

Authors' Response to Reviewer 2 of GMDD Manuscript “Operational chemical weather forecasting with the ECCC online Regional Air Quality Deterministic Prediction System version 023 (RAQDPS023) – Part 1: System description” by Moran et al. (2026)

General comments:

This manuscript presents the operational chemical weather forecasting system of ECCC. I would like to express my applause for the authors' many works to summarize this. This will be beneficial to trace the entire history of modeling development in ECCC, and we can learn from this broad perspective in this manuscript. Therefore, it's unavoidable that it ends up being long. I do not have any critical concerns about its current presentation quality, but I have minor requests for improving the readability.

Response: We thank the reviewer for their generous assessment of this manuscript and for their helpful comments. We respond below (in blue font) to their specific comments.

Specific comments:

Abstract (after line 30): Because the Part 2 manuscript presents the modeling performances not only for PM_{2.5} but also for gases and depositions, it would be better to provide this relevant information, such as ADOM-2 gas-phase chemistry. The current description just relies on the aerosol.

Response: Thank you for this comment. We have modified lines 34–37 of the Abstract to include information about the gas- and aqueous-phase chemical schemes.

“Details covered in this paper include a summary of the dynamical representations and physical parameterizations used in the three GEM-based forecast systems, which are highly harmonized, the chemical **species and** parameterizations used in the MACH chemistry module, **including gas-phase, aqueous-phase, and inorganic heterogeneous schemes and associated** numerical solvers, system inputs, including both anthropogenic and natural emissions of chemical species, system outputs, and run configuration, strategies, and timings. One simplification **in addition to the use of the condensed ADOM-2 gas-phase chemistry scheme that was made** to reduce RAQDPS023 execution time for operational deployment was to ...”

Lines 967-968: I understand that these emissions were not considered in RAQDPS023, but is there a rationale for excluding them from the forecasting system in Canada? Regarding the aeolian dust, I could see the discussion in the final paragraph of Section 3.12; what about other sources?

Response: We agree with the reviewer that a one-sentence mention of model simplifications with respect to natural emissions is insufficient. We have moved this sentence to the end of Section 3.11.3 and expanded it to give a rationale as follows:

“Note, however, that some other sources of natural emissions, including lightning emissions, volcanic emissions, pollen and other biological emissions, **oceanic gas-phase emissions**, and aeolian dust emissions, were not considered by the RAQDPS023. While all of these emissions affect atmospheric chemistry, their impacts on near-surface gas-phase and PM_{2.5} concentrations over Canada are assumed to be small, especially when compared to biogenic, biomass burning, and sea-salt emissions, the three types of natural emissions that are considered. Lightning NO

emissions occur intermittently above the Earth's surface. While they have little influence on surface concentrations locally, they can influence NO_3^- wet deposition (e.g., Appel et al., 2011; Zhang et al., 2018b). Volcanic SO_2 emissions can affect atmospheric concentrations and deposition, but active volcanoes are not a significant source in populated areas of Canada or the U.S. although this is not true in Mexico (e.g., Fioletov et al., 2016). Pollen and other biological PM emissions are an important source of atmospheric PM and aeroallergens, but they occur mainly as particles larger than $2.5 \mu\text{m}$ in diameter, including pollen grains generally larger than $20 \mu\text{m}$ but fungal spores in the $1\text{--}10 \mu\text{m}$ range (e.g., Efstathiou et al., 2011; Sierra-Heredia et al., 2018; Subba et al., 2021). Oceanic emissions of gas-phase species such as DMS and isoprene contribute to background atmospheric chemistry, although DMS emissions are small at higher latitudes and marine isoprene emissions are small compared to terrestrial emissions (e.g., Bates et al., 1992; Khan et al., 2025). However, as discussed in Sect. 6.2 emissions of halogen species such as iodine can affect surface ozone levels. Aeolian dust emissions are discussed further in Sect. 3.12, but such emissions are very sporadic and are much less important in Canada than the U.S.”

Appel, K. W., Foley, K. M., Bash, J. O., Pinder, R. W., Dennis, R. L., Allen, D. J., and Pickering, K.: A multi-resolution assessment of the Community Multiscale Air Quality (CMAQ) model v4.7 wet deposition estimates for 2002–2006, *Geosci. Model Dev.*, 4, 357–371, <https://doi.org/10.5194/gmd-4-357-2011>, 2011.

Bates, T. S., Lamb, B. K., Guenther, A., Dignon, J., and Stoiber, R. E.: Sulfur emissions to the atmosphere from natural sources, *J. Atmospheric Chem.*, 14, 315–337, <https://doi.org/10.1007/BF00115242>, 1992.

Efstathiou, C., Isukapalli, S., and Georgopoulos, P.: A mechanistic modeling system for estimating large-scale emissions and transport of pollen and co-allergens, *Atmos. Environ.*, 45, 2260–2276, <https://doi.org/10.1016/j.atmosenv.2010.12.008>, 2011.

Fioletov, V. E., McLinden, C. A., Krotkov, N., Li, C., Joiner, J., Theys, N., Carn, S., and Moran, M. D.: A global catalogue of large SO_2 sources and emissions derived from the Ozone Monitoring Instrument, *Atmospheric Chem. Phys.*, 16, 11497–11519, <https://doi.org/10.5194/acp-16-11497-2016>, 2016.

Khan, M. A. H., Holland, R., Mould, C., Bacak, A., Percival, C. J., and Shallcross, D. E.: Isoprene emissions, oxidation chemistry and environmental impacts, *Atmosphere*, 16, 259, <https://doi.org/10.3390/atmos16030259>, 2025.

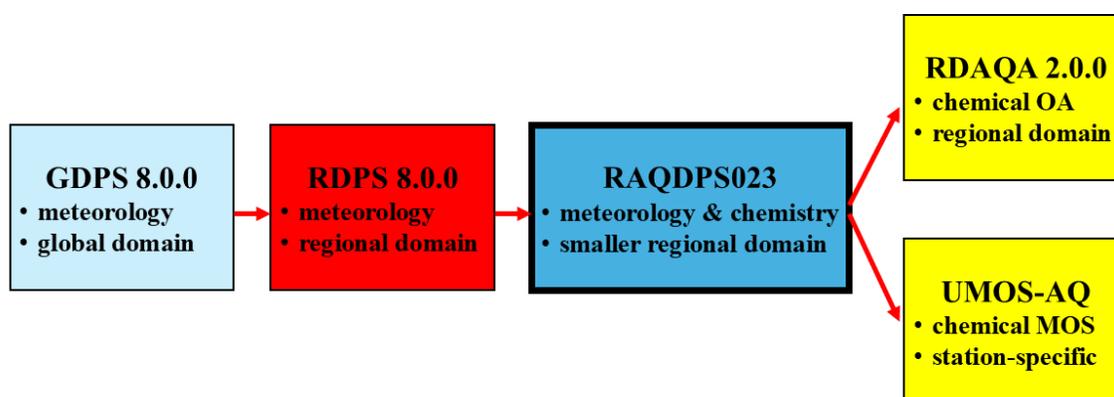
Sierra-Heredia, C., North, M., Brook, J., Daly, C., Ellis, A. K., Henderson, D., Henderson, S. B., Lavigne, É., and Takaro, T. K.: Aeroallergens in Canada: Distribution, public health impacts, and opportunities for prevention, *Int. J. Environ. Res. Public Health*, 15, 1577, <https://doi.org/10.3390/ijerph15081577>, 2018.

Subba, T., Lawler, M. J., and Steiner, A. L.: Estimation of possible primary biological particle emissions and rupture events at the southern Great Plains ARM site, *J. Geophys. Res. Atmospheres*, 126, e2021JD034679, <https://doi.org/10.1029/2021JD034679>, 2021.

Zhang, Y., Mathur, R., Bash, J. O., Hogrefe, C., Xing, J., and Roselle, S. J.: Long-term trends in total inorganic nitrogen and sulfur deposition in the US from 1990 to 2010, *Atmospheric Chem. Phys.*, 18, 9091–9106, <https://doi.org/10.5194/acp-18-9091-2018>, 2018b.

Line 3290 (Figure 1): I would like to request an improvement in this figure. For example, RAQDPS includes various sub-components, and it could be included within this figure. As the final application (post-processing), RDAQA and UMOS-AQ are described, but the purposes for each part could be briefly described in the arrow. Moreover, the colors for RDPS and RAQDPS could be unified in Figure 2 for better presentation.

Response: As suggested by the reviewer we have revised this figure to add more information about key characteristics of each system. We have also made the colours for the RDPS and RAQDPS boxes consistent with the colours used in Fig. 2 for the corresponding system grids.



Technical points:

Lines 321, 335, 910, 916, 1150, 1380, 1528, 1531, 1604: For Moran et al. (2025), it will be better to represent this as “a companion paper by Moran et al. (2025)” (Line 52).

Response: This is a good suggestion, and we have made changes in a number of places in the paper to adopt it. We have also made similar changes in the Part 2 paper to refer to this paper.

Line 520: Use a subscript for the chemical species shown in this line.

Response: We have clarified the meaning of “species” in this sentence, which refers to the model gas-phase species listed in Table 3, by making the following modifications (in bold):

“... abundances of 42 of these **model** gas-phase species were forecast and advected while the abundances of four **model** species (CH₄, C₂H₆, **O₂**, M) had ...”.

Line 577: Use subscript “NH₃”.

Response: Made change as suggested.

Line 3263: Please define “LRT”.

Response: “LRT” is defined in the footnotes to Table 7. However, we have reordered these footnotes for clarity so that we first define L, R, and T, and we have also modified the nomenclature slightly by changing “LRT” to “ L_wRT ”, in order to avoid confusion with the use of the symbol L (for liters) in the units of the universal gas constant R.