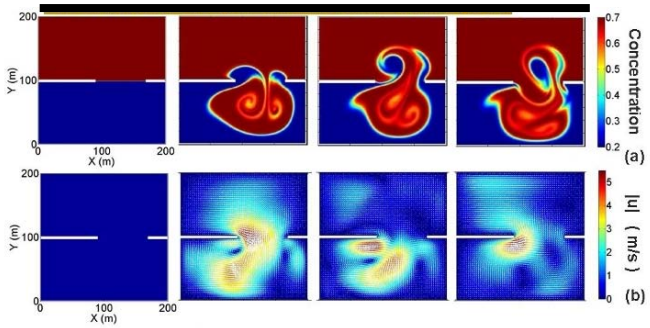
Fluid Flow at LSU

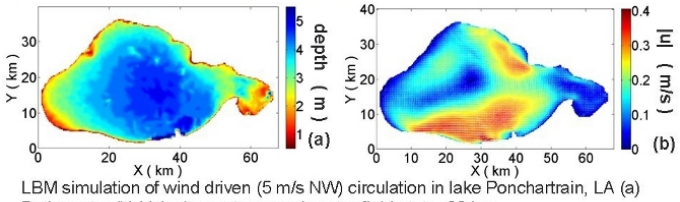
DEMONSTRATION OF LBM

Shallow Water and Mass Transport



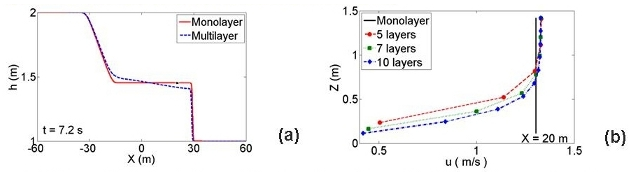
LBM simulation of passive mass transport coupled to partial dam break problem. Concentration profile (a) and velocity magnitude and vector field (b).

Wind Driven Circulation



LBM simulation of wind driven (5 m/s NW) circulation in lake Ponchartrain, LA (a) Bathymetry (b) Velocity contours and vector field at t = 20 hrs

Multi-layer Shallow Water



Multi-layer LBM simulation of dam break problem. (a) Total water depth profiles for monolayer and multilayer solutions at t = 7.2 s (b) Vertical velocity profile for multilayer, M = 5, 7, and 10 layers.

A lattice Boltzmann method (LBM) on high performance computing (HPC) environments for three-dimensional shallow water flow fields coupled to mass transport is developed. Recently, the LBM has become an attractive numerical method to solve various fluid dynamics phenomena. However, LBM has not been extensively applied to shallow water equations. The shallow water equations have wide applications in ocean and hydraulic engineering which can benefit from the advantages of the LBM. The standard LBM for two dimensional shallow water flows is extended to three dimensional flows by solving the multi-layer shallow water equations. LBM is an attractive method for solving the multi-layered shallow water equations because the extension to multi-layers is straight forward and all simplicities and advantages of the LBM are retained. The performance of the LBM for both the shallow water equations and anisotropic advection dispersion are investigated and optimized in HPC environments. We numerically demonstrate the applicability of the LBM in mass transport in shallow water flows and the LBM performance on traditional CPU-based and graphics processing unit (GPU)-based HPC environments.

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Speedup: 10X

System Specs: NVIDIA Tesla 8-Series GPU, and an Intel 3.33 GHz Quad Core CPU

JACKET RESULTS

LBM performance results using Jacket for MATLAB® on a single NVIDIA Tesla 8-series GT GPU.

(a) Average time per time step on the graphics card versus a single core on a 3.33ghz Quad Core CPU
(b) Speedup with increasing problem size.
(c) As much as **4x performance difference** with Jacket on growing grid size