

EEMS Demonstration Model Description

DM_Lock_Exchange_Density_Flow

1 Objective

This demonstration model uses EFDC+ Explorer (EE) and EFDC+ to simulate density-driven flow in a closed rectangular tank. The model is designed to demonstrate and aid the understanding of how salinity-induced density gradients generate buoyancy-driven circulation within the EFDC+ framework, using a highly resolved vertical grid to accurately capture the stratification and pressure gradients that drive the flow.

The tank configuration provides a controlled, idealized test environment in which density flow dynamics can be isolated from external forcing such as wind, tides, or river inflow, making it a useful benchmark for verifying the salinity transport formulations in EFDC+.

2 Model Description

The model configuration is summarized in Table 1 and the model domain is shown in Figure 1. The domain represents a rectangular tank approximately 2 m wide and 1 m tall, discretized with a fine horizontal and very fine vertical resolution (200 layers) to resolve the density interface and the resulting gravitational circulation. The 0 m bottom elevation confirms the tank geometry with no bathymetric slope.

Table 1 Model configuration summary

Run Period (Julian Time)	Horizontal Cells	Vertical Layers	Activated Modules
0-0.0007	400 cells	200 layers standard sigma	- Hydrodynamics - Salinity Transport

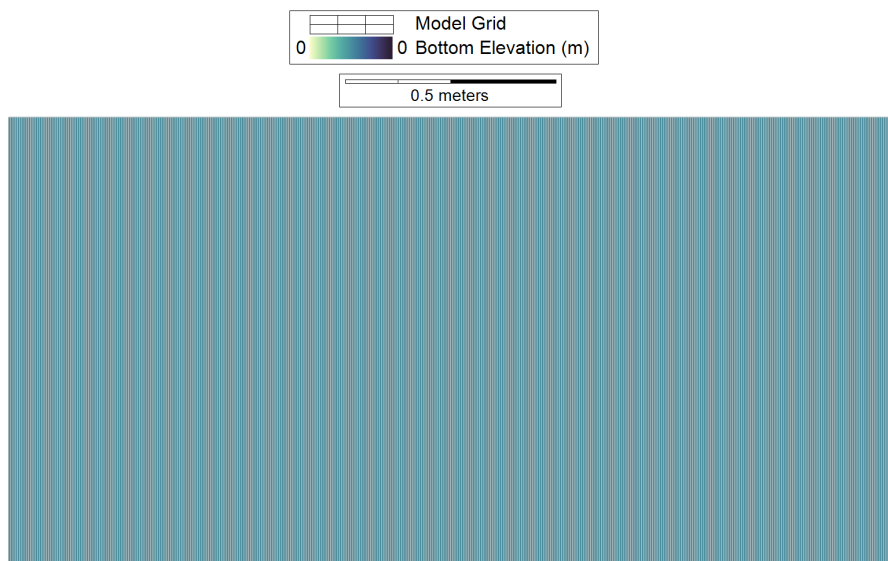


Figure 1 Model domain

2.1 Density Flow Dynamics

Density-driven flow arises when horizontal salinity gradients create lateral differences in hydrostatic pressure. In this model, an initial salinity contrast is established across the tank. The denser saline water at one end generates a higher hydrostatic pressure at depth relative to the fresher side, driving a near-bed current toward the fresher side. A compensating return flow develops near the surface, establishing a two-layer gravitational circulation pattern characteristic of salt-wedge and lock-exchange type flows.

The 200-layer vertical discretization is essential for resolving this process: the sharp density interface between the saline and fresh water masses requires fine vertical resolution to avoid excessive numerical diffusion that would otherwise smear the interface and suppress the baroclinic response. No boundary concentration series are applied. Turbulence is parameterized with a background vertical eddy viscosity of $AVO = 1 \times 10^{-7} \text{ m}^2/\text{s}$ and a horizontal diffusivity of $AHD = 0.05 \text{ m}^2/\text{s}$.

2.2 Salinity Configuration

Salinity transport is the sole active constituent module, with salinity controlling density through the equation of state. The initial condition establishes a sharp step-change in salinity at the mid-point of the domain: the upstream half (cells $I = 3\text{--}200$, approximately 2,000 m) is initialized at **0 ppt** (fresh water), and the downstream half (cells $I = 201\text{--}402$) is initialized at **30 ppt** uniformly across all 200 vertical layers. This is a classic lock-exchange configuration. Upon release, the denser saline water (right half) intrudes as a gravity current along the bottom toward the fresh side, while the lighter fresh water overrides it near the surface, establishing a two-layer exchange flow.

3 Model Results

Figure 2 shows a 2DV cross-section of salinity and velocity vectors along row $J=3$ at Julian time 0.00006 (approximately 5 seconds into the simulation). The lock-exchange dynamics are clearly visible. The left portion of the tank (0–0.2 m) retains the initial fresh water, while the right portion (beyond $\approx 1.8 \text{ m}$) remains at the initial saline condition. Between these two ends, a well-developed density interface has formed: the dense saline gravity current advances along the bottom from right to left, while the lighter fresh water overrides it near the surface as a return flow moving left to right. The velocity vectors confirm this two-layer exchange structure, with near-bed vectors pointing left and near-surface vectors pointing right throughout the mid-tank region. The sharp, curved salinity front progressing from the bottom-left toward the upper-right is characteristic of a classical lock-exchange gravity current. The 200-layer vertical discretization resolves this interface without excessive numerical diffusion, which is the primary purpose of this demonstration model.

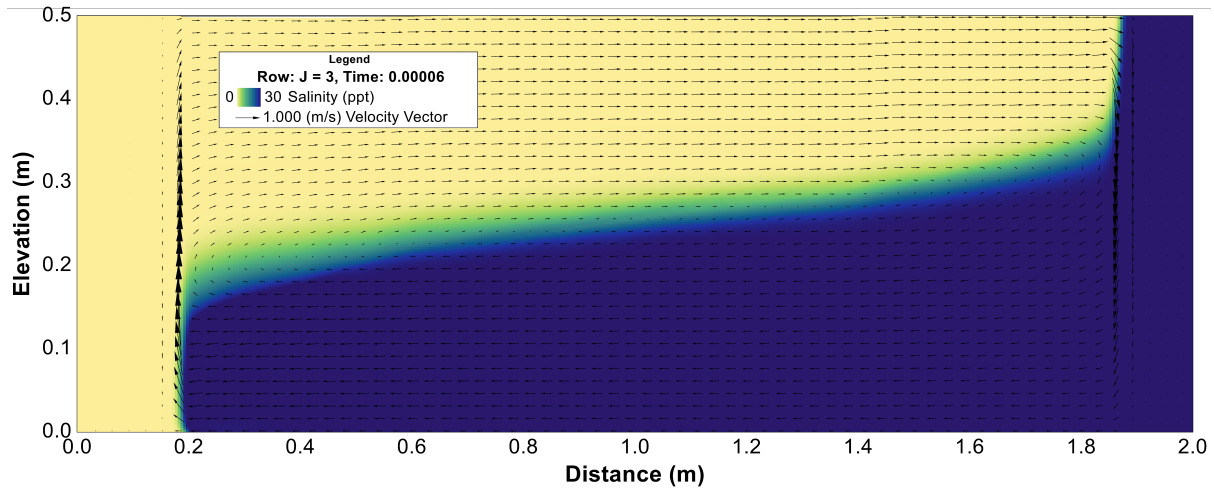


Figure 2 2DV cross-section of salinity at Julian time 0.00006

4 Notes

4.1 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.

4.2 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.

4.3 Support

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