# Documenting CMIP Model development Consensus model evaluation

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Climate model data for climate services workshop
Reading, March 2018



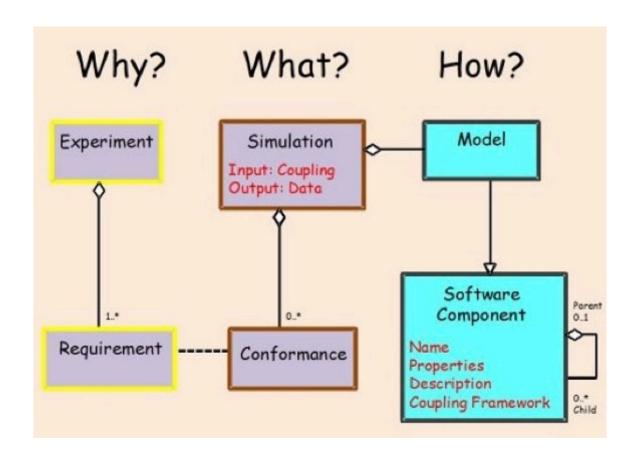








## Capturing the concepts of climate modelling: the Common Information Model - CIM



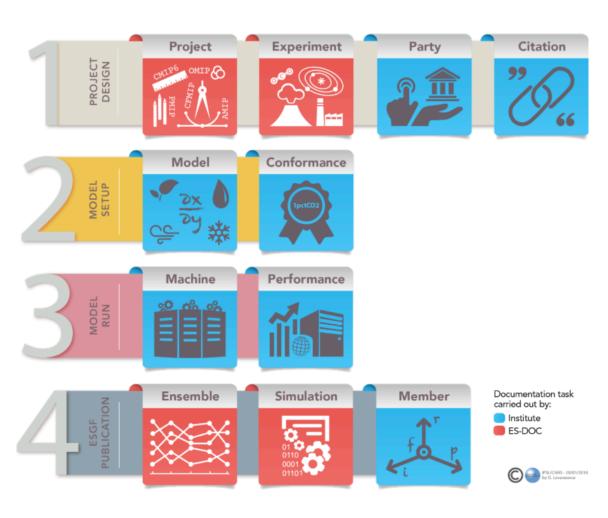


## **CMIP6** documentation



#### The documentation workflow:

- About half of the documents automated or ES-DOC generated
- The others <u>produced by groups</u> when ready
- Links from "futher\_info\_URL":
  - Institute's general homepage
  - Description of the experiment
  - Scientific description of model
  - Description of the ensemble
  - Institute's own page
  - Dataset errata information
  - Citation information
  - Performance
  - Datasets in ESGF
- Note: conformance document tocapture exact forcing used by groups

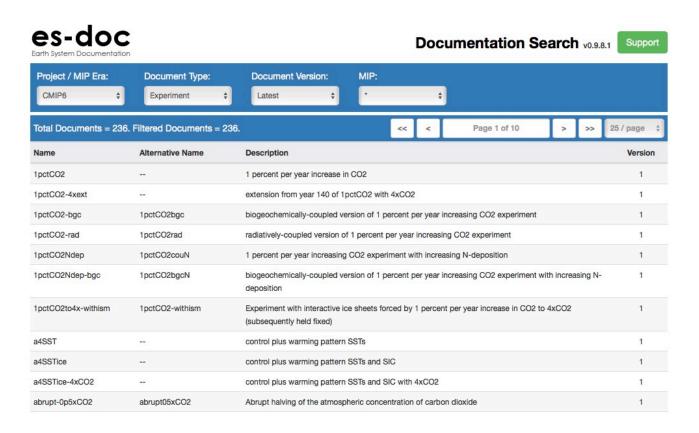


Full support and step by step process documentation on <a href="https://es-doc.org/cmip6">https://es-doc.org/cmip6</a>



## CMIP6 experiment documentation

- ES-DOC documented all MIPs <u>experiments</u>
- Numerous exchanges with MIP coordinators acted as QC
- Acts as official reference for CMIP6 MIPs description





Baroclinic Dynamics > Type

Overview

#### CMIP6 Specializations Viewer vo.9.8.1

Support



#### CMIP6 > Ocean > Timestepping Framework

Other

Description	Overview of time stepping in	verview of time stepping in ocean					
Type   Cardinality	str   1.1	1.1					
Diurnal Cycle							
Description	Diurnal cycle type	Diurnal cycle type					
Type   Cardinality	enum   1.1						
Allowed Options	None	No diurnal cycle in ocean					
	Via coupling	Diurnal cycle via coupling frequency					
	Specific treatment	Specific treament					

User Defined

Tracers > Scheme							
Description	Tracers time stepping scheme	Tracers time stepping scheme					
Type   Cardinality	enum   1.1						
Allowed Options	Leap-frog + Asselin filter	Leap-frog scheme with Asselin filter					
	Leap-frog + Periodic Euler	Leap-frog scheme with Periodic Euler					
	Predictor-corrector	Predictor-corrector scheme					
	Runge-Kutta 2	Runge-Kutta 2 scheme					
	AM3-LF	AM3-LF such as used in ROMS					
	Forward-backward	Forward-backward scheme					
	Forward operator	Forward operator scheme					
	Other	User Defined					

Tracers > Time Step					
Description Tracers time step (in seconds)					
Type   Cardinality	int   1.1				

Description	Baroclinic dynamics type					
Type   Cardinality	enum   1.1					

## **ES-DOC for CMIP6 status**



#### **CMIP6 documentation scope:**

 Climate modelling community has a responsability to document data output for users beyond the WGCM community – this is a key issue for many stakeholders

#### Designed so that process is easier for modelling groups:

- Large fraction is automated
- Option to start model description from CMIP5 version
- Modular and agile process
- Documentation for all steps (+ published WIP white paper)

#### **Community review:**

• Science contents of model documentation (realms, short tables) on-going

#### Beta testing phase on-going (GFDL, IPSL, UKMO and CCMA, IITM, BCC)

Report to be provided March 2018

#### Time line:

- Science contents of realms ready (V1.0)
- iPython notebook/xls entry tool with CMIP5 seeding ready (in beta test)
- Cdf2cim tool ready for ESGF ingestion
- Community support tools (checklist, training, webcasts, ...) ready April 15<sup>th</sup>
- May 1st for full end-to-end release for model and simulation documentation
- IS-ENES3 preparation





## The ES-DOC team



#### The development team:

- Atef Ben Nasser (IPSL): development
- Chris Blanton (GFDL): beta testing
- Mark Elkington (UKMO): requirements and beta testing
- Mark Greenslade (IPSL): core development
- Eric Guilyardi (IPSL/NCAS): coord., requirements and realm work
- David Hassell (NCAS): user support, realm work and development
- Bryan Lawrence (NCAS): CIM, coord.
- Charlotte Pascoe (STFC): experiments and realm work
- Ruth Petrie (NCAS): realm work
- Ag Stephens (STFC): link with CMIP6 ESGF stack
- Martina Stockhause (DKRZ): link with CMIP6 citation service
- Allyn Treshansky (NOAA): development (until July 2017)

#### The Pls:

- Balaji (GFDL)
- Sébastien Denvil (IPSL)
- Eric Guilyardi (NCAS/IPSL)
- Bryan Lawrence (NCAS)
- Cecelia de Luca (NOAA)
- Karl Taylor (PCMDI)

Follow our work on https://github.com/ES-DOC





## Looking ahead: strengths and challenges

- Strong expertise fostered by PRISM/METAFOR/IS-ENES support and legacy – common understanding of issues
- International coordination, overseen by WIP
- Number of operational tools maturing ecosystem, CIM2
- CMIP6 documentation workflow well defined and organised around modelling groups perspective
- Long term sustainability
- Further engage with documentation users
  - Standards, codes, scientific realms governance
- Extend scope (Obs4MIPs, S2D, downscaling, model evaluation,...)
- Engage with other initiatives, e.g. Copernicus



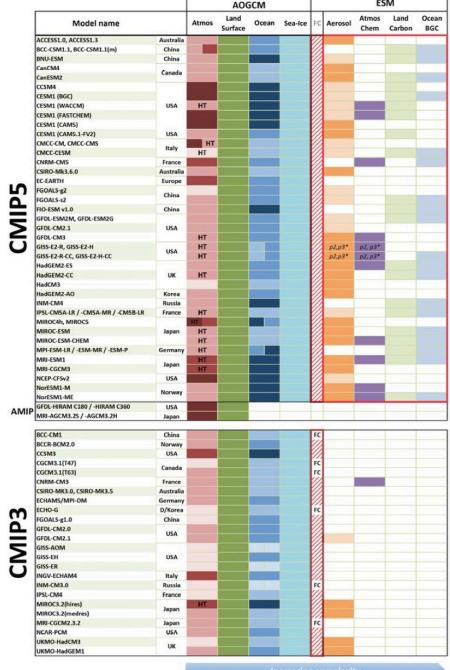






## Model development

- Balance between resolution/complexity/ensem ble size/simulation length
- Evolution from CMIP5:
  - Increased model variety (e.g. resolution)
  - New processes: interactive chemistry, active land processes, ice sheets, permafrost,...
- Model tuning better documented
- ES-DOC will help explore models structure



8000 30000 52000

12000 50000 110000

Increasing resolution Atmosphere / Ocean

(total number of horizonal grid points)

## **CMIP6: Participating Model Groups**

	Institution	Country		Institution	Country		Institution	Country
1	AWI	Germany	12	DOE	USA	23	MRI	Japan
2	BCC	China	13	EC-Earth-Cons	Europe	24	NASA-GISS	USA
3	BNU	China	14	FGOALS	China	25	NCAR	USA
4	CAMS	China	15	FIO-RONM	China	26	NCC	Norway
5	CasESM	China	16	INM	Russia	27	NERC	UK
6	CCCma	Canada	17	INPE	Brazil	28	NIMS-KMA	Republic of Korea
7	CCCR-IITM	India	18	IPSL	France	29	NOAA-GFDL	USA
8	CMCC	Italy	19	MESSY-Cons	Germany	30	NUIST	China
9	CNRM	France	20	MIROC	Japan	31	TaiESM	Taiwan, China
10	CSIR-CSIRO	South Africa	21	MOHC	UK	32	THU	China
11	CSIRO-BOM	Australia	22	MPI-M	Germany	33	Seoul Nat.Uni	Republic of Korea

#### New in CMIP:

2 new model groups from Germany (AWI, MESSY-Consortium)

4 new model groups from China (CAMS, CasESM, NUIST, THU)

1 new model group from Brazil (INPE)

1 new model group from India (CCCR-IITM)

1 new model group from Taiwan, China (TaiESM)

1 new model group from USA (DOE)

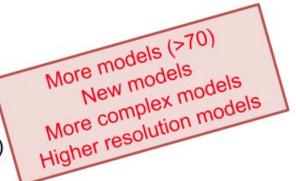
2 new model group from Republic of Korea (NIMS-KMA, SAM0-UNICON)

1 new model group from South Africa / Australia (CSIR-CSIRO)

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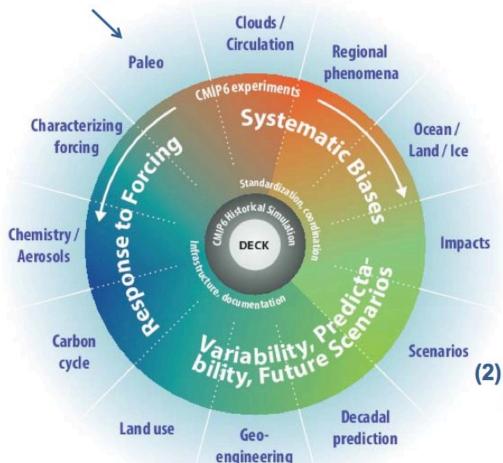
#### ⇒ 13 new model groups so far





#### CMIP: a More Continuous and Distributed Organization

## (3) CMIP-Endorsed Model Intercomparison Projects (MIPs)



#### (1) A handful of common experiments

#### DECK (entry card for CMIP)

- AMIP simulation (~1979-2014)
- Pre-industrial control simulation
- iii. 1%/yr CO2 increase
- iv. Abrupt 4xCO<sub>2</sub> run

## CMIP6 Historical Simulation (entry card for CMIP6)

- V. Historical simulation using CMIP6 forcings (1850-2014)
- (2) Standardization, coordination, infrastructure, documentation

DECK (Diagnosis, Evaluation, and Characterization of Klima) & CMIP6 Historical Simulation to be run for each model configuration used in CMIP6-Endorsed MIPs

Eyring et al., GMD, 2016

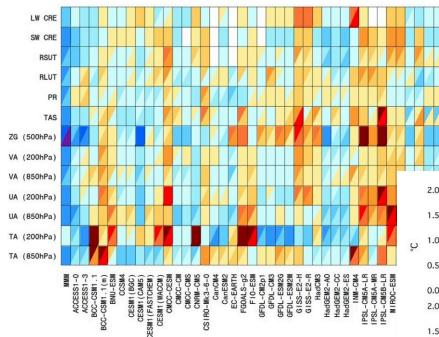
## **Evaluating climate models**

0.5

0.2

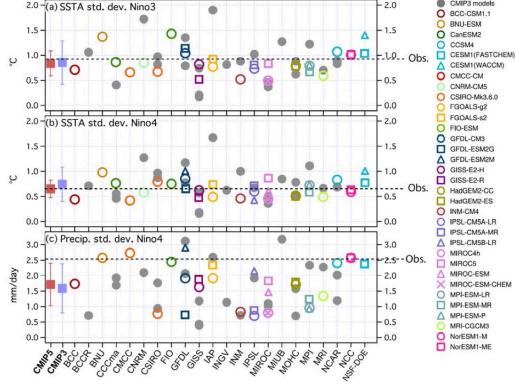
-0.1





Produce such figures Cf. Chap 9 IPCC AR5

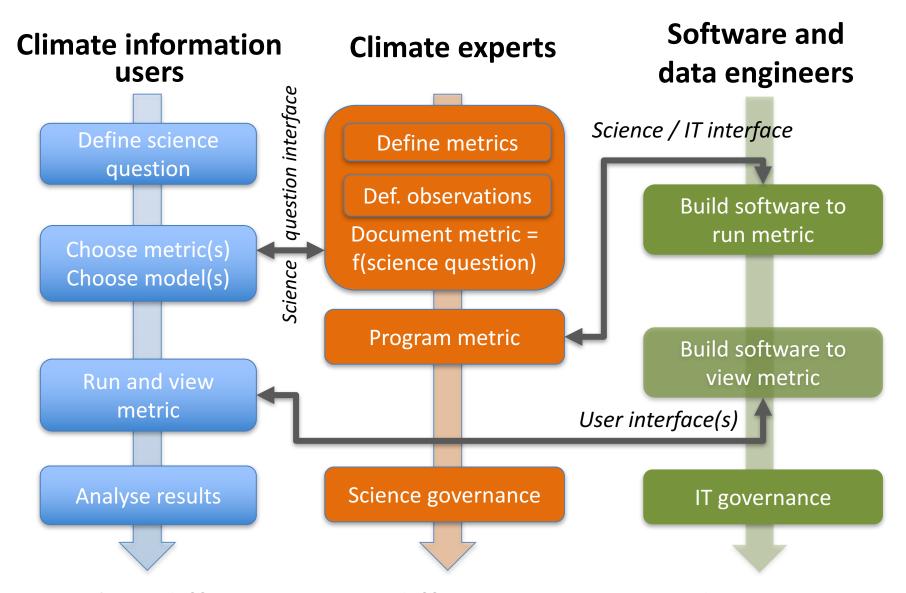
Vast array of science questions adressed by a growing number of model users



## Evaluating climate models

- Distinguish exploratory model evaluation from consensus model evaluation
- Metrics vs. diagnostics
- In scope here: <u>consensus model evaluation</u> metrics and diagnostics

## Model evaluation workflow



Articulate different actors, different expertise and expectations

## Separation of concerns

- User needs state-of-the-art :
  - Science of model evaluation
  - Software tools for model evaluation
- Different experts -> different governance & maintenance
- Otherwise one of them becomes obsolete
  - High risk of mis-use
  - Loss of trust, wasted ressources
- Articulation/modularity via clear interfaces
- e.g. lessons learned for CMIP, ESGF, ES-DOC,...

## Science of consensus model evaluation

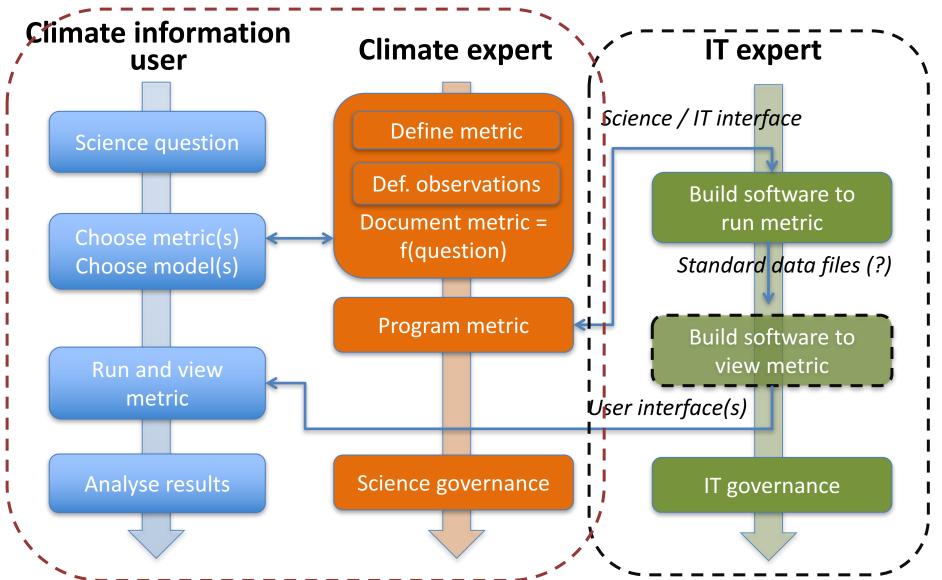
- What is the scientific question ?
- What are the related metrics (performance, process-based, teleconnections,...) ?
- What are the reference "observations"?
  - Obs4MIPs,...
- Who has the knowledge for governance/trust?
  - Climate scientists, observations experts
  - WCRP/CLIVAR/PAGES/... panels that gather scientific expertise on specific topics (climate sensitivity, ENSO, monsoons, THC, MJO, salinity, carbon cycle,...)

## Software for model evaluation

- How to best compute the metrics (get data, run on computer, visualize,...)
- Challenging project: define workflow, process, development, modularity, funding, etc.

- Who has the knowledge for governance/trust?
  - IT and data experts
  - e.g. ENES, WIP, ESGF, ES-DOC, C3S,...

## Challenge: how do we organise this?



## Testing concepts with ENSO metrics

- Work on common interface with several model evaluation tools PMP/ESMValTool/CLIMAF
- Start from PMP implementation of Bellenger et al. (2014) metrics
- People involved so far:
  - Eric Guilyardi and Yann Planton (IPSL/LOCEAN for ENSO RF)
  - Peter Gleckler and Jiwoo Lee (PCMDI for PMP)
  - Veronika Eyring and Axel Lauer (DLR for ESMValTool)
  - Jérôme Servonnat (IPSL for CLIMAF)



## Document science provenance of metric

- What is the scientific question ?
- What are the related metrics?
- What are the reference "observations"?

 Introduce concept of Metric collection (MC) to address specific science question

	Metric 1	Metric 2	Metric 3	Metric 4	Metric 5
Collection Q1					
Collection Q2					
Collection Q3					
•••					

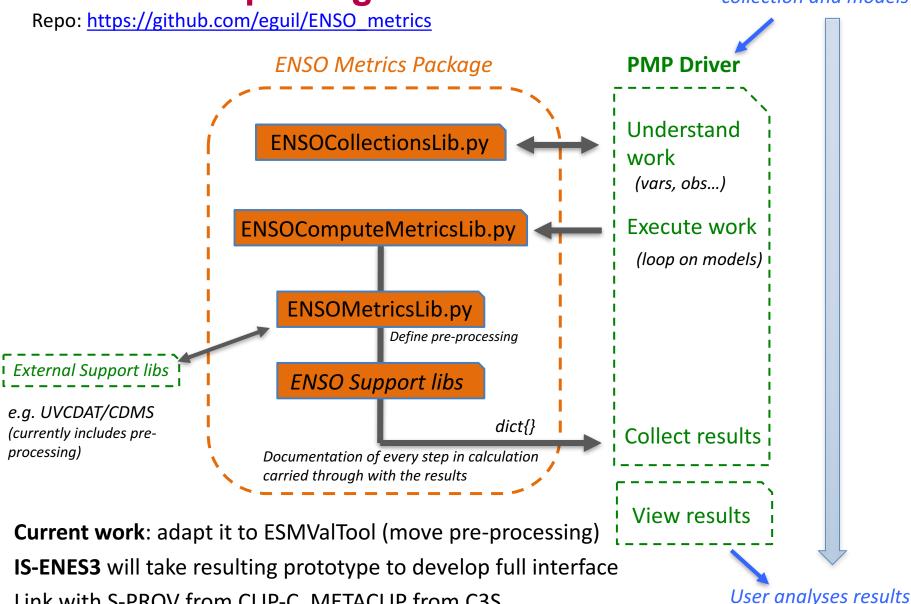
## List of science questions

- ENSO performance in historical
- ENSO teleconnections in historical
- ENSO processes
- Details of metrics to provide (10 max):
  - Documentation: whys and hows of the metric and the collection
  - Math definition of the metric
  - Frequency (DA, MO,...)
  - Observations (as many as possible), including which period to use
  - Reference to show the robustness of metric
  - Minimum number of realisations (for metric to make sense)
  - Minimum lenght of simulation needed (for metric to make sense)

## **Current structure of ENSO** package

Link with S-PROV from CLIP-C, METACLIP from C3S,...

User chooses metric collection and models



## Which science governance?

- How to label consensus model evaluation?
- Like for MIPs proposed by the community, a panel (e.g. a consensus « model evaluation panel ») could define quality criteria and label packages
- Criteria would include process, maturity, level of documentation, review etc. maybe following IPCC-like process
- An ad-hoc group would oversee the technical standard for the science provenance (like WIP for WGCM)
- Currently in discussion as part of WCRP strategy update

