

## Article

# Comparative Study on Water Temperature Stratified Flow under Different Vertical Coordinate Systems in Delft3D

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**Abstract:** Reservoirs often suffer from water blooms, which are likely related to the hydrodynamic and water temperature characteristics of the tributary bays. To obtain the detailed changing process of hydrodynamics and water temperature stratification, it is necessary to choose a suitable vertical coordinate system in order to achieve the required precision. Based on a physical model experiment of cold water flowing into the Generalized Reservoir Hydraulics (GRH) flume, both the  $\sigma$ -coordinate system model and the  $z$ -coordinate system model are built for comparison. For the  $z$ -coordinate system model, the influences of different grid resolutions and different bottom slopes on the simulation accuracy are also analyzed. The results show that the  $\sigma$ -coordinate system model can simulate cold-water underflow in a reservoir better than the  $z$ -coordinate system model, and the numerical errors of the  $z$ -coordinate system model can be reduced but not eliminated by increasing the horizontal grid resolution. When the bottom slope of the reservoir is less than 18‰, the  $z$ -coordinate system model can also be used to simulate cold-water underflow in a reservoir. The conclusions about vertical coordinate systems can be applied to the development of a three-dimensional hydrodynamic and water temperature model of reservoirs.

**Keywords:** water temperature; numerical simulation; vertical coordinate system; density flow



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## 1. Introduction

Since the impoundment of the Three Gorges Reservoir (TGR), water blooms frequently occur in several tributary bays, which has aroused widespread public concern [1–3]. Some studies have suggested that water temperature stratification and density flow are the main causes of water blooms in these tributary bays [4–8]. Previous field observations and numerical simulations show that the hydrodynamic exchange process between the tributary bays and the Yangtze River provides rich nutrients and suitable hydrodynamic conditions for algae growth [9–13]. Therefore, the hydrodynamic and water temperature characteristics in the tributary bays are important to explain the mechanism of water blooms [14]. Numerical simulation is an economical and practical method to obtain the hydrodynamic characteristics and water temperature stratification in the tributary bays. The Delft3D model is widely used for the numerical simulation of gravity flow in reservoirs and estuaries, and it is employed to build the three-dimensional hydrodynamic and water temperature numerical models in this study.

Generally, there are the following two-common types of vertical coordinate systems in Delft3D when building a three-dimensional model: one is the  $z$ -coordinate system, and the other is the  $\sigma$ -coordinate system [15]. The  $\sigma$ -coordinate system model is a boundary-fitted model that can simulate the changes in the bottom and free surface. For a steep bottom slope in combination with vertical water temperature stratification, the  $\sigma$ -coordinate system model introduces artificial vertical diffusion due to truncation errors in the approximation of the horizontal pressure gradient force [16–18]. The  $z$ -coordinate system model has horizontal grid lines and is not boundary-fitted in the vertical direction. The bottom and free surface are represented as a staircase, which causes numerical errors in bed shear

# Comparative Study Of Temperature Fluctua

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