Development of global 1 km hybrid 3-D hydrological model and associated land surface datasets for regional and global climate modeling

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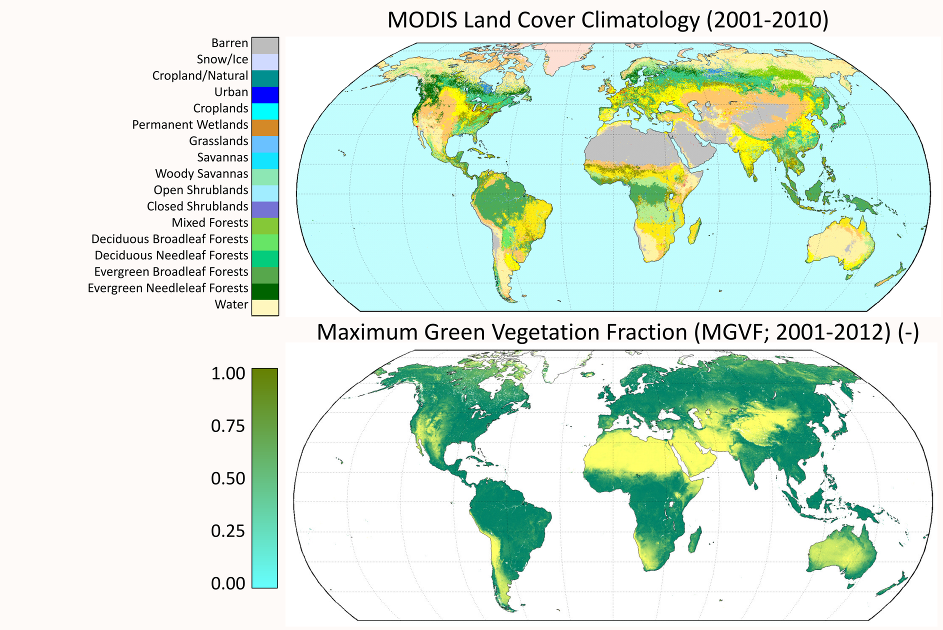
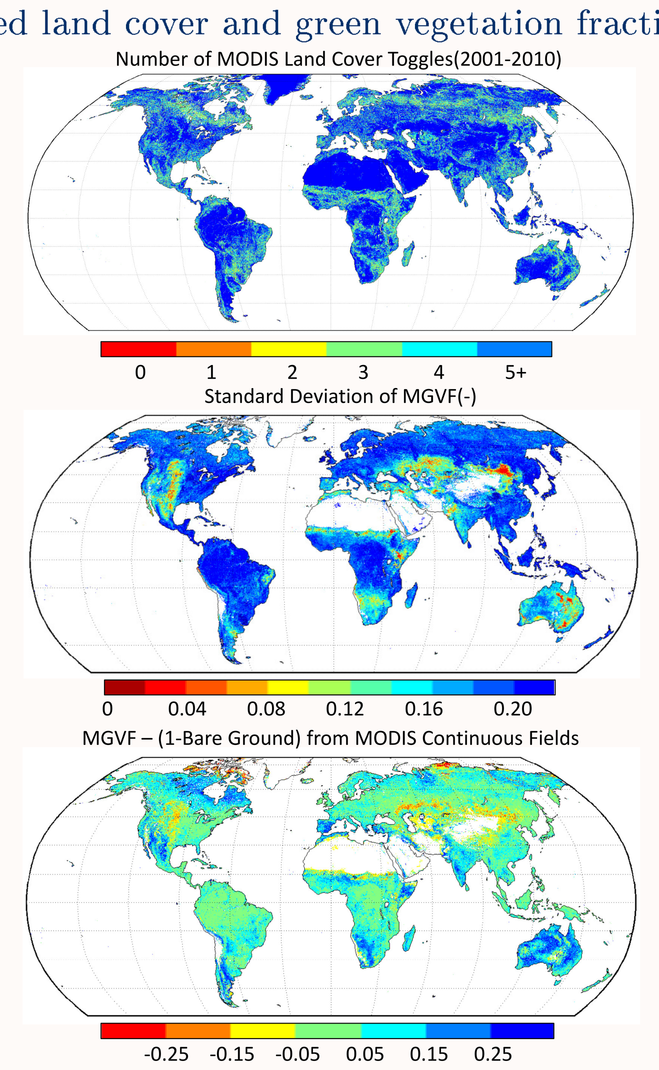
1. Motivation

The increase in computational power enables us to more accurately represent important **small-scale horizontal hydrological processes**. A **grand challenge in hydrological science** is therefore the **efficient high-resolution hydrological modeling.**

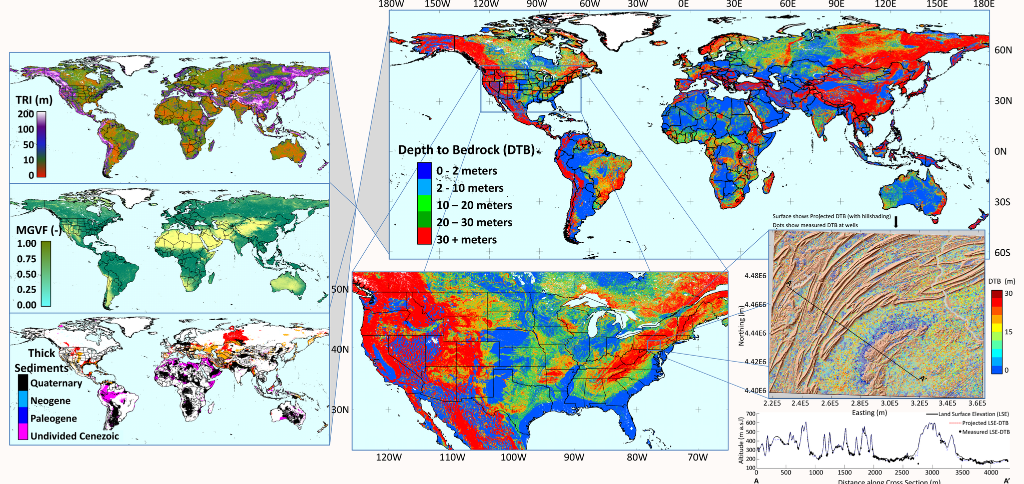
2. Global dataset development



Modis based land cover and green vegetation fraction

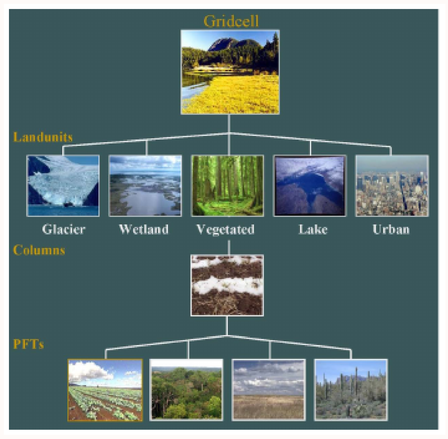


Toggling between different land cover types (top), the interannual variability of MGVF (middle), and comparison to the bare ground continuous fields (bottom)

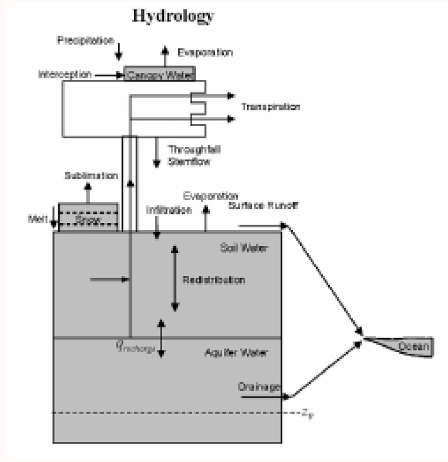


Global depth to bedrock estimated at 1 km^2 pixel resolution

4. Current hydrology in CLM

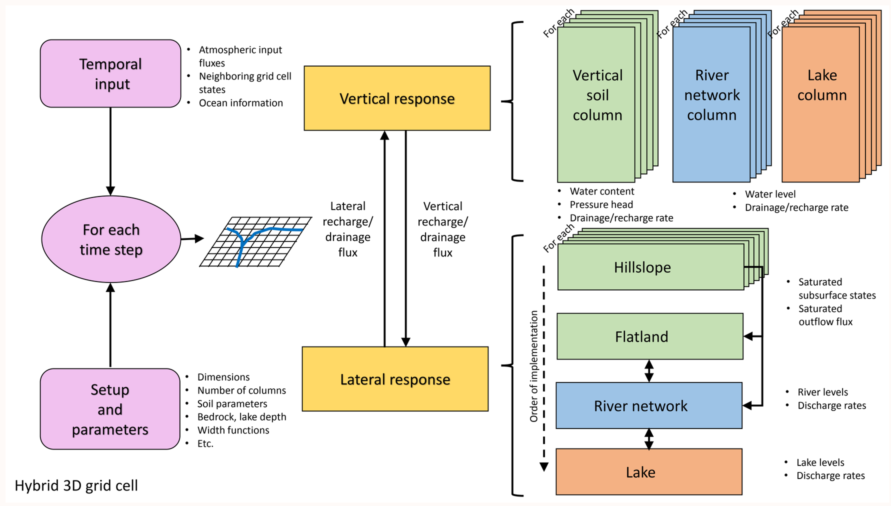


Subgrid variability



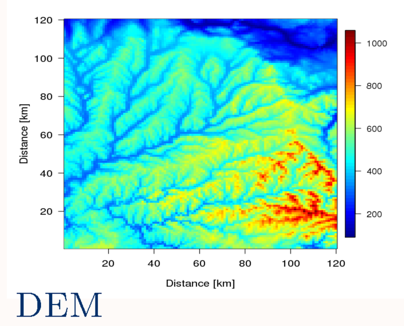
Vertical hydrological representation

6. Computational implementation

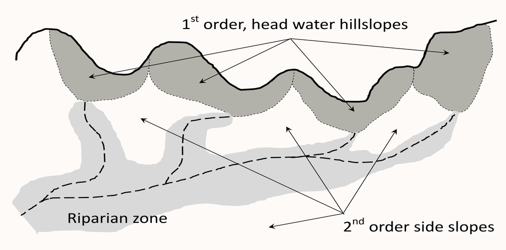


Differentiation between vertical response (CLM) and high-resolution lateral hydrological response

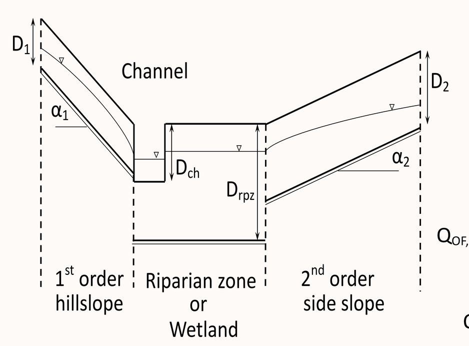
5. Our new hybrid 3-D approach



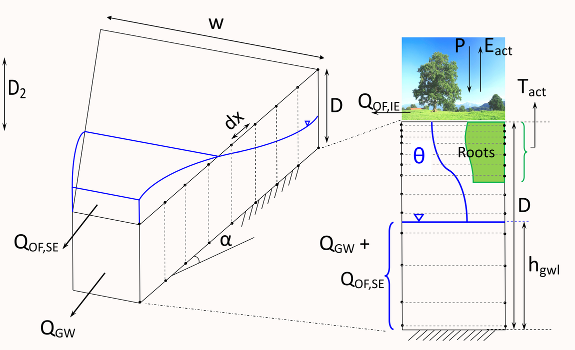
DEM



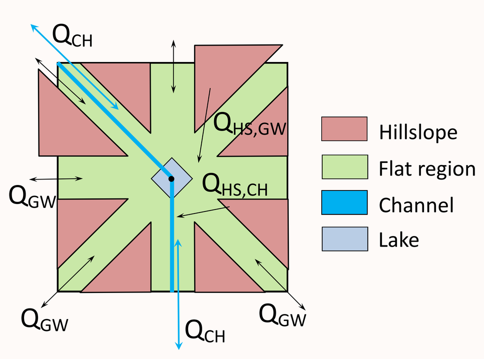
Perceptual model



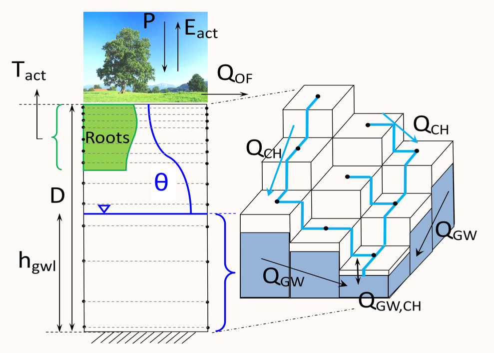
Conceptual model of 1 km^2 pixel



Hillslope response



Pixel representation

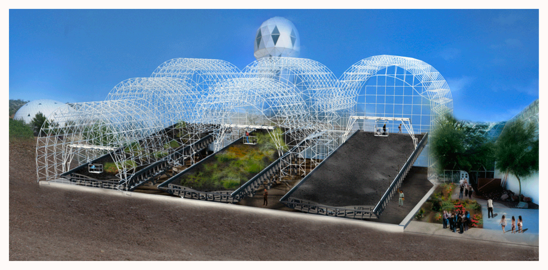


Pixel interactions

9. Preliminary conclusions

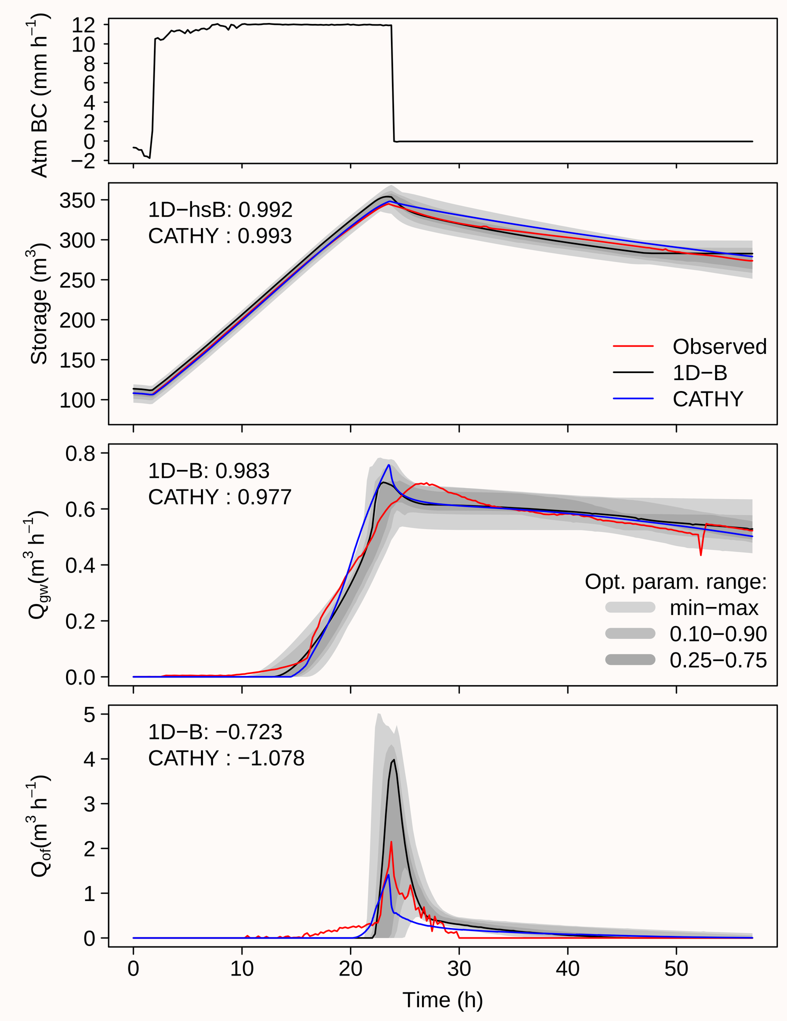
- **We have developed a preliminary framework to represent the horizontal hydrological response at the 1 km pixel level using a physically based approach, while taking sub-pixel information into account (e.g. hillslopes, riparian zones, wetlands, river network).**
- The lateral **1 km pixel** information is then aggregated to enable **interaction** with a **globally variable average vertical soil column in the ESM grid box** and hence with the atmosphere in ESMs.
- By taking a hybrid 3-D approach our new algorithm is **computationally efficient**.
- As part of our project **we have developed high-resolution global datasets (e.g. depth to bedrock, hillslope width, land cover and green vegetation fraction)** needed to run the model.

7. Small-scale testing



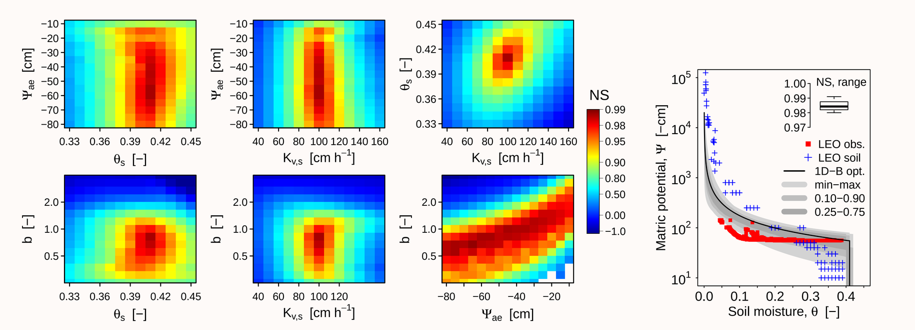
The landscape evolution observatory (LEO) of Biosphere 2

- Ensuring the hybrid 3-D approach is properly tested for a controlled indoor experiement.



Observed and simulated storage and runoff behavior of hybrid 3-D approach and the 3-D Richards model CATHY

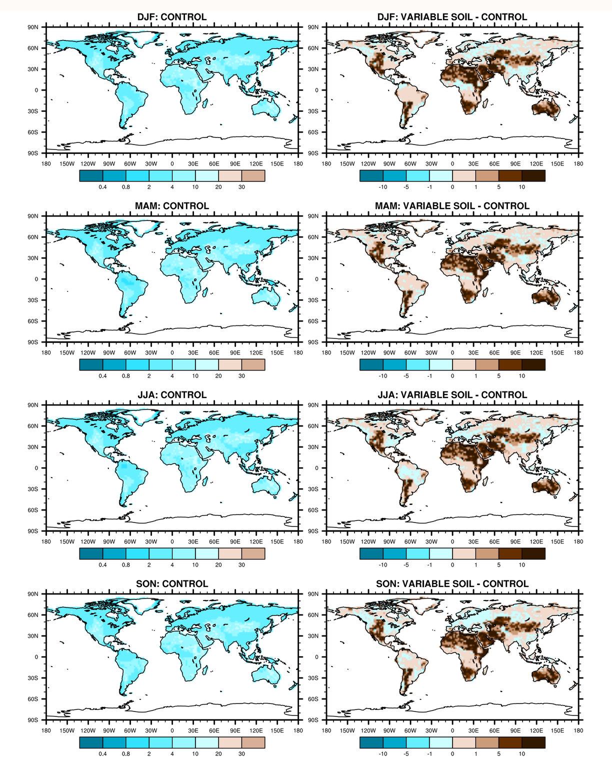
- Enables testing of parameter sensitivity and applicability.



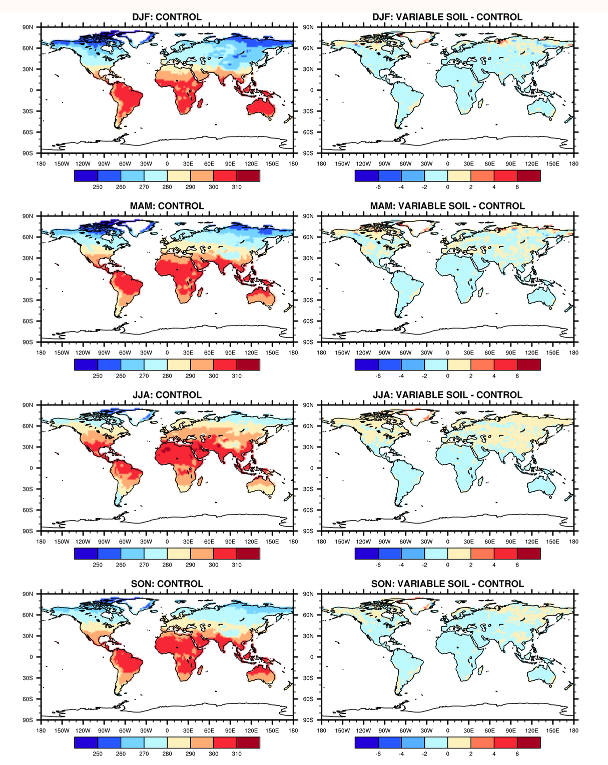
Parameter uncertainty and correspondence of optimal parameter sets to observations

3. The impact of globally varying soil depth on CLM simulations

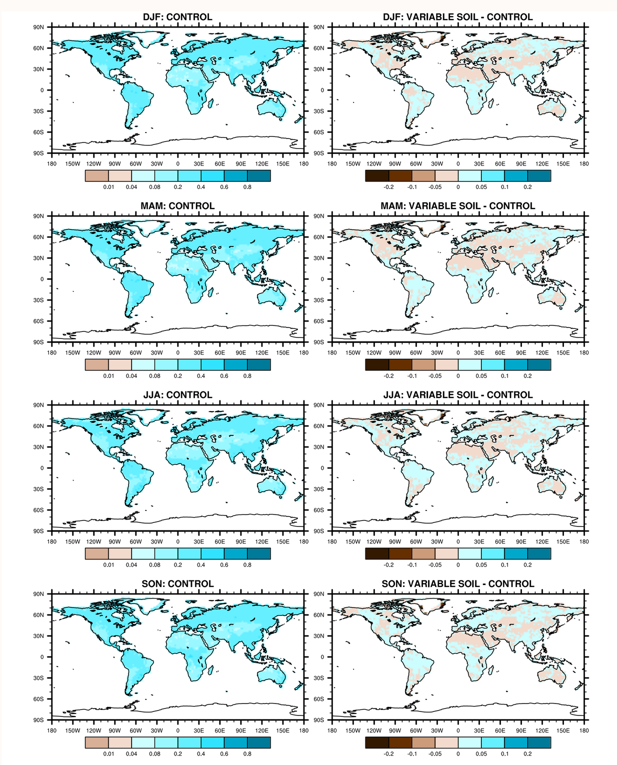
- Difference between current version of CLM (control) and taking the impact of a globally variable depth to bedrock into account.



Mean water table



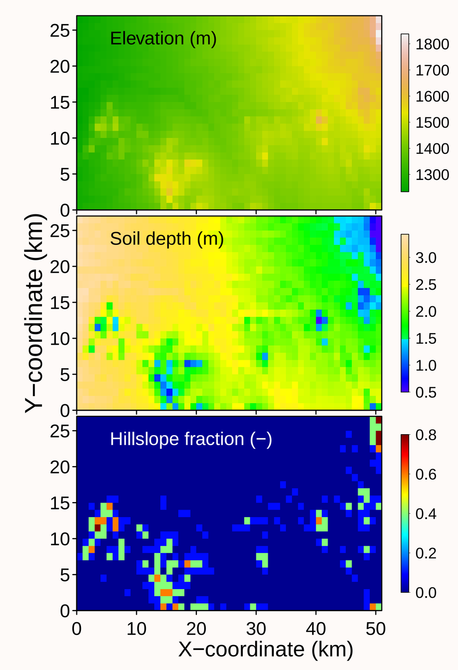
Soil temperature in upper 100 cm



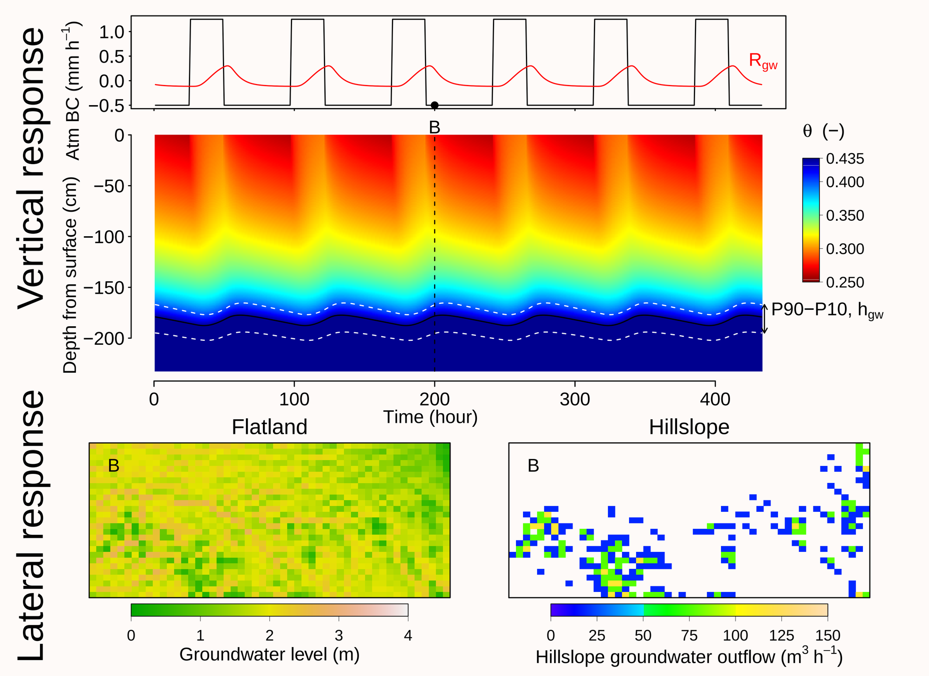
Soil moisture in upper 50 cm

8. Large scale implementation

- Simulating the hydrological response of a vertical column representative for a large scale region (as in CLM) while interacting with the lateral response of hillslopes and flatlands at 1 km^2 pixel resolution.



Catchment information



Interaction between vertical column of gridcell and small scale lateral pixel dynamics at 1 km^2