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Interactive comment on "Soil moisture controls on patterns of grass green-up in Inner Mongolia: an index based approach" *by* H. Liu et al.

Anonymous Referee #2

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The manuscript "Soil moisture controls on patterns of grass green-up in Inner Mongolia: an index based approach" by Liu et al. is a data-based regional study centered around three indices based on the concept of degree day applied to temperature, precipitation and soil moisture. The goal is the description of the timing of grass green up in semi-arid regions. The method is applied to an area in Inner Mongolia, characterized by relatively cold very dry winters and slightly wetter summers. The main conclusion of the manuscript, i.e., that soil moisture is a better descriptor of green up timing than precipitation and temperature, is rather expected. In fact, the region under scrutiny has a seasonally dry climate, with the wetter season mostly coinciding with the growing season. Hence, it is not surprising that vegetation green up date is best described by hydrologic indices rather than by thermal ones. Low temperatures may delay green up,

but in absence of water no green up can occur in a such dry climate. Because rainfall generally begins in May, it is likely that rainfall occurrence (and not temperature) is the main driver of vegetation activity (and indeed in very dry years green up does not occur at all). Furthermore, it is not surprising that soil moisture is a better predictor of green up (and plant water status in general) than cumulated precipitation. Moreover, in its present form, the model cannot serve as a predicting tool, i.e., to explore the effects of climate change, as somehow implied by the authors in some sentences. In fact, the length of the period over which the soil moisture, precipitation or temperature are summed up to obtain the index and the last day of summation depend on the observed green up day. Similarly, running VIC to get soil moisture will require information on plant status and, specifically, on transpiration rate, so that VIC itself requires an assumption/observation on the greening status of vegetation. As such, the proposed methodology can be used to assess which is the dominant driver in green up day at different locations (i.e., under different combinations of temperature and precipitation), but not in a prognostic manner as there is no guarantee that the results of the maximization algorithm will hold also under future climates. Nevertheless, as pointed out above, currently the manuscript achieves rather predictable results. There are some indications of interannual variability in temperature rise and rainfall occurrence. For this reason (and two avoid issues with observed trends – see below), it would be a lot more interesting and probably also more correct to consider the problem year by year, developing a methodology that does not require optimization over multiple years and that allows presenting results relative to single years as opposed to averages over more than two decades. This would allow clarifying the dominance level of the factors at play year by year.

I also have some concerns regarding the method itself: - While dehardening processes may indeed be driven by cumulated degree days, the same concept may not be fully applicable to precipitation. In fact (as also shown by the results of the paper) plants respond to soil water availability: precipitation is the main input to the soil water balance, but losses via runoff or deep infiltration may reduce soil water availability with passing time; hence, cumulated rainfall is likely not to be a good predictor of green up, unless the focus is on a very short period of time. The typical values of optimal summing period, Nmax, are not reported in the manuscript, but figure 3 suggests that Nmax may span several weeks. - The results are presented as averages over the period 1982-2006, with the optimization algorithm trying to maximize the agreement between model prediction and observed days of green up over the entire period. However, as clarified in Fig. 8, the area witnessed an increasing trend in temperature over the period, with possible repercussions on the most dominant driver and timing of greenup. I wonder if this averaging over the period is appropriate given this clear trend. - As noted also by the authors, it is most likely that Mongolian grasses respond to a combination of thermal and hydrologic cues, and that the dominance of one or the other likely varies from year to year. The authors include the combination of thermal and hydrologic indices in section 2.5, but it remains obscure to me how this result is achieved and whether the methodology can provide information on the degree of dominance of one factor over the other.

Finally, I would like to add a few comments on the presentation of material. Several sections are unnecessarily long, including general definitions (e.g., of phenology beyond the case of vegetation) and details, that are not very relevant for the problem at hand. At the same time, the (many) figures are generally only briefly described and over-detailed with respect to the amount of information provided in the text and figure caption. Therefore, I suggest that number of figure should be reduced and the remaining figures should be described in more detail. Figures 1 and 4 are two examples of figures that could be removed without loss of information (Fig. 4 could be easily substituted by a measure of the agreement between observed and modeled discharges). Figure 3 is good example of a very detailed figure lacking explanations, both in the caption and text.

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