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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Optimal well locations using genetic algorithm for Tushki Project, Western Desert, Egypt" *by* S. Khalaf and M. I. Gad

A. L. Hojberg (Referee)

alh@geus.dk

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General comments

The manuscript addresses a relevant topic on optimisation of well location and extraction rates by combining a groundwater simulation code (MODFLOW) with a new optimization code based on a generic algorithm. The combined model is demonstrated for the Tushki Project in Egypt. The MS contributes especially by considering not only optimal rates but also optimal locations in the optimisation.

A major revision of the MS is, however, required prior to its publication:

1. The language needs to be improved significantly. In its present form, several parts

of the MS is difficult or not possible to understand

2. The detail of the descriptions is very varying. Some aspects is devoted much space without providing much relevant descriptions, e.g. descriptions of GA starting with Darwin and genes, while other aspects is almost not described leaving the reader with questions, e.g. description of the model calibration. The length of the text describing the different aspects should be more balanced, reflecting what is relevant for the present study.

3. The structure of the MS is generally good, but needs to be revised at some places to better guide the reader, especially where the calibration of MODFLOW and the optimisation with OLGA is described

4. In the downloaded version of the MS the legends and text in the figures are very difficult to read.

5. There are 13 figures, some may be removed and some need improvements

Specific comments

1. Introduction: The introduction includes a description of several previous studies on optimisation techniques, including a short list of the detailed results from these studies, such as number of wells, abstractions rates or costs. These results is not relevant for the present study and it is not explained how the present study builds on top of existing studies. It should be more clear how the present study utilise knowledge from previous studies and what is new in the present study. The introduction should thus be revised.

1.3 Hydrological aspects

"General groundwater flow direction is from SW to NE direction" this cannot be seen from the figure. It is wrong or does it refer to a regional flow not visible in the figure?

"The groundwater flow rate was estimated as 0.044mday−1 (near Nasser Lake) and decreased to 0.044mday−1 towards northwestern parts (El-Sabri et al., 2010)" it is the

same number twice

2. Materials and methods

The last paragraph is repetition and can be left out

2.2 conceptual model

“The basement surface forms an impervious lower boundary for the aquifer and acts as a barrier to the lateral groundwater flow in some locations” What is meant by "some locations", what is the condition elsewhere?

2.4 Model calibration: This section is simply some textbook materials of little use in the MS. Instead the section should describe the calibration methodology used including:

Observation data: is it only calibrated to hydraulic heads? How many observations wells? (appears to be 9 from the figures). Where are they located?

How many parameters where included in the calibration? Horisontal/vertical conductivities – one for each geological units? What is the assumption with respect to the faults? What is the interaction with the lakes? Is the boundary conditions calibrated – how?

For the transient calibration what type of data is used – are there any time series of head from observation wells or is storage calibrated by first calibrating the heads to the 2008 data and then calibrating the storativities by running the model to 2010 and comparing to the 2010 data?

Have any attempt been made to validate the model. It seems that little information is available on head data and the dynamics of the aquifer. The simulated drawdown in the scenarios are very dependent on the calibrated specific yields, thus uncertainty in these estimates will result in uncertainties in the simulated drawdown. What will this uncertainty mean for the final results and recommendations?

2.5 Optimisation technique + 2.6 Testing scenarios

The optimisation procedure and the test of scenarios is difficult to understand. What is e.g. meant by “After completing the stage of calibration, the output of the first round is used to replace the initial condition with the condition of implementing the exploitation policies.”

Equation 3 – 6 list the constraints in the GA optimisation, but which values where used in the constraints

What is the actual objective function – how is drawdown and optimal Q weighted?

3 Results and discussion

The results from the calibration of the groundwater model and the results from the optimisation should be in individual sub-sections

In table 4-6 and in the discussions I have problem understanding what variables are 1) results, and what are 2) constraints in the GA optimisation.

a. r(m): I guess it is a constraint during optimisation, but numbers in the tables are the final results – what constraint has then been used?

b. Qmin/well – as above

c. Qmax/well, is this only a constraint or has the optimisation resulted in this Qmax for some wells?

d. Qopt: I guess this is the total daily extraction for the optimised setup

Why do you end up with different Qopt in the different scenarios. Should Q_demand not be the same for scenario 1 and 2, while 3 should be larger to include the reclaimed land? The Qopt in scenario 3 is actually lower than in scenario 2?

It is very difficult to follow the results, especially on the drawdown, one value is listed in the table, another provided in the text, which is much lower, with reference to some large drawdown in southwest, but that cannot be seen from the figure.

Tables:

Table 1 and 2 is of little value. Instead the resulting values (transmissivity and storage) should be provided

Table 4-6 may be combined to one table

Figures:

Figure 3, is not too relevant and can be excluded

Figure 5, what is the information of this? We do not need just the discretisation. It should show the different types of internal and external boundaries, where are they located and what type is used? We can only see the fixed head in the lakes, what about the others? What are the two black lines – roads? Some grids have shades from brown to blue, what is that – topography?

Figure 6, I do not understand this figure, what does is illustrate?

Figure 7. Very relevant figure, but I do not quite understand it. Left side illustrates a MOFLOW simulation without wells? How does this simulation generate initial population? On the right figure is the second box MODFLOW MODEL (Simulation model) With wells a simulation with one possible well distribution i.e. one member of the population?

Figure 8a and 8b can be left out and replaced by a table with the final results from the calibration

Figure 9, why is there no background for this figure displaying the results of scenario, while the results from the two other scenarios (Figure 11 and 13) have a background

Figure 10, provides little information, either skip this figure or include the present location of the wells with another colour

While some figures can be left out, it would be nice to have the following figures:

One displaying the conceptual model with a cross section and the thickness of NSATA

One displaying the location of the observation wells used in the calibration of the groundwater model

Number of wells:

Different number of wells in the area is mentioned. In the site description it is stated "About 155 wells were already for this purpose (Fig. 1) besides 210 wells will be drilled by the end of the year 2017". In figure 1 there is not 155 wells, the figure caption mentions 48 flowing wells (abstractions wells?) and in the optimisation scenarios the existing number of production wells is 68?

Units:

Different units are used throughout the text, e.g. acres and square meters, please use SI units

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