**MOSART-lake: development and global validation**

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The current lake module in the land component of E3SM, ELM, is subject to two simplifications: 1) there are no lateral fluxes between lakes and rivers but only vertical fluxes between lakes and atmosphere; 2) the lake surface areas do not change with water level (or storage) in the lakes. The real-world lakes, however, are actively exchanging water and heat fluxes with their upstream and/or downstream rivers, and their surface areas usually change significantly with the varying water levels. To overcome these limitations, we propose and develop a new lake module within the riverine component of E3SM, Model for Scale Adaptive River Transport (MOSART), denoted as MOSART-Lake. MOSART-Lake is featured by three major innovations: 1) it explicitly accounts for the lateral water and heat fluxes between lakes and rivers, in addition to the vertical water and heat fluxes between lakes and atmosphere such as precipitation and evaporation; 2) its new lake geometry parameterization now allows both lake surface area and water storage to gradually decrease with decreasing water depth, and vice versa; 3) the water and heat exchanges within a lake are captured using a newly developed multi-layer thermo-stratification scheme. We validate MOSART-Lake globally against the observed monthly lake surface area time series at over 1,000 large lakes and monthly lake surface area time series at over 1.4 million lakes. Finally, we discuss current limitations of MOSART-Lake and further improvement directions.