

Webinar “Hydrodynamic modeling on the Northwest European Shelf and North Sea: new opportunities with Delft3D Flexible Mesh”

1. Do I understand correctly that two separate models (DCSM and ZuNo) are nested one into another?

Yes, these two grids are coupled using a domain decomposition approach. This means that during the computation information is exchanged on a time-step level in both directions. Therefore, while two separate structured grids are prescribed, these function as one model.

2. Did I understand correctly, that the model uses HiRLAM data as input for wind speed in real time and you also then correct it with the Kalman filter?

For meteorological surface forcing the model uses time- and space varying wind speed (at 10 m height) and air pressure (at MSL) provided by the Numerical Weather Prediction (NWP) high-resolution limited area model (HiRLAM). The resulting wind stress is adjusted by means of a steady state Kalman filter fed with water level observations. More information about the model with Kalman filter can be found in [Zijl et al. 2015].

3. Am I correct in assuming that in the model you include on the boundary the surge as a boundary condition. Normally one does a computation without meteo and then imposes the meteo and wind forecast on this. Could you explain how the coupling is done? Is it an iterative process?

The model has both surge and tide imposed on the open boundaries. Local generation of surge is dealt with by imposing wind speed (converted to surface stress using Charnock formulation for sea surface roughness) and air pressure.

I presume that your question also refers to the manner in which these models are used in an operational forecasting setting. In the old generation DCSMv5 (and other European forecasting models) the representation accuracy of tide-surge models suffers especially from insufficiently accurate tidal representation. Therefore, only the surge component from DCSMv5 is used operationally, while the harmonically predicted tide, from harmonic analysis of tide gauge measurements, is added to predict the full water level signal at tide gauge locations. The surge is computed by doing a tide only run (no meteo surface forcing, only tide imposed on lateral boundaries) and subtracting this from a meteo+tide run (meteo surface forcing + tide+surge on the lateral boundaries).

In DCSMv6 the tidal representation has improved to the extent that the above described astronomical correction no longer improves the accuracy of the total water level representation. Therefore, with the new model we use the much more straightforward method of directly predicting the total water levels with a meteo+ tide run. This is also described in [Zijl et al 2013].

4. What algorithm was used for parameter optimization?

We used the DUD algorithm which is available in the open source data assimilation toolbox OpenDA. DUD is a derivative-free algorithm for nonlinear least squares (Ralston and Jennrich, 1978) that minimises a quadratic cost function by adjusting model parameter (see also [Zijl et al., 2013]).

5. Where do you get the tidal constituents at open boundaries from?

The amplitudes and phases of the eight main diurnal and semi-diurnal constituents have been derived by interpolation from a dataset derived from the GOT00.2 global ocean tide model (Ray, 1999). The amplitudes and phases of 13 smaller diurnal and semi-diurnal constituents have been derived from the eight main constituents by means of the admittance method (see also [Zijl et al., 2013]). In the most recent model version, additional constituents have been added based on the FES2012 global tide model.

6. How did you obtain the surge corrections for the boundary and how did you apply these to the boundary?

While wind setup at the open boundary can safely be neglected because of the deep water locally, the (non-tidal) effect of local pressure will be significant. This so-called inverse barometer (IB) effect, which varies in time and space dependent on local atmospheric pressure, is approximated with the following equation:

$$\zeta_u(\vartheta, \lambda, t) = -\frac{1}{\rho_0 g} \left(P(\vartheta, \lambda, t) - \overline{P_{\Omega_o}}(t) \right),$$

where $\overline{P_{\Omega_o}}(t)$ is the spatial average of $P(\vartheta, \lambda, t)$ over the global oceans Ω_o at time t .

Time dependency in the in the last term is neglected and replaced with a constant value of 1013.3 hPa. The inverse barometer effect is added to the tidal water levels prescribed at the open boundaries.

7. Do you use an adaptive time step?

Yes, Delft3D Flexible Mesh (Delft3D FM) uses an adaptive time step to ensure stability, indeed.

8. Have you considered applying the flexible mesh into the whole model domain, not just connecting two grids?

The domain decomposition approach was used for the presently operational models (DCSMv6 and DCSMv6-ZUNOV4). For the next generation models, we will make use of the enhanced flexibility that Delft3D FM offers, by focusing the resolution in the areas where local spatial scales require it.

9. Would it also be possible to use boundary conditions from ocean current models such as HYCOM?

Boundary conditions can be taken from any source that is available. Nesting in larger scale ocean models is definitely an option.

10. Use of the flexible mesh, moving from quadrilateral grids via triangle meshing can often cause problems at that rapid transition. How were errors mitigated in these quickly changing regions of resolution (e.g., the layer of triangles)?

We have used relatively small transition areas, where we refined by a factor of 2 (using triangles). In that case there is only a limited reduction in accuracy.

11. What is the order of magnitude of the horizontal viscosity you are typically using? is it used the same way as bottom friction for calibration?

A uniform horizontal eddy viscosity of $10 \text{ m}^2/\text{s}$ has been applied. This is a common value for this kind of application, with the grid resolution used. The sensitivity to the eddy viscosity is limited in this application.

12. What is the amplitude of the surge, in which order?

Since the Northwest European Shelf is relatively wide, and varies in depth, the magnitude of the surge also varies enormously. For example, during the 5-6 December storm a skew surge of more than 3 m occurred at tide gauge station Delfzijl in the Ems-Dollard Estuary, while in Vlissingen (at the entrance of the Western Scheldt) the skew surge was around 1.5 m.

13. Could you tell me, when the Z-layers function will become available in Delft3D FM?

Although the research results using the Z-layers option are promising, for the upcoming Delft3D Flexible Mesh Suite 2017, our focus is on 3D modeling with sigma layers.