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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 1**

Referee comments in Italics

#### **General comments**

1. *The manuscript “Attribution of satellite observed vegetation trends in a hyper-arid region of the Heihe River Basin, Central Asia” by Wang et al. focuses on the method of distinguishing between changes in NDVI due to prosperity changes in desert vegetation or changes in irrigation schemes. While I appreciate the author’s efforts to assess their method regarding sensitivity to distinct rainfall databases, I doubt that the manuscript can be considered as research article according to HESS’ manuscript types, unless results are discussed in the context of other studies with similar or contrasting results and in the context of climate and land use. In this regard, the authors seem to lower the expectations of the reader towards the goal of the study from (i) a general assessment of the suitability of remote sensing imagery (title) to (ii) the impact of climate change on vegetation cover (abstract) and, eventually, (iii) a case study for Central Asia (introduction). As long as the authors don’t elaborate on any possible implications regarding management of land use (vegetation and water resources), their method remains meaningless and could possibly (at the discretion of the Editor) be considered as technical note if much more detailed technical information is provided.*

**We thank the reviewer for the comments and suggestion. In terms of comparable work, there have been many previous studies that presented NDVI (or similar) trends in vegetation as per the citations we gave in the manuscript. However, in the central Asian region, we are not aware of any existing study that has attempted to disaggregate those trends in terms of climate vs land use. It is that disaggregation that creates the management options. That was explained in the introduction but we can also add it to the abstract to make that clear.**

#### **Specific comments**

2. *Throughout the paper there are tense issues, particularly with regard to the presentation of methods (Section 2) and results (Section 3), which should always be written in past tense rather than present or future tense. Further, some inconsistencies occur with regard to equations and sub-headers.*

**We will revise the tense and inconsistencies relating to English in the manuscript.**

3. *Title: The title is too vague given that the paper only uses NDVI based on MODIS rather than a range of other “satellite observed vegetation trends”.*

**This is a matter of opinion but we note that the method proposed is suitable for use with any satellite vegetation cover product. It is not specific to MODIS (which we mentioned in the abstract).**

4. *P1529L5-7 and P1532L10-13: While the abstract suggests assessing the “trend of fractional green vegetation cover to climate change and to human activity”, the last paragraph of the introduction lowers the bar to “a component due to greening (browning) of the deserts and a second component due to changes in irrigation”. I see how irrigation is a human activity. What I don’t see is how climate change fits into the picture. Since the paper doesn’t consider any trends in climate changes (neither in the past nor in the future) I assume the authors refer to climate or weather variability rather than change.*

**Good point. We agree that we did not examine independent measures of climate and did not attempt to attribute the trend in desert greenness to one or more factors. We can point this out more clearly in the revision.**

5. *P1531L11-17: References are required for each of the possible causes of vegetation changes.*

**We will add more references and explanatory details into the revision.**

6. *P1532L6-7: What are the management implications for the two distinct scenarios? This should be discussed in detail in Section 4.*

**Management options are restricted to the irrigated areas where human intervention has, and will continue to, occur. We will discuss more about the implications of the findings in the revision.**

7. *P1535L11: Elaborate on the “trial and error” approach to conclude that areas with NDVI > 0.1 are irrigated. At this stage this approach is too arbitrary to be considered as scientifically sound.*

**Good point. We have the detailed information describing how we decided on the NDVI > 0.1 threshold. We can incorporate that into the revision, perhaps in an appendix. We also have a complete uncertainty analysis that we will add as well.**

*P1535L20 and P1536L11: Equations (1) and (2) refer to the same variable (fv), yet they are different. Change variable names to make the equations unique.*

**The first equation defines fv in terms of the original satellite measurement. The second refers to the disaggregation in terms of area/cover of the two land cover**

**types. We need to keep both equations.**

8. *P1536L11 and L15: Equations (2) and (3) refer the same variable and should be renamed as (2a) and (2b).*

**Agreed.**

9. *P1537L24: Be consistent with the terminology. You refer to  $f_v$  as “foliage cover”, whereas in other parts of the paper  $f_v$  is referred to as “fractional vegetation cover” (e.g., P1535L18).*

**$f_v$  is referred to as “fractional vegetation cover” in this paper. We will revise it to avoid confusion. Thank you.**

10. *P1538L9 and L21: Sections 3.2 and 3.2.2 are entitled the same.*

**Thank you for pointing out. We will revise it in the revision.**

11. *P1538L17-18: Language issue: “The most sensitive factor is relative variations in the fractional irrigated area”. Please reword.*

**Agreed. How about: From that equation we infer that the relative change in fractional green vegetation is most sensitive to variations in the fractional irrigation area ( $A_I^*$ ).**

12. *P1541L4-6: This finding has to be discussed in the context of other studies with similar or contrasting results in the context of climate and land use.*

**We are not aware of any previous studies that have attempted to separate these two sources of variation before in a central Asian context.**

*P1541L7: Refer to  $f_D$  as non-irrigated areas in the discussion to make it easier for the reader to understand (and to avoid re-browsing the methods section).*

**Agreed.**

*P1541L7-8: Discuss why this result was “as expected in such an arid region”.*

**Agreed. We can add a discussion about that result.**

13. *P1541L17-28: Discuss these and further studies in the context of your findings rather than just listing them.*

**We accept that point will expand on the discussion in the revision.**

14. *P1541L28-29: Elaborate on the “larger regional setting”.*

**Good point. The related material belongs in section 2.1. We need to extend further and can do that in the revision. Thank you.**

15. Fig. 1a: Language issue: "Climatology Precipitation. Please reword.

**Thank you for pointing out. We will reverse the words to Precipitation Climatology.**

16. Fig. 1c: Please indicate where this part of the basin is located in Fig. 1b.

**Fig.1c occupies the northern part of the basin delineated by the heavy dark line in Fig.1b. Given the confusion we need to perhaps use a heavier dark line in Fig.1b. Thank you.**

17. Fig. 4: Scale issue: Values for  $f_l$  appear to be much smaller than values of the other graphs, yet  $f_l$  is in the range of 16-19%, whereas the other graphs range between 2 and 5%.

**Good pickup. We would like to adjust the axis to make it better. Thank you.**

18. Fig. 8: I assume that GPCC rainfall was used XP? Also, refer to Fig. S2 for other sources of rainfall observations.

**Yes. XP refers to contribution of precipitation from GPCC in Fig.8 and from other sources of precipitation in Fig.S2.**

#### **Technical comments**

19. P1532L24: "non-mountain regions" . . . flatlands?

**Yes, we can use that term instead.**

20. Fig. 3: In the legend, use the same line style as for the graphs (dotted, dashed, etc.).

**Agreed. Thank you.**

21. Fig. 4, caption: What does the number 3 in "( $f_D$ , 3 left scale)" refer to?

**It is a typo.**

22. Fig. 8: Typo in "vegetaion".

**Thank you.**

We thank reviewer 1 for the insightful and helpful comments.

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