CMIP6 Model Documentation

Institute:	EC-EARTH-CONSORTIUM
Model:	EC-EARTH3-AERCHEM
Topic:	aerosol
Doc. Generated:	2020-04-08
Doc. Seeded From:	Spreadsheet
Specialization Version:	1.0.2
Further Info:	https://es-doc.org/cmip6
Note:	* indicates a required property

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1 Key Properties

Key properties of the aerosol model

1.1.1 Top level properties

Key properties of the aerosol model

1.1.1.1 Name *

Name of aerosol model code

TM5

1.1.1.2 Keywords *

Keywords associated with aerosol model code

Enter COMMA SEPARATED list:

1.1.1.3 Overview *

Overview of aerosol model.

Enter TEXT:

1.1.1.4 Scheme Scope *

Atmospheric domains covered by the aerosol model

- ☒ Troposphere
- ☐ Stratosphere
- ☐ Mesosphere
- ☐ Whole atmosphere
- ☐ Other - please specify:

1.1.1.5 Basic Approximations *

Basic approximations made in the aerosol model

Enter TEXT:

1.1.1.6 Prognostic Variables Form *

Prognostic variables in the aerosol model

- ☒ 3D mass/volume ratio for aerosols
- ☒ 3D number concentration for aerosols
- ☐ Other - please specify:

1.1.1.7 Number Of Tracers *

Number of tracers in the aerosol model

28.0

1.1.1.8 Family Approach *

Are aerosol calculations generalized into families of species?

Select either TRUE or FALSE:

☐ True ☐ False

1.2.1 Software Properties

Software properties of aerosol code

1.2.1.1 Repository

Location of code for this component.

Https://svn.ec-earth.org/ecearth3/tags/3.3.2/sources/tm5mp/

1.2.1.2 Code Version

Code version identifier.

TM5-mp version 3.0

1.2.1.3 Code Languages

Code language(s).

Fortran

1.3.1 Timestep Framework

Physical properties of seawater in ocean

1.3.1.1 Method *

Mathematical method deployed to solve the time evolution of the prognostic variables

☐ Uses atmospheric chemistry time stepping

☒ Specific timestepping (operator splitting)

☐ Specific timestepping (integrated)

☐ Other - please specify:

1.3.1.2 Split Operator Advection Timestep

Timestep for aerosol advection (in seconds)

1800.0

1.3.1.3 Split Operator Physical Timestep

Timestep for aerosol physics (in seconds).

1800.0

1.3.1.4 Integrated Timestep *

Timestep for the aerosol model (in seconds)

3600.0

1.3.1.5 Integrated Scheme Type *

Specify the type of timestep scheme

- ☐ Explicit
- ☐ Implicit
- ☐ Semi-implicit
- ☐ Semi-analytic
- ☐ Impact solver
- ☒ Back Euler
- ☐ Newton Raphson
- ☐ Rosenbrock
- ☐ Other - please specify:

1.4.1 Meteorological Forcings

1.4.1.1 Variables 3D

Three dimensional forcing variables, e.g. U, V, W, T, Q, P, conventive mass flux

Enter COMMA SEPARATED list:

1.4.1.2 Variables 2D

Two dimensional forcing variables, e.g. land-sea mask definition

Enter COMMA SEPARATED list:

1.4.1.3 Frequency

Frequency with which meteorological forcings are applied (in seconds).

21600.0

1.5.1 Resolution

Resolution in the aerosol model grid

1.5.1.1 Name *

This is a string usually used by the modelling group to describe the resolution of this grid, e.g. ORCA025, N512L180, T512L70 etc.

2x3 degrees

1.5.1.2 Canonical Horizontal Resolution

Expression quoted for gross comparisons of resolution, eg. 50km or 0.1 degrees etc.

2x3 degrees lat-lon

1.5.1.3 Number Of Horizontal Gridpoints

Total number of horizontal (XY) points (or degrees of freedom) on computational grid.

Enter INTEGER value:

1.5.1.4 Number Of Vertical Levels

Number of vertical levels resolved on computational grid.

34.0

1.5.1.5 Is Adaptive Grid *

Set to true if the grid resolution changes during execution.

☐ True ☒ False

1.6.1 Tuning Applied

Tuning methodology for aerosol model

1.6.1.1 Description *

General overview description of tuning: explain and motivate the main targets and metrics retained. Document the relative weight given to climate performance metrics versus process oriented metrics, and on the possible conflicts with parameterization level tuning. In particular describe any struggle with a parameter value that required pushing it to its limits to solve a particular model deficiency.

The offline version of TM5, which is driven by meteorological reanalysis data, contains some tuning parameters. The TM5 version applied in EC-Earth3-AerChem uses the same tuning parameter settings as the offline model driven by ERA-Interim.

1.6.1.2 Global Mean Metrics Used

List of metrics of the global mean state used in tuning model/component

Enter COMMA SEPARATED list:

1.6.1.3 Regional Metrics Used

List of metrics of regional mean state used in tuning model/component

Enter COMMA SEPARATED list:

1.6.1.4 Trend Metrics Used

List observed trend metrics used in tuning model/component

Enter COMMA SEPARATED list:

2 Grid

Aerosol grid

2.1.1 Top level properties

Aerosol grid

2.1.1.1 Name

Name of grid in aerosol model.

Reduced regular grid

2.1.1.2 Overview

Overview of grid in aerosol model.

Regular grid with resolution of 2x3 degrees latitude x longitude. A reduced grid is applied towards the poles. Surface emission fluxes and dry deposition velocities are calculated on a regular 1x1 degree grid.

2.1.1.3 Matches Atmosphere Grid *

Does the atmospheric aerosol grid match the atmosphere grid?

☐ True ☒ False

2.2.1 Resolution

Resolution in the atmospheric aerosol grid

2.2.1.1 Name *

This is a string usually used by the modelling group to describe the resolution of this grid, e.g. ORCA025, N512L180, T512L70 etc.

2x3 degrees

2.2.1.2 Canonical Horizontal Resolution

Expression quoted for gross comparisons of resolution, e.g. 50km or 0.1 degrees etc.

2x3 degrees lat-lon

2.2.1.3 Number Of Horizontal Gridpoints

Total number of horizontal (XY) points (or degrees of freedom) on computational grid.

Enter INTEGER value:

2.2.1.4 Number Of Vertical Levels

Number of vertical levels resolved on computational grid.

34.0

2.2.1.5 Is Adaptive Grid *

Set to true if grid resolution changes during execution.

☐ True ☒ False

3 Transport

Aerosol transport

3.1.1 Top level properties

Aerosol transport

3.1.1.1 Name

Commonly used name for the transport in aerosol model.

TM5

3.1.1.2 Overview

Overview of aerosol transport in aerosol model.

Transport by advection, cumulus convection, vertical diffusion, and sedimentation (see van-Noije-et-al-2014). Advection is described using the first-order "slopes" advection scheme from Russell and Lerner (1981).

3.1.1.3 Scheme *

Method for aerosol transport modelling

- ☒ Uses atmospheric chemistry transport scheme
- ☐ Specific transport scheme (eulerian)
- ☐ Specific transport scheme (semi-lagrangian)
- ☐ Specific transport scheme (eulerian and semi-lagrangian)
- ☐ Specific transport scheme (lagrangian)

3.1.1.4 Mass Conservation Scheme *

Methods used to ensure mass conservation.

- ☒ Uses atmospheric chemistry transport scheme
- ☐ Mass adjustment
- ☐ Concentrations positivity
- ☐ Gradients monotonicity
- ☐ Other - please specify:

3.1.1.5 Convention *

Transport by convention

- ☒ Uses atmospheric chemistry transport scheme
- ☒ Convective fluxes connected to tracers

- ☐ Vertical velocities connected to tracers
- ☐ Other - please specify:

4 Emissions

Atmospheric aerosol emissions

4.1.1 Top level properties

Atmospheric aerosol emissions

4.1.1.1 Name

Commonly used name for the emissions in aerosol model.

CMIP6

4.1.1.2 Overview

Overview of atmospheric aerosol emissions in aerosol model.

Anthropogenic and biomass burning emissions of aerosols and precursor gases from CMIP6. Other emissions as described by van-Noije-et-al-2020.

4.1.1.3 Method *

Method used to define aerosol species (several methods allowed because the different species may not use the same method).

- ☐ None
- ☐ Prescribed (climatology)
- ☐ Prescribed CMIP6
- ☐ Prescribed above surface
- ☒ Interactive
- ☒ Interactive above surface
- ☐ Other - please specify:

4.1.1.4 Sources

Sources of the aerosol species are taken into account in the emissions scheme

- ☒ Vegetation
- ☒ Volcanos
- ☒ Bare ground
- ☒ Sea surface
- ☒ Lightning
- ☒ Fires
- ☒ Aircraft

☒ Anthropogenic

☐ Other - please specify:

4.1.1.5 Prescribed Climatology

Specify the climatology type for aerosol emissions

Select SINGLE option:

☐ Constant

☐ Interannual

☐ Annual

☐ Monthly

☐ Daily

4.1.1.6 Prescribed Climatology Emitted Species

List of aerosol species emitted and prescribed via a climatology

4.1.1.7 Prescribed Spatially Uniform Emitted Species

List of aerosol species emitted and prescribed as spatially uniform

Enter COMMA SEPARATED list:

4.1.1.8 Interactive Emitted Species

List of aerosol species emitted and specified via an interactive method

Enter COMMA SEPARATED list:

4.1.1.9 Other Emitted Species

List of aerosol species emitted and specified via an "other method"

Enter COMMA SEPARATED list:

4.1.1.10 Other Method Characteristics

Characteristics of the "other method" used for aerosol emissions

Enter TEXT:

5 Concentrations

Atmospheric aerosol concentrations

5.1.1 Top level properties

Atmospheric aerosol concentrations

5.1.1.1 Name

Commonly used name for the concentrations in aerosol model.

Enter TEXT:

5.1.1.2 Overview

Overview of atmospheric aerosol concentrations in aerosol model.

Enter TEXT:

5.1.1.3 Prescribed Lower Boundary

List of species prescribed at the lower boundary.

See description of atmospheric chemistry component

5.1.1.4 Prescribed Upper Boundary

List of species prescribed at the upper boundary.

See description of atmospheric chemistry component

5.1.1.5 Prescribed Fields Mmr

List of species prescribed as mass mixing ratios.

Enter COMMA SEPARATED list:

5.1.1.6 Prescribed Fields Aod Plus Ccn

List of species prescribed as AOD plus CCNs.

Enter COMMA SEPARATED list:

6 Optical Radiative Properties

Aerosol optical and radiative properties

6.1.1 Top level properties

Aerosol optical and radiative properties

6.1.1.1 Name

Commonly used name for the optical radiative properties in aerosol model.

Enter TEXT:

6.1.1.2 Overview

Overview of aerosol optical and radiative properties in aerosol model.

6.2.1 Absorption

Absortion properties in aerosol scheme

6.2.1.1 Black Carbon

Absorption mass coefficient of black carbon at 550nm (if non-absorbing enter 0)

Enter FLOAT value:

6.2.1.2 Dust

Absorption mass coefficient of dust at 550nm (if non-absorbing enter 0)

Enter FLOAT value:

6.2.1.3 Organics

Absorption mass coefficient of organics at 550nm (if non-absorbing enter 0)

Enter FLOAT value:

6.3.1 Mixtures

6.3.1.1 External *

Is there external mixing with respect to chemical composition?

☒ True ☐ False

6.3.1.2 Internal *

Is there internal mixing with respect to chemical composition?

☒ True ☐ False

6.3.1.3 Mixing Rule

If there is internal mixing with respect to chemical composition then indicate the mixing rule

Effective-medium approximations are applied to calculate the refractive indices of the internally mixed modes. Sulfate (incl. MSA), ammonium-nitrate, organic aerosols, sea salt, and water are treated as homogeneous mixtures described by the Bruggeman mixing rule. When black carbon and/or dust are present in the mix, these are treated as inclusions in a homogeneous background medium, using the MaxwellGarnett mixing rule.

6.4.1 Impact Of H2o

The impact of H2O on aerosols

6.4.1.1 Size *

Does H2O impact size?

☒ True ☐ False

6.4.1.2 Internal Mixture *

Does H2O impact aerosol internal mixture?

☒ True ☐ False

6.4.1.3 External Mixture *

Does H2O impact aerosol external mixture?

☒ True ☐ False

6.5.1 Radiative Scheme

Radiative scheme for aerosol

6.5.1.1 Overview *

Overview of radiative scheme

The radiation scheme is McRad, which uses RRTMG_SW and RRTMG_LW for the shortwave and longwave, respectively. See description of atmosphere model.

6.5.1.2 Shortwave Bands *

Number of shortwave bands

16.0

6.5.1.3 Longwave Bands *

Number of longwave bands

14.0

6.6.1 Cloud Interactions

Aerosol-cloud interactions

6.6.1.1 Overview *

Overview of aerosol-cloud interactions

Enter TEXT:

6.6.1.2 Twomey *

Is the Twomey effect included?

☒ True ☐ False

6.6.1.3 Twomey Minimum Ccn

If the Twomey effect is included, then what is the minimum CCN number?

Enter INTEGER value:

6.6.1.4 Drizzle *

Does the scheme affect drizzle?

☒ True ☐ False

6.6.1.5 Cloud Lifetime *

Does the scheme affect cloud lifetime?

☒ True ☐ False

6.6.1.6 Longwave Bands *

Number of longwave bands

14.0

7 Model

Aerosol model

7.1.1 Top level properties

Aerosol model

7.1.1.1 Name

Commonly used name for the model in aerosol model.

TM5

7.1.1.2 Overview *

Overview of atmospheric aerosol model

7.1.1.3 Processes *

Processes included in the aerosol model.

- ☒ Dry deposition
- ☒ Sedimentation
- ☒ Wet deposition (impaction scavenging)
- ☒ Wet deposition (nucleation scavenging)
- ☒ Coagulation
- ☒ Oxidation (gas phase)
- ☒ Oxidation (in cloud)
- ☒ Condensation
- ☐ Ageing
- ☒ Advection (horizontal)
- ☒ Advection (vertical)
- ☒ Heterogeneous chemistry
- ☒ Nucleation

7.1.1.4 Coupling

Other model components coupled to the aerosol model

- ☒ Radiation
- ☒ Land surface

- ☒ Heterogeneous chemistry
- ☒ Clouds
- ☒ Ocean
- ☐ Cryosphere
- ☒ Gas phase chemistry
- ☐ Other - please specify:

7.1.1.5 Gas Phase Precursors *

Gas phase aerosol precursors.

- ☒ DMS
- ☒ SO2
- ☒ Ammonia
- ☐ Iodine
- ☒ Terpene
- ☒ Isoprene
- ☐ VOC
- ☒ NOx
- ☐ Other - please specify:

7.1.1.6 Scheme Type *

Type(s) of aerosol scheme used by the aerosol model (potentially multiple: some species may be covered by one type of aerosol scheme and other species covered by another type).

- ☒ Bulk
- ☒ Modal
- ☐ Bin
- ☐ Other - please specify:

7.1.1.7 Bulk Scheme Species *

Species covered by the bulk scheme.

- ☐ Sulphate
- ☒ Nitrate
- ☐ Sea salt
- ☐ Dust

- ☐ Ice
- ☐ Organic
- ☐ Black carbon / soot
- ☐ SOA (secondary organic aerosols)
- ☐ POM (particulate organic matter)
- ☐ Polar stratospheric ice
- ☐ NAT (Nitric acid trihydrate)
- ☐ NAD (Nitric acid dihydrate)
- ☐ STS (supercooled ternary solution aerosol particule)
- ☐ Other - please specify: