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Hydrology and Earth System Sciences Discussions

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Interactive Comment

Interactive comment on "Urban hydrology in mountainous middle eastern cities" *by* T. Grodek et al.

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GENERAL COMMENTS This article deals with the impact of urbanization on runoff generation processes and on the potential groundwater recharge in two mountainous Middle Eastern cities. This research assesses relevant scientific questions, which are within the scope of HESS. Measured hydrological data is presented to assess the impact of urbanization, and the hydrological response in urban areas is compared with the response in natural areas. The authors determine that the two investigated cities are typical examples of many Mediterranean areas and propose hydrological guidelines for urban development in this region. Nevertheless, several points need clarification before the paper is considered for publication. For instance, the uncertainties associated with the results (see specific comments) should be better assessed and clarified. Moreover, the large number of "major" technical errors proved that the paper should be deeply revised (e.g. up to fifteen references cited in the text are not present in the bibliographic list).

Authors' Response: the authors are grateful to the referee for the careful reading and commenting. The comments will improve the paper significantly. Especially the reference section will be checked carefully.

SPECIFIC COMMENTS 2 Study area I think there is an unbalance between the description of the global (50 lines) and the local (15 lines) contexts. Moreover, several characteristics listed in the global description are not necessary to understand the article and, inversely, the local characteristics are insufficient to correctly grasp the local hydrological context.

Authors' Response: the study area section will be rewritten and improved according to the comments. We will start with subchapter on global characteristics of the region (e.g. climate, (hydro-) geology, landuse history) followed by a chapter on local characteristics of the towns (morphology, town characteristics). We will balance the length of both subchapters.

3 Methodology 3.1 Maps and urban surveys: If I understand it correctly, no information is available concerning the natural topography of Ramallah prior to urbanization. In this case, how is it possible to determine DDn (pre-urbanization drainage densities) for Ramallah? (cf. 3.4)

Authors' Response: Detailed topography maps are available since 1940 and some are even from earlier periods. This British maps (1:40,000 – from the first world war; 1:20,000 around the 30s ; and 1:100;000 and today the 1:50:000) are still in use in the entire Middle East countries. Actually the DTM 25m is made (officially) out of these maps. At this period, Ramallah was still a small village. We will mention these historical facts and clarify this issue in the methods section of the revised manuscript. DDn (prior

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urbanization) was defined by a standard GIS-technique using topography derived from a DTM (we will give more details how we did this, see also 3.4). Hence the derived stream network is in some kind theoretical but relates to natural topography. But it is comparable in both towns since the same methodology and the same (historical derived) DTM was used.

3.2 Rainfall: With the available information, it is difficult to judge the quality of the two rain gauges network retained (What is the altitude difference in Ramallah for example?). Despite the different topography of the two areas studied and the potential spatial variability of the rain, the number of rain gauge for the two different cities is unbalanced (3 for a 8.4 km2 watershed against 9 for a 0.61 km2 watershed). Moreover, the formula used to determine the rainfall in Ramallah seems not correctly referenced (the references are not in the references list, could you please correct that?).

Authors' Response: This section will be clarified according to the reviewer comments. Ramallah at about $\sim$800 m.a.s.l experiences generally steep slopes of about 30%. Therefore we expected a high variation in rainfall between hills and valleys. Modiin with general slope of only 2% the rainfall variation was expected to be much lower. This was the main reason for the high number of raingauges in Ramallah compared to Modiin. As a result of our measurements in Ramallah, we discovered major differences between valley and mountain type stations, while the values for different stations of the same type were comparable. Since not all stations were operational throughout the entire study period, a different distribution of station types would have changed the catchment rainfall and would have blurred a comparison of different events and general statements. To clarify this issue we will give statistical details on the rainfall distribution with station type. Of course we will include the references where this valley-mountain effect was studied in detail. We are sorry that this mistake occurred. In Modiin we discovered strong similarities among the different stations, although they had larger distances. Again we will give statistical details in the revised version to proof this.

3.3 Runoff quantity and quality: With the information in the text and the associated figures, it is difficult to understand the hydrology of the investigated areas (watershed boundaries and sub-watersheds ... etc.) and how representative are they for the two cities.

Authors' Response: We will include watershed boundaries into the figure 2c and 2d. This will clarify that our stations are draining the city centers and attached outer city districts of both cities.

3.4 Drainage Density Index – DDI: The method for calculation of DDn is not clear (raw data used, threshold used for the streams determination). The DTM 25 m mentioned is this section is not mentioned in the section 'Map and urban surveys 3.1'. Finally, how did you determine the DDn with a DTM 25x25m for the small watershed studied? (i.e. LS more or less 150 pixels)

Authors' Response: This relates also to 3.1 above. We will give more information on the GIS-procedure used to identify DDn, e.g. also quantifying the threshold of contributing area used for stream determination and relation to the resolution of the DTM used. Clearly this procedure has limits for small catchments, we will discuss this.

4 Results 4.1 Rainstorms: In Ramallah, I think that the "good" correlation between MR and VR in the first season is just due to the two extreme high points. If you delete these 2 points, the slope seems to be near to 1 (and not 1.8). In the same way, the reconstitution of the rain for the second year seems biased.

Authors' Response: This is a critical point and we will include a paragraph in the discussion to discuss limits and uncertainties. Although only 2 points are at the higher rainfall amount, the pattern is clear and consistent over the entire network of raingauges. We will also show that without the two extreme high points we arrive at a strong relationship between valley and mountain stations with a comparable slope (much higher than 1). So the impact of the two big events is not as crucial as it first might seem from the picture. We will also raise the point that these two big events make up a large fraction of the seasonal rainfall and hence should be included into the analysis. Also we used

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this equation just in the second season when the valley station failed to operate. In all other cases the real values measured were used. We will show other studies in the region (see also 3.2 above) about rainfall differences between mountain and valley stations which go in line with our findings.

4.2 Rainfall-runoff relationships: Taking into account the previously mentioned problems, it seems it would be appropriate to reformulate the results: Ramallah: rain reconstitution problem (see correction of 4.1) Modiin: Do you speak about station M-I or M? the text and the figure do not correspond.

Authors' Response: Ramallah: As stated above (3.2 and 4.1) we will discuss the rainfall regionalization approach in Ramallah and show that our rainfall analysis is the best way to correctly represent the variability of rainfall in Ramallah. We will show that the regression should include the entire range of events and the entire seasonal rainfall. Modiin: We will correct the figure, of course (M-I) is displayed on the figure, as we talk about the urban impact. We will re-check the entire manuscript to clarify and name correctly where we use M and where M-I.

4.3 High magnitude events: The problem for the Ramallah LS (limited inlet capacity) could be better explained.

Authors' Response: We will better explain the limited inlet capacity and present a photo of this station where the problem is shown.

4.4 Hydrograph shape: It seems that the comparison for different hydrographs proposed in Figure 7 in term of impact of “geometry of the urban drainage network” was biased because of the spatial scaling effect (watershed of 0.11 and 0.41 km2 in Ramallah against a watershed of 8.4 and 5.5 km2 in Modiin) and differences in the rain events. Moreover, the explanation of the hydrograph shape for Ramallah WA Station seems wrong. The authors say ”a more complex road network generated secondary, smaller peaks” but I think that the second peak was simply due to the second rain peak (see Fig 7b).

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Authors' Response: We will re-draw figure 7 to make clear what is meant by multi peaks. To avoid scaling effects and the impacts of different rainfall events, which certainly make comparisons difficult, we will concentrate our analysis on the two Modiin stations (M and I) which are about the same size and respond to the same rainstorms.

4.5 Urban Pollution: During the "dry season", the sewer pipe of Modiin station M is clearly influenced by human water. So, I wonder if it is the case for all the stations? Which is the impact of theses potential water volumes on the estimated runoff coefficients and other quantitative alculations?

Authors' Response: We will address this issue in the discussion. In figure 8 the raw data (water level) is shown where the artificial runoff does not exceed 1 cm. This corresponds to a very small flow rate. Thereafter the natural response rises to 3 cm which is an orders of magnitude higher flow rate, and this was a very small event at the onset of the season. Although we cannot exclude human input during all events, their quantitative impact remains small. The main problem is in cases where the urban runoff flows through downstream towns (Tel-Aviv in our case) that suffer from such heavily polluted water. Another relevant issue is aquifer pollution that might be enhanced in flood detention ponds with stagnant polluted water.

5 Discussion & 6 Conclusion I think that the discussion and the conclusion are too ambitious and the problems and uncertainties associated with the results should be further taken into account.

Authors' Response: Including all points above we will elaborate the discussion about uncertainties of our analysis. We will address all types of uncertainties raised above (rainfall distribution, measurement uncertainties, human artificial flow, etc,) and give an estimate about the total uncertainty resulting.

TECHINICAL CORRECTIONS The reference list does not match with the references cited within the text: I counted more or less fifteen references that were cited in the text which are not present in the bibliographic list. In the same way, I could not find in the

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text ten references that are listed in the bibliographic list. Please, correct that.

Authors' Response: we are very sorry about this mistake and will re-check all references.

Page 7310 line 5: what does it mean "Nari"?

Authors' Response: (Nari, Calcrete, Caliche) is a pedogenic carbonate crust precipitated from evaporating soil moisture. We will explain in detail also with reference.

Page 7312 line 3: the surface of 5.5 km2 for the station I corresponds with the value listed in Table 2, but not with the values listed in Table 6. Is this a mistake?

Authors' Response: We will correct and unify the surface area (5.5 km2) This is clearly a mistake.

Page 7312 line 11: the surface of 8.4 km2 for the station M does not fits with the values listed in Tables 2 and 6.

Authors' Response: corrected

Page 7312 line 12: the surface of 8.4 km2 for the station "M-I" does not fits with the values listed in Tables 2 and 6.

Authors' Response: corrected to 8.5 as the number refer to the total contributing area, I + M.

Page 7314 line 22: The rainstorm of 107 mm for Ramallah does not fit with the value listed in Table 4 (109 mm).

Authors' Response: corrected to 107.1 mm

Table1: What do you mean for "Evaporation"? real evaporation? potential evaporation? evaporation or evapotranspiration? I would suggest changing the unit: from mm/d to mm/month

Authors' Response: the data are from Class A evaporation pan. So we will change to potential evaporation and we will change the values to mm/month.

Table 2: What does it mean ‘Percentage of Road Length’? There are no public, private and parks areas in Ramallah? This seems not clear, could you further explain this?

Authors’ Response: The percentage of the road length will be omitted. In Ramallah we did not distinguish public and private open areas but put all together to natural slopes, because they cannot be classified explicitly. The part of Ramallah under current research is a traditional Arab town. Contrary to planning rules used in western countries, the old core of Ramallah (where the research is conducted) there are almost no public areas (we assume that the situation is different in the new parts of Ramallah). We will think again how to structure table 2 to make a comparison between the two cities more easy (may be to include all open areas also in Modiin).

Table 4 and 3: The reference in the text to Tables 3 and 4 are sometimes inversed. All the reference should be checked.

Authors’ Response: We will check carefully and correct all the references for tables and figures in the text

Table 5: The punctuation should be coherent through the manuscript: 24-26/2/03 not 24-26.2.03, check all the listed volumes and replace points by commas.

Authors’ Response: we will check punctuation errors and make it coherent through the manuscript.

Table 1,2,3,4,5 and 6: I think you should always indicate the units in the same form, i.e. or in the table captions, or inside the table. Homogenisation would make the manuscript easier to read.

Authors’ Response: We will homogenize units

Table 2,3,5 and 6: The name of stations “M” and “M-I” are always different (M=M-I, M-I=M*, M=M, M-I=M-I). Please check these. I think that the best is to always indicate

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M and M-I and their respective information.

Authors' Response: We will check and correct for "M" and "M-I", see also 4.2 above.

Figure 2: Rain gauge not rain guage. Where is the Station J? The Zooms on the urban center do not seem necessary. Moreover, the Zoom on Ramallah urban center is not really a zoom. Could you adopted for this figure a more detailed legend? i.e. list the different land use types, watershed border,: : :etc

Authors' Response: We will change to Rain gauge. Station J is out of the map range and we will explain where it is situated in the text. We will include catchment areas to the zooms on the urban areas to make them instructive (See 3.3 above). Also we will improve the legend (with landuse types, etc.).

Figure 4: Trend lines in white are not convenient. What does it mean station M in this figure? (M or M-I?). Please, correct this. In the title: LS not Ls

Authors' Response: We will change the colour of the trend lines. And change to (M-I). Also we will correct LS

Figure 7: Which is the scale for the Figure 7 (a)? The information on the three maps seems to be different from Figure 2. The network design is not clear (eg. What does the arrow means? and the water flow? The driving way?)

Authors' Response: Here we will concentrate on Modiin (see 4.4 above). We will produce a new figure on the basis of figure 2. The arrow mean the way the water takes via the road network. This will be clarified.

Figure 9: Details should be provided to the reader about how did you define this conceptual model.

Authors' Response: We will provide more details on the definition of this model. The points inside the diagram are real data (average responses) for the different stations. The contributing areas are the conceptual part. They are derived mainly from observa-

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tions (e.g. contributing roads, runoff from public parks only during the high magnitude event). We will include more details about our observations in the discussion section.

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