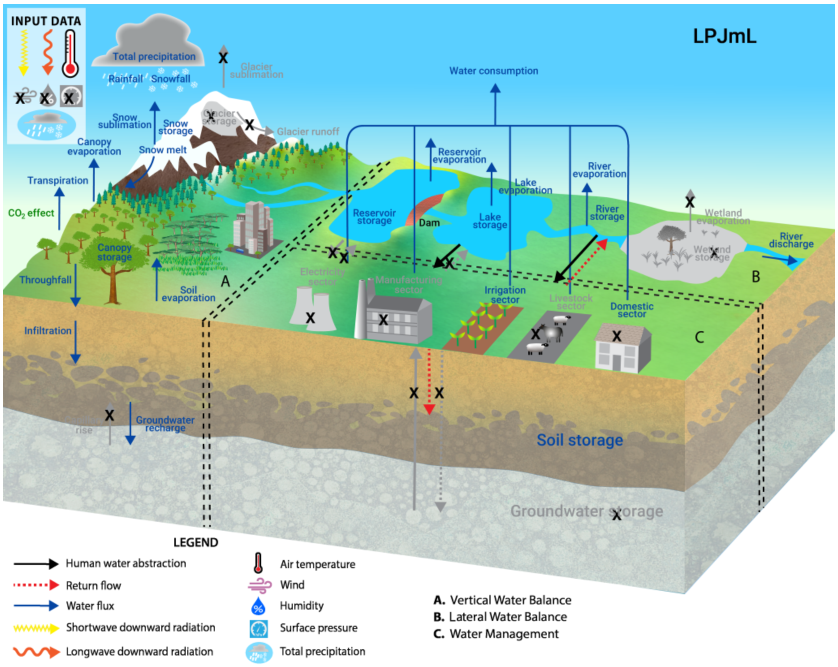

Figure S21. The "LPJmL" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey). Domestic sector is not simulated by the model itself but considered as input data.

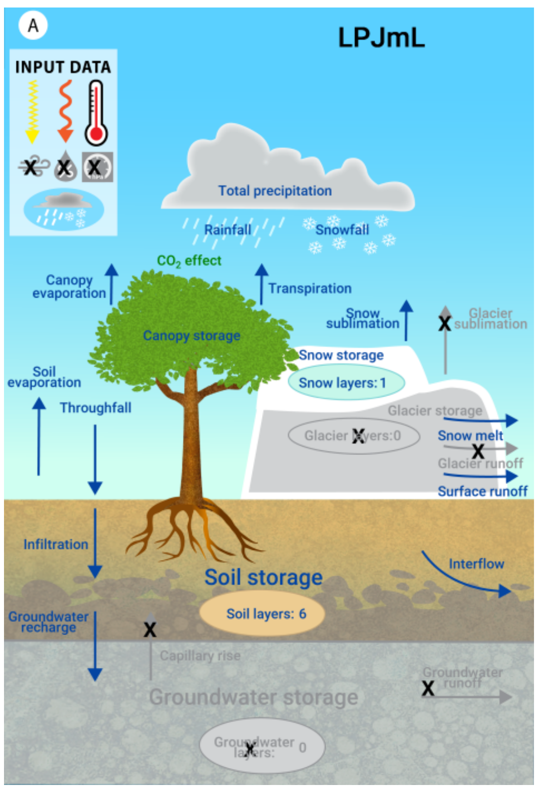

Figure S22. The "LPJmL" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance. There 5 hydrological active layers and the 6th is a thermal layer.

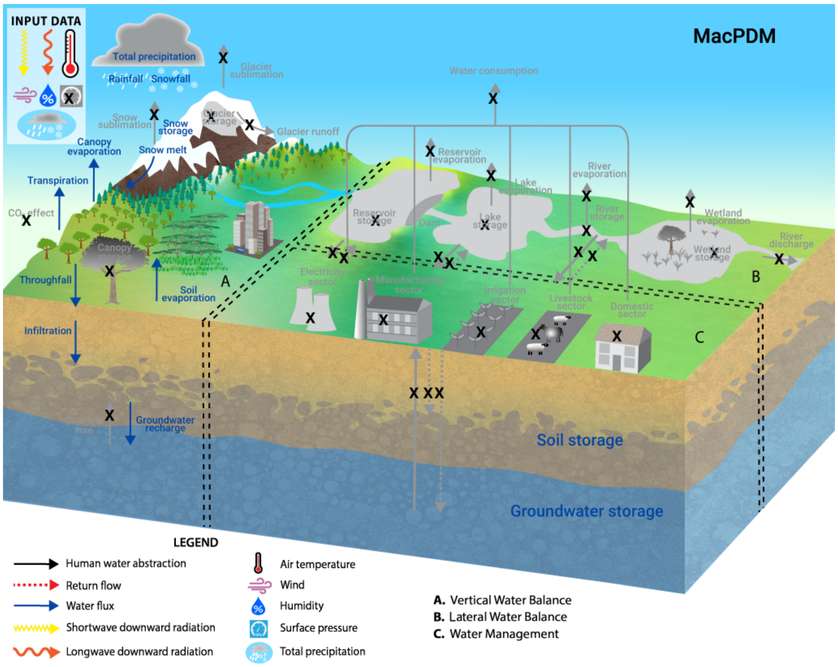

Figure S23. The "MacPDM" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

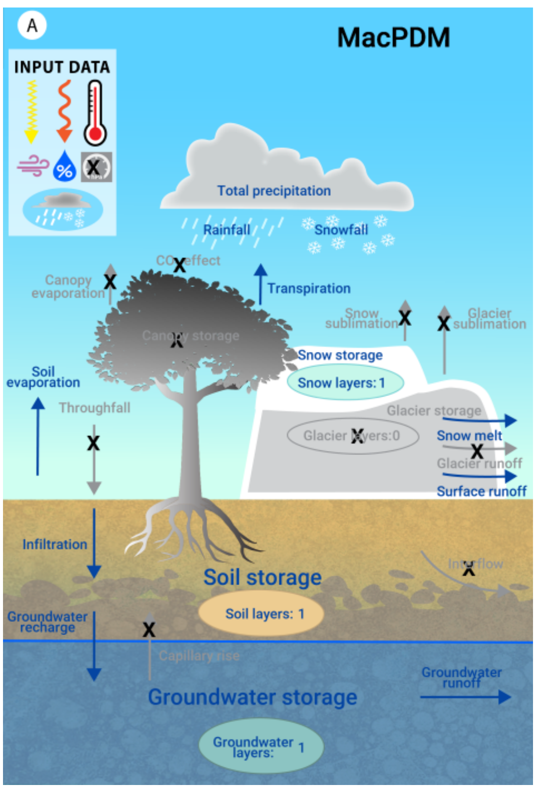

Figure S24. The "MacPDM" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

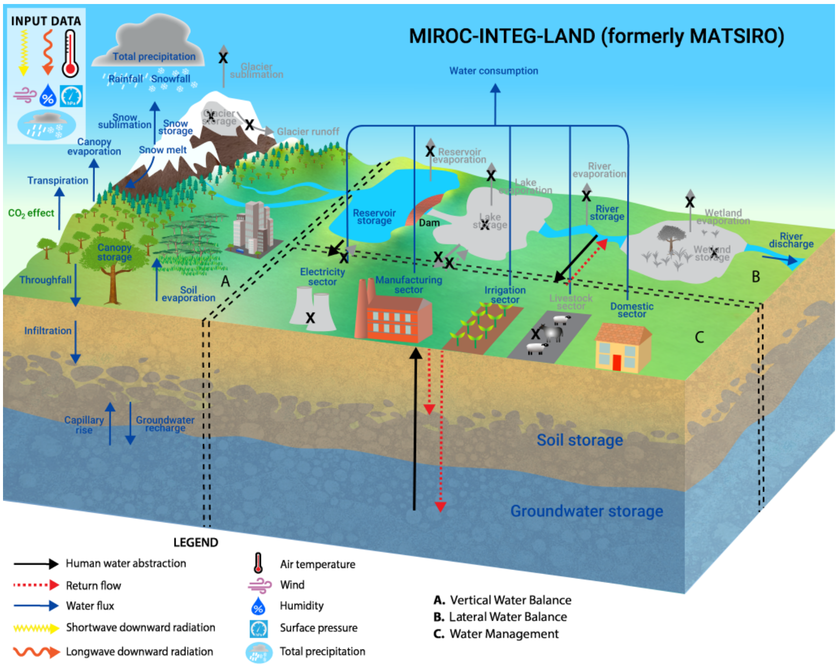

Figure S25. The "MIROC-INTEG-LAND (formally MATSIRO)" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

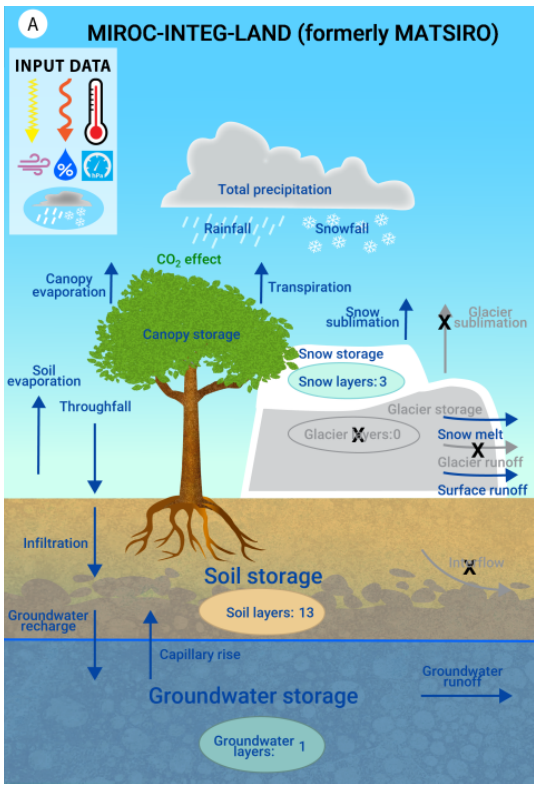

Figure S26. The "MIROC-INTEG-LAND (formally MATSIRO)" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance. MATSIRO does not separately deal with groundwater storage and soil layer. Saturated soil layer (separated in up to 13 layers) is regarded as groundwater storage.

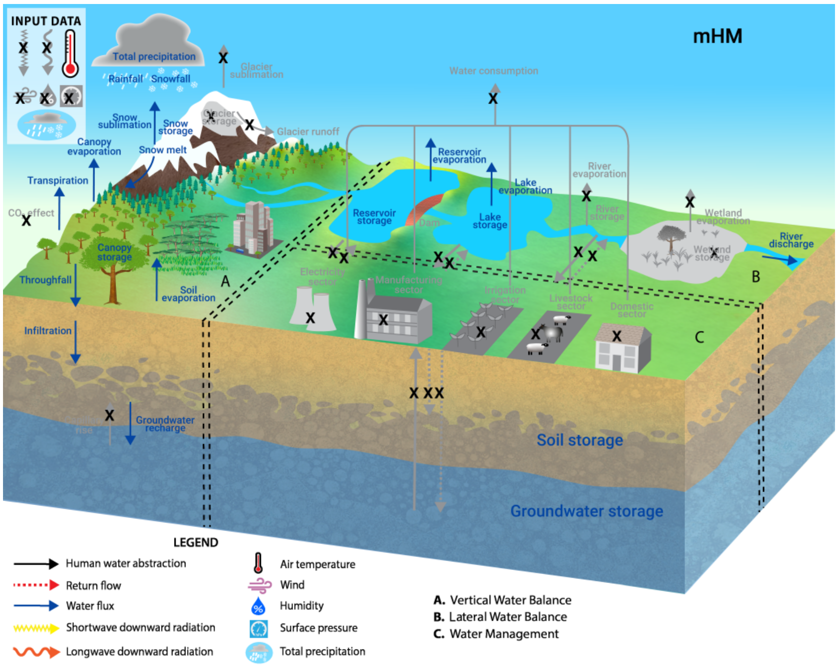

Figure S27. The "mHM" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

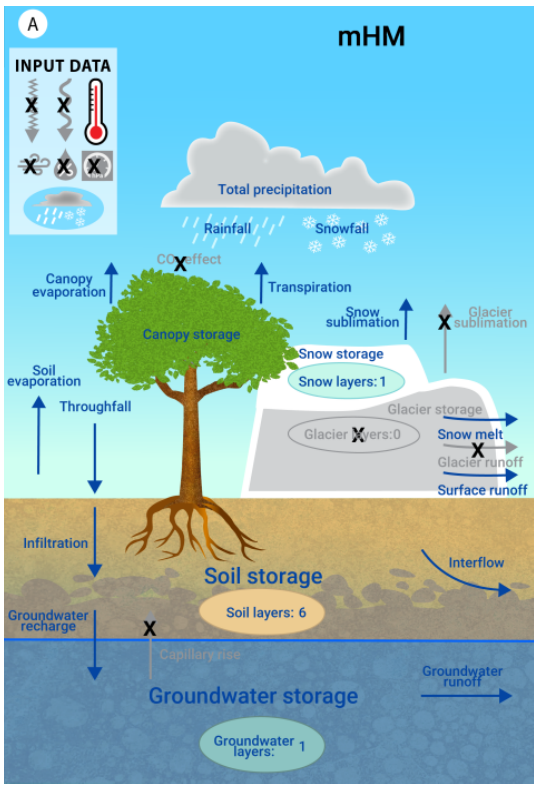

Figure S28. The "mHM" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

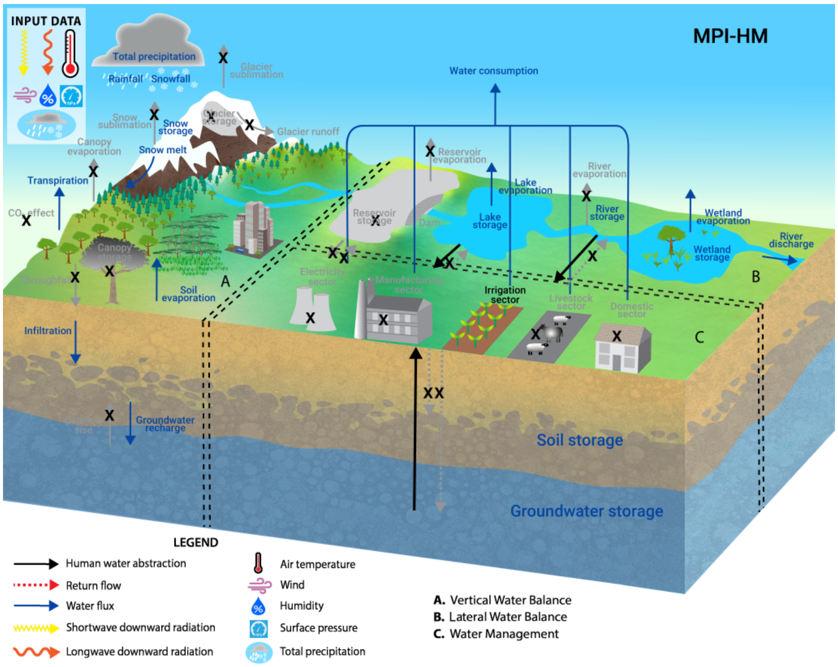

Figure S29. The "MPI-HM" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

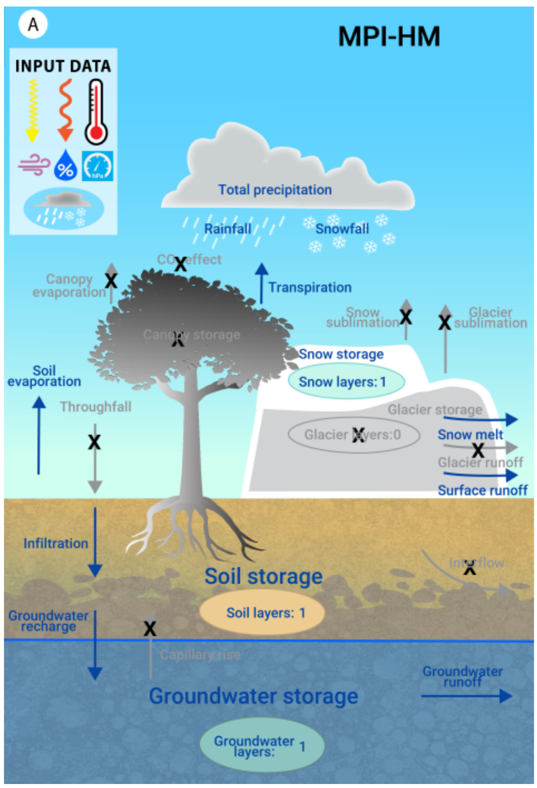

Figure S30. The "MPI-HM" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

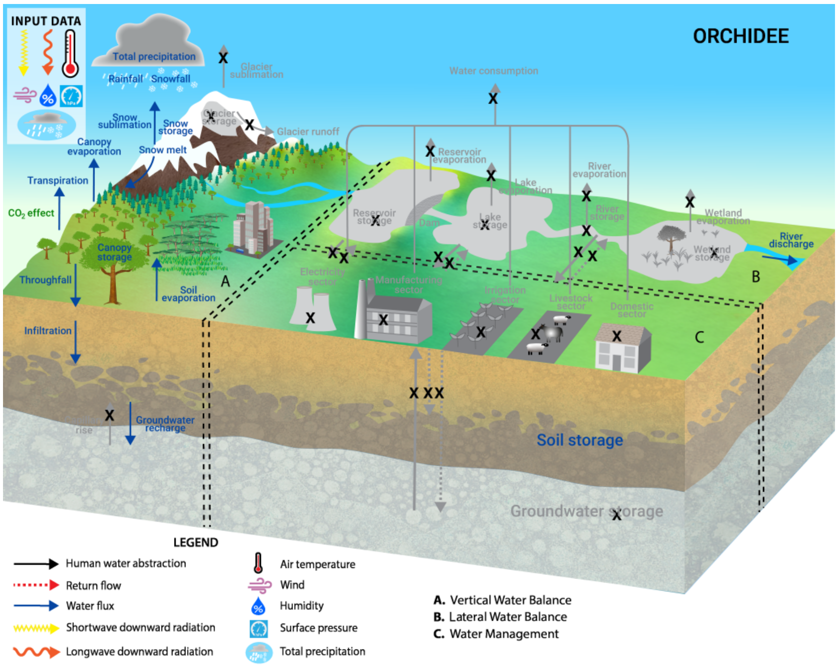

Figure S31. The "ORCHIDEE" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

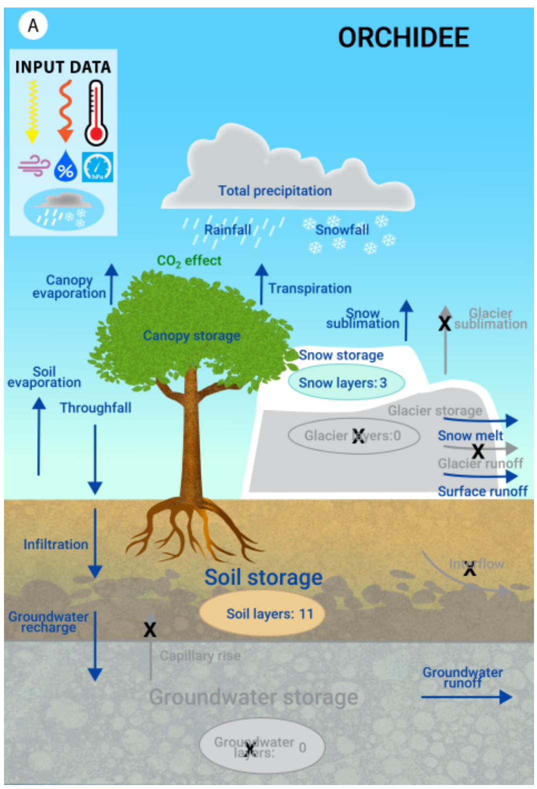

Figure S32. The "ORCHIDEE" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

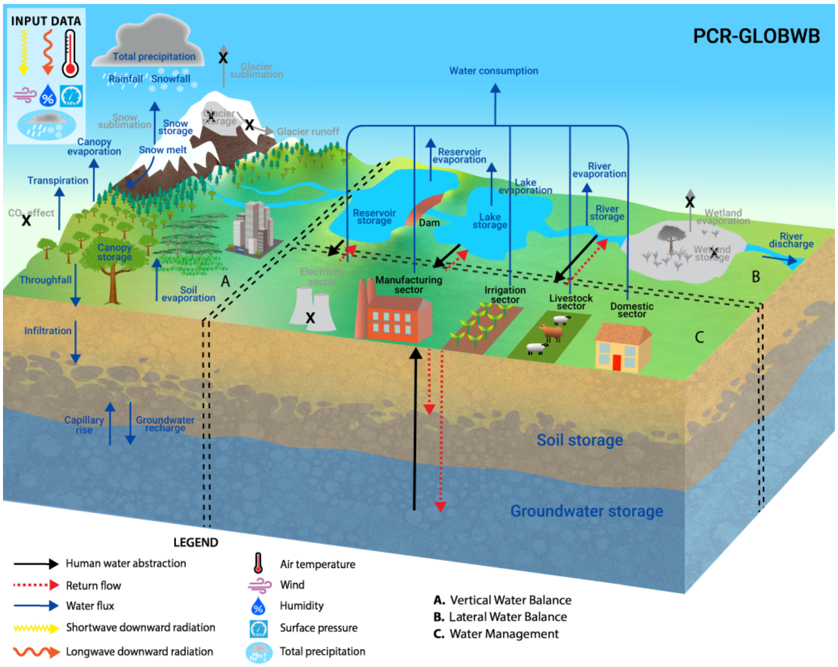

Figure S33. The "PCR-GLOBWB" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

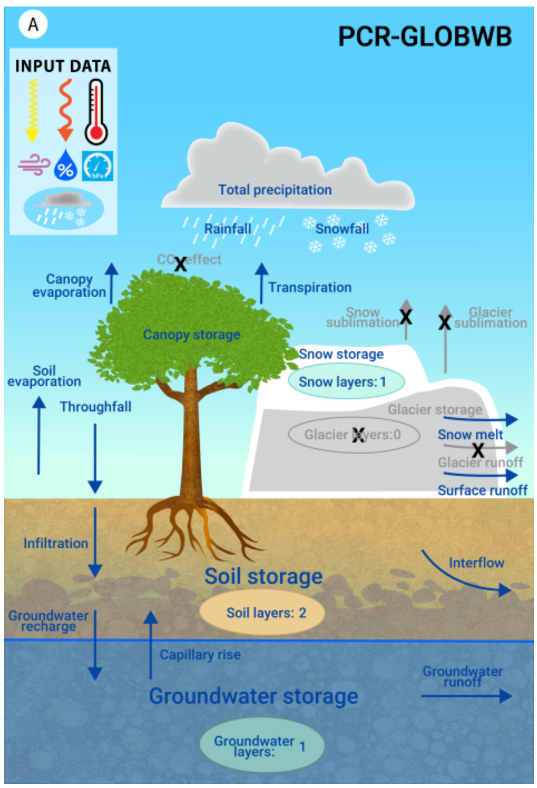

Figure S34. The "PCR-GLOBWB" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

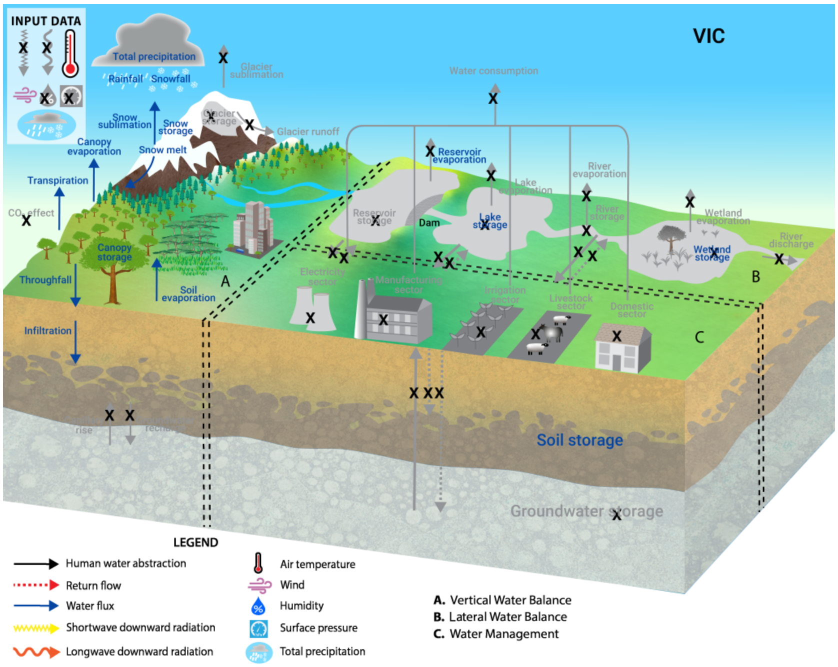

Figure S35. The "VIC" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

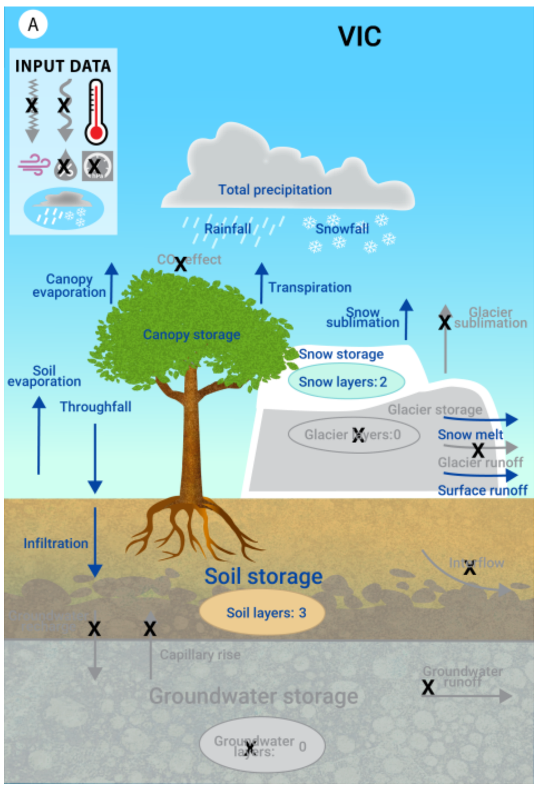

Figure S36. The "VIC" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

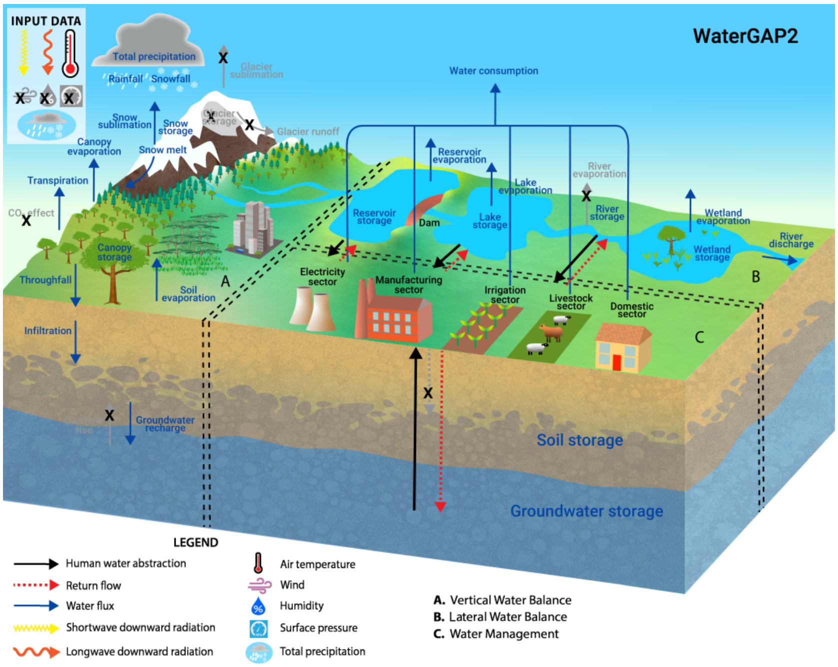

Figure S37. The "WaterGAP2" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

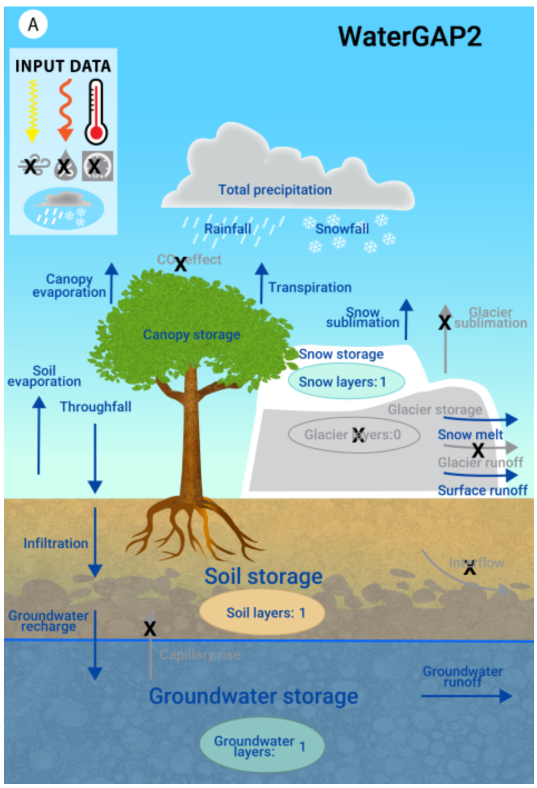

Figure S38. The "WaterGAP2" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.

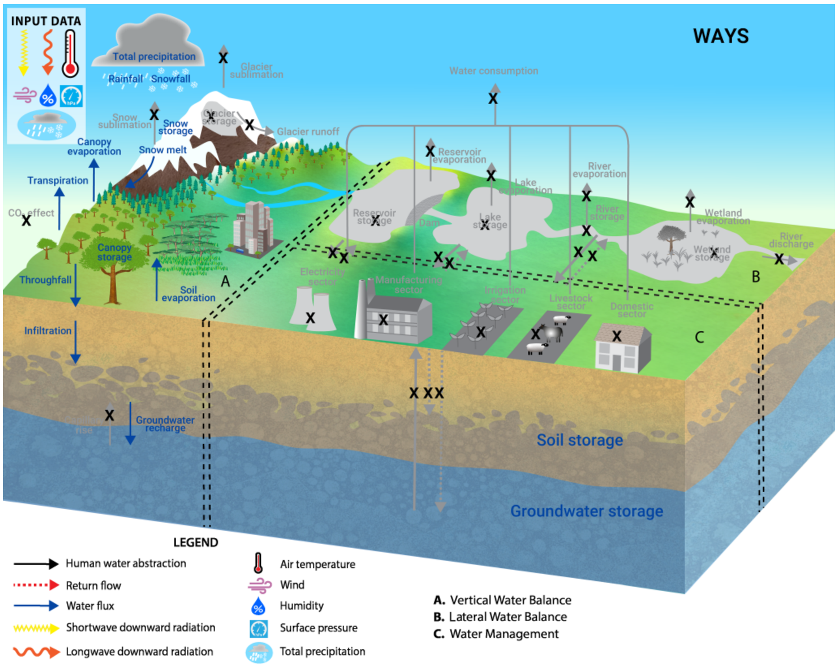

Figure S39. The "WAYS" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey).

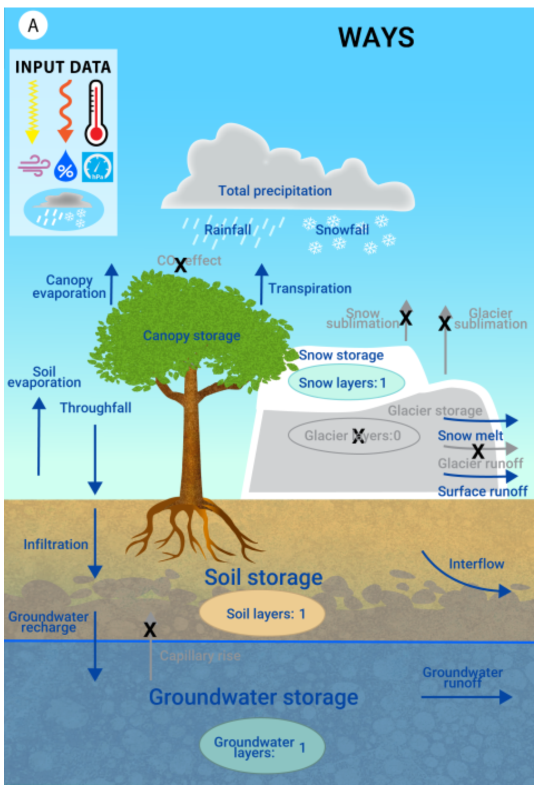

Figure S40. The "WAYS" model representation of included components (fluxes, storages and processes) (shown in color) and of components that are not represented (shown in grey) for the vertical water balance.