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

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Anonymous Referee #1

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Fuchs and colleagues develop a contemporary (1950–2010), spatially explicit (1 km) land cover reconstruction for the European Union and Switzerland. In pursuit of this product, the study explores several critical issues in the context of land use reconstructions, namely spatial resolution and validation. Major improvements in the spatial detail of historic land use reconstructions arise from 1) the method (in particular, working backward from conditions circa 2000, including satellite-based land cover information),

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and 2) the quality and consistency of survey information on net land cover changes for Europe.

I am concerned that the paper focuses heavily on the trends in land cover across the region. While interesting, and possibly traceable to specific national or regional circumstances, these values are derived entirely from census data at a national scale. Sections 3.1 and 4.1 are therefore quite speculative. In contrast, the ability to reproduce reasonable patterns for changes in land cover is more novel. This study is primarily about spatial allocation, not modeling land use changes. The hindcasting approach in this study is particularly apropos for Europe, a region with a long history of settlements and agricultural production.

COMMENT The reviewer is correct, the spatial allocation of historic land change is the main innovation made. However, also progress is made in harmonizing the different national scale time series data. We can clarify the scope of the paper in the revision.

My second concern is with the assertion that the HILDA product is more suitable for studies of emissions from land use change than previous reconstructions (sections 4.3 and 4.4). As the authors admit, net land use changes differ significantly from gross land use changes (perhaps by 50-100% in the case of Europe, Pg. 14846, Line 15-18). This missing dynamism is critical for greenhouse gas emissions estimates. I would encourage the authors to indicate which specific applications would see a meaningful improvement in the ability to account for carbon or other greenhouse gas emissions using HILDA. This is especially important as the time period for the HILDA product encompasses the satellite era, and many reporting mechanisms for greenhouse gas emissions at the national or regional scale would be better served with direct estimates of contemporary changes.

COMMENT We agree with the reviewer. In a revised version we can more clearly indicate the added value of the data for emission inventories, being:

1. the HILDA data set covers a longer period than modern reporting mechanisms for

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greenhouse gas emissions, which is important for legacy effects (e.g. soil carbon) and understanding of GHG processes. 2. Related remote sensing products cannot cover this time span. 3. None of the previous reconstruction products considered the most important land use classes (cropland, grasslands and forests) in one product and at an appropriate spatial resolution, in order to observe these land conversion types. 4. HILDA combines and harmonizes multiple reporting mechanism in one product and adds a spatial component. 5. Since gross changes cannot be directly derived from one product for the whole period, they have to be estimated by additional information. This difference to net changes should be applied on already existing structures. The HILDA approach can be used for that.

Specific comments: 1. Abstract and Introduction: Land use change does not currently account for 30% of carbon emissions from human activity. The core concept, as stated later in the paragraph (the relative contribution from land use change continues to shrink as fossil fuel emissions grow) is sound, and does not diminish the need to characterize land use dynamics of large regions/long timeframes. I would encourage the authors to avoid the 30% statement (see van der Werf et al., 2009), especially as this study finds a net increase in forest cover over the study period.

COMMENT In a revision we will avoid stating that currently 30% of carbon emissions are caused by land use change.

2. I agree that the spatial allocation of a settlement category is important, and the methods are sound. However, this category accounts for a small (and diverse, in terms of carbon stocks) fraction of total land area in Europe. Similarly, the statements throughout the manuscript about the importance of other lands (for 100% coverage) could be toned down, as the paper actually excludes other lands from change estimates (Pg.14833).

COMMENT Settlements and other land areas comprise together 8.5% (1950) and 9.22% (2010) which is a relevant part. Although of minor impact for emissions it is

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important to exclude this amount from the triangle of change (cropland, grassland, forest) as it is otherwise directly assigned to these three classes.

3. This analysis identifies, but not does not confront, one important inflection point in global land management: the green revolution after the second world war. Is this advantage for HILDA, which begins in 1950, a disadvantage in the context of nesting these results with other global or longer term land use reconstructions? How to harmonize the large changes in cropland extent in 1950, both in terms of total extent (figure 8) and spatial allocation (figure 7)?

COMMENT We used one of the first available reports of the Forest Resource Assessment from 1946 to estimate the cropland extent. Global and long term land use reconstructions might start with assumptions before the first FAO data in 1961, which might also lead to the discrepancies of the models. The harmonization of the various data sets is difficult, since actually more input data is needed to verify these trends and the total extent. Furthermore, these new input data should be accessible for all models.

4. Why are the validation R² values higher in 1950 than in 1990? Might this relate to the stability of cover types (as discussed in validation efforts), such that backing up to 1950 involves fewer change allocations?

COMMENT This is probably an unclear statement. The values were decreasing from 1990 to 1950. We will clarify that in the revision.

5. Word choice: (“demand”) on pg 14832, 24-26 is confusing term.

COMMENT Can be changed in revision by ‘aggregate area to be allocated’

6. Pg 14841. Urbanization, if that is the driving factor behind increasing population, involves two changes (from-to). How do these coupled changes influence the overall results?

COMMENT This comment is not entirely clear. We assume the reviewer meant the changes between two land cover classes (e.g. from cropland to settlement) and not

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the migration from rural to urban. In this case we considered these conversion types by using our described hierarchical approach. We don't think that completely different assumptions on conversion types would have an influence on the overall results but definitely for understanding these land change processes.

7. Limitations: It would seem as though other satellite data could help provide landscape information, e.g., early Landsat data. This might be an issue to explore in the discussion section on methods and potential improvements for contemporary land use reconstructions.

COMMENT We agree with the reviewer that this is an option and we can include this in the discussion. We will include the suggestion that compiling such databases based on early Landsat is a good option but requires a lot of effort to do at a European scale.

8. How important are other land use transitions (such as logging) that do not change land cover but do impact greenhouse gas emissions studies? Time since clearing?

COMMENT In case of logging (a management practice) it is important whether the area is afforested again or not. If it is not afforested it is considered as land change. In this paper we focused on areal extent of land use, not on the production intensity (per ha) of e.g. cropland or forest. In general, it definitely has an important influence on GHG emission studies. But, this clearly addresses the management practices. Several groups and sectorial models exist, dealing with specific management impacts (e.g. grassland, cropland (crop rotator), forest (logging, harvesting)). These groups perform their models on top of land cover change products.

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