

Dear Editor and reviewers,

Please find in this letter our answers to the reviewers for the article:

Ozone and aerosols tropospheric concentrations variability analyzed using the ADRIMED measurements and the WRF-CHIMERE models, by L. Menut, S. Mailler, G. Siour, B. Bessagnet, S. Turquety, G. Rea, R. Briant, M. Mallet, J. Sciare, and P. Formenti

We acknowledge the two reviewers for their interesting and constructive comments. All suggestions and remarks were taken into account and the article was entirely revised to follow their recommendations.

To summarize our changes in the manuscript, we found the reviewers mainly focused on these specific questions:

1. The main goal of the study appears unclear: the text was changed in order to present only one main focus for this study. This corresponds to the questions in the Introduction and this is now more explicitly written in the abstract, the introduction and the conclusions.
2. Some explanations were found to be not enough accurate. Numerous parts of the paper were rewritten to be more precise. About details on the ADRIMED campaign, all details will be published in the ADRIMED review paper, under preparation by Mallet et al. About details on the CHIMERE scheme and the specific AOD calculation, the whole methodology is presented in a companion paper by (Mailler et al., 2015, this special issue) but we added details in this paper too.

Our answers are in blue in the text and after each reviewers remark.

1 Anonymous Referee #1

Review of the ACPD paper "Ozone and aerosols tropospheric concentrations variability analyzed using the ADRIMED measurements and the WRF-CHIMERE models" by L. Menut, S. Mailler, G. Siour, B. Bessagnet, S. Turquety, G. Rea, R. Briant, M. Mallet, J. Sciare, and P. Formenti

In this paper the authors look at the levels of ozone and aerosol over N. Africa and Mediterranean region in the period of June-July 2013, discussing their temporal and spatial variability. The study is based on the combined use of observational data and modelling results. The measurements included data from European Climate Gridded dataset (E-OBS) for meteorological parameters, EEA air quality monitoring data?) from AirBase, AERONET sun-photometer AOD measurements and aircraft measurements of ozone during the ADRIMED campaign. The calculations were performed by CHIMERE CTM driven by off-line meteorology from WRF meteorological model. To evaluate the accuracy of meteorological parameters from WRF, the paper compares calculated and E-OBS measured daily surface temperature (which indicated in general a slight negative bias) and accumulated precipitation (showed reasonable agreement in terms of the amount and occurrence). Then the results of comparison of CHIMERE calculated ozone and PM10 concentrations, as well as AOD, with the available measurements for the studied period are discussed. Further, the authors present CHIMERE calculated aerosol chemical composition, showing the dominance of mineral dust, both at surface and through most of the troposphere, at most sites in the region. Also, aerosol size distribution from CHIMERE is compared with derived data from AERONET.

The paper is indeed organized in two steps: (i) a comparison between observations and model to estimate the ability of the model to reproduce the observed atmospheric composition, (ii) knowing the results quality, use the model to have more details on this atmospheric composition by analyzing the aerosols chemical composition and the size distribution variability. This is now more clearly presented in the manuscript.

In general, the presented material is quite interesting and the work represent a valuable contribution to air quality study in the Mediterranean region which is influenced in a complex way by the emissions from anthropogenic and natural sources. The work is well suited to be published in ACP, but the text and content of some parts of the paper should be thoroughly revised and edited by the authors.

In this new version, all requested changes were done and are detailed in the text below.

For the most, the paper is written following a certain logical structure, still there are several paragraphs/parts of the text (some of them are pointed below) which need some improvements in terms of clarity. In particular, the

main findings and conclusions should be better summarized. It is also strongly recommended to do a thorough check of the correctness of English language use before the paper is re-submitted for publication. [The whole text was revised and the conclusion was rewritten.](#)

1.1 Overall comments:

My main concern is that the paper seems to lack a clearly defined goal which in several places leads to somewhat superficial analysis and eventually to the lack of profound conclusions. For example, "the ozone and aerosols concentrations are studied. . ." (Abstract), "The main purpose of this study is to better understand ozone and aerosols content " (p. 3067), "The goal of this paper being to evaluate the ability of a model to estimate hourly pollutants concentrations. . ." (p. 3080), "One goal of this paper is to calculate and discuss the chemical speciation of the aerosols" (p. 3083), "A focus was done on aerosol size distribution" (p. 3090), etc.. In addition, there several "questions to answer" listed in Introduction. I'd highly recommed to the authors to establish one well-defined goal for the paper, clearly specified sub-goals/questions and to make sure that the paper follows its main purpose and that the answers to the posed by the authors questions are given in Discussions/Conclusions. [We completely understand this remark and the article was simplified. The goal corresponds to the questions : Are models able to reproduce the complex variability of ozone and aerosol in this region? what is the chemical composition of the aerosol? The abstract, the introduction and the conclusions were changed accordingly.](#)

In its present form, the paper does not really study the ozone/aerosol pollution in Mediterranean, but rather presents CHIMERE comparison with the measurements, thus appearing as a model evaluation work. Then doing so, the paper does not offer much of analysis of the reasons for disagreement between the model and observations, supported e.g. by sensitivity studies/trajectory analysis and other axiliary material in order to better interpret the results, but rather describes them hypothesizing on the explanations, and it does not either propose ideas on how to improve the model. As the authors are widely using the term "analyze the results", I'd recommend to include more in-depth analysis, or change the word to "discuss/look at. . . the results".

[When a modelling study is performed, the first mandatory step is to compare the results to the available data. Thus, it is clear that this procedure may appear as 'just a model validation'. And this can be the case if there is only these results. But, in this paper, there is three added values: the vertical structure of the pollutants in the troposphere, the chemical composition of the aerosols at locations where these is not the corresponding measurements and the aerosol size distribution variability. If we want to properly discuss these added values, we have to compare the model results to measurements. This enables to estimate if the model is realistic or not, how are its biases. Thus, after this first step, the discussion on the new results is more clear.](#)

Hourly measurements were available for the studied period. Those are valuable for diurnal analysis for getting better insight in chemical/meteorological processes. It is strange and disappointing that the authors have not made a better use of the hourly measurements, choosing to average them, though they state "The goal of this paper being to evaluate the ability of a model to estimate hourly pollutants concentrations".

[Yes, we understand this remark: in a first version of this article, we presented both hourly and daily model outputs and measurements for the surface stations. This led to a too long paper and the added value with hourly comparisons for the time series was not enough. In order to be more synthetic, and knowing that we are studying a very large area and for two months, we considered this would be more clear to have only daily informations but interesting to keep several ways to express the results \(maps, time series and vertical profiles\). However, for the comparison with specific measurements, hourly comparisons remain: for the aircraft measurements and the AERONET size distributions.](#)

Two meteorological surface parameters from WRF are evaluated with observations, but the evaluation results have not been used for further interpretation of CTM results.

[Sentences were added in the conclusion, following this remark. The fact that the temperature was moderated and precipitation events occurred is the explanation to the moderate pollution levels. The fact that the model is able to reproduce this meteorology increases our confidence in the modelled aerosol concentration variability and consequently in the aerosol chemical composition.](#)

1.2 Other general comments:

- Several places: misleading use of "close to sources" and "remote" (referring here to the proximity to erosion dust sources, but not anthropogenic). This should be formulated more precisely.
This was changed accordingly in the manuscript.
- The choice of the dates for maps and timeseries should be better justified. Sometimes they seem random (16, 20, 24 June, and then 17, 21 for ozone and aerosols)
In fact, the choice of the several dates is not random. These dates were mainly driven by the availability of the data when we are doing comparisons between observations and model. Please note that the caption of Fig.5 was not correct and is now corrected: this maps corresponds to the 21 June 12:00 UTC. The Fig.7 presents maps for the 16, 20 and 24 June in order to cover the major part of the studied period with a constant time step of 4 days. This is the same for Fig. 9. The Fig.11 presents a map for 17 June as an example, because the multi ozone plumes are easy to see (and this was not always the case for the other days). The Fig.12 presents comparisons for days when aircraft measurements are available. Fig.17 presented vertical profiles for 21 June because this corresponds to a maximum of dust concentrations in altitude. Finally, Fig.18 presents results for 17 and 21 June, corresponding to available AERONET data for many sites (not always the case). This is now better explained in each section.
- Almost nothing noted on anthropogenic component of air pollution at the selected sites
Yes, we are here only studying atmospheric concentrations of pollutants. These concentrations correspond to the final budget after several processes such as emissions, chemistry, deposition, mixing, transport. The relative part of the anthropogenic emissions is included in the spatio/temporal evolution of a chemical species but can not be extracted directly and independently. The quantification of the relative contribution of the anthropogenic component would require scenarios studies, or source apportionment modelling, for example, and this is not the goal of this paper.
- The aerosol composition vertical profiles show rather high dust concentrations aloft, till very high altitudes, suggest a significant dust source on the top of the model domain. Please explain.
There is no mineral dust source at the top of the domain. This is only due to vertical mixing and long range transport. But these very important values may come from model uncertainties and errors in the calculation of vertical transport and diffusion: a well-known problem of CTMs, difficult to correct. This is better explained in the text with "This maximum is due to the long range transport: huge concentrations are emitted at the surface in Africa and quickly transported in altitude due to important mixing. These concentrations are injected above the Atlantic ocean in thin layers and transported towards Mediterranean sea."

1.3 Specific comments (just some):

- Abstract should clearly define the purpose of the paper and summarise the main findings of the study of air quality-concentration variability in the Mediterranean region (rather than a few, arbitrary selected notes on model performance).
The abstract contains the two main findings: the chemical composition of the aerosols and the need for a more accurate representation of the aerosols size distribution. This latter point corresponds to the state of the art of the current regional CTMs and the abstract points out the need to go further in the model representation of this distribution.
- p. 3065, line 7-8: "...not highly polluted" - compared to what? Typical levels? Critical levels?...
Not highly polluted compared to typical levels observed during summer in this area and during the last years.
- line 12-13: Suggested: change "quantified" with "calculated by the model" as it's not verified
OK, corrected
- line 14-15: it was just shown that for a few hours the modelled aerosol size distribution is shifted. . . .
The results presented are just for few hours but the tendency was diagnosed for all available measurements.
This was added in the section
- line 16-17: remove "even if". There is no prove of "correctly reproduced total mass of aerosols" - whatever the authors mean by that, whereas AOD indeed compares better with observations, but is not quite "correct". Besides AOD calculations can include some error compensation
Yes, this last part of the sentence was not correct and was removed.
- p.3066 line22-23: aerosol composition does not depend, but means or can be quantified by the relative contribution of the individual species
OK, corrected

- line 26: aerosol life cycle or aerosol properties?
Yes, "properties", this was corrected.
- line 27: sun-photometers do measure AOD
OK, corrected
- p. 3067 line 7: "significant development" or "significant modelling efforts to assess. . .", or perhaps "significant development of the CHIMERE"?
OK, corrected
- Lines 20-23: is not this a prerequisite for accurate modelling in many (or any) regions?
Yes, that's right but this is not the case of all models currently doing atmospheric composition modelling. For example, and among all models used for the ADRIMED experiment analysis, CHIMERE is the only one explicitly representing all sources and all aerosols.
- p. 3068 line 10-11: "having in mind the strength and weakness(es)" - I could not say this was discussed in sec. 8
Yes, the term is a little bit too general and was replaced by: "having in mind the model performances". In fact, this is not possible to have a very synthetic view of a model, depending on too many sources and processes.
- line 23-24 : repetition
OK, the sentence was not very useful and was removed.
- line 25: analyze meteorological parameters?? Perhaps characterise met. Situation, or evaluate WRF??
The sentence was replaced by "In order to characterize the meteorological situation and to evaluate the WRF simulation, the surface measurements provided by the E-OBS database are used."
- p.3069 line 7 : In order to the modelled meteorology???
Yes, strange sentence replaced by: "Comparisons with the daily average 2m temperature..."
- Line 15: what is meant by "homogeneous databases"? Harmonized? Coordinated??
It means that the database providers made an important quality check of the data. The sentence is now: "For regulatory pollutants, many measurements are routinely performed and well organized in quality checked databases."
- p. 3070 line 14-15: the surface measurements of temperature and precipitation are not in the paper
Correct and this sentence was removed.
- l. 18 : perhaps "year day" instead of Julian day (check definition)?
Yes that's right. I thought that the Julian day was the counter of days during one year, starting at one the 1st January, but this is not the correct definition (http://en.wikipedia.org/wiki/Julian_day). Thus, "Julian day" was replaced by "year day" in the whole manuscript. The figures 8, 12, 16 are corrected.
- p. 3071 line 6 : NCEP/GFS - reference?
The sentence was changed and is now: "The global meteorological analyses from NCEP/GFS (Kalnay et al., 1996) are provided on a regular $1.125^\circ \times 1.125^\circ$ grid."
- p. 3072 line 3-4 : precalculated by WRF
OK corrected.
- line 6-7: what was the horizontal resolution?
This is the same horizontal resolution since CHIMERE is directly using the WRF horizontal grid, i.e 60 x 60km. This was added in the text.
- line 13-15: what about aerosol growth by condensation of gases? Wet scavenging and dry deposition
All these processes are taken into account and precisely described in (Menut et al., 2013). In this section, we just want to show that the model is not neglecting an important process.
- lines 18-20 and there after: explain if modelled AOD is dry or the effect of aerosol hygroscopic growth is taken into account
Yes, some explanations were added. In this model version, the modelled AOD considered the aerosol is dry. But the hygroscopic growth is currently under development in the model.
- p. 3073 line 21 Analysis of meteorology?? Meaning WRF evaluation?
No the meteorology is different since the previous studies were for other periods. But the model configuration is the same i.e all parameterizations chosen to run WRF. These parameterizations are listed in section 3.1 But the title was changed following this remark and is now "Modelled meteorology evaluation".
- Line 23: "...and use of CHIMERE model" is probably irrelevant information here;
OK, removed.
- Line 25-25: meteorological parameters; "realistic enough fields" - explain better please

Yes, this is difficult to quantify. We know that the meteorological model is not perfect and may contain biases. In addition, compared to measurements, with another spatial representativity, additional differences may appear. But knowing the model biases, uncertainties and problems of representativity, if the meteorological fields show the same tendencies than the observations, we can consider that these fields are 'realistic enough' to model atmospheric composition variability. To try to better explain this point, the paragraph is now: "It was shown that the model is able to accurately reproduce the main meteorological variables over the Euro-Mediterranean area: the day to day and the hourly variabilities are well reproduced for all variables, the biases are known and the model representativity is adapted to the main variations of gaseous and aerosols formation and transport."

- Line 27: rather that the model performance is variable for different regions/locations
OK corrected.
- p. 3074 line 18-20 : rather thin conclusion
Yes, we agree with that. But daily maps are only able to see if the model catch the large scale structures. A deeper analysis is proposed in the next section and with the time series.
- p. 3075 lines 15-23: somewhat unclear formulations
Ok, the paragraph was rewritten and is now: "The daily precipitation amount Pr has to be analyzed differently than the temperature. For the temperature, the model has to provide a correct space and time variability and a bias as low as possible. For the precipitation, the space and time variability is the most important since for chemistry-transport modelling, when a precipitation event is diagnosed, the atmospheric column is scavenged. This is why, in place of correlation, we introduce here the hit rate score."
- p. 3076 line 4-5: "correctly" or fairly well?
OK for "fairly well".
- p. 3077 line 17-18 : Function of the station type sounds strange.. Perhaps function of the distance from the coast? Proximity to the coast line?
Yes, this was corrected and is now: "Results are splitted as a function of the AirBase surface station: close to the coast (inland but less than 10km to the coast) or continental."
- line 20-21: Rather that the performance is variable between the sites; Any finding regarding at what locations the model is best/worst and why?
No, in fact we tried to order the results with several criteria: the distance to the coast, the topography, the proximity to urbanized or industrial areas, but no clear result appears. This is mainly due to (i) the horizontal resolution too large to make this kind of sort, (ii) the nature of the studied pollutants plumes, able to be transported during several days and long distances.
- p. 3079 line 20: which models? Explain better "the lack of deposition"
New explanations were added as: "This ozone deposition underestimation is rarely documented and quantified, but some previous studies showed that the dry deposition velocities used over oceans for gaseous species may be underestimated, due to a misrepresented turbulence as pointed out by (Garland et al., 1980), (Ganzeveld et al., 2009) and (Coleman et al., 2010), for example."
- p. 3081 line 4-5: rather speculative explanation; any trajectory analysis to support this? AOD
Yes, we agree this is a speculative explanation but there is no studies already done and published for this specific event. A trajectory analysis would help to know the main wind direction, but this is known. The question is if this is a fire or mineral dust plumes (or a mixing of the two) and it deserves a specific model studies for that. And this model study, to be accurate, needs for an hemispheric or global model whereas CHIMERE is just a regional model. But this is not the main focus of our paper, and we just wanted to point out that, at the boundaries of our domain, the satellite has detected high AOD not modelled.
- line 26: Better to say that AOD quantifies, or IS, aerosol extinction...
OK corrected. It was page 3079 (not 3081)
- Line 27: "well and often measured" should be exchanged by more meaningful and precise formulation
OK the sentence was simplified to be more clear. It was also page 3079.
- p. 3081 line 1-4 : should be discussed that CHIMERE underestimates AOD over Europe where anthropogenic sources dominate
OK this was added in the text.
- line 11: perhaps "often influenced by dust pollution/outbreaks.." would be better
OK corrected.
- lines 24-27: rather superficial explanation; any supporting studies/tests?
This is not superficial but just here to introduce the fact that we will study more in detail the possible reasons

in the following parts of the paper.

- p. 3083 line 1: really "satisfactory"? No improvements needed?
This is page 3082. Yes, improvements are needed and this is the main goal of the last section of this paper to show that aerosol size distributions are not well modelled. But the sentence was changed here to be less definitive.
- line 14: comparison model vs. measured PM10 for "the understanding of the aerosol life cycle" ?
This sentence was not clear and not useful, thus is now removed.
- p. 3083 lines 12-14: Better agreement for AOD could also be due to other reasons, e.g. compensation from the effect of relative humidity . . . please discuss.
Yes, an explanation was added about possible errors compensation. (this is page 3082)
- line 14,16: better "overestimated" or "exaggerated" instead of "too important"; correct "diffusion"
OK corrected.
- p. 3084 line 5-8: no need, should be enough with model description section
Ok this part was removed.
- line 19: Please explain how can we see that the "local dust emissions" are too large?
Yes, we agree, we can not. There is too many possible factors able to explain these high values. The sentence was removed.
- p. 3085 lines 7-14: should be it observation/sites description chapter
If the remark is about the stations locations, this is already in the Table 1 and this is here just a reminder.
- line 21: better "most likely due to the proximity..."
OK corrected.
- line 26: how representative this instance?
Modelled vertical profiles may be considered as representative of long range transport in altitude, but this is difficult to quantify. The real interest is to examine the vertical structure.
- Page 3086 line 4-5 : check the statement
Sorry, this paragraph was very confused... It was rewritten as: "In Champforgeuil, the most important concentrations are modelled at 1000m AGL, around $19 \mu\text{g m}^{-3}$. This peak is constituted of a mixing of sea salt, sulphates, nitrate, ammonium and mineral dust. A secondary peak is observed at 2000m AGL, mainly due to mineral dust and explaining the large vertical extension of the aerosol concentrations."
- Line 15-17: "The understanding is sensitive the the size distribution"???
The whole paragraph was rewritten as: "*The way the aerosols can evolve in the atmosphere also depends on their size distribution. Depending on the types of aerosols, abundance will vary according to different size classes. This will cause a different deposition and therefore a different long range transport. Accurately model the size distribution of aerosols is thus important to track the aerosols over long periods (several days) and large areas (several thousand of kilometers). Unfortunately, the size distribution is difficult to measure and model. In this section, we compare measured and modelled aerosol size distribution in order to see if discrepancies between model and measurements may be due to a bad representation of this quantity.*"
- p. 3088 line 21: perhaps should be "period was studied within the framework..."
Yes, corrected.
- p. 3089 line 4: "Meteorological parameters, namely. . ."; Better to write "Compared with available measurements. . ."
Yes, corrected.
- Line 18: "correct"? Looks like the model tends to overestimate ozone, especially aloft
Ok, "correct" is probably not the best word. The comparison between regional model and aircraft measurements for ozone are not often done and, in this case, we considered that the differences between model and measurements are not very large, compared to the model uncertainties. In altitude, the difficulty is that the regional model is mainly driven by its boundary conditions, in our case monthly averaged values. We replaced "correct" by "acceptable".
- p. 3090 line 7: dust sources
This was rewritten. The paragraph is now: "*A focus was done on aerosols size distribution by using AERONET products time series over numerous sites, in Africa, where are the sources of mineral dust, and in Europe, where a mix of several sources is present: local erosion, anthropogenic and biogenic emissions, vegetation fires. The ability of the model to reproduce the aerosol size distribution was quantified and it was shown that, in Africa, the coarse mode is underestimated when, in the Euro-Mediterranean area, the fine mode is mainly overestimated by the model.*"

- Tables 5, 6: what is mean by "representative"?
Yes, this word has no sense here. This was removed.
- Figure 16: for PM40, right?
Yes, this is correct. And this was added in the caption.

2 Anonymous Referee #2

Review of the paper "Ozone and aerosols tropospheric concentrations variability analyzed using the ADRIMED measurements and the WRF-CHIMERE models" by L. Menut, S. Mailler, G. Siour, B. Bessagnet, S. Turquety, G. Rea, R. Briant, M. Mallet, J. Sciare, and P. Formenti.

The material presented in the paper is of interest both in terms of results of comparing the measurement data obtained during the ADRIMED campaign and the results of simulation with the WRF and CHIMERE models, and from the point of view of studying variability of aerosol characteristics and ozone content over the Mediterranean basin. The article can be published in the ACP, but the text of the paper need to be meticulously edited.

2.1 General comments:

- Authors write that "The main purpose of this study is to better understand ozone and aerosols content in the lower troposphere over the Mediterranean area, using a combined analysis of atmospheric measurements and regional CTM simulations". However, this version of the manuscript for the most part is devoted to the comparison of the simulation results and observation data obtained during the ADRIMED intensive campaign from 1 June to 15 July 2013. Issues concerning the state and variability of ozone and aerosols over the Mediterranean area during a specified period are not reflected comprehensively enough. It seems to me, when discussing the variability of these characteristics, the specifics of ADRIMED campaign period could be described in detail concerning the situations which are typical for this region, and (or) the season. Another alternative is to formulate the objectives of this work more specifically and clarify the more specific objectives of the study in the introduction.

Yes, we agree with this remark. It is a problem because all specifics of the ADRIMED campaign will be in a review paper not yet published. This review paper, by (Mallet et al.), is in preparation for ACPD and this special issue. It contains all informations including the meteorological situations, the instrumental set-up etc. Without this paper, we changed the present manuscript by formulating more specifically the main objectives in the introduction, following the reviewer suggestion.

- In the work, the WRF and CHEMIRE regional models are used. The authors point out the names of schemes and modules that are used for simulation of the atmospheric characteristics: for example, MELCHIOR 2 - to describe the chemical evolution of gaseous species, Fast JX radiation module - to calculate photolysis rates, etc. One of the main characteristics, which are considered in the article, is the aerosol optical depth (AOD). Comments made by the authors about the features of AOD modeling are presented very scarce. One can agree with the authors and lead only references to the literature in which the features of the model are described in detail (Section 3.2). However, comparison of the observation data and simulation results show that in some cases the serious discrepancies exist. Therefore, it is advisable to give a brief description of some of the most important - in relation to the purposes of the article - paragraphs that would be useful in the analysis of differences between observations and simulation results.

The AOD calculation is fully described in a companion paper, (Mailler et al., 2015), also dedicated to the ADRIMED study. But to be more precise about this point, we added more details about the schemes used and the AOD calculations in the section devoted to the CHIMERE model.

- When analyzing quality of the model by comparing simulation results and observations, the qualitative assessment is often used: P. 3073: "It was shown that the model is able to accurately reproduce the main meteorological variables over the Euro-Mediterranean area and to provide realistic enough fields for chemistry-transport modeling". P. 3074: "For the 2m temperature, we note that the observed and modelled values are similar. ... For Pr, the main structures and the relative amount are also well modeled". It would be more accurate to adduce the quantitative estimates indicating to which atmospheric situations (dust outbreaks, fire, background conditions, etc.) these estimates belong.

For the main results, we added more quantified results in the discussion.

- Considering the AOD and the particle size distribution, the data from AERONET sites, located in Africa or the Mediterranean islands, are used. Why not consider data on continental stations, located in Europe? Especially since the European stations were selected (Figure 2) when considering data on ozone and PM10. Yes, it was a choice to focus on AOD for Africa and surface concentrations for Europe. We made scores also over Europe for AOD but the Aeronet stations are not the same that the Airbase stations. This added a lot of stations and we found that, regarding the focus of this paper (long range transport and variability), there was no added value in the conclusion. But this is a good remark and a study specifically devoted to validate the model with all existing measurements is currently under preparation (probably more in GMDD than in ACPD, and over a longer period to have statistics both in summer and winter).
- In parts devoted to the analysis of meteorological parameters and ozone surface concentrations (Sections 4.1 and 5.1) the daily maps for 3 days (16, 20 and 24 June) are considered. Why these three days? These three days correspond to the ADRIMED intensive observation period: from middle to end of June. We thus selected three days (to have only three maps) with a four days interval in order to see the long range transport, from one map to the next one.
- In Section 5.2, the results are divided on the basis of coastal or continental station type. It would be preferable, apparently, to use the criterion of distance from the coast station. Yes, we agree. It was done but certainly not enough explained in the paper. The selection was made considering that the coastal stations are less than 10km from the coast. This is now precised in the text and the section "Observations".
- The text of the article includes a large number of acronyms (EUCARRY, CHIMERE, ESCOMPTE, etc.) which are not explained at all or decoded immediately after the first mention. Apparently, it is advisable to bring a list of acronyms in the table or in the application. The acronyms are now explained in the text as for ADRIMED. But all names are not acronyms, such as CHIMERE which is just a name. The same for EUCAARI: thi is not an acronym and the long name of the project is: Aerosol Climate Air Quality Interactions. Another example is ESCOMPTE which is an acronym but in French: its significance was added but perhaps not of great helps for the readers. For all other acronyms having a real meaning, such as CHARMEX, EARLINET, we added the full explanation.
- The phrases stating the purposes of the work are often appeared throughout the text. Therefore, the paper is losing its entirety. The main goal of the paper was revised and is now more clear.

2.2 Other comments:

We thank the reviewer for these useful corrections. They were all taken into account.

There are many inaccurate phrases and expressions which are difficult to interpret, for instance:

- P. 3066: "...composition. The latter depends on the relative contribution of various chemical species such as...";
This sentence was replaced by: *"Aerosols are also highly variable in space, time and composition. Their composition can be quantified by the relative contribution of various chemical species such as organic matter, sulphates, nitrates, ammonium, mineral dust and sea salt"*.
- P. 3069: "In order to the modeled meteorology, ...";
The paragraph was rewritten and is now: *"Comparisons with the daily average 2m temperature and precipitation amount taken from the European Climate Gridded dataset (E-OBS) (Haylock et al., 2008) are undertaken."*
- P. 3073: "This WRF model configuration...". In my point of view, it is not the best way (with the words "This WRF model ...") to start new Section.
The sentence is now: *The meteorological modelling was already done and evaluate with the WRF model, for the same kind of domain and resolution in ...*
- P. 3077: "The most important surface concentrations...",
OK this was replaced by: *"The highest surface concentrations..."*
- P. 3083: lines 14-16, "too important". It is not clear what is meant by "important".
Yes, we agree. It was also noted by the reviewer #1 and the sentence is now: *"This can be, partially, a problem of exaggerated vertical diffusion, often diagnosed in deterministic Eulerian models"*
- P. 3077: "Results are split as a function of the AirBase surface station type...";

OK. The new sentence is *"Results are splitted as a function of the AirBase surface station: close to the coast (inland but less than 10km to the coast) or continental."*

- P. 3079: "For measurements near the surface, the model is mostly closer to the measurements": reword the sentence, please.

Ok this is now: *"The differences between model and observations are lower when the aircraft is under 1000m AGL. Below this altitude, observed ozone concentrations values up to 60 ppb are not always well captured by the model. This is a direct effect of the limitation due to the horizontal resolution, the model being not able to represent local ozone plumes as presented in Figure 9."*

- P. 3086: "A peak of mineral dust...", "The understanding of aerosols concentrations after emissions, transport and chemistry is very sensitive to their size distribution": reword the sentences, please.

It is clear it was not clear at all, the reviewer #1 pointed out the same problem. The new paragraph is now: *"The way the aerosols can evolve in the atmosphere also depends on their size distribution. Depending on the types of aerosols, abundance will vary according to different size classes. This will cause a different deposition and therefore a different long range transport. Accurately model the size distribution of aerosols is thus important to track the aerosols over long periods (several days) and large areas (several thousand of kilometers). Unfortunately, the size distribution is difficult to measure and model. In this section, we compare measured and modelled aerosol size distribution in order to see if discrepancies between model and measurements may be due to a bad representation of this quantity."*

- The introduction of the Section 2 (P. 3068) must be rewritten: the text contains multiple repetitions of "are used". The same is observed in lines 22-25 of P. 3072. Section 8.2 contains multiple repetitions of "most important" (P. 3085).

OK and the text is now: *"In order to characterize the meteorological situation and the atmospheric composition, and to estimate the realism of the model, many observations are used in this study. An overview of the pollution over the area is done with the MODIS satellite AOD measurements. With the surface measurements of the E-OBS database, the temperature and the precipitation are characterized. Using the EEA network, the surface ozone and particulate matter concentrations are studied. The optical depth is quantified using the AERONET network. Temperature and ozone variabilities are estimated in the troposphere thanks to the aircraft observations of the ADRIMED project. The location of the measurement sites used in this study is summarized in Table 1."*

- The word "aerosol" is used in the text as plural noun, for instance, "aerosols optical depth", "aerosols size distribution", "aerosols composition", etc. In my view, the form "aerosol" is more preferable, common and readable.

This was corrected in the whole manuscript.

- P. 3066: line 27, I would replace "optical thicknesses" to "optical depths". As a whole, the phrase "optical thicknesses deduced from sunphotometers" is incorrect in the current context.

We agree and the sentence is now *"optical depths measured by sunphotometers"*

- P. 3072: A misprint, probably: "... from 40 to 40 μm ...".

Yes, this is strange, the text is correct in the original manuscript. Perhaps a problem with the ACP edition (even if we sent a Latex file). The sentence (correct in our manuscript) is: "...from 40 nm to 40 μm ".