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# *Interactive comment on* "Trend and climatic sensitivity of vegetation phenology in semiarid and arid ecosystems in the US Great Basin during 1982–2011" *by* G. Tang et al.

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Interactive comment on "Trend and climatic sensitivity of vegetation phenology in semiarid and arid ecosystems in the US Great Basin during 1982–2011" by G. Tang et al.

Anonymous Referee #2 Received and published: 3 October 2015

General Notes: As noted by the authors, the phenology of drylands is relatively understudied compared to deciduous forests, despite the substantial role these ecosystems play in the global carbon cycle. Here, Tang and colleagues utilize station meteorology and GIMMS NDVI imagery to assess long-term trends in phenological indices (SOS,



EOS, and GSL) and vegetation greenness (mean NDVI) in the US Great Basin region, as well as the relative importance of temperature and precipitation in explaining their interannual variability. The central findings are that GSL has extended at the rate of 3 days per decade due to delayed autumn senescence, driven largely by increases in mean seasonal temperature, but variability in vegetation greenness is better explained by precipitation variabil- ity, in particular preseason precipitation (DJF). The analysis is well devised, and the paper is very well written. The paper would be improved, in my opinion, if the authors attempted to connect their results with the carbon cycle and/or future climate changes, even if it were only informed speculation. I also wonder about the extensive spatial averaging and the lack of analysis of local weather/phenology relationships (do the relationships hold at the station-level?). Despite these shortcomings, I think this is a nice contribution to the literature and would support its publication.

Response: Thanks for your positive comment. In terms of how shifts in vegetation phenology will affect or have affected carbon cycle and how future climate change will affect vegetation phenology in the semiarid and arid ecosystems of the US Great Basin, additional study is needed to answer these questions. As far as the relationship between vegetation phenology and local weather at the station level is concerned, some of our results (e.g., Fig. 4b, c, d) suggest that the basin-wide average relationship between vegetation phenology and regional climate change may not always apply at the local scale due to the spatial heterogeneity of climate condition (including both temperature and precipitation) across the study region.

Specific Notes: - Why would you consider both SOS_SSA and SOS_Spring models (e.g. Table 2)? Since SSA is calculated over spring, summer, and autumn Temperatures, the difference between Spring T and SSA are FUTURE temperatures, right?

Response: The main reason for calculating the relationships between SOS and spring temperature as well as between SOS and SSA temperature is because changes in GSL are subject to both SOS and EOS. Thus, quantifying the relationship between spring temperature and GSL will help us understand how changes in spring tempera-

ture (e.g., spring warming) are likely to affect GSL. Sorry, we are a bit confused about the meaning of the statement of “the difference between Spring T and SSA are FUTURE temperatures”.

- The rates of mean NDVI increase are quite small (e.g. 5e-4), and so would only contribute to an increase of 0.015 over the 30 year period. This seems very slight, is it ecologically significant? Of course, it is consistent with the magnitudes noted by other authors like Fensholt.

Response: Thanks for coming up with such a very good and tough question. First, the magnitudes of NDVI are between 0 and 1.0. In semiarid and arid ecosystems of the Great Basin, the NDVI values of ecosystems at lower elevation zone are mostly less than 0.30. Generally, because the magnitudes of NDVI values are low, the resulting changing rate from one year to the next is also very small. Whether or not such small changes in NDVI values are ecologically significant, we need to conduct additional study to answer it. However, a model-based study (Tang et al., 2015 in review by Ecohydrology) suggested that changes in leaf area index (LAI) in semiarid and arid mountain watershed in the Great Basin can greatly affect soil moisture condition and the exchange of water fluxes between the atmosphere and the land despite the relatively low values in NDVI, indicating that even these small changes can have a significant impact in arid ecosystems.

- How well do the splines fit? Sometimes they can go "off the rails" and interpolate much higher/lower NDVI values, especially in the presence of missing data.

Response: Good question! In our study, because we focused on NDVI values from March to November, missing data were rare. At each of the 4145 points considered in this study, time series of bi-weekly NDVI values are generally continuous. Because NDVI values are continuous, the interpolation of bi-weekly NDVI values into daily values by cubic spline functions rarely caused the interpolated values to fall out of the range of original high and low NDVI values.



Technical Notes - P11388, L25: Since vegetation would presumably respond to climate change regardless of its cause, I’d suggest "climate change" instead of "anthropogenic climate, change"

Response: Changed “anthropogenic climate change” to “climate change”

- P11389, L8-9: Unclear what "consequent information" means here, perhaps: "Consequently, phenological information has important applications..."

Response: Thanks! We changed “Consequent information” to “Consequent information – such as climate change-associated shifts in vegetation phenology and biogeochemistry –”

- P11389, L22: "and ARE particularly sensitive"

Response: Thanks! We changed “particularly sensitive” to “are particularly sensitive”.

- P11392, L1-5: Which version of the GIMMS dataset?

Response: We revised the related text. The data used in our study is GIMMS NDVI3g.

- P11393, L24: The acronym "SSA" was defined in the abstract, but not in the main text before its use here, it wouldn’t hurt to do so.

Response: Actually, the “SSA” was defined in line 14 on page 11392. In the revised manuscript, we changed “considered the period of March to November (i.e., spring, summer, autumn and hereafter SSA)” to “considered the period of March to November (i.e., hereafter SSA).”

- P11397, L21: Change "points were exhibited" to "points that exhibited" or similar

Response: Thanks! We changed “points where exhibited” to “points that exhibited”

- P11399, L1: Probably not "surprising" since it was the implicit hypothesis

Response: We deleted “Surprisingly” in the revised manuscript.

- P11401, L4-7: Wouldn't these spatial differences argues for a more spatially explicit analysis (i.e. less extensive spatial averaging)? If altering the study are slightly would change the sign of a regression coefficient, and the inference based on that relationship, what does that say about the robustness of the findings?

Response: We agree with your comment. Due to the complexity of environmental factors in affecting vegetation phenology, a more spatially explicit analysis is likely to help answer how local environmental condition may affect vegetation phenology. To some degree, changing the extent of study region is likely to alter the sign of relationship between climate and vegetation phenology. Nevertheless, our study focused on regional-scale relationship between vegetation phenology and climate change. Because of the homogeneity of regional warming and because changes in precipitation at regional scale are mainly determined by large-spatial scale atmospheric circulation, we believe that the overall relationship between vegetation phenology and climate change we observed for the Great Basin is robust.

- P11401, L15: What is meant by "ameliorate soil moisture conditions"?

Response: Thanks! We changed "ameliorate soil moisture conditions" to "increase soil moisture content"

- P11402, L23-27: But you have the station-data to test whether or not the local trends are consistent with their local climatic variation, right?

Response: Yes, we do have field observations of time series daily precipitation. Our initial analysis of daily precipitation across 100 field stations suggested that precipitation indeed varies spatially in the study region. We are currently working on another paper focusing on the variation of daily precipitation and precipitation extremes in the Great Basin. Even though we acknowledge this to be an important point we felt it was outside the scope of our current paper that deals with large-scale regional patterns

- P11403, L1: Suggest changing "agreed well" to "were consistent" Saying that the ob-



servations "agreed" with the ground observations implies that their interannual variations are consistent. The datasets could share a lack of long-term trend without "agreeing" at all.

Response: Thanks! We changed "Agreed well" to "were consistent" in the revised manuscript.

- P11403, L15-17: Stronger warming at higher latitudes may be only one of multiple factors leading to contrasting Northern Hemisphere SOS results, vegetation assemblages are also different, for instance.

Response: Thanks for your good comments!

- P11405, L17: Suggest changing "we are lack of" to "we lack"

Response: We changed "we are lack of" to "we lack of" by deleting "are".

- Table 1: There are two AIC columns with the heading: "STP/PSP", should one be "SMT/PSP"?

Response: Sorry for the confusion. Originally, the heading "STP/PSP" means that precipitation may be either seasonal total precipitation or pre-season precipitation". We revised Table 1 for clarity.

- Table 1: footnote: "minimum" would be better than "smaller" in this case since smaller could be interpreted as "closer to zero" rather than "most negative" Also on P11404 L25

Response: Thanks! For clarity, we changed "the smaller the AIC values are" to "the smaller the magnitude of the AIC value is".

- Table 3: It's clear from Table 3's footnote, but not the text, that PSP refers to DJF precipitation. This should be in the text, in my opinion. Response: Thanks. PSP was defined as "Pre-season precipitation" in the main text (line 17 on page 11399 in the earlier version of this manuscript). In most cases, PSP refers to DJF (December,

January and February) precipitation. However, there are cases where PSP refers to seasonal precipitation such as spring.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C7271/2015/bgd-12-C7271-2015-supplement.pdf

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