Manuscript Details:

Hydrol. Earth Syst. Sci. Discuss., 11, 1529–1554, 2014

Attribution of satellite observed vegetation trends in a hyper-arid region of the Heihe River Basin, Central Asia

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Response to Referee Comments by Referee 3

Referee comments in Italics

General comments

1. *This study demonstrated one approach how to identify and quantify the factors for the satellite observed 'greening' trends during 2000-2012 over a region within the Heihe River Basin in northern China. The study of this kind is very important and definitely needed, particularly for the water resource management and policy development. The content of this study suits the audience of HESS well. This manuscript is well written and the structure is generally well designed. However, there are a few major issues that need to be addressed before considering for publication in HESS.*

We thank the reviewer for the positive comments.

Major issues:

2. *One highlight of the MODIS observation (10+ years) is to provide a spatial distribution of long-term trends in land surface vegetation status. The authors should present a few spatial maps in this manuscript, e.g. spatial map of annual average NDVI over the growing season, and spatial map of annual change in NDVI during 2000-2012. Apart from the change in mean NDVI, it is probably a good idea to add the spatial map of averaged annual max NDVI and change in annual max NDVI during 2000-2012.*

Good point. We presented a map of the mean growing season vegetation cover in Fig4a. As to the annual change and annual maximum NDVI, we can incorporate these into the revision, perhaps in an appendix.

3. *Over the hyper-arid regions, satellite based NDVI products always have higher uncertainty. The authors may would like to add some discussion in this regard.*

We agree that it is hard to evaluate vegetation cover in hyper-arid region. However, we have used the high resolution MODIS database and we avoid noise from snow by only using growing season vegetation cover. We will add more about the uncertainty in the discussion.

4. *The spatial map of annual precipitation change rate is also missing from the current manuscript. It is necessary to present and compare these spatial maps*

from various precipitation datasets and also with spatial map of annual NDVI change. The authors only presented the time series of precipitation over the entire study area. The spatial pattern match is also very important in the study to identify the contribution of climate change (e.g. precipitation) to the observed change. Otherwise, the 'correct' results may come from the 'wrong' reasons.

Good idea. We will present these spatial precipitation datasets into the revision. Given comment 2, perhaps the best approach is to add a new figure 4 that has four panels, mean P and mean (growing season) fractional vegetation cover, supplemented with trend in P and trend in fractional vegetation cover. The existing Figure 4 could become Figure 5 and present the annual time series (currently Fig. 4c).

5. *The authors identified that the increasing precipitation and irrigation as the primary reasons for the observed 'greening' trends. But the irrigation is highly dependent on the increasing river runoff which is largely a contribution from the surrounding mountain regions. The audience may be wondering whether this increasing irrigation trend is sustainable or not. I suggest to add one paragraph to discuss the possible reasons for the increasing river runoff from surrounding regions, e.g. precipitation increase, temperature increase leading to more snow melt, or both combined, or something else.*

Agreed. We were unable to separate the runoff into a rainfall + change in storage (e.g. melting glaciers) time series because the rainfall data are simply inadequate at this stage. We will point this out in the discussion with an appropriate discussion.

We thank reviewer 3 for the helpful comments.

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31/3/2014