# CMIP6 Model Documentation

**Institute**:                     HAMMOZ-CONSORTIUM
**Model**:                         MPI-ESM-1-2-HAM
**Topic**:                         Top Level

**Doc. Generated**:                2020-04-08
**Doc. Seeded From**:              Spreadsheet

**Specialization Version**:        1.1.1

**Further Info**:                  https://es-doc.org/cmip6

**Note**:                          * indicates a required property

# Documentation Contents

# 1 Key Properties

*Key properties of the model*

## 1.1.1 Top level properties

*Key properties of the model*

### 1.1.1.1 Name *

*Name of coupled model*

**MPI-ESM1.2-HAM**

### 1.1.1.2 Keywords *

*Keywords associated with coupled model*

**ECHAM6.3, HAM2.3, MPIOM1.6.3, JSBACH3.20, HAMOCC6**

### 1.1.1.3 Overview *

*Top level overview of coupled model*

**MPI-ESM1.2-HAM is the latest version of the Max Planck Institute for Meteorology Earth System Model (MPI-ESM1.2) coupled with the Hamburg Aerosol Module (HAM2.3), developed by the HAMMOZ consortium. The HAMMOZ consortium is composed of ETH Zurich, Max Planck Institut for Meteorology, Forschungszentrum Jlich, University of Oxford, the Finnish Meteorological Institute and the Leibniz Institute for Tropospheric Research, and managed by the Center for Climate Systems Modeling (C2SM) at ETH Zurich.**

## 1.2.1 Flux Correction

*Flux correction properties of the model*

### 1.2.1.1 Details *

*Describe if/how flux corrections are applied in the model*

**Enter TEXT:**

## 1.3.1 Genealogy

*Genealogy and history of the model*

### 1.3.1.1 Year Released *

*Year the model was released*

**2019**

### 1.3.1.2 CMIP3 Parent

*CMIP3 parent if any*

**Enter TEXT:**

### 1.3.1.3 CMIP5 Parent

*CMIP5 parent if any*

**Enter TEXT:**

### 1.3.1.4 CMIP5 Differences

*Briefly summarize the differences between this model and its CMIP5 parent, if applicable*

**Enter TEXT:**

### 1.3.1.5 Previous Name

*Previously known as*

**Enter TEXT:**

## 1.4.1 Software Properties

*Software properties of model*

### 1.4.1.1 Repository

*Location of code for this component.*

**Https://redmine.hammoz.ethz.ch/projects/aerchemmip**

### 1.4.1.2 Code Version

*Code version identifier.*

**MPI-ESM1.2-HAM**

### 1.4.1.3 Code Languages

*Code language(s).*

**Fortran**

### 1.4.1.4 Components Structure

*Describe how model realms are structured into independent software components (coupled via a coupler) and internal software components.*

**The atmosphere component ECHAM6.3 is directly coupled to the aerosol and cloud microphysics module HAM2.3 and the land surface model JSBACH3.20. The ocean dynamic model MPIOM1.6.3 is directly coupled to the ocean biogeochemistry model HAMOCC6. These two major components are coupled via the coupler OASIS3-MCT.**

### 1.4.1.5 Coupler

*Overarching coupling framework for model.*

☐     OASIS - The OASIS coupler - prior to OASIS-MCT

☐     OASIS3-MCT - The MCT variant of the OASIS coupler

☐ ESMF - Vanilla Earth System Modelling Framework

☐ NUOPC - National Unified Operational Prediction Capability variant of ESMF

☐ Bespoke - Customised coupler developed for this model

☐ Unknown - It is not known what/if-a coupler is used

☐ None - No coupler is used

☐ Other - please specify:

## 1.5.1 Coupling

### 1.5.1.1 Atmosphere Double Flux *

*Is the atmosphere passing a double flux to the ocean and sea ice (as opposed to a single one)?*

**Select either TRUE or FALSE:**

☐ True        ☐ False

### 1.5.1.2 Atmosphere Fluxes Calculation Grid

*Where are the air-sea fluxes calculated*

**Select SINGLE option:**

☐ Atmosphere grid

☐ Ocean grid

☐ Specific coupler grid

☐ Other - please specify:

### 1.5.1.3 Atmosphere Relative Winds *

*Are relative or absolute winds used to compute the flux? I.e. do ocean surface currents enter the wind stress calculation?*

**Select either TRUE or FALSE:**

☐ True        ☐ False

## 1.6.1 Tuning Applied

*Tuning methodology for model*

### 1.6.1.1 Description *

*General overview description of tuning: explain and motivate the main targets and metrics/diagnostics retained. Document the relative weight given to climate performance metrics/diagnostics versus process oriented metrics/diagnostics, 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.*

See Mauritsen et al. (2019) for tuning of MPI-ESM1.2-LR. In order to use the ocean spin-up of MPI-ESM1.2-LR for MPI-ESM1.2-HAM, the energy input into the ocean (global mean net surface energy flux) was tuned to be similar. Also the pre-industrial global mean surface temperature in MPI-ESM1.2-LR was tuned to be similar to the one in MPI-ESM1.2-LR. Both together should minimize drift. In order to obtain acceptable Arctic sea ice cover and volume several adjustments were made including a higher minimum cloud droplet number concentration over land than over ocean and a different sea salt parameterization than the default one used in ECHAM6.3-HAM2.3. The minimum cloud droplet number concentration over ocean was adjusted to best meet the observed warming during the historical time period.

### 1.6.1.2 Global Mean Metrics Used

*List set of metrics/diagnostics of the global mean state used in tuning model*

Net surface energy flux, surface temperature

### 1.6.1.3 Regional Metrics Used

*List of regional metrics/diagnostics of mean state (e.g THC, AABW, regional means etc) used in tuning model/component*

Arctic sea ice cover, Arctic sea ice volume

### 1.6.1.4 Trend Metrics Used

*List observed trend metrics/diagnostics used in tuning model/component (such as 20th century)*

Surface temperature evolution since 1850

### 1.6.1.5 Energy Balance *

*Describe how energy balance was obtained in the full system: in the various components independently or at the components coupling stage?*

Enter TEXT:

### 1.6.1.6 Fresh Water Balance *

*Describe how fresh_water balance was obtained in the full system: in the various components independently or at the components coupling stage?*

Enter TEXT:

## 1.6.2 Heat

*Global heat conservation properties of the model*

### 1.6.2.1 Global *

*Describe if/how heat is conserved globally*

For ECHAM6.3 and MPI-ESM1.2-LR see Mauritsen et al. (2019). Error 2 described in Mauritsen et al. (2019) is eliminated differently in ECHAM6.3-HAM2.3 and MPI-ESM1.2-HAM. The

phase of detrained condensate is passed from the convection scheme to the stratiform scheme but in the stratiform cloud scheme the phase of the detrained condensate is recalculated based on atmospheric conditions (allowing supercooled liquid water) and the latent heat of fusion is released to the atmosphere if necessary.

### 1.6.2.2 Atmos Ocean Interface

*Describe if/how heat is conserved at the atmosphere/ocean coupling interface*

**Enter TEXT:**

### 1.6.2.3 Atmos Land Interface *

*Describe if/how heat is conserved at the atmosphere/land coupling interface*

**Enter TEXT:**

### 1.6.2.4 Atmos Sea-ice Interface

*Describe if/how heat is conserved at the atmosphere/sea-ice coupling interface*

**Enter TEXT:**

### 1.6.2.5 Ocean Seaice Interface

*Describe if/how heat is conserved at the ocean/sea-ice coupling interface*

**Enter TEXT:**

### 1.6.2.6 Land Ocean Interface

*Describe if/how heat is conserved at the land/ocean coupling interface*

**Enter TEXT:**

## 1.6.3 Fresh Water

*Global fresh water convervation properties of the model*

### 1.6.3.1 Global *

*Describe if/how fresh_water is conserved globally*

**Enter TEXT:**

### 1.6.3.2 Atmos Ocean Interface

*Describe if/how fresh_water is conserved at the atmosphere/ocean coupling interface*

**Enter TEXT:**

### 1.6.3.3 Atmos Land Interface *

*Describe if/how fresh water is conserved at the atmosphere/land coupling interface*

**Enter TEXT:**

### 1.6.3.4 Atmos Sea-ice Interface

*Describe if/how fresh water is conserved at the atmosphere/sea-ice coupling interface*

**Enter TEXT:**

### 1.6.3.5 Ocean Seaice Interface

*Describe if/how fresh water is conserved at the ocean/sea-ice coupling interface*

**Enter TEXT:**

### 1.6.3.6 Runoff

*Describe how runoff is distributed and conserved*

**Enter TEXT:**

### 1.6.3.7 Iceberg Calving

*Describe if/how iceberg calving is modeled and conserved*

**Enter TEXT:**

### 1.6.3.8 Endoreic Basins

*Describe if/how endoreic basins (no ocean access) are treated*

**Enter TEXT:**

### 1.6.3.9 Snow Accumulation

*Describe how snow accumulation over land and over sea-ice is treated*

**Enter TEXT:**

## 1.6.4 Salt

*Global salt convervation properties of the model*

### 1.6.4.1 Ocean Seaice Interface

*Describe if/how salt is conserved at the ocean/sea-ice coupling interface*

**Enter TEXT:**

## 1.6.5 Momentum

*Global momentum convervation properties of the model*

### 1.6.5.1 Details

*Describe if/how momentum is conserved in the model*

**Enter TEXT:**

# 2 Radiative Forcings

*Radiative forcings of the model for historical and scenario (aka Table 12.1 IPCC AR5)*

## 2.1.1 Top level properties

*Radiative forcings of the model for historical and scenario (aka Table 12.1 IPCC AR5)*

### 2.1.1.1 Name

*Commonly used name for the radiative forcings in toplevel model.*

**Enter TEXT:**

### 2.1.1.2 Overview

*Overview of radiative forcings of the model for historical and scenario (aka table 12.1 ipcc ar5) in toplevel model.*

**Enter TEXT:**

## 2.1.2 CO2

*Carbon dioxide forcing*

### 2.1.2.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐ N/A - Not applicable - forcing agent is not included

☐ M - Emissions and concentrations determined by the model state rather than externally prescribed

☐ Y - Prescribed concentrations, distributions or time series data

☐ E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐ ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐ C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐ Other - please specify:

### 2.1.2.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Enter TEXT:**

## 2.1.3 CH4

*Methane forcing*

### 2.1.3.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.3.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Enter TEXT:**

## 2.1.4 N2O

*Nitrous oxide forcing*

### 2.1.4.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.4.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Enter TEXT:**

## 2.1.5 Tropospheric O3

*Troposheric ozone forcing*

### 2.1.5.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.5.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Enter TEXT:**

## 2.1.6 Stratospheric O3

*Stratospheric ozone forcing*

### 2.1.6.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.6.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Enter TEXT:**

## 2.1.7 CFC

*Ozone-depleting and non-ozone-depleting fluorinated gases forcing*

### 2.1.7.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.7.2 Equivalence Concentration *

*Details of any equivalence concentrations used*

**Select SINGLE option:**

☐     N/A - Not applicabale (CFCs not included or emissions and concentrations determined by the model state)

☐     Option 1 - CFCs, including CFC-12, are provided as actual concentrations

☐     Option 2 - CFC-12 is provided as actual concentrations and any other gases are provided as an equivalence concentration of CFC-11

☐     Option 3 - Ozone depleting gases, including CFC-12, are provided as an equivalence concentration of CFC-12 and all other fluorinated gases are provided as an equivalence concentration of HFC-134a

☐     Other - please specify:

### 2.1.7.3 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Enter TEXT:**

### 2.1.8 SO4

*SO4 aerosol forcing*

#### 2.1.8.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

#### 2.1.8.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

    **Enter TEXT:**

### 2.1.9 Black Carbon

*Black carbon aerosol forcing*

#### 2.1.9.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.9.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

> **Enter TEXT:**

## 2.1.10 Organic Carbon

*Organic carbon aerosol forcing*

### 2.1.10.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

- ☐ N/A - Not applicable - forcing agent is not included

- ☐ M - Emissions and concentrations determined by the model state rather than externally prescribed

- ☐ Y - Prescribed concentrations, distributions or time series data

- ☐ E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

- ☐ ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

- ☐ C - Fixed prescribed climatology of concentrations with no year-to-year variability

- ☐ Other - please specify:

### 2.1.10.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

> **Enter TEXT:**

## 2.1.11 Nitrate

*Nitrate forcing*

### 2.1.11.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

- ☐ N/A - Not applicable - forcing agent is not included

- ☐ M - Emissions and concentrations determined by the model state rather than externally prescribed

- ☐ Y - Prescribed concentrations, distributions or time series data

- ☐ E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

- ☐ ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

- ☐ C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.11.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

    **Enter TEXT:**

## 2.1.12 Cloud Albedo Effect

*Cloud albedo effect forcing (RFaci)*

### 2.1.12.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.12.2 Aerosol Effect On Ice Clouds *

*Radiative effects of aerosols on ice clouds are represented?*

☒   True      ☐   False

### 2.1.12.3 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

    **Aerosol-cloud interactions for stratiform liquid, mixed-phase and cirrus clouds are computed online. Detrained cloud droplets from convective clouds depend on the number of activated aerosol particles at the convective cloud base. Aerosol activation is computed using a Khler-theory based parameterization. For stratiform mixed-phase clouds heterogenous nucleation (immersion and contact freezing) of supercooled cloud droplets is computed. For stratiform cirrus clouds homogeneous nucleation of solution droplets is computed. Size dependent wet scavenging of aerosol particles in-cloud and below cloud is included. The below cloud collection efficiencies as a function of aerosol and rain drop or snow crystal size are read from a look-up table. The in-cloud scavenging scheme takes nucleation scavenging and impaction scavenging of aerosol particles with cloud droplets and ice-crystals into account.**

## 2.1.13 Cloud Lifetime Effect

*Cloud lifetime effect forcing (ERFaci)*

### 2.1.13.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.13.2 Aerosol Effect On Ice Clouds *

*Radiative effects of aerosols on ice clouds are represented?*

☒ True       ☐ False

### 2.1.13.3 RFaci From Sulfate Only *

*Radiative forcing from aerosol cloud interactions from sulfate aerosol only?*

☐ True       ☒ False

### 2.1.13.4 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**See 2.1.12.3**

## 2.1.14 Dust

*Dust forcing*

### 2.1.14.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐    C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐    Other - please specify:

### 2.1.14.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Dust emissions are computed online based on 10-m wind speed. For details see Tegen et al. (2018).**

## 2.1.15 Tropospheric Volcanic

*Tropospheric volcanic forcing*

### 2.1.15.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐    N/A - Not applicable - forcing agent is not included

☐    M - Emissions and concentrations determined by the model state rather than externally prescribed

☐    Y - Prescribed concentrations, distributions or time series data

☐    E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐    ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐    C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐    Other - please specify:

### 2.1.15.2 Historical Explosive Volcanic Aerosol Implementation *

*How explosive volcanic aerosol is implemented in historical simulations*

☐    Type A - Explosive volcanic aerosol returns rapidly to zero (or near-zero) background.

☐    Type B - Explosive volcanic aerosol returns rapidly to constant (average volcano)

☐    Type C - Explosive volcanic aerosol returns slowly (over several decades) to constant (average volcano) background.

☐    Type D - Explosive volcanic aerosol set to zero

☐    Type E - Explosive volcanic aerosol set to constant (average volcano) background

☐    Other - please specify:

### 2.1.15.3 Future Explosive Volcanic Aerosol Implementation *

*How explosive volcanic aerosol is implemented in future simulations*

☐    Type A - Explosive volcanic aerosol returns rapidly to zero (or near-zero) background.

☐     Type B - Explosive volcanic aerosol returns rapidly to constant (average volcano)

☐     Type C - Explosive volcanic aerosol returns slowly (over several decades) to constant (average volcano) background.

☐     Type D - Explosive volcanic aerosol set to zero

☐     Type E - Explosive volcanic aerosol set to constant (average volcano) background

☐     Other - please specify:


### 2.1.15.4 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**See Zhang et al. (2012) for details.**


## 2.1.16 Stratospheric Volcanic

*Stratospheric volcanic forcing*

### 2.1.16.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:


### 2.1.16.2 Historical Explosive Volcanic Aerosol Implementation *

*How explosive volcanic aerosol is implemented in historical simulations*

☐     Type A - Explosive volcanic aerosol returns rapidly to zero (or near-zero) background.

☐     Type B - Explosive volcanic aerosol returns rapidly to constant (average volcano)

☐     Type C - Explosive volcanic aerosol returns slowly (over several decades) to constant (average volcano) background.

☐     Type D - Explosive volcanic aerosol set to zero

☐     Type E - Explosive volcanic aerosol set to constant (average volcano) background

☐     Other - please specify:

### 2.1.16.3 Future Explosive Volcanic Aerosol Implementation *

*How explosive volcanic aerosol is implemented in future simulations*

☐ Type A - Explosive volcanic aerosol returns rapidly to zero (or near-zero) background.

☐ Type B - Explosive volcanic aerosol returns rapidly to constant (average volcano)

☐ Type C - Explosive volcanic aerosol returns slowly (over several decades) to constant (average volcano) background.

☐ Type D - Explosive volcanic aerosol set to zero

☐ Type E - Explosive volcanic aerosol set to constant (average volcano) background

☐ Other - please specify:

### 2.1.16.4 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Enter TEXT:**

## 2.1.17 Sea Salt

*Sea salt forcing*

### 2.1.17.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐ N/A - Not applicable - forcing agent is not included

☐ M - Emissions and concentrations determined by the model state rather than externally prescribed

☐ Y - Prescribed concentrations, distributions or time series data

☐ E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐ ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐ C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐ Other - please specify:

### 2.1.17.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Sea salt emissions are computed online based on 10-m wind speed. For details see Tegen et al. (2018).**

## 2.1.18 Land Use

*Land use forcing*

### 2.1.18.1 Provision *

*How this forcing agent is provided (e.g. via concentrations, emission precursors, prognostically derived, etc.)*

☐     N/A - Not applicable - forcing agent is not included

☐     M - Emissions and concentrations determined by the model state rather than externally prescribed

☐     Y - Prescribed concentrations, distributions or time series data

☐     E - Concentrations calculated interactively driven by prescribed emissions or precursor emissions

☐     ES - Surface emissions (and 3-D concentrations away from the surface) derived via the model from the prescribed surface concentration

☐     C - Fixed prescribed climatology of concentrations with no year-to-year variability

☐     Other - please specify:

### 2.1.18.2 Crop Change Only *

*Land use change represented via crop change only?*

☐ True       ☒ False

### 2.1.18.3 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Enter TEXT:**

## 2.1.19 Solar

*Solar forcing*

### 2.1.19.1 Provision *

*How solar forcing is provided*

☐     N/A - Not applicable - solar forcing is not included

☒     Irradiance - Solar irradiance forcing

☐     Proton - Proton pathway to solar forcing

☐     Electron - Electron pathway to solar forcing

☐     Cosmic ray - Cosmic ray pathway to solar forcing

☐     Other - please specify:

### 2.1.19.2 Additional Information

*Additional information relating to the provision and implementation of this forcing agent (e.g. citations, use of non-standard datasets, explaining how multiple provisions are used, etc.).*

**Enter TEXT:**