

Response to Referee 2 Comments

Abstract, line3: You really only are more consistent with respect to the meteorological part of the modeling system. This should be stated. **Done**

Line 20/21: Where do you show that consistency between models is important? I believe you, but I do not see proof for this in your paper.

This comment is similar to the point raised by Referee 1 and the response is also similar:

Since one of the key differences between the RCM and AQUM simulations arises from differences in the photolysis scheme we believe that this study highlights the importance of aligning process modelling schemes as far as possible when comparing nested model runs. We have therefore modified the abstract text to state: "This study highlights the point that the resolution of models is not the only factor in determining model performance - consistency between nested models is also important."

Introduction: You should find references for modeling systems that you cite: WRF-CMAQ, WRF-Chem, CESM, CESM-NCSU. **Done**

Section 2: A little table would be nice to get an easy look at what parameterizations and chemical modules are used.

Table A4 has been added.

What atmospheric radiation scheme is used?

This is stated in Table A4.

You mention you have the capability to use radiative and microphysical feedbacks. Why did you switch them off?

We have added the following explanation:

"The reasons for this were two-fold: (1) the primary goal of this study was on the simulation of air quality, and not on the impact of air quality on model dynamics, and (2) for statistical significance, much longer simulations are required when radiative and microphysical feedbacks are active (typically 20–30 model years as opposed to 5–7 years without these feedbacks)."

Is there any direct coupling of the convective parameterization to atmospheric radiation and photolysis? This could have a significant impact on Ozone evaluations (see also section 4.2.2).

There is no direct coupling but convection does influence photolysis through the radiation and cloud schemes in the online photolysis scheme used in AQUM. In the offline scheme used in the GCM and RCM the cloud is prescribed. A summary outline of the photolysis treatment in all three models is included in Table A4:

	GCM	RCM	AQUM
Photolysis	Offline, 2-D model with prescribed cloud and aerosol		Fast-J, using online cloud and aerosol

How complex is the aqueous phase chemistry that is being used (I am assuming you have some aqueous phase chemistry, since you allow for interaction with microphysics).

This is stated in Table A4:

“oxidation of SO₂ by both H₂O₂ and O₃ to form dissolved SO₄

For my understanding, in section 3 you mention that sea salt and dust emissions are computed interactively based on surface wind speed, but in section 2 you say that sea salt is diagnosed on ocean grid points. I am assuming that means sea salt is not advected or transported in any way? And there is no memory, so it is purely instantaneous and based only on wind speed?

We have added the following text to Section 3.2 to clarify the treatment of sea salt and mineral dust:

“Mineral dust is a fully prognostic, advected species but, as mentioned in section 2.1, sea salt is not advected and makes no contribution to model aerosol concentrations over land.”

You also indicate that the missing proper treatment of sea salt could be a reason for poor performance of PM₁₀ evaluation. Are there observations that can give you an idea on what the fraction of sea salt with respect to total PM₁₀ is?

We believe sea salt plays a role in the biases but is not the only factor. In section 4.2.3 we have added the following text which addresses this point:

“Poor modelling performance for PM₁₀ is a common feature of many global composition and regional air quality models (e.g. Colette et al., 2011; Im et al., 2015) and is often attributed to the unreliability of primary emissions of coarse component aerosol, both from anthropogenic and biogenic sources. In our simulations the lack of sea salt in modelled values over land points plays a significant role in this under-prediction. Putaud et al. (2010) estimate that over NW Europe sea salt contributes on average between 7% (kerbside sites) 12% (rural sites) of observed annual mean PM₁₀. In periods of strong winds and at sites close to the coast downwind of the sea values may be considerably higher. A related consequence of our lack of inclusion of sea salt is that our aerosol

modelling does not include sodium nitrate and so this coarse component of secondary aerosol is also missing from our estimates.”