We have answered point-by-point to all the comments raised by the referee in the attached PDF. The answers are provided below each comment in blue font. We would like to thank the reviewer for the quality and detailed reviewing provided. We would also like to notify the referee that this manuscript was selected as an Executable Research Compendia (ERC) pilot (see here https://o2r.info/pilots/) and the code to process the data and the table and figures will be available and reproducible after reviewing.

Referee Comment 3

The manuscript by d'Andrimont et al. "summarizes the LUCAS Copernicus protocol to collect homogeneous land cover and proposes a methodology to create a ready-to-use dataset for Earth Observation land cover and land use applications with high resolution satellite imagery". Both aims are conducted in the frame of a new LUCAS module that is specifically tailored to EO, the LUCAS Copernicus module. The module but most of all a standardized way to provide in-situ data as training data for further LULC developments is of high importance and crucial. Both, the data set and the efforts of all persons involved are highly appreciated.

The present manuscript describes the protocol how in-situ data are obtained and proposes a methodology to create a ready to use dataset for further usage. It is well written, concise and informative. In certain parts it lacks clarity especially for an interested reader who is not a LULC expert. Some of it is induced by a diversity of used terms whose relation is not directly tangible. Some other relates to numerous points (LUCAS theoretical grid point, LUCAS Copernicus point point) and metrics (buffer and distances) for which it is unclear what really is of relevance and used during the survey or later on to e.g. define homogeneity. Regarding the term diversity a glossary may provide the essential light in the dark, while a simple process chart could disentangle the point/metric puzzle.

Thank you for the suggestions provided. We have added a glossary to the manuscript. We have also tried to clarify the whole text of the manuscript. However, we haven't found how to figure out the data with an additional processing chart as the data combines survey and processing. However, we believe that Figure 1 is a good illustration to clarify and have thus tried to improve the related text for the sake of clarity.

Since it is a data paper in which it is also asked to check the data quality and usability, let me mention that one decisive file was missing (LUCAS_2018_Copernicus_attributes.csv). Thus I could not completely verify its content, but I will gladly do it as soon as the revised version of the manuscript is available.

The file should have been available previously. After updating the files, we have also uploaded them to the JRC open data catalog :
http://data.europa.eu/89h/cfe66a0c-bdee-4074-96e1-a2f7030b9515.

These comments alongside further smaller ones are added to the *.pdf to facilitate preparing the final version of the manuscript that I would be happy to receive again.

Yet, overall the manuscript is very well developed and needs just some tweaks before being publishable. Congratulations.

Sincerly, Ulf Mallast

We thank the reviewer for the useful comments and suggestions. We have tried to include them all and are addressing them point by point below.

Comments in the PDF

L71: Is the copernicus data the same as the LUCAS Copernicus module? and the LUCAS Copernicus in-situ survey? and LUCAS core?

At certain locations, and coming from a different field compared to the authors, it is sometimes hard to follow the narrative, given the diversity of terms that is not really clear. I suggest two approaches: 1. I would encourage the authors to include a gloassary and 2. possibly even a process chart on how each of the terms are interrelated (if the latter makes sense).

Thank you for the suggestions provided. We have added a glossary at the end of the manuscript. We have also tried to clarify the whole text of the manuscript. However, we haven't found how to figure out the data with an additional processing chart as the data combines survey and processing.

L89: A question that directly pops up in my head, when it comes to design is the following: Are the LUCAS points always the same for each of the survey years?

The 2-km grid is static and contains about 1.1 million of points. Out of the 337,854 points surveyed in 2018, 23% points had been included in three previous surveys (2009, 2012, and 2015), 25% had already been surveyed once or twice before (e.g. in 2009 and 2015), and the remaining 52% of the points were new entries.

And, unaware of the exact locations of each of the survey points, it would make a lot of sense to include long-term observatories/sites (see here: DEIMS.org) that record their land use/cover in regular intervalls (in in the near future also in a standardized fashion) but spatially explicit. In turn, one would not only rely on a regular LUCAS grid every 2km but could include spatially continuous data that in itself contains gradients that the grid cannot depict.

Indeed, it would be interesting to link with ecologically monitored zones such as DEIMS. However, the goal of LUCAS is to collect statistics about Land Use and Land Cover along with their dynamic though time at the EU level. The sampling scheme and methodology is thus designed for that and cannot be modified.

L92: As idea for the future, it might also be worthwile to include RTK drones data that are amazingly cheap and provide a high resolution NADIR view of the LUCAS polygon as well. The latter could be evaluated concerning homogeneity or vegetation gaps/density.

This would indeed be very valuable information however there is currently no plan to use drones for LUCAS 2022 campaign. This is expensive and need to have a policy support of the different involved DGs of the commission. For your information, the EMBAL (European Monitoring of Biodiversity in Agricultural Landscapes) project which is currently in a pre-pilot phase is looking at this option. However, because this type of survey is pretty expensive at the EU-level and different national uav regulations are in place, there is , to the best of our knowledge, no plan for such a survey.

L106-109: If I understood correctly, the observer assigns the land cover from the observation point to the unreachable LUCAS point.

If so, in cases of a LUCAS point being located at or in close proximity to land cover boundary , it may happen that a LUCAS point is assigned a wrong land cover. Can this be the case and is the observer asked to note down (e.g. in the metadata) the actual obervation point?

The surveyor has a GPS and ground document with a map of the points on a very high resolution orhophoto to help him to locate the point he has to reach. If he cannot reach it, he registers an information in the metadata ("obs_type": 1 - In situ < 100 m; 2 - In situ > 100 m ...) along with the distance to the point ("obs_dist"). For the Copernicus point, the distance to the point should be less than 100 m. In case he cannot reach the point, he is asked to note down the actual observation point Land cover at level 2 in addition to the one observed on the LUCAS grid points.

L116: "fraction" is enough, I would even suggest to think about providing the exact percentage (1-7%), given the fact that fraction is very descriptive

"Subfraction" was changed to "fraction" and the percentage was added.

L119: What is the accuracy? Are surveyors requested to use a high end GPS device with submeter accuracy or even subcentimeter accuracy or is it sufficient to use GPS integratd in mobile phones? The later is in the range of 5-10m and would certainly pose a risk.

The hand-held GPS receiver has not a sub-meter accuracy which could indeed pose a risk of location inaccuracy. To limit the risk, the surveyor uses a ground document includes a topographic map (the most widely used types of maps with a scale usually between 1:10.000 and 1:200.000) and an orthophoto (an orthorectified aerial photograph, thatis, free from the distortion caused by inclination angle and relief, with a scale that normally, varies between 1:10.000 and 1:2.000). The ground document is the base for the surveyor to locate the point and to estimate the area of the parcel the point is located in. Additionally the precision of the GPS is collected (and available as metadata) and the location of the points are cross checked afterwards in the office.

L121-122: But how is it done in the field? I assume the surveyor estimates it visually from her/his earth-bound observation point, and this is very subjective and error prone.
Here especially I would suggest to include drones to either get a better estimation or even provide a "homogenity-factor".

To measure the distance, the surveyor uses the GPS and the ground document on which the grid points are displayed with the orthophoto in the background. If needed, measurement could be done also a posteriori in the office using the orthophoto. The detailed field collection protocol of the Copernicus module including specific cases is available pp.57-67 of the C1 document (https://ec.europa.eu/eurostat/documents/205002/8072634/LUCAS2018-C1-Instructions.pdf)
Using drones would indeed be optimal but, as described previously, it is not planned for the next campaign.

L126: How do the 50m relate to the radii of 1.5 and 20m mentioned before. Is it just another feature the surveyor has to record?

The question leads me back to the general sampling design of sampling point spacing of 2km. Why not look and predefine a homogenous area in close proximity to LUCAS points with the 2km spacing instead of insisting on these 2km LUCAS points? That way heterogeneity would not play a role.

And second, if the surveyors are provided a bird-view map from these points (from drones or VHR sateliites e.g. Quickbird), with exact distances and angles to landmarks the geolocation uncertantiy may be reuduced. Even more so, if certain marks can be permantently installed (such as the plastic head plate fom surveyors) that define the point of interest.

For the first part of the question, the general sampling design is a stratified sample (n=337,854) selected among a systematic 2km grid (n=1.1 million).

On these points the observation radius is **1.5m** if the point is falling in a homogeneous area.

When the land cover is not homogeneous, for example when it is composed of trees or shrubs interspersed with grass, the scale of observation has to be changed to classify it. In these cases a systematic observation of the “environment” in the vicinity of the point, which in LUCAS is called the extended window of observation, has to be adopted. The extended window of observation expands to a radius of **20 meters** of distance.

Finally, on a subset of the points which are part of the Copernicus module, an additional extent information is collected up to **50 m**.

About the second remark, this is a valid remark and indeed, it would be more convenient to have a very high resolution image (from a drone or a satellite) concurrent to the survey. However, from a practical point of view, it is difficult to obtain and much more expensive. For the CAP monitoring the member states are usually collecting orthophoto with a submetric resolution at least once every 3 years and the data could then be re-used for this exercise.

However, we fully agree with the reviewer that having such type of data would be very valuable.

L154: Again, I am a bit confused, how do the Copernicus Point and the theoretical grid point relate to each other? I thought that if the surveyor could reach the theoretical point the theoretical grid points is equal to the Copernicus point. But if only 1.5 are evaluated in terms of homogeneity, how can the entire polygon represent a homogenuos area?

To disentangle the puzzle, I suggest to include a simple processing chart that pictures what the authors have described in the text..

The Figure 1 aims to clarify the puzzle. Indeed, if the surveyor could reach the theoretical point, the LUCAS copernicus point and the LUCAS grid point should be the same. The Copernicus polygon is homogenous.

L157-159: I do not understand a) how the number is generated and b) why it is important. Can the authors please elaborate?

The Table 1 describes in detail the numbers. Out of the 337,854 points surveyed in 2018, 63,364 were effectively also surveyed with the Copernicus protocol. The number is important as it is the total number of points for which the Copernicus protocol was applied. To clarify, we have added a reference to Table 1.

L165: the conversion is very general and with these numbers only valid at the equator. Given that Europe is the spatial frame for the current MS, I suggest to provide a better conversion.

Indeed, it was not realistic for the longitude. We have modified the manuscript calculating the metric distance based on a latitude of 50 degree N.

L169: sometimes it is "polygon" sometimes it is "point". Please be consistent.

Indeed, thanks for the remark, we have modified accordingly to be consistent.

L174: 2?

Indeed, it was a typo, thanks.

FIGURE3 : If I may suggest, it would round up the overall impresssion, if the geospatial graphics have the same layout and design. Could the authors please adapt this figure to figure 1 regarding e.g. the frame, the coordiantes, axis titles etc.

The Figure 3 was generated by a R script while Figure 1 was done with QGIS, thus it is impossible to have the same layout. Also, as this manuscript is part of a pilot to generate an ERC (Executable Research Compendium) with reproducible code (https://o2r.info/), we prefer to have different layout but reproducible code.

Since level-2 data were mentioned before, I would naturally assume to see level-2 data in the graphic. If possible and still comprehensible, I would thus suggest to present level-2 here, instead of level-1, if the authors find it presentable with 26 classes.

Indeed, we have tried with the level-6 26 Classes but it was not presentable.

L179: I have mentioned it before, for the sake of clarity, it would be worthwile thinking about a glossary/ scheme to assign more detail to these terms (LUCAS core data, Copernicus polygons, Copericus module)

Along with the Figure 1, a glossary has been added a t the end of the manuscript describing the following terminology:
LUCAS core data,
LUCAS theoretical grid point,
LUCAS Copernicus point
LUCAS Copernicus polygons,
LUCAS Copernicus module

L213-214: I mentioned with the integration of long-term monitoring sites (observatories) and usage of drones in future surveys two points before, that could also be mentioned here and shorty discussed, as it would represent an interesting option and provide further added value.

Because of LUCAS main objective and methodology, i.e. collecting statistics about Land Use and Land Cover systematically over the whole EU, the integration of long-term monitoring sites seems unlikely to happen within this survey framework. About the drone survey, we have added a comment in the discussion of the manuscript.

L217: wouldn't it be relevant to all sensors in the high resolution section (=<30m GSD)? It is intended for 10m Sentinel due to Copernicus affiliation, but genuinely it could be used for Landsat, Quickbird, ASTER, WorldView etc.

This was added in the manuscript.

L226: If I am not mistaken the decisive csv file with all attributes is missing. Can the authors please check?

The file should have been available previously. After updating the files, we have also uploaded them to the JRC open data catalog.