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DYPTOP: a cost-efficient TOPMODEL implementation to simulate sub-grid spatio-temporal dynamics of global wetlands and peatlands

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Abstract. Simulating the spatio-temporal dynamics of inundation is key to understanding the role of wetlands under past and future climate change. Earlier modelling studies have mostly relied on fixed prescribed peatland maps and inundation time series of limited temporal coverage. Here, we describe and assess the the Dynamical Peatland Model Based on TOPMODEL (DYPTOP), which predicts the extent of inundation based on a computationally efficient TOPMODEL implementation. This approach rests on an empirical, grid-cell-specific relationship between the mean soil water balance and the flooded area. DYPTOP combines the simulated inundation extent and its temporal persistency with criteria for the ecosystem water balance and the modelled peatland-specific soil carbon balance to predict the global distribution of peatlands. We apply DYPTOP in combination with the LPX-Bern DGVM and benchmark the global-scale distribution, extent, and seasonality of inundation against satellite data. DYPTOP successfully predicts the spatial distribution and extent of wetlands and major boreal and tropical peatland complexes and reveals the governing limitations to peatland occurrence across the globe. Peatlands covering large boreal lowlands are reproduced only when accounting for a positive feedback induced by the enhanced mean soil water holding capacity in peatland-dominated regions. DYPTOP is designed to minimize input data requirements, optimizes computational efficiency and allows for a modular adoption in Earth system models.

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