Authors' Response to Referee Comments by T. Russo

General Comments:

Overall this is an interesting paper on an important topic. The data collection methods seem thorough, and use current technology to quantify previously difficult fluxes. The water balance model is quite simple and in some ways not explained thoroughly. The paper could benefit greatly by omitting much of Sections 2 and 5, improving the description of the methods, especially the calculations, and ensuring that the Discussion and Conclusion actually focus on the results of this paper, rather than reviewing other literature.

Response:

Thank you for the generally positive comments. I appreciate your suggestions and would like to revise and modified the paper accordingly.

For the model explanation, the Section 3.3 (Methodology) has been revised to describe the model more clearly. To improve the structure of the manuscript, Section 2 has been greatly simplified, and the Section 5 (Discussion) and Section 6 (Conclusion) have been modified to focus on the measurements and results of the study. The quantitative results obtained from field experiments have been thoroughly discussed in Section 5.1.3 (Balanced development stage).

While we acknowledge that our field experiments were specifically carried out in a cotton field under mulched drip irrigation condition, our results can indeed be QUALITATIVELY extended to other crop fields under different irrigation methods. With these extensions, we can discuss the interactions between social and hydrological systems in this hyper-arid inland oasis, which is also the purpose of this special issue 'Predictions under change: water, earth, and biota in the anthropocene'. Such broad perspective also can help us gain deep insight into the multifaceted effects of irrigation method conversion and achieve a sound policy for sustainable water management.

Specific Comments:

1. The history of the TRB is interesting, but not needed to support the paper conclusions.

Response:

According to the comments, we have shortened the history of TRB. Still the history is mentioned in the Introduction and Discussion parts since the anthropogenic effects on water resources are important for oases development. As we'd like to discuss the groundwater dynamics results from a socio-hydrological perspective, the TRB history is necessary, which can help us not only understand the current situation of TRB, but also predict the future when the irrigation method has been changed.

2. Statement that water saving irrigation mitigates soil salinization is arguable. I can't find the paper (Ma et al, 2010) in English. If this was a conclusion of that paper, then it should be introduced as a hypothesis, or at least stated with respect to areas with shallow water tables only.

Response:

We agree with the referee that soil salinization trend is still unclear under water-saving irrigation condition. In general, water-saving irrigation can mitigate soil salinization when groundwater table is shallow (Dou et al., 2011; Rajak et al., 2006). However, salinization also can be caused by deficient leaching water under water-saving irrigation (Chen et al., 2010).

In TRB, groundwater table in most irrigated croplands had risen to less than 1 m below the surface due to long-term flood irrigation in the late 1990s and soil salinization was severe because of the intense phreatic evaporation. Therefore, the application of water-saving irrigation indeed mitigates the soil salinization in TRB (Ma et al., 2010; Wang et al., 2011). To ensure the statement clear, we have revised the statement. Now it reads: "Recently, water-saving irrigation has been popularized within the TRB to enhance the irrigation efficiency and mitigate soil salinization in the irrigated farmlands where the groundwater table

is quite shallow (Dou et al., 2011; Ma et al., 2010; Wang et al., 2011)". In addition, more relevant papers have been cited here for reference.

3. Section 2 can be shortened to include only the relevant material for the project.

Response:

Thank you for the suggestion. Section 2 has been shortened from 1059 words to 744 words now.

4. Do you calibrate between the two SWC methods, hydra sensors and gravimetric method?

Response:

Thank you for the interesting question. We did not calibrate anything, but we did compare the soil water content results measured by different methods (see Fig. A). The figure shows that the SWC results by soil sensors and gravimetric method agree well. Moreover, in this study, we only considered the change of soil water storage (ΔS) during water balance analysis. Although there will be some systemic errors between different methods, the SWC change for each method is relatively consistent and reliable.

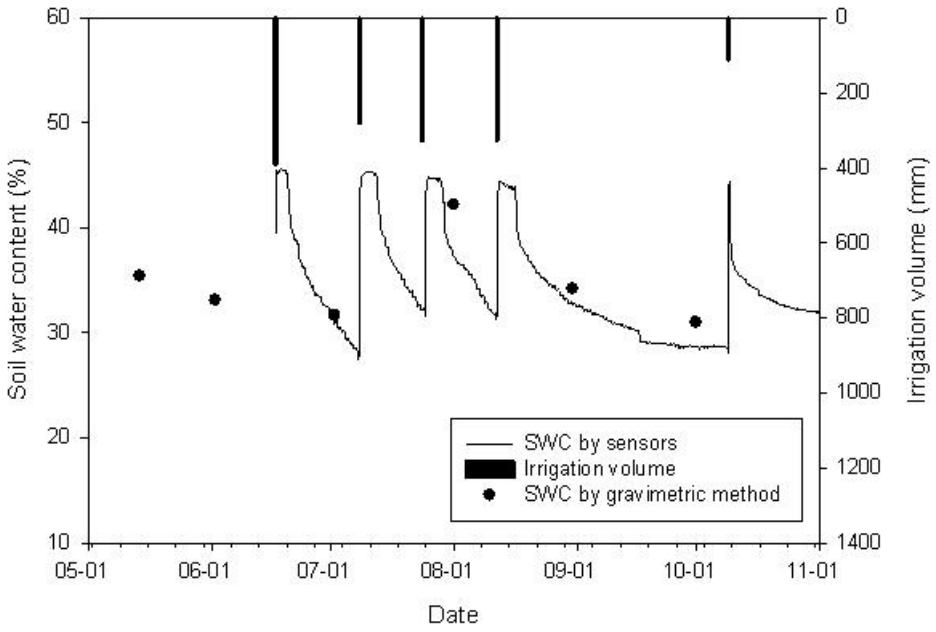

Fig.A Soil water content measured by different methods in 2011

5. Lateral flow is ignored in Eq 1 because it's negligible in the control volume, however it's included in Eq 2. Is LF needed to close the water balance in this case? Please explain why it is needed here and not before.

Response:

We have modified Section 3.3 (Methodology) to make it clearer. Actually, Eq. 1 focuses on the water balance of soil column which is above the groundwater table. The lateral flow is trivial in the unsaturated zone. However, Eq. 2 focuses on the groundwater balance, and the lateral flow is significant below the groundwater table.

6. Please explicitly define ΔS, ΔS_D, and S_D and make sure their use is consistent. When you discuss in section 4 changes in the soil water, does this refer to ΔS or ΔS_D?

Response:

Thanks for the suggestions. The manuscript is revised to make sure ΔS, ΔS_D, *and* S_D *explicitly defined in Section 3.3. In Section 4, the expressions of*

“changes in soil water” have been revised to be more specific to avoid misunderstanding.

7. $(\theta_{sat} - \theta^{'})\Delta Z_{wt}$ is the change in water storage associated with the change in water table, and the description of ΔS_D makes it sound like the change in water storage between the water table (the bottom of the control volume) and the upper boundary of water table variation (where the water table was?). These appear to be the same. Please clarify the text to differentiate between these two, and confirm that they account for the full mass balance without counting anything twice.

Response:

Sorry for the confusion. Actually, the control volume in this study refers to the soil column stretching from ground surface to 90 cm soil depth. Therefore, ΔS_D *is the soil water storage change in the zone between 90 cm (bottom of control volume) and upper boundary of groundwater table variation, and* $(\theta_{sat} - \theta^{'})\Delta z_{wt}$ *is the soil water storage change associated with a falling or rising groundwater table.*

The calculation is correct and the results shown in the paper are precise. We have revised the expressions to avoid misunderstanding.

8. Clarify Figure 2 to illustrate what areas ΔS and ΔS_D apply to. This will also be clearer when you define them in the text (previous comment).

Response:

Revised according to suggestion.

9. p1790, ln 21. How did you measure the porosity? Did you also determine θ_{sat} from any saturated SWC measurements?

Response:

Three undisturbed soil columns were collected in the experimental field using the special containers, and gravimetric method was adopted to measure the saturated SWC by a drying oven. θ_{sat} *was determined as 0.42.*

The results of hydra sensors verified the value of θ_{sat}*. SWC measured by hydra sensors was 0.424 within 50 cm soil depth during the first three days of spring flush in 2013. The surface soil in this period was regarded as saturated soil due to the large amount irrigation volume and remarkable water ponding. Therefore, it is reasonable to assign a value of 0.42 to* θ_{sat} *in this study.*

10. Section 5. The discussion on human-water systems, including the review of water use in the area seems like an appendix to the paper, rather than an integrated part. It should either be omitted or shortened significantly and justified by integrating with the results of the paper.

Response:

Thank you for the suggestion and we have modified the Section 5 to make it more concise. Although, the authors would like to keep the broad discussion and literature review, as explained in the response to general comments. Specifically, in this paper, the exchange flux and groundwater dynamics have been studied based on the field experiments under water-saving irrigation condition. The results have been discussed in the sub-section "5.1.3 Balanced development stage", the key part of Section 5. However, in order to well understand the effects of irrigation method conversion on human-water system, the other two stages of human-water system development have also been discussed here. This broad view may help us to evaluate the effects of water-saving irrigation and predict the future of oases.

11. The paper would benefit from a limitations section in the discussion.

Response:

Thanks for the suggestion. We have reorganized and shortened the

Discussion Section.

12. The Conclusion section should emphasize the findings and conclusions drawn explicitly from this paper, rather than summarize the motivation for the study.

Response:

Thank you for the suggestion. The Conclusion Section has been revised to focus on the findings and results drawn from this paper.

Technical Corrections:

1. Several language issues p1781 ln 22, (and elsewhere in text) "mainstream" should be"main stream" or "primary channel"

Response:

Thank you for the suggestion. The term “mainstream” has been revised to “main stream”.

2. overuse of the word "serious" and "seriously"

Response:

Thank you for the comment. Unnecessary "serious" and "seriously" have been replaced or deleted.

3. p1781, line 27, start new paragraph with "Large-scale irrigation..."

Response:

Done according to suggestion.

4. p1783 ln14, no "in general"

Response:

Done according to suggestion.

5. p1784 ln 4, "conveyed" should be "conveying" or "routing"

Response:

Done according to suggestion.

6. Section 4.2. Please revise and clarify the first sentence.

Response:

This sentence has been rewritten as "The seasonal groundwater dynamics are analyzed in this section using the Eq. (2)".

7. Table 1 needs more explanation. Should 2012 and 2013 listed be the same year?

Please also list the year for the bottom two rows.

Response:

There are some typesetting problems in Table 1. First two rows are the data in 2012, and bottom two rows are the data in 2013. It will be corrected in the new version.

8. Figure 1. Can't read the lat/lon values in the top two maps, too small.

Response:

Thank you for the comment. Figure 1 has been splitted into two, also that all the characters can be read in the larger figures.

9. Figure 3. Hard to distinguish between two grays. It also might be more intuitive to flip the y-axis for exchange flux to show negative flux going up.

Response:

Revised according to suggestion.

10. Overall could benefit from an English language review, I did not edit for language throughout the manuscript.

Response:

Thanks for the edition. We have reorganized the manuscript, corrected

language mistakes and modified the expressions.

Reference:

Chen, W., Hou, Z., Wu, L., Liang, Y., and Wei, C.: Evaluating salinity distribution in soil irrigated with saline water in arid regions of northwest China, Agric. Water Manage., 97, 2001-2008, 2010.

Dou, C., Kang, Y., Wan, S., and Hu, W.: Soil salinity changes under cropping with Lycium Barbarum L. and irrigation with saline-sodic water, Pedosphere, 21, 539-548, 2011.

Ma, Y., He, J., Hong, M., and Zhao, J.: Analysis of development process and tendency of drip irrigation under film technology in Xinjiang, Water saving irrigation, 12, 87-89, 2010 (In Chinese with English abstract).

Rajak, D., Manjunatha, M. V., Rajkumar, G. R., Hebbara, M., and Minhas, P. S.: Comparative effects of drip and furrow irrigation on the yield and water productivity of cotton (Gossypium hirsutum L.) in a saline and waterlogged vertisol, Agric. Water Manage., 83, 30-36, 2006.

Wang, R., Kang, Y., Wan, S., Hu, W., Liu, S., and Liu, S.: Salt distribution and the growth of cotton under different drip irrigation regimes in a saline area, Agric. Water Manage., 100, 58-69, 2011.