

# Aerosols

Aerosols in CAM-Chem are represented using the 4-mode version of the modal aerosol model (MAM-4) from [Liu et al., 2016](#). Background and a description of the basic aerosol model performance can be found in [Liu et al., 2012](#). The 4 modes are accumulation (a1), Aitken (a2), coarse (a3) and primary carbon (a4).

**Special note regarding CAM6 coarse mode:** The geometric mean diameter and standard deviation were changed for CAM6 from those used in CAM5. See Li et al., Geosci. Model Dev., 2022 (<https://doi.org/10.5194/gmd-15-8181-2022>) for more details.

The species that are included in the base chemical mechanism are:

- Black Carbon (bc)
- Primary Organic Matter (pom)
- Sulfate (so4)
- Dust (dst)
- Sea Salt (ncl)
- Secondary Organic Aerosol (soa)
- Number (num)

Secondary organic aerosol is treated using a volatility basis set (VBS) scheme, with 5 volatility bins, derived from [Hodzic et al., 2016](#), including updates to the chemical reaction rates from [GECKO-A](#). More details are available in [Tilmes et al. \(JAMES, 2019\)](#) and [Emmons et al. \(JAMES, 2020\)](#).

The release version of CESM 2.0 also includes diagnostics for surface  $PM_{2.5}$  and three dimensional fields of  $PM_{2.5}$ . The calculation is performed in `/components/cam/src/chemistry/utils/modal_aero_wateruptake.F90`.

CESM2.2 includes scavenging of aerosols in convective transport, as described in [Wang et al., 2013](#).

Currently in development for release are the inclusion of ammonium and nitrate aerosols, along with their aqueous-phase heterogeneous chemical reactions following the MOSAIC scheme combined with MAM4.

## Additional information about the emissions of aerosol numbers

See the supplement of Liu et al., 2012 for more information. In summary, the number emissions must be calculated to match the compound emissions, based on a number of parameters.

$$M_{\text{particle}}[\text{kg/particle}] = (\rho_{\text{spec}}[\text{kg/m}^3] * (PI/6) * (D_{\text{spec}})^3[\text{m}^3])$$

$$E_{\text{number}} [\text{particles/cm}^2/\text{s}] = E_{\text{mol}}[\text{molecules/cm}^2/\text{s}] * mw[\text{g/mole}] * 1.e-3[\text{kg/g}] / Avog[\text{molecules/mole}] / (M_{\text{particle}}[\text{kg/particle}])$$

where,  $Avog = 6.022e23$  [molecules/mole];  $\rho$  and  $D$  depend on species and mode and sector

CESM scales emissions when read in by

$$amufac = 1.65979e-23 \text{ (which is: } (1E-3\text{kg/g}) * (1E4\text{cm}^2/\text{m}^2) / Avog)$$

to convert  $\text{molec/cm}^2/\text{s}$  to  $\text{kg/m}^2/\text{s}$ , therefore number emissions files need to be scaled by  $1/amufac * (1E3 \text{ g/kg}) = 6.02e26$ , so values in emissions files are:

$$E_{\text{file}} = [\text{particles/cm}^2/\text{s}] * (1E3\text{g/kg}) * Avog(\text{molec/mol})$$

So, once in CESM they become

$$[\text{particles/cm}^2/\text{s}] * (1E3\text{g/kg}) * Avog * [(1E-3\text{kg/g}) * (1E4\text{cm}^2/\text{m}^2) / Avog] = [\text{particles/m}^2/\text{s}]$$

So programs creating emissions for CESM can use:

$$MP[\text{kg/particle}] = (\rho_{\text{spec}}[\text{kg/m}^3] * (PI/6) * (D_{\text{spec}})^3[\text{m}^3])$$

$$E_{\text{number}} [\text{particles/cm}^2/\text{s}] = E_{\text{mol}}[\text{molecules/cm}^2/\text{s}] * mw[\text{g/mole}] / (MP[\text{kg/particle}])$$