is-enes
INFRASTRUCTURE FOR THE EUROPEAN NETWORK FOR EARTH SYSTEM MODELLING

Institut Pierre Simon Laplace

ES-DOC: CIM-2 & CMIP6

From definitions to specializations a technical overview

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es-doc
Earth System Documentation

Agence Nationale de la Recherche ANR - CONVERGENCE
MODÈLES NUMÉRIQUES

Part 1: CIM v2.0

CIM v2.0 – Definition

A data model for documenting climate modelling experiments, processes, output, simulations, workflows.

The data model is partitioned into packages, each package addressing a particular documentation/problem space.

An eco-system of tools & services is built upon the data model.

CIM v2.0 – Packages

Activity	Data	Designing
DRS	Platform	Science
Shared	Software	Time

CIM v2.0 – 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 v2.0 – 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 v2.0 – Tooling

Definitions

Validator | **Parser** | **Generators**

CIM v2.0 – Tooling – Generator 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 v2.0 – Tooling – Generator Output

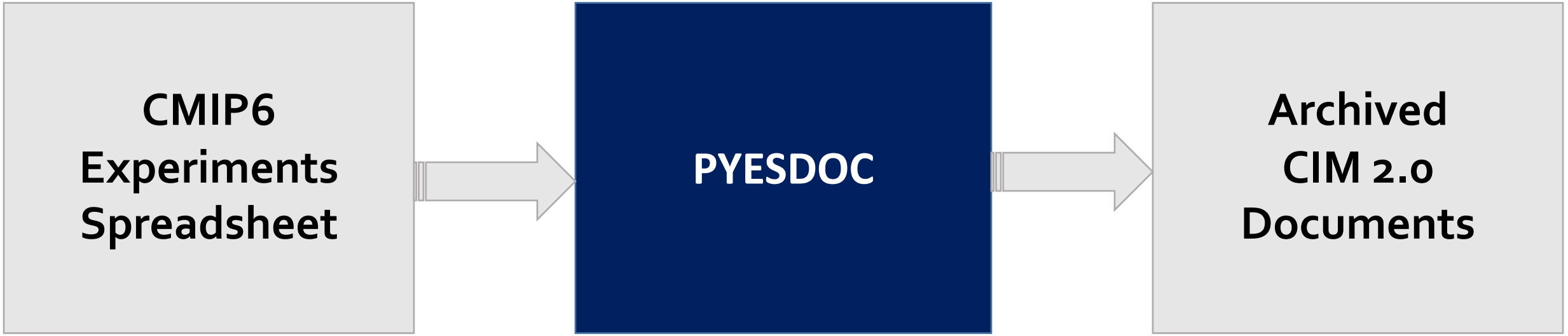
```
class CouplingFramework(object):
    """An enumeration within the cim v2 type system.

    The set of terms which define known coupling frameworks.
    """
    is_open = False
    members = [
        "Bespoke",
        "ESMF",
        "NUOPC",
        "None",
        "OASIS",
        "OASIS3-MCT",
        "Unknown"
        ]
```

CIM v2.0 - PYESDOC

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

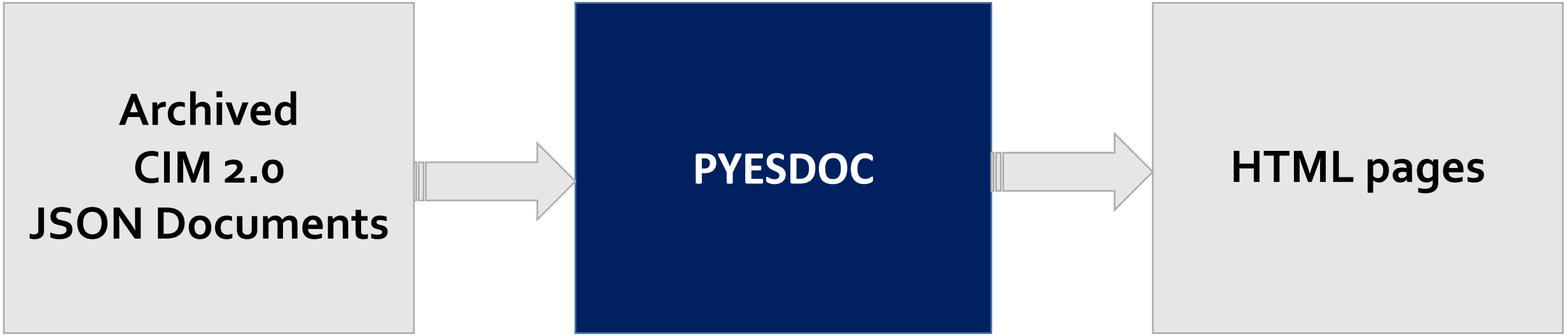
Create	Search	Publish
Archival	XML / JSON	I/O

CIM v2.0 - PYESDOC



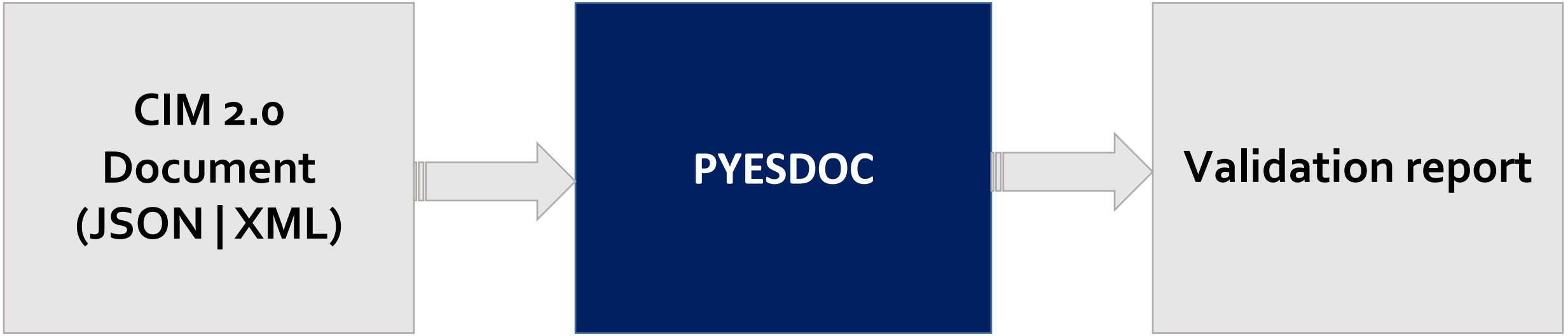
pyesdoc usage scenario – transforming a spreadsheet into archived CIM 2.0 documents

CIM v2.0 - PYESDOC



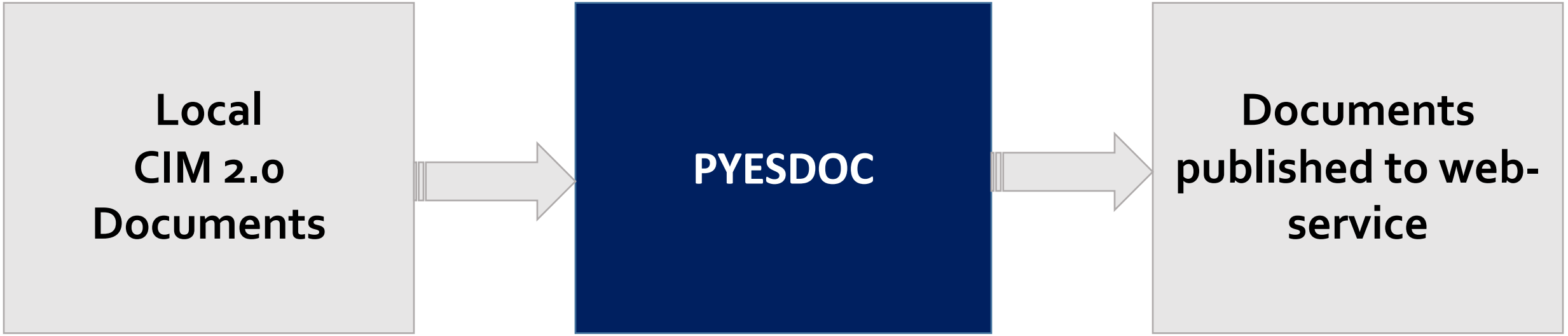
pyesdoc usage scenario – transforming documents into HTML pages

CIM v2.0 - PYESDOC



pyesdoc usage scenario – validating a CIM 2.0 document

CIM v2.0 - PYESDOC



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

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 v2.0 – Web Service

Web Service Endpoints @ 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 v2.0 – Search & View

Documentation search & view @ search.es-doc.org

Project / MIP Era: CMIP6-DRAFT | Document Type: Experiment | Document Version: Latest | Sub MIP: 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 | damip | dcpp | gmmip | highresmip | ismip6 | ls3mip | lumip | rfmip
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

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Ipython Notebook

http://barcelona-rda.es-doc.org

~/pyesdoc/exploring-pyesdoc.ipynb

Part 2: CMIP6 Specializations

CMIP6 Specializations – Problem Space

CIM 2.0 is a set of **static** data structures – think standardization.

However on a project by project basis we need to capture much finer grained documentation – think fluid scientific narratives.

Specializations allow the scientific community to decide what (model) documentation they wish to capture.

The CIM moves from the foreground to the background (where it belongs).

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;

Only the community can decide 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-**aerosols**
https://github.com/ES-DOC/cmip6-specializations-**atmosphere**
https://github.com/ES-DOC/cmip6-specializations-**atmospheric-chemistry**
https://github.com/ES-DOC/cmip6-specializations-**landice**
https://github.com/ES-DOC/cmip6-specializations-**landsurface**
https://github.com/ES-DOC/cmip6-specializations-**ocean**
https://github.com/ES-DOC/cmip6-specializations-**ocean-bgc**
https://github.com/ES-DOC/cmip6-specializations-**seaice**

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 momemtum scheme in the ocean'),
        ('order', 'ENUM:latphys_operator_order_types', '1.1',
            'Order of lateral physics momemtum scheme in the ocean'),
        ('discretisation', 'ENUM:latphys_operator_discret_types', '1.1',
            'Discretisation of lateral physics momemtum scheme in the ocean'),
        ]
}

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

Very simple python data structures

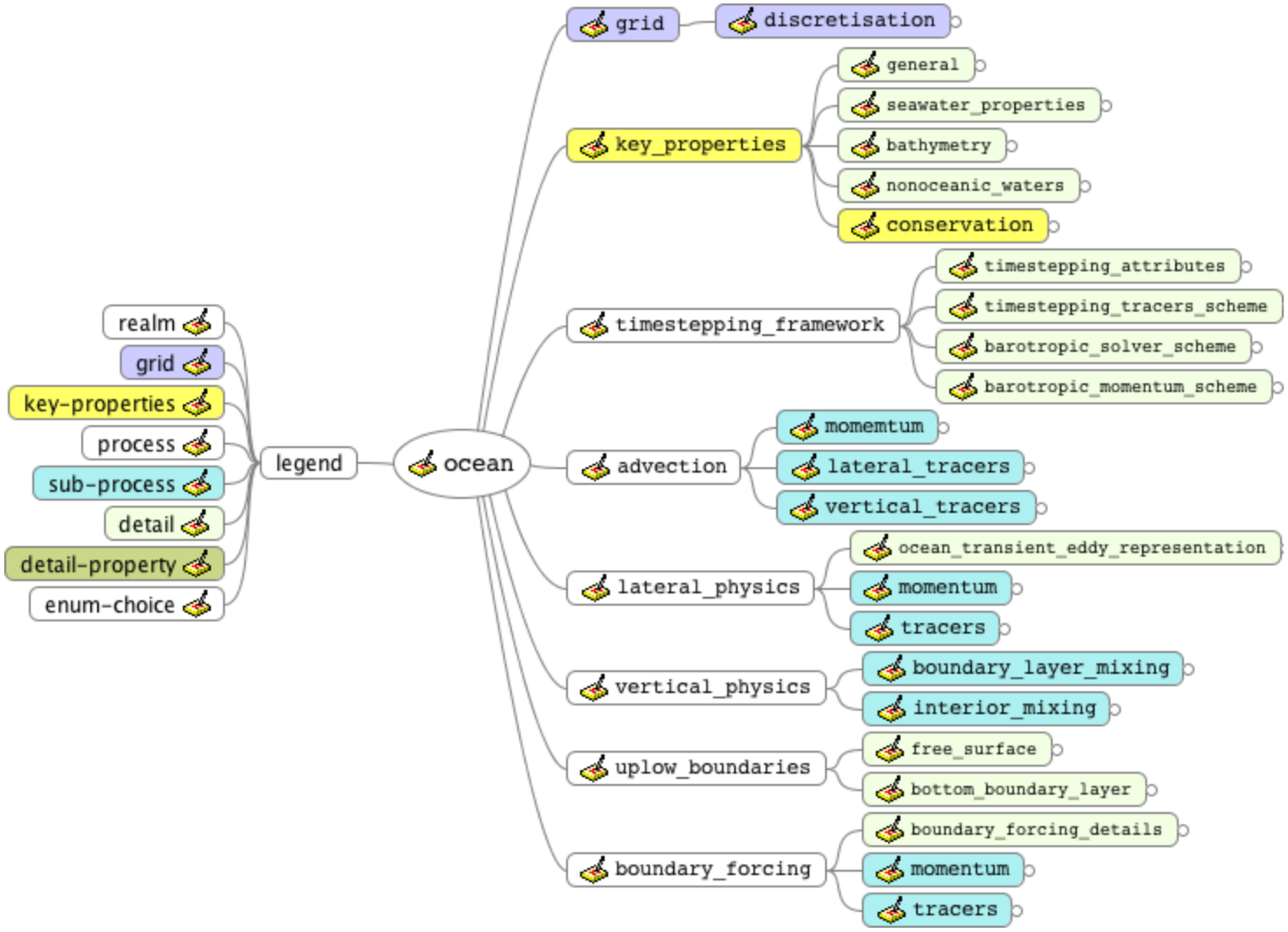
Help guides & support from ES-DOC

Validation tool to sanity check

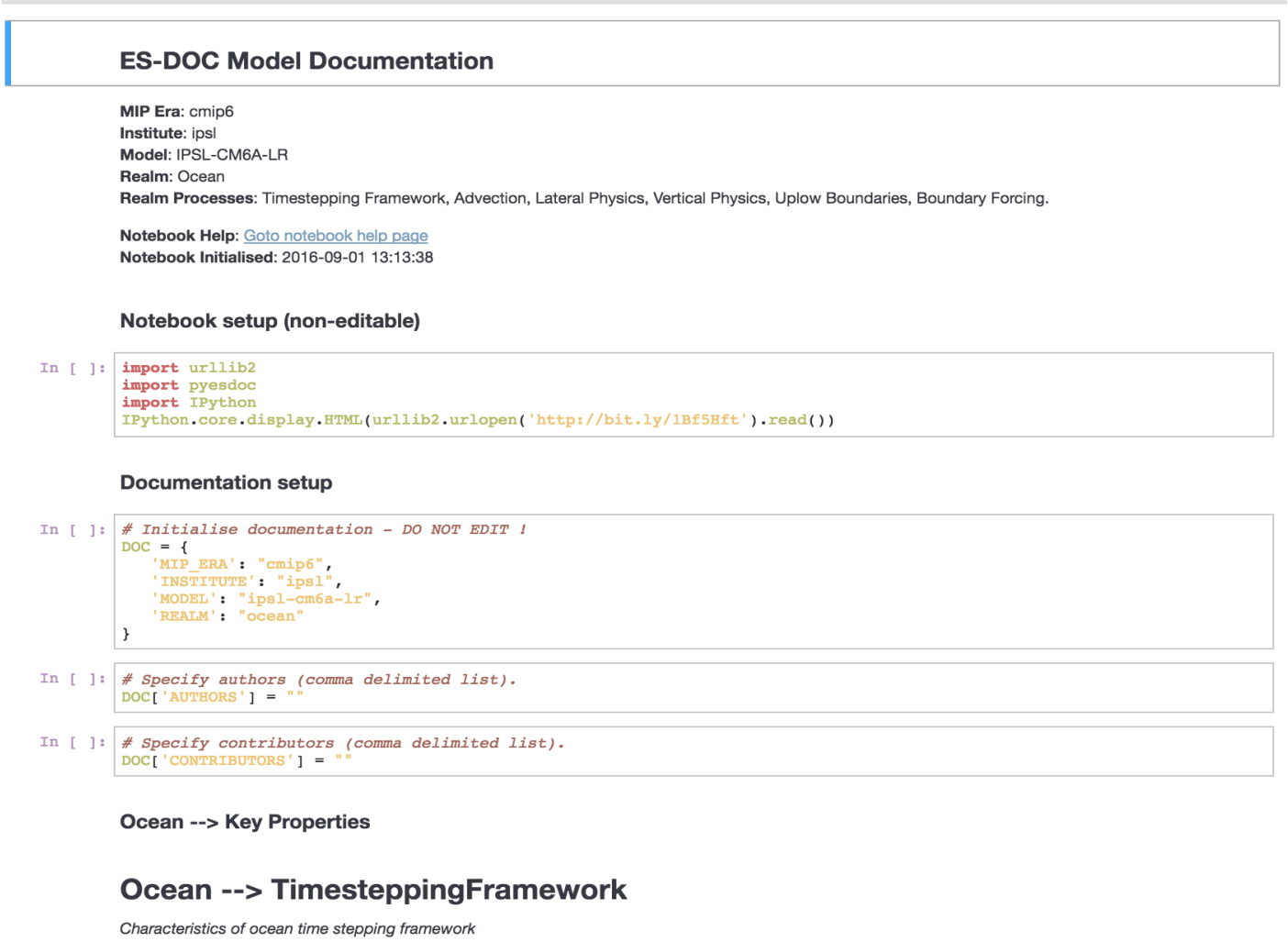
Great for small workshops

CMIP6 Specializations - Tooling

CMIP6 Specializations - Mindmap



CMIP6 Specializations – IPython Notebooks



ES-DOC Model Documentation

MIP Era: cmip6
Institute: ipsl
Model: IPSL-CM6A-LR
Realm: Ocean
Realm Processes: Timestepping Framework, Advection, Lateral Physics, Vertical Physics, Uplow Boundaries, Boundary Forcing.

Notebook Help: Goto notebook help page
Notebook Initialised: 2016-09-01 13:13:38

Notebook setup (non-editable)

In [ ]:
```
import urllib2
import pyesdoc
import IPython
IPython.core.display.HTML(urllib2.urlopen('http://bit.ly/1Bf5Hft').read())
```

Documentation setup

In [ ]:
```
# Initialise documentation - DO NOT EDIT !
DOC = {
    'MIP_ERA': "cmip6",
    'INSTITUTE': "ipsl",
    'MODEL': "ipsl-cm6a-lr",
    'REALM': "ocean"
}
```

In [ ]:
```
# Specify authors (comma delimited list).
DOC['AUTHORS'] = ""
```

In [ ]:
```
# Specify contributors (comma delimited list).
DOC['CONTRIBUTORS'] = ""
```

Ocean --> Key Properties

Ocean --> TimesteppingFramework

Characteristics of ocean time stepping framework

IPython notebooks are generated from specializations.

One notebook per model per realm.

As the specializations evolve, so do the notebooks.

CMIP6 Specializations – IPython Notebooks

```
In [ ]: DOC['lateral_physics.momentum.operator.direction'] = ""
        # Direction of lateral physics momemtum scheme in the ocean
        # OPTIONAL ENUM - choose ONE from:
        #     "Geopotential"
        #     "Horizontal"
        #     "Iso-level"
        #     "Isoneutral"
        #     "Isopycnal"
        #     "Other: [Please specify]"

In [ ]: DOC['lateral_physics.momentum.operator.order'] = ""
        # Order of lateral physics momemtum scheme in the ocean
        # OPTIONAL ENUM - choose ONE from:
        #     "Bi-harmonic"
        #     "Harmonic"
        #     "Other: [Please specify]"

In [ ]: DOC['lateral_physics.momentum.operator.discretisation'] = ""
        # Discretisation of lateral physics momemtum scheme in the ocean
        # OPTIONAL ENUM - choose ONE from:
        #     "Flux limiter"
        #     "Higher order"
        #     "Second order"
        #     "Other: [Please specify]"

In [ ]: DOC['lateral_physics.momentum.eddy_viscosity_coeff.type'] = ""
        # Lateral physics momemtum eddy viscosity coeff type in the ocean
        # OPTIONAL ENUM - choose ONE from:
        #     "Constant"
        #     "Space varying"
        #     "Time + space varying (Smagorinsky)"
        #     "Other: [Please specify]"

In [ ]: DOC['lateral_physics.momentum.eddy_viscosity_coeff.constant_coefficient'] = ""
        # If constant, value of eddy viscosity coeff in lateral physics momemtum scheme (in m2/s)
        # MANDATORY INTEGER

In [ ]: DOC['lateral_physics.momentum.eddy_viscosity_coeff.variable_coefficient'] = ""
        # If space-varying, describe variations of eddy viscosity coeff in lateral physics momemtum scheme
        # MANDATORY STRING

In [ ]: DOC['lateral_physics.momentum.eddy_viscosity_coeff.coeff_background'] = ""
        # Background value of eddy viscosity coeff in lateral physics momemtum scheme (in m2/s)
        # OPTIONAL INTEGER

In [ ]: DOC['lateral_physics.momentum.eddy_viscosity_coeff.coeff_backscatter'] = ""
        # Is there backscatter in eddy viscosity coeff in lateral physics momemtum scheme ?
        # OPTIONAL BOOLEAN - choose ONE from:
        #     "True"
        #     "False"
```

The notebooks can be iteratively completed over time.

The notebooks will be hosted by ES-DOC.

Light-weight but effective solution to gathering a lot of complex information.

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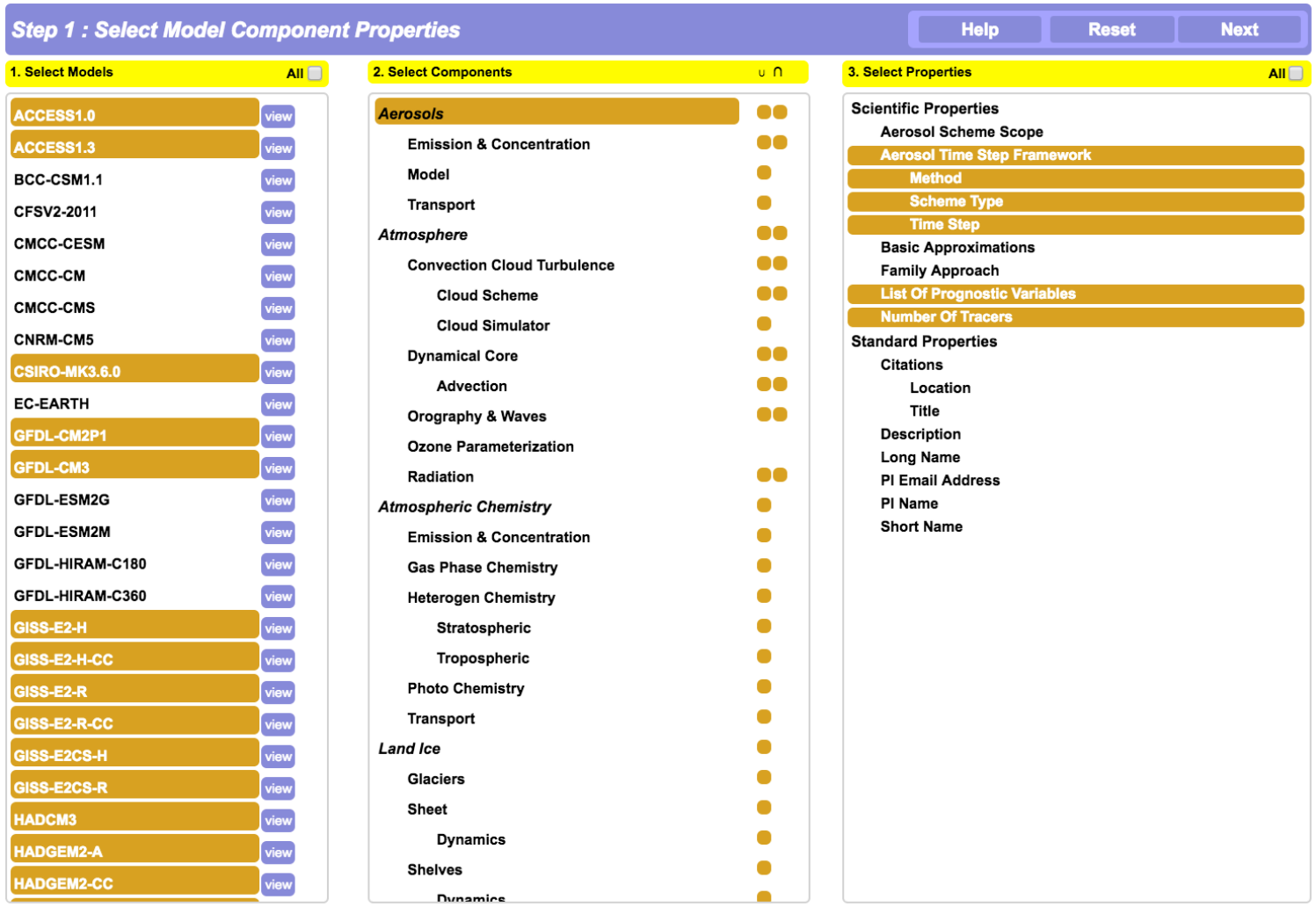
CMIP6 Specializations – Comparator



Model comparison
@ compare.es-doc.org

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Ipython Notebook

http://barcelona-rda.es-doc.org

~/cmip6/seaice.ipynb

Part 3: CMIP6 Vocabularies

PYESSV

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

Create	**Load**	**Parse**
Archival	**XML / JSON**	**I/O**

PYESSV-ARCHIVE

- pyessv-archive = vocabulary archive
- https://github.com/ES-DOC/pyessv-archive.git
- Iniitialized with WCRP-CMIP6 vocabularies

Ipython Notebook

http://barcelona-rda.es-doc.org

~/pyessv/pyessv-and-cmip6.ipynb