Authors' Response to Comments by Anonymous Referee #4

General Comments:

This paper investigated the water balance of an arid inland basin, where knowledge about the interactions between water and salt balance is very important for sustainable socio-economic, agricultural, ecological and water resources managements. Measurements by contemporary advanced eddy co-variance techniques was used in this paper, which facilitate the researchers to close water balance and help us to derive more reliable knowledge about this kind of important ecosystem. Overall, the topic is important and interesting. However, this paper is subjected to major revision for publication. I am reporting below two general comments and some specific remarks, which I hope are useful.

Response:

Thank you for the comments.

1. Quantitative analysis of salt balance is needed.

This paper only presented one essential cycle, i.e. water balance, for the sustainable water management in an arid inland basin. Without quantitative results of the other critical cycle, i.e. salt balance, and coupling between two cycles given me a strong perception that, at current stage, novelty of this paper for sustainable water management in the Tarim River was very limited and the discussion digressed from data and results. So, major revision is expected.

Response:

We agree with the referee that soil salt balance is critical for the sustainable development of an arid inland basin. We did investigate soil salt condition just like water balance we presented in this manuscript. Some relationships between salinization trend and exchange flux have been explored (Fig. A). The results show that the salinization has been mitigated when the upward exchange fluxes are significantly reduced. Since the water balance and

groundwater dynamics under water-saving irrigation is the major concern of this paper, and the relationships of soil water and salt need a lot of analysis and discussions, the salt balance is excluded in this paper. We plan to discuss the coupling of two critical balances (water and salt) in a separate paper in future.

We have also reorganized this manuscript and made it more concise. Section 2 (Description of Tarim River and Kaidu-Kongqi River Basins) has been greatly simplified. Meanwhile, the Section 5 (Discussion) and Section 6 (Conclusion) have been modified to focus on the measurements and results of the study.

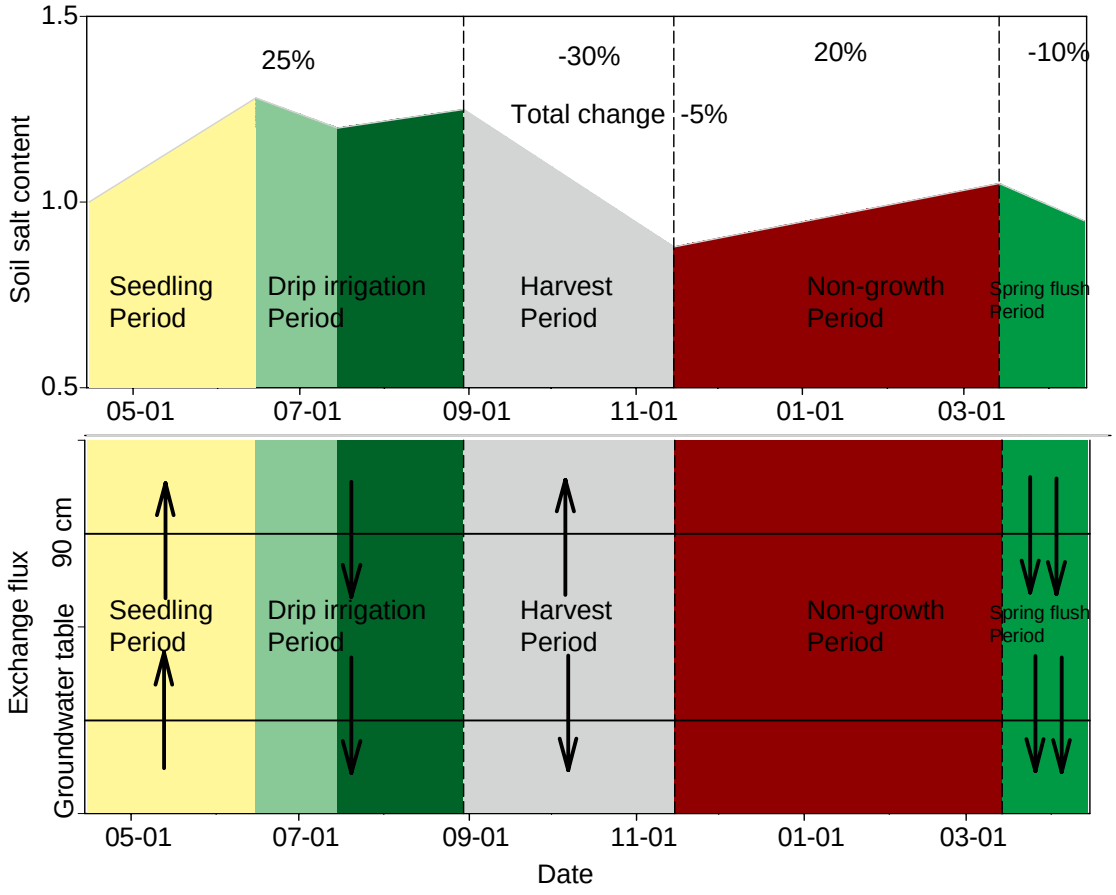

Fig.A Relationships between soil salinization and exchange flux

2. More attention should be paid to uncertainty in EC data.

EC data provided observed evidences of water evaporated from control volume. However, this data includes many uncertainties for estimating ecosystem evapotranspiration, such as closure of energy balance as authors

mentioned. According to the data and methodology, uncertainty in EC measured ET was eventually introduced into exchange flux (EF) of the control volume, which is very critical for understanding groundwater table dynamics and salt cycle. Uncertainty in ET derived from EC data has important consequences to results of this study. Figure 4 shown daily upward EF could be larger than 10 mm/day. It was larger than I thought. I was wondering that to what extent the estimation of EF was affected by the uncertainty in ET. Soil water contented data of multiple layers has been collected. It can be used to quantify these uncertainties.

Response:

The error analysis including uncertainty in ET measured by EC has been carried out and the results are shown in a separate section (Section 4.5). We agree with the referee that there will be some uncertainties in EC data such as the energy imbalance. However, although the reasons underlying the energy imbalance has been investigated by numerous researchers over the past few decades, these are complicated and not yet fully understood, and Eddy Covariance is still regarded as the most reliable instrument to determine ET. The ET results obtained by EC and sap flow in this experimental field in 2012 are shown in Fig. B. The consistent trend provides more confidence on EC measurements (Zhang et al., 2014).

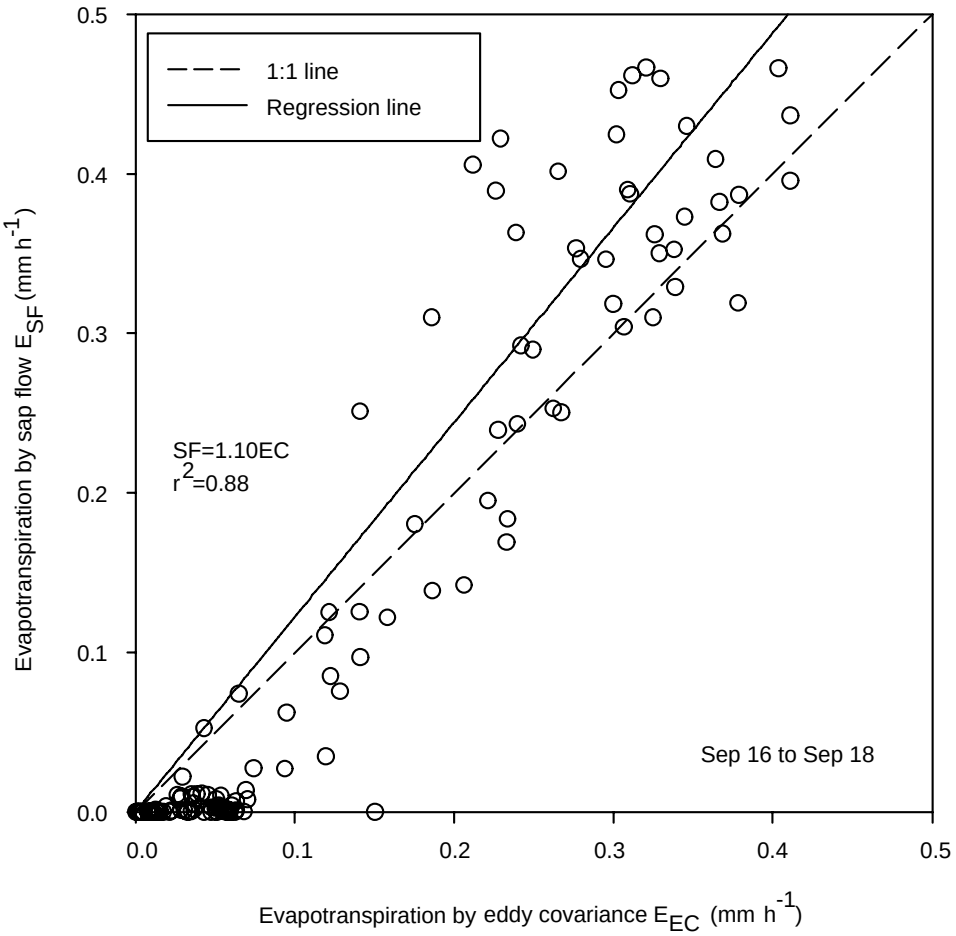

Fig.B Evapotranspiration obtained by Eddy Covariance and Sap Flow

Specific Comments:

1. Providing maximum rooting depth at the experimental site.

Response:

Done as suggested.

2. Using mm as unit of soil and water depths in the context, figures and tables.

Response:

Done as suggested.

3. P1789-L7: exchange flux (EF) is too general. Cannot recall easily and directly what specific process it represents.

Response:

Thank you for the comment. Exchange flux (EF) specifically refers to the water flux between the different soil layers in this paper. EF has been used to simplify the expressions. More descriptions of exchange flux have been added to the introduction and methodology sections to make the definitions clearer.

4. P1789-L10: Lateral flow can be considered as one component of runoff. Should R here be defined as overland flow?

Response:

R here can be defined as overland flow and the definition has been revised in the paper.

5. P1789-L14: during the flooding period, the depth of groundwater table is less than 0.9 m. Thus, control volume was NOT always above the groundwater table. And, please introduce how equation (1) was tackled under this situation.

Response:

We have modified Section 3.3 (Methodology) to make it clearer. During period of spring flush, the groundwater table exceeds the bottom boundary of control volume. Under this situation, R and F_L in the control volume also can be ignored due to the homogeneous irrigation condition and short duration of water ponding and shallow groundwater table. The water flows along vertical direction are dominant rather than those on horizontal direction. Therefore, the Eq. (1) also can be used in the spring flush period.

6. P1790-L19: why measurement of SWC at 150cm does not represent SWC at depth at 130 170 cm as those intervals centred on measurement points at depth of 100 and 120cm?

Response:

Thanks for the comments. There are two reasons that the SWC at the depth of 150 cm was assumed to apply to the soil level at 130–200 cm but not the soil level at 130-170 cm: (1) The change of SWC in deep soil layer has trivial effect

on the water balance analysis. (2) SWC is more homogeneous in the deep soil layer, thus the SWC at 150 cm can be applied to the broader range.

7. P1791-L20-22: “The sum of …. during period 1” What does this sentence mean?

Response:

The precipitation were 3.5 and 23.2 mm during period 1 in 2012 and 2013, respectively. Meanwhile, the upward EFs at 90 cm depth were 53.5 and 36.5 mm in 2012 and 2013, respectively. The sum of precipitation and EF was almost the same for the two years (2012: 3.5+53.5=57 mm; 2013: 23.2+36.5=59.7 mm), indicating the consistent water demand for evapotranspiration during Period 1.

The sentence has been revised to be clearer.

8. Discussion section: if salt balance will not be analysed, the discussion should be shortened significantly.

Response:

We have modified the Section 5 (Discussion) to make it more concise.

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. Since the experiments were mainly implemented in the cotton field under mulched drip irrigation, information and data about other irrigation methods were mainly collected from the relevant literatures. The results from experiments and information from literatures were both discussed in the Discussion Section.

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.

9. P1901-L13-15: "The results show that …. than in spring and autumn". Please provide which figure or table supports this conclusion.

Response:

The subsurface flow was analyzed in Section 4.2 (P1794, L 25 – P 1795, L 5) and this conclusion was drawn based on the Table 3.

The lateral flow out of the analysis zone during Periods 2 and 5 was expected to be high due to the recharge caused by irrigation and the high groundwater table. However, in Table 3, the outflow rate was only 1.0 and 3.0 mm day^{-1} during Period 2, indicating that the lateral flow into this zone was also significant. In fact, snowmelt happened during spring and summer, and the precipitation is also concentrated in the summer period in the mountainous areas. They resulted in significant subsurface flow into this zone during Period 2. Similarly, snowmelt in spring led to the subsurface flow into this zone, resulting in the fact that the net lateral flow was larger during Period 3 than during Period 1.

10. Figure 3: Define "IP" and "GWTD" here and for hereinafter use.

Response:

Done as suggested.

11. Figure 3: Make the width of bars equal to corresponding width of time interval. Space between bars was not easy to understand.

Response:

Done as suggested.

12. Figure 3: why downward EF occurred before next IP event between 5-13 and 5-20 of 2013?

Response:

Precipitation occurred on May 14 and 17, and downward EF occurred on May 16 and 17. The reasons for the mismatch of the dates may be that the soil water storage affected the EF and delayed the soil water movements, which should be further explored.

Reference

Zhang, Z., Tian, F., Hu, H., and Yang, P.: A comparison of methods for determining field evapotranspiration: photosynthesis system, sap flow, and eddy covariance. Hydrol. Earth Syst. Sci., 18, 1053-1072, 2014b.