Author Response to the Reviewer Comments to the manuscript “High-resolution land-use land-cover change data for regional climate modelling applications over Europe – Part 1: The plant functional type basemap for 2015" [essd-2021-251] submitted to Earth System and Science Data.

We would kindly thank the Editor David Carlson and the whole editorial team for being highly responsive and helpful throughout the review process. Further, we thank Editor David Carlson and one anonymous referee for their additional reviews. These have been very useful for improving the manuscript, especially the visualization of the results. The individual comments are listed below (shown in blue) including our responses (shown in black). The changes discussed in this reply will be included in the revised manuscript and will thus become visible after re-submission.

Additional changes

As decided together with the Editor David Carlson, the companion paper to this publication (essd-2021-252) was rejected. Therefore, we decided to change the title of essd-2021-251 to have it labelled as a standalone publication.

Former title:

High-resolution land-use land-cover change data for regional climate modelling applications over Europe – Part 1: The plant functional type basemap for 2015

Updated title:

High-resolution land-use land-cover dataset for regional climate modelling: A plant functional type map for Europe 2015

Other changes include the correction of typos or missing punctuation, which are fully documented in the track-changes document submitted together with this supplement.

Response to Reviewer 1

The manuscript has been improved. I think there are two outstanding issues: 1) The description of the cross-walking tables (CWTs) and the cross-walking procedure (CWP) still needs improvement (see comment below regarding Line 95 in revised manuscript); 2) The validation approach needs to be more fully described.

Regarding validation and the accuracy of the transformed PFT map... The authors wrote in their response: "During the modification process of the CWTs the authors looked at the intermediate results and compared the maps to reference data such as CORINE and google earth images, specifically for small regions throughout Europe, where expert knowledge is present. Since there is no quantification for that we decided to eliminate that sentence from the manuscript." I don't agree that this information

should be omitted simply because it is a qualitative assessment. The authors should include this in the manuscript as part of their discussion of their validation approach ().

Thank you for this comment. We included a paragraph on the qualitative assessment in the discussion where we clearly state that the efforts done by us were non-quantifiable but that the conduction of a qualitative assessment within the map development process is strongly recommended.

I am satisfied with the validation approach overall. Reviewer 1 is right to point out the problem of proceeding with validation using a grid-based overlay with a grain size 25 times larger (2.5 degrees) than the product under evaluation (0.1 degrees). However, as the authors indicate, "the accuracy metrics are calculated based on the individual LANDMATE PFT grid cells." However, the authors should make this clear in the manuscript (not just the response to reviewers). For example, Line 370 might be updated to distinguish clearly between the 2.5-degree grid used (only) for visualization and the 0.1-degree grid used for accuracy assessment. Furthermore, the various figures showing User's Accuracy and Producer's Accuracy as a function of the minimum dominant PFT fraction should have their captions updated on this point.

Thank you for pointing this out. We added a paragraph with more explanation to section 4.1 "research area" where the 2.5° auxiliary grid is mentioned and shown (Fig.4) for the first time.

One important thing to mention is that for the validation of LANDMATE PFT, the map was produced and used in 0.018° resolution to match the resolution of GT-SUR. To make that clearer to the reader we added this information again in the beginning of the results. We also added a reference to Appendix B where the results (confusion matrices) are available on LANDMATE PFT cell-level.

Table 1 is formatted with very small text. I think this is going to need to be a horizontal/ landscape, full-page table.

Thank you for pointing that out. The table layout is adjusted and in addition, steps were taken to make the table more user friendly (according also to suggestions by other reviewer).

Line 95 in revised manuscript: "For each HLZ in the first column, the LC class 40 is translated into varying fractions of the LANDMATE PFTs." I still do not understand why there are "varying fractions." It seems to me that, for a given pixel, there must be exactly one PFT class. The example CWT and discussion here is a slight improvement over the original manuscript, but the exact use of the CWT is still too vague. I would appreciate it if the authors could extend this example one step further... If I had a GPP model calibrated for LANDMATE PFTs, for this pixel with LC class 40 in HLZ 1 or 2, would I model GPP as the *weighted sum* of GPP in Tundra (35%), Swamps (30%), and Cropland (PFT 13) (35%) canopy? I believe that a concrete example of the *use* of the fractional PFTs, such as this, is essential for conveying how the CWTs are to be used.

Thank you for this comment. We tried to be clearer in the explanation of the CWTs and added a reference to Wilhelm et. al (2014) where the implementation and use of PFTs in the Regional Climate Model REMO is described in detail.

Response to Reviewer 2

The manuscript is considerably better than the first draft. There are still several issues that should be considered in my opinion.

paper does not clearly articulate how PFTs are partly seen as outdated for some. Indeed, some models are increasingly turning towards trait-based characterizations of the land instead of using PFTs (see https://doi.org/10.1073/pnas.1304551110 for an example, among others). It is true that current RCMs still use PFTs and thus the present work has value for them, but at the same time I think it is worth mentioning more some of the caveats about PFTs and the future directions that are currently undertaken.

Thank you for emphasizing this. We added a paragraph in the introduction citing relevant sources, where we mention the Plant Functional Traits as parallel concept. However, the Plant Functional Traits are rather to be used in the global climat modelling community. Davin et al. (2020) show clearly that RCM families with a big global user community, such as CLM are employing PFTypes. This citation should help to make it clear to the reader why the LANDMATE PFT map is highly valuable for the RCM community.

Following some of my inquiries about C3/C4 traits the authors state that carbon is not prioritized because RCMs do not model C. However, in Line 35 it is clearly stated that the functional groups are based on both biophysical and biochemical properties. I think this choice of not focusing so much on the carbon should be stated more clearly up-front in the intro/objectives. This should also be reinforced in section 2.2.6. A warning that the C4 trait is inherited from other data, and that it is not evaluated, should be made somewhere in the discussion. Note that it could have been evaluated, as the LUCAS / GT-SUR dataset used does provide crop type, and maize could be used to evaluate if C4 is well caught (as it is the main C4 in Europe).

Thank you for this comment. We clearly state now that the focus of the dataset is to support the RCMs to account for the biophysical processes both in the introduction and in Section 2.2.6. We also state in the discussion that the C3 and C4 grass separation was not evaluated because LUCAS / GT-SUR does not provide this information. Thank you further for pointing put the possibility to evaluate C4 crops using maize as a proxy (at least in Europe). However, in LANDMATE PFT we do not distinguish between different crop types.

L96: missing parenthesis

The parenthesis before the word "Mosaic" was there accidentally and was replaced by a hyphen (according to the class nomenclature by ESA-CCI

Table 1: Make it more user friendly. This could involve (according to me) increasing the fonts, using a colour background for the table cells with numbers, with the intensity of the colour proportional to the magnitude of the number, and perhaps the colour based on the type (Tree, Grass, Crops, etc...). The types of veg could be aligned vertically to allow shrinking the column size. This should then be harmonized with all the tables in the end of the document.

Thank you for pointing this out. The table was modified to be more user friendly. The table was turned sideways, and the font was enlarged as much as possible to still fit on one page. All tables were modified into a common layout using gray row colors every second row starting after the header.

Figure 2: really perturbing choice of colours: Deserts in Cool Temp, have the darkest shade of green. Also, as mentioned in the first review, why are colour intensities in Tropical and Warm going in the opposite of those in cool and boreal? this is not very intuitive... and probably not ideal for colourblind people.

Thank you for this comment. We updated the color scale in order to be more user friendly. The color intensities are going from dry (light) to wet (dark) climates. In addition, the individual color scales for the superior climate zones (e.g. warm temperate, subpolar…) were exchanged to better stand out next to each other. A colorblind check was done to ensure clear distinction between the HLZs on the map. In this course, some minor mishaps with the numbering of the HLZs on the map was discovered and straightened out.

Figure 3: Grasslands should not be in green to avoid confusion with Trees. The hues in the 6 classes of trees are already too similar and are hard enough to find/identify on the map. The figure caption needs to include an explanation of why the "cropland irrigated" class mentioned as "empty". This is important as it strikes the eye as a major error in the map, as people will expect to see some irrigation dominate areas as in the Po Valley in Italy, or in the Indus and Ganges valley in South Asia.

We updated the color scale to make it easier for the user to identify the individual PFTs. Grassland and trees are kept in green shades but way more distinguished than in the initial figure. A colorblind check was done to ensure clear distinction between the PFTs on the map.

It is correct, that the empty irrigation fractions need to be mentioned within the figure caption. Therefore, a reference to the cropland PFT section 3.4 has been added, where the missing irrigated cropland fractions are addressed in detail.

Section 3.1: this addition of 2 extra tree species boils down to separating "Temperate" from "Tropical" trees. This is thus only added the "tropical" trees beyond the ESA CCI LC, which for Europe is probably VERY marginal (Madeira?). For biophysical effects in Europe (Bright et al) one would expect you make the distinction of Boreal trees. Please comment on this. And perhaps acknowledge the amount to "tropical" trees that are in Europe and that benefit from this increase in PFTs. It is welcome to increase tree PFTs to satisfy the models, but it seems you are not increasing the important type of trees (for Europe that is).

There are tropical trees in the European Domain (which is quite large and also covers part of Africa, Middle east etc.). You are right that a distinction between temperate and boreal tree PFTs could be done as well. We based our CWP on previous work from Wilhelm et al. (2014), who distinguished between the 6 tree PFTs, which are now PFT classes in LANDMATE PFT. If there is a future need for more tree species, it is possible to further refine the CWP distinction could be added in future versions but requires a considerable amount work. We added a paragraph on this issue to the discussion.

L225: missing table ref.

Thank you for pointing this out. The table was excluded from the manuscript within the last review round. The reference points now to the LANDMATE PFT figure where the PFT names and numbers are included.

The justification of not using some irrigation because datasets don't agree fully is a bit weak. This argument could be used also for C4/C3 and for Urban/Bare. At the minimum, this should be re-stated as a caveat in the discussion.

Thank you, you are right. There is additional uncertainty held by the external C4 datasets. However, urban areas are taken from ESA-CCI LC directly and bare ground were also derived from the ESA-CCI LC via the CWP. We included a short paragraph in the discussion on the uncertainties of C4 datasets and that irrigation could be included in future LANDMATE PFT releases.

L262: typo...

The typo was erased.

Figure 5 and 7: remove zeros in y axis by saying counts are in thousands. Also, Fig 5 could be avoided as it can be readily inferred from Fig 7.

See comment below

Figures 8 and 9 should be panels a) and b) of the same figure, one above the other. (Maybe even combind with Fig 7, which would further avoid wasting space with the legend shown 3 times)

Thank you for pointing that out. All changes were done according to reviewers' suggestions. All graphs containing aggregated accuracy metrics for the groups 0.1-1.0 are now panels of fig. 6. Former fig. 5 was eliminated from the manuscript.

Section 5.1: good that this new section was made, as it more clearly provides an idea of where the LANDMATE PFTs might be better than the baseline. It would be good to articulate a bit why the PA for CROPLAND is lower in LANDMATE.

Thank you for pointing this out. Yes, this should indeed be addressed. We added an extra paragraph in section 5.1 where we elaborate on the reason for the worse PA for cropland, which is mainly the translation of cropland types in the Mediterranean region.

L505: "extremely" is probably an exaggeration here, especially since the ESA-CCI provided the CWT approach to deal with this in the first place.

Thank you for this important hint. We modified the sentence and added information in order to acknowledge the default PFT translation given by ESA-CCI.