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Development of Vertically Integrated 2D Lake Victoria Flow Models in COMSOL Multiphysics

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Abstract : Lake Victoria is the second largest fresh water body in the world, located in East Africa with a catchment area of 250,000 km², of which 68,800 km² is the actual lake surface. The hydrodynamic processes of the shallow (40–80 m deep) water system are unique due to its location at the equator, which makes Coriolis effects weak. The paper describes a St.Venant shallow water model of Lake Victoria developed in COMSOL Multiphysics software, a general purpose finite element tool for solving partial differential equations. Depth soundings taken in smaller parts of the lake were combined with recent more extensive data to resolve the discrepancies of the lake shore coordinates. The topography model must have continuous gradients, and Delaunay triangulation with Gaussian smoothing was used to produce the lake depth model. The model shows large-scale flow patterns, passive tracer concentration and water level variations in response to river and tracer inflow, rain and evaporation, and wind stress. Actual data of precipitation, evaporation, in- and outflows were applied in a fifty-year simulation model. It should be noted that the water balance is dominated by rain and evaporation and model simulations are validated by Matlab and COMSOL. The model conserves water volume, the celerity gradients are very small, and the volume flow is very slow and irrotational except at river mouths. Numerical experiments show that the single outflow can be modelled by a simple linear control law responding only to mean water level, except for a few instances. Experiments with tracer input in rivers show very slow dispersion of the tracer, a result of the slow mean velocities, in turn, caused by the near-balance of rain with evaporation. The numerical and hydrodynamical model can evaluate the effects of wind stress which is exerted by the wind on the lake surface that will impact on lake water level. Also, model can evaluate the effects of the expected climate change, as manifest in changes to rainfall over the catchment area of Lake Victoria in the future.

Keywords : bathymetry, lake flow and steady state analysis, water level validation and concentration, wind stress
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