Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-5-RC1, 2016

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Fresh groundwater resources in a large sand replenishment" *by* S. Huizer et al.

Anonymous Referee #1

Received and published: 8 February 2016

Paper Review for Hydrology and Earth System Sciences

Authors Huizer et al. have submitted the manuscript (ms) entitled "Fresh groundwater resources in a large sand replenishment" to Hydrology and Earth System Sciences.

The authors investigate the effect of local sand replenishment along a Dutch coastal regional on fresh groundwater resources. Effects of climatic change are also included in the study. A 3D variable-density groundwater flow model is constructed and used to predict long-term effects of the added sand. Results indicate that the sand replenishment can both protect the coastline and secure freshwater resources at the same time. It is concluded that sand replenishment can have that combined positive effect along many other low-lying coastal areas worldwide.

The ms is a valuable and novel contribution to coastal flow research. The ms is well

written and organized. Figures are of good quality. The key message is novel and should be made available to the scientific community. However, the manuscript does have room for some substantial improvement that mainly concerns its modeling part. My major points of criticism are given as General Comments, followed by some specific and technical comments that must also be addressed. I recommend acceptance of the manuscript with major revisions.

General Comments

1. P6L1-6. The authors give details on the spatial grid. The last phrases indicate that the authors are aware of spatial discretization problems inherent to variable-density flow simulations. However, it appears that the authors have not conducted a grid convergence test. Does that spatial discretization exclude numerical round-off and truncation errors? The simulations are certainly transient (the authors should say so), so have the authors examined the effect of temporal discretization? What is the time-step size? Which time-stepping scheme is adopted, constant, adaptive, error-controlled? Both the spatial and temporal discretization must be justified. All of this must be clarified in the revised ms version.

2. P6L7-14. Please clearly explain the definition of BCs, this is not clear from Fig. 4. A 2D slice might be helpful. What is a general-head BC? Does the constant-head BC apply to the top of the sea or to the sea floor?

3. P7L31-34 (and other locations). It should be clarified and clearly listed which processes both models simulate, and how they are incorporated. For example, how is coastal erosion incorporated in the groundwater model? While I do understand that Delft3D is a sediment transport model, I do not see that it can also simulate erosion? Please clarify. Also, how was sea-level rise incorporated in the groundwater model? Your model is not a box-type model domain so your beach is actually inclined. As a consequence, more beach surface area is inundated as a result of sea-level rise. This changes the type of BC of beach nodes from Dirichlet to Neumann. How was this

issue dealt with? And also, it appears from P8L27 that tidal activity was simulated by the groundwater model, is this correct? If so, more details on that BC are required: which tidal signal was imposed, how does the time-step size change as a results of tidal activity? How was that tidal BC incorporated on the beach boundary?

4. Section 3.2 Initial Conditions. It is unclear to me which model(s) you run to attain initial conditions. I would believe it is computationally almost impossible to simulate a coupled morphodynamic-groundwater model for 510 years that includes sediment transport, erosion, saltwater intrusion, sea-level rise, tidal activity, submarine freshwater discharge, variable-density groundwater flow, salt transport. That simulation alone would require a very rigorous choice of spatial and temporal discretization, and the small time-step size would very significantly increase the CPU times. Again, listing of processes simulated by which model is obligatory here. Also, it appears from P8L4f that you are simulating the salt distribution at the onset of your actual simulation. This implies that the salt concentration in the North Sea is not at steady state, which requires clarification.

5. How was the newly simulated sand distribution communicated to the groundwater model? Was the spatial grid deformed corresponding to the newly simulated bathymetry? Did you re-mesh the model area? How was the sea-zone represented: high-K zone? Which K does the sea have?

6. Section 4.1 Model Calibration. It must be clarified and justified here that you calibrated on steady-state (recent) values of head and salinity. That calibrated steady-state model is then used to run transient scenarios. Hence, the transient model is, strictly speaking, uncalibrated!

Specific Comments

7. P1L24. Inhabitants are not vulnerable, ecosystems are.

8. P2L6. Are the Netherlands a delta? Either call it “region” or “country, or simply

delete.

9. P2L19f. This is ill-phrased. What you mean is that instead of putting a little bit of sand everywhere, people think about putting a lot of sand on one point in space. The term “small-scale” is misleading here because it is actually a large-scale distribution of sand that is being replaced by point-wise replenishment of sand. This needs to be written in appropriate terms.

10. P2L23. The “surface level including the sea bed level” is simply the bathymetric surface, or even simpler the bathymetry.

11. P4L24. It is unclear which unit the phreatic aquifer is. I am guessing the green unit in Fig. 3? A legend in Fig. 3 would be helpful.

12. P4L34. There is no freshwater lens in your coastal aquifer. To my understanding, freshwater lenses only form below islands and in coastal aquifers under heavy influence of groundwater extraction that pushes the saltwater-freshwater interface upwards forming a lens on the seaside of the pumping wells. Neither is the case here.

13. P5L1f are obvious, delete.

14. P5L10. Swap words: “frequently measured”. Also, how frequently?

15. P6L7. Delete “outer” since all boundaries are along the outside. Also, some boundaries are parallel to the coastline, so the first phrase needs rewording. Please indicate the location of your model area in Fig. 2. As is, it is unclear where exactly you are modeling. Is it the rectangle in Fig. 1?

16. P6L15-20. Please indicate in Fig. 4 which is an aquifer and which is an aquitard. All units could simply be named aquifer 1,2,... aquitard 1,2,..., phreatic aquifer etc., and a legend should be given. Also, please put all the parameter values in a table and delete from the text.

17. P6L22f. I do not see the phreatic aquifer nor the two hydrogeological layers in any

figure. This must be clarified.

18. P6L29ff. Do you mean spatially or temporally averaged values? Surely, the simulation is transient, then are all these values constant-in-time and spatially distributed?

19. P7L6. The *linear* relation?

20. P7L27. Delete “method” and “of”. Replace “adjustment” by “calibration”. How was the model calibration done, manually, PEST? Please clarify. Same for P8L10-14, how did you actually find the values of the finally calibrated parameter?

21. P9L16. “evenly or randomly” is ill-worded.

22. P11L12-24 are Intro material and should be shifted.

23. P13L9. Unclear which “local circumstances” you mean. Either clarify or delete.

24. Fig. 10. What causes the oscillations? Tidal activity? This must be explained and it must be said, which tidal signal is applied. A scale on the time axis is missing, probably 2011-2050? Simulating tidal activity for 40 years would require a very small time-step size. Or did you only consider the lunar cycle in the change of the sea level?

25. Fig. 11 (and corresponding interpretation in text). Did you consider the morphological situation of 2050 as a steady state? What happens after 2050?

26. Literature. References on the effect of tidal activity and storm surges on coastal freshwater resources could be mentioned: Kooi, H., Groen, J., Leijnse, A., 2000. Modes of seawater intrusion during transgressions. Water Resources Research 36, 3581-3589. Violette, S., Boulicot, G., Gorelick, S.M., 2009. Tsunami-induced groundwater salinization in southeastern India. Comptes Rendus Geoscience 341, 339-346. Yang, J., Graf, T., Herold, M., Ptak, T., 2013. Modelling the effects of tides and storm surges on coastal aquifers using a coupled surface-subsurface approach. J. Contam. Hydrol. 149, 61-75. Yang, J., Graf, T., Ptak, T., 2015. Sea level rise and storm surge effects in a coastal heterogeneous aquifer: a 2D modelling study in northern Germany.

Grundwasser 20, 39-51.

Technical Comments

27. P2L4, P2L14, P2L31 (and many other locations in the ms). Please add a comma: “Fortunately,”, “Since 2001,”, “In September 2011,”. I found approximately 30 missing commas.

28. P2L11. “have”

29. P3L1. “800 m into the sea”

30. P3L2. Fig. 2 not 1

31. P3L4. Delete “(local mega-nourishment)”, it is now clear.

32. P3L17. Consistently use “variable-density” with “-“.

33. P3L23 (and other locations). Replace “scenario’s” by “scenarios”.

34. P4L26. Delete “grained”.

35. P5L6. “long-term”.

36. P5L28. “were simulated”.

37. P10L12. “similar to the situation”.

38. P10L21. “volume of groundwater”.

39. P10L22. Replace “lower” by “smaller”.

40. P11L3. Replace “with” by “by”.

41. P11L5. Replace “pace” by “rate”.

42. P13L5. Swap words: “substantially grow”.

43. Table 1. Plus the effect of the Sand Engine gives a total of 10 scenarios? Please

clarify.

44. Fig. 7b. Give values of the zoom plot a different symbol to better differentiate.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-5, 2016.