

Interactive comment on “Investigation of seasonal river–aquifer interactions in a tropical coastal area controlled by tidal sand ridges” by H. Calderon and S. Uhlenbrook

Anonymous Referee #1

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The authors investigate groundwater-surface water exchange flows for a river transect about 500 m upstream of the river outflow into the sea. This river section is dominated by large water level fluctuations as a result of the formation and then sudden erosion of sand bars blocking the river outflow. In turn, these river water level fluctuations dominate the dynamics of hydraulic heads in the river plain. The analysis is based on river stage data and hydraulic head data from 10 piezometers along the cross section. This data is used for the parameterization of HYDRUS and subsequent simulation of exchange rates a) across the river bed and b) across the river banks.

The rationale behind the study is that the aquifer provides the surrounding population

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with their drinking water and as a result water quantity and quality is important. The study is thus important for water management in this area. The other point is the claim that methodologies for the study of groundwater-surface water interactions which are used in temperate regions might not be applicable in tropical regions due to the difference in rainfall characteristics (however, the only point the authors explicitly mention is the difficulty with small temperature gradients between surface and groundwater – the same problem exists in temperate regions during spring and fall).

General comments:

Reading the manuscript I was disappointed that the authors do not come back to a detailed discussion of the above issues in the in the context of their results and so one is left with the results: a) occurrence of flow reversal between groundwater and surface water depending on river stage fluctuations as a result of the formation and breaking of the sand dam and b) propagation of a dynamic pressure wave from the river to the piezometers in the floodplain. The methods used for this study are standard and similar mechanisms have been observed by other researchers around the world (as cited by the authors). In the end it does not become clear how this study extends beyond the level of a case study, it seems like the final step is still missing (or it needs to be better explained).

The discussion section is incomplete and mainly focusses on pressure waves. Much of the first part of the discussion is actually still reporting results.

Specific comments:

Title: I would remove “Seasonal” from the title. Seems out of context here.

I would be interested in seeing an analysis of time lags (response and peak) between river fluctuations and the response of the piezometers and also to see how well the model performs in this respect.

Tables:

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Table 1: add more information to the caption: K_s – initial value = average of slug tests, min and max = range of slug test results. The header “optimized K_s .” over the initial value and the range is confusing as this only refers to the last column.

Table 2: change headers to “Dry period (calibration period)” and “Rainy period (validation period)”. Add Nash-Sutcliffe efficiencies. Discuss the fact that the model always seems to overestimate.

Figures:

Figure 1: Cross-section hardly visible on the photo. Make photo larger and indicate the sand ridge. What is the lens of shale on the eastern side? Add the river more clearly into the sketch. Give information on how you know the subsurface topography of the shale. (how much of this is a guess and how much is based on data?). Labels in the sketch need to be bigger.

Figure 2: Do you have data on the erosion events? Indicate timing on the graph. How can you get groundwater exfiltration if the river stage is continuously higher than the hydraulic heads in the piezometers? Caption: these are daily averages of hydraulic heads – not of the daily average fluctuation. (remove “fluctuation” – this comes up twice in the caption). In the caption you refer to a), b) c) which does not show up in the graphs. Try to split the y-axis if the precipitation plot so that the large event does not obscure the normal events so much.

Figure 3: the way this is plotted it is hard to make out the hysteresis (for which piezometers is the difference between limbs outside of the measurement error of the sensors?).

Figure 4: Why not show the other piezometers as well? Here we only see the two located in the clay – what about the ones in the alluvium and the shale? I would change the orientation and the format of the x-axis labels (omit the year and add this info to the caption). Add “(validation period)” to the end of the caption.

Figure 5: Shade periods with presence and absence of the sand dam in different

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colours. If the spikes are due to the tide coming in – why does this show up as a spike and not more gradually? Do the spikes also show up in the days after the 21st? This is difficult to see. Remove the precip axis from the second plot. I would not use the scientific notation on the y-axis (scientific notation of the numbers is not shorter in this case).

Figure 6: Make the precipitation bars less prominent (they obscure the other time series) – you do not discuss them. Add river stage to the graphs. Add labels for dry and wet conditions to the plots. Change y-axis title to exchange flows or something similar, otherwise the first association is that you are showing discharge. This is the event you generated to investigate bankfull flow conditions – this information is missing in the caption. The asymmetric behavior of the two banks should be discussed in the text.

p.9760, l.3: explain what you mean by seasonal river-aquifer interactions

l.7 how does this influence water availability?

l.9 rephrase “river-aquifer flows” to groundwater-surface water exchange

l.14 add what the unit length is in this case.

l.14 rupture (fast erosion)

l.17 not clear what bank storage flows are. Clarify how you distinguish this from the groundwater exfiltration mentioned in the sentence before.

l.19 “behaves as confined” - unclear, needs a little more explanation

p.9763

l. 1: need more details on why and how the interactions between groundwater and surface water should be so different in the tropics.

l.7 control the river water level fluctuations. . . (the water level fluctuations are here more important than the discharge fluctuations)

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l.20 clay and alluvial deposits (delete "unit") give conductivity ranges for both clay and alluvial deposits (add conversion to m/s (or replace) – more commonly used SI Unit)

p.9764

l. 3 coastal geomorphology (can you show a photo of how these sand ridges look?)

l.11-13: confusing: what is averaged here? First you are referring to October, but the next value does not seem to be the October average. Add the October value directly after the first reference to this month.

l.20 What are the depths of the piezometers? Where are they screened?

l.26 where was the baro diver located?

p.9765

Did the ERT cross section cover the entire transect? Why are the results not shown?

l.13 depending on the method used the differences in gw and sw temperatures are important, not the fluctuations. Your daily fluctuations are very large with 17 °C difference between day and night. You could use the propagation of these fluctuations into the sediment to determine groundwater discharge if you measure temperature profiles. Explain why this was not an option.

l.16 does the model domain match exactly the sketch in Figure 1 (apart from going deeper)? If not indicate the model domain on the sketch or state that the lateral extent of the model domain is shown in the sketch.

l.21-27 not clear why you chose asymmetric boundary conditions. Why not use the variable seepage/atmosph. boundary condition consistently across the entire domain or ? Explain in more detail what you mean by "allows groundwater flow".

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l. 13. How far was the climate station from the site?

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l.16 I am confused by the unit length of river cross section. You are already modeling the cross section in 2D. Do you mean unit length of river bank or stream reach or something perpendicular to the cross section you are modeling?

p.9768

The section on river stage change simulations is slightly confusing and needs to be rewritten.

l. 10-11 needs more information – unclear. The start of the new paragraph – is this a new topic or the continuation of the explanations before?

How was infiltration capacity estimated?

l. 19-20. Unclear, needs more detail

p.9769

l. 3-9 this refers to the same period – why do you break the discussion up by starting a new paragraph? If the data during that period is corrupted due to construction, does it make sense to discuss the increase in heads? Why do you attribute this increase to groundwater discharge instead of the dam effect of the sand bank? You then suddenly change the topic to the sand ridges – please make this paragraph more consistent and easier to follow.

l.14-29: you start with two events and then suddenly you mention a third event. Please stay consistent.

p.9770

section 4.2: show the data in a figure

l.9 how much did the temperatures drop?

section 4.3: why did you only include 2 events into the analysis?

In the text, refer to a, b, c, d in figure 3 to make it clear what you are describing.

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What about comparing ridge vs. no ridge?

p.9771

l. 8 why do you interpret the data from P3E1 if you say it cannot be trusted?

Section 4.5.1 Rainy period (validation period)

l. 25 – what heterogeneities? Explain in model setup section and refer to these explanations from here.

p.9772

what are the actual measured time lags? (response and peak lags between river stage and all piezometers?)

l.3-5 rephrase this sentence – unclear

l.16 does this refer to recharge from the river or also from infiltration or lateral inputs?

l.21 why was there a gradual change in flow direction?

p.9773

l.3 what are mixed tides? What is the difference in water level increase in the river between the two tides?

Section 4.5.2 Hypothetical bankfull stage peak

l.7 “both sets” – we need a little more introduction here or the reader is lost or has to go back to the methods section. What sets?

l.10 from the graph it looks like more than 0.1

l.11 you are referring to peak river discharge several times in discussing this figure – need to show discharge and/or stage in the graph

p.9774

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l.2 The largest observed rise in river stage (0.6 m) – not clear what you mean by increments

l.5 This release resulted in lower river water levels and caused. . .

Section 5.2 Bank storage – can you estimate the amount of bank storage?

l.12 fast – how fast? What are the response lags and the lags between peaks? Also line 14

How do you differentiate between bank storage recharge and groundwater recharge? Should be in the methods section and then consistent differentiation throughout the manuscript (or combine the two into a joint recharge term if this is more helpful).

l.20 “Hydraulic gradients across river banks shift with peak river stage” - where is this shown?

l.22 “which supports the analysis of the bank storage. . .” how does it support it?

p. 9775

l. 3 – what are the time lags or are they totally synchronized?

l. 4-7 this is just a repetition of the results

how well is does the model simulate this pressure wave? Show data and simulation.

p. 9777

l.12-19 how is this different to other locations (not tropic)

l.16-19: is this your final conclusion? Was this not obvious from the start? And this is the same problem that you have for half of the year in more temperate regions when groundwater and surface water temperatures are too similar to use the gradient. What about looking at the dampening of daily temperature fluctuations within the sediment? What about other methods to investigate these interactions?

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Technical comments:

Several minor spelling mistakes throughout the document

p.9761 l.18 need for l.27 sediment instead of sediments

p.9763

l. 1: rephrase "...leaves a gap..." need

l.9 analysing the hysteretic relationship between

l.14 located in the Pacific?

l.17 live

p.9764

l. 17 either depths or increases

p.9766

l. 20 descent not descend

p.9767

l. 23 write "the calibrated model was then used to.." instead of "the same model"

p.9768

l.3 short-term not short-terms

p.9769

l. 19 experienced instead of "suffered"

l. 23 rain gauges instead of rain stations

l. 28 the rupture instead of the ruptured

l.29 remove LT

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 9759, 2014.

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