

## Authors' Response to comments of Anonymous Referee #1

### General Comments

*The paper presents another important evaluation for the efficient thermodynamic and chemical aerosol model EQSAM including some additional information on parameterizations and an application. This should be reflected more clearly in the title. EQSAM can be used as module in global and regional models or forecasting systems which should be mentioned explicitly in the introduction. The manuscript might be published after minor revision.*

We thank the anonymous reviewer for her/his positive response and appreciate the thorough review and constructive feedback. We have addressed all comments to enhance the clarity and quality of our manuscript. Our point-by-point response (in black) addresses all comments (in blue).

Title Clarification: We acknowledge your suggestion regarding reflecting the importance of the evaluation of the EQSAM model more explicitly in the title. We have revised the title to better emphasize the significance of the evaluation and its application in global and regional models or forecasting systems. New title: "*A computationally efficient parameterization of aerosol, cloud and precipitation pH for application at global and regional scale (EQSAM4Clim-v12)*".

Introduction Clarity: Thank you for highlighting the importance of explicitly mentioning EQSAM's applicability as a module in global and regional models or forecasting systems in the introduction.

We have revised the introduction accordingly at line 24ff: "*This makes EQSAM4Clim suited not only for climate simulations, but also applicable to air quality applications at the regional and global scale and ideal for high resolution Numerical Weather Predictions (NWP) ...*"

### Specific Comments

*Line 96: This sentence has to be improved for clarity. Does this mean a total factor of 100 in case D3? The use of 'N' together with 'XN' is also confusing, better use another letter (or 'Xn').*

Line 96: Yes, this means a total factor of 100 in case D3. We'll consider using 'YN' instead of 'N' and we have revised the sentence for clarity to:

"For cases outside this range ( $XN \geq 0.9$  or  $T \geq 293K$ ), XN needs to be scaled by 10 and multiplied by the factor YN given in Table 1, ..."

*Line 159: "including E-AIM" should be inserted after "models" for better understanding the following.*

Line 159: We have inserted "including E-AIM" after "models" for better comprehension. The revised sentence reads:

"In Pye et al. (2020) five distinct cases were defined and used to evaluate the simulated pH of various thermodynamic models applied in large-scale models, including E-AIM."

*Lines 167-177: This can be expressed in a shorter way.*

Lines 167-177: We have condensed it to two lines (instead of three) for each bullet by replacing "2646 data points" by "N=2646", "The Netherlands" by "NL", "China" by "CN", and by deleting "composition including" and "reduced composition" for each bullet point.

*Line 234: Refer also to Fig 7b and say that V10 is worse here.*

Line 234: We'll refer to Fig 7b and specify that V10 performs worse in this scenario: "Bi-sulfates are not always captured in the gas/liquid partitioning compared to cases which include semi-volatile compounds (Cabauw, Tianjin, WINTER), but v12 still outperforms v10 (comparing Fig. 7a and b)."

### *Technical corrections*

*Line 10: Define acronym, line 44 is too late.*

Line 10: Changed to: ... Extended Aerosol Inorganics Model (E-AIM) ...

*Line 13: The acronym is already defined in abstract.*

Line 13: Changed to: EQSAM was developed ...

*Line 16: Define acronym IFS, line 28 too late.*

Line 16: Changed to: ... ECMWF's Integrated Forecasting System (IFS) ...

*Line 25: Acronym already defined in abstract.*

Line 25: Changed to: ... NWP ...

*Line 17: Has the accompanying paper a reference? Or the references in lines 27, 243f? Define acronym.*

Line 17: We have added the missing references of the the accompanying paper Rémy et al. (2024) (<https://egusphere.copernicus.org/preprints/2024/egusphere-2023-3072>) and we have defined the IFS-COMPO acronym so that the sentence now reads:

"... implemented in the Integrated Forecasting System (IFS), with extensions to represent aerosols, trace and greenhouses gases, being called "IFS-COMPO" (also previously known as "C-IFS", Flemming et al. (2015)); see the accompanying paper (Rémy et al. (2024))."

*Line 74: Define also Z\* and H+\* here (missing for Eqn.5).*

Line 74: We have extended the sentence to include: "... (following the neutralization reaction order given by Table 3 of Metzger et al. (2016a)), by using the effective hydrogen concentrations  $H^{+*}$  and  $Z^{*}$  that are derived from Eqs. (1–8)."

*Line 84: Parentheses messed up.*

Line 84: Changed to: ... "auto-dissociation of water  $K_w$  [ $\text{mol}^2/\text{kg}^2(\text{H}_2\text{O})$ ]".

*Line 91: Typo*

Line 91: Changed to: "depends".

*Lines 117 and 144: Remove the repetitions of the definitions in line 109f.*

Line 117, 144: We have removed the repetitions of the definitions.

*Line 166ff: This punctuation is confusing, use ',' instead of '-' between species and '+' instead of '/' as in caption of Fig. 2.*

Line 166ff: We have changed the punctuation accordingly.

*Figure 2 to 6: It would be better to use actual time as abscissa than the data point number (as Fig. 8). The additional title near the abscissa of panel d should be removed and might appear in caption.*

Figure 2-6: We prefer not to consider using the actual time as the abscissa for Figures 2 to 6, since the data gap is too large which will reduce and not enhance clarity. The gaps can be seen in Figure 8 for the Cabauw case, which shows the data too condensed to be clear for most of the other cases.

*Figure 8: Don't mess up different notations for time at abscissa (dd/mm/yy and mm.dd.yyyy.hh).*

Figure 8: We have changed the time notation for Figure 8.