Reply to Anonymous Referee #1

We would like to thank the reviewer for the comments and careful reading of the manuscript. Point-by-point replies to the comments are provided below.

1. *Page 4 Line 27, Aerosol species are assumed as a complete internal mixture in each mode, what do you mean the mass of the included species are tracked by separate prognostic variables? Please clarify it.*
2. *Page 4 Line 29, How the prognostic total number of aerosols of each mode is calculated in the TM5?*

The first two questions of the reviewer both concern the representation of aerosols in the M7 scheme. M7 includes five aerosol species (sulphate, black carbon, particulate organic matter, sea salt and mineral dust) distributed over 7 lognormal modes. Each species has multiple prognostic tracers for mass, one for each mode the species exists in. For example, sea salt is assumed to exist in 2 modes: accumulation soluble mode (ACS) and coarse soluble mode (COS); therefore 2 prognostic tracers are used to describe the mass of sea salt aerosol. In total, there are 18 prognostic tracers for aerosol mass. An overview of the distribution of the species over the modes is shown in Figure 3 on page 12 of the manuscript. Additionally, because the aerosol modes are assumed to be internally mixed, each mode has one prognostic variable for aerosol number, so 7 in total. Altogether, M7 uses 25 prognostic tracers to describe atmospheric aerosol. More details can be found in the original paper describing the M7 scheme (Vignati et al., 2004). We adapted the corresponding line in the manuscript to clarify the prognostic variables used in M7 and refer to Figure 3 in the text.

3. *Page 5 Line 1, how do you calculate the optical properties due to the condensed ammonium nitrate?*

Ammonium nitrate is not described by the M7 scheme. A separate routine called EQSAM is used to calculate the partitioning of semivolatile species like ammonium nitrate. The mass of condensed ammonium nitrate is added to the M7 ACS mode. For the calculation of aerosol optical properties, ammonium nitrate is treated similar to sulphate, i.e. the same refractive index is used. This value is taken from OPAC (Hess et al., 1998) and is based on a solution of 75% sulphuric acid. This way, ammonium nitrate has the same impact on the radiative properties as sulphate per unit volume. We have clarified the text and refer to the paper describing the routine: Aan de Brugh et al. (2011).

4. *Page 5, Line 21, How do you set the time step for the TM5, 6 hours or not? What do you mean of the next time step and the artificially introducing mixing?*

The maximum duration of a time step in TM5 is set to 1 hour. Additionally, the Courant-Friedrichs-Lewy(CFL) criterion is applied and time steps are shortened when the threshold is exceeded. The meteorology that TM5 uses, however, is only updated every 6 hours. Consequently, cloud cover, precipitation and thus scavenging strength do not change at every time step in TM5.

In TM5, the removal due to scavenging by large-scale clouds and precipitation is reduced in proportion to the cloudy fraction of a gridbox. However, since the model doesn't have separate tracers for the cloudy and clear parts of the gridbox, this removal reduces the gridbox total amounts. In the subsequent time step the aerosol concentration in the cloudy and clear part is again the same and the aerosols have been 'numerically' moved/mixed from the clear part of the gridbox to the cloudy part. As a consequence, scavenging would remove aerosol too fast from partly clouded grid boxes. To compensate for this, a mixing time scale is introduced, which effectively delays the

mixing between the clear and cloudy parts within the gridbox (see e.g. Vignati et al., 2010). This mixing time scale is set to 6 hours.

The description of TM5 (Section 2.2) has been adjusted to explicitly mention the time stepping of TM5.

5. *Page 6, Line 11, Does the coupler only exchange the meteorological fields at the time snapshot of only every 6 hours? How about the intermediate fields at every 45 minutes?*

Coupled meteorological fields are a time average of the preceding 6 hours prior to the time of exchange. We have clarified the description of the timing of the meteorological fields in Section 2.4.

6. *Page 8, Line 17, How does the IFS calculate the evaporated precipitation fraction?*

IFS does not explicitly calculate evaporated precipitation fraction. Instead, this quantity is diagnosed in the wet deposition routine of TM5 using the values of falling precipitation and precipitation evaporation.

Text has been adjusted to explicitly state that evaporated precipitation fraction is calculated in TM5.

7. *How do you compare the simulated AODs with MODIS? Do you consider the time inconsistent? MODIS combined Terra and Aqua generally only have twice observations per days.*

In this work, simulated AOD is compared to MODIS observations on a monthly mean basis. We do agree with the reviewer that collocation of model results with MODIS overpasses makes the evaluation more consistent. However, such a detailed analysis requires hourly output, slowing down the model considerably. Because the main focus of this work is to address the importance of including the effects of precipitation evaporation and introducing a method to implement this process in a global modal, the choice was made to produce monthly means from daily mean AOD to be compared to the monthly mean MODIS product. For a fair comparison that justifies complete collocation of the simulations and observations, other uncertainties of the aerosol emissions should also have to be addressed and the model would have to be re-tuned.

References

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