

EEMS Demonstration Model Description

DM_West_Lake_Wind_Wave

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate wind-driven hydrodynamics, temperature transport, sediment resuspension, and internally generated wind waves in West Lake (Hô Tây), Hanoi, Vietnam (latitude $\approx 21^\circ$ N). Field data were collected by DSI and are used to configure the boundary conditions. The model was originally developed by DSI for demonstrating the internally generated wave sub-model coupled to EFDC+ in a shallow lake environment.

The model captures wind-driven circulation and wave generation across a 10-day winter simulation period. A single sewer inflow at $I = 8$, $J = 85$ provides temperature and sediment boundary conditions. The wave model computes internally generated wind waves and their influence on bed shear stress and sediment resuspension throughout the lake.

2 Model Description

The model configuration is summarized in Table 1 and the model domain is shown in Figure 1. The domain represents the crescent-shaped West Lake with bottom elevations ranging from 3 m to 5 m (above datum). The simulation covers 10 days, with a nominal time step of 2 s and a dynamic maximum of 3,600 s.

Table 1 Model configuration summary

Run Period (days)	Horizontal Cells	Vertical Layers	Activated Modules
1-11	5,060 cells	• 1 layer	• Hydrodynamics • Temperature • Sediment transport • Wave

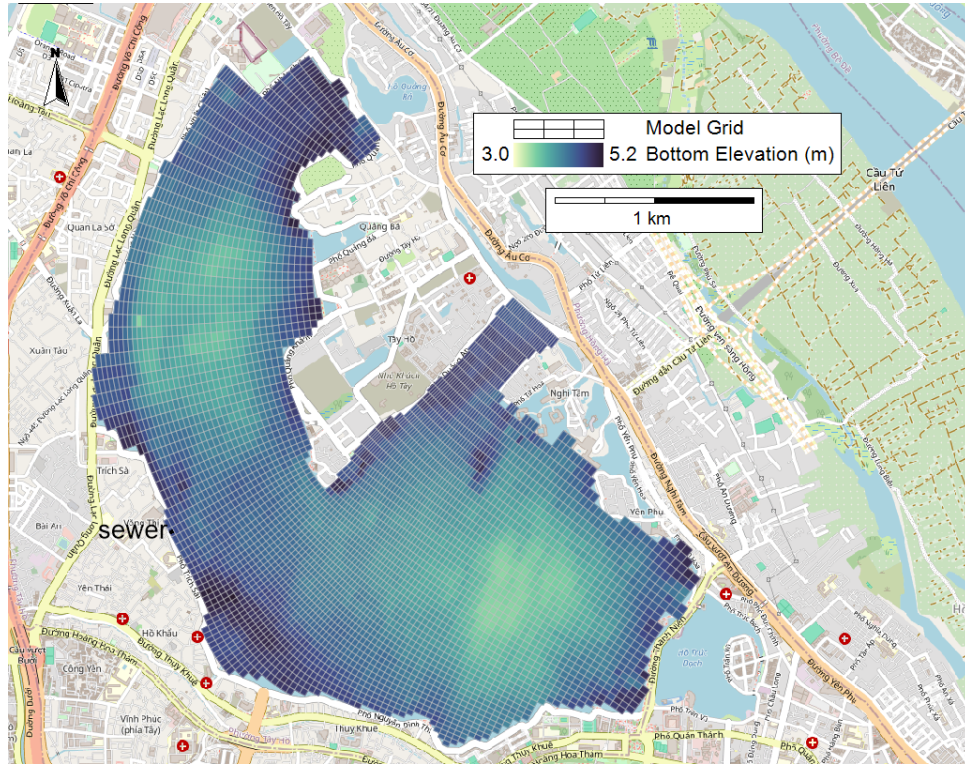


Figure 1 Model domain of West Lake, Hanoi, Vietnam

2.1 Hydrodynamic Configuration

The model uses a two-time-level integration scheme on a single-layer, depth-averaged curvilinear grid. Horizontal momentum diffusion is activated. Wetting and drying is activated with a minimum depth of 0.02 m and a wet threshold of 0.04 m. Coriolis forcing is applied at latitude 21° N ($\text{CORIOLIS} = 5.225 \times 10^{-5} \text{ s}^{-1}$). Wind forcing is applied via a single wind time series; no atmospheric heat exchange is applied.

One flow boundary condition is configured: a sewer inflow at $I = 8$, $J = 85$ with a constant flow rate of $1.5 \text{ m}^3/\text{s}$, assigned temperature time series 1 (**Temp.dat**) and sediment concentration time series 1 (**Cohesive Sediments.dat**, **Non-cohesive Sediments.dat**). No open pressure boundaries are applied.

2.2 Internal Wave Model Configuration

The internally generated wave model is activated, using the steady-state wave solution and a bed roughness length scale of $K_s = 2.5 \times 10^{-5} \text{ m}$ (**Ks_Rough**). The wave model computes wave height, period, and direction from the local wind field and fetch geometry at every time step, then feeds the wave-enhanced bed shear stress back into the sediment transport calculations. This coupling is the key feature of this demonstration model, following the approach documented in [?].

2.3 Temperature Configuration

Temperature transport is active with a reference temperature of 14.5°C and a vertical diffusion coefficient of $1.0 \text{ m}^2/\text{s}$. No surface heat exchange is applied, so the only thermal forcing is the inflow temperature time series at the sewer boundary.

2.4 Sediment Transport Configuration

Both cohesive and non-cohesive sediment transport are active. The cohesive class has an initial water column concentration of 50 mg/L, initial bed mass of 10 g/m², specific gravity of 2.65, settling velocity of 2.8×10^{-4} m/s, and a near-zero critical shear stress for deposition ($\tau_{AUD} = 1 \times 10^{-7}$ Pa). Resuspension uses the Sanford and Maa approach with resuspension rate 0.01 g/m²/s, critical shear stress for erosion $\tau_{crit} = 1 \times 10^{-6}$ Pa, and exponent 0.5. The non-cohesive class has an initial water column concentration of 50 mg/L, initial bed mass of 12 g/m², specific gravity of 2.65, and settling velocity of 2.0×10^{-4} m/s.

3 Folder Structure

The model package contains the following components:

- **Model:** The complete EFDC+ model project directory, loadable directly in EFDC+ Explorer for pre- and post-processing, including the internal wave model configuration.
- **Data:** Input data organized into two subfolders:
 - *Bathymetry:* West Lake Bathymetry Raw Data 2009.p2d, West Lake Outline.p2d
 - *Boundaries:* Flow.dat, Temp.dat, Cohesive Sediments.dat, Non-cohesive Sediments.dat
- **Grid:** Westlake.gpc (Grid Plus format for EE), Westlake.kml (viewable in Google Earth).
- **Maps-Images:** Geo-referenced imagery of the study area (West Lake.jpg, West Lake.geo).

4 Model Results

Figure 2 shows the plan-view depth-averaged temperature and depth-averaged velocity vectors at Julian day 6.67.

The temperature field exhibits a broad spatial gradient across the lake, with cooler water concentrated at the narrowing connecting channel between the northern arm and the southern basin, and warmer water dominating the deeper open water areas. The velocity vector field reveals a complex, wind-driven circulation pattern characterized by two prominent counter-rotating gyres: one occupying the larger southern basin and one in the northern arm, with maximum velocities along the western shoreline and at the channel constriction. The gyre structure is a direct response to the prevailing wind direction acting over the lake geometry, consistent with the expected behavior of a wind-driven shallow lake circulation. These results demonstrate that the EFDC+ internal wave model correctly generates realistic wind-driven circulation patterns and their interaction with temperature transport in a shallow lake environment.

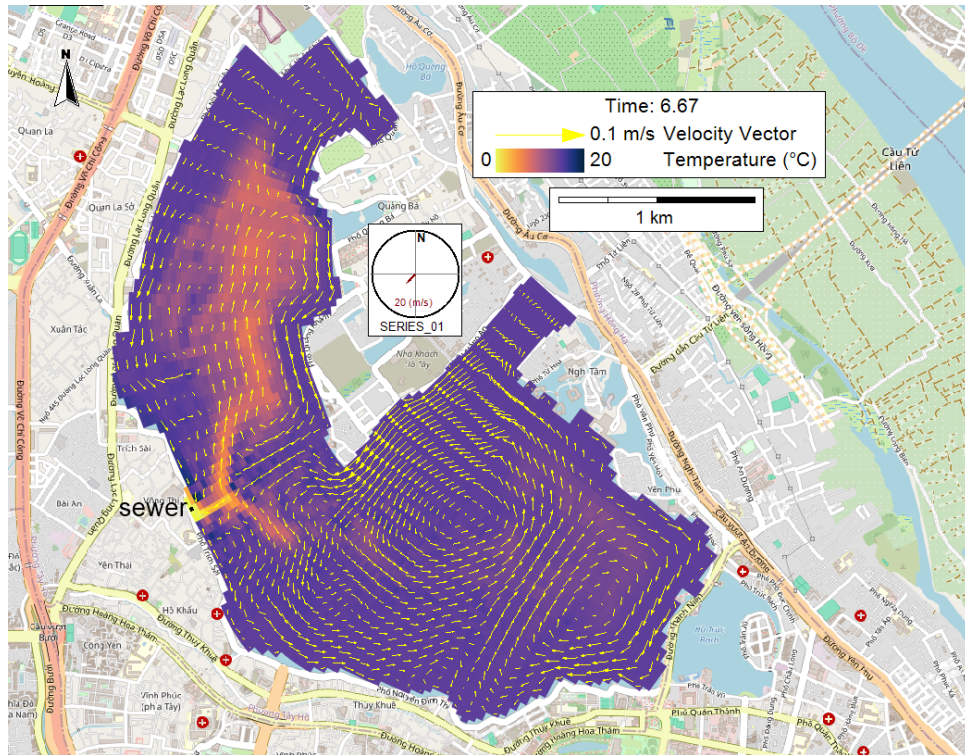


Figure 2 2DH depth-averaged temperature (°C) and velocity vectors at day 6.67

References

Craig, P.M. and Dang Huu Chung (2009). A wave-induced sub-model coupled to the Environmental Fluid Dynamics Code. *4th International Conference on Estuaries and Coasts*, 8–11 October 2012, Water Resources University, Vietnam.

5 Notes

5.1 Disclaimer

This model is provided to demonstrate that EFDC+ Explorer and EFDC+ can be used to build and analyze this type of models. The simulation results are consistent with expected behavior; however, the model should not be considered a final or validated product. Users are encouraged to review, modify, and refine model parameters to obtain results appropriate for their specific application.

5.2 EEMS Demo Mode

In Demo mode, the model is validated against a set of predefined signatures, including grid size, domain area, center coordinates, transport count, and module configuration. While certain parameter values may be adjusted, the grid cannot be modified, transports cannot be added, and the prescribed module setup cannot be altered. Any deviation from these conditions results in the model no longer being considered a valid demo model.

5.3 Support

For technical support, additional documentation, or to obtain the latest version of EFDC+ Explorer, please visit: www.eemodelingsystem.com