

EEMS Demonstration Model Description

DM_Lake_T_Hydrodynamics_and_Water_Quality

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate hydrodynamics, heat transport, and water quality in Lake Thonotosassa, a shallow subtropical lake located near Tampa, Florida (latitude $\approx 28^\circ$ N).

The demonstration encompasses three model variants of increasing complexity, allowing users to progressively build from a basic hydrodynamic setup to a full coupled water quality simulation:

- **Hyd Model:** depth-averaged hydrodynamic model with temperature, wind, and atmospheric forcing.
- **Hyd_5Layer Model:** same as above but with 5 vertical sigma layers to resolve vertical structure.
- **WQ Model:** the full coupled model adding CE-QUAL-ICM Level 1 water quality kinetics to the depth-averaged hydrodynamic base.

2 Model Description

The model configuration is summarized in Table 1 and the model domain is shown in Figure 1. The domain represents the bathymetry of Lake Thonotosassa with bottom elevations ranging from 7 m (deep central basin) to 11 m (shallow littoral margins). The lake is shallow and well-mixed, making the depth-averaged configuration appropriate for the hydrodynamic and water quality simulations. All three model versions share the same 355-cell grid.

Table 1 Model configuration summary (WQ Model)

Run Period	Horizontal Cells	Vertical Layers	Activated Modules
2012-06-30 to 2012-12-27	355 cells	• 1 layer (Hyd and WQ Model) • 5 layers (Hyd_5Layer)	• Hydrodynamics • Temperature • Water Quality (only in WQ Model)

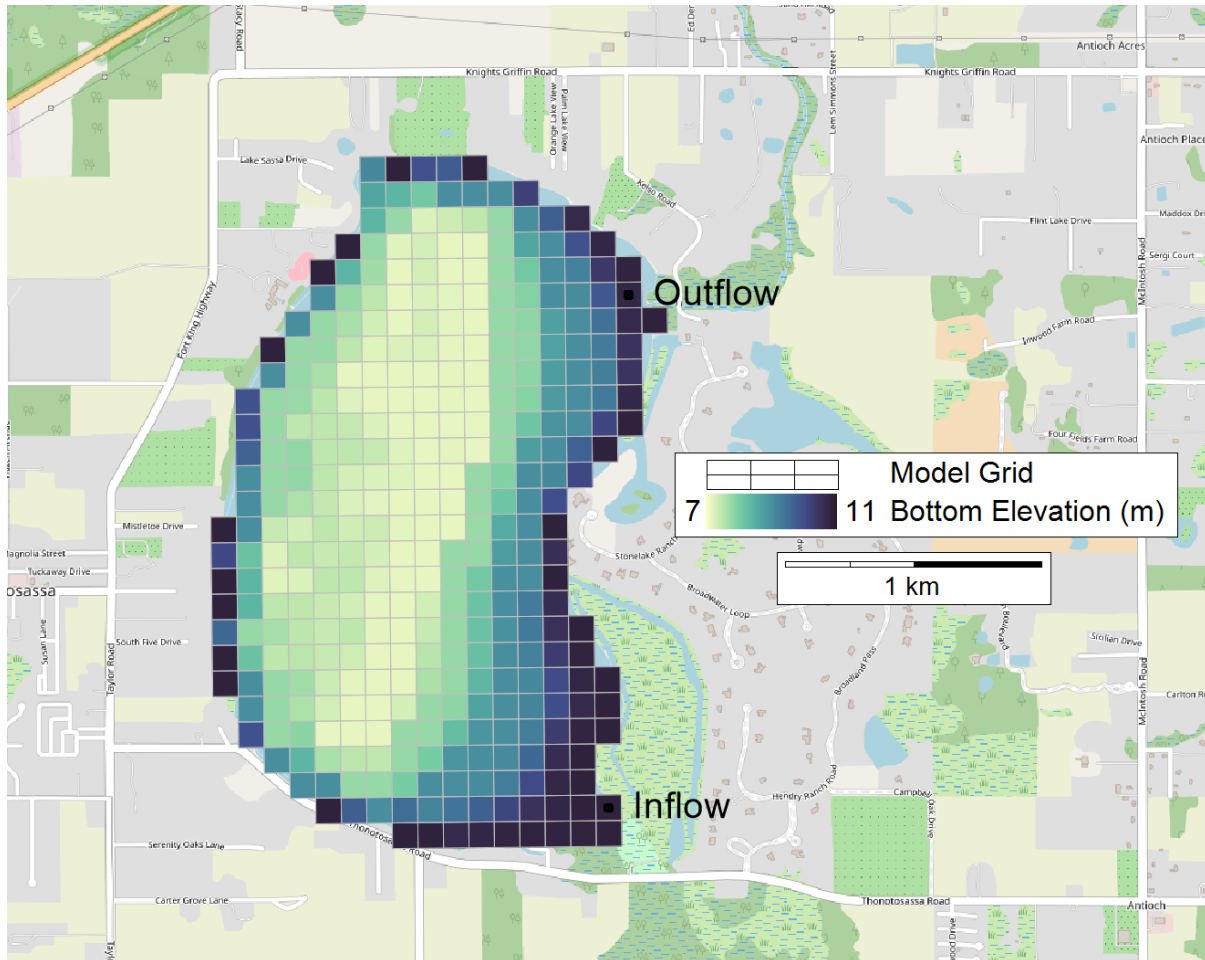


Figure 1 Model domain

2.1 Hydrodynamic and Thermal Configuration

The hydrodynamic model is driven by time-varying wind forcing and atmospheric conditions. Temperature module uses the full atmospheric heat exchange option, computing surface heat flux from the atmospheric time series. Wetting and drying is activated to capture the variable inundation of the shallow littoral zones. The Coriolis parameter is $f = 6.842 \times 10^{-4} \text{ s}^{-1}$ (latitude $\approx 28^\circ \text{ N}$).

Two flow boundaries are configured:

- **Inflow** ($I = 18, J = 4$): time-varying discharge with temperature boundary conditions from `Inflow.dat` and `Temperature.dat`
- **Outflow** ($I = 19, J = 24$): time-varying withdrawal from `Outflow.dat`

2.2 Water Quality Configuration

The WQ model activates the CE-QUAL-ICM kinetics module with 20 state variables, of which 13 are active. Table 2 summarizes the active constituents.

A single mobile algae group — **Green Algae** — is simulated, a settling velocity of 0.1 m/day, and optimal growth temperatures of 22–28°C with the maximum growth rate of 3.5 day⁻¹. Phosphorus and nitrogen half-saturation constants are 0.001 mg/L and 0.01 mg/L respectively. The carbon-to-chlorophyll-*a* ratio is 0.2 and the carbon-to-biomass ratio is 3.8. Solar radiation absorption uses spatially and temporally varying extinction coefficients, with a background

Table 2 Water quality state variables

Group	Active Variables
Carbon	ROC, LOC, DOC
Phosphorus	ROP, LOP, DOP, PO ₄
Nitrogen	RON, LON, DON, NH ₄ , NO _x
Oxygen	DO
Algae	Green Algae

light extinction coefficient of 0.45 m^{-1} and a minimum fraction absorbed in the top layer of 0.3. Water column constituent contributions to light extinction include chlorophyll-*a* (0.031 m^{-1} per g/m^3 , exponent = 1) and particulate organic carbon (1.0 m^{-1} per g/m^3); dissolved organic matter does not contribute to extinction in this configuration. Sediment diagenesis is not activated. Water quality boundary conditions and constituent concentrations are provided in WQ Data-Lake2D.xls.

3 Folder Structure

The model package contains the following components:

- **Model:** Three EFDC+ model project directories:
 - Hyd.Model1: depth-averaged hydrodynamic and temperature model
 - Hyd.5Layer.Model1: 5-layer hydrodynamic and temperature model
 - WQ.Model1: depth-averaged model with full CE-QUAL-ICM water quality
- **Data:** Contains all input data organized into two subfolders:
 - *Bathymetry*: Bathymetry.dat, Outline.p2d
 - *Boundaries*: Inflow.dat, Outflow.dat, Temperature.dat, Winds.dat, Atmospheric.dat, BC.locations.dat, WQ Data-Lake2D.xls
- **Grid:** Lake.T.gpc (GridPlus format for EE) and Lake.T.kml (viewable in Google Earth).
- **Maps-Images:** Geo-referenced imagery (Lake.T.jpg/.jgw) for use as a basemap in EE.

4 Model Results

Figures 2 and 3 show depth-averaged temperature and dissolved oxygen at Julian day 315 from the WQ Model. The inflow boundary is located at the southern end of the lake and the outflow at the northeastern shore, as labelled.

Figure 2 shows water temperature ranging from 10°C (near the inflow) to 20°C (central lake). The cool inflow signature is visible at the southern boundary, with warmer water occupying the central and northern portions of the lake. This spatial gradient reflects the combined effect of the warmer ambient lake water and the cooler inflowing water that has not yet fully mixed across the domain by day 315.

Figure 3 shows dissolved oxygen ranging from 10 to 11 mg/L, with near-uniform distribution across most of the lake ($\approx 10.5 \text{ mg/L}$). Slightly lower DO values ($\approx 10 \text{ mg/L}$) are visible in the central lake and near the inflow, while marginally higher values occur along the northern margins toward the outflow. The narrow DO range reflects the well-mixed, shallow character of Lake Thonotosassa.

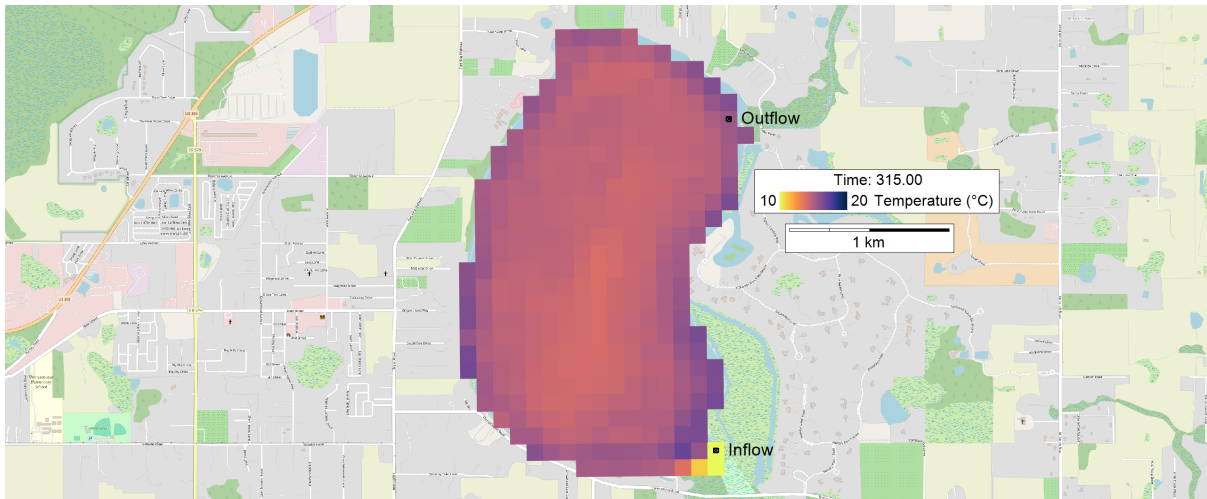


Figure 2 Depth-averaged water temperature (°C) at Julian day 315

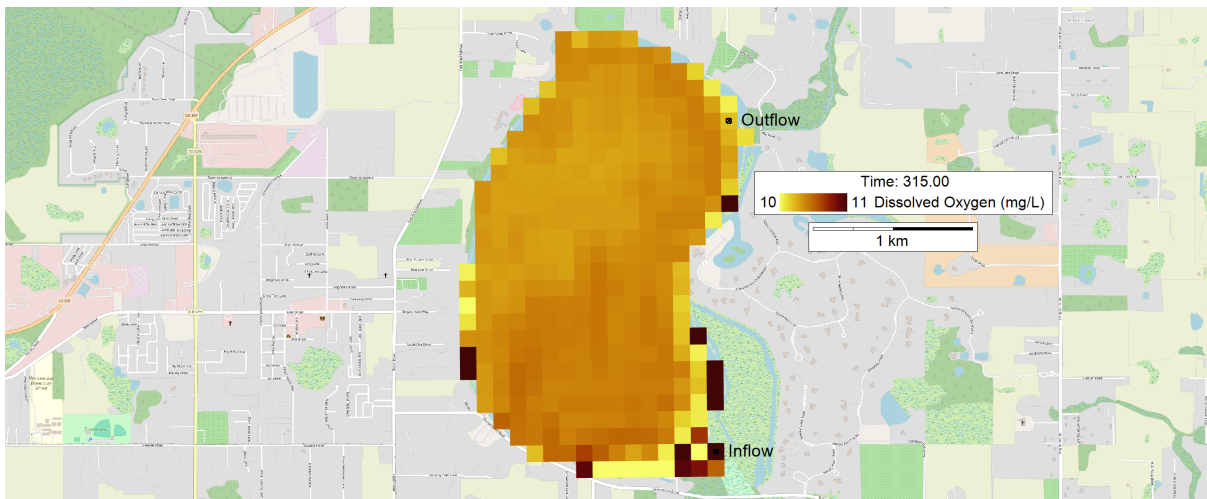


Figure 3 Depth-averaged dissolved oxygen (mg/L) at Julian day 315

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