OpenDA applications

OpenDA

Twin-Test Calibration Using the Friesian Estuary Model

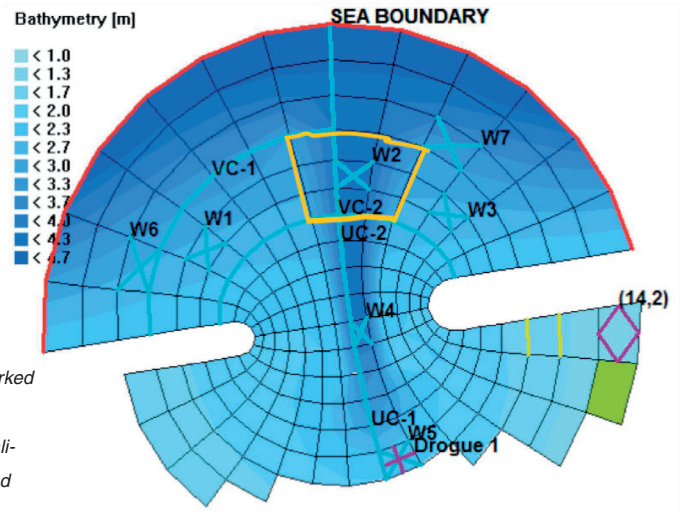

Figure 1: Friesian Estuary Model showing location of open boundary (marked as Sea Boundary where tidal and mean level forcing are prescribed and adjusted), the observation locations (X's) of which some were used for calibrating the model; the yellow box indicates the region where the depth and bed friction were varied.

Delft3D-Flow

Delft3D is a world leading 2D/3D modelling system to investigate hydrodynamics, sediment transport and morphology and water quality for fluvial, estuarine and coastal environments. The FLOW module is the heart of Delft3D and is a multi-dimensional (2D or 3D) hydrodynamic (and transport) simulation program which calculates non-steady flow and transport phenomena resulting from tidal and meteorological forcing on a curvilinear, boundary fitted grid.

OpenDA and Delft3D-Flow

For Delft3D-Flow, a so-called "model wrapper" has been made which takes care of structured data exchange between OpenDA and Delft3D-flow, independent of the specifications of the actual Delft3D-flow application.

Delft3D-flow model application

The Friesian Estuary Model (FE) is a Delft3D-Flow model application which has been developed to study the flow interactions in the region of the Friesian Estuary for ecological purposes. The model has a grid size of 294 cells (N=14, M=21). It was modified for the current purpose by incorporating mixed tidal forcing (K1 and S2) along the open boundary. The model is conceptually simply, requires little computer resources and is ideal for testing, learning and tutorials.

FI twin test calibration experiment

In a twin test experiment a model setup with given solution ("synthetic observations") is perturbed. OpenDA is applied to re-estimate the original model settings, starting from simulations with the perturbed settings. First, amplitudes and phases of the K1 and S2 tidal prescription along the outer boundary is perturbed. In a second set of runs, depth and bed friction were varied in a section of the grid. The optimisation routine in OpenDA (here: DUD) minimises a least squares criterion formulated in terms of water level differences over the twenty five day simulation in a user selected set (s) of synthetic observation stations of the model domain.

$$GoF = \frac{1}{2}\sum_{s=1}^{s=S\max} w_s \left(H_s^{sim}(t) - H_s^{obs}(t)\right)^2 \Big/ \left(\sigma_{Hobs}\right)^2 ,$$

$w_s=0$ or $w_s=1$ depending on whether the station is included in the GoF measure.

Test	Parameter *(p)* varied	Observation stations used	*P*	*ITER*	%Diff from unperturbed (expected) values					
					H(K1)	*G(K1)*	*H(S2)*	*G(S2)*	*Depth*	*Friction*
1	Amplitude of K1	W3, W4	1	3	0	N/A			N/A	
2	Phase of K1, S2	W3, W4	2	8	0.01	N/A	0.1	N/A		
3	Phase & Amp. Of K1, S2	W3, W4	4	28	2.67	-11.02	0.67	-9.70		
4		W1, W2, W3	4	17	0	-0.04	-0.67	0.63		
5		W1, W2, W3, W4, W5	4	29	0.67	-5.51	-0.67	-8.84		
6	Depth	W1, W2, W3, W4, W5	1	4	N/A				0.09	N/A
7	V-Friction	W1, W2, W3, W4, W5	1	5					N/A	-1.10

Table 1. OpenDA simulation results showing the type of parameters varied in the twin test, the observation stations used, number of parameters P, number of model iterations ITER and the percentage difference from the expected value for the parameters that were tested. Test 1, 4 and 6 give best results.

Proof of concept / Results

A series of simulations was made, differing in the variables selected for possible adjustment: K1 and/or S2, amplitudes and/or phases; depth, or V-friction. Table 1 shows the results for several of these simulations, plus the difference from the expected value.

Conclusions

The present application has shown that OpenDA can be used in to optimise uncertain model parameters and forcing in a Delft3D-flow model application. Variation of observation stations shows that their sensitivity to specific perturbations can differ significantly. The user can visualise the optimisation process, and easy to evaluate scores are available to assess the results.

References

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