Development of iMOD Groundwater Model for the Coastal Area of SocTrang, Mekong Delta, Vietnam

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1. Introduction

Mekong Delta (MD) is one of the most vulnerable regions in the world especially under impacts of climate change and sea level rise. In the coastal zones of MD, since surface water resources are suffered by salinity intrusion and water pollution, groundwater has been considered and accessed as a water supply resource for human activities. Unexceptionally, SocTrang prefecture, which is located in the coastal area of MD (Figure 1), has used groundwater resources for water supply since more than ten years ago. However, lack of assessment on amount of groundwater resources may cause challenges to sustainable development in the area. In recent years, monitoring wells installed in SocTrang have shown a significant drawdown trend of groundwater table in aquifers, especially in the Pleistocene aquifer.

Mathematical models are very essential in water resources management in general and particularly in groundwater management. An appropriate groundwater model setting for SocTrang will help to provide an assessment of the impacts on groundwater levels which may be caused by current and future development there. The previous groundwater model (MODFLOW) for the Mekong Delta region has calculated steady

Figure 1. The SocTrang prefecture.

state groundwater and given the results of those, such as: maps of piezometric contour and flow directions, inventories of water balance. However, as the modeling was carried out for a very large area, its detail was still limited and the groundwater flow was not clear at some places. The SocTrang groundwater model to be discussed in this study employs iMOD model interface which can provide different data. Through considering local model factors, it aims at showing other aspects of movement process of groundwater the regional model could not show.

2. Methodology

2.1 The iMOD approach

The development of the iMOD approach took off in The Netherlands in 2005 when Deltares and a group of 17 stakeholders decided to jointly build a numerical groundwater model for their common area of interest. The iMOD approach allows gathering the available input data to be stored at its finest available resolution; these data don't have to be clipped to any pre-defined area of interest or pre-processed to any mode grid resolution. Resolutions of parameters can differ and the distribution of the resolution of one parameter can also be heterogeneous. In addition, the spatial extents of the input parameters

Figure 2. The iMOD approach.

don't have to be the same. iMOD will perform up- and down scaling whenever the resolution of the simulation is lower or higher than that of the available data. This approach allows the modeler to interactively generate models of any sub-domain within the area covered by the data set. When priorities change in time (e.g. due to changing political agenda's) the modeler can simply move to that new area of interest and apply any desired grid resolution. Utilizing the internal up- and down-scaling techniques ensures that sub-domain models remain consistent with the bigger regional model or that the regional model can locally be updated with the details added in the sub-domain model (Figure 2).

2.2. Development of groundwater model in SocTrang

The first attempt was done by Haskoning B. V. and Division for Water Resources Planning and Investigation for the South of Vietnam (DWRPISV) to set up a regional groundwater model for Nam Bo region including the Mekong Delta. The model was used to study the groundwater flow in the aquifers, to determine the recharge mechanism as well as to evaluate the groundwater potential for water supply. Secondly, a study to demonstrate the down-scaling ability of the groundwater model for SocTrang city is implemented. Boundary conditions were defined based on the results of regional model (Figure 3).

3. Results and discussion

3.1. Boundary condition

3.1.1 Groundwater head: The regional model was built on

Figure 3. The development of groundwater model processes.

a coarse scale of 1000m x 1000m (Figure 4-a), by a simulation network of 308 columns and 410 rows and 8 model aquifers of Mekong Delta. Result of phreatic heads for Pleistocene aquifer was upgraded at scale of 100m x 100m in iMOD model (Figure 4-b). It was assigned as starting head for groundwater head boundary of SocTrang model.

3.1.2 Hydrogeological profile: The subsoil of the model was built from boreholes data provided by DWRPISV for which each borehole was categorized by aquifer number. In total of 6 hydrological profiles were set into the model (Figure 4-c).
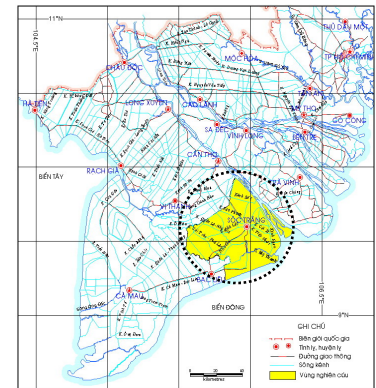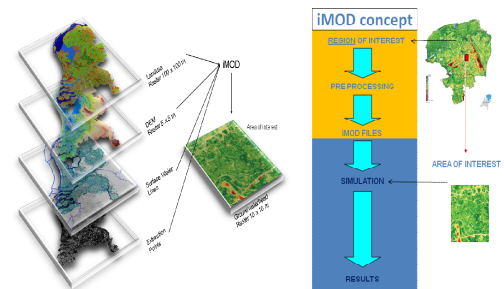
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Moreover, provided geological sections from DWRPISV were included to incorporate more detail; such as out wigging of aquitards as well as local modification of interfaces in between boreholes.

3.1.3 Drainage & surface layer: A surface elevation on a resolution of 1000m x 1000m was used in the regional model. The local model needed to be able to compute at least the low-lying area in SocTrang. Digital elevation map (DEM) on resolution of 100m x 100m (Figure 4-d) was set up in iMOD by data map files from the SRTM digital elevation data, produced by NASA originally. It has been used to update the top of the hydrological system, as well as the drainage levels throughout the SocTrang province.
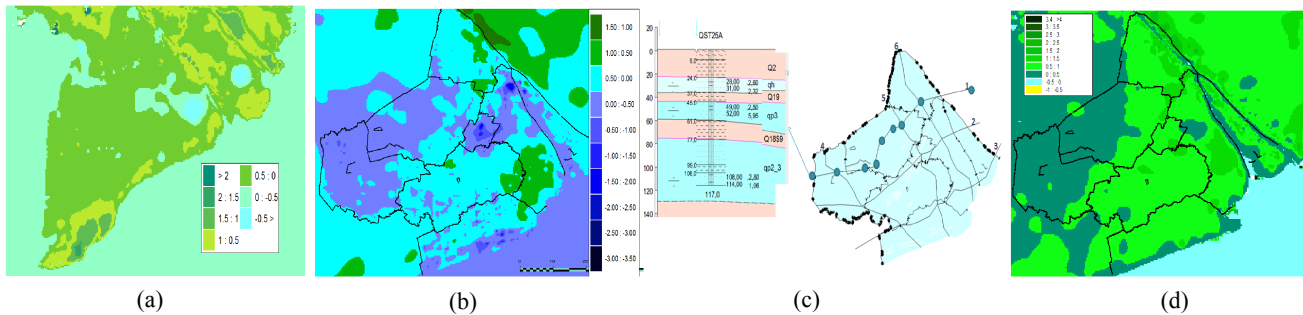

(a)	(b)	(c)	(d)

Figure 4. (a) Regional model result; (b) Groundwater head boundary; (c) Hydrogeological profiles; (d) The DEM (100x100) m2.

3.2 Steady state model

Figure 5 shows the steady state simulation of groundwater head on 15th, Jan. 2013 at scale of 100m x 100m includes the effect of abstraction wells. Recharge, hydraulic conductivities and storage coefficients were calibrated for the steady state of 15th, Mar. 2012 and 15th, Jan. 2013. Table 1 gives results of the steady state calibration. The steady state model calibrates best in the middle of the model and accuracy declines as boundaries are approached.

Table 1 Calibration result for 3/2012 & 01/2013

	Mar.2012			Jan. 2013		
Wells	Simulated Head_Hs (m)	Observed Head Ho (m)	Residual _Ho-Hs (m)	Simulated Head_Hs (m)	Observed Head Ho (m)	Residual _Hs-Ho (m)
NMN21	-11.93	-11.72	0.21	-12.44	-11.63	0.81
KCNN5	-9.12	-9.14	-0.02	-9.56	-10.15	-0.59
PhuLoi17	-8.94	-9.70	-0.76	-9.40	-10.05	-0.65
MyXuyen3	-6.58	-5.89	0.69	-7.02	-6.45	0.57
LongPhu3	-7.36	-7.04	0.32	-7.81	-7.08	0.73
Kesach4	-7.51	-8.05	-0.54	-7.93	-8.08	-0.15
DaiNgai2	-9.02	-8.27	0.75	-9.50	-8.60	0.90
HungLoi1	-7.14	-7.08	0.06	-7.58	-8.82	-1.24
VC4	-9.77	-10.00	-0.23	-10.47	-11.37	-0.90
MyTu2	-6.51	-8.00	-1.49	-6.92	-8.50	-1.58

3.3 Transient model

For the transient simulation, 1950 transient stress periods were conducted by estimated recharge and exploitation based on meteorology and abstraction wells data from 2011 to 2013. Figure 6 shows output of simulated groundwater level values from iMOD compared with local observed stations of KCNN, NMN, PhuLoi, MyTu, VC4, MyXuyen and national observed stations of Q598020, Q409020.
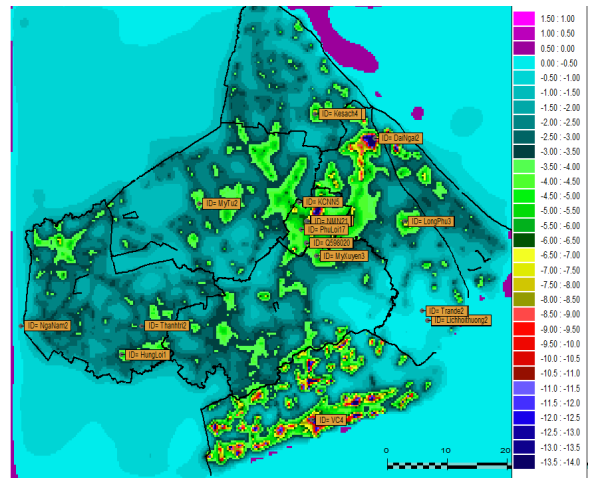

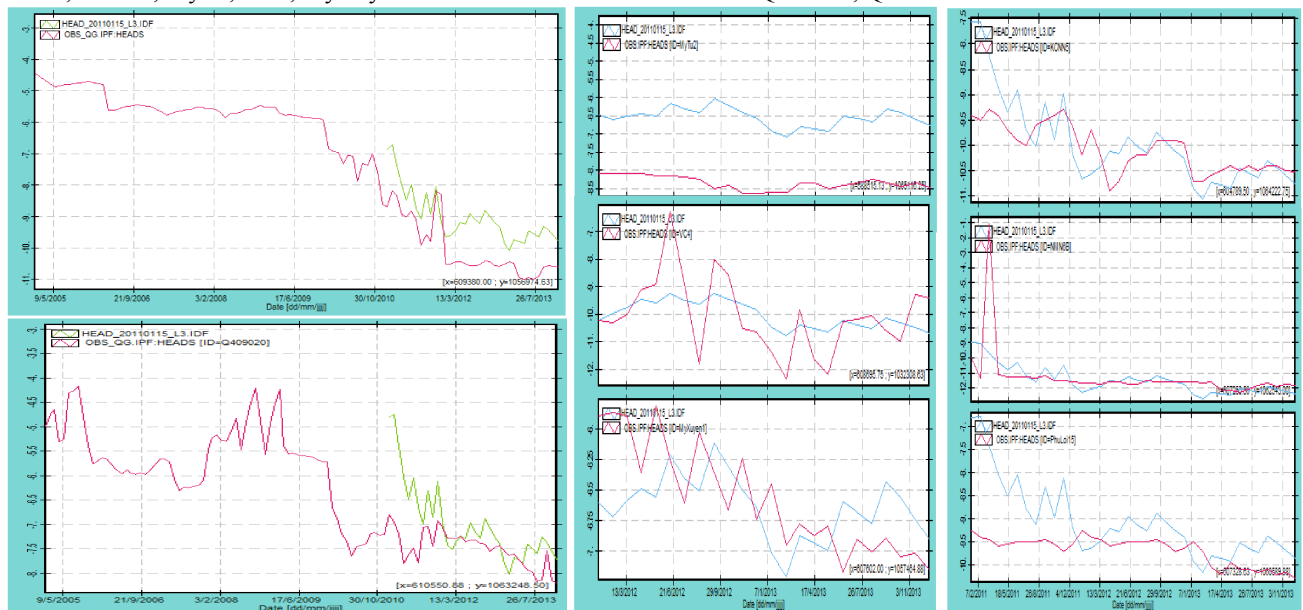Figure 5. Steady state simulation of Pleistocene aquifer.

Figure 6. Output of simulated transient steps from iMOD compared to monitored stations of groundwater level.

4. Conclusion

Since aquifers in SocTrang are affected by groundwater pumping, abstraction wells data should be sufficiently updated in the model. Although hydraulic conductivities were calibrated in model, the data set needs to develop in more detail. Basically, the model could be used to predict groundwater situation bases on groundwater demand in future of SocTrang. In addition, impacts of changing of sea level, rainfall and evaporation on groundwater could be addressed by scenarios development in model.