ABSTRACT

We summarize in this work a recent development of a SELFIE-based three-dimensional numerical model for the Yellow and East China Seas (YCES), equipped with multiple-scale circulation, wave, and multiple-sediment transport modules. Some important improvements have been made to deal with the multi-scale circulation, we have introduced an open boundary condition to absorb multiple scales of waves, and we have an absence of multi-scale simulations. We have retained for non-cohesive sediments model of SELFIE for the fine-scale application to cohesive and non-cohesive sediments, and our aim is to implement an extended form of erosion rate and a simulation model for the determination of settling velocity of cohesive flow. We assume that erosion of cohesive sediments is due to non-cohesive and cohesive sediments (and is independent if it is computed) and simulate how waves and wave have been computed with newly constructed GOCI images.

3D Baroclinic Circulation Model

For the calculation of 3D baroclinic circulation the model SELFIE has been used. Here details of the model are omitted, only the open boundary condition is described. Along the open boundary, a mixed form of open boundary condition (oceanic boundary condition plus reflection boundary condition for the velocity) is newly added.

3D Sediment Transport Model

Sediment transport in the water column is described by advection-diffusion equation:

\[ 
\frac{\partial c}{\partial t} + \nabla \cdot (v c) = D \nabla^2 c + F \nabla c + S
\]

where \( c \) is the volume concentration of suspended sediment in class \( j \), \( \theta \) are the horizontal coordinates, \( \nabla \) is the velocity component on the horizontal plane, \( D \) is the diffusivity coefficient, \( \nabla c \) is the settling velocity of suspended sediment in class \( j \).

Bottom boundary condition: the exchange of sediment between the bed and flow are defined by

\[ 
\frac{\partial c}{\partial t} + \nabla \cdot (v c) = D \nabla^2 c + F \nabla c + S
\]

where \( \delta \) is the deposition flux of sediments of class \( j \), \( \gamma \) is the erosion flux of sediments of class \( j \), \( \eta \) is the water depth.

Deposition and Erosion of Non-cohesive Sediment

Deposition of non-cohesive sediment \( \delta_j \) is given by

\[ 
\delta_j = \frac{\alpha_{de} \cdot \gamma_j}{\eta}
\]

where \( \alpha_{de} \) is the concentration in bottom computational cells of sediments of class \( j \).

Erosion flux is calculated using van Rijn (1984) formulation:

\[ 
\gamma_j = -\left(\frac{\alpha_{de} \cdot \eta}{\alpha_{de} \cdot \eta + \alpha_{de} \cdot \delta_j}\right)
\]

where \( \alpha_{de} \) is the erosion rate, \( \delta_j \) is the sediment particle diameter, \( \alpha_{de} \) is the porosity, \( \eta \) is the water depth, \( \alpha_{de} \) is the volume concentration of non-cohesive and cohesive sediments in the bed, \( \gamma_j \) is the bottom shear stress, \( \alpha_{de} \) is critical shear stress for sediment class \( j \), \( \delta_j \) is the water depth.

Deposition and Erosion of Cohesive Sediment

Deposition flux of the cohesive sediment \( \delta_j \) appears only if stress is less than critical shear stress for deposition.

\[ 
\delta_j = \frac{\alpha_{de} \cdot \gamma_j}{\eta}
\]

where \( \alpha_{de} \) is critical shear stress for the deposition of cohesive sediment.

Erosion flux of the cohesive sediment is formulated following Arisathithi and Antsaklis (1998):

\[ 
\gamma_j = -\left(\frac{\alpha_{de} \cdot \eta}{\alpha_{de} \cdot \eta + \alpha_{de} \cdot \delta_j}\right)
\]

where \( \alpha_{de} \) is critical shear stress for the erosion of cohesive sediment.

For the mixture of cohesive and non-cohesive sediments we follow the approach by van Loon (2004) and the mixing conditions in the sediment fraction (in the bed is above critical, \( \alpha_{de} \) erosion and deposition occur is cohesive, erosion, \( \alpha_{de} \) below critical, \( \alpha_{de} \) erosion and deposition occur in non-cohesive regime).

Wave Model

The 3D generation spectral wave model (NWEM-D) embedded in SELFIE system is used (Roland et al., 2012).

The wave action equation in the system:

\[ 
\nabla \cdot (c_n \nabla \phi_n) + \nabla \cdot (c_n \nabla \phi_n) = 0
\]

where \( c_n \) is the wave action density spectrum, \( i \) and \( c_n \) are the wave propagation velocities in the and direction, respectively, \( \phi_n \) and \( \phi_n \) are the wave propagation velocities in the and direction, respectively, \( \kappa \) is the relative wave frequency, \( \eta \) is the wave direction, \( \eta \) is the wave direction, \( \eta \) is the wave direction, \( \eta \) is the wave direction, \( \eta \) is the wave direction, \( \eta \) is the wave direction, \( \eta \) is the wave direction.