

Dear A. Kerkweg, journal editor,

We first thank the three reviewers for their useful comments and suggestions. All remarks were taken into account and all corrections were done.

We also thank you for your answer to the reviewer #1 about the article scope: his remarks and your answer helped a lot to better describe the focus of the paper. In this way, the abstract, introduction and conclusion were thoroughly changed.

The main changes are:

- All suggested corrections of text and wording were done, including the font problem due to the translation from word to latex for some specific articles parts.
- The abstract and conclusion were changed to clearly show this paper is a reference model description paper. Results are just cited as examples to pedagogically illustrate the main model parts and to present scientific choices made during the model developments, as highlighted by the editor.
- Concerning the sections 11 to 13, presenting results obtained with the model, the table of contents was changed, more remarks were added and a specific section entitled 'specific applications' was added following reviewer #2 suggestion.
- The title was changed following the editor recommendation
- The section 4.1 was updated to be more clear and with new references.
- The MELCHIOR2 gas-phase chemical mechanism was added at the end of the article, in Appendix, following the reviewers recommendations
- Figure 21 and the last few lines were removed from the conclusion, following the reviewers recommendations to have a more conclusive conclusion.

Note that two authors were added in the authors list for their contributions to the model development: Nadège Blond and Guillaume Siour.

In this letter, the three reviewers remarks and the editor's answer are in black. *Our answers are in blue and after each remark.*

Anonymous Referee #1

This paper is partly a description of the CHIMERE-CTM, but largely a review of the CHIMERE-CTM research already published. As far as I can tell, it does not contain any new research. The manuscript bears the impression that it was not fully read through before submission, even containing a paragraph or two that clearly should have been deleted.

The manuscript was completely read and checked before submission, but some errors occurred. This is for example the problem of the PDF file, having some authors working with word, others with Latex, the manuscript being finally in Latex. We apologize for these problems and the revised manuscript was carefully screened and corrected.

The abstract does not indicate the purpose of the paper. Is it a description of the CHIMERE-CTM, or is it a review of existing research using it? The title indicates the latter, for which I think GMD is the wrong place. There is no conclusion in the conclusions section. A thorough model description is useful and should be suitable for GMD, but at this stage I think the paper lacks substance and details: Several equations in the describing/technical sections lack references, which needs to be sorted out. Other equations are given along with references, so it would be good to comment on why equations are repeated. I agree that repeating would be suitable for a proper manual or technical document, if that is what the authors aim at. The last sections (11-12) do not really describe much, other than listing earlier research and that the model can assimilate observations and be run in forecast. I find the review of existing research too long and uninteresting, mainly listing results from previous studies. That said, although a model description paper should have some model evaluations included, it may be that it can be enough to refer to other publications

instead of repeating it. But I struggle to find the news in this paper, and also to see the aim of it. I think that for GMD the paper should be more technical than it is, really describing the model. However, I wonder, with the large amount of publications referred to, aren't the parts of the model description already included in those papers? Or is the aim of this paper to collect all the bits and pieces to one reference and in that sense to produce a CHIMERE review?

The goal of the paper is to provide a reference model description paper for users, students working in the field of atmospheric composition modeling. All remarks were taken into account: the abstract was rewritten and the sections at the end of the paper were changed.

I would not suggest publication at this stage; I think you need to do major changes depending on what kind of paper this is (description vs. model review). As already said, I do not think GMD is the place for a model review without any scientific news. However, I have still included my list of general and specific comments below, that also should be addressed before a possible publication, should the editor decide upon that.

1 General comments

In addition to the above comments, I have only few general comments: There is inconsistent use of e.g. modeling/modelling. I assume GMD prefer English (not US-English), so the author should use "modelling" consistently, also in the title. Also "on-line" vs. "online" should be checked.

The complete text was checked and corrected accordingly. We thank this reviewer for the time he spent for all corrections, it was very useful for us and all corrections were taken into account.

2 Specific comments

Abstract

As already said, the abstract lacks the purpose of the paper.

The abstract was completely rewritten to show this paper is a reference model description paper.

Introduction

Page 206, Line 11: Remove comma after community.

done

P206, L12: "Local" and "urban" are good words; I don't see any reason for putting quotation marks around them.

OK, quotations were removed

P206, L29: Change "trends" to "trend".

done

P207, L13: Are there several chemical schemes? If not, change "schemes" to "scheme".

There is several chemical schemes, for gas and aerosols.

Section 2

P208, L6: I find the "scenarios" a bit vague, or "scenario studies", for that matter. With a CTM you can argue that all simulations are scenario studies. What I understand from "scenario studies" is that you run two simulations with different input.

Yes, correct. This is mainly meteorological scenarios (using different parametrizations) and emissions scenarios. We changed to scenarios studies.

P208, L6: "operational" is misspelled ("operationnal")

OK done

P208, L24: Misspelled "northern"

corrected

P208, L26-27: I suggest to remove the last part of the sentence, starting with: "an its first . . .". Having a parallel code is the important part; it is of no interest what kind of machine it uses. If you don't remove it, at least correct "an" -> "and".

Ee corrected "and". The citation to ECMWF is not for the machine but to say the model is running in the European meteorological center for short-term forecast.

P209, L5: Reference for the AQMEII?

Yes, we added the reference to [Solazzo et al., 2012]

P209, L16: Suggest “the most simple as possible” -> “an easy”

OK done

P209, L17: What is GPL?

The sentence was changed to "CHIMERE is under the General Public License (GPL)."

P209, L23: Why quotation marks around the Institute name?

Yes, OK, removed.

P210, L3: “completely” -> “solely”.

completely was removed.

P210, L5: Change “ifort” to “Intel’s ifort”.

OK done

P210, L13: “an MPI”: Either “a MPI” or remove “an”.

OK corrected.

P210, L28: Remove “. . .”, you have already written “e.g.”.

OK removed.

P211, L5 and throughout the document: “Splitted” is wrong, correct word is “split”.

OK this was corrected throughout the document.

P211, L15: “if the user time step is too low . . .”: I think you mean either “too long”, and that the sentence should be: “If the specified time step is longer than the recommended time step, the recommended time step will be used in model integrations.”

Yes, that's right. This was corrected following the sentence recommendation.

P211, L17: “lower” should then be “shorter”.

OK done.

P212, L18: “but can be changed to the recommended one”: What would then be the purpose of the user time step?

No this part was not correct and removed.

P212, L23: Remove comma after “formulation” and change “step,” with “step and”.

OK done.

Section 3

P213, L13-14: Is it not inconsistent if you have a varying grid, but assume it is equal over 5 boxes for transport?

No, this is not inconsistent, this is just a limitation for specific cases. To have a varying grid is possible and works. In the specific case of using PPM (but most users are using the VanLeer scheme), it is recommended to have a longitude/latitude regular grid. This was added in the text.

P213, L17-23: What is the typical minimum pressure (i.e. model top)? Typical number of levels?

The minimum pressure and the number of vertical levels may vary a lot depending on the study. A paragraph and a Table were added in the paper, showing examples of domains, citing corresponding references.

P213, L24: Remove “otherwise”.

OK done

P215, L6: Suggest change “whole” to “temporal and spatial extent of the”.

Yes, OK this was done.

Section 4

P218, L19: Change to lower-case on “Summer”.

OK

P221, L1: Remove “takes”.

OK, removed.

P222, L13: Where are these observed? In the model or by observations? Reference?

They are not observed, this is an hypothesis made in the already cited reference.

P223, L10: Misspelled “poollutant”.

OK corrected

Also please note that corrections were done to the equations (5) and (6) after an internal review.

Section 5

P223, L21: At the end of the sentence, add "with velocity v ".

Done accordingly

P224, L19: I don't understand "parallel strategy"; please clarify.

The correct terminology was "dimension-split strategy", not "parallel strategy"

P224, L20: "cancel out" -> "cancel"

Done accordingly

P224, L22-24: I don't understand the sentence "The way these . . .". Do the different fluxes use different schemes? The sentence should be clarified.

The sentence has been change beginning with "The way these fluxes are estimated numerically..." in order to clarify the sentence.

P225, L10: "CHIMERE model": i.e. not the CTM?

The word "model" was useless and confusing, changed "the way the CHIMERE model ..." to "the way CHIMERE ..."

P225, L12-13: The sentence "in the direction orthogonal to the interface . . ." is difficult. Rewrite, e.g. by removing most of the sentence ". . . at the interfaces is interpolated linearly from grid center winds."

Much clearer as suggested, we made this change.

P225, L16: Misspelled "Independant" -> "Independent"

Done accordingly

P226, L1-4: The word "constant" indicates that it does not change, but transport will change it. You mean that there is no gradient information; please consider rewriting.

This completely true. "Uniform" was meant, not "constant", we made the corresponding change.

Also "which imposes the tracer concentration at the cell interface" is a weird sentence. I would suggest rewriting the whole paragraph.

The paragraph was indeed not clear at all. It has been rewritten as follows : "The assumption made in this scheme is that the tracer concentration is uniform in each grid cell, so that the mass flux at the interface between two cells is the product of the wind at the interface by the tracer concentration in the upwind cell."

P227, L5-11: So it is not really of second order, but approximately because the cross derivatives cancel?

This scheme is of 3rd order when applied to a 1d problem, but only order two when applied to a twodimensional problem using a dimension-split strategy (treat each dimension separately), as it is the case in CHIMERE. This is because the cross-derivatives can not be taken into account with such an approach and a multidimensional transport scheme can not be more than 2d order without using the cross-derivatives. However, Ullrich et al. 2010 indicate that "In many cases, however, one finds that the error introduced due to neglecting the cross-derivatives is approximately negated when using a symmetric approach". Therefore, the PPM scheme as implemented in CHIMERE is formally only 2d order only, but practically much less diffusive than a simple order-2 scheme such as the Van-Leer scheme, because on each horizontal direction the scheme is 3rd order. We clarified this point in the new version.

The corresponding paragraph has been clarified.

P228, L5: Comma after "user".

Done accordingly

P229, L19: Reference on this? Seems like this is something found in a study.

These considerations are not based on a particular study but on the domain sizes that we typically use for CHIMERE simulations, I do not find a suitable reference for this point. Therefore, as we agree that the lack of reference about the typical domains used is problematic, a new table has been added in the section "domains geometry" listing a few domains on which CHIMERE has been used, along with a discussion on the usual vertical and horizontal resolutions used in CHIMERE.

P229, L24: "seems important" is vague. Better to use "is important".

OK, done accordingly

P229, L25: Can you represent thin dust layers in the vertical resolution of the model? Which I do not know what is (see earlier comment).

The vertical resolution of the model is user-defined, it is the user's responsibility to choose a vertical resolution fine enough for the phenomenon he wishes to represent. Usually, as it is mentioned in the section "Domains geometry" of the revised version, applications of CHIMERE to long-range transport of dust or volcano ashes use 15-20 levels from the surface to 200 hPa.

Section 6

P230, L5: "shall therefore": I would suggest rewriting to "is planned to" or "will".

We assume this is page 229, L5: and OK, corrected.

P230, L11: Define Kz and hk. Change "enables to diagnose ..." to "allows ... to be diagnosed as" and then give equation (27).

We assume this is page 229, L11. OK corrections done.

P230, L12: A physical interpretation of "(...)/hk" would be appreciated.

This is a turbulent vertical velocity as already in the text.

P230, L9: Suggest "it has also used" -> "the model is also used with"

OK corrected

P231, L9: What is SNAP? It is not defined.

Yes, the acronym SNAP is for "Selected Nomenclature for Air Pollutants". This was added in the text.

P232, L4: "soil NO": But since you are talking about anthropogenic emissions; I see no need for this parenthesis – it is only confusing.

Yes, but we often have the question from Chinese users. So we removed the soil NO and we added the following sentence: In these files, soil NO has not to be provided being considered as biogenic emissions (even if agricultural activities are anthropogenic).

P232, L4-6: "This leads to 12x nspec . . .": Remove this sentence. The number of files are irrelevant, besides, you have specified that they are monthly.

OK corrected.

Please note that the Figure 9 was slightly changed to remove colors (not useful).

P232, L6-8: Skip "for example ..."; suggest rewriting sentence: " For the Melchior chemical mechanism implemented by default in Chimere, emitted species are listed in Table 2."

done

P232, L12-14: "In both cases ...": Suggest simplifying: "These data are spatially interpolated to the model grid."

OK replaced.

P232, L18: Here it says yearly emissions; wasn't it monthly?

The raw data are in tons per year but a disaggregation file is delivered by the data provider to project from year to month. This was explained in the item 'step 1' p.231 L.20.

P232, L18-20: Perhaps it is better to rewrite sentence: "Menut et al quantified the improvement by using an hourly profile on a yearly mean dataset, showing that ..."

OK done

P233, L21: Add "diameters" in front of Ø.

done

P233, L26: "often called in this manual" "we refer to them as"

replaced

P233, L27-: Again, why is soil NO in the anthropogenic section?

this is the agricultural part.

P235, L17-23: I think you could have a separate section on sea salt. Also, I find the wording "because they depend on meteorology" weird. It seems to me that you have to specify whether an emission dataset is anthropogenic or biogenic, but strictly speaking, I'm not sure why you make a point out of it, unless you want to describe how to include emissions. I would suggest a separate section, and call it sea salt emissions.

Yes, OK, this sounds good. A subsection was created and the first sentence is now: In the same way than the biogenic emissions, the sea salt emissions need to know the meteorological parameters at an hourly time step and over the whole simulated period and domain.

P235, L25-26: I suggest rather starting with why dust is important in the first place, then mention physical processes and parameterizations and long-range transport.

Yes, good suggestion. This sentence was added: "In this model version, CHIMERE is able to make calculations on regional areas anywhere on Earth. The most important source of particulate matter is mineral dust. In the northern hemisphere, mineral dust are mainly emitted in Africa (Sahara and Sahel), when some emissions are also observed over land such as Europe. These emissions are sporadic but intense. In order to correctly model the total budget of particulate matter, mineral dust emissions are

diagnosed in the model."

P236, L22: ". This shows this is possible to calculate" -> ", showing it is possible to model"

OK done

P239, L2: Where is the web page? Give URL.

already done in p.209 L.18.

P239, L3: Add ":" or ";" after "Particles"

done

P239, L4-: Suggest "In Chimere, where dust production generally depend on wind and land cover, dust emissions are mainly found over Africa, and seldom over Europe."

OK replaced.

P239, L7-8: "This was only shown ..." Already mentioned.

The sentence was shortened.

P239, L15: Consider "that this" vs. "that the"

OK done

P240, L2: "close the PM10 mass": Missing a "budget", or I don't understand the meaning.

yes "budget" was missing. corrected.

P240, L3: "absence of any information": from where?

From measurements dedicated to resuspension. This was added in the text.

P240, L4: "supposed to be": I believe it either is or isn't. "Supposed to be" sounds like the model does not work as was intended.

yes, this is not the goal of the sentence. Just to say we made an hypothesis for the particle redistribution.

This was rewritten.

P240, L6: Suggest "distributed as for the" -> "in the same three modes as". Also, what about PM1-2.5?

OK corrected. And for PM1-PM2.5, this was a typo error and this is PM10-PM2.5. This was corrected.

Section 7

P240, L11: "human readable" -> "ascii"

Done.

P240, L12-14: Not very relevant; consider removing.

We haven't removed the sentence, as we believe this is a useful information for the new user, who will not find the chemistry files ready when downloading the code.

P240, L18: comma after "aerosols",

Done.

P240, L18-19: "At the end ...": I don't see how this is relevant.

We agree and removed the sentence.

P240, L19-20: "To add ...": Already mentioned in L11-12.

Sentence removed.

P240, L22: "photorates" -> "photodissociation rates"

Done.

P240, L23-25: "the sum operator": I don't know what this is, but I suggest rewriting the sentence. E.g. "... may also be changed and chemical families may be defined, e.g. NO_x=NO+NO₂. This is the processed by the pre-processor. Families can be diagnosed as other tracers."

The text suggested by the reviewer makes the sentence more readable and clear. We modified the text accordingly.

P241, L1-7: Suggest change to: "By default, there exist one aerosol scheme and two versions of the gas phase schemes. The complete gas scheme, which is the original (ref), describes ... gaseous species. In Chimere this is used by a suite of scripts and programs called "chemprep"."

The sentence was modified accordingly, and the last sentence moved at the beginning of the "chemical preprocessor" section.

P241, L8: Is this the same as in the EMEP model now?

No, we modified the sentence in "The hydrocarbon degradation is derived from that of the EMEP gas phase mechanism (Simpson, 1992), with modifications in particular for ..."

P241, L10: Surely, this is updated to more recent IUPAC and JPL versions? 2006 or 2010, perhaps?

No, the reaction rates are actually those of Atkinson and DeMoore. The sentence now reads "Rate constants are taken from ...", i.e. we avoided the use of the misleading "updated" term.

P241, L15-16: "etc..." Perhaps rather include a table of species?

We added two tables in the appendix with full list of both species and gas-phase reactions.

P241, L21: "latter being" -> "latter only"

Done.

P242, L2: What is COV? Do you mean VOC?

Yes, this is a typo from the French acronym. Corrected to VOC.

P242, L2: "than in": I think you mean "as in"?

Comment not clear, ignored.

P242, L7: "would have been resulted" -> "also results"

Done.

P242, L15: "oxydes" -> "oxides"

Done.

P242, L27: Perhaps add ", and is useful for forecasts".

The aim of saving time with the reduced mechanism (as may needed for forecasts) is pointed out at the beginning of the paragraph. Here we point out that the mechanism is optimized for polluted conditions. The text was changed in "...optimized for polluted conditions".

P242, L27: Skip "in particular".

Done.

P243, L1-2: Suggest ". In a general way, in this concept" -> ", where"

Done.

P243, L7: Missing "polluted" in "moderately conditions"?

Yes, added.

P243, L10: I assume there is a reference for this?

The sentence was removed.

P243, L12: What is TUV?

"Tropospheric Ultraviolet and Visible (TUV) radiation model", text changed accordingly.

P244, L1: Suggest "longitudinal cut in" -> "latitude-height cross section of"

Agree, text changed.

P244, L9-17: Remove. This is clearly left-overs that should have been removed earlier; much of the text is already mentioned above.

Removed. We apologize for that, it was caused by direct editing of text by many authors.

P244, L26: After "base converted " add "to ammonium".

Done.

P244, L27: "Ammonia" -> "Ammonia, ammonium"

Done.

P245, L3: "etc.": please specify. "other dissolved salts"?

Changed to "...and other salts consistently with the ISORROPIA thermodynamic equilibrium model (Nenes et al., 1998, see below)."

P245, L16-17: Remove "If", change "then" -> "giving". Or rewrite e.g.: "Discretising Q for a given I and for aerosol components k as Q_k, the total mass ..."

We modified text according to first suggestion.

P246, L6-9: Please explain which terms are what. I would assume one term is coagulation of smaller sizes into I (production for I) and growth to larger particles (i.e. loss term for I)?

Referring to the original paper of Gelbard and Seinfeld (1980), the four terms in the r.h.s. of eq (36) represent, respectively: the gain in section I due to coagulation of particles in sections lower than I, the loss in section I due to coagulation of particles in section I with those in sections lower than I, the loss by intrasectional coagulation in section I, and the loss due to coagulation of particles in section I with those in sections higher than I. The information is added to the text.

P247, L10: Skip line break; do not start new paragraph.

Done.

P248, L7-8: Suggest "a precalculated look-up table" -> "from pre-calculated values"

We preferred to keep the term look-up table, which is routinely used in these cases.

P248, L11: Small letters on sodium and chloride.

Done.

P248, L14: After "some errors can occur" -> "at the expense of accuracy"

Done.

P248, L16: “. The use” -> “, finding that the use”

Done.

P249, L13: “there” -> “however,”

Added “however”.

P249, L14: Remove comma after “since”

Done.

P249, L15: “it” = “the nucleation”

Done.

P250, L10: Remove “but”, correct spelling of “uncontrolled”

Done.

P250, L11: “to be realistic” -> “for the results to be realistic”

Done.

P250, L13: “onto” -> “on”

Done.

P251, L1: “go” ???

Correct spelling is “of”, corrected.

P251, L7: deMore 1994: Not any recent update? JPL 2006? 2010?

Not at the moment in the default mechanism (see section 7.2).

P251, L8: Can you really say 2003 is recent?

Changed in “Aumont et al. (2003) ... “

P251, L10: “so a new reaction is added” -> “which is included in chimere”

Done.

P252, L26: “and the results have shown ...” -> showing a tendency to underpredict 2-8 times ...”

Done.

P253, L4: I don’t understand what you mean by “modern carbon amounts”.

Modern is non fossil carbon. Sentence changed to “, ... which is an indicator of modern (i.e. non fossil) carbon amount”.

Section 8

P253, L15: Comma after “Second”

OK added

P253, L16: Remove “and” after “Third,”.

done

P253, L17: “solubility” -> “water solubility”

done

P253, L18-19: “the particle ...” Velocity is not a force, rewrite e.g. as “the particle is subject to gravity, falling with a settling velocity vs”.

Yes right, this was changed.

P254, L6: What do you mean by “slip correction factor”? What is it physically? Drag? Wind resistance?

yes, this is a drag coefficient accounting for the fact that particles may become smaller. We added the reference to [Seinfeld and Pandis, 1998] for details.

P255, L3: Reference for ψ (psi)?

Yes, this is a similarity function and the reference of [Zhang et al., 2001] was added. The sentence was also rewritten to be more clear.

P255, L7-10: Change “=” to “ff”. I’ve seen this when you cut and paste from pdf into text editors. NOTE that there are several of these in this section!

Yes, it seems there is a problem like that. But compiling with pdf_latex, all these characters are not visible. We checked the complete paper to avoid this by retyping manually all signs.

Section 9

P256, L20-21: And for each of the partial COD, the model picks one, right?

yes, one depending on the model level. This was added in the text.

P257, L1: “using an assumption” -> “assuming”

corrected

P257, L2: “an assumption” -> “and”

corrected

P257, L6: Reference for this?

no, this is a simple scheme made by chimere developers.

P257, L15-19: Reference?

no, this is a simple scheme made by chimere developers.

P257, L23: put "and" between "acid" and "ammonia".

done

P257, L24: Consider "revertible" vs. "reversible".

OK corrected.

P258, L1: "two phases ..." -> "gas and aqueous phases, there are two simultaneous reactions occurring"

OK corrected

L258, L5-6: Reference?

yes this is [Bessagnet et la., 2004] cited a fewlines before.

L258, L16: Reference?

always [Bessagnet et la., 2004]

L259, L2-3: This sentence seem out of place.

Yes! right and removed.

L259, L23: Why will it be improved?

Not clear and just a promise... removed.

Section 10

P260, L2: Remove "fields".

OK removed

P260, L19: Remove "...", instead use "e.g." up front.

OK done

P261, L4: "which constitute an opportunity to use" -> "which comprise"

OK replaced

P261, L29: Misspelled "campaing" -> "campaign". Change "ran" after "model".

OK done (with "was used")

P261, L29: What is previsibility?

Sorry, this is predictability.

P262, L2: "aerosols": which aerosols? All?

No only dust. This was already said one sentence before then removed.

P262, L14: "faithfully"? Use a better word.

OK and this is accurately

P263, L6-8: Sentences are, or seem, irrelevant.

yes and this was removed.

P263, L11: "certainly" -> "probably"

OK corrected.

P264, L18-19: "were the duration of these comparisons ...": This makes no sense, please correct what is wrong or rewrite sentence.

OK.

Section 11

P265, L20: Are you introducing "hybridation" as another word for "assimilation"? What is the difference?

We changed this title to Data assimilation. The title of Section 11.3 has been changed into "Analysis of concentration fields".

P265, L21: "direct": Is there an indirect CTM?

"Direct" or "forward" are often used to distinguish the forward model from the adjoint. We changed "direct" into "forward".

P266, L2: "these" -> "the mentioned". But which of the applications are not powerful tools?

Change done. The adjoint is a powerful tool but other tools are also available (and sometimes are actually more efficient in practice) for example, analytical inversion using only the forward model if the problem is linear enough, or using a Lagrangian model to compute footprints instead of the adjoint of a Eulerian one.

P266, L3: "adjoint": I'm not familiar with this use of the word. Do you mean "version"? "branch"? What is the difference to the "model" only?

P266, L10: "model adjoint" see point above.

The adjoint code realizes the adjoint of the model in the sense given to "adjoint" in linear algebra: it computed the derivative of a simulated quantity (e.g. a concentration) to all input parameters (e.g. emission fluxes, temperature, reaction rates). The adjoint is then a different code from the forward model but follows the same architecture. "model adjoint" changed into "model's adjoint"

P266, L10: "to have a parallel version to apply to": weird/difficult or wrong sentence.

Sentence changed into: "Currently, a new branch of the model's adjoint is under development: the version applied to regional CO2 fluxes inversion over western Europe (Broquet et al., 2011) is being parallelized."

P266, L13: "were for the Paris area pollution" -> "were for pollution in the Paris area"
Change done.

P266, L19: "NOx are" -> "NOx is"
Change done.

P267, L8: "specie" -> "species", "than" -> "as"
Changes done.

P267, L24: "surface and satellite ozone" -> "surface and satellite measurements of ozone"
Change done.

Section 12

P268, L 5-6: Remove "by studying its predictability", it is included in "to validate".
Certainly p.269, not 268. Corrected.

P268, L9: "developments" -> "development"
corrected.

P268, L16: "LSM": define this.
OK. Added in the text: Land Surface Models (LSM)

P269, L2: "in several" -> "on several"
OK corrected.

P269, L3: "...": Use "e.g. O3, NO2, PM10, PM2.5."
certainly p.270 here. OK corrected.

P269, L7-9: "recommendations for the protection of sensitive people": Rephrase the whole sentence, e.g. "Forecasts of pollution above accepted threshold levels are essential for public information."
OK corrected.

P269, L13: "to set-up": Either remove "-" ("set up") or remove "to set-up" altogether.
OK for set up.

P269, L14: Remove "to communicate"
removed

P269, L25: "modulation": I don't know what it means, but remove comma after. Also, the sentence is difficult; perhaps better as "the modulation of wood burning emissions from residential heating with temperature" or "the temperature modulation of ..."

Yes the sentence was not clear and is now: "The wintertime PM episodes forecasts are also improved by taken into account the variability of climatic conditions when calculating the wood burning emissions from residential heating."

P269, L26: Misspelled "contitions" -> "conditions"
corrected.

Section 13

I don't see any conclusions here. The subsections are not conclusions, hence misplaced. They seem to be future aspects, which you could put into a section before conclusions.

This last section was changed by creating new sections and moving some parts to be more precise with the future applications and a real conclusion of the paper.

P271, L21: "plumes" -> "emission plumes"
in fact this is: "for concentrations plumes due to mineral dust, forest fires and volcanic emissions."

P271, L22: Remove "The main specificity", change "(" and ")" into commas, change "their" -> "having", remove "is that they".
complex but OK, done

P272, L1-4 : Do these act as clouds above the model also ?
No, not for the moment, but this is certainly a development to do.

P272, L16: "default" -> "standard"

changed

P274, L2: "associated to": I think you mean "were set for"
yes, correct and corrected.

P274, L19: "contours" -> "conditions"
of course, corrected.

P276, L12: Comma after "scenarios"
OK done

P277, L20: "we are interested to" -> "are"
OK corrected.

Tables & Figures

Table 1: "needleaf" -> "needleleaf"
OK corrected.

Table 4: There are several "(*)", but it does not say what it means.

This is in the caption: stars are for ions molecules and crystals.

Table 8: "which data were used": Used for what? That has been used in Chimere comparisons?

OK we changed to "International projects involving CHIMERE (in chronological order). Names with a * correspond to field campaigns for which meteorological and chemical data were used to validate CHIMERE."

Figure 1: misspelled "stabds" -> "stands"
done and also for "length"

Figure 4: "et" -> ""
done

Figure 5: "needleaf" -> "needleleaf"
corrected

Figure 20: "After Valari and Menuit": Shouldn't it be "Valari et al (2011)"?
No, the reference here is correct.

Answer to reviewer #1 by A. Kerkweg (Editor)

Dear reviewer,

thank you for your thorough review. As Editor I think I have to comment on your general remarks, which are given in bold italics below:

This paper is partly a description of the CHIMERE-CTM, but largely a review of the CHIMERE-CTM research already published. As far as I can tell, it does not contain any new research. The manuscript bears the impression that it was not fully read through before submission, even containing a paragraph or two that clearly should have been deleted.

This implies a different view of the aims of an access review performed by the topical editor as is given in the guidelines of GMD, see:

http://www.geoscientific-model-development.net/review/review_process_and_interactive_public_discussion.html

There you read:

"2) The Topical Editor is asked to evaluate whether the manuscript is within the scope of the journal and whether it meets a basic scientific quality. The Topical Editor can suggest technical corrections (typing errors, clarification of figures, etc.) before publication in GMDD. Further requests for revision of the scientific contents are not allowed at this stage of the review process but shall be expressed in the interactive discussion following publication in GMDD."

Therefore, I decided that the paper meets in general the scope of GMD and it is technically in a shape to be released for the public discussion. It is not my duty to ask for the deletion of section etc at this stage. This is the task of the reviewer. The paper does not need to include new scientific contents, so I agree with you, that the technical model description should be intensified, while the description of the already performed

science could be shortened.

The abstract does not indicate the purpose of the paper. Is it a description of the CHIMERE-CTM, or is it a review of existing research using it? The title indicates the latter, for which I think GMD is the wrong place.

As I see it, the paper as model description paper, I agree with you, that the abstract does not really contain a description of the contents of the article. A slight change of the title may lead to a better indication of the contents, for example: "CHIMERE: a model for regional atmospheric composition modelling"

There is no conclusion in the conclusions section.

I agree, if the section is kept, it should be labeled differently.

A thorough model description is useful and should be suitable for GMD, but at this stage I think the paper lacks substance and details: Several equations in the describing/technical sections lack references, which needs to be sorted out. Other equations are given along with references, so it would be good to comment on why equations are repeated. I agree that repeating would be suitable for a proper manual or technical document, if that is what the authors aim at.

In principle I agree, but it would have been very helpful to be more precise about the equations/references. So we all have to guess which ones you meant.

The last sections (11-12) do not really describe much, other than listing earlier research and that the model can assimilate observations and be run in forecast. I find the review of existing research too long and uninteresting, mainly listing results from previous studies. That said, although a model description paper should have some model evaluations included, it may be that it can be enough to refer to other publications instead of repeating it.

Basically I agree, but I would say that the content of sections 10-13 should be condensed, however a pure list of references would be too short from my point of view. I am very interested in the views of the other reviewers especially concerning this point.

That said, although a model description paper should have some model evaluations included, it may be that it can be enough to refer to other publications instead of repeating it. But I struggle to find the news in this paper, and also to see the aim of it. I think that for GMD the paper should be more technical than it is, really describing the model. However, I wonder, with the large amount of publications referred to, aren't the parts of the model description already included in those papers? Or is the aim of this paper to collect all the bits and pieces to one reference and in that sense to produce a CHIMERE review?

As GMD was established in order to provide the opportunity to publish the developments and technical whereabouts of a model in reviewed literature, I think it is ok to aggregate all bits of technical description of a model in one GMD paper to have a citable basis (similar to a technical report in grey literature prior to the existence of GMD). It should not be a review paper of the scientific research performed with this model. Nevertheless, a short overview of the research performed with the model so far, is an interesting information from my point of view.

Anonymous Referee #2

This paper gives an overview of the parameterizations in the standard CHIMERE model configuration for regional atmospheric composition modeling. Also available optional parameterizations are described, along with a brief discussion of their respective performances. Also a glimpse of the historic perspective and outlook for future developments is given. From the manuscript it is clear that CHIMERE is used in a wide variety of applications, and the manuscript seems not have the intention to document the performance of a

baseline CHIMERE model version. However, for an outsider it is unclear which version of CHIMERE this manuscript refers to and how version control is managed in practise.

The manuscript was updated because between the submission and this revision, we released the new version, CHIMERE2013. And this is the name now given in the manuscript.

Furthermore, due to the scope of the manuscript, it is quite lengthy. Also it provides many types of information that does not necessarily be part of a peer-reviewed publication. Especially the historical perspective, mentioned at times throughout the manuscript, and various presentations of the model illustrated with figures is rather anecdotic and does not yield quantitative information. The reader is rightly referred to relevant papers though. I acknowledge that having this information combined with the technical details in a single manuscript makes it more useful as a reference model description paper. Therefore I don't object, but also don't have many comments on these aspects.

Yes, this is the goal, to have a reference model description. We agree this is a little bit lengthy. But we think this is the right moment for us (model developers) to write all development choices we made and to explain them.

The manuscript is generally reasonably well written, although the English formulation would benefit from a textual revision. I recommend this manuscript to be published in GMD after responding on the comments given below, and after a double-check on the language mistakes (some of them I mention in the technical comments).

General comments:

Abstract:

The abstract reads like an anecdote of what CHIMERE is and what it used for. It should be made clearer what can be expected in the manuscript. Therefore I recommend to include in the abstract one (or two) sentence(s) like: "In this paper all numerical and scientific choices in CHIMERE are described in detail, as well as ongoing and planned developments."

OK, done. The abstract was completely rewritten to explain this paper is a reference model description paper.

P209, L15: In this section I miss a description of the code management procedure, and the actual version name, or number, of the model as described in this manuscript (see also my comment above). How often is the standard CHIMERE software being updated? Is standard version performance in some way being monitored, guaranteed, and/or documented?

OK this was added. The paragraph was slightly changed to be more clear.

In conclusions I miss a summary of the strengths and weaknesses of parameterizations as adopted in CHIMERE, as could be composed from the extensive model description given before. This could form the basis of a set of recommendations for improvements of existing parameterizations.

Yes, this is correct and this is the new conclusion.

Now it seems the summary mainly consists of an outlook of future applications of CHIMERE. In the current form I would also suggest to rename this section "Conclusions and Outlook".

This was done accordingly with one section "specific applications", "future directions", then "conclusion".

Otherwise, considering that the subsections, e.g. Sect. 13.3: "Heavy metals", is rather lengthy and don't really fit as a "conclusion", the authors may want to move these subsections outside the conclusions, e.g. including a new "specific applications" section just before.

Yes, this corresponds to the new sections.

Technical comments:

P205, l 9-10: “. . .quantified within chemistry-transport models (CTMs). The offline CTM CHIMERE uses. . .

OK corrected

P206, l 6:”sulphur dioxide”

corrected

P206, l 11: “action” -> “influence”

corrected

P206, l 12: “inaccurately” -> “incorrectly / erroneously”

corrected

P206, l 7:”. . .and the results of recent studies.” Which results? What aim? Please clarify briefly.

we added: "included in the CHIMERE model and the results of recent studies explaining why were made the last model improvements."

P208, l3:”than”->”as”

corrected

P209, l12:”One goal of this paper is to describe in detail all. . .”

corrected

P209, l16:”CHIMERE is available under. . .”

corrected

P209, l24:”. . .to the users of the model.”

corrected

P210, l16:”. . .from a Cartesian. . .”

corrected

P213, L24-L25: Consider reformulation of this sentence; please align with p228, l5.

In this section, we are presenting the way to make a vertical mesh. This is not the same than in page 228, where we are explaining how is managed the vertical transport (independently of the vertical mesh). But the sentence was reworded to be more clear.

P215, L1, “. . .classes, the CHIMERE land. . .”

corrected

P215, l6:”. . .whole simulation period.”

corrected

P224, l10:”When it is. . .” Please consider reformulation (break-up) of this sentence.

The sentence has been shortened and reformulated, and an error in the direction of the inequality has been corrected.

P225, l3:”. . .simple 1st order numerical schemes. . .”

Done

P227, l 9:”. . . due to the neglect of. . .”

Done

P230, l8: Timmermans et al., 2009. It is a bit confusing to see the reference to Timmermans wrt the use of the TNO inventory. I would expect a reference to “van der Gon et al.” or so.

Yes, that's right. We changed this reference by:

Kuenen, J. H. Denier van der Gon, A. Visschedijk, H. van der Brugh, High resolution European emission inventory for the years 2003-2007, TNO report TNO-060-UT-2011-00588, Utrecht, 2011. (<https://gmes-atmosphere.eu/documents/deliverables/d-emis/>)

P231, l2: “. . .are key in pollution. . .”

corrected

P231, l6-10: Consider reformulation (break-up) of sentence. Consider the language use.

break-up done

P231, l19 :”. . .two distinct stages (see Fig. 9):”

done

P232, l12:”TNO” please include appropriate reference (see comment above)

OK done.

P232, l18-l22: consider reformulation of sentence.

OK done

P238, l26: "experiment" should be "development".

now this is "on-going"

P239, l3: It is a bit confusing to read once again a section on dust emissions. Please merge this section with sec. 6.3, or make more clear the distinction between the two sections.

Yes, that's right, the two sections were merged.

P244, l9-l17: remove these two obsolete sections.

Removed. We apologize for that, it was caused by direct editing of text by many authors.

P251, l13: ". . .scheme for SOA formation implemented. . ."

Done.

P256, l3: "corrections": What kind of corrections are those? Please clarify briefly.

Done.

P256, l8: "Impact of clouds on photolysis": Please make more clear what is the recommendation.

Also it might be interesting to learn about the magnitude of degradation when one of the simplified assumptions for evaluation of COD is selected.

This sentence was added: " If the liquid and ice water content are available in the input meteorological fields, we recommend to use the first option."

Yes, this could be interesting to make an evaluation of all configurations: we made this and we saw this is very sensitive to the input meteorological used and to its vertical resolution. This was never published but could be an interesting future study.

P257, l24, P258, l14: ". . .irreversible. . ."

done

P259, l21-l22: Consider reformulation of sentence.

yes, done.

P261, l29: "previsibility"-> "forecast performance"

changed by predictability

Figures: It seems not all figures are referred to from the text (e.g. Figs 3/9/10). Please check.

Yes, that's right and this is now fixed.

Anonymous Referee #3

1. General summary

This paper presents a very detailed overview of the CHIMERE model from its initial development to current ongoing work. The model structure, including the dynamical and physical cores, is described in great detail and plenty of references are given for further reading. Ample space is also given to the description of the input data (emissions) and the possible applications of this type of model. Evaluation and data assimilation are also discussed in dedicated sections.

The paper is written with a pedagogical application in mind and I can see its usefulness for new users of the model, as well as PhD students wanting to learn about atmospheric composition modelling. I assume that this type of detailed description is appropriate for the readership of GMD.

The paper is well-written. I only have a few comments to improve readability (see below), but I do recommend publication without any doubts.

We thank the reviewer for his suggestions and remarks, all taken into account in the manuscript.

2. Specific comments

Abstract

p. 205 l. 15: "It is a part..." Replace with "CHIMERE is also a part..."

OK

p. 205 l. 20: Full-stop after "scale". Please remove "or at the other end of the spectrum" with "CHIMERE is also being used".

OK

p.205 l.22: Replace "but also, at larger scale" with ", as well as"

The abstract was completely rewritten.

Introduction

p. 206 l. 9: remove “and although it has always existed”

done

p. 206 l. 14: “over long distances”

done

p.206 l. 23: remove “calculations”

done

p.206 l.25: “for community use”

done

p.206 l.28: “experiments, analysis studies, and for long-range...”

corrected

p.207 l.13: remove “preparation” and add “and”

in fact, all the beginning of the sentence was removed. This is now more clear.

p.207 l.16: full-stop after “10”. “The hybridation (is that a word?) between model and observations... is discussed in Section 11.”

Yes hybridation is correct and a dot was added.

CHIMERE model overview

p.208 l.6: “operational”

corrected

p. 208 l.7: “over health”

corrected

p.208 l.9: “(1997)” replace with “released in 1997”

The sentence is now: "The first model version was released in 1997 and was a box model covering the Paris area..."

p.208 l.13: “At the same time...”

OK corrected.

p.209 l.12: Remove “finely”. “Describe” instead of “described”

OK corrected.

p. 209 l.18: replace “technic” with “technical”

OK corrected.

p. 209 l.21: move “files” before the parenthesis

done

p. 209 l.27: “two-day”

done

Emissions

p.230 l.22: “split”

done

p.230 l.11: replace “in the course” with “on-going”

done

p.231: “anthropogenic emissions have to be prepared in a bottom-up way” - there has been studies showing that inverse modelling (i.e. top-down) approaches can also work well. Could you reword the sentence to make a more general statement and mention also “new” approaches by giving a reference? For example:

Huneus, N., O. Boucher, and F. Chevallier: Atmospheric inversion of SO₂ and primary aerosol emissions for the year 2010, Atmos. Chem. Phys. Discuss., 13(3), 6165-6218, 2013.

Huneus, N., Chevallier, F., and Boucher, O.: Estimating aerosol emissions by assimilating observed aerosol optical depth in a global aerosol model, Atmos. Chem. Phys., 12, 4585-4606, doi:10.5194/acp-12-4585-2012, 2012.

Yes, there is not only the bottom-up approach for emissions. Inverse modelling is widely used to retrieve emissions but this is mainly for global emissions (not regional) and for species not very chemically reactive.

A previous study was done at the regional, Pison et al., and is described later in the paper. The proposed references are very interesting studies but a little bit out of the scope of this section about "anthropogenic emissions". But, the second one [Hunneus et al., 2012] is relevant for the dust sections and was added at the end of the description of dust emissions.

p.232 l.18: "The data is delivered as tons per year. A sensitivity study...profiles. It was shown that..."
this part was completely rewritten

p.233 l.21: strange symbol for size, use "r" or "D"
OK replaced.

p.233 l.28: "This inventory estimates the soil emission to be of the order of 20% of the emissions from combustion on a European average, during the summer months, but with large difference between the countries."
OK done

p. 234: "Biogenic and sea-salt emissions"
This is now two sections.

p.234 l.5: "CHIMERE"
OK

p.235 l.17: "Sea salt emissions are processed"
yes already changed

p.235 l.25: "and estimate the relative part of mineral dust in the total budget of aerosols near the surface, after long-range transport. This latter process influences air quality in Europe and needs to be accounted for."
thanks. A new sentence is proposed.

p.236 l.22: "This shows that it is possible..."
OK changed

p.236 l.23: before "observed", put "such as those"
done

p.236 l.26: please provide a short one-line summary of the findings from Menut (2008) relating to the impact of the meteorological forcing.
OK we added: It was shown that a meteorology is able to diagnose one dust event and not the other, depending on the wind speed and the time period. This highlighted the huge sensitivity of dust emissions to the surface meteorology used.

p.238 l.26: replace "under experiment" with "on-going"
done

p.239: I would suggest moving section 6.5 to be 6.4 as it is more relevant right after the discussion of the dust emissions. The fire emission section can be last.
yes, done.

Chemistry

p.239 l.6: remove parenthesis.
OK done

p.239 l.7: remove "only"
yes removed

p.239 l.11: "...by turbulence is also a distinct process. The extraction results from the..."
OK corrected.

p.240 l.3: "In absence"
OK done

p.241 l.4: put "applications" after "forecast"
The sentence was removed.

p.242 l.22: "The results show that MELCHIOR1 simulated yields agree within 20% with the reference mechanisms. This agreement increases to 5%..."
Done.

p.243 l.15: "COD" in parenthesis.
Done.

p.244 lines 6-17: repeated lines, please remove.

Removed. We apologize for that, it was caused by direct editing of text by many authors.

p.248 l.2: remove the extra "the"

Done.

p.248 l.4: numerate 1. and 2. the bullet points and then refer to them as "Case 1" and "Case 2".

Done.

p.248 l.10: 3% and 99%

Done.

p.248 l.14: "but" before "some errors"

The sentence was changed.

p.251 l.10: replace "is" with "has been" and remove parenthesis

The sentence was changed.

8. Dry Deposition

p.253 l.7: remove "as" before "commonly"

OK done

p.253. l.9: Figure 13 is not very clear

The caption was rewritten to better explain the figure.

p.253 l.20: "The dry deposition velocity for gaseous species is expressed as"

OK done

p.254: replace "used as" with "set to"

corrected

p.254 l.13: "where M_{air} is ..."

corrected

p.254: Section 8.2 should come directly after the description of "Dry deposition"

yes the two sections were exchanged.

p.255 l.14: "summer"

corrected

p.256 l.13: COD is already defined

Yes, but the article is very long and we prefer to repeat some acronyms for the reader.

p.257 l.6: I actually disagree with this statement. Liquid/ice water contents receive a lot of attention so you cannot say that they are "unverified" and "unstable" parameters. You can say that they are uncertain parameters but so is cloud fraction. I actually think that a parameterization for COD based on LWC and IWC would be better than what currently in the model. It would be something worth looking at. Perhaps the impact will be small but the current parameterizations for COD seem too crude.

Yes this is right. A sentence was added about the best way to estimate COD. And the "unverified" and "unstable parameters" were removed from the text.

The sentence is now: "Another choice is a parameterisation using relative humidity only. It consists in parameterising the COD as a function of the integral"...

p.257 l.24: "reversible"

corrected

p.258 l.14: "irreversible"

corrected

p.259, Equation 59: is "Q" defined? In general, please double-check that all symbols are defined.

yes this was done. Q is the deposition flux.

p.260 l.19: "(i.e. monthly variability, ..., emissions)"

done

p.261 l.3: "French, Spanish, Italian"

done

p.261 l.18: "speciated"

done

p.261 l.20: "campaign"

corrected

p.261 l.29: "campaign"

corrected

p.261 l.21-22: "exercises" and "developing"

OK

p.263 l.3: after "Eyjafjallajokull" add "volcanic plume"

done

p.263 l.11: replace "certainly the oldest" with "a good"

done

p.263 l.17: remove "always", full-stop after "surface data". Rephrase "the changes during the last ten years....capabilities" as it's not very clear.

OK we add: "Enjoying the increase of computational capabilities, these comparisons evolve from a few surface dataset to complete hourly validation over several years."

p.263 l.21: "larger domains"

OK corrected.

p.263 l.23: replace "a lot" with "many"

OK replaced

p.264 l.19: replace "its" with "their"

corrected

p.264 l.28: replace "an overestimation" with "to overestimate"

done

Hybridation between model and observations

p.266 l.26: full-stop after "area".

Change done: "the Paris area. The results"

p.267 l.10: full-stop after "large". Add "therefore" after "was"

Changes done.

p.267 l.13:"suburban"

Change done.

p.268 l.11: "simulations"

Change done.

Forecast

p.269 l.16: LSM, has the acronym been defined - please check all acronyms.

Yes, Land Surface Model was added. All acronyms were checked.

p.270 l.13: remove "to set up".

done

p.270 l.21: "Current research efforts"

done

Conclusions

p.271: Add "and remaining challenges" to the title of the section

The sections were changed and the conclusion is now only a conclusion.

p.271 l.25: Replace "But" with "However,"

done

p.273 l.25: remove "unfortunately"

we completely remove the sentence, not useful.

p.274 l.19: replace "contours" with "conditions"

yes done

Figure 1: replace "stabds" with "stands"

OK done

Figure 3: "with respect to". Define CFL.

OK this was precised, including in the text.

Figure 13: not clear

OK, the caption was extended to better explain the figure content.