

## ***Interactive comment on “A high-resolution and harmonized model approach for reconstructing and analyzing historic land changes in Europe” by R. Fuchs et al.***

**Anonymous Referee #2**

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Overall, the manuscript is of good quality, both in terms of the robustness and relevance of the work reported, and of the structure, clarity and writing of the paper itself.

For the record and clarity of the discussion, I will here rediscuss some issues raised in the preliminary screening, and whenever useful the author's responses.

I don't have major corrections to request, but I do have some remarks concerning (i) some unclear aspects of the method, (ii) some of the assumptions used for the reconstructions of past land cover changes, and (iii) remarks related to the validation.

\*\*\*\*\* Unclear aspects of the methods: \*\*\*\*\*

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On some unclear aspects of the methods, I had two concerns:

1/ I was not sure to understand how the authors did, given the combination of heterogeneous data sources, to make sure that the total area by country remained consistent, and no gap (area with no land cover) occurs. The authors replied by inserting a paragraph at the end of section 2.3. Their answer is satisfactory but raises an additional question. Given that they say that “To correct for discrepancies between the total area per country and the sum of all land categories, the one with the highest variance, in this case grasslands, was used to match the sum of all land categories with the total area per country”, is this likely to introduce specific biases or artifacts in that grassland category, and thus how the aspects of the results and discussion that refer to the grasslands category might be affected by this part of the method?

2/ Related to that, I'm still not sure to understand what happens with the land becoming unclassified when a land cover contracts. Does this land receives some form of priority for being reallocated to the expanding land covers? The authors write (section 2.4, p.14833) that “The area is then converted into unclassified area, which can be incorporated in other increasing classes later on as part of their increase mask (Fig. 2, middle box). Since the sum of all land categories is matched with the total area per country (see Sect. 2.2), no unclassified pixels are left after a processed time step.”. And “Considering a class is increasing, it masks all other classes in the LCM and selects the highest values in the relevant probability map (PM) within this mask until the right area for that class is obtained”, there is thus no mention here of a prioritization of unclassified areas for being reallocated to another land class.

\*\*\*\*\* Assumptions: \*\*\*\*\*

Further, I had two concerns about the assumptions used:

1/ The authors assume that the relations between biophysical, geographic and socioeconomic factors on one hand, and land use choices on the other hand, remain constant (i.e. the probabilities maps (PM) remain constant). The authors discuss the

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first assumption and replied (section 4.3, p.14845): “Although many factors are considered to be quite stable in time (e.g. climate-, terrain- and soil factors), this may have been different in the past for some of them (e.g., for accessibility or population density). However, the estimation of the probability maps has been done at national scale (with country specific factors) and was widely used and tested in multiple land use modelling efforts in a foresight mode (Verburg and Overmars, 2009; Verburg et al., 2008, 2010)”. I think this deserves some more discussion. The point, by contrast with what the authors reply, is not only whether the factors are constant (e.g. climate and soils as constant factors, versus accessibility which is changing with time), but also whether the relations between land use decisions and proximate factors is changing with time. Just to give an example of the logic: when the labor versus capital intensity of agriculture changes, it is likely that the relation between population density or accessibility to settlements, and land uses is changed, as the demand for labour force changes. Similarly, depending on the dominant crop types, themselves possibly influenced by whether agriculture produces for local/regional markets or for international ones, environmental constraints differ. These are two examples of agricultural transformations which, by different degrees, affected Europe over the last decades. I indeed do take note that, as the authors explain, the factors that they used are those widely used in such types of historical land use reconstructions. Thus, I don't dispute that the author's work is robust compared to the usual approaches, and thus, essentially, deserves to be published as such, as long as this caveat is properly explained. But, not being directly in that field myself, I might ask the same question to authors of the other cited land use reconstructions. Some works explore sensitivity of the results to assumptions about technological factors, e.g. Kaplan's paper. But it essentially affect the total demand for land, which is here constrained by empirical data, rather than the rules governing spatial pattern. I think that this is something that could be at least discussed with reference to empirical historical studies (of land use changes in Europe, there are plenty), and deserve at least some thoughts to see how it might have influenced the results.

2/ Similarly, the authors assume that the relation between population and settlement C6000

area remains constant. For Europe over the last half-century, this is unlikely to have been the case given the massive explosion of peri- and sub-urbanization over that period. I don't think that I have seen a response to that.

\*\*\*\*\* Validation: \*\*\*\*\*

Beyond the points discussed here above, the authors might go further on the validation of their maps, in several aspects.

First, the spatial pattern could be validated using quantitative indicators - e.g. fuzzy indicators, or Pontius and Millones 2011 approach to separate quantity and location disagreement, both overall and for the high resolution data. Second, for some countries at least, it is possible to find subnational historical data to compare with the maps, which would also allow to more precisely validate the spatial distribution of land cover changes inside countries. Third, the authors appropriately discuss the issue of land cover trajectories - i.e. some land cover expand preferentially over others, or are converted preferentially to some others. Indeed, the lack of gross change data prevents the explicit use of trajectories in the design of the model, but it is still possible to a posteriori validate whether the reconstructed trajectories more or less match with trajectories of change observed with higher resolution case studies. As far as I see, the authors have not addressed or discussed these issues at the stage of the technical corrections.

\*\*\*\*\* Minor issues: \*\*\*\*\*

- p.14825: “Currently, up to 30% of the global carbon emission is estimated to originate from human induced land use and land changes”: clarify that this is total historical emissions, and not current emissions rates.

- p.14827: “Thus, they require high resolution data sets to observe and study these local heterogeneous processes”: such a dataset is very welcome for modelling Earth System and bio-geo-chemical fluxes, but the authors should make it clear that, for

studying processes in the sense of causes, drivers, dynamics of land change, the way the dataset is constructed – as any of the similar land use reconstructions – in itself creates endogeneity. This dataset should thus not be used for that purposes. This is not a criticism, just a clarification to be made of the limits of this dataset.

- p.14829: “While remote sensing data could provide spatially explicit land cover and use information and its changes, it temporally covers only a relatively small proportion of the investigated time frame (1990s – 2010 vs. 1950 – 2010).” Actually, Landsat 1 (with MSS) was launched in 1972, and Landsat 4 (the first with TM) in 1982, but this does not undermine the whole argument that reconstructions are needed.

- p.14829 (l.24): “trans. shrub” : put “transitional”

- p.14929: is there a rationale for including wetland in the grassland category rather than in “Other Land”?

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