

## ***Interactive comment on “Semi-automatic extraction of lineaments from remote sensing data and the derivation of groundwater flow-paths” by U. Mallast et al.***

**U. Mallast et al.**

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Reply to Reviewer 1 – RC 749

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 general comments and answer his questions.

Reviewer comment The methodology is not very advanced, is not very accurate, nor is it very robust. However, due to its simplicity, this method seems useful for areas where only coarse topographic data is available and where groundwater flow paths are largely unknown. In particular it would be beneficial in the context of motivating a field

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campaign where one could benefit from knowing ahead of time where to investigate. The authors make this exact comment in the very last line of their conclusions, but I feel it should be introduced earlier as a fundamental motivation. The simplifications performed and the use of low resolution data would be then justified. I would not try to justify the use of very coarse topography, as the authors did, simply by the fact that few man-made features can be seen in it, and thus present a less confusing input to their procedure. In the study of other linear features (such as fault systems, e.g. EarthScope Northern California LiDAR Project), the highest resolution data (such as LiDAR) is always sought, and man-made features don't present too much of a problem as they can be removed efficiently by many filtering algorithms. I would motivate the authors' approach by the fact that for large parts of the world these data are not available, and a crude automated analysis would inform field campaigns. In the presence of high-resolution data this approach would not, in my opinion, be justified.

**Answer** We agree with the reviewer that it is always sought to have highest possible resolution for a DEM in order to answer geological, geo-morphological, tectonical etc. questions. If available those data has to be favoured and would produce even better and high resolution results. We are convinced that our approach is scale independent. The lineament extraction does not depend on the scale of the data, but on its resolution. We also agree that in most parts of the world such high resolution and, as mentioned, data from e.g. LiDAR is not available. Furthermore, recording such data would potentially be an option but also price intensive.

Coincidentally, we assume that many of those parts of the world have limited information on groundwater and its flow-paths within their country either. This underlines the fact that was mentioned by the reviewer as well, that the proposed method in combination of the freely and globally available ASTER GDEM is reasonable for data-limited regions mainly and equally for projects with limited budget. During the revision of the manuscript the suggested accentuation of this fact as well as the aspect of motivating

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a field campaign will be followed.

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Review Comment I think that this paper would also benefit from being more focused on the task at hand: delineating lineaments of this specific area near the Dead Sea. I think that if the method were the focus of this study, as implied by the title of the article and by the abstract, then not only it would have to be motivated differently (as mentioned above), but many of the choices made would have to be more clearly justified: why not use a Laplacian of Gaussians instead of median filter then a Laplacian filter; why this filter size; why only 4 directions; why 30 training samples; why remove objects less than 20 pixels; why 0.8 threshold in binarization; why and what are the suitable lineament link parameters based on our own criteria", just to mention a few examples. I do not dispute these choices for this site, and I applaud the authors for tweaking a vast number of parameters to get good results. However, for this procedure to be transferable to other sites such choices need to be made less arbitrary and some guidance offered to the reader as to how one may come up with a parameterization for a different location. In my view, this does not imply making major changes to the article, but rather some rebranding or re-packaging: a title change, some re-ordering in the abstract, and in the conclusions. I think this was a more than reasonable approach to follow in this specific site, as the lack of LiDAR and other digital data did not permit more sophisticated approaches. With suitable parameterizations, this approach may be used in other areas where little data is available before going into the field and drilling wells at random.

Answer We would like to keep the focus on the method as correctly implied by the title. Due to this, we agree with the reviewer that the introduction/ motivation needs to be amended and that the ordering is misleading. We will, as suggested, shift the method to the second position right after the introduction and then introduce the study area. Additionally, the conclusion and the abstract will parallelly be adapted. On the other hand, the choice of processing parameters is reasonably easy and the method

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can easily be adapted to any part of the world. Concerning the clear justification of applied steps, we already included many explanations to enable the reader to follow our choices. Nevertheless, we will carefully go through this section and add explanations where it seems to be unclear. At this point we would like to answer some questions that were mentioned by the reviewer. Some of those answers will be added to the revised manuscript as well to offer more guidance.

Why not use a Laplacian of Gaussians instead of median filter then a Laplacian filter? Using a Gaussian instead of a Median filter, as asked by the reviewer, would impair the signal as the Gaussian acts similar to a Mean Filter. Gaussian as well as the Mean filter would remove the noise from the raw DEM and smooth it, as desired, but both are unfavourable if it is intended to preserve edges, since they are linear filter. This is especially true for areas where we would assume low level noise like in our case. Here, the Median filter clearly outcompetes the Gaussian filter, which was described by Arias-Castro and Donoho (2009). This was the reason why we applied the Median and not the Gaussian filter.

Why this filter size? Unmentioned results of applied smaller filter sizes still showed artefacts inherited in the DEM, which would influence the result. Those artefacts originally stem from the ASTER DEM and result of systematic failure during the DEM processing.

Why only 4 directions? The applied 4 directions include North, Northwest, West and Southwest as mentioned in the manuscript. Those filter directions also include sub-tending directions (South, Southeast, East, Northeast) and therefore all 8 possible main directions.

Why 30 training samples? Foody et al. (2006) proposed that 30 training samples are the minimum for a sufficient statistical accuracy and an accurate classification result. Moreover, the training areas were homogenously distributed throughout the image, to ensure no asymmetry or misclassification in the result.

Why remove objects less than 20 pixels? Objects with more than 20 pixels reflect

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the intended geological structures. Pixel objects below that number represent small size objects that do not represent geological structures. Due to this reason they were removed.

Why 0.8 threshold in binarization During the classification every pixel obtained a classification probability. During the binarization step, the probability was used as indicator by equidistantly changing the threshold value by 0.05 starting with 0.6. The result of every iteration was always compared to the input image. The threshold of 0.8 showed the best congruent result and was therefore the value of choice. This value can change for different users depending on the classification result.

Why and what are the suitable lineament link parameters based on our own criteria? Primarily in focus were lines or later lineaments that have a certain length to be of (hydro) geological significance. Secondly, we did not want to use too much interpretation. Choosing larger numbers e.g. for the “maximum gap between line ends” we might connect object that do not have any connection in reality. But since we cannot say if it is true or not all we could do is to keep those numbers rather small and to stay with the extracted linear features that we have. However, we need to admit that those numbers are completely subjective and could be altered.

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Review Comment The ordering of the sections is inconsistent regardless of what the authors may feel about my comments in 2). If, in spite of my previous comments, the method were to remain the focus, then it should be presented before a detailed description of the study area. If, on the contrary the focus of the paper is shifted to the extraction of lineaments in this specific site, then the method should be mention after the problem at hand is stated in both the abstract and in the conclusions. The body of the paper does present the study area first and lists the methodology in the methods section, in a fashion that is consistent with being a site-specific study.

Answer As stated before we think to leave the method in focus. But to do so, we will

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follow the suggestions and reorder the paragraphs and change certain passages and the motivation within the abstract and the conclusion.

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Review Comment The English in this draft is at times a little awkward. Editing by a native English speaker for clarity should be completed during this review process. I have taken the liberty of suggesting some such edits in the specific comments below.

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

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### Specific Comments and Technical Corrections

All specific comments and corrections will be changed and unclear (Page 1413, lines 20-22 and lines 27-29) passages will be carefully rewritten. Different caption fonts in the figures will be changed as well.

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### Used References:

Arias-Castro, E. and Donoho, D.L., 2009. Does Median Filtering Truly Preserve Edges Better Than Linear Filtering? *Annals of Statistics*, 37(3): 1172-1206. Foody, G.M., Mathur, A., Sanchez-Hernandez, C. and Boyd, D.S., 2006. Training set size requirements for the classification of a specific class. *Remote Sensing of Environment*, 104(1): 1-14.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 1399, 2011.

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