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Development of a dynamical wetlands hydrology scheme and its application under different climate conditions

Tobias Stacke

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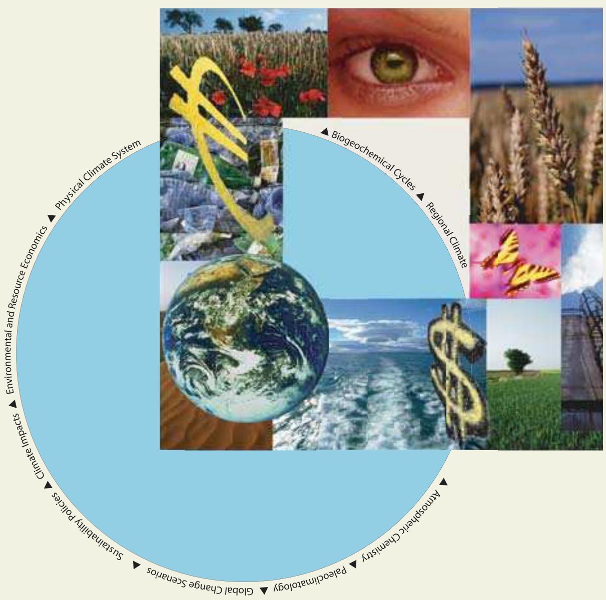

Abstract

This PhD study concerns the development and validation of the dynamical wetland extent scheme (DWES) as well as its application under projected past and future climate conditions. The DWES is designed for global scale hydrological simulations. It solves the water balance of wetlands and derives their extent dynamically. Currently the scheme is embedded into the Max Planck Institute – Hydrology Model (MPI-HM), which was used as testbed for the scheme's development. The DWES might be applied to generate hydrological boundary data for the biogeochemical modeling of the wetland carbon cycle or to simulate the response of wetlands to changes in climatic conditions.

The core component of the DWES is the water flux equilibrium approach. The idea underlying this approach is that wetland water flows depend differently on water volume, depth and extent of the wetland. The wetland extent can then be adapted until the overall water inflows and outflows are balanced, resulting in a wetland which is stable under these hydrological conditions. The approach is further modified by the subgrid slope distribution of the respective model grid cell. This distribution determines how fast the wetland extent may adapt to changes in the water balance.

For present climate, the model validation reveals a good agreement between the occurrence of simulated and observed wetlands on the global scale. The best result is achieved for the northern hemisphere where not only the wetland distribution pattern but also their extent is simulated reasonably well by the DWES. However, the wetland fraction in the tropical parts of South America and Central Africa is strongly overestimated. The validation on monthly basis demonstrates a good correlation between observed and simulated wetland extent variations. Large scale processes like the influence of northern snow melt on wetland extent as well as its reaction to the rainy and dry seasons in the tropics are successfully reproduced by the DWES.

Simulations under past and future climate conditions yield plausible wetland distributions in respect to the forcing data. For the Mid-Holocene period, the DWES demonstrates its ability to represent realistic water level changes in accordance to Mid-Holocene lake level reconstructions for most regions. Discrepancies can mostly be attributed to the climate forcing data and to missing feedbacks between the DWES and the atmosphere. Likewise, the wetland simulations for the future time period are strongly influenced by the climate forcing. Their results reveal wetland growth in regions where precipitation exceeds evaporation while they desiccate in areas with reduced precipitation. Exceptions occur locally where processes like lateral water flow modify the direct climate forcing influence. Here, rivers efficiently drain the land surface in spite of a moisture surplus or transport water into an otherwise dry region.

In summary, the validation analysis and the model applications demonstrate the DWES' ability to simulate the global distribution of wetlands and their seasonal variations. Thus, it can provide hydrological boundary conditions for methane modeling as well as for paleoclimate studies. In future applications, the DWES should be implemented into an earth system model to study feedbacks between wetlands and climate.