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2DV Numerical Modeling of Stratified Saline Water Using a Nonlinear *k-ε* Model

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Abstract

The commonly used linear *k-ε* turbulence model is shown to be incapable of accurate prediction of turbulent flows where non-isotropy is dominant. One example of non-isotropic flows which is due to stratification and consequently variation of density through vertical layers is saline water flow. In this paper a nonlinear *k-ε* turbulence model firstly presented by Speziale (1986) is implemented in the existing hydrodynamic model. The hydrodynamic model solves the fully nonlinear Navier-Stokes equations based on an ALE (Arbitrary Lagrangian Eulerian) description. The model is an extension to WISE (Width Integrated Stratified Environments) 2DV numerical model, originally developed by Hejazi (2004). The simulation results have been compared with the experimental data and have shown acceptable agreements. The predictions are also compared with the results of the original model employing a standard buoyant *k-ε* turbulence model, which show the advantage of the new model in prediction of non-isotropic flows.

Keywords: Nonlinear *k-ε* turbulence model, Stratified flows, Salinity, non-Isotropic turbulence model, Gravity currents.

1. INTRODUCTION

Despite the intensive research efforts of the past decades to develop more general turbulence models, *k-ε* models still remain the most widely used approach by engineers and scientists for the solution of practical problems. The main advantage of *k-ε* turbulence models is due to the reasonable computational time compared with the more complicated models which may have somehow more accurate predictions in some cases in the cost of enormous computational time.

To improve the predictions of *k-ε* turbulence model a lot of research work has been carried out. An extensive research effort was carried by Speziale (1986) to enable turbulence modeling with consideration of anisotropy by the application of nonlinear *k-ε* models. One example, where anisotropy is dominant and is widely applicable and important in geophysical, environmental and some other engineering turbulence flows, is stratified flow. The density variations due to stratification may be caused by temperature gradients, salinity or other species concentration difference across the depth of the flow. The flows which lie in this category may increase or damp turbulence fluctuations depending on occurrence of stable or unstable shear layers. In stratified flows, stress induced anisotropy is present. Therefore linear turbulence models may result in inaccurate predictions of turbulence and hydrodynamics characteristics of such flows.

The aim of the present study is to model saline water flow and turbulence characteristics using the nonlinear *k-ε* turbulence model which has been firstly presented by Speziale (1986). The model has been simulated for three lock-release type tests, which the laboratory experimental values were reported in the literature. Velocity and salt concentration profiles have been compared with the measured values and linear *k-ε* model predictions.

2. GOVERNING EQUATIONS

Continuity and conservative Navier-Stokes equations in ALE description (Eqs. 1, 2 and 3) have been deployed and implemented in the hydrodynamic model (WISE) originally developed by Hejazi (2004):