EEMS Demonstration Model Description

DM_Lake_T_Ice_Formation

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate hydrodynamics, temperature, and ice formation and melt in Lake T (Lake Thonotosassa, Florida). The model uses artificially generated temperature and atmospheric forcing data specifically designed to drive ice formation for demonstration purposes, since Lake Thonotosassa does not naturally freeze under its subtropical climate.
The primary objective is to demonstrate how the EFDC+ ice sub-module is configured in EE to simulate the full cycle of ice growth and decay in a lake environment. The model shows how atmospheric temperature forcing controls the timing and spatial distribution of ice cover, and how the 5-layer vertical grid captures the thermal structure of the water column beneath the ice.

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 T with bottom elevations ranging from 7 m (deep central basin) to 11 m (shallow littoral margins). The lake is the same domain used in DM-14, but here with 5 sigma layers to resolve the vertical thermal structure relevant to ice–water heat exchange. The simulation runs for 60 days, spanning the artificial cold season imposed by the synthetic atmospheric forcing.

Table 1 Model configuration summary

Run Period (Julian time)	Horizontal Cells	Vertical Layers	Activated Modules
240-300	356 cells	• 5 layers (standard sigma)	• Hydrodynamics • Temperature • Dye

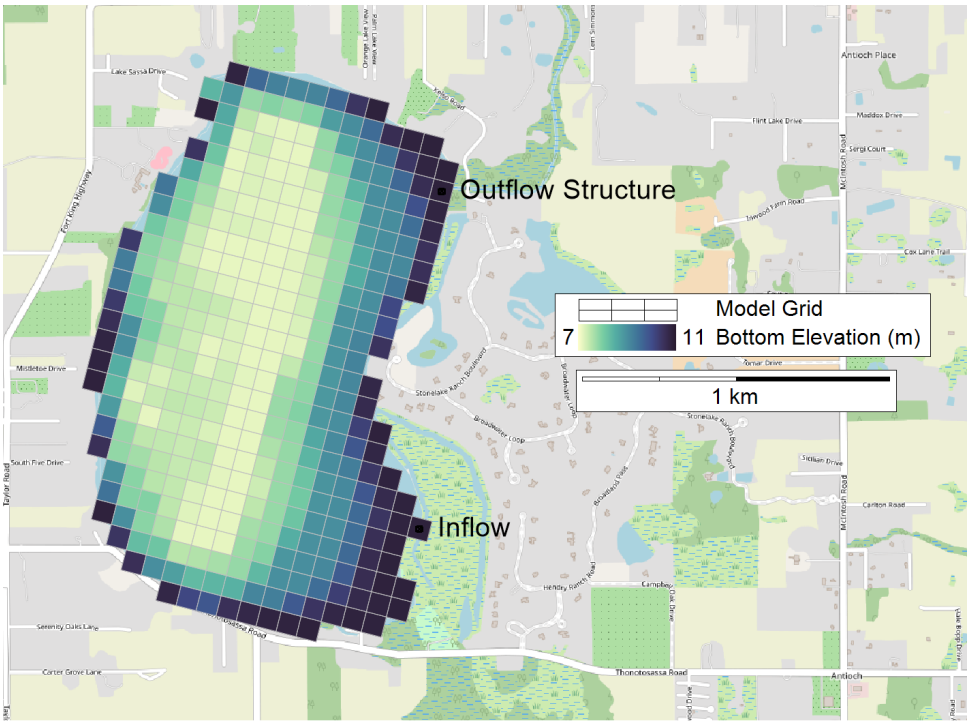

Figure 1 Model domain

2.1 Hydrodynamic and Thermal Configuration

Atmospheric and wind forcing are provided as time-varying series using artificially generated data designed to produce sub-freezing atmospheric temperatures during the simulation period. Temperature transport uses the full atmospheric heat exchange option, computing surface heat flux including the ice–atmosphere exchange when ice is present.
Two flow boundaries are configured:

- **Inflow** (I = 20, J = 9): time-varying discharge with temperature boundary condition from `Inflow.dat` and `Temp.dat`
- **Outflow Structure** (I = 17, J = 25): time-varying withdrawal from `Outflow.dat`

2.2 Ice Configuration

Ice sub-module is activated, which enables EFDC+ to dynamically simulate ice growth and melt based on the atmospheric heat balance at the ice–water interface. The key ice parameters are listed in Table 2.

Table 2 Ice thermodynamics parameters

Parameter	Value
Ice option (computed thermodynamics)	4
Water temperature at ice–water interface	0.1°C
Ice drag coefficient	0.001
Maximum allowable ice thickness	1 m
Initial ice thickness	1 m

With `ISICE` = 4, EFDC+ computes ice formation when the surface water temperature falls to 0.1°C according to the settings, and ice melt when the atmospheric heat flux becomes positive. The ice drag coefficient applies a momentum sink to the surface layer beneath the ice, damping wind-driven circulation when the lake is ice-covered.

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 input files organized into two subfolders:
  - *Bathymetry*: `Outline.p2d`
  - *Boundaries*: `Inflow.dat`, `Outflow.dat`, `Temp.dat`

  Note that the atmospheric and wind time series are embedded in the model directory and are artificially generated for this demonstration.
- **Grid**: `Lake_T.gpc` (GridPlus format for EE) and `LakeT.kml` (viewable in Google Earth).
- **Maps-Images**: Geo-referenced imagery (`LakeT.jpg/.jgw`) for use as a basemap in EE.

4 Model Results

Figure 2 shows time series of top-layer temperature, bottom-layer temperature, and ice thickness at cell 184 (I = 11, J = 15) over the full 60-day simulation. Figure 3 shows the spatial distribution of ice thickness at Julian day 266, near the time of peak ice extent.

Ice Growth and Melt Cycle

The time series in Figure 2 illustrates the full ice thermodynamic cycle driven by the atmospheric forcing. During the early simulation (days 240–257), the top-layer temperature fluctuates near 0–1°C and ice thickness begins to develop intermittently, reaching ≈0.12 m by day 253 before a brief warm spell melts it back to zero around day 257. The bottom-layer temperature remains consistently warmer (3–4.5°C) than the surface throughout the simulation, reflecting the insulating effect of the ice cover and the thermal inertia of the deeper water column.
Ice growth resumes after day 257 and increases steadily to a peak of ≈0.37 m around day 278. During this period the top-layer temperature is suppressed to near 0.1°C, confirming that the ice–water interface temperature constraint is active. After day 278 ice thickness decreases gradually as the atmospheric forcing warms, with complete melt occurring around day 293–295.

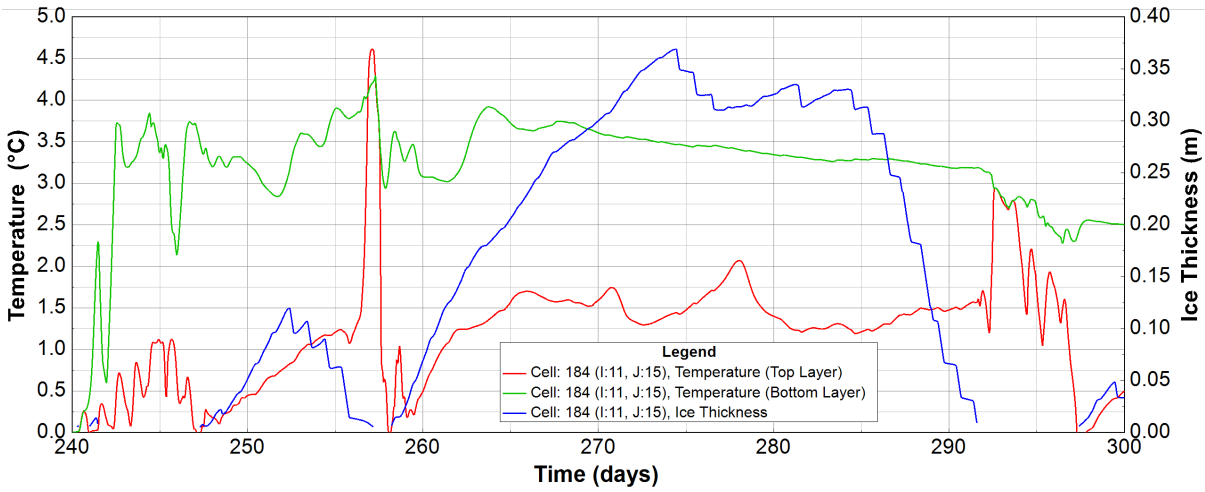

Figure 2 Time series of temperature at top and bottom layet along with ice thickness at cell 184 (I = 11, J = 15) over Julian days 240–300

Spatial Distribution of Ice Thickness

Figure 3 shows the 2DH plan view of ice thickness at Julian day 266, during the main ice growth phase. Ice thickness ranges from 0 to 0.40 m, with the thickest ice occupying the central and northern portions of the lake away from flow influences. The southern portion of the lake near the inflow boundary shows notably thinner ice, reflecting the moderating effect of the warmer inflowing water preventing the surface from cooling fully to the freezing threshold.
Together, the two figures demonstrate that the EFDC+ computed ice thermodynamics correctly capture both the temporal evolution of ice growth and decay and the expected spatial pattern of differential ice thickness driven by the interplay between atmospheric cooling and hydrodynamic heat inputs.

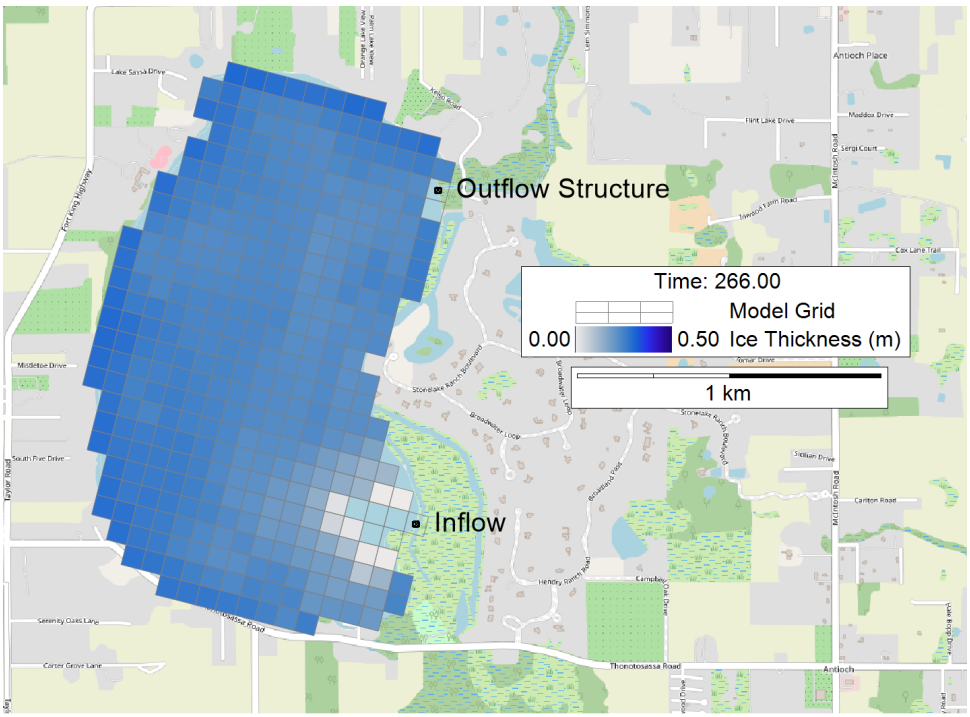

Figure 3 2DH plan view of ice thickness (m) at Julian day 266

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