We would like to thank reviewer #1 for their constructive feedback on the manuscript and useful comments, questions and suggestions, which all have been addressed. We believe the manuscript has been improved that way. Point-by-point responses are provided below. The original review comments are shown in black, our responses are shown in blue.

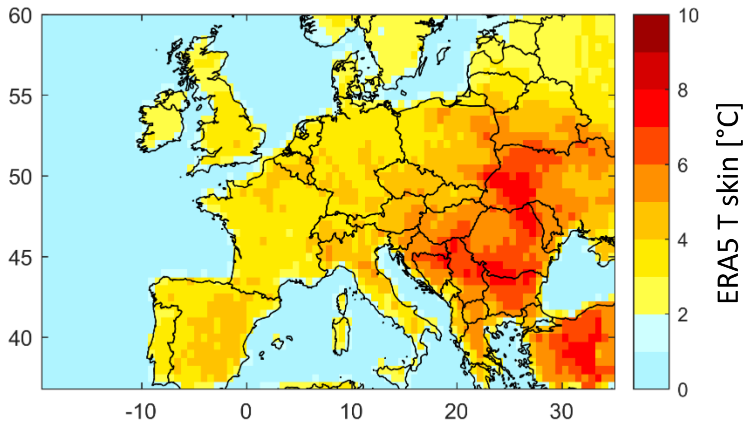
The article has estimated ammonia emission potentials from agricultural land using satellite remote sensing data and a chemical transport model. The analysis was done across the European continent. Future implications of climate change on emission potentials are also analysed. I am not expressing my opinion about the article acceptance at this stage. The other reviewers might have an opinion in this regard. However, after reading the article, I have following major concerns.

Major concerns

1. The study period seems to be only the month of March 2011 which marks the starts of growing season (Line 26-27). Since the equation (2-1) points a direct relationship between the ammonia emission potential (Γ_{soil}) and the soil temperature.

   How much monthly skin temperature variations are there across the Europe?

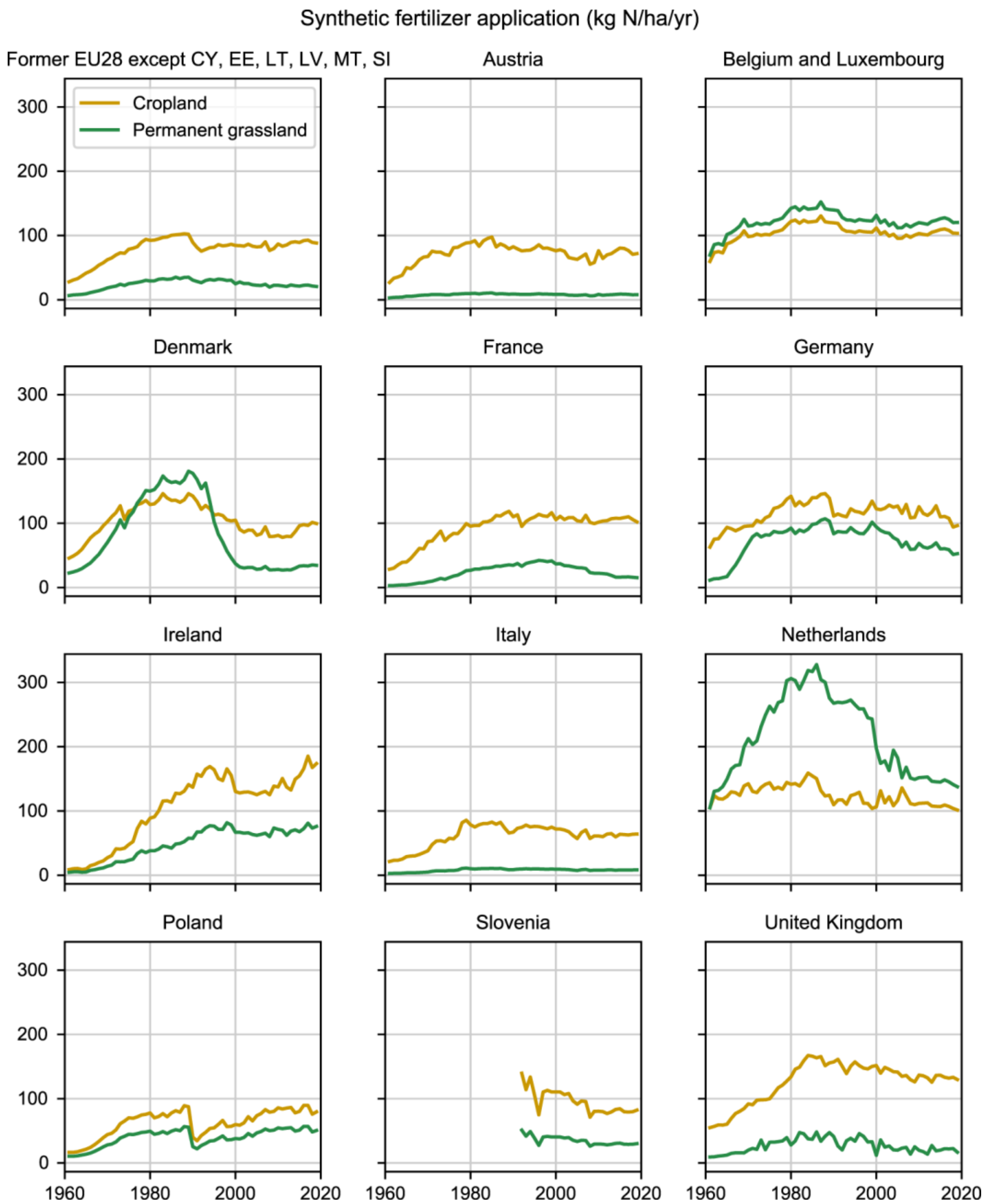
   Skin temperature in Europe varies with a standard deviation on the daily average that is mostly between 2 and 6°C, in Northern, Central, Western and Southwestern Europe. And between 4 to 8°C in Eastern Europe. Review Figure 1, shows the standard deviation on the daily average for the month of March 2011 in Europe, calculated from ERA5.



   Review Figure 1. The standard deviation on the daily average for the month of March 2011 in Europe.

   The following sentence was added in section 2.2: "Skin temperature in Europe varies with a standard deviation on the daily average that is mostly between 2 and 6°C, in Northern, Central, Western and South-western Europe. And between 4 to 8°C in Eastern Europe (not shown here)."

   What are the fertilization practices in the region? Are there any seasonal variations of fertilizer application rates?



Review Figure 2. Average rates of synthetic N fertilizer applied to cropland and permanent grassland. The figure shows all countries where more than 3% of the cumulative N fertilizer use has been applied to permanent grassland. The top left panel shows results for the 22 present-day countries which this study covers 1961–2019. Figure is from Einarsson et al. (2021).

It is not easy to get accurate information on the frequency of fertilizers application in all Europe. However, a survey conducted in 2011 mentioned that the fertilizer application in France takes place one to four times per season, according to the crop type (Agreste, 2014). While we do not have information on the practices in other European countries, we show below the N-fertilizers application per surface area in the EU-28 countries. Review Figure 2 is the synthetic fertilizer application (kg N/ha/yr) in different European countries, the figure is from Einarsson et al. (2021). We can see that the N applied per surface area is quite stabilized after year 1980, with some fluctuations from year to year in most countries. To answer the question about the seasonal variation of fertilizer application, yes, the application can change from year to year. But the fluctuations are less pronounced between year 2000 and 2020 as the graph shows (Review Figure 2).

Ammonia concentrations peak twice a year, during summer and spring. Van Damme et al. (2022) studied the weekly seasonal variation of ammonia concentrations in Europe, and found that ammonia peaks during the weekdays preceding the weekend. For instance, in the Po Valley in Italy, ammonia peaks on Saturday and starts decreasing on Sunday. In the Ebro Valley in Northwestern Europe, ammonia peaks on Thursday-Friday, and the decrease starts again on Sunday (Van Damme et al., 2022).

These aspects are missing in the article. If you consider all these aspects to its minimum, the logic behind one month simulation and drawing future changes (%) in Γ_{soil} is not justified.

The future estimation of ammonia considers only March under different socioeconomic scenarios (SSPs), although March doesn't reflect the whole spring season (March-April-May), it can however tell us how the season will start.

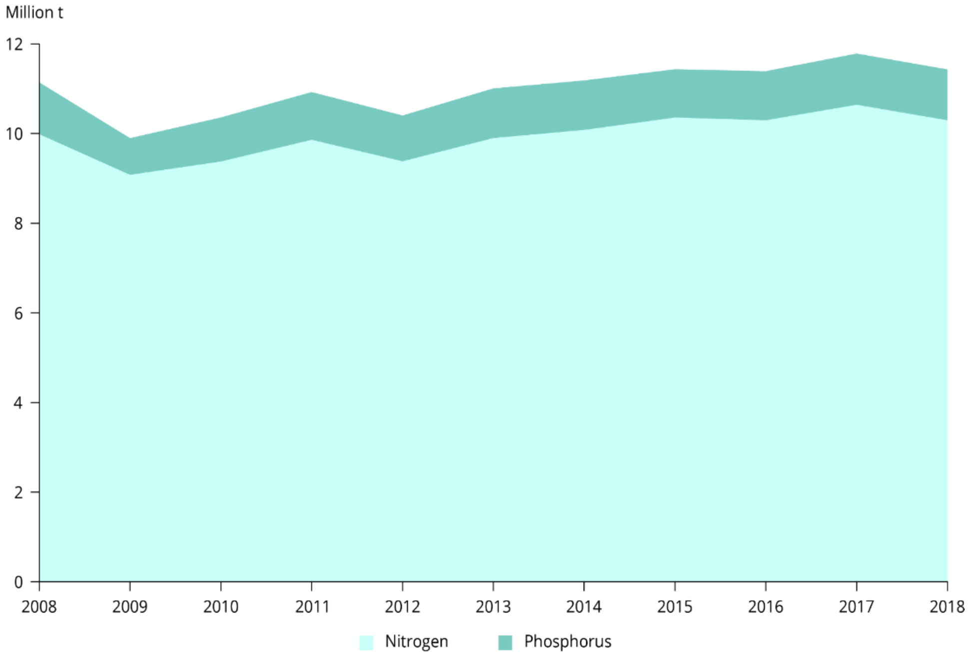
Ammonia volatilization from the soil is enhanced by higher temperatures, and the fluctuations of other meteorological parameters. We use simulation data for the month of March during 2011, because during that period Europe witnessed isolated and connected ammonia and particulate matter pollution episodes that were in part due to intensive fertilization during this month (Viatte et al., 2022). The second reason is that the fertilizers spreading activities start in March in Europe, as shown by the FAO NDVI (e.g. start of the growing season in Ireland (FAO Earth Observation, 2022)). Ammonia concentrations are expected to increase during March every year, due the increase in air and land temperatures and decrease in precipitations (as compared to February). Since wet deposition is considered a sink of atmospheric NH_3.

Moreover, we now changed the title of the last section "The effect of temperature change on the volatilization of ammonia" in order to correctly reflect its content: it is meant to show a case study of what would be NH_3 concentrations given *only* the increase in temperature due to climate change.

What type of fertilizers are used in the region? How much NH_3 content each fertilizer has?

The NH_3 is a by-product of the fertilizer application, and its concentration depends, as we show here, on many factors, in the soil and in the near surface.

However, we note that in Europe, roughly 90 % of the mineral fertilizers used are nitrogen-based (N-fertilizers), and 10 % are phosphorus-based (Review Figure 3). Among the N-fertilizers used, urea (22 %) and nitrate fertilizers (45 %) dominate the market in the 27 EU countries (Fertilizers Europe, 2016). These two will release NH_3.



Review Figure 3. Estimated mineral fertiliser consumption by agriculture in the EU-27, 2008-2018 (European Environmental Agency, 2022). Figure and data can be accessed via the following link: https://www.eea.europa.eu/data-and-maps/figures/estimated-mineral-fertiliser-consumption-by.

Moreover, in the context of the study, we are not concerned about the fertilizer content since we derive the emission potential values directly from the atmospheric concentration of NH_3. The method we use does not require the information about the fertilizer content.

To address the previous comment, the following paragraphs were added to the manuscript:

"Around 90 % of the mineral fertilizers used in Europe are nitrogen-based, with urea and nitrate fertilizers dominating the market in the 27 EU countries, since they make up 22 % and 45 % of the total market (Fertilizers Europe, 2016)."

"The frequency of fertilizers application can vary per crop type and per country, as well as from year to year. In Europe, however, the N applied per surface area is quite stabilized after year 1980, with some interannual fluctuations in most European countries (Einarsson et al., 2021). As to our knowledge, accurate information on the application frequency per country is not reported. While the application frequency can change from year to year, the fluctuations are less pronounced after the year 2000. For instance, in France and Belgium the nitrogen content fluctuates between 100 and 110 kg N/ha/year, from 2000 to 2020 (Einarsson et al., 2021)."

Why did authors choose to assigned mass transfer coefficient (*k*) values to non-fertilized forests, shrublands and grasslands that ultimately resulted in Γ_{soil} ranges of 10 – 10^2 in a non-fertilized soil. The justification given between lines (337-343) require some literature-based support to establish the linkage between SO_2 and NH_3 *k* values over non- fertilized land-use.

New explanation is added to the addressed paragraph (lines 334-343). Now it reads as the following:

"For water bodies and other land types that are not considered here (see Sect. 2.2), the mass transfer values k were set to zero and represented in grey colour in Figure 4. In a laboratory experiment, Svensson et al. (1993) reported $k = 4.3 \times 10^{-3}$ m s^{-1} for a mixture of soil and swine manure, as therefore, we assign this value to croplands. Due to the lack of NH_3 k values for non-fertilized forests, shrublands and grasslands in the literature, we used values originally assigned for SO_2, bearing in mind that these are approximate values and they reflect mostly the conditions of the soil cover type (short, medium or tall grass) rather than the gas itself. In Aneja et al. (1986), the authors estimated the mass transfer coefficient for both NH_3 and SO_2 above different types of crops, they found similar values. For NH_3, k varied between 0.3 and 1.3 cm s^{-1}, and for SO_2 it varied between 0.5 and 1.5 cm s^{-1} (Aneja et al., 1986). Since the latter study estimates several values for NH_3 mass transfer coefficient, over different types of crops, we will use the k provided by Svensson et al. (1993), since it is better adapted to reflect NH_3 emission from fertilizers, and is not dependent on the crop type. To assign a k value for forests, we used values reported in Aneja (1986) ($k = 2 \times 10^{-2}$ m s^{-1}), which originally represent deposition velocity (mass transfer) of SO_2 in a forest (high crops), since both SO_2 and NH_3 showed similar k in above crops. For shrublands and grasslands (the two land types have the same k), we used the value $k = 8 \times 10^{-3}$ m s^{-1} that has been reported in Aneja et al. (1986) as the deposition velocity (mass transfer) of SO_2 in a grassland (medium crops)."

2. Any bias correction of SSP scenarios was done before analysing future climate change implications on Γ_{soil}?. If so, kindly mention it in the article.

   No bias correction was done.

3. The study is based on number of assumptions e.g., assuming $[NH_3]_{atm}$ equals to $[NH_3]_{col}$ (line 597). The questions raised above are also based on assumptions. So, it would be better to discuss the limitations of this analysis thoroughly in a separate sub-section.

   Most of the atmospheric NH_3 is present near the surface in the lower boundary layer (Dammers et al., 2019), that is why we can say that $[NH_3]_{atm}$ is equal to $[NH_3]_{col}$. This information was added to the Appendix in order to justify this assumption: "[…]; $[NH_3]^{soil}$ is the concentration of $NH_{3(g)}$ in the soil, and $[NH_3]^{atm}$ is the concentration of $NH_{3(g)}$ in the atmosphere near the surface (molecules m^{-3}). We can consider that $[NH_3]^{atm}$ is identical to the total column of NH_3 provided by IASI and denoted here as $[NH_3]^{col}$. This is because most of the atmospheric NH_3 are located in the lower boundary layer (Dammers et al., 2019)."

Minor concerns

1. Paragraph two (lines 52-56) is too short either expand it or merge it with adjacent paragraphs.

   We merged paragraph two with the previous paragraph. It now reads as "Soils are known to be a source of atmospheric ammonia, especially in areas of intensive agricultural practices (Schlesinger and Hartley, 1992), and this is due to enriching the soil with the reactive nitrogen present in fertilizers. The increase in the application of synthetic fertilizers, and intensification of agricultural practices is believed to be the dominant factor of the global increase in ammonia emissions over the past century (Behera et al., 2013; McDuffie et al., 2020). In addition to agriculture, ammonia can be emitted from industrial processes, biomass burning (Van Damme et al., 2018), and natural activities such as from seal colonies (Theobald et al., 2006)."

1. There is no Result section it would be better to term section 3 as Results rather than "GEOS-Chem model simulation: validation and analysis".

   The title of section 3 was changed to "Results and discussions".

2. Discussion and conclusion should be separate.

   The title "discussion and conclusions" was replaced by "conclusions", since the last section reflects the conclusion and the results cited listed, rather than the discussion.

3. The sentence structure and grammatical errors can be rectified by employing some professional services. I would highly recommend that.

   we made changes throughout the manuscript, we hope that this rectifies the sentence structure.

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