

EEMS Demonstration Model Description

DM_Lake_Okeechobee_Wind-Driven_Circulation

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate hydrodynamics, heat transport, and passive dye tracing in Lake Okeechobee, Florida. Lake Okeechobee is the largest freshwater lake in the southeastern United States, with a surface area of approximately 1,900 km² and a characteristically shallow bathymetry averaging less than 3 m.

The model is designed to demonstrate how wind-driven circulation can generate a persistent lake-scale eddy, and how dye tracer injected at tributary inflows can be used to visualize the resulting transport pathways. The temperature module illustrates how heat exchange with the atmosphere is configured for a real lake system. The model follows the approach described in Ji (2008), the primary reference for this demonstration.

2 Model Description

The model configuration is summarized in Table 1 and the model domain is shown in Figure 1. The bathymetry ranges from approximately -4.5 m (deep central basin) to -1.5 m (shallow margins), reflecting the saucer-shaped bathymetric profile of Lake Okeechobee. Sigma-Z vertical layering is used with 5 active layers. The Coriolis parameter is set to $f = 6.589 \times 10^{-5} \text{ s}^{-1}$, corresponding to a latitude of approximately 26.9° N, consistent with the lake's location in south-central Florida.

Table 1 Model configuration summary

Run Period (Julian Days)	Horizontal Cells	Vertical Layers	Activated Modules
136–164	2,121 cells	• 5 layers (Sigma-Z)	• Hydrodynamics • Temperature • Dye

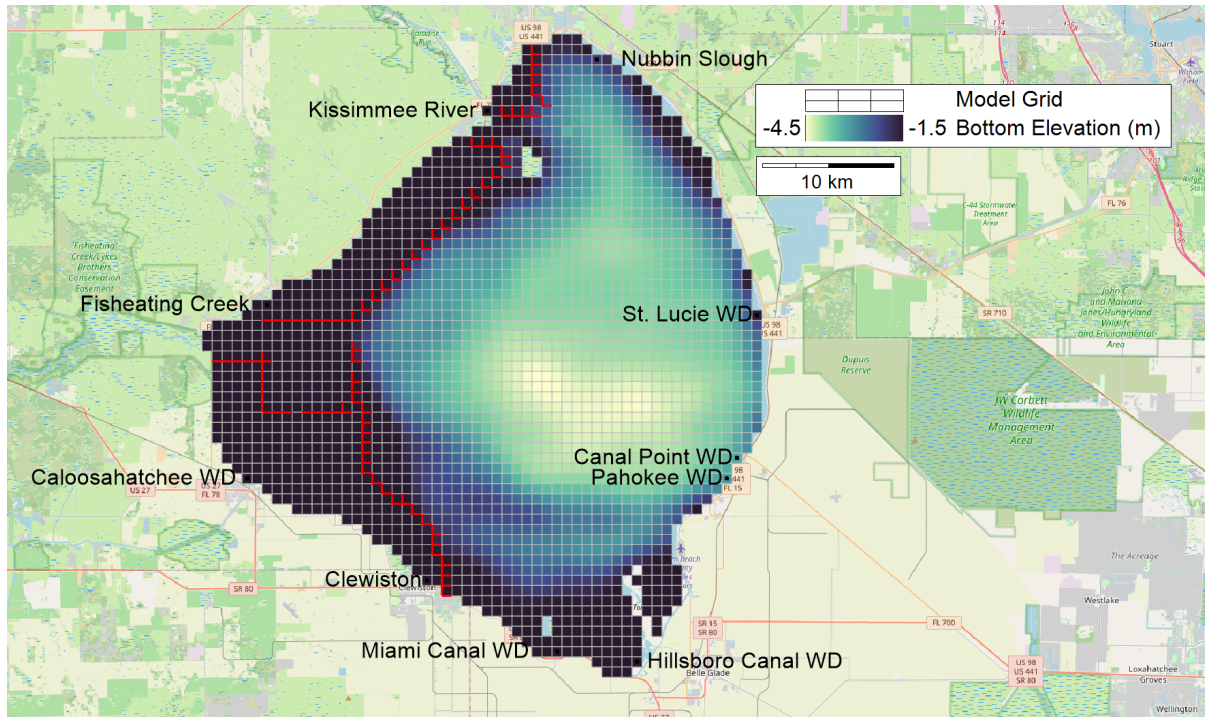


Figure 1 Model domain, with the red lines showing masks specified

2.1 Hydrodynamic and Turbulence Configuration

The model is driven by time-varying wind forcing (1 wind time series) and atmospheric conditions, both applied uniformly over the lake surface. The horizontal momentum diffusion coefficient is set to $AHD = 0.025$. Vegetation resistance is activated to account for the significant macrophyte communities present in the shallow littoral zones. The Mellor–Yamada 2.5 turbulence closure scheme is active in this model.

2.2 Temperature Configuration

Temperature transport is simulated with the full atmospheric heat exchange option, which computes surface heat flux from atmospheric forcing data. The equilibrium temperature transfer coefficient is $HEQT = 1 \times 10^{-6}$ m/s and the reference equilibrium temperature is set to $TEMO = -22.23$. The atmospheric time series provides the meteorological forcing required for the heat budget computation.

2.3 Flow Boundaries and Dye Configuration

Ten flow boundary cells are configured representing the major tributaries and water control structures around the lake perimeter, each linked to an individual time-varying flow series (QSER_1 through QSER_10). All inflows carry temperature time series from the `Temp.dat` boundary file. Table 2 summarizes the boundary locations.

Two dye classes are configured with 2 dye concentration time series. Dye is injected through the Kissimmee River inflow (dye series 1) and Fisheating Creek (dye series 2), the two principal freshwater inflows entering the lake from the north and northwest respectively. The dye acts as a conservative tracer to visualize how inflowing water is transported and dispersed by the wind-driven circulation.

Table 2 Flow boundary conditions

Boundary Name	Cell (I, J)	Dye Series
St. Lucie WD	(58, 38)	—
Canal Point WD	(56, 24)	—
Hillsboro Canal WD	(46, 4)	—
Miami Canal WD	(38, 5)	—
Caloosahatchee WD	(7, 22)	—
Kissimmee River	(31, 58)	Dye series 1
Fisheating Creek	(9, 39)	Dye series 2
Nubbin Slough	(42, 63)	—
Pahokee WD	(55, 22)	—
Clewiston	(25, 12)	—

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.
- **Data:** Contains all boundary condition and bathymetry input files, organized into two subfolders:
 - *Bathymetry:* Elevation_NAVD88_UTM_NAD83.DAT, Elevation_NGVD29_UTM_NAD83.DAT, and Lake_Okeechobee_Bathymetry_Summary.pdf
 - *Boundaries:* Temp.dat, Dye.dat, and QSER_1.dat through QSER_10.dat
- **Grid:** Contains the model grid in two formats: Lake_Okeechobee.cvl (CVL format for EE) and Lake_Okeechobee.kml (viewable in Google Earth).
- **Maps-Images:** Contains geo-referenced background imagery (Okeechobee.geo, Okeechobee.jpg) for use as a basemap in EFDC+ Explorer.

4 Model Results

Figures 2–3b show surface layer (Layer 1) results at Julian day 160, near the end of the 28-day simulation. The three figures together illustrate the wind-driven circulation pattern, the thermal structure of the lake, and the independent transport pathways of the two tributary inflows.

Temperature

Figure 2 shows the surface layer temperature distribution across Lake Okeechobee. A pronounced warm core ($\approx 25\text{--}28^\circ\text{C}$) is concentrated in the west-central portion of the lake, while the northern and eastern margins are substantially cooler ($\approx 15\text{--}20^\circ\text{C}$). This spatial thermal gradient is consistent with wind-driven upwelling and downwelling: the prevailing wind pushes warm surface water toward the western and southwestern shore, while cooler water is drawn to the surface along the windward (northern and eastern) margins.

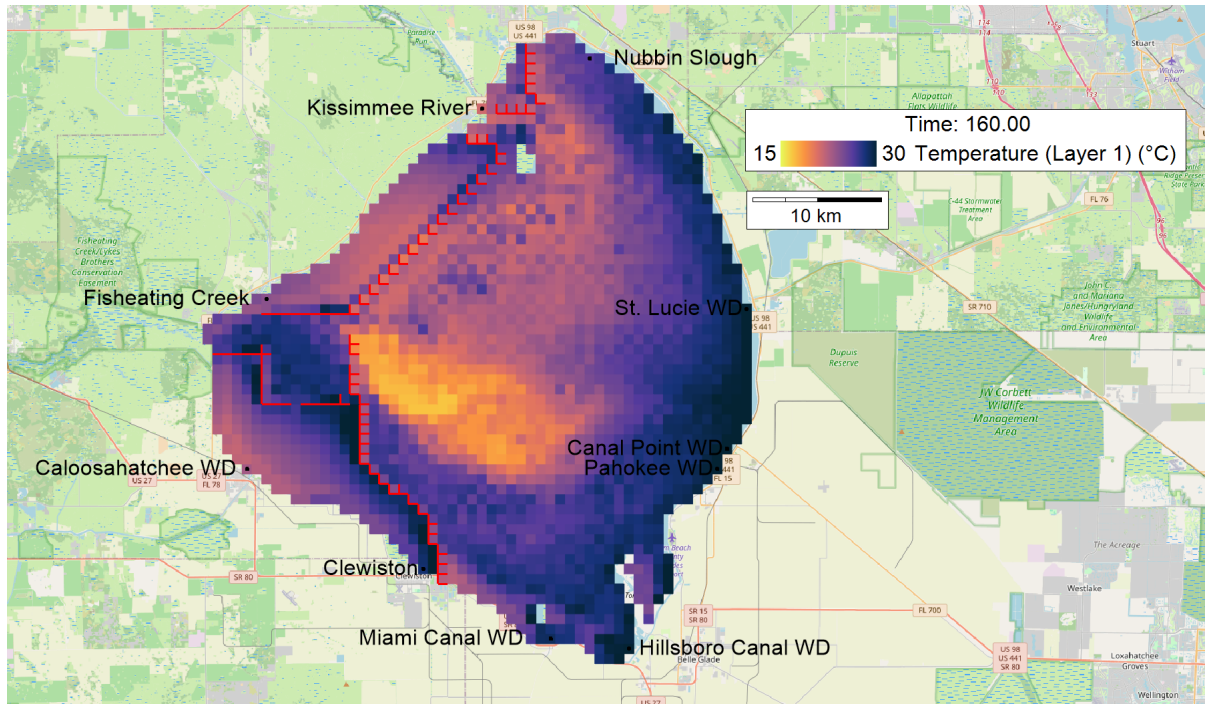


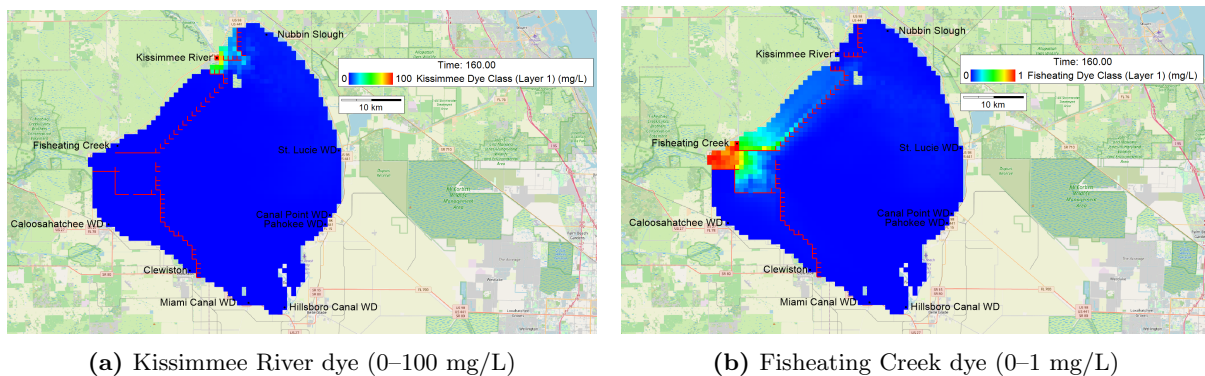
Figure 2 Surface layer (Layer 1) temperature ($^{\circ}\text{C}$) at Julian day 160

Dye Transport

Figures 3 show the surface layer (Layer 1) dye concentrations for the Kissimmee River and Fisheating Creek tracers at Julian day 160. Note that the two color scales differ significantly (0–100 mg/L for Kissimmee River; 0–1 mg/L for Fisheating Creek) and should be interpreted accordingly.

The Kissimmee River dye remains almost entirely confined to the immediate vicinity of its northern inflow cell, with peak concentrations up to 100 mg/L decaying rapidly over only a few grid cells. The rest of the lake remains at essentially zero concentration, indicating that Kissimmee River water has very limited penetration into the main lake body under the simulated wind conditions over the 28-day period.

In contrast, the Fisheating Creek dye has dispersed substantially into the lake, forming a broad plume extending northward along the western shore. Peak concentrations (≈ 1 mg/L) are present near the inflow cell, transitioning to intermediate values extending toward the northern margin. The greater spatial extent of the Fisheating Creek plume reflects its position on the lee side of the wind-driven circulation, where along-shore convergence facilitates northward advection.



(a) Kissimmee River dye (0–100 mg/L)

(b) Fisheating Creek dye (0–1 mg/L)

Figure 3 Surface layer (Layer 1) dye concentrations at Julian day 160. Note the difference in color scales between the two panels

5 References

- Ji, Z.-G. (2008). *Hydrodynamics and Water Quality: Modeling Rivers, Lakes, and Estuaries*. John Wiley and Sons.

6 Notes

6.1 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.

6.2 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.

6.3 Support

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