"Forty years of improvements in European air quality: the role of EU policy-industry interplay" by M. Crippa et al., ACPD 15, C5896-C5899, 2015

The authors are grateful to Referee #2 for the interest and comments on the paper. Referee #2 offers 5 major suggestions ("general comments") for improving our paper. In this author comments we outline how we will address in our revised manuscript these major remarks.

We tried to improve the paper as requested with an additional energy scenario and more clarifications.

General Comments

1. "*Most of the comments I have are about clarity in the presentation of results.*"
   Some of scenario concepts of this publication indeed need to be explained better, especially in view of understanding the difference with a prior publication by Rafaj et al., (2013), that addresses similar issues, however following a rather different approach.

   Specifically in our revised manuscript we will:
   - explain better the purpose of comparing the reference situation with a fictive situation (based on the 2010 baseline but switching off either the technological development keeping the fuel consumption of 2010 or the fuel evolution keeping the 2010 technology). The purpose of our work was not to provide hindcast scenarios which decompose the effect of drivers. This has already been done by Rafaj et al (2013), and we will better explain the reasons of not repeating that work. Instead we analyse the benefits of introduction of new air pollution control technology and on the other hand how much of this was offset by the increased consumption of the different fuels. In our revised paper we will compare in more detail the approach of Rafaj et al. (2013), to show the difference with our work. Besides the difference in approach, our paper evaluates the health and vegetation impacts of the measures, which goes beyond what Rafaj et al. (2013) were analyzing.
   - highlight that our paper aims at assessing the impacts of the European emission reductions (and as such policies in general) on health and crop production, not only in Europe, but also globally via spill-over effects.
   - replace the figure placing the four cases (Figs. 3a and 4a) with another figure illustrating our base case with the other fictive situations (with stagnation of respectively technology or fuel consumption).
   - put more figures in the main text, presenting our results more clearly

2. "*I don't see the STAG_FUEL scenario as having much real-world meaning" - instead reviewer 2 proposes two different scenarios.*

   Reviewer #2 as well as Reviewer #1 give alternatives for our STAG_FUEL scenario. Both reviewers make these remarks from a theoretical 'decomposition' framework, where the evolution of emissions decomposed to driving factors adds up to 'real' emission.

   We agree that the STAG_FUEL, defined with the fuel consumption and fuel mix of 1970 but the 2010 technological development does not allow to conclude on the increased energy consumption because of the difference in fuel mix in 1970 and 2010. To provide a clean illustration of the impact of changes in fuel mix, we propose a new additional scenario STAG_EFFICIENCY, which analyses the energy efficiency improvement partially by climate

policy measures, partially by the development of machines with lower fuel consumption. The comparison of the STAG_EFFICIENCY and the REF_2010 allows the observation of the energy efficiency benefits with the 2010 technology by the reduced fuel consumption per unit of activity (per kWh generated or km driven).

We propose to shift the STAG_FUEL scenario in the supplementary of the paper, because some modelers are using also this scenario and would like to see it described. In addition we will evaluate the increase in total energy demand in TJ between 1970-2010 to assess better the importance of the different fuel mixes between 2010 and 1970.

3. *Reviewer # 2 is confused by the reference framework to which changes are compared.*
In our revised manuscript we will consistently compare to the reference situation 2010 and all scenarios will be evaluated against it. We are confident that this will address the justified concerns of Reviewer #2.

4. *Compare the reference scenario with observations.*
The modeling framework and data availability do not allow a detailed analysis of our reference scenario with observations. Specifically, the model simulations underlying TM5-FASST (the 1x1 degree resolution TM5 model), did not include inter-annual-meteorological variability. The role of this variability and the timescales involved are quite different for ozone and PM2.5. While very few ozone observations go back to 1970, more data became available since 1990. Peak ozone concentrations started to come down since 2000 or so, but inter-annual variability still precludes to pick up these trends at the majority of the stations. Very few PM2.5 observations are available before 2000s, but more robust observations are available for PM components like sulfate. We intend to make a qualitative comparison with the recent reports from the UNECE WGE, and TF MM as available in the draft EMEP assessment report.

5. The authors agree and most of the figures are upgraded from the supplement to the main text accordingly with the Reviewer's suggestion.

Specific Comments

They will be addressed in detail at resubmission of our manuscript.

p. 20247, line 17: "...understanding the impacts of primary and secondary anthropogenic air pollutants which are released into the atmosphere..." Please rewrite this sentence. As written, it makes it sound like secondary pollutants are also "released into the atmosphere," which is not correct. We will correct this sentence as suggested by the reviewer.

Top of section 3.2.1, p. 20259. "Figure S4.1 ...". If you are leading off the discussion with this figure, it belongs in the main body of the paper, not the supplemental material. We agree with the Reviewer to add Figure S4.1 to the main text.

p.20261, lines 5-6: "contrary to a global-scale emissions doubling..." It is unclear to me why a global-scale emissions doubling is expected, or what this comparison is referring to. We can clarify it.

p.20262, lines 10-14. "Furthermore, EURO standards reduced NOx emissions, at the expense of increasing NH3 emissions (which is the only substance that increased in emission under the STAG_TECH scenario)." Shouldn't this be decreased? STAG_TECH has less NH3 emissions than

REF_2010, is that correct? It is correct as written. However, we can clarify the sentence to be consistent with the whole manuscript and figures.

p.20262, beginning of 2nd paragraph: Since Figure S4.2 is being discussed in some detail, I would suggest it be part of the main body of the paper rather than the supplement. We agree with the Reviewer to add Figure S4.2 to the main text.

p. 20262, lines 8-10. "NH3 emissions increased with the implementation of catalysts on gasoline vehicles, leading to a decrease of 70% in NH3 European emissions when catalysts are not considered..." To me this comparison is backwards, since time only
moves forwards. From 1970-2010 the emissions of NH3 increased because of catalysts. Talking about an emissions decrease doesn't make sense to me. We propose: "The 2010 emissions of NH3 in Europe are today 330% higher than in 1970 because of the catalysts on gasoline vehicles."

Figure 2. Without studying this figure very closely, it is not clear to me what it is showing. I think a table describing the different scenarios in words rather than pictures might be more effective and easier to understand. We do not agree that a table is easier to be understood. However, we will try to clarify as much as possible figures and text as requested by the reviewer.

Figure 9. I find this figure not very easy to understand. Why do the authors show REF_1970 - REF_2010, instead of the other way around? At least for this reviewer, when REF_1970 - REF_2010 is used, then I need to think about time going backwards, which is not very intuitive. For loss of life expectancy and crop loss, I suggest that the authors change their axis labels to have a more quickly-grasped real world meaning. For instance, an "increase in life expectancy" would be more intuitive than a negative loss in life expectancy.
We are going to change the x-axis labels as requested by the reviewer (e.g. life expectancy and crop yield). In addition we are going to clarify also the y-axis labels (e.g. avoided losses in life expectancy due to change in technologies…)

Tables SI-2. This is not critical, but it would be interesting to be able to compare emissions totals to other European emission inventories (e.g., the TNO-MACC inventory, see Kuenen et al., ACP 2014). For that purpose, I would be interested in seeing total emissions for a "standard" European domain (e.g., the EMEP model domain, or the TNO domain). I assume this would be OECD Europe + Central Europe + part of Russia + Tur key, etc., but as is it is not directly comparable to other European emission inventories. Section 5 of the supplementary material is already dedicated to the comparison of the EDGARv4.3 emissions with the one of MACCity. We will add there a comparison of our total emissions with the one provided by TNO or EMEP for Europe as suggested by the Reviewer.

Figures SI-6.3.1 and SI-6.3.2. These figures are quite interesting, the authors could consider putting at least the ones for Europe in the main text. We agree with the Reviewer that Figs. 6.3.1 and 6.3.2 are interesting, however we do not want to overload the main text with figures (there are already 9 figures containing a lot of information in there), so we prefer to keep these 2 figures in the supplement, but we'll make sure that their message is clearly mentioned in the main text.