

## Comments on "Development and testing of scenarios for implementing Holocene LULC in Earth System Model Experiments" by Sandy Harrison et al.

This is an interesting manuscript that deals with formulating and describing a highly needed protocol for constructing and improving land use and land cover (LULC) changes over the Holocene with the ambition to derive LULC scenarios for use in climate modeling applications. Methods of incorporating archeological data for reconstruction of LULC changes are described together with methods of how to evaluate the results and potentially improving them. Such an evaluation could involve climate model experiments and/or carbon cycle model experiments. Deviations between models when forced with reconstructed LULC and the reconstructed climate could then be used for pointing at regions where reconstructions need more work.

I'm not an expert in land-use or past changes in land-use but as a climate modeler with some limited experience in paleoclimate modelling I think that the paper would benefit from some more detailed discussion of potential limitations with the formulated strategy. In particular, the results illustrating the methods show: large spread, poor correlation and small differences between experiments with and without land-use (Figure 8). This could compromise the idea constraining land use change by climate model simulations. In parallel to the climate model uncertainty, what is the uncertainty associated with the carbon cycle models proposed to be used for constraining the land use? Is it small enough to allow for a meaningful estimate of land use? I think the paper would benefit from a more in-depth discussion about these uncertainties. Consideration could also be given if there would be a place for more detailed regional and local studies to further constrain land use?

### General comments:

Some words and concepts are quite difficult for a climate modeler (definition of time periods like the Holocene and Mesolithic and Neolithic times, taphonomic (L190)).

The manuscript needs to be checked for consistency in how time is referenced (sometimes 6 ka BP, sometimes 6 ka). Also please explain what this means at the first reference.

### Line-by-line specific comments:

L1: Please don't use LULC in the title, better to spell out what it is about.

L36: Unclear what is meant by "Current LULC scenarios". Is it current scenarios for the Holocene? Which part of the Holocene? Or, is it scenarios of LULC for the current climate (likely not, but it should be made more clear).

L42-45: From this it is unclear if the paper is just on evaluation of scenarios or if it is also about further refinement of the scenarios.

L44: What kind of “carbon-cycle simulations” are referred to here? Earth-system model simulations? Carbon cycle model simulations? Anything else?

L53-54: The new IPCC special report on land states that 70% of land is being influenced by anthropogenic activities. Is there a discrepancy here?

L56-57: Please define what is meant by “Mesolithic and Neolithic”.

L79: “LULC change during the Holocene”. It is unclear what is meant here. Is it over the full Holocene? Or, from any particular time in early or mid Holocene to any point during late Holocene (preindustrial?).

L189: “Lack of uniform sampling through time” – does this include different national sampling strategies/resources for archeological excavations/sampling?

L190: What is taphonomic?

L331-343: Here, it is unclear whether the “already produced reconstructions” are products of REVEALS or if there are any other methods that have been involved.

L361: Suggest changing “observed climate” to “reconstructed climate”.

L386-390: Here it is discussed changes in land use over time. The text gives the impression that there is always increasing land use with time “more conversion in earlier periods implies less conversion in later periods”. Seems logical, but does this argument hold in a situation when land use is fluctuating with time (e.g. no land use – some land use – forest regrowth – no land use – again more land use ...)?

L395: “to” missing after “due”.

L440: How is land-use implemented in the models? Is it binary (i.e. 0 or 1) or fractional? In the latter case I guess that dynamical vegetation models could be used in combination with the land use information to derive vegetation type for the part of a gridbox not associated with land use.

L444-445: “free atmospheric CO<sub>2</sub>” needs a better explanation – for instance something like “..., allowing atmospheric CO<sub>2</sub> concentrations to evolve in concert with fluxes to and from land and oceans”.

L466: Please elaborate a bit on how good the assumption on “equilibrium” is for the Mid-Holocene? Was the carbon cycle (and climate) at equilibrium at that time?

L482-488: All references here are more than 10 years old. Are there no more recent studies of relevance?

Comments related to the Figures:

Figure 1: The color scale with the relatively dark green makes it difficult to see any of the rather small areas with land-use. It is difficult to understand why these two years have been chosen from the datasets (why not use the same reference year?). The font size at the color bar is too small.

Figure 2: The figure is difficult to read and it is not easy to see what is the final outcome of the scheme based on the figure. If it is something like “LULC scenario” I guess this should be something popping out on the right-hand side after going through the three steps in Phases 1-3. Also, it is not clear from the figure if there is any iterative part in the process where info is added to the scenarios based on constraints from phases 2-3? This could be better explained here and would also help to make the paper a bit more clear on a general level.

Figure 3. Here, font sizes are too small everywhere. What is SDPs? Please explain what the shading is for the maps (areas under human use?) and give a color bar. What are the circles in the lowermost panels?

Figure 4. Here is a box (Extensive/Minimal land use) that lacks some Level 2/3 information. Or it is redundant and can be removed? The labels on the land-use classes are quite specialized and several of the words are not everyday terms from my perspective (pastoralism, chinampas, taro pondfields, Peri-urban, Swidden). It would be good if these were a bit better explained, alternatively use different words). Also, why are there only Level 3 boxes for some of the Level 2 boxes?

Figure 5. This figure is not easily readable. The font size in the legends is way too small, the red dots in the upper panels are hardly distinguishable and the land-cover classes in the lowermost figure are not readable. Is the order left/right OK here? The figure indicates more people and land use at the earlier period (right panels) if I’m interpreting the figures correctly. In the figure caption “cal BC and BP” are used without definition anywhere. Also in the figure caption intervals defining the Middle and Early Neolithic time periods are given. Are these related to the more general statement on 156-57?

Figure 6. Realizing that these figures are conceptual they still need some better illustration. What are the different “squares” in the left panel second from the top? Gridsquares on a spatial map? Same question for the plots on the third row (and what is the bar with shading representing?)? Units lowermost left panel? Why is there a label “HYDE 3.x” on the top?

Figure 7. A suggestion here could be to remove the panel with the differences and make the other two a bit bigger and more easy to read (including larger font size on the color bar).

Figure 8. What are all the dots in the panels? Are the sites covering large areas? Biased to some regions? Evenly spread? Are all three panels for areas north of 30N? What are the associated uncertainty bars with the proxy-based data? With the models?

Comments on Table 1:

Why is “Modern” paleogeography and ice sheets used instead of “piControl”? And, how (if at all?) are these two differing? In the table “LC6k” is used supposedly for “LandCover6k”, please spell out. What does it mean that pasture and crop distributions are “imposed”? I guess “imposed on top of the default vegetation in the 6ka experiment”.