The contribution of land-use change versus climate variability to the 1940s CO2 plateau: Former Soviet Union as a test case
Bastos et al. *Biogeosciences*

Response to Editor's comment #3

Please find below a point-by-point reply to this comment, which we are not sure is from the Editor, from reviewer #1 or from another reviewer, as no information about this comment is included in the tracking system. We would like to note that we received on Oct 23 an indication that the manuscript needed major revisions, based on the previous referees' comments, which we are currently addressing. All of the issues raised here match the same concerns posed by the initial two reviews, which we are confident that our revision of the manuscript (to be submitted until December 4) settles.

"The contribution of land-use change versus climate variability to the 1940s CO2 plateau: Former Soviet Union as a test case" In this study, authors attempted to explain why the stabilization of atmospheric CO2 concentration was observed during the 1940s. Earlier, Bastos et al. 2016 have showed that the global CO2 budget in terrestrial ecosystems during this period has a gap sink of 0.4-1.5 PgC yr-1. To explain this gap, authors made 2 hypotheses: (1) huge land-abandonment due to the socioeconomic and demographic disruptions during World War II that might lead to an additional Csequestration and (2) the warming observed in the high-latitudes for the same period, which might cause the enhancement of the natural C sink to vegetation. Unfortunately, I see some very serious problems, which do not allow to support the publication of this MS. I could agree that croplands abandonment took place in FSU during WWII. However, the period when current croplands were not used was short – not more 1-2 yrs. People which stayed on territory occupied by Nazi, had to produce food for them and themselves. Besides, withdrawn area was much less than it reports in the study – 62 Mha between 1940-1943. Here I support completely anonymous Rev # 2. Authors often used incorrected agricultural statistics.

AR: These concerns are the same as the ones posed by Referee #1 and Referee #2, to which we already replied elsewhere. Nevertheless, we would like to note:

- Whether there was or not land abandonment in large areas of FSU during WWII is not a matter of opinion, but has been reported extensively in the literature referred in our manuscript. As in all report-based statistics, uncertainty exists concerning the exact values, but still different datasets can be compared for their impact on resulting CO2 fluxes. Indeed the data we collected may present some discrepancies in the nazi-occupied area, but the alternative dataset (LUH/HYDE) does not report any cropland abandonment during this period, which is arguably more inaccurate. In this regard, the referee could explain why they find that extrapolating cropland area based on total population prior to 1961 is less uncertain than our data based on official statistics.
- The high uncertainty in LUH/HYDE due to the method used prior to 1961 is precisely why we took the effort to collect statistics that are reliable (up to the degree to which most official statistics are reliable), and why we decided to base our analysis solely on the data we were able to collect and not on personal impression about the extent of abandoned area. The referee does not indicate any reference that can provide alternative figures and question our number. This is due to the indeed scarcity of the data for the early 20th century. As it so often happens in science, these numbers can be revised if alternative data becomes available.
- Still, we emphasize that the goal of this paper is to **compare two datasets** that, to the best of our knowledge, attempt to provide estimate of cropland variations in FSU during the 20th century using valid datasets and methods. We do not claim our data are free from errors or uncertainty, nor is LUH/HYDE (see Gasser and Ciais (2013) or Pongratz et al. (2014)). Our work provides a comparison of two equality valid datasets and discuss their impacts in resulting fluxes from land-use change emissions.

It's also important to consider that the abandonment of high fertility soils can led to C-losses especially during first years after withdrawal (Romanovskaya, 2008; Lyuri et al., 2010, Kalinina et al., 2015). Such situation took place in Ukraine and south part of Russia, which were occupied by Nazi during WWII. So, I guess, that the amount of C sequestrated due to agricultural land abandonment are strongly overestimated, and even some additional soil C can be released as CO2.

AR: Kurganova et al. (2014) have reviewed the changes in soil C and C sequestration following land-abandonment in the 1990s. They provide values from several works, all pointing to an increase in C-sequestration and soil C following abandonment due to the collapse of FSU (see Table below).

Table 3 Estimations of total carbon sequestration in former arable lands of Russia

Period	Area (M ha)	Approach	Total C sequestration (Tg C)	Average rate of C sequestration (Mg C ha^{-1} yr^{-1})	Reference
1990–2011	45.5*	Soil-GIS	870 (254)*	0.92 (0.28)	Present study
1990–2011	45.5*	Approximation	861 (646)*	0.96 (0.72)	Present study
1990–2006	30.2	Soil GIS	648 (47)	1.26 (0.09)	Kurganova *et al.*, 2010;
1990–2006	30.2	Approximation	585 (33)	1.14 (0.06)	Kurganova *et al.*, 2010;
1990–2005	27.9	RothC model	248 (37)	0.55 (0.08)	Romanovskaya, 2008;
1991–2000	20.0	Orchidee model	64	0.47	Vuichard *et al.*, 2008; **
1990–2004	34.0	Approximation	660	1.29	Larionova *et al.*, 2003

Also, Kurganova et al. 2010 provide a synthesis of site-level measurements of changes in soil C following land-abandonment in the 1990s.

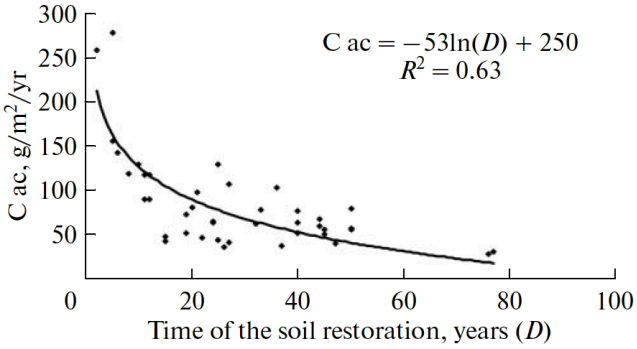

Fig. 1. Relationships between the carbon accumulation in the 0- to 20-cm-thick layer and the time of restoration of the arable soils (the number of pairs is 41).

As the referee may note, they find C-accumulation in the soils even a few years after abandonment, with the highest accumulation rates in the early years after abandonment. They conclude: "*On the whole, the carbon sequestration (20 million t of C/yr) because of the removal of croplands from agricultural use is considerable in the carbon budget of the plant ecosystems in Russia.*"

Nevertheless, we agree that it is important to provide comparisons of our results to observation-based and modelled results for similar processes and there include now one Table in the revised version of the manuscript comparing our estimates of C-sequestration following abandonment with the values compiled by Kurganova et al. (2014) from several studies. In their review, C-sequestration in former arable soils during the first 15 years following abandonment varies between 47-129 gC/m2/yr depending on the method. In our simulations, absolute C-sequestration in former arable soils during the first 15-yrs following the large cropland decrease in 1942 are 101-130 gC/m2/yr, for S_{FOR} and S_{GRA} respectively. Therefore, even if our values are in the higher range of the values provided in Kurganova et al. (2014), they are in line with previous studies.

For correct estimation of C budget on FSU territory during the 1940s, authors have to take account of other disturbances which might to impact on C balance. Here are some of them: - large amount of CO2 emitted to atmosphere as a result of forest fires, burning biomass in abandoned fields, fires in thousands of villages and many big cities on the occupied territory; - decrease C sink due to deforestation in European and especially East part of FSU to provide the functioning of military factories and heating of housing possible only by wood during the WWII; - possible decrease of emitted CO2 due to collapse in transport, coal industry, and industry during first 1-3 years of WWII. Of course, it's very complicated aim to estimate all disturbances caused by WWII, but authors have to be more thoughtful and interpret more carefully statistical data and results of modelling.

As mentioned in the manuscript, our model does account for forest fires (the referee may note that fire emissions are provided in Figure A4). As we mention in the text, the model incorporates the SPITFIRE module and has been shown to be able to simulate boreal fires (Yue et al., 2014; 2015). As for fires related to war in villages and fields or bombing, we do not have any data that could allow considering such processes, but lower population density is usually associated with less ignitions (Knorr et al., 2016). Likewise, these processes are not included in any of the estimates of ELUC using LUH/HYDE, and therefore, since we are **comparing two analogous datasets**, they should not affect the conclusions obtained through such comparison.

As for fossil fuel emissions, as discussed extensively in Bastos et al. (2016), uncertainty in fossil fuel emissions is very small (0.1PgC/yr) during this period, while for LUC emissions uncertainty is more than ten-fold higher (1.5PgC/yr). Again, we would like to remember that the goal of this paper is not to provide an exhaustive analysis of the global CO2 budget during WWII (redundant with Bastos et al. 2016), but to perform a comparative analysis of processes that could explain a terrestrial C sink higher than the one estimated by current state-of-the-art

reconstructions. As discussed in replies to the other referees and the editor our approach and model used are among the state-of-the-art methods used by the community and are therefore, **scientifically valid**.
We have re-structured the manuscript, included additional figures and comparisons with observation-based datasets, and therefore believe our revision of the manuscript (yet to be submitted) addresses all the referee's concerns.

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