

Anonymous referee comments on

“An improved representation of aerosol acidity in the ECMWF IFS-COMPO 49R1 through the integration of EQSAM4Climv12” by Samuel Rémy et al.

This publication presents the new version (49r1) of the IFS-COMPO model. The main new development compared to the version 48r1 is the integration of EQSAM4Clim (v12) to compute the equilibrium between gas, liquid and solid partitioning of secondary inorganic aerosol as long as crustal species. This new implementation also enables the model to deal with aerosol and precipitation pH. Wet deposition also has been updated in particular by rationalising parametrization between gas and aerosols. Other small updates have been included on desert dust, sea salt, carbonaceous aerosols and on aerosol optical properties. After presenting the changes made to the model, the authors presents an evaluation of the aerosol concentrations, especially secondary inorganic aerosols, and pH in aerosol and rain.

This publication is interesting as it presents new developments with a potential of interesting elements linked to aerosol and rain pH and the associated retroactions. The document is sometimes unclear and lacks of references. As the code is not publicly available I did not try to download and use it. Also the data correspond to the three simulations mentioned in the publication are not available.

General comments

The title of the publication highlights the work done on acidity in the model, but the content does not reflect this title. I would recommend change it for something like “An improved representation of aerosol in the ECMWF IFS-COMPO 49R1 through the integration of EQSAM4Climv12”, and maybe add “First attempt at using aerosol acidity”.

The description of the previous version of the IFS-COMPO model, cy48r1, is very unclear. I would recommend to rewrite section 2.1 by avoiding the mention of other version than 48r1, and to be more clear of how different components interacts within IFS-COMPO. Also I would recommend to add a box on Figure 1 that represents IFS-COMPO.

The newly implemented features are too rapidly described and don't give enough details to allow the reproduction of the work done. For example, it would have been interesting to have a table with old and new mass extinction for desert dust (section 2.3.2) or the details of the carbonaceous aerosols ageing parametrization (section 2.3.3).

The results section is also not so clear. I would recommend to have a section for the evaluation in which subsections refers to a comparison type (PM concentrations, AOD, etc). In each subsections you could detail the observational datasets used followed by the comparison. Also when presenting data, a good habit is to present a map with the location of the measuring points used in the study. Moreover, when evaluating simulation against gas and aerosol concentrations, it might have been interesting to also have SO₂ concentrations in order to evaluate the SO₂ oxidation. Then

another section would be used to assess the impact on simulated nitrogen and sulphur life cycle. Also I would recommend to add some possible explanations for the highlighted behaviour when possible. Following this different reasons, I would recommend major revisions before reconsidering publication.

Specific comments

- Page 5, line 139: 'MF' is not used later, you can delete it
- Page 7, line 203-206: Please add a reference to support the affirmation.
- Page 8, line 212-214: Please add a reference.
- Page 10, line 277: [NI] is written twice.
- Page 10, line 284-286: Please add a reference.
- Page 10, line 299 and 304: i2dk, b2cn and i392 are not used later. Please remove them.
- Page 11, line 314: What wavelength is used for AERONET data?
- Page 11, line 317: Please keep AERONET information data together.
- Page 12, line 343: "For SO_4^{2-} moderate increases occur over land" → Do you have an explanation?
- Page 12, line 344: "Which are somewhat moderated by the application of EQSAM4Clim" → Do you have an explanation?
- Page 12, line 353: "(around 2.5 Tg yr^{-1})" → (2.4 Tg yr^{-1})
- Page 12, line 354: "to 2.5 days" → to 2.4 days
- Page 12, line 356: "The lifetime of SO_2 exhibits strong seasonality" → add "not shown".
- Page 12, line 357: Lifetime you get is about 2.5 days, much greater than the ones you give as reference measured by satellite. Do you have an explanation?
- Page 12, line 358; " SO_4 ". There is a "2" missing.
- Page 13, line 375: HNO_3/NO_3 → $\text{HNO}_3/\text{NO}_3^-$
- Page 13, line 377: NH_3^+ → NH_3
- Page 13, line 377-379: Do you have an explanation?
- Page 14: I would suggest to separate Table 2, into two tables, one for PM one for AOD. Also please add the number of measuring stations used for each parameters.
- Page 15, lines 405-409: Air quality exceedances are not properly defined nor shown. Please clarify the sentence and add a figure. Also I would recommend to move this part at the end of this section as it is in the middle of a coherent block.
- Page 15, line 412: "whose observational composite is derived from a wider range of sampling sites" → I don't understand this sentence, could you please clarify your thought.
- Page 15, line 417: You say that the desert dust might be modified by the changes in the wind gust parametrization. But page 11, line 302, you say that the only differences between the experiments

“come only from atmospheric composite modelling updates, and not from changes from the meteorological part of the IFS”. Could please clarify the situation and illustrate the changes in the wind field if necessary.

- Page 15, line 424: “by the CY48R1 and CY49R1 experiments in 20417”. Does that mean that you use other simulation for 2017 or that you compare observations for 2017 to simulations for 2019? There might a correction to do on Figure 6.

- Page 15, line 425: Figure 6 → there is a missing parenthesis.

- Page 16, line 440: between 0.25-1.00 AOD units → I don’t understand to what part of the figure this part make reference.

- Page 16, line 450: “The simulated AE decreases by around 0.1 [...] especially over regions in Africa.” Please add a mention like ‘not shown’ or else as you don’t provide a map of mean AE over this region.

- Page 16, line 452: “SO₄⁻”. I would recommand to have a consistent way of writing SO₄²⁻.

- Page 16, line 457: “are limited”. There is a missing blank.

- Page 17, line 484: “similar to NO₃⁻.” There are two points.

- Page 19, line 519-531: “Simulation and evaluation of aerosol ph at surface”. In this section the authors present aerosol acidity data, but there is no exploitation of the comparison. Please move the part from the next section back to this one and elaborate the discussion.

- Page 19, section 5.2: It seems that your analyse on precipitation pH is based on the fact that precipitation amount are right. Did someone an evaluation of the precipitation rate to support this?

- Page 20, line 555: “the simulaed values show a persistent negtive bias of 0.2-0.4” → Do you have an explanation for this behaviour?

- Page 21, Acknowledgements: this section seems to need an update (MODIS, VIIRS ?, AMON, etc).

- Page 28, Figure 2: These plots are hardly readable. Maybe split it on 2 pages might help. Also, is it possible to adapt the colorbar for NH₃ and NH₄⁺ differences?

- Page 29, Figure 3: The legend on the right panels seems wrong. I think it is CY49R1-CY48R1.

- Page 30, Figure 4: Please change in the legend CY49R1NOEQSAM4CLIM to CY49R1_NOE4C. Also is it possible to add the number of stations used either in the caption or on the plots?

- Page 31, Figure 5: I think there is a mistake, “CY48R1-CY49R1” should be “CY49R1-CY48R1”. Same for CY49R1_NOE4C. The caption indicates than top-right panel is VIIRS annual average, but there is no plot there.

-Page 33, Figure 7: Is it possible to add the number of stations used either in the caption or on the plots?

- Page 34, Figure 8: Same comment

- Page 35, Figure 9: Same comment. Is it possible to complete the caption with the top, middle, bottom indications, and the use of red lines?

- Page 37, Figure 11: the grey line for observations is missing in the legend.
- Page 38-39, Figure 12-13: As you compare pH data in aerosols and precipitation, it would be helpful to have the same colour scale on both figures.
- Page 40, Figure 14: top panels are blurred. Please add the number of stations for the bottom scatter plot.
- Page 41, Figure 15: Please add the number of stations for the three subdomain.