CMIP6 Model Documentation

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Documentation Contents

1 Key Properties

Atmosphere key properties

1.1.1 Top level properties

Atmosphere key properties

1.1.1.1 Name *

Name of atmos model code

LMDZ6A

1.1.1.2 Keywords *

Keywords associated with atmos model code

Enter COMMA SEPARATED list:

1.1.1.3 Overview *

Overview of atmos model.

The atmospheric general circulation model LMDZ6A-LR is based on a finite-difference formulation of the primitive equations of meteorology (Sadourny and Laval, 1984) on a staggered and stretchable longitude-latitude grid (the Z of LMDZ standing for Zoom). Water vapor, liquid and solid water and atmospheric trace species are advected with a monotonic second order finite volume scheme (Van Leer, 1977; Hourdin and Armengaud, 1999). In the vertical, the model uses a classical so-called hybrid sigmapressure coordinate. As concerns physics parameterizations, IPSL participated to CMIP5 with two versions : a "Standard Physics" version (atmospheric component LMDZ5A used in IPSL-CM5A, Hourdin et al., 2013a) and an "New Physics" version (LMDZ5B used in IPSL-CM5B, Hourdin et al., 2013b) based on a full rethinking of the parameterizations of turbulence, convection and clouds on which the 6A version is built. This NP package includes in particular a trubulent sceme based on the prognostic equation for the turbulent kinetik energy that follows Yamada (1983), a mass flux representation of the organized structures of the convective boundary layer called "Thermal Plume Model" (Hourdin et al., 2002, Rio et al., 2008, Rio et al., 2010) and a parameterization of the cold pools or wakes created below cumulonimbus by the evaporation of convective rainfall (Grandpeix et al., 2010ab). The episodic mixing and buoyancy sorting scheme originally developed by Emanuel (1991) used for deep convection was modified to make the closure and triggering rely on the description of the subcloud vertical motions by thermal plumes and wakes (Rio et al, 2009). Concerning convection, two important improvement were made from version 5B to 6A : a modification of the lateral detrainment in the thermal plume model that allows to represent satisfacory well the transition from stratocumulus to cumulus clouds (Jam et al., submitted to James) and the introduction of a statitical triggering for deep convection (Rochetin et al., 2014). The radiation scheme is inherited from the European Center for Medium-Range Weather Forecasts and includes in the 6A version the RRTM code for thermal infra-red radiation and 6 bands in the solar radiation. Cloud cover and cloud water content are computed using a statistical scheme using a log normal function for deep convection (Bony and Emanuel, 2001) and bigaussian for shallow cumulus (Jam et al., 2013). With 79 vertical layers, the 6A version extends to the stratosphere and includes representation of gravity waves generated by mountains as well as by convection (Lott and Guez, 2013) and fronts (de la Cmara and Lott 2015, de la Cmara et al., 2016). The 6A-LR version is based on a regular horizontal grid with 144 points regularly spaced in longitude and 142 in latitude, corresponding to a resolution of 2.5 1.3.

1.1.1.4 Model Family *

Type of atmospheric model.

☐ AGCM - Atmospheric General Circulation Model

☐ ARCM - Atmospheric Regional Climate Model

☐ Other - please specify:

1.1.1.5 Basic Approximations *

Basic approximations made in the atmosphere.

☒ Primitive equations

☐ Non-hydrostatic

☐ Anelastic

☐ Boussinesq

☒ Hydrostatic

☐ Quasi-hydrostatic

☐ Other - please specify:

1.2.1 Resolution

Characteristics of the model resolution

1.2.1.1 Horizontal Resolution Name *

This is a string usually used by the modelling group to describe the resolution of the model grid, e.g. T42, N48.

LR

1.2.1.2 Canonical Horizontal Resolution *

Expression quoted for gross comparisons of resolution, e.g. 2.5 x 3.75 degrees lat-lon.

2.5 1.3 lon-lat

1.2.1.3 Range Horizontal Resolution *

Range of horizontal resolution with spatial details, eg. 1 deg (Equator) - 0.5 deg

Regular 2.5 1.3 lon-lat

1.2.1.4 Number Of Vertical Levels *

Number of vertical levels resolved on the computational grid.

79

1.2.1.5 High Top *

Does the atmosphere have a high-top? High-Top atmospheres have a fully resolved stratosphere with a model top above the stratopause.

☒ True ☐ False

1.3.1 Timestepping

Characteristics of the atmosphere model time stepping

1.3.1.1 Timestep Dynamics *

Timestep for the dynamics in seconds

129

1.3.1.2 Timestep Shortwave Radiative Transfer

Timestep for the shortwave radiative transfer in seconds.

5400

1.3.1.3 Timestep Longwave Radiative Transfer

Timestep for the longwave radiative transfer in seconds.

5400

1.4.1 Orography

Characteristics of the model orography

1.4.1.1 Type *

Type of orographic representation.

☐ Fixed: present day

☒ Fixed: modified - Provide details of modification below

☐ Other - please specify:

1.4.1.2 Modified

If the orography type is modified describe the adaptation.

☐ Related to ice sheets

☐ Related to tectonics

☐ Modified mean

☒ Modified variance if taken into account in model (cf gravity waves)

☐ Other - please specify:

1.4.1.3 Time-varying

Describe any time varying orographic change

Enter TEXT:

1.5.1 Tuning Applied

Tuning methodology for atmospheric component

1.5.1.1 Description *

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

The tuning of the IPSL-CM6A model has been a long process alternating phases of tuning or improvements of individual components in stand alone mode (Orchidee for continental surfaces, LMDZ for the atmosphere and NEMO for the ocean) and phases of tests of the full coupled model. Tuning of the atmospheric component LMDZ for the coupled model was a long lasting 3-year iterative process. Phases of code modification (or tuning of a particular aspect) in standalone atmospheric simulations (with continental surfaces but with imposed SSTs) included retuning of the energetics. This systematic retuning has been done about 20 times, each time by running one or a few series of typically 10 sensitivity experiments to the most uncertain parameters that control most the radiative budget: cloud and convection parameters. Not only the global energy balance was targeted in this tuning but also individually the long-wave (LW) and short-wave (SW) radiation, the contribution of Cloud Radiative Effect (CRE), as well as key elements of their space-time distribution that were targeting the reduction in particular of SST biases of the coupled model.

1.5.1.2 Global Mean Metrics Used

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

Total radiation at TOA, Cloud radiative forcing at TOA in the visible and in the infra-red

1.5.1.3 Regional Metrics Used

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

Zonal mean of the TOA radiative fluxes and cloud radiative effect, separating visible and infrared, same metrics for the high seen as contrast between the high latitudes and tropics or between the East side of tropical oceans (region of classical SST warm biases) and the rest of the tropics, same for a decomposition between subsiding, convective and intermediate regimes in the tropics over oceans.

1.5.1.4 Trend Metrics Used

List observed trend metrics used in tuning model/component

Enter COMMA SEPARATED list:

2 Grid

Atmosphere grid

2.1.1 Top level properties

Atmosphere grid

2.1.1.1 Name

Name of grid in atmos model.

C-grid

2.1.1.2 Overview

Overview of grid in atmos model.

Longitude-latitude regular C-grid. Vertical grid based on hybrid sigma-pressure coordinate.

2.1.2 Horizontal

Atmosphere discretisation in the horizontal

2.1.2.1 Scheme Type *

Horizontal discretisation type

- ☐ Spectral
- ☒ Fixed grid
- ☐ Other - please specify:

2.1.2.2 Scheme Method *

Horizontal discretisation method

- ☐ Finite elements
- ☒ Finite volumes
- ☐ Finite difference
- ☐ Centered finite difference

2.1.2.3 Scheme Order *

Horizontal discretisation function order

- ☒ Second
- ☐ Third
- ☐ Fourth

☐ Other - please specify:

2.1.2.4 Horizontal Pole

Horizontal discretisation pole singularity treatment

☒ Filter

☐ Pole rotation

☐ Artificial island

☐ Other - please specify:

2.1.2.5 Grid Type *

Horizontal grid type

☐ Gaussian

☒ Latitude-Longitude

☐ Cubed-Sphere

☐ Icosahedral

☐ Other - please specify:

2.1.3 Vertical

Atmosphere discretisation in the vertical

2.1.3.1 Coordinate Type *

Type of vertical coordinate system

Select MULTIPLE options:

☐ Isobaric - Vertical coordinate on pressure levels

☐ Sigma - Allows vertical coordinate to follow model terrain

☐ Hybrid sigma-pressure - Sigma system near terrain and isobaric above

☐ Hybrid pressure

☐ Vertically lagrangian

☐ Other - please specify:

3 Dynamical Core

Characteristics of the dynamical core

3.1.1 Top level properties

Characteristics of the dynamical core

3.1.1.1 Name

Commonly used name for the dynamical core in atmos model.

Enter TEXT:

3.1.1.2 Overview

Overview of characteristics of the dynamical core in atmos model.

Enter TEXT:

3.1.1.3 Timestepping Type *

Timestepping framework type

- [ ] Adams-Bashforth
- [ ] Explicit
- [ ] Implicit
- [ ] Semi-implicit
- [x] Leap frog
- [ ] Multi-step
- [ ] Runge Kutta fifth order
- [ ] Runge Kutta second order
- [ ] Runge Kutta third order
- [ ] Other - please specify:

3.1.1.4 Prognostic Variables *

List of the model prognostic variables

- [ ] Surface pressure
- [ ] Wind components
- [ ] Divergence/curl
- [ ] Temperature

- [x] Potential temperature
- [ ] Total water
- [ ] Water vapour
- [ ] Water liquid
- [ ] Water ice
- [x] Total water moments
- [ ] Clouds
- [ ] Radiation
- [ ] Other - please specify:

3.2.1 Top Boundary

Type of boundary layer at the top of the model

3.2.1.1 Top Boundary Condition *

Top boundary condition

- [x] Sponge layer
- [ ] Radiation boundary condition
- [ ] Other - please specify:

3.2.1.2 Top Heat *

Top boundary heat treatment

Enter TEXT:

3.2.1.3 Top Wind *

Top boundary wind treatment

Enter TEXT:

3.3.1 Lateral Boundary

Type of lateral boundary condition (if the model is a regional model)

3.3.1.1 Condition

Type of lateral boundary condition

Select SINGLE option:

- [ ] Sponge layer

- [ ] Radiation boundary condition
- [ ] Other - please specify:

3.4.1 Diffusion Horizontal

Horizontal diffusion scheme

3.4.1.1 Scheme Name

Horizontal diffusion scheme name

Iterated Laplacian

3.4.1.2 Scheme Method *

Horizontal diffusion scheme method

- [x] Iterated Laplacian
- [ ] Bi-harmonic
- [ ] Other - please specify:

3.4.2 Tracers

Tracer advection scheme

3.4.2.1 Scheme Name

Tracer advection scheme name

- [ ] Heun
- [x] Roe and VanLeer
- [ ] Roe and Superbee
- [ ] Prather
- [ ] UTOPIA
- [ ] Other - please specify:

3.4.2.2 Scheme Characteristics *

Tracer advection scheme characteristics

- [ ] Eulerian
- [ ] Modified Euler
- [ ] Lagrangian
- [ ] Semi-Lagrangian

- [ ] Cubic semi-Lagrangian
- [ ] Quintic semi-Lagrangian
- [ ] Mass-conserving
- [x] Finite volume
- [ ] Flux-corrected
- [ ] Linear
- [ ] Quadratic
- [ ] Quartic
- [ ] Other - please specify:

3.4.2.3 Conserved Quantities *

Tracer advection scheme conserved quantities

- [ ] Dry mass
- [ ] Tracer mass
- [ ] Other - please specify:

3.4.2.4 Conservation Method *

Tracer advection scheme conservation method

Select SINGLE option:

- [ ] Conservation fixer
- [ ] Priestley algorithm
- [ ] Other - please specify:

3.4.3 Momentum

Momentum advection scheme

3.4.3.1 Scheme Name

Momentum advection schemes name

Select SINGLE option:

- [ ] VanLeer
- [ ] Janjic
- [ ] SUPG (Streamline Upwind Petrov-Galerkin)
- [ ] Other - please specify:

3.4.3.2 Scheme Characteristics *

Momentum advection scheme characteristics

- [ ] 2nd order
- [ ] 4th order
- [ ] Cell-centred
- [x] Staggered grid
- [ ] Semi-staggered grid
- [ ] Other - please specify:

3.4.3.3 Scheme Staggering Type *

Momentum advection scheme staggering type

- [ ] Arakawa B-grid
- [x] Arakawa C-grid
- [ ] Arakawa D-grid
- [ ] Arakawa E-grid
- [ ] Other - please specify:

3.4.3.4 Conserved Quantities *

Momentum advection scheme conserved quantities

- [ ] Angular momentum
- [ ] Horizontal momentum
- [x] Enstrophy
- [ ] Mass
- [ ] Total energy
- [ ] Vorticity
- [ ] Other - please specify:

3.4.3.5 Conservation Method *

Momentum advection scheme conservation method

Select SINGLE option:

- [ ] Conservation fixer
- [ ] Other - please specify:

4 Radiation

Characteristics of the atmosphere radiation process

4.1.1 Top level properties

Characteristics of the atmosphere radiation process

4.1.1.1 Name

Commonly used name for the radiation in atmos model.

Morcrette (SW) and RRTM (LW)

4.1.1.2 Overview

Overview of characteristics of the atmosphere radiation process in atmos model.

Enter TEXT:

4.1.1.3 Aerosols *

Aerosols whose radiative effect is taken into account in the atmosphere model

- [x] Sulphate
- [x] Nitrate
- [x] Sea salt
- [x] Dust
- [ ] Ice
- [ ] Organic
- [ ] BC - 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 particle
- [ ] Other - please specify:

4.2.1 Shortwave Radiation

Properties of the shortwave radiation scheme

4.2.1.1 Name

Commonly used name for the shortwave radiation scheme

Morcrette

4.2.1.2 Spectral Integration *

Shortwave radiation scheme spectral integration

- [x] Wide-band model
- [ ] Correlated-k
- [ ] Exponential sum fitting
- [ ] Other - please specify:

4.2.1.3 Transport Calculation *

Shortwave radiation transport calculation methods

- [x] Two-stream
- [ ] Layer interaction
- [ ] Bulk - Highly parameterised methods that use bulk expressions
- [ ] Adaptive - Exploits spatial and temporal correlations in optical characteristics
- [ ] Multi-stream
- [ ] Other - please specify:

4.2.1.4 Spectral Intervals *

Shortwave radiation scheme number of spectral intervals

6

4.2.1.5 General Interactions *

General radiative interactions e.g. with aerosols, cloud ice and cloud water

- [x] Emission/absorption,
- [x] Scattering
- [ ] Other - please specify:

4.3.1 Shortwave GHG

Representation of greenhouse gases in the shortwave radiation scheme

4.3.1.1 Greenhouse Gas Complexity *

Complexity of greenhouse gases whose shortwave radiative effects are taken into account in the atmosphere model

☐ CO2 - Carbon Dioxide

☐ CH4 - Methane

☐ N2O - Nitrous Oxide

☐ CFC-11 eq - Summarize the effect of non CO2, CH4, N2O and CFC-12 gases with an equivalence concentration of CFC-11

☐ CFC-12 eq - Summarize the radiative effect of the Ozone Depleating Substances, ODSs, with a CFC-12 equivalence concentration

☐ HFC-134a eq - Summarize the radiative effect of other fluorinated gases with a HFC-134a equivalence concentration

☐ Explicit ODSs - Explicit representation of Ozone Depleting Substances e.g. CFCs, HCFCs and Halons

☐ Explicit other fluorinated gases - Explicit representation of other fluorinated gases e.g. HFCs and PFCs

☒ O3

☒ H2O

☐ Other - please specify:

4.3.1.2 ODS

Ozone depleting substances whose shortwave radiative effects are explicitly taken into account in the atmosphere model

Select MULTIPLE options:

☐ CFC-12 - CFC

☐ CFC-11 - CFC

☐ CFC-113 - CFC

☐ CFC-114 - CFC

☐ CFC-115 - CFC

☐ HCFC-22 - HCFC

☐ HCFC-141b - HCFC

☐ HCFC-142b - HCFC

☐ Halon-1211 - Halon

☐ Halon-1301 - Halon

☐ Halon-2402 - Halon

☐ Methyl chloroform - CH3CCl3

- [ ] Carbon tetrachloride - CCl4
- [ ] Methyl chloride - CH3Cl
- [ ] Methylene chloride - CH2Cl2
- [ ] Chloroform - CHCl3
- [ ] Methyl bromide - Ch3Br
- [ ] Other - please specify:

4.3.1.3 Other Flourinated Gases

Other flourinated gases whose shortwave radiative effects are explicitly taken into account in the atmosphere model

Select MULTIPLE options:

- [ ] HFC-134a - HFC
- [ ] HFC-23 - HFC
- [ ] HFC-32 - HFC
- [ ] HFC-125 - HFC
- [ ] HFC-143a - HFC
- [ ] HFC-152a - HFC
- [ ] HFC-227ea - HFC
- [ ] HFC-236fa - HFC
- [ ] HFC-245fa - HFC
- [ ] HFC-365mfc - HFC
- [ ] HFC-43-10mee - HFC
- [ ] CF4 - PFC
- [ ] C2F6 - PFC
- [ ] C3F8 - PFC
- [ ] C4F10 - PFC
- [ ] C5F12 - PFC
- [ ] C6F14 - PFC
- [ ] C7F16 - PFC
- [ ] C8F18 - PFC
- [ ] C-C4F8 - PFC
- [ ] NF3

- [ ] SF6
- [ ] SO2F2
- [ ] Other - please specify:

4.4.1 Shortwave Cloud Ice

Shortwave radiative properties of ice crystals in clouds

4.4.1.1 Physical Representation *

Physical representation of cloud ice crystals in the shortwave radiation scheme

Select MULTIPLE options:

- [ ] Bi-modal size distribution - Small mode diameters: a few tens of microns, large mode diameters: typically hundreds of microns
- [ ] Ensemble of ice crystals - Complex shapes represented with an ensemble of symmetric shapes
- [ ] Mean projected area - Randomly oriented irregular ice crystals present a greater mean projected area than spheres
- [ ] Ice water path - Integrated ice water path through the cloud kg m-2
- [ ] Crystal asymmetry
- [ ] Crystal aspect ratio
- [ ] Effective crystal radius
- [ ] Other - please specify:

4.4.1.2 Optical Methods *

Optical methods applicable to cloud ice crystals in the shortwave radiation scheme

- [ ] T-matrix - For non-spherical particles
- [ ] Geometric optics - For non-spherical particles
- [ ] Finite difference time domain (FDTD) - For non-spherical particles
- [ ] Mie theory - For spherical particles
- [ ] Anomalous diffraction approximation
- [ ] Other - please specify:

4.5.1 Shortwave Cloud Liquid

Shortwave radiative properties of liquid droplets in clouds

4.5.1.1 Physical Representation *

Physical representation of cloud liquid droplets in the shortwave radiation scheme

- [x] Cloud droplet number concentration - CDNC
- [x] Effective cloud droplet radii
- [ ] Droplet size distribution
- [x] Liquid water path - Integrated liquid water path through the cloud kg m-2
- [ ] Other - please specify:

4.5.1.2 Optical Methods *

Optical methods applicable to cloud liquid droplets in the shortwave radiation scheme

- [x] Geometric optics - For non-spherical particles
- [ ] Mie theory - For spherical particles
- [ ] Other - please specify:

4.6.1 Shortwave Cloud Inhomogeneity

Cloud inhomogeneity in the shortwave radiation scheme

4.6.1.1 Cloud Inhomogeneity *

Method for taking into account horizontal cloud inhomogeneity

Select SINGLE option:

- [ ] Monte Carlo Independent Column Approximation - McICA
- [ ] Triplecloud - Regions of clear sky, optically thin cloud and optically thick cloud, Shonk et al 2010
- [ ] Analytic
- [ ] Other - please specify:

4.7.1 Shortwave Aerosols

Shortwave radiative properties of aerosols

4.7.1.1 Physical Representation *

Physical representation of aerosols in the shortwave radiation scheme

- [x] Number concentration
- [ ] Effective radii
- [x] Size distribution

- [ ] Asymmetry
- [ ] Aspect ratio
- [ ] Mixing state - For shortwave radiative interaction
- [ ] Other - please specify:

4.7.1.2 Optical Methods *

Optical methods applicable to aerosols in the shortwave radiation scheme

- [ ] T-matrix - For non-spherical particles
- [ ] Geometric optics - For non-spherical particles
- [ ] Finite difference time domain (FDTD) - For non-spherical particles
- [ ] Mie theory - For spherical particles
- [ ] Anomalous diffraction approximation
- [ ] Other - please specify:

4.8.1 Longwave Radiation

Properties of the longwave radiation scheme

4.8.1.1 Name

Commonly used name for the longwave radiation scheme.

RRTM

4.8.1.2 Spectral Integration *

Longwave radiation scheme spectral integration

- [x] Wide-band model
- [ ] Correlated-k
- [ ] Exponential sum fitting
- [ ] Other - please specify:

4.8.1.3 Transport Calculation *

Longwave radiation transport calculation methods

- [ ] Two-stream
- [x] Layer interaction
- [ ] Bulk - Highly parameterised methods that use bulk expressions
- [ ] Adaptive - Exploits spatial and temporal correlations in optical characteristics

- [ ] Multi-stream
- [ ] Other - please specify:

4.8.1.4 Spectral Intervals *

Longwave radiation scheme number of spectral intervals

16

4.8.1.5 General Interactions *

General radiative interactions e.g. with aerosols, cloud ice and cloud water

- [x] Emission/absorption,
- [ ] Scattering
- [ ] Other - please specify:

4.9.1 Longwave GHG

Representation of greenhouse gases in the longwave radiation scheme

4.9.1.1 Greenhouse Gas Complexity *

Complexity of greenhouse gases whose longwave radiative effects are taken into account in the atmosphere model

- [ ] CO2 - Carbon Dioxide
- [ ] CH4 - Methane
- [ ] N2O - Nitrous Oxide
- [ ] CFC-11 eq - Summarize the effect of non CO2, CH4, N2O and CFC-12 gases with an equivalence concentration of CFC-11
- [ ] CFC-12 eq - Summarize the radiative effect of the Ozone Depleating Substances, ODSs, with a CFC-12 equivalence concentration
- [ ] HFC-134a eq - Summarize the radiative effect of other fluorinated gases with a HFC-134a equivalence concentration
- [ ] Explicit ODSs - Explicit representation of Ozone Depleting Substances e.g. CFCs, HCFCs and Halons
- [ ] Explicit other fluorinated gases - Explicit representation of other fluorinated gases e.g. HFCs and PFCs
- [x] O3
- [x] H2O
- [ ] Other - please specify:

4.9.1.2 ODS

Ozone depleting substances whose longwave radiative effects are explicitly taken into account in the atmosphere model

- [ ] CFC-12 - CFC
- [ ] CFC-11 - CFC
- [ ] CFC-113 - CFC
- [ ] CFC-114 - CFC
- [ ] CFC-115 - CFC
- [ ] HCFC-22 - HCFC
- [ ] HCFC-141b - HCFC
- [ ] HCFC-142b - HCFC
- [ ] Halon-1211 - Halon
- [ ] Halon-1301 - Halon
- [ ] Halon-2402 - Halon
- [ ] Methyl chloroform - CH3CCl3
- [ ] Carbon tetrachloride - CCl4
- [ ] Methyl chloride - CH3Cl
- [ ] Methylene chloride - CH2Cl2
- [ ] Chloroform - CHCl3
- [ ] Methyl bromide - Ch3Br
- [ ] Other - please specify:

4.9.1.3 Other Flourinated Gases

Other flourinated gases whose longwave radiative effects are explicitly taken into account in the atmosphere model

Select MULTIPLE options:

- [ ] HFC-134a - HFC
- [ ] HFC-23 - HFC
- [ ] HFC-32 - HFC
- [ ] HFC-125 - HFC
- [ ] HFC-143a - HFC
- [ ] HFC-152a - HFC
- [ ] HFC-227ea - HFC
- [ ] HFC-236fa - HFC
- [ ] HFC-245fa - HFC

☐ HFC-365mfc - HFC

☐ HFC-43-10mee - HFC

☐ CF4 - PFC

☐ C2F6 - PFC

☐ C3F8 - PFC

☐ C4F10 - PFC

☐ C5F12 - PFC

☐ C6F14 - PFC

☐ C7F16 - PFC

☐ C8F18 - PFC

☐ C-C4F8 - PFC

☐ NF3

☐ SF6

☐ SO2F2

☐ Other - please specify:

4.10.1 Longwave Cloud Ice

Longwave radiative properties of ice crystals in clouds

4.10.1.1 Physical Reprenstation *

Physical representation of cloud ice crystals in the longwave radiation scheme

☐ Bi-modal size distribution - Small mode diameters: a few tens of microns, large mode diameters: typically hundreds of microns

☐ Ensemble of ice crystals - Complex shapes represented with an ensemble of symmetric shapes

☐ Mean projected area - Randomly oriented irregular ice crystals present a greater mean projected area than spheres

☒ Ice water path - Integrated ice water path through the cloud kg m-2

☐ Crystal asymmetry

☐ Crystal aspect ratio

☐ Effective crystal radius

☐ Other - please specify:

4.10.1.2 Optical Methods *

Optical methods applicable to cloud ice crystals in the longwave radiation scheme

- ☐ T-matrix - For non-spherical particles
- ☐ Geometric optics - For non-spherical particles
- ☐ Finite difference time domain (FDTD) - For non-spherical particles
- ☐ Mie theory - For spherical particles
- ☐ Anomalous diffraction approximation
- ☐ Other - please specify:

4.11.1 Longwave Cloud Liquid

Longwave radiative properties of liquid droplets in clouds

4.11.1.1 Physical Representation *

Physical representation of cloud liquid droplets in the longwave radiation scheme

- ☐ Cloud droplet number concentration - CDNC
- ☐ Effective cloud droplet radii
- ☐ Droplet size distribution
- ☒ Liquid water path - Integrated liquid water path through the cloud kg m-2
- ☐ Other - please specify:

4.11.1.2 Optical Methods *

Optical methods applicable to cloud liquid droplets in the longwave radiation scheme

- ☐ Geometric optics - For non-spherical particles
- ☐ Mie theory - For spherical particles
- ☐ Other - please specify:

4.12.1 Longwave Cloud Inhomogeneity

Cloud inhomogeneity in the longwave radiation scheme

4.12.1.1 Cloud Inhomogeneity *

Method for taking into account horizontal cloud inhomogeneity

Select SINGLE option:

- ☐ Monte Carlo Independent Column Approximation - McICA
- ☐ Triplecloud - Regions of clear sky, optically thin cloud and optically thick cloud, Shonk et al 2010

- [ ] Analytic
- [ ] Other - please specify:

4.13.1 Longwave Aerosols

Longwave radiative properties of aerosols

4.13.1.1 Physical Representation *

Physical representation of aerosols in the longwave radiation scheme

- [x] Number concentration
- [ ] Effective radii
- [x] Size distribution
- [ ] Asymmetry
- [ ] Aspect ratio
- [ ] Mixing state - For shortwave radiative interaction
- [ ] Other - please specify:

4.13.1.2 Optical Methods *

Optical methods applicable to aerosols in the longwave radiation scheme

Select MULTIPLE options:

- [ ] T-matrix - For non-spherical particles
- [ ] Geometric optics - For non-spherical particles
- [ ] Finite difference time domain (FDTD) - For non-spherical particles
- [ ] Mie theory - For spherical particles
- [ ] Anomalous diffraction approximation
- [ ] Other - please specify:

5 Turbulence Convection

Atmosphere Convective Turbulence and Clouds

5.1.1 Top level properties

Atmosphere Convective Turbulence and Clouds

5.1.1.1 Name

Commonly used name for the turbulence convection in atmos model.

LMDZ New Physics (NP)

5.1.1.2 Overview

Overview of atmosphere convective turbulence and clouds in atmos model.

Compared to the "Standard Physics" (SP) version LMDZ5A used for most of the CMIP5 with the IPSL model, the NP version was characterized by a profound rethinking of the representation of convection and clouds. Specific parameterizations were introduced for the representation of the organized structures of the convective boundary layer, the so-called "thermal plume model" (Hourdin et al., 2002, Rio et al., 2008, Rio et al., 2010), and for the cold pools created below cumulonimbus by reevaporation of convective rainfall (Grandpeix et al., 2010ab). Above that, the triggering and closure of the deep convection scheme is controlled in this NP version by subgrid scale vertical velocities associated with boundary layer convective plumes, and air rising downwind of the cold pools gust front. A bi-Gaussian PDF for the subgrid scale water was also coupled to the thermal plume model to better represent cumulus clouds. One important aspect of those developments was to promote an object oriented framework for the parameterization of convection. While many authors advocate for the development of unified parameterizations for convection, the deliberate choice was made to identify as separate objects boundary layer convection (unified between dry and cloudy), cumulonimbus and cold pools, and to develop explicit parameterizations that control their interplay. This approach favors the possibility for different regimes to coexist within the same model column. A first NP version was used in the LMDZ5B versions delivered for CMIP5. Compared to this 5B versions, the main modifications in the 6A version concern the introduction of a stochastic triggering designed to make the frequency of occurrence of new convective systems within a mesh aware of the grid cell size(scale awareness, Rochetin et al., 2014a, Rochetin et al., 2014b), a modification of the thermal plume model for the representation of stratocumulus clouds (Jam et al., in revision)

5.2.1 Boundary Layer Turbulence

Properties of the boundary layer turbulence scheme

5.2.1.1 Scheme Name

Boundary layer turbulence scheme name

- [x] Mellor-Yamada
- [ ] Holtslag-Boville
- [ ] EDMF - Combined Eddy Diffusivity Mass-Flux
- [ ] Other - please specify:

5.2.1.2 Scheme Type *

Boundary layer turbulence scheme type

- [x] TKE prognostic
- [ ] TKE diagnostic
- [ ] TKE coupled with water
- [ ] Vertical profile of Kz
- [ ] Non-local diffusion
- [ ] Monin-Obukhov similarity
- [ ] Coastal Buddy Scheme - Separate components for coastal near surface winds over ocean and land
- [ ] Coupled with convection
- [ ] Coupled with gravity waves
- [ ] Depth capped at cloud base - Boundary layer capped at cloud base when convection is diagnosed
- [ ] Other - please specify:

5.2.1.3 Closure Order *

Boundary layer turbulence scheme closure order

2

5.2.1.4 Counter Gradient *

Uses boundary layer turbulence scheme counter gradient

- [x] True
- [ ] False

5.3.1 Deep Convection

Properties of the deep convection scheme

5.3.1.1 Scheme Name

Deep convection scheme name

Emanuel (91-93)

5.3.1.2 Scheme Type *

Deep convection scheme type

- [x] Mass-flux
- [ ] Adjustment
- [ ] Plume ensemble - Zhang-McFarlane
- [ ] Other - please specify:

5.3.1.3 Scheme Method *

Deep convection scheme method

- ☐ CAPE - Mass flux determined by CAPE, convectively available potential energy.
- ☐ Bulk - A bulk mass flux scheme is used
- ☐ Ensemble - Summation over an ensemble of convective clouds with differing characteristics
- ☐ CAPE/WFN based - CAPE-Cloud Work Function: Based on the quasi-equilibrium of the free troposphere
- ☐ TKE/CIN based - TKE-Convective Inhibition: Based on the quasi-equilibrium of the boundary layer
- ☐ Other - please specify:

5.3.1.4 Processes *

Physical processes taken into account in the parameterisation of deep convection

- ☒ Vertical momentum transport
- ☒ Convective momentum transport
- ☒ Entrainment
- ☒ Detrainment
- ☒ Penetrative convection
- ☒ Updrafts
- ☐ Downdrafts
- ☒ Radiative effect of anvils
- ☐ Re-evaporation of convective precipitation
- ☐ Other - please specify:

5.3.1.5 Microphysics

Microphysics scheme for deep convection. Microphysical processes directly control the amount of detrainment of cloud hydrometeor and water vapor from updrafts

- ☐ Tuning parameter based
- ☒ Single moment
- ☐ Two moment
- ☐ Other - please specify:

5.4.1 Shallow Convection

Properties of the shallow convection scheme

5.4.1.1 Scheme Name

Shallow convection scheme name

Thermal Plume Model

5.4.1.2 Scheme Type *

Shallow convection scheme type

- [x] Mass-flux
- [ ] Cumulus-capped boundary layer
- [ ] Other - please specify:

5.4.1.3 Scheme Method *

Shallow convection scheme method

- [ ] Same as deep (unified)
- [ ] Included in boundary layer turbulence
- [ ] Separate diagnosis - Deep and Shallow convection schemes use different thermodynamic closure criteria
- [ ] Other - please specify:

5.4.1.4 Processes *

Physical processes taken into account in the parameterisation of shallow convection

- [x] Convective momentum transport
- [x] Entrainment
- [x] Detrainment
- [x] Penetrative convection
- [ ] Re-evaporation of convective precipitation
- [ ] Other - please specify:

5.4.1.5 Microphysics

Microphysics scheme for shallow convection

Select MULTIPLE options:

- [ ] Tuning parameter based
- [ ] Single moment
- [ ] Two moment
- [ ] Other - please specify:

6 Microphysics Precipitation

Large Scale Cloud Microphysics and Precipitation

6.1.1 Top level properties

Large Scale Cloud Microphysics and Precipitation

6.1.1.1 Name

Commonly used name for the microphysics precipitation in atmos model.

Enter TEXT:

6.1.1.2 Overview

Overview of large scale cloud microphysics and precipitation in atmos model.

Enter TEXT:

6.2.1 Large Scale Precipitation

Properties of the large scale precipitation scheme

6.2.1.1 Scheme Name

Commonly used name of the large scale precipitation parameterisation scheme

Hourdin et al (2006)

6.2.1.2 Hydrometeors *

Precipitating hydrometeors taken into account in the large scale precipitation scheme

- ☒ Liquid rain
- ☒ Snow
- ☐ Hail
- ☐ Graupel
- ☐ Other - please specify:

6.3.1 Large Scale Cloud Microphysics

Properties of the large scale cloud microphysics scheme

6.3.1.1 Scheme Name

Commonly used name of the microphysics parameterisation scheme used for large scale clouds.

LeTreut and Li (1991)

6.3.1.2 Processes *

Large scale cloud microphysics processes

Select MULTIPLE options:

- [ ] Mixed phase
- [ ] Cloud droplets
- [ ] Cloud ice
- [ ] Ice nucleation
- [ ] Water vapour deposition
- [ ] Effect of raindrops
- [ ] Effect of snow
- [ ] Effect of graupel
- [ ] Other - please specify:

7 Cloud Scheme

Characteristics of the cloud scheme

7.1.1 Top level properties

Characteristics of the cloud scheme

7.1.1.1 Name

Commonly used name for the cloud scheme in atmos model.

Enter TEXT:

7.1.1.2 Overview

Overview of characteristics of the cloud scheme in atmos model.

Enter TEXT:

7.1.1.3 Scheme Type *

Describes the type(s) of cloud scheme: prognostic, diagnostic, other.

Select MULTIPLE options:

☐ Prognostic

☐ Diagnostic

☐ Other - please specify:

7.1.1.4 Uses Separate Treatment *

Description for when different cloud schemes are used for different types of clouds e.g. convective, stratiform and boundary layer)

Yes

7.1.1.5 Processes *

Processes included in the cloud scheme

☐ Entrainment

☐ Detrainment

☐ Bulk cloud

☐ Other - please specify:

7.1.1.6 Prognostic Variables

List the prognostic variables used by the cloud scheme, if applicable.

Select MULTIPLE options:

- [ ] Cloud amount
- [ ] Liquid
- [ ] Ice
- [ ] Rain
- [ ] Snow
- [ ] Cloud droplet number concentration - To document the use of two-moment cloud microphysics schemes
- [ ] Ice crystal number concentration - To document the use of two-moment cloud microphysics schemes
- [ ] Other - please specify:

7.1.1.7 Atmos Coupling

Atmosphere components that are linked to the cloud scheme

Select MULTIPLE options:

- [ ] Atmosphere_radiation
- [ ] Atmosphere_microphysics_precipitation
- [ ] Atmosphere_turbulence_convection
- [ ] Atmosphere_gravity_waves
- [ ] Atmosphere_natural_forcing
- [ ] Atmosphere_observation_simulation

7.2.1 Optical Cloud Properties

Optical cloud properties

7.2.1.1 Cloud Overlap Method

Method for taking into account overlapping of cloud layers

Select SINGLE option:

- [ ] Random
- [ ] Maximum
- [ ] Maximum-random - Combination of maximum and random overlap between clouds
- [ ] Exponential
- [ ] Other - please specify:

7.2.1.2 Cloud Inhomogeneity

Method for taking into account cloud inhomogeneity

Enter TEXT:

7.3.1 Sub Grid Scale Water Distribution

Sub-grid scale water distribution

7.3.1.1 Type *

Sub-grid scale water distribution type

- ☐ Prognostic
- ☒ Diagnostic

7.3.1.2 Function Name *

Sub-grid scale water distribution function name

Generalyzed log normal

7.3.1.3 Function Order *

Sub-grid scale water distribution function type

2

7.3.1.4 Convection Coupling *

Sub-grid scale water distribution coupling with convection

- ☒ Coupled with deep
- ☐ Coupled with shallow
- ☐ Not coupled with convection

7.4.1 Sub Grid Scale Ice Distribution

Sub-grid scale ice distribution

7.4.1.1 Type *

Sub-grid scale ice distribution type

Select SINGLE option:

- ☐ Prognostic
- ☐ Diagnostic

7.4.1.2 Function Name *

Sub-grid scale ice distribution function name

Enter TEXT:

7.4.1.3 Function Order *

Sub-grid scale ice distribution function type

Enter INTEGER value:

7.4.1.4 Convection Coupling *

Sub-grid scale ice distribution coupling with convection

Select MULTIPLE options:

- [ ] Coupled with deep
- [ ] Coupled with shallow
- [ ] Not coupled with convection

8 Observation Simulation

Characteristics of observation simulation

8.1.1 Top level properties

Characteristics of observation simulation

8.1.1.1 Name

Commonly used name for the observation simulation in atmos model.

Enter TEXT:

8.1.1.2 Overview

Overview of characteristics of observation simulation in atmos model.

Enter TEXT:

8.2.1 Isscp Attributes

ISSCP Characteristics

8.2.1.1 Top Height Estimation Method

Cloud simulator ISSCP top height estimation methodUo

- [ ] No adjustment
- [x] IR brightness
- [x] Visible optical depth
- [ ] Other - please specify:

8.2.1.2 Top Height Direction

Cloud simulator ISSCP top height direction

- [x] Lowest altitude level
- [ ] Highest altitude level
- [ ] Other - please specify:

8.3.1 Cosp Attributes

CFMIP Observational Simulator Package attributes

8.3.1.1 Run Configuration

Cloud simulator COSP run configuration

- ☒ Inline
- ☐ Offline
- ☐ Other - please specify:

8.3.1.2 Number Of Grid Points

Cloud simulator COSP number of grid points

9026

8.3.1.3 Number Of Sub Columns

Cloud simulator COSP number of sub-cloumns used to simulate sub-grid variability

20

8.3.1.4 Number Of Levels

Cloud simulator COSP number of levels

39

8.4.1 Radar Inputs

Characteristics of the cloud radar simulator

8.4.1.1 Frequency

Cloud simulator radar frequency (Hz)

94

8.4.1.2 Type

Cloud simulator radar type

- ☐ Surface
- ☒ Space borne
- ☐ Other - please specify:

8.4.1.3 Gas Absorption

Cloud simulator radar uses gas absorption

☒ True ☐ False

8.4.1.4 Effective Radius

Cloud simulator radar uses effective radius

☒ True ☐ False

8.5.1 Lidar Inputs

Characteristics of the cloud lidar simulator

8.5.1.1 Ice Types

Cloud simulator lidar ice type

☒ Ice spheres

☐ Ice non-spherical

☐ Other - please specify:

8.5.1.2 Overlap

Cloud simulator lidar overlap

Select MULTIPLE options:

☐ Max

☐ Random

☐ Other - please specify:

9 Gravity Waves

Characteristics of the parameterised gravity waves in the atmosphere, whether from orography or other sources

9.1.1 Top level properties

Characteristics of the parameterised gravity waves in the atmosphere, whether from orography or other sources

9.1.1.1 Name

Commonly used name for the gravity waves in atmos model.

Enter TEXT:

9.1.1.2 Overview

Overview of characteristics of the parameterised gravity waves in the atmosphere, whether from orography or other sources in atmos model.

Enter TEXT:

9.1.1.3 Sponge Layer *

Sponge layer in the upper levels in order to avoid gravity wave reflection at the top.

Select SINGLE option:

☐ Rayleigh friction

☐ Diffusive sponge layer

☐ Other - please specify:

9.1.1.4 Background *

Background wave distribution

Select SINGLE option:

☐ Continuous spectrum

☐ Discrete spectrum

☐ Other - please specify:

9.1.1.5 Subgrid Scale Orography *

Subgrid scale orography effects taken into account.

☒ Effect on drag

☒ Effect on lifting

- [ ] Enhanced topography - To enhance the generation of long waves in the atmosphere
- [ ] Other - please specify:

9.2.1 Orographic Gravity Waves

Gravity waves generated due to the presence of orography

9.2.1.1 Name

Commonly used name for the orographic gravity wave scheme

Enter TEXT:

9.2.1.2 Source Mechanisms *

Orographic gravity wave source mechanisms

- [ ] Linear mountain waves
- [ ] Hydraulic jump
- [ ] Envelope orography
- [ ] Low level flow blocking
- [x] Statistical sub-grid scale variance
- [ ] Other - please specify:

9.2.1.3 Calculation Method *

Orographic gravity wave calculation method

- [ ] Non-linear calculation
- [x] More than two cardinal directions
- [ ] Other - please specify:

9.2.1.4 Propagation Scheme *

Orographic gravity wave propogation scheme

- [x] Linear theory
- [ ] Non-linear theory
- [ ] Includes boundary layer ducting
- [ ] Other - please specify:

9.2.1.5 Dissipation Scheme *

Orographic gravity wave dissipation scheme

- [x] Total wave
- [ ] Single wave
- [ ] Spectral
- [ ] Linear
- [ ] Wave saturation vs Richardson number
- [ ] Other - please specify:

9.3.1 Non Orographic Gravity Waves

Gravity waves generated by non-orographic processes.

9.3.1.1 Name

Commonly used name for the non-orographic gravity wave scheme

Enter TEXT:

9.3.1.2 Source Mechanisms *

Non-orographic gravity wave source mechanisms

- [ ] Convection
- [ ] Precipitation
- [x] Background spectrum
- [ ] Other - please specify:

9.3.1.3 Calculation Method *

Non-orographic gravity wave calculation method

- [x] Spatially dependent
- [x] Temporally dependent

9.3.1.4 Propagation Scheme *

Non-orographic gravity wave propogation scheme

- [ ] Linear theory
- [x] Non-linear theory
- [ ] Other - please specify:

9.3.1.5 Dissipation Scheme *

Non-orographic gravity wave dissipation scheme

Select SINGLE option:

- ☐ Total wave
- ☐ Single wave
- ☐ Spectral
- ☐ Linear
- ☐ Wave saturation vs Richardson number
- ☐ Other - please specify:

10 Natural Forcing

Natural forcing: solar and volcanic.

10.1.1 Top level properties

Natural forcing: solar and volcanic.

10.1.1.1 Name

Commonly used name for the natural forcing in atmos model.

Enter TEXT:

10.1.1.2 Overview

Overview of natural forcing: solar and volcanic. in atmos model.

Enter TEXT:

10.2.1 Solar Pathways

Pathways for solar forcing of the atmosphere

10.2.1.1 Pathways *

Pathways for the solar forcing of the atmosphere model domain

Select MULTIPLE options:

☐ SW radiation - Shortwave solar spectral irradiance.

☐ Precipitating energetic particles - Precipitating energetic particles from the sun (predominantly protons) and the magnetosphere (predominantly electrons) affect the ionization levels in the polar middle and upper atmosphere, leading to significant changes of the chemical composition

☐ Cosmic rays - Cosmic rays are the main source of ionization in the troposphere and lower stratosphere.

☐ Other - please specify:

10.3.1 Solar Constant

Solar constant and top of atmosphere insolation characteristics

10.3.1.1 Type *

Time adaptation of the solar constant.

☒ Fixed

☐ Transient

10.3.1.2 Fixed Value

If the solar constant is fixed, enter the value of the solar constant (W m-2).

1366.0896

10.3.1.3 Transient Characteristics

Solar constant transient characteristics (W m-2)

Enter TEXT:

10.4.1 Orbital Parameters

Orbital parameters and top of atmosphere insolation characteristics

10.4.1.1 Type *

Type of orbital parameter

☒ Fixed

☐ Transient

10.4.1.2 Fixed Reference Date

Reference date for fixed orbital parameters (yyyy)

2000

10.4.1.3 Transient Method

Description of transient orbital parameters

Enter TEXT:

10.4.1.4 Computation Method

Method used for computing orbital parameters.

☒ Berger 1978

☐ Laskar 2004

☐ Other - please specify:

10.5.1 Insolation Ozone

Impact of solar insolation on stratospheric ozone

10.5.1.1 Solar Ozone Impact *

Does top of atmosphere insolation impact on stratospheric ozone?

☒ True ☐ False

10.6.1 Volcanoes Treatment

Characteristics and treatment of volcanic forcing in the atmosphere

10.6.1.1 Volcanoes Characteristics *

Description of how the volcanic forcing is taken into account in the atmosphere.

Enter TEXT:

10.6.1.2 Volcanoes Implementation *

How volcanic effects are modeled in the atmosphere.

Select SINGLE option:

- ☐ High frequency solar constant anomaly
- ☐ Stratospheric aerosols optical thickness
- ☐ Other - please specify: