Sensitivity Analysis of the Flow and Sediment Transport of Vietnamese Mekong Delta Using Coupled Telemac-2D and Sisyphe

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INTRODUCTION

Numerical applications have been widely used in many world's large river systems to investigate the hydro- and sediment dynamics necessary for river management practices because of limited monitoring data which are not enough to provide a full understanding of the flow and sediment behaviors. Due to data limitation, modelers have to analyze the sensitivity of all governing physical and numerical parameters, which affect their model results. First, they roughly run a number of simulations to determine the most sensitive parameters. Then more simulations are conducted to find the best value of each sensitive parameter which can well reproduce a real flow and sediment dynamics of river system.

Sensitivity analysis using hydrodynamics and sediment transport models have been widely conducted (i.e., Chow et a., 2018). In the Vietnamese Mekong Delta (VMD), Manh et a., (2014) analyzed the sensitivity of some physical parameters for 1D (MIKE 11) hydrodynamics and sediment transport models. The ultimate goal of our research is to develop a coupled Telemac-2D and Sisyphe model to precisely simulate flow dynamics and bed evolution of the VMD's rivers under changes of flow and sediment budgets from the Mekong River. In this paper, we introduce a sensitive analysis in the calibration process of that coupled model.

METHODOLOGY

Telemac-2D and Sisyphe are open sources (components of Telemac Mascaret system), developed by the National Hydraulics and Environment Laboratory of Electricité de France (EDF). Telemac-2D is a hydrodynamics model, solving depth-averaged free surface flow equations (Saint-Venant) while Sisyphe is a sediment transport and bed evolution model. Suspended sediment transport is modelled by Sisyphy by solving the two-dimensional advection-diffusion equation. In the coupled model, at each time step, the estimated bed shear stresses and other relevant hydrodynamics variables achieved by solving governing continuity and momentum equations of Telemac-2D are sent to the sediment transport model in Sisyphe to calculate the sediment transport rate and update the bed geometry which is then sent back to Telemac-2D to estimate hydrodynamics variables in the next time step.

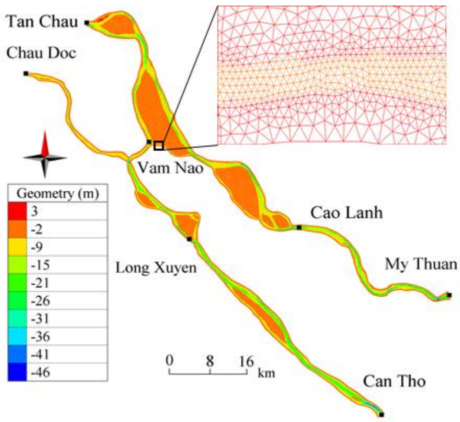

Fig. 1 Study domain and geometry mesh

More than 90% of the suspended sediment in the VMD is composed by silt and clay. Our collected sample in the VMD in September 2018 showed that the median diameter of SSC at Cao Lanh (**Fig. 1**) is 12.63 μm. Therefore, our coupled model simulates cohesive suspended sediment transport and bed evolution for the upper part of the VMD from Tan

Chau/Chau Doc to My Thuan/ Can Tho (**Fig. 1**). 200-300 m floodplain wide is considered to make the model stabilized. The simulated domain uses triangles mesh having a grid spacing of 80 m with 30 or 40 m in narrow channels. The mesh is then incorporated with rivers' bathymetry measured in 2014 to produce geometry mesh. The model uses hourly water discharges and daily SSCs in the upstream boundaries and hourly water levels in the downstream boundaries.

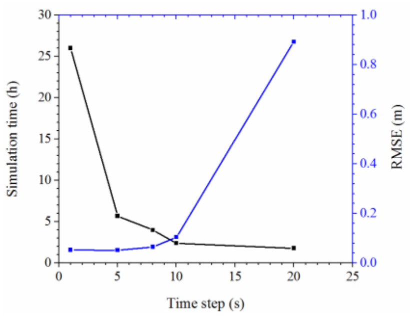

Fig. 2 Sensitivity of time step model accuracy and simulation time - Long Xuyen station

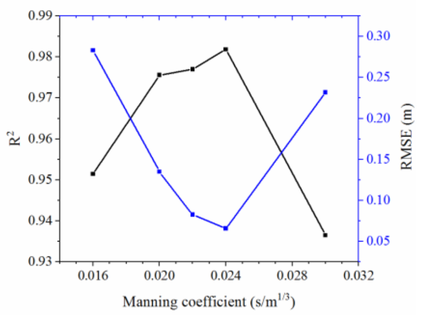

Fig. 3 Sensitivity of Manning coefficient on model accuracy

RESULTS AND DISCUSSIONS

We test the sensitivity of various physical and numerical parameters of Telemac-2D, including Manning coefficient (n), velocity diffusivity (ν), time step (Δt), type of advection (TA), free surface compatibility (FSC), and implicitation for depth (IMD) and velocity (IMV), in which time step and Manning coefficient are the most sensitive. Time step of 1s, 5s, 8s, 10s, and 20s are tested. **Figure 2** shows that the accuracy is relatively similar while the simulation time is significantly different when time step is within 1-8 second; therefore, time step of 8s is selected, leading to maximum Courant number of 0.78.

Increasing Manning coefficient reduces the magnitude and range of water level fluctuations and vice versus. In our model, three zones of Manning coefficients are applied. We test the sensitivity of Manning coefficient in each zone to find the best value. For example, the zone from Long Xuyen to Can Tho (**Fig. 1)** uses Manning coefficient of 0.016, 0.02, 0.022, 0.024, and 0.03. We found that the value of 0.024 is the best for this zone (**Fig. 3**). A set of best parameters of Telemac-2D is shown in **Table 1**, which reproduces a good simulated results (**Fig. 4**), for example at Long Xuyen: R^2 =0.976 and Nash-Sutcliffe (NSE) = 0.958, RMSE = 0.066m.

Table 1 Set of best Telemac-2D's parameters

Δt (s)	ν (m^2/s)	TA	FSC	IMD	IMV
8	10^{-6}	14;5	0.5	1	1

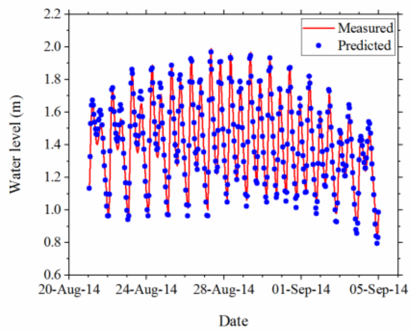

Fig. 4 Predicted vs measured water levels at Long Xuyen

In the cohesive suspended sediment transport and bed evolution model in Sisyphe, we test various physical and numerical parameters, including critical shear stress for erosion (τ_{ce}) , critical shear velocity for deposition (u_*^{cr}), setting velocity (ω_s), Krone-Partheniades constant (M), option for dispersion, dispersion coefficient, and solver for suspension, in which the most sensitive parameters are τ_{ce}, u_*^{cr}, ω_s, and M which need more simulations to find the best values.

REFERENCES

Chow, C., Ramirez, J., Keiler, M. (2018): Application of sensitivity analysis for process model calibration of natural hazards, Geosciences, Vol. 8, pp. 1-28.

Manh, V.V., Dung, N.V., Hung, N.N., Marz, B., Apel, H. (2014): Large-scale suspended sediment transport and sediment deposition in the Mekong Delta, Hydrol. Earth Syst. Sci., Vol. 18, pp. 3033-3053.