Dear Editor,
we are pleased to submit the revised version of the paper "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.
First of all, we want to acknowledge the contribution of Reviewer 1 and 2 for their valuable comments which helped in improving both the content and the structure of the paper.
We are sending you the final version of the manuscript, figures and supplementary material.
In addition to the public ACPD version of our replies to the reviewers' comments, we provide here our updated answers highlighting major changes we performed in our revised version of the paper.

We strongly revised the introduction in order to highlight the novelty of our work and we clarified the results description comparing each scenario always with the 2010 reference data.
We believe that our work significantly improved also developing a new scenario (STAG_ENERGY) as suggested by both reviewers.
Finally, a slightly different title is suggested ("Forty years of improvements in European air quality: regional policy-industry interactions with global impacts") and new figures (e.g. Fig.2, Fig.3 and 4, Fig. 8, Fig.10) are produced (following the reviewers' suggestions) to make our results more evident.

We hope to find your agreement on all changes we made.

Thanks a lot!

Best regards

Monica Crippa

**"Forty years of improvements in European air quality: regional policy-industry interactions with global impacts" 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.*"

The comparison with the Rafaj paper, as well as with previous literature works, has been addressed in the introduction as following:

"In our work we make use of the EDGARv4.3 emission data (http://edgar.jrc.ec.europa.eu/index.php) to compare the recent (year 2010) situation with retrospective scenarios (years 1970–2010) that assess the importance of changes in fuel use and air pollution abatement technology in determining the trends of air pollutant emissions in Europe and around the world, and their impact on air quality, health and crops. Most literature on emission scenarios focuses on projecting actual emissions into the future to assess possible pathways of air quality and climate in view of new policies. So far, limited attention has been given to assess the role of the policy-industry interplay in avoiding emissions. Some publications have analyzed past emissions trends for the most important air pollutants, but mainly focused on selected substances or specific regions (e.g., Klimont et al. (2013) for global $SO_2$, or Kurokawa et al. (2013) for Asia). Historical global emissions data sets for the past decades or century have been compiled by combining several emission inventories, e.g., Lamarque et al. (2010) for 1850–2000 and Granier et al. (2011) for 1980–2010. However, an analysis of the factors driving these emissions trends is difficult because of the heterogeneity and regional differences of the original data that might show inconsistencies over the full time period and in global coverage and cause artificial variability. Amann et al. (2013) report the evolution of anthropogenic emissions of key air pollutants between 1990 and 2010 for several world regions using the GAINS (Greenhouse Gas Air Pollution Interactions and Synergies) model. GAINS is also used to provide scenarios of future emissions (up to the year 2050) including specific assumptions of air quality and climate policies (e.g., Cofala et al., 2007). Few studies have been devoted to understand the drivers of historical emissions trends. Paruolo et al. (2015) performed a statistical causality analysis of income and $SO_2$ and $CO_2$ historic emission time series using EDGARv4.2, challenging the often assumed causal relationship between increasing GDP and decreasing emissions assumed in the environmental Kuznetz curve. Rafaj et al. (2014) aimed to identify the driving factors (historical energy balances, population and economic growth, fuel mix, etc.) of air pollutants emissions in Europe from 1960 to 2010, using the RAINS (Regional Air Pollution and Simulation) and GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) (http://gains.iiasa.ac.at/models/) modelling frameworks. They decomposed the emissions into determinant factors (energy intensity, conversion efficiency, fuel mix and pollution control) to understand the evolution for $SO_2$, $NO_x$ and $CO_2$ in Europe. They found that in Europe $SO_2$ emissions declined due to the combined effect of reduced energy intensity and shift to cleaner fuels, while abatement measures mainly reduced $NO_x$ emissions. In this work, we do not seek to analyze and decompose the emission determinant factors in view of assessing further potential of optimized reduction policies, but rather want to demonstrate the cumulative effect on emission levels in 2010 of two major factors influencing air pollution: increasing energy use and the combined technology-policy achievements to reduce emissions. To this end we develop two retrospective scenarios for 1970-2010 from a European industry-air policy perspective (Fig. 2), and representing a range of emissions that would have been reached in 2010 under different scenario assumptions. The first and highest emission scenario, STAG_TECH, assumes after 1970 no further improvements in technologies and abatement measures. The second retrospective and lowest emission scenario (STAG_ENERGY) assumes stagnation of energy consumption since 1970, while the fuel mix, energy efficiency, emission factors and abatements are assumed as in the reference 2010 data. The change in global energy consumption over the last decades for the energy sector amounted to a factor 3.6, and 2.6 for the transport sector; i.e. much more than the global population increase (1.8-fold). In addition, historical fuel consumption showed shifts in the energy mix. The latter is country-specific and depends, among others on policy choices, as well as on accessible natural reserves, the fuel price and stability, and the energy stored per unit of fuel volume. Compared to future scenarios analysis, retrospective scenarios have the advantage of using the well-known activity data time series. Obviously, no new policies can be proposed retrospectively, but compared to decomposition analysis (e.g. Rafaj et al. 2014), our results more explicitly show the impact of policy and technology choices, and energy developments in arriving at 2010 emission levels. The data-driven analysis focuses both on European and global historical (1970-2010) emissions for a relatively complete set of gaseous air pollutants, $SO_2$, $NO_x$, CO, non-methane volatile organic compounds (NMVOCs) and $NH_3$ and particulate matter, i.e. $PM_{10}$, $PM_{2.5}$, black carbon (BC) and organic carbon (OC)."

Moreover clearer figs. 3 and 4 have been produced in order to be able to directly compare the 1970 situation with the reference 2010 one, as well as with the two additional scenarios (STAG_ENERGY, lower limit and STAG_TECH upper limit).

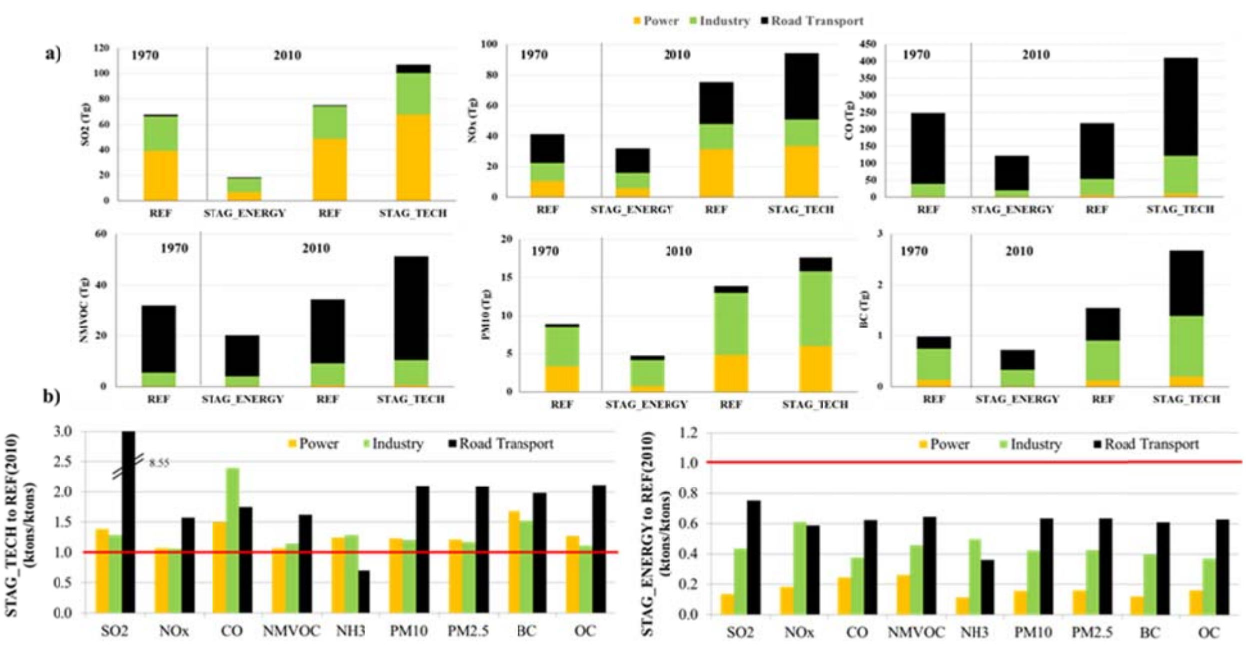



**Figure 3 – (a) Overview of 1970 (only for REF) and 2010 emissions for REF, STAG_TECH and STAG_ENERGY at the global scale for the power generation, industry and road transport sectors. (b) The ratios in 2010 of STAG_ENERGY to REF(2010) and STAG_TECH to REF(2010) are presented. The red-line indicates no change relative to the reference emissions in 2010.**

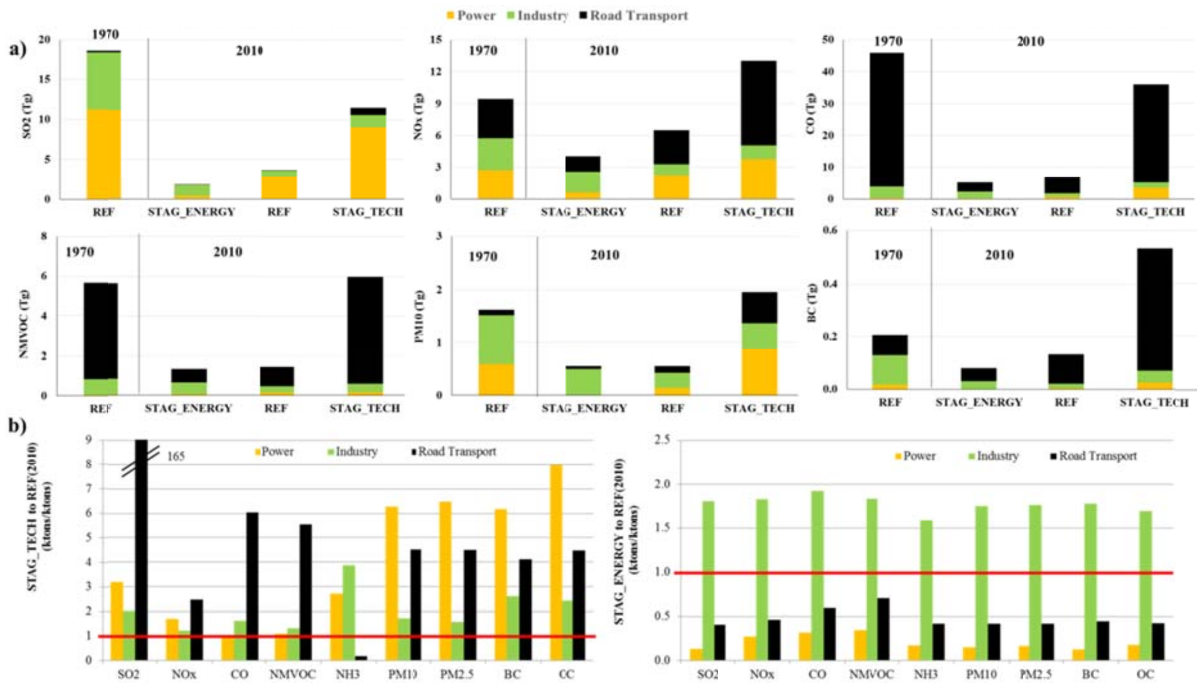



**Figure 4 – (a) Overview of 1970 (only for REF) and 2010 emissions for REF, STAG_TECH and STAG_ENERGY at the European scale for the power generation, industry and road transport sectors. (b) The ratios in 2010 of STAG_ENERGY to REF(2010) and STAG_TECH to REF(2010) are presented. The red-line indicates no change relative to the reference emissions in 2010.**

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

In line with the reviewers' comments we reconsidered the STAG_FUEL scenario and replaced this scenario with the STAG_ENERGY scenario, where we took also the fuel shift and fuel economy effects on board. In order to avoid confusion we do no longer refer in this paper to the STAG_FUEL scenario. The modelers who are using the STAG_FUEL scenario, are for a full description referred to the discussion paper (Crippa, ACPD, 2015).

We call the new STAG_ENERGY scenario as such, because with our 2010 reference we look at what would have been the situation in 2010 if we would have used the energy resources from 1970, taking into account the improved energy efficiency and fuel shifts of 2010. This leaves us clearly with a lowest emission scenario (contrary to the STAG_FUEL scenario) and provides the nice range of lower and upper emission scenario 4 decades after 1970. Even though we planned to filter out the energy efficiency solely, this did not show much variation, because most of the fuel savings are taken up by an increase in the fuel use (e.g. cars fuel economy has been improved by large improvements on the engine, but the car doubled weight and includes now also fuel internal equipment. We clearly wanted to refer all scenarios to 2010 as our standard (in view also of spanning the range of emission scenarios for 2010) and so we opted to use the 2010 technology and fuel shift and fuel efficiency but 1970 energy consumption (in TJ). The scaling per sector and country of the TJ energy consumption was easily done with the IEA (2014) data, but the fuel efficiency data for 1970 were hard to derive, for which we invested large effort in finding literature with statistics and in contacting experts for their advice on fuel economy (especially of cars/trucks in 1970). We do hope that this STAG_ENERGY scenario, which is a stagnation of the energy use, but not a stagnation of the energy efficiency, gets your interest (and positive advice at the review of this paper).

In the revised version of the manuscript the STAG_ENERGY scenario has been presented as following:

In the introduction:

“In this work, we do not seek to analyze and decompose the emission determinant factors in view of assessing further potential of optimized reduction policies, but rather want to demonstrate the cumulative effect on emission levels in 2010 of two major factors influencing air pollution: increasing energy use and the combined technology-policy achievements to reduce emissions. To this end we develop two retrospective scenarios for 1970-2010 from a European industry-air policy perspective (Fig. 2), and representing a range of emissions that would have been reached in 2010 under different scenario assumptions. The first and highest emission scenario, STAG_TECH, assumes after 1970 no further improvements in technologies and abatement measures. The second retrospective and lowest emission scenario (STAG_ENERGY) assumes stagnation of energy consumption since 1970, while the fuel mix, energy efficiency, emission factors and abatements are assumed as in the reference 2010 data.”

In the methodology section:

“STAG_ENERGY: The STAG_ENERGY scenario was modeled by assuming that the three sectors of interest consumed the same amount of energy (TJ) as in 1970, but with the 2010 fuel mix, energy efficiency, technologies, and end-of-pipe abatements. Since the fuel market is to a large extent global, this scenario was implemented in all countries for the three selected sectors. All power plants, vehicles and industries with the reference 2010 emissions standards consume coal, gas and oil with the 2010 share but at 1970 energy level (in TJ). In addition to the calibration per sector of the energy consumption level (in TJ), we evaluated the change in energy efficiency by fuel type, sector and region. For the power generation sector we  we scaled for each country the “main activity producer electricity plants (TJ)” with the 1970 over 2010 ratio of the “electricity output of main activity producer electricity plants (GWh)” from IEA (2014). For the road transport sector we scaled the “fuel consumption for road transport” with a factor composed of the 1970 over 2010 road transport fuel consumption ratio multiplied with the 1970 over 2010 fuel efficiency ratio. The latter was calculated with the macro-regional averaged values of petrol and diesel economies (l/100km) in 2010 and 1975 (because of missing 1970 data) for different type of vehicles (passenger cars, light duty vehicles, heavy duty vehicles, busses, mopeds and motorcycles) distinguishing the fuel consumption for petrol and diesel based on the EPA Trends report (EPA, 2013). The comparison of the STAG_ENERGY emissions scenario with the reference emissions REF in 2010 highlights the emission reductions that were not realized because of increased energy consumption (e.g. to generate extra kWh electricity or to drive more distance per vehicle) with the 2010 technology and 2010 end-of-pipe abatement. Compared to the 1970 reference emissions, STAG_ENERGY demonstrates the benefit of all industrial developments towards less energy-intensive and less polluting technologies. It includes not only the technological progress with end-of-pipe measures but also the shifts towards less carbon-intensive fuels (e.g. natural gas instead of coal) and increase of fuel economy and energy efficiency. It should be noted that pre-combustion treatment (cleaning) of fuels, such as coal washing or desulfurization of diesel and heavy residual fuel oil is not part of the STAG_ENERGY scenario but is addressed as a technology effect in the STAG_TECH scenario. Therefore, the fuel quality directives show their emissions savings (mainly on sulfur) in the STAG_TECH scenario while the fuel taxation policies (e.g. preferring diesel over petrol) are present in the STAG_ENERGY scenario.

In the ACPD version of this paper (Crippa et al., 2015, ACPD), another scenario called STAG_FUEL discussed the combined impact of stagnation of fuel-mix and fuel amount. However, in revising the manuscript we decided to focus on the consumption of energy (TJ) instead of fuel because we consider the fuel mix and efficiency choices as exogenous variables just as the technology progress and end-of-pipe measures. When considering a stagnation of fuel with constant fuel mix and energy since 1970, due to the remaining contributions of relatively dirty fuel, this scenario results in higher emissions than STAG_ENERGY. This scenario is here not further discussed, since the interpretation of results is not adding much to the STAG_ENERGY scenario. The interested reader is referred to the corresponding ACPD paper."

Updated results on this scenario are also presented in section 3 (emission comparison) and 4 (TM5-FASST results). Moreover, the STAG_FUEL data have been replaced by the STAG_ENERGY one in the supplementary material (sections S1 and S2).

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

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 picking 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.

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.

New sentence:

"It is crucial to understand the impacts of anthropogenic air pollutants which are released into the atmosphere by large and small-scale combustion, industrial processes, transportation, waste disposal, agriculture and forest and land-use change."

Please note that the whole introduction has been strongly modified in order to be more effective.

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.
This figure has been moved to the main text as Figure 5.

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.

This sentence is not anymore in the text.

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?

The sentence has been modified as following:

Furthermore, EURO standards reduced $NO_x$ emissions by 2.5 times, at the expense of a 5.5 times increasing $NH_3$ emissions because of the catalysts ($NH_3$ is the only substance that is decreased in emissions under the STAG_TECH scenario, refer to Fig. 4b and Table S1.1).

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.

This figure has been moved to the main text as Figure 7.

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.

The sentence has been modified as following:

Furthermore, EURO standards reduced $NO_x$ emissions by 2.5 times, at the expense of a 5.5 times increasing $NH_3$ emissions because of the catalysts ($NH_3$ is the only substance that is decreased in emissions under the STAG_TECH scenario, refer to Fig. 4b and Table S1.1).

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 improved figure 2 as well as its caption:

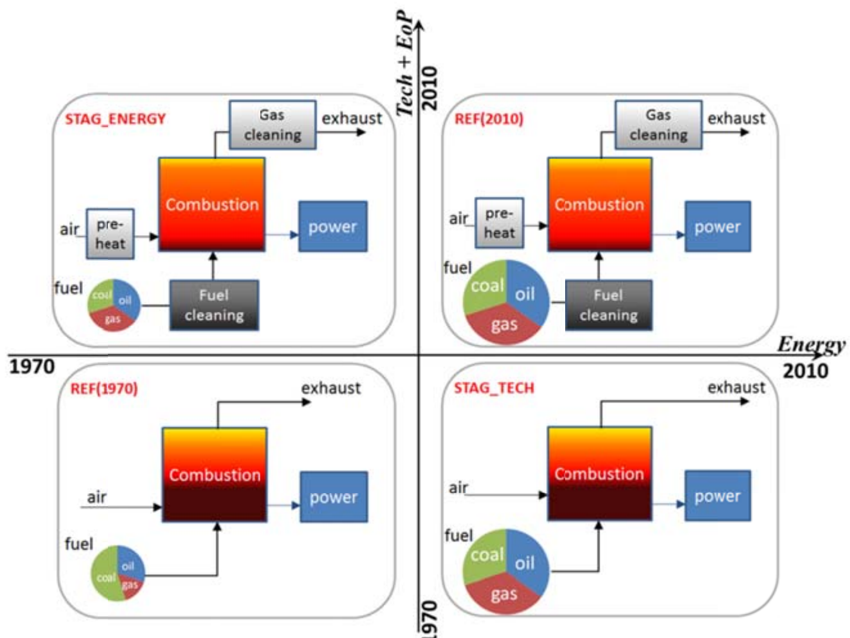
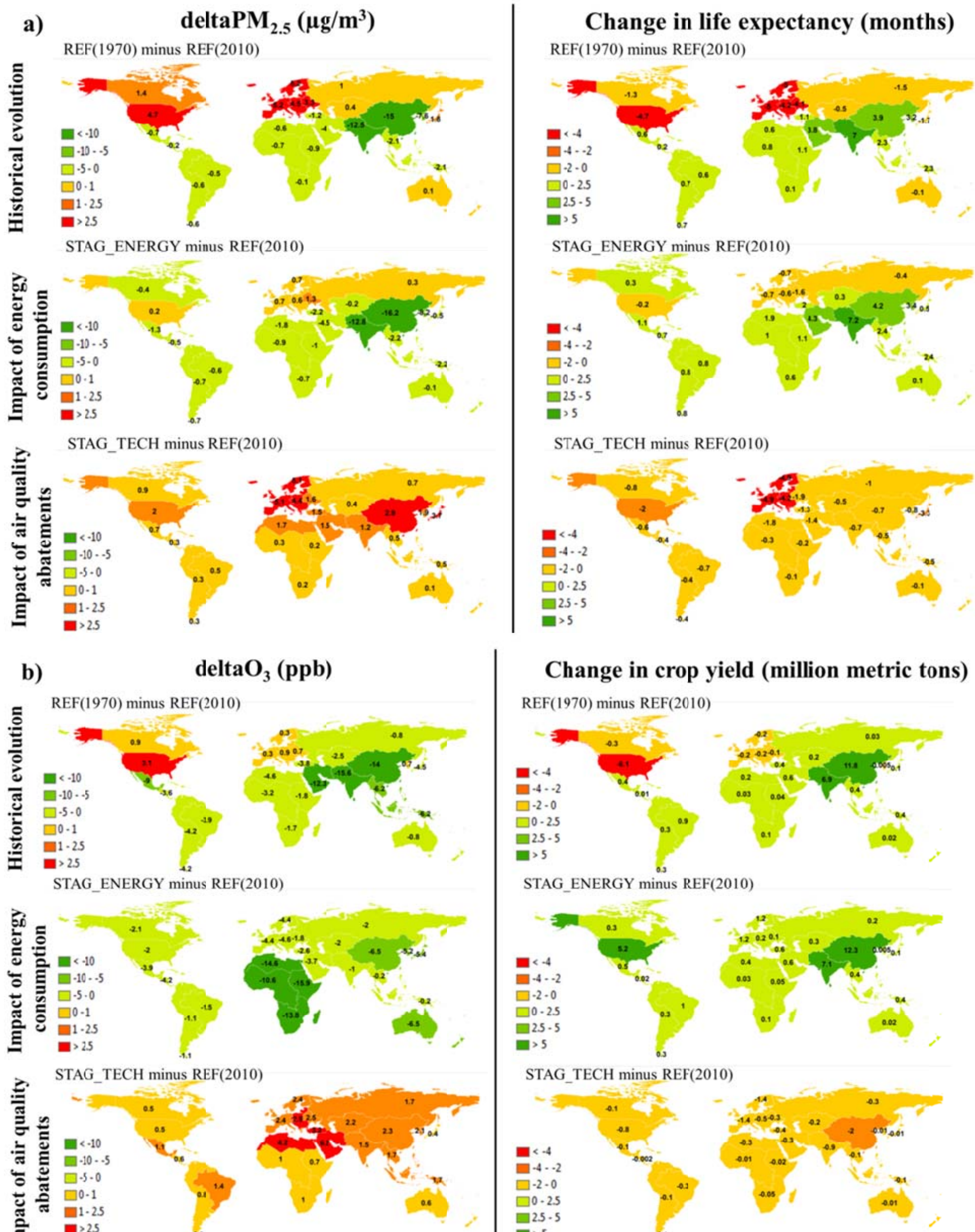



**Figure 2 – Schematic of the considered emission scenarios: REF_1970, REF_2010, STAG_ENERGY and STAG_TECH. The x axis represents the change in energy consumption form 1970 to 2010 (shown also by the increasing size of the fuel pie charts), while the y axis represents the change in abatement measures (EoP) and technologies from 1970 to 2010. The STAG_TECH scenario has the same technologies and abatements of the REF_1970 scenario, but increased energy consumption and different fuel mix (as shown in the pie chart composition) as in 2010. The STAG_ENERGY scenario considers the energy consumption of 1970 but it includes all the technologies, abatements, fuel mix and energy efficiency of 2010.**

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.

A clearer version of this figure is now included in the paper and we also improved its results description in section 4.

**"Figure 10 – Relative change between the scenarios (STAG_ENERGY, STAG_TECH and REF_1970) and the reference case (REF(2010)): regional change in a) $PM_{2.5}$ ($\mu g/m^3$) and associated life expectancy (months) and b) in ozone mixing ratios (ppb) and associated impacts on crops. Note that the same color scales are used for delta$PM_{2.5}$ and delta$O_3$ (positive delta are associated with red colors representing negative impacts, while negative delta are in green colors representing improvements) Opposite color scales are applied for change in life expectancy and crop yield compared to the delta one (positive values are reported in green and negative values in red representing good and bad impacts, respectively)."**



a)
deltaPM2.5 (µg/m3)
Change in life expectancy (months)
Historical evolution
REF(1970) minus REF(2010)
Impact of energy consumption
STAG_ENERGY minus REF(2010)
Impact of air quality abatements
STAG_TECH minus REF(2010)
< -10
-10 - -5
-5 - 0
0 - 1
1 - 2.5
> 2.5
< -4
-4 - -2
-2 - 0
0 - 2.5
2.5 - 5
> 5
b)
deltaO3 (ppb)
Change in crop yield (million metric tons)

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 3 of the supplementary material is already dedicated to the comparison of the EDGARv4.3 emissions with the one of MACCity and HTAP_v2.2 (which includes TNO data for Europe).

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 (updated numbering: S4.3.1 and S4.3.2) are interesting; however we do not want to overload the main text with figures, so we prefer to keep these two figures in the supplement.

**"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 #1 (R. Maas) for the interest and comments on the paper. In this author comment we outline how we will address in our revised manuscript his major remarks.***

*Referee #1 discusses the difference between a decomposition analysis (as in Rafaj et al., 2013), and our analysis framework. His main criticism is about the STAG-FUEL scenario (fuel consumption and fuel mix remain constant from 1970-2010), and suggests that it implicitly assumes additional energy policy measures that would compensate for increased fuel use to match the growth of GDP.*

In line with the reviewers' comments we reconsidered the STAG_FUEL scenario and replaced this scenario with the STAG_ENERGY scenario, where we took also the fuel shift and fuel economy effects on board. In order to avoid confusion we do no longer refer in this paper to the STAG_FUEL scenario. The modelers who are using the STAG_FUEL scenario, are for a full description referred to the discussion paper (Crippa, ACPD, 2015).

We call the new STAG_ENERGY scenario as such, because with our 2010 reference we look at what would have been the situation in 2010 if we would have used the energy resources from 1970, taking into account the improved energy efficiency and fuel shifts of 2010. This leaves us clearly with a lowest emission scenario (contrary to the STAG_FUEL scenario) and provides the nice range of lower and upper emission scenario 4 decades after 1970. Even though we planned to filter out the energy efficiency solely, this did not show much variation, because most of the fuel savings are taken up by an increase in the fuel use (e.g. cars fuel economy has been improved by large improvements on the engine, but the car doubled weight and includes now also fuel internal equipment. We clearly wanted to refer all scenarios to 2010 as our standard (in view also of spanning the range of emission scenarios for 2010) and so we opted to use the 2010 technology and fuel shift and fuel efficiency but 1970 energy consumption (in TJ). The scaling per sector and country of the TJ energy consumption was easily done with the IEA (2014) data, but the fuel efficiency data for 1970 were hard to derive, for which we invested large effort in finding literature with statistics and in contacting experts for their advice on fuel economy (especially of cars/trucks in 1970). We do hope that this STAG_ENERGY scenario, which is a stagnation of the energy use, but not a stagnation of the energy efficiency, gets your interest (and positive advice at the review of this paper).

In the revised version of the manuscript the STAG_ENERGY scenario has been presented as following:

In the introduction:

"In this work, we do not seek to analyze and decompose the emission determinant factors in view of assessing further potential of optimized reduction policies, but rather want to demonstrate the cumulative effect on emission levels in 2010 of two major factors influencing air pollution: increasing energy use and the combined technology-policy achievements to reduce emissions. To this end we develop two retrospective scenarios for 1970-2010 from a European industry-air policy perspective (Fig. 2), and representing a range of emissions that would have been reached in 2010 under different scenario assumptions. The first and highest emission scenario, STAG_TECH, assumes after 1970 no further improvements in technologies and abatement measures. The second retrospective and lowest emission scenario (STAG_ENERGY) assumes stagnation of energy consumption since 1970, while the fuel mix, energy efficiency, emission factors and abatements are assumed as in the reference 2010 data."

In the methodology section:

"STAG_ENERGY: The STAG_ENERGY scenario was modeled by assuming that the three sectors of interest consumed the same amount of energy (TJ) as in 1970, but with the 2010 fuel mix, energy efficiency, technologies, and end-of-pipe abatements. Since the fuel market is to a large extent global, this scenario was implemented in all countries for the three selected sectors. All power plants, vehicles and industries with the reference 2010 emissions standards consume coal, gas and oil with the 2010 share but at 1970 energy level (in TJ). In addition to the calibration per sector of the energy consumption level (in TJ), we evaluated the change in energy efficiency by fuel type, sector and region. For the power generation sector we  we scaled for each country the "main activity producer electricity plants (TJ)" with the 1970 over 2010 ratio of the "electricity output of main activity producer electricity plants (GWh)" from IEA (2014). For the road transport sector we scaled the "fuel consumption for road transport" with a factor composed of the 1970 over 2010 road transport fuel consumption ratio multiplied with the 1970 over 2010 fuel efficiency ratio. The latter was calculated with the macro-regional averaged values of petrol and diesel economies (l/100km) in 2010 and 1975 (because of missing 1970 data) for different type of vehicles (passenger cars, light duty vehicles, heavy duty vehicles, busses, mopeds and motorcycles) distinguishing the fuel consumption for petrol and diesel based on the EPA Trends report (EPA, 2013). The comparison of the STAG_ENERGY emissions scenario with the reference emissions REF in 2010 highlights the emission reductions that were not realized because of increased energy consumption (e.g. to generate extra kWh electricity or to drive more distance per vehicle) with the 2010 technology and 2010 end-of-pipe abatement. Compared to the 1970 reference emissions, STAG_ENERGY demonstrates the benefit of all industrial developments towards less energy-intensive and less polluting technologies. It includes not only the technological progress with end-of-pipe measures but also the shifts towards less carbon-intensive fuels (e.g. natural gas instead of coal) and increase of fuel economy and energy efficiency. It should be noted that pre-combustion treatment (cleaning) of fuels, such as coal washing or desulfurization of diesel and heavy residual fuel oil is not part of the STAG_ENERGY scenario but is addressed as a technology effect in the STAG_TECH scenario. Therefore, the fuel quality directives show their emissions savings (mainly on sulfur) in the STAG_TECH scenario while the fuel taxation policies (e.g. preferring diesel over petrol) are present in the STAG_ENERGY scenario.

In the ACPD version of this paper (Crippa et al., 2015, ACPD), another scenario called STAG_FUEL discussed the combined impact of stagnation of fuel-mix and fuel amount. However, in revising the manuscript we decided to focus on the consumption of energy (TJ) instead of fuel because we consider the fuel mix and efficiency choices as exogenous variables just as the technology progress and end-of-pipe measures. When considering a stagnation of fuel with constant fuel mix and energy since 1970, due to the remaining contributions of relatively dirty fuel, this scenario results in higher emissions than STAG_ENERGY. This scenario is here not further discussed, since the interpretation of results is not adding much to the STAG_ENERGY scenario. The interested reader is referred to the corresponding ACPD paper."

Updated results on this scenario are also presented in section 3 (emission comparison) and 4 (TM5-FASST results). Moreover, the STAG_FUEL data have been replaced by the STAG_ENERGY one in the supplementary material (sections S1 and S2).