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PALADYN, a comprehensive land surface-vegetation-carbon cycle model of intermediate complexity

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PALADYN is presented, a new comprehensive and computationally efficient land surface-vegetation-carbon cycle model designed to be used in Earth system models of intermediate complexity for long-term simulations and paleoclimate studies.
The model treats in a consistent manner the interaction between atmosphere, terrestrial vegetation and soil through the fluxes of energy, water and carbon. Energy, water and carbon are conserved. The model explicitly treats permafrost, both in physical processes and as important carbon pool. The model distinguishes 9 surface types of which 5 are different vegetation types, bare soil, land ice, lake and ocean shelf. Including the ocean shelf allows to treat continuous changes in sea level and shelf area associated with glacial cycles. Over each surface type the model solves the surface energy balance and computes the fluxes of sensible, latent and ground heat and upward shortwave and longwave radiation. It includes a single snow layer.
The soil model distinguishes between three different macro surface types which have their own soil column: vegetation and bare soil, ice sheet and ocean shelf. The soil is vertically discretized into 5 layers where prognostic equations for temperature, water and carbon are consistently solved. Phase changes of water in the soil are explicitly considered. A surface hydrology module computes precipitation interception by vegetation, surface runoff and soil infiltration. The soil water equation is based on Darcy's law. Given soil water content, the wetland fraction is computed based on a topographic index.
Photosynthesis is computed using a light use efficiency model. Carbon assimilation by vegetation is coupled to the transpiration of water through stomatal conductance. The model includes a dynamic vegetation module with 5 plant functional types competing for the gridcell share with their respective net primary productivity.
Each macro surface type has its own carbon pools represented by a litter, a fast and a slow carbon pool in each soil layer. Carbon can be redistributed between the layers by vertical diffusion. For the vegetated macro surface type, decomposition is a function of soil temperature and soil moisture. Carbon in permanently frozen layers is assigned a long turnover time which effectively locks carbon in permafrost. Carbon buried below ice sheets and on flooded ocean shelfs is treated differently. The model also includes a dynamic peat module. The model explicitly simulates carbon isotopes 13C and 14C, which are tracked trough all carbon pools. Isotopic discrimination is modeled during photosynthesis.
A simple methane module is implemented to represent methane emissions from anaerobic carbon decomposition in wetlands (including peatlands) and flooded ocean shelf.
First results of offline model simulations will be presented.