Response to anonymous referee #2 (Comments in black, Answers in blue, Suggested revisions in green)

General comments:

The LPJ-GUESS model was used here to examine seven crop management practices and their effect on soil carbon (C) pool, nitrogen (N) loss, and crop yields under different climate scenarios that is the present-day climate situation in Eastern Africa and its potential for the future. The study tackles an important topic and will allow us to improve our understanding of how improved agricultural management can protect soils and lessen soil greenhouse gas emissions in Eastern Africa, where there are currently very few such data available. I thus believe that the topic is very interesting and of great relevance to Biogeosciences. In terms of design and evaluation results, the manuscript is well written with a good structure. The authors have really done their work in the discussion of the results which are well referenced. I believe the work is very relevant and very important, apart from a few very minor adjustments that should be made to the manuscript.

We thank the reviewer for the expressed interest in our manuscript. In the revisions to the manuscript we will be addressing the raised questions as described below.

For example, the authors should briefly explain what they mean by standard management and standard simulation in the manuscript, which has been used throughout the manuscript.

Thanks for this comment. We will revise the 'standard management' to 'conventional management' throughout the manuscript as suggested, and give an explanation on standard simulation in the foot note of Table 3: "std – standard simulation, representing a conventional management prevalent in Eastern Africa."

In Kenya, beans and maize are intercropped primarily. Since beans represent one of Kenya's major crops, is there any reason they weren't included here? Otherwise, this work for me has been well done.

We do agree with the reviewer's comment that common beans and faba bean are very important crops in Kenya and Ethiopia, respectively. Currently, crops in LPJ-GUESS are modelled as crop functional types (CFTs, see Table S1), i.e. group of crops with similar functional behaviors. In this study, beans with N fixation capacity are simulated as pulses, which in the model generally stands for faba bean, common bean, cowpea, etc. To make it clear, we will add an explanation in Sect. 2.3.2: "In this study we performed simulations with six CFTs—maize, pulses (representing faba bean and common bean), sorghum, wheat, rice, and soybean—which are grown widely in Kenya and Ethiopia."

We also compared the simulated pulses areas (rain-fed and irrigated) over the historic period with statistical harvested areas from FAO (see Fig. S4a below), finding that the modelled areas generally agree with FAO-based records in two countries and thus that our simulation does reflect the changes of pulses planting areas in the past several decades. Fig. S4 will be added to the SI in the revised manuscript. Meanwhile, we will highlight that common bean and faba bean in this study are simulated as pulses in the caption of Fig.S4:"Inputs used for simulations in Eastern Africa: (a) simulated crop-specific areas (rain-fed and irrigated) over the historic period compared to statistics from FAO (ha); (b) mean rates of mineral N fertilizer and manure applied to each crop type (kg N ha^{-1}) from 1901-2014; (c) annual CO_2 concentration (ppm, right scale), and mean temperature (°C, left scale) from CRUJRA (B1, Table 1) and five GCMs (C1 and C2, Table 1). The faba bean and common bean are simulated as pulses in (a) and (b). The black, blue, green, and red thick solid lines in (c) denote the temperature averaged by five GCMs for historical, SSP1-26, 3-70 and 5-85 scenarios, respectively; thin lines in light color represent the temperature from individual GCM. Dashed lines show CO_2 concentrations."

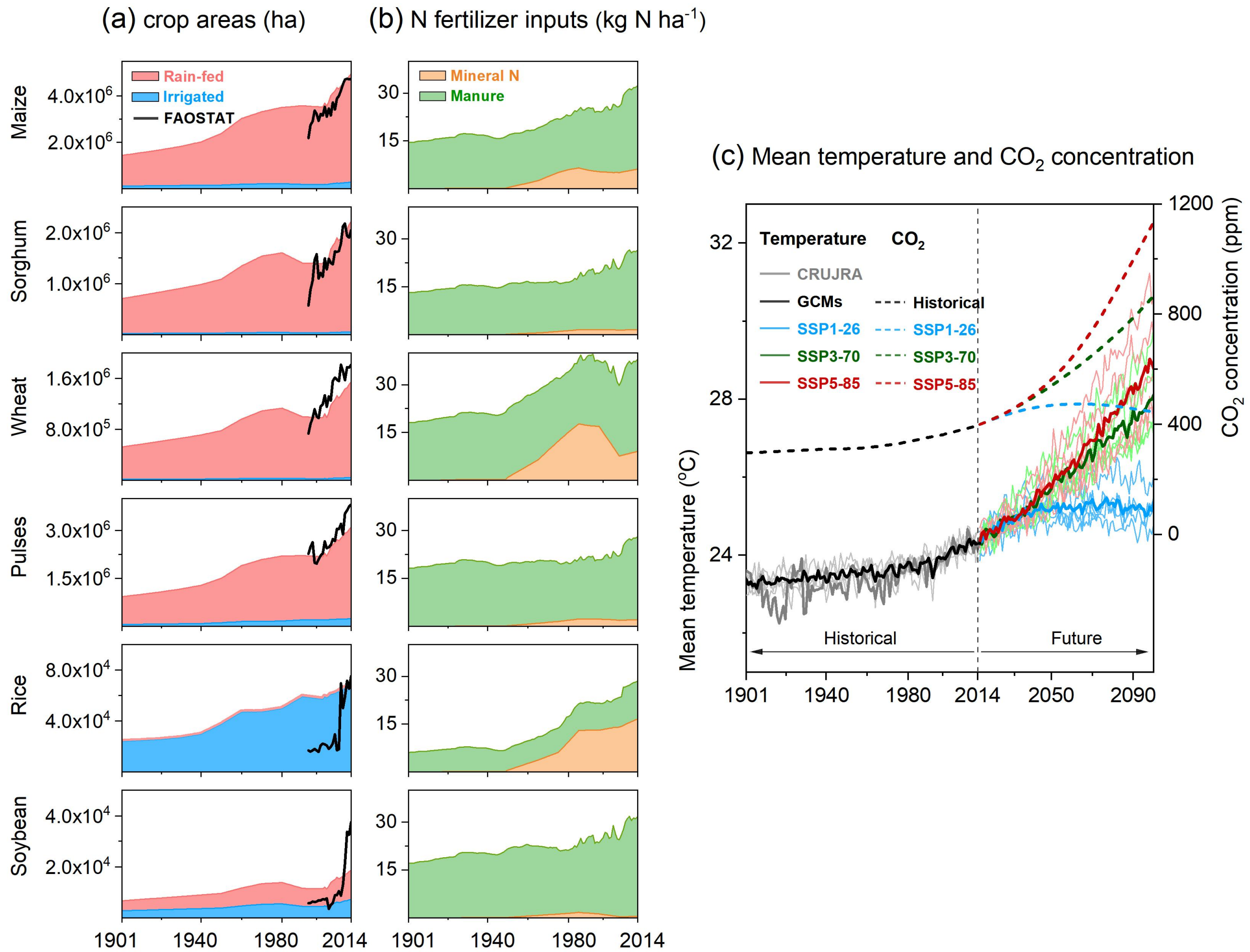

Figure S4. Inputs used for simulations in Eastern Africa: (a) simulated crop-specific areas (rain-fed and irrigated) over the historic period compared to statistics from FAO (ha); (b) mean rates of mineral N fertilizer and manure applied to each crop type (kg N ha^{-1}) from 1901-2014; (c) annual CO_2 concentration (ppm, right scale), and mean temperature (°C, left scale) from CRUJRA (B1, Table 1) and five GCMs (C1 and C2, Table 1). The faba bean and common bean are simulated as pulses in (a) and (b). The black, blue, green, and red thick solid lines in (c) denote the temperature averaged by five GCMs for historical, SSP1-26, 3-70 and 5-85 scenarios, respectively; thin lines in light color represent the temperature from individual GCM. Dashed lines show CO_2 concentrations.

Specific comments

LN 380 Is there an explanation for the overestimation in production in pulses and sorghum in Fig 4.

Wortmann et al. (2009) reported that insect pests, particularly shoot flies and stalk borers, have been identified as a major constraint to sweet sorghum production in SSA due to the high sugar content in the crop, resulting in yield reduction of ca. 15-88% in Eastern Africa. LPJ-GUESS does not yet take pests into account, which could contribute to the large overestimation of sorghum production. Regarding pulses, Ma et al. (2022) argued that the high legume N fixation capacity modelled by LPJ-GUESS in warm and moist climates would result in overestimation of grain legume production, mainly because BNF may reduce the N constraints on leaf photosynthesis and subsequently strengthen the flow of carbon assimilation to storage organ.

Since both referees (see the comments from Referee#1) are concerned about the reasons for the overestimation of crop yields in the model, we will give an in-depth discussion in Sect. 4.2 to explain the potential reasons: "A strong overestimation in pulses production was seen for both countries (Fig. 4). This can be likely explained by the high legume N fixation capacity modelled by LPJ-GUESS in warm and moist climates (Ma et al., 2022). A high rate of BNF may reduce the N constraints on leaf photosynthesis and subsequently strengthen the flow of carbon assimilation to storage organs, resulting in high production in N-fixing crops. Yet, similar to pulses, our simulated sorghum yields at country level were also significantly greater than FAO records (Fig. 4). This suggest that other factors are at play as well. For example, insect pests, particularly shoot flies and stalk borers, have been identified as the major constraint to sorghum production in SSA (Wortmann et al., 2009), leading to an estimated yield reduction of 11-49% in western Africa and 15-88% in Eastern Africa (Okosun et al., 2021). LPJ-GUESS does not yet take pests into account, which could contribute to the large overestimation of sorghum production in our studied region. Additionally, a good representation of photosynthate allocation to various plant organs is important when modelling crop yields (Bondeau et al., 2007). In this study we updated the daily assimilate partitioning scheme of sorghum based on the existing literature (Fig. S3), but this process has not yet been parameterized and calibrated against observations from field experiments. Whether or not this related to the large-scale yield overestimation needs to be further investigated in future work."

LN447: I wonder if you can explain the unexpectedly low soil C sequestration rates from 2004-to 2015 by looking at the history of the experimental field.

We agree with the reviewer's idea that land use history would affect SOC sequestration. We add the discussion in Sect. 4.1: " Both INM3 and CT1 sites in this study were under natural grassland before the trials start (see A1 and A2, Table 1), hence SOC losses in observations and simulations reflected a) grassland soils tending to store more carbon than cropland, and b) a new SOC equilibrium may not have been reached in the maize cropping systems after 10+ years of cultivation (Lal, 2008)." In addition, we also add the plot of the modelled SOC over 1901-2002 (Fig S2) to the SI in the revised manuscript, where the readers can clearly see the simulated impacts of land use change on SOC stocks at both sites.

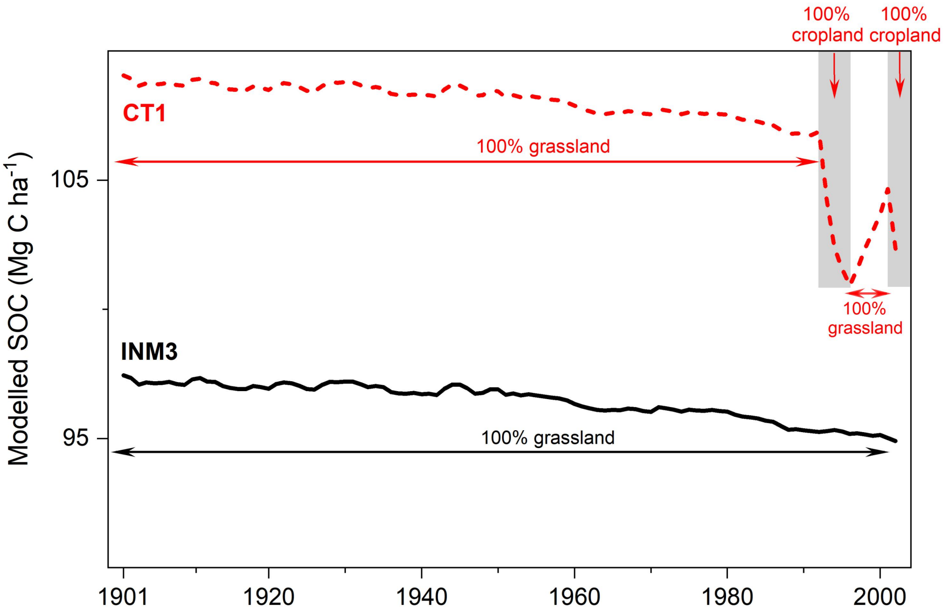

Figure S2. The modelled SOC stocks (0-150cm) by LPJ-GUESS at the CT1 and INM3 sites between 1901 and 2002. The shaded areas represent the period of cropland systems. All the above-ground biomass in grassland systems was returned to the soils in the simulations (see Sect. 2.3.1).

LN452. In Kenya, 80% of the land is semi-arid and arid. I think you need to point out the western part of the country, however.

Thanks for this comment, this sentence will be revised to: "Furthermore, fast turnover of the SOM in the humid tropics could be another factor affecting the SOC trends because of the prevailing warm and moist climate (i.e., western Kenya in this study)."

LN 458 Did you observe any termite mounds in the experimental fields?

Yes, termite activity was observed in the field experiments. Kihara et al. (2015) studied the impacts of termite activity on SOC at the same sites that we used for evaluation.

References

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