Reply to Reviewer 1 – C3160

We want to thank Reviewer 1 for his thoughtful contribution and comments on our manuscript. We would like to take this opportunity to explain our point of view concerning the specific comments and answer the raised questions. In the following we also comment on technical comments given by the reviewer.

Specific comments

Reviewer comment

Is the language fluent and precise? In general the language is quite clear, but should be improved. The structure of the sentences is more “German” than “English”. I provide some, although non-comprehensive, suggestions in the technical corrections below.

Answer

We will follow the suggestion and have it proof-read by a native speaker before publishing.

Reviewer comment

The first paragraph of the Introduction introduces the problem of sustainable management of water resources, but the paper does not provide results that are directly or straightforwardly applied to this ultimate goal. In fact the notion of sustainable water management is treated by a large number of papers, which are neglected by the authors in their introductory section. Therefore, I suggest to start directly from the scientific problem of the determination of groundwater discharge in surface water bodies.

Answer

The authors understand the stated comment and we agree that the manuscript does not directly address the development of a sustainable management. Nevertheless, in our opinion it is worthwhile and necessary to state an overall reason as background for the focus of the manuscript. If the reviewer does not mind, we would therefore rather keep the current introduction, but would also be interested which mentioned papers on sustainable management would also be useful to cite?

Reviewer comment

Page 4903, lines 17-25. I suggest to substitute “water bodies (lakes, ocean)” with “lakes”, because the statement that “the spatio-temporal SST pattern is similar for the entire water body” should require further discussion when applied to oceans.

Answer

We agree with reviewer 1 and changed it to “lakes” according to the suggestion.

Reviewer comment

As mentioned above, the definition of IF, namely equation (4), is wrong or incomplete and involves SRT and CAT, which are defined later, in section 4.2.1. I think that it would be much better to introduce the method and then discuss the details of its application to the Dead Sea. In other words, I would appreciate separating theory from application, so that the distinction among the proposed methodology, the basic assumptions, the approximations introduced for the specific application, etc. should be clear.

Answer

We again agree with reviewer 1. Equation 4 was too generalized and therefore incomplete and not matching the results given e.g. in Fig. 6. We changed equation 4 (now equation 6) accordingly and would kindly ask reviewer 1 to carefully cross-check our changes. We also tried to follow the suggestion by reviewer 1 concerning the re-ordering of this section. Indeed, theory and application was somewhat mixed and difficult to follow. We now separated theory and application strictly that also leads to the correct order of first defining SRT and CAT and then introducing the IF for example. In our opinion, this reordering significantly improved this part and hence we really want to thank reviewer 1 for this comment.

Reviewer comment

Several, somehow arbitrary, parameters are introduced in the application, for instance, water emissivity and the lengths to define the SR investigation areas or the central area. It would be nice to provide a discussion of the sensitivity of the results with respect to these parameters. This problem is partly discussed in section 6, but it would deserve further investigation.

Answer

We partly disagree with reviewer 1 at this point. In the opinion of the authors the inclusion of water emissivity belongs to a complete conversion of raw DN (radiance) values provided by satellite data to sea-surface temperature. Not including emissivity would result in higher SST values and also in slightly changed IF values. Since most readily processed SST products apart from Landsat, are already converted to SST including emissivity values a direct comparison of the presented approach obtained with different data sets (e.g. MODIS, MSG) would be hampered by not including emissivity.
We also tried to include the aspect of sensitivity of the mentioned parameter in section 6. Together with the before addressed uncertainties and we are now convinced that the manuscript provides an adequate discussion to the reader concerning transferability of the presented approaches and possible influence on the result.

Reviewer comment

A very naive groundwater flow model (see section 4.3) is applied to provide estimates of surface-runoff influence time.

Answer

We agree with reviewer 1 that the approach is simplified. However, it is still valid for the purpose of comparing the possible influence time obtained from thermal analysis and using

Darcy's law. In the opinion of the authors an application of a sophisticated model would be beyond the scope of the manuscript.

Technical comments

Page 4902, line 4	"larger" changed to "large"
Page 4902, line 5.	"why" changed to "Due to that reason […]"
Page 4902, line 10.	The acronym SST is defined later at line 18. - changed
Page 4902, lines 10-11.	Modify "19... data", changed to "19... scenes".
Page 4902, line 11.	Substitute "in the example of" with "to" – changed.
Page 4902, line 13.	Modify "surface-runoff influenced images" –changed to "scenes influenced by surface-runoff".
Page 4902, line 17;	page 4906, line 4. Erase "per-" -changed.
Page 4902, line 25.	Erase "number" - changed.
Page 4903, line 10.	Move "(IAEA, 2007)" immediately after the quotation marks and before the full stop – changed.
Page 4903, line 11.	Modify "At least for the spatial scale" – changed to "For the spatial scale […"]
Page 4903, line 16.	Modify "in an array of patterns varying in space and time" changed to " […] in different patterns that vary in space and time."
Page 4903, line 24.	Modify "contrastingly" – changed to "In contrast […]".
Page 4905, lines 3-4.	Modify "From these applications only two account for" – Only two of these studies account for…
Page 4905, lines 9-10.	Modify "primarily" and "secondarily". In particular "primarily" is in the wrong position and makes it difficult to follow the sentence – changed to "These subjective criteria may not be transferable to other study sites and requires an accurate and adequate rainfall data basis that specifically in arid regions can be limited (Cohen and Laronne, 2005)".
Page 4905, line 10.	Modify "it", because the subject of the last sentence was "these criteria" – changed with previous modification.
Page 4905, line 17.	Modify "This expectation uses Tcherepanov et al. (2005)" changed to "Tcherepanov et al. (2005) exploit this expectation and show […].
Page 4905, line 22.	Substitute "there" with "their". Am I right? – you are right – changed.
Page 4905, line 27.	Modify "image statistics based approach" – changed to "The first objective concerns the development of an objective approach that compares SSTs of a proximal sea area at wadi outlets to SSTs of a central lake area using solely image statistics. This comparison allows differentiating between thermal anomalies caused by groundwater from these caused by surface-runoff.
Page 4905, line 28.	Modify "off" - changed with previous modification.
Page 4906, line 14.	Modify "limy" – changed to " […] Cretaceous Judea Group composed of limestone and dolomite and from Quaternary alluvial [..]"
Page 4907, line 10;	Table 1. Siebert et al. (2011) is missing in the reference list – added.
Page 4907, line 13.	USGS (2011) is missing in the reference list – The reference was erroneously inserted with a different style as the output style from Copernicus publications did not foresee an author for web pages. It is now correctly updated.
Page 4908, line 20.	Modify "alternate"- changed to "vary".
Page 4909, line 7.	Modify "is ETM+ specifically adapted" – changed to "is adapted […] "ETM+" is included the equation description.

Page 4909, line 13. Modify “0.5±0.8 K” – not changed. Can the reviewer state why this should be changed?

Page 4911, lines 26-27 Rephrase the sentence “Essential...contrasts” – changed to “An essential requirement is a sufficient temperature contrast between surface runoff and the central area to obtain thermally observable influences.”

Page 4913, line 2. Modify “this step” –changed by deleting “this step”.

Page 4913, line 5. Please, provide reference for the D8 flow model - included.

Page 4913, line 18. Substitute “maintains” with “remains”- changed.

Page 4914, line 2. Modify “not-surface runoff influenced” – changed to: “these images are not influenced by surface runoff.”

Page 4914, line 8. Substitute “−0.1 > x _ 0” with “−0.1 < x _ 0” – changed.

Page 4915, line 10. Modify “applied”- exchanged with “all”.

Page 4915, line 21. Modify “and – fans” changed to “wadi fans”.

Page 4915, line 24. Is “trough-flown” correct? – no, this is German. We apologize and are thankful for the comment. It is changed to “cross-section of throughflow”.

Page 4916, line 22. Substitute “physical” with “physically” - changed.

Page 4918, line 4. Substitute “adaption” with “adaptation”. Am I right? – both could be taken, but after discussion with an expert on this field “adaption” is the better term to be used.

Page 4918, line 22. Modify “Given is a groundwater velocity...” and “Also given are water densities...”.changed to: “Applied water densities are the maximum measured value 1.19 $g \cdot cm^{-3}$ for brackish groundwater and 1.24 $g \cdot cm^{-3}$ for DS water”

Page 4919, line 4. Erase “_”- changed.

Page 4920, line 10. Modify “larger” – changed to “that the other two terrestrial springs with higher discharge volumes”

Page 4920, line 29. IHS (2012) is missing in the reference list – added.

Page 4921, line 17. Erase an “r” from “Corriolis” – changed.

Page 4922, line 3. Modify “a method independent main advantage” – partly changed to “a method-independent main advantage”.

Page 4923, line 2. Modify “constellation” – changed to:“For that case a differentiation between both waters would be impeded for the single image case.”

Page 4923, line 25. Modify “as the often...capable” –changed to “In the case of arid environments this is unfavourable as the often scarce data situation is mostly not capable of adequately reflecting high spatio-temporal variability of rainfall fields.”

Page 4925, line 19. Add “s” to “reason” – changed to “the reason”.

Page 4925, line 22-23. Modify “In parallel rises the air-temperature the native groundwater temperature of...” – Not changed. Can the reviewer state why it should be modified?

Page 4925, line 26. I have not found Figure 11, I think this should be Figure 10. Am I right? – Correct. We changed it.

Page 4926, line 13. Add “n” to “show” -changed.

Page 4927, line 27. Modify the sentence “the higher...the slower adapts...”.- changed to “suggest for larger discharge volumes a slower adaption of the native groundwater temperature to ambient Dead Sea temperatures through mixing.”

Page 4928, line 9. Substitute “the current” with “this” – changed to “In that context, this study presents a […]”

Page 4935, line 14. The reference “Landsat ETM+ (2011)” is misplaced and possibly wrong – Yes and No. This reference corresponds to the before by the reviewer correctly mentioned USGS 2011 reference. Both (reference and citation in the text were not congruent. It is changed. The

correct/complete reference is
USGS: Landsat ETM+ product description from the Earth Resources Observation and Science (EROS) Center: http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/ETM access: 17.11.2011, 2011.

Figure 1. Hall (200) is missing in the reference list. Substitute “subset” with “inset”. Substitute “climatological stations” with “meteorological stations”. – changed and added.

Figure 2. The colour scale is not very useful to highlight the interesting features. Why are high values differentiated with a fast variation of colours from blue to green, yellow and red? These high values appear in the south-western corner for a couple of images, don’t they? Can the Authors comment on this?
The colour scale was intentionally used to highlight especially the surface runoff influence shown in white colors. The images 15.02.2000, 31.12.2000, 19.01.2002, 19.11.2002 and 28.10.2000 clearly underline the usefulness of the chosen colour scale. The large blue portion of the scale was defined to suppress small SST variation in the center of the Dead Sea that would be visible with equidistant class limits. This allows to present a less noisy image, where the interesting feature (surface runoff) can directly be observed.

Figure 3. It is not clear what is the “mean SST range”. May be, “range” –could be erased from the figure, the figure caption and the text-changed.

Figure 9. Modify the format “_ 0.01− < 0.1”-changed.