

ES-DOC infrastructure for CMIP6

ontology + specialisations + vocabularies

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Part I: CIM v2

Ontology - CIM v2.0

- Semantic model for documenting climate modelling experiments, processes, output, simulations, workflows.
- <https://github.com/ES-DOC/esdoc-cim-v2-schema>

CIM v2 Packages

Activity

Data

Designing

DRS

Platform

Science

Shared

Software

Time

CIM v2 Class Definition

```
def numerical_experiment():
    """Defines a numerical experiment.

    """
    return {
        'type': 'class',
        'base': 'activity.activity',
        'is_abstract': False,
        'properties': [
            ('related_experiments', 'linked_to(designing.numerical_experiment, designing.experimental_relationships)', '0.N',
             "Other experiments which have defined relationships to this one."),
            ('related_mips', 'linked_to(designing.project)', '0.N',
             "MIP's that require this experiment."),
            ('required_period', 'linked_to(designing.temporal_constraint)', '1.1',
             "Constraint on start date and duration."),
            ('requirements', 'linked_to(designing.numerical_requirement)', '0.N',
             "Additional requirements that conformant simulations need to satisfy.")
        ],
        'constraints': [
            ('cardinality', 'duration', '0.0'),
            ('cardinality', 'rationale', '1.1')
        ]
    }
```

CIM v2 – ENUM Definition

```
def coupling_framework():  
    """The set of terms which define known coupling frameworks.  
  
    """  
    return {  
        'type': 'enum',  
        'is_open': False,  
        'members': [  
            ("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")  
        ]  
    }
```

CIM v2 – Tooling

Definitions

Validator

Parser

Generators

CIM v2 – Tooling – Output

```
class NumericalExperiment(activity.Activity):
    """A concrete class within the cim v2 type system.

    Defines a numerical experiment.

    """
    def __init__(self):
        """Instance constructor.

        """
        super(NumericalExperiment, self).__init__()

        self.related_experiments = []           # designing.NumericalExperiment (0.N)
        self.related_mips = []                  # designing.Project (0.N)
        self.required_period = None              # designing.TemporalConstraint (1.1)
        self.requirements = []                  # designing.NumericalRequirement (0.N)
```


CIM v2 – Tooling – Output

```
class CouplingFramework(object):  
    """An enumeration within the cim v2 type system.  
  
    The set of terms which define known coupling frameworks.  
    """  
  
    is_open = False  
    members = [  
        "Bespoke",  
        "ESMF",  
        "NUOPC",  
        "None",  
        "OASIS",  
        "OASIS3-MCT",  
        "Unknown"  
    ]
```

Ontology - CIM v2

<https://github.com/ES-DOC/esdoc-cim-v2-schema>

Part II: pyesdoc

CIM v2 - PYESDOC

- pyesdoc = python client to the esdoc eco-system
- at the heart of the ES-DOC eco-system
- mature, unit-tested, pip installable

Create

Search

Publish

Archive

Codecs

I/O

CIM v2 - PYESDOC



pyesdoc usage - transforming a spreadsheet into archived CIM v2 documents

CIM v2 - PYESDOC



pyesdoc usage - transforming documents into HTML pages

CIM v2 - PYESDOC



pyesdoc usage - validating a CIM 2.0 document

CIM v2 - PYESDOC



pyesdoc usage - publishing documents to ES-DOC web-service

Part III: CIM v2 on the web

CIM v2.0 - Web Assets

Web Services

api.es-doc.org

Search

search.es-doc.org

View

view.es-doc.org

Compare

compare.es-doc.org

CIM v2 – Web Services

<https://api.es-doc.org>

Publishing

/2/document/create
/2/document/delete
/2/document/retrieve
/2/document/update

Search

/2/document/search-drs
/2/document/search-externalid
/2/document/search-id
/2/document/search-name
/2/summary/search
/2/summary/search-setup

CIM v2 – Search & View

<https://search.es-doc.org>

Project / MIP Era:	Document Type:	Document Version:	Sub MIP:
CMIP6-DRAFT	Experiment	Latest	AERCHEMMIP
Total Documents = 241. Filtered Documents = 34.			
<< < Page 1 of 2 > >> 25 / page			
Name	Alternative Name	Description	Version
hist-1950HC	HISTghg+ntcf+hc1950	historical forcing, but with1950s halocarbon concentrations	1
hist-piAer	histghgntcf	historical forcing, but with pre-industrial aerosol emissions	1
hist-piNTCF	HISTghg	historical forcing, but with pre-industrial NTCF emissions	1
historical	cmip6Historical	all-forcing simulation of the recent past	1
histSST	histSST	historical SSTs and historical forcing	1
histSST-1950HC	HISTsstghgntcfhc1950	historical SSTs and historical forcing, but with1950 halocarbon concentrations	1
histSST-piAer	HISTsstghgntcf	historical SSTs and historical forcing, but with pre-industrial aerosol emissions	1
histSST-piCH4	WMFORCch4	historical SSTs and historical forcing, but with pre-industrial methane concentrations	1
histSST-piN2O	WMFORCn20	historical SSTs and historical forcings, but with pre-industrial N2O concentrations	1
histSST-piNTCF	HISTsstghgntcf1850	historical SSTs and historical forcing, but with pre-industrial NTCF emissions	1
histSST-piO3	HISTsstghg	historical SSTs and historical forcing, but with pre-industrial ozone precursor emissions	1
piClim-2xDMS	piSSTclim-2xDMS	pre-industrial climatolgical SSTs and forcing, but with doubled emissions of DMS	1
piClim-2xdust	piSSTclim-2xdust	pre-industrial climatolgical SSTs and forcing, but with doubled emissions of dust	1
piClim-2xss	piSSTclim-2xss	pre-industrial climatolgical SSTs and forcing, but with doubled emissions of sea salt	1
piClim-aer	piSSTclim-Aer	Pre-industrial timeslice with fixed SSTs, but 2014 aerosol emissions	1
piClim-BC	piSSTclim-BC	pre-industrial climatolgical SSTs and forcing, but with 2014 black carbon emissions	1
piClim-CH4	piSSTclim-CH4	pre-industrial climatolgical SSTs and forcing, but with 2014 methane concentrations (including chemistry)	1
piClim-control	piSSTclim	pre-industrial with prescribed climatological SSTs	1
piClim-control	erf-piControl	RFMIP pre-industrial control effective radiative forcing	1
piClim-HC	piSSTclim-HC	pre-industrial climatolgical SSTs and forcing, but with 2014 halocarbon concentrations (including chemistry)	1
piClim-N2O	piSSTclim-N2O	pre-industrial climatolgical SSTs and forcing, but with 2014 N2O concentrations (including chemistry)	1
piClim-NOX	piSSTclim-NOX	pre-industrial climatolgical SSTs and forcing, but with 2014 NOx emissions	1
piClim-NTCF	piSSTclim-NTCF	pre-industrial climatolgical SSTs and forcing, but with 2014 NTCF emissions	1
piClim-O3	piSSTclim-O3	pre-industrial climatolgical SSTs and forcing, but with 2014 ozone precursor emissions	1
Total Documents = 241. Filtered Documents = 34.			
Documentation Search v0.9.5.0 © 2016 ES-DOC			



CMIP6-DRAFT Experiment : Historical

Overview

MIP Era	cmip6-draft
Related MIPs	aerchemmip c4mip cmip6 damp dcpp gmmip highresmip ismip6 ls3mip lumip rf mip
Canonical Name	historical
Alternative Names	cmip6Historical
Internal Name	CMIP6Historical1.1
Long Name	all-forcing simulation of the recent past
Description	Simulation of recent past (1850 to 2014). Impose changing conditions (consistent with observations). Should be initialised from a point early enough in the pre-industrial control run to ensure that the end of all the perturbed runs branching from the end of this historical run end before the end of the control.
Rationale	Spans the period of extensive instrumental temperature measurements from 1850 to the present. Evaluate model performance against present climate and observed climate change.
Keywords	CMIP6 Historical Reference
Related Experiments	amip esm-hist piControl

Model Configuration

Atmosphere-Ocean General Circulation Model Configuration

Name	AOGCMconfiguration
Description	Use a coupled Atmosphere-Ocean general circulation model
Conformance Requested ?	False
Keywords	AOGCM Atmosphere-Ocean General circulation model

Temporal Constraints

1850/01/01 - 2015/01/01

Start Date	1850-01-01
Required Duration	165 years
Description	Historical, pre-Industrial to present
Conformance Requested ?	False
Keywords	1850 2014 Historical Recent Past pre-industrial to present IPCC

Forcing Constraints

Historical Simple Aerosol Plume Climatology

Name	HistoricalSimpleAerosolPlumeClimatology
Description	Apply fields of aerosol optical properties (fine and coarse mode aerosol optical depth (AOD), single scattering albedo (SSA), asymmetry parameter (ASPD) and cloud albedo/anthropogenic increment in drag number (AIAD))

CIM v2 – Explore

<https://explore.es-doc.org>

WCRP ES-DOC Explorer v1.1.4

CMIP6 Model: CNRM-CERFACS > CNRM-CM6-

Institute

CNRM-CERFACS

Model

CNRM-CM6-1

Realm > Process

Top Level

Radiative Forcings

Aerosol

Grid

Transport

Emissions

Concentrations

Optical Radiative Properties

Model

Atmosphere

Grid

Dynamical Core

Radiation

Turbulence Convection

Microphysics Precipitation

Cloud Scheme

Observation Simulation

Gravity Waves

Natural Forcing

Atmospheric Chemistry

Grid

Transport

Emissions Concentrations

Gas Phase Chemistry

Stratospheric Heterogeneous Chemistry

Tropospheric Heterogeneous Chemistry

CNRM-CERFACS > CNRM-CM6-1 :: Atmosphere	
Top Level Properties	
Atmosphere > Name	
Description	Name of atmos model code
Value	ARPEGE-Climat Version 6.3
Atmosphere > Keywords	
Description	Keywords associated with atmos model code
Value	ARPEGE-Climat, dynamical core, cloud parameterization, turbulence parameterization, convection parameterization, gravity wave parameterization
Atmosphere > Overview	
Description	Overview of atmos model.
Value	ARPEGE-Climat Version 6.3 is the atmospheric component of the CNRM climate and Earth System models (CNRM-CM6-1 and CNRM-ESM2-1). It is based on the cycle 37 of the ARPEGE/IFS model (declared in 2010), developed under a collaboration between Météo-France and ECMWF. ARPEGE-Climat shares a large part of its physics and dynamics with its NWP counterpart ARPEGE used operationnally at Météo-France. In comparison to ARPEGE-Climat Version 5.1 used for the CMIP5 exercise in CNRM-CM5.1, most of the atmospheric physics has been updated or revisited (Roehrig et al. 2019, Voldoire et al. 2019). For the surface, it is coupled to the SURFEX platform (Decharme et al. 2019).
Atmosphere > Model Family	
Description	Type of atmospheric model.
Value	AGCM: Atmospheric General Circulation Model
Atmosphere > Basic Approximations	
Description	Basic approximations made in the atmosphere.
Values	Hydrostatic Boussinesq Primitive equations
Resolution	
Resolution > Horizontal Resolution Name	
Description	This is a string usually used by the modelling group to describe the resolution of the model grid, e.g. T42, N48.
Value	T127
Resolution > Canonical Horizontal Resolution	
Description	Expression quoted for gross comparisons of resolution, e.g. 2.5 x 3.75 degrees lat-lon.
Value	Roughly 150x150 km (1.4x1.4 degrees lat-lon at the equator)
Resolution > Range Horizontal Resolution	
Description	Range of horizontal resolution with spatial details, eg. 1 deg (Equator) - 0.5 deg

Part IV: CMIP6 Specializations

CMIP6 Specializations – Problem Space

Consider capturing information related to a model's :

- ocean advection schema;
- ocean lateral & vertical physics;
- atmosphere transport layer;
- sea-ice radiative properties;
- ocean bio-geochemistry boundary forcing;

The community decides what to capture - not ES-DOC.

CMIP6 Specializations – Community role

Let the community own a set of specializations **per modelling realm**:

Let the community define a specialization **per realm process**.

Let the community automatically **validate** each specialization.

Let the community automatically **generate** artefacts, e.g. mindmaps.

CMIP6 Specializations – ES-DOC role

Let ES-DOC guide the realm experts via workshops & training resources.

Let ES-DOC aggregate the various specializations.

Let ES-DOC build value added downstream tools.

Let ES-DOC ensure visibility of final documentation.

CMIP6 Specializations - GitHub

One GitHub repo per modelling realm - community owned

<https://github.com/ES-DOC/cmip6-specializations-ocean>

<https://github.com/ES-DOC/cmip6-specializations-toplevel>

<https://github.com/ES-DOC/cmip6-specializations-seaice>

<https://github.com/ES-DOC/cmip6-specializations-aerosol>

<https://github.com/ES-DOC/cmip6-specializations-atmosphere>

<https://github.com/ES-DOC/cmip6-specializations-landice>

<https://github.com/ES-DOC/cmip6-specializations-land>

<https://github.com/ES-DOC/cmip6-specializations-atmoschem>

CMIP6 Specializations - Authoring

```
SUB_PROCESS_DETAILS['momentum:operator'] = {
    'description': 'Properties of lateral physics operator for momentum in ocean',
    'properties': [
        ('direction', 'ENUM:latphys_operator_direc_types', '1.1',
         'Direction of lateral physics momentum scheme in the ocean'),
        ('order', 'ENUM:latphys_operator_order_types', '1.1',
         'Order of lateral physics momentum scheme in the ocean'),
        ('discretisation', 'ENUM:latphys_operator_discret_types', '1.1',
         'Discretisation of lateral physics momentum scheme in the ocean'),
    ]
}

SUB_PROCESS_DETAILS['momentum:eddy_viscosity_coeff'] = {
    'description': 'Properties of eddy viscosity coeff in lateral physics momentum scheme in the ocean',
    'properties': [
        ('type', 'ENUM:latphys_eddy_visc_coeff_types', '1.1',
         'Lateral physics momentum eddy viscosity coeff type in the ocean'),
        ('constant_coefficient', 'int', '0.1',
         'If constant, value of eddy viscosity coeff in lateral physics momentum scheme (in m2/s)'),
        ('variable_coefficient', 'str', '0.1',
         'If space-varying, describe variations of eddy viscosity coeff in lateral physics momentum scheme'),
        ('coeff_background', 'int', '1.1',
         'Background value of eddy viscosity coeff in lateral physics momentum scheme (in m2/s)'),
        ('coeff_backscatter', 'bool', '1.1',
         'Is there backscatter in eddy viscosity coeff in lateral physics momentum scheme ?')
    ]
}
```

- Very simple python data structures
- Help guides & support from ES-DOC
- Validation tool to sanity check
- Great for small workshops

CMIP6 Specializations - Tooling

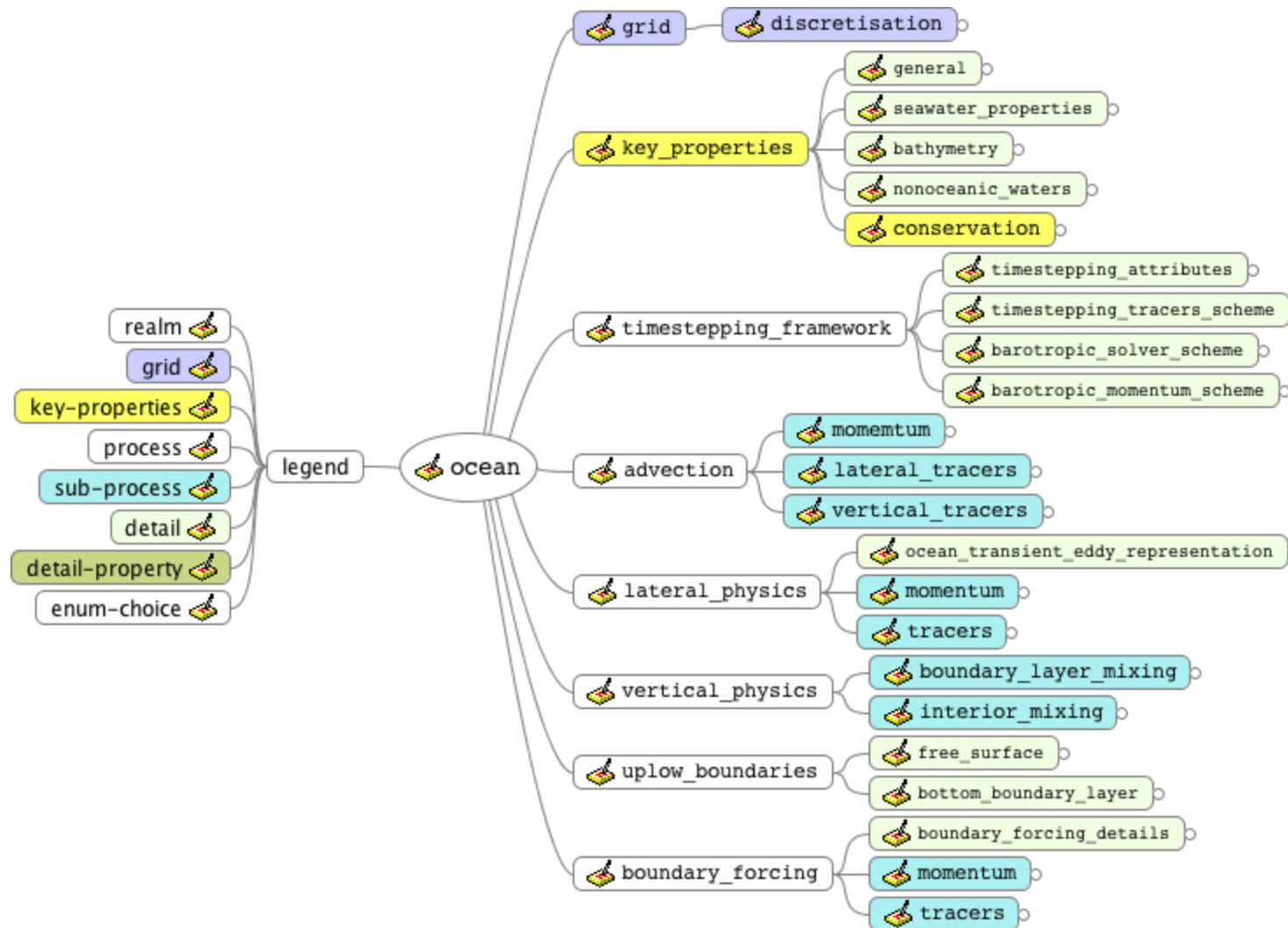
Specializations

Validator

Parser

Generators

CMIP6 Specializations - Mindmap



CMIP6 Specializations – Comparator

Step 1 : Select Model Component Properties Help Reset Next

1. Select Models All

- ACCESS1.0 view
- ACCESS1.3 view
- BCC-CSM1.1 view
- CFSV2-2011 view
- CMCC-CESM view
- CMCC-CM view
- CMCC-CMS view
- CNRM-CM5 view
- CSIRO-MK3.6.0 view
- EC-EARTH view
- GFDL-CM2P1 view
- GFDL-CM3 view
- GFDL-ESM2G view
- GFDL-ESM2M view
- GFDL-HIRAM-C180 view
- GFDL-HIRAM-C360 view
- GISS-E2-H view
- GISS-E2-H-CC view
- GISS-E2-R view
- GISS-E2-R-CC view
- GISS-E2CS-H view
- GISS-E2CS-R view
- HADCM3 view
- HADGEM2-A view
- HADGEM2-CC view

2. Select Components u n

- Aerosols**
 - Emission & Concentration
 - Model
 - Transport
- Atmosphere**
 - Convection Cloud Turbulence
 - Cloud Scheme
 - Cloud Simulator
 - Dynamical Core
 - Advection
 - Orography & Waves
 - Ozone Parameterization
 - Radiation
- Atmospheric Chemistry**
 - Emission & Concentration
 - Gas Phase Chemistry
 - Heterogen Chemistry
 - Stratospheric
 - Tropospheric
 - Photo Chemistry
 - Transport
- Land Ice**
 - Glaciers
 - Sheet
 - Dynamics
 - Shelves
 - Dynamics

3. Select Properties All

- Scientific Properties**
 - Aerosol Scheme Scope
 - Aerosol Time Step Framework
 - Method
 - Scheme Type
 - Time Step
 - Basic Approximations
 - Family Approach
 - List Of Prognostic Variables
 - Number Of Tracers
- Standard Properties**
 - Citations
 - Location
 - Title
 - Description
 - Long Name
 - PI Email Address
 - PI Name
 - Short Name

Model comparison
@ compare.es-doc.org

Part V: CMIP6 Vocabularies

PYESSV

- pyessv = python vocabulary manager
- at the heart of the ES-DOC eco-system
- mature, unit-tested, pip installable
- <https://github.com/ES-DOC/pyessv>

Create

Load

Parse

Archival

Codecs

I/O

PYESSV-ARCHIVE

- pyessv-archive = vocabulary archive
- <https://github.com/ES-DOC/pyessv-archive>
- Initialized with WCRP-CMIP6 vocabularies