

EEMS Demonstration Model Description

DM_Lake_T_Phytoplankton_Zooplankton_Dynamics

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate hydrodynamics, water quality, and zooplankton dynamics in Lake Thonotosassa, Florida (latitude $\approx 28^\circ$ N). The model was originally developed by DSI for testing the zooplankton module in EFDC+.

The model extends the DM-14 water quality configuration by adding a coupled zooplankton group that grazes on the simulated phytoplankton (Green Algae). This allows the full food web including nutrients, phytoplankton, and zooplankton to be simulated within a single EFDC+ framework, demonstrating how the zooplankton module interacts with the water quality kinetics to produce coupled algae–zooplankton dynamics.

2 Model Description

The model configuration is summarized in Table 1 and the model domain is shown in Figure 1. The domain represents Lake Thonotosassa with bottom elevations ranging from 7.16 m (deep central basin) to 10.82 m (shallow littoral margins). The simulation covers a 180-day period, spanning the warm growing season through to late autumn.

Table 1 Model configuration summary

Run Period (Julian time)	Horizontal Cells	Vertical Layers	Activated Modules
182-362	355 cells	• 1 layer	• Hydrodynamics • Temperature • Water Quality • Zooplankton

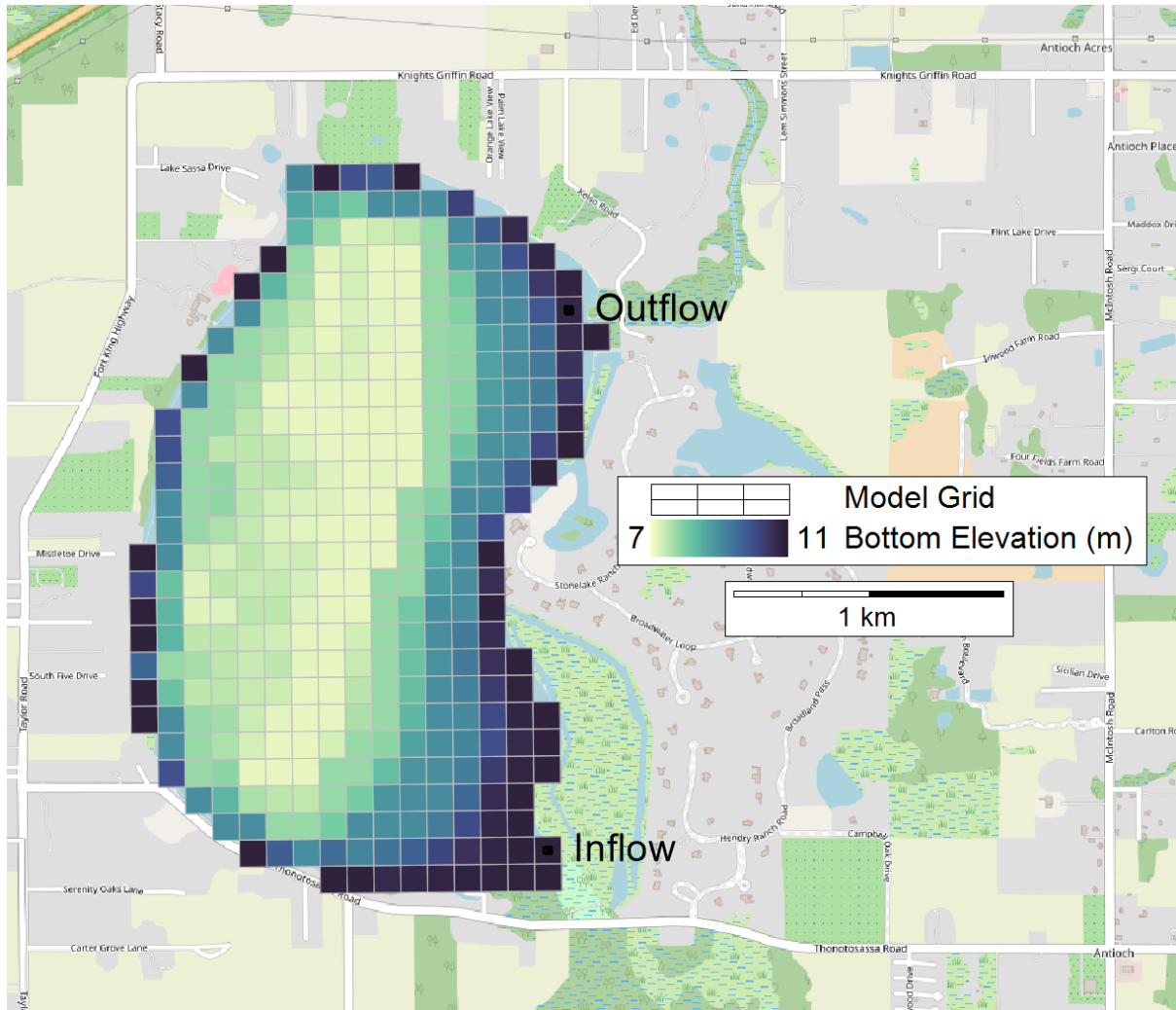


Figure 1 Model domain

2.1 Hydrodynamic and Thermal Configuration

The hydrodynamic configuration is identical to DM-14. Wind forcing (*Winds.dat*) and atmospheric heat exchange (*Atmospheric.dat*) drive the circulation and thermal budget. Wetting and drying is activated. Two flow boundaries are configured: an inflow at $I = 18$, $J = 4$ (*Inflow.dat*, *Temperature.dat*) and an outflow at $I = 19$, $J = 24$ (*Outflow.dat*).

2.2 Water Quality Configuration

The WQ module uses CE-QUAL-ICM Level 1 kinetics with 21 state variables, of which 14 are active. The configuration is the same as DM-14 (ROC, LOC, DOC, ROP, LOP, DOP, PO₄, RON, LON, DON, NH₄, NO_x, DO, Green Algae) with the addition of one zooplankton variable (ZOO1). Initial conditions are: DO = 7 mg/L, Green Algae (ALG1) = 0.1 mgC/L, and ZOO1 = 0.1 mgC/L. Light extinction uses a background coefficient of 0.45 m⁻¹ with chlorophyll-*a* and POC contributions of 0.031 and 1.0 m⁻¹ per g/m³ respectively. Sediment diagenesis is not activated.

2.3 Zooplankton Configuration

One zooplankton group is simulated, with key parameters summarized in Table 2.

Table 2 Mesozooplankton kinetic parameters

Parameter	Value
Maximum grazing ration	1.0 day ⁻¹
Optimal grazing temperature range	20–25°C
Prey carbon threshold	0.05 mg/L
Half-saturation prey density	0.175 mg/L
Algae utilization (Green Algae)	1.0
LPOC utilization	0.1
RPOC utilization	0.1
Basal metabolism rate (20°C)	0.186 day ⁻¹
Predation rate (20°C)	0.2 day ⁻¹
Critical DO for mortality	2.0 mg/L
Anoxic mortality rate	4.0 day ⁻¹
N:C ratio	0.20 g/g
P:C ratio	0.02 g/g

Mesozooplankton grazes exclusively on Green Algae (utilization = 1.0) and POC, with no inter-zooplankton predation. Metabolism products are partitioned into dissolved organic and inorganic nitrogen and phosphorus pools. Mortality is enhanced under low-oxygen conditions, with the death rate increasing to 4.0 day⁻¹ when DO approaches zero from the critical threshold of 2.0 mg/L.

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 zooplankton module configuration.
- **Data:** Contains all input files 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).

4 Model Results

Figure 2 shows time series of depth-averaged Mesozooplankton, Green Algae, and particulate organic carbon (POC) concentrations at cell 184 ($I = 8$, $J = 16$) over the full 180-day simulation. The time series reveals classic coupled predator–prey dynamics between Green Algae and Mesozooplankton. Three distinct algal bloom events are visible. In each case, the mesozooplankton biomass rises in response to the algal pulse, lagging the phytoplankton peak by approximately 10–15 days as grazing pressure builds. The zooplankton peak following the day 270 algal bloom reaches ≈ 3.7 mg C/L and is the highest of the simulation, reflecting the accumulated grazer biomass from the preceding bloom period.

POC mostly tracks algal biomass during the growth phases, rising as algal carbon accumulates in the water column and declining as grazing and settling remove it.

After day 275, all three variables decline sharply and remain at low concentrations (<0.5 mg C/L) through the remainder of the simulation, consistent with reduced phytoplankton growth as temperatures fall below the optimal range of 22–28°C in late autumn. This result demonstrates that the coupled algae–zooplankton kinetics in EFDC+ correctly reproduces the expected seasonal succession and the delayed zooplankton response to phytoplankton bloom dynamics.

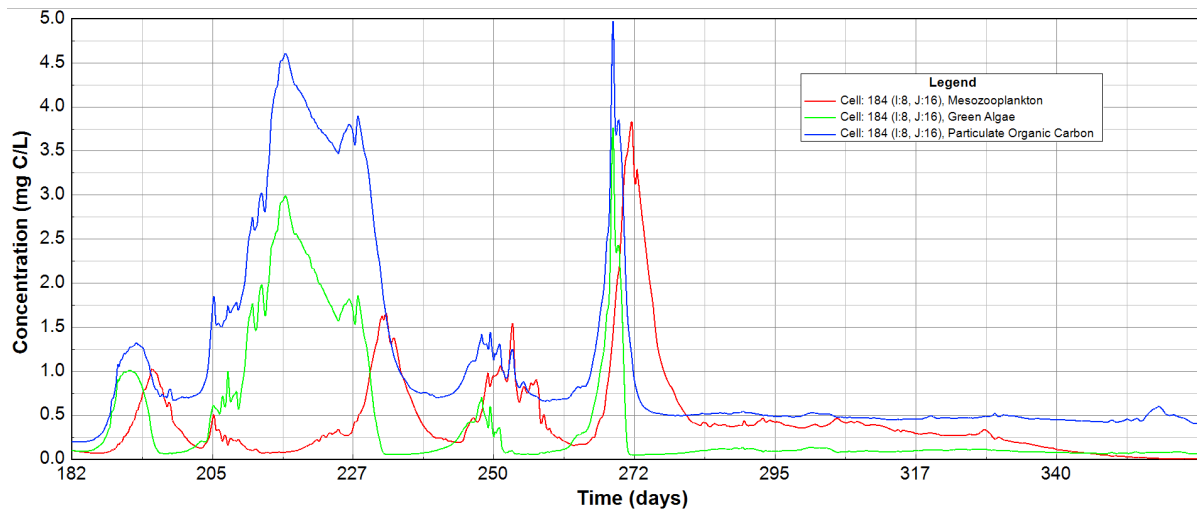


Figure 2 Time series of depth-averaged Meso zooplankton, Green Algae, and POC at cell 184 ($I = 8$, $J = 16$), Julian days 182–362

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