CMIP6's Reliance on ESGF Infrastructure: Present and Future

Karl E. Taylor

With contributions from
The WGCM Infrastructure Panel and PCMDI

Presented at the

8th Annual Earth System Grid Federation Conference

Washington D.C.

3 December 2018

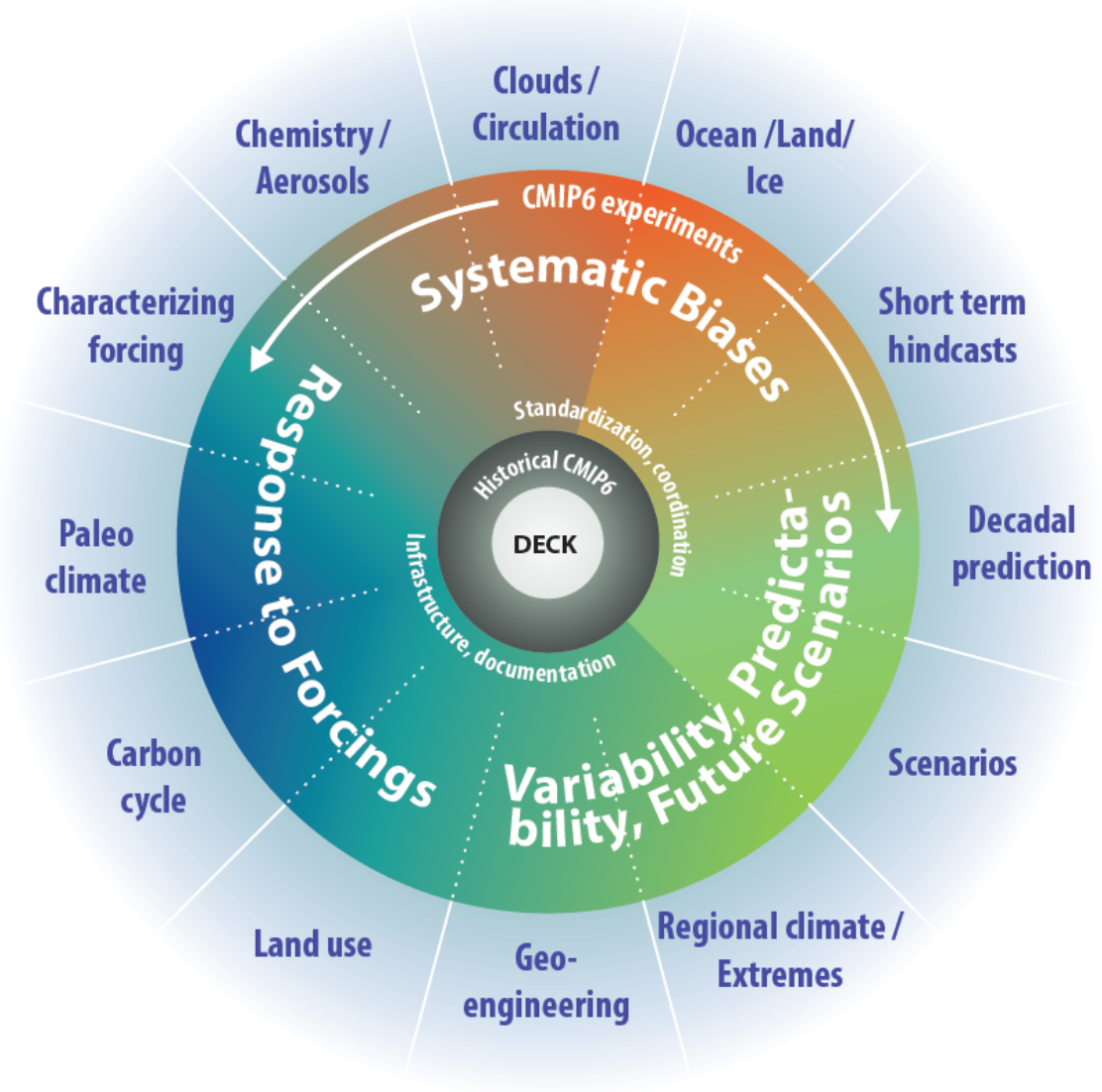
CMIP and the climate modeling community rely on ESGF to serve critical ongoing needs

- Modeling centers have invested heavily in adapting their simulation work flow to be consistent with CMIP requirements.
- Users now expect easy access to multi-model simulation output.
- The WCRP advocates use of ESGF to serve data from international coordinated climate research efforts (e.g., obs4MIPs, CORDEX, input4MIPs)
- We must ensure sufficient resources continue to be invested in ESGF

Outline

- CMIP6 project status
- Review major components of infrastructure supporting CMIP6
  - Present status
  - Deficiencies
- Remarks on longer-term issues

CMIP6 design overview:



DECK

- Small set of benchmark runs
- To evolve only slowly (e.g. OMIP, LMIP)

Historical CMIPX

- Forcing to be updated for each new phase

CMIP6-endorsed MIPs

- An evolving collection to address specific scientific issues

CMIP5/6 evolution: More institutions, more models, more experiments, more data

- 44 institutions/consortia have officially registered for CMIP6
- 100 models are registered
- 287 experiments defined
- order 20 PB of model output expected

CMIP6_CVs

https://github.com/WCRP-CMIP/CMIP6_CVs

Core Controlled Vocabularies (CVs) for use in CMIP6

Registering Institutions, Models, or requesting changes to CVs:

To register your institution or model or to request changes to a CV, please submit an issue/ticket following the instructions on the CMIP6_CVs issue page.

Some support for CMIP participating modeling groups is available: pcmdi-cmip@llnl.gov

To view the current `experiment_id` entries point your browser to CMIP6_experiment_id.html

To view the current `institution_id` entries point your browser to CMIP6_institution_id.html

To view the current `source_id` entries point your browser to CMIP6_source_id.html

The CVs build on logic that is described in the CMIP6 Global Attributes, DRS, Filenames, Directory Structure, and CV's document

E. Taylor

CMIP6 status: data availability and IPCC timeline

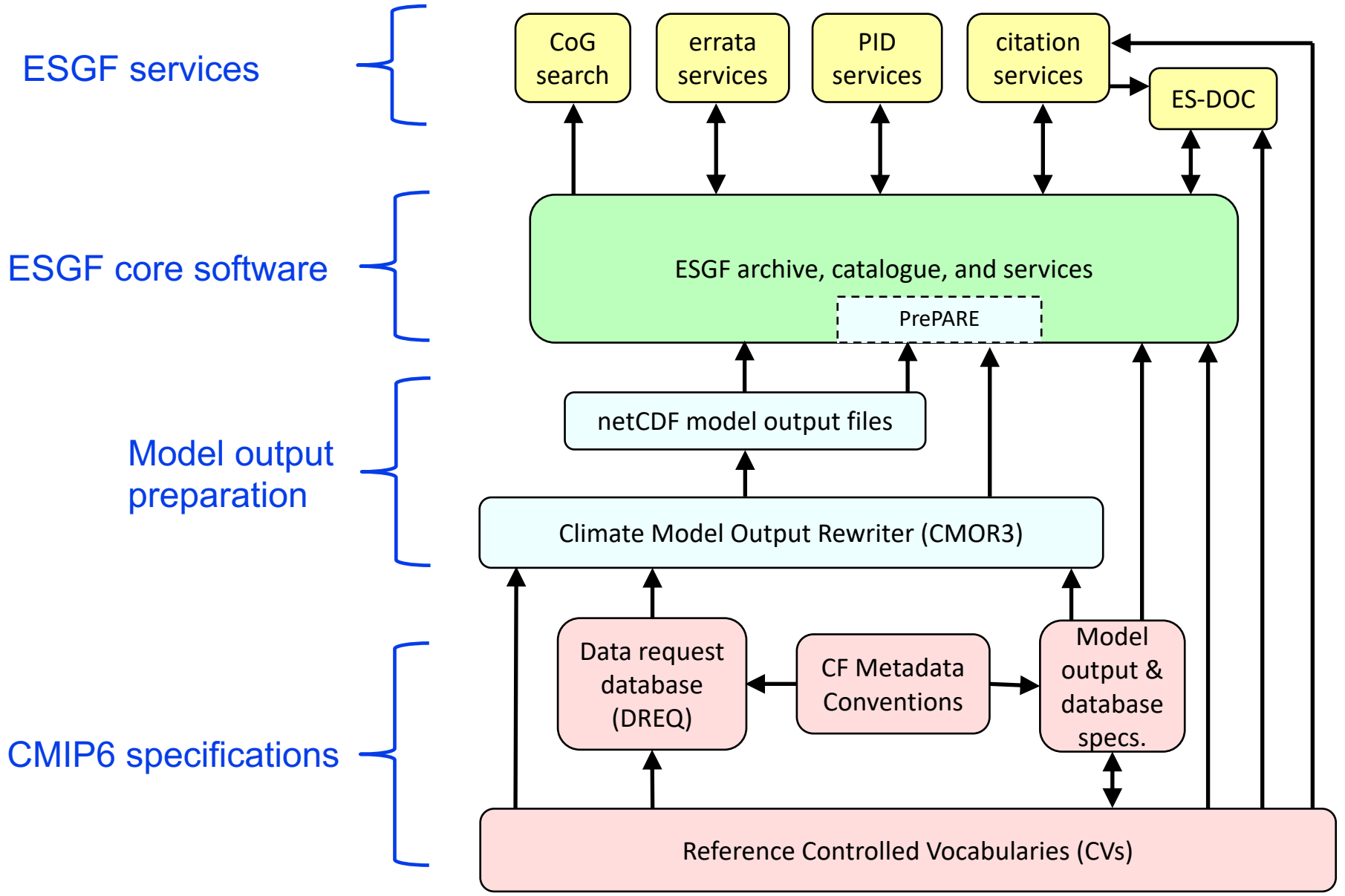
- Model output now being served by ESGF from 4 institutions (6 models) and 19 experiments
- Much output to be made available over the next year

2019	
January 7	Second Lead Author Meeting
April 29	First order draft expert review
August 26	Third Lead Author Meeting
2020	
March 2	Second order draft expert review
June 1	Fourth Lead Author Meeting
October 18	Submission of final draft
2021	
April 16	IPCC acceptance/adoption/approval

31 December 2019: Journal articles submitted

30 September 2020: Journal articles accepted

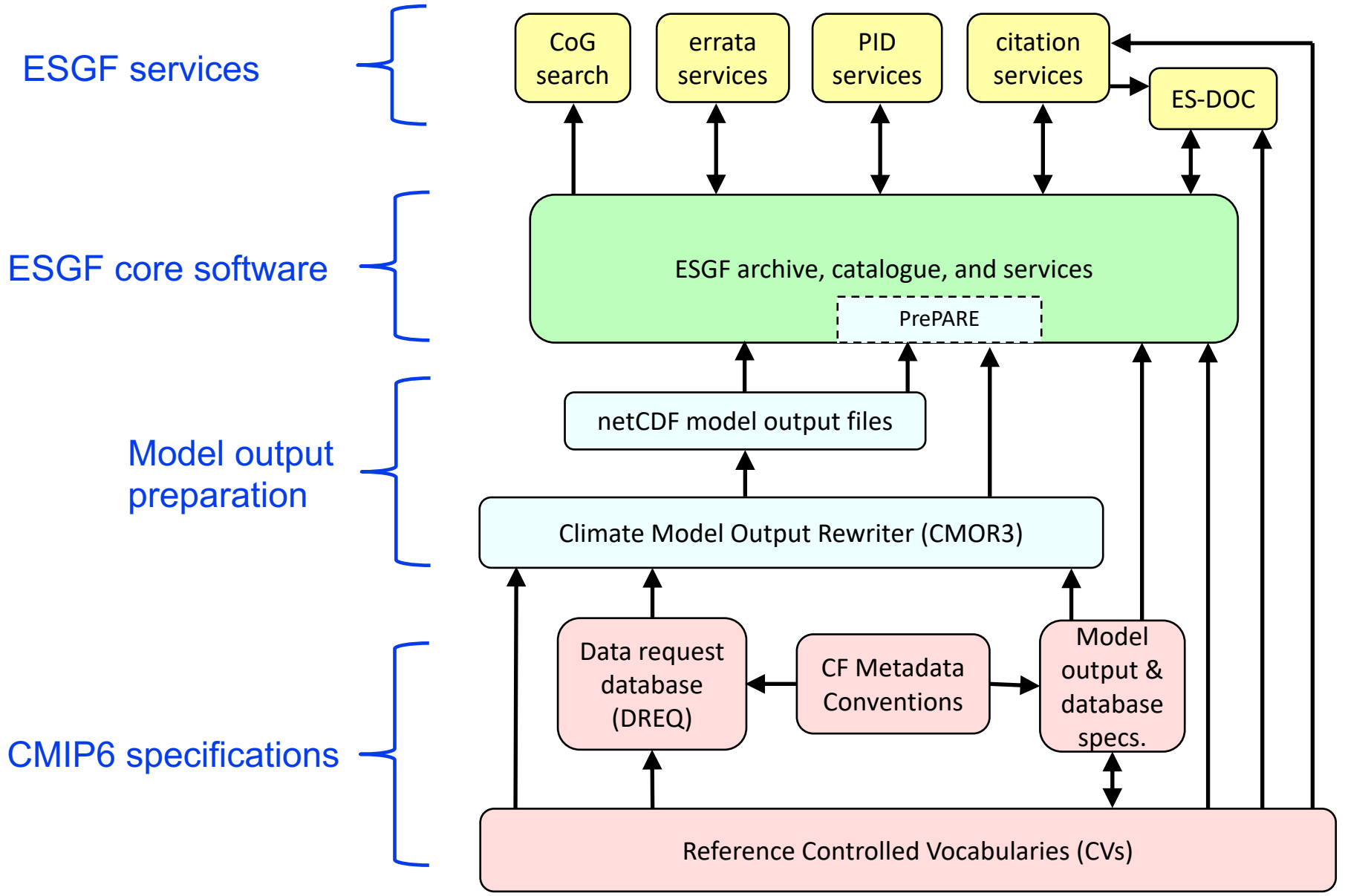
Infrastructure components and dependencies



Model output & data base specifications and global metadata requirements

- Status: In place!
- Should not be modified.
- Reasonably well documented:
  - Definition of CMIP6 netCDF global attributes
  - Specifications for file names, directory structures, and CMIP6 Data Reference Syntax (DRS)
  - Specifications for output file content, structure, and metadata.
  - Guidance on grid requirements
  - Guidance on time-averaging (with masking)
  - Specification for search facets
- See: https://pcmdi.llnl.gov/CMIP6/Guide/modelers.html#5-model-output-requirements

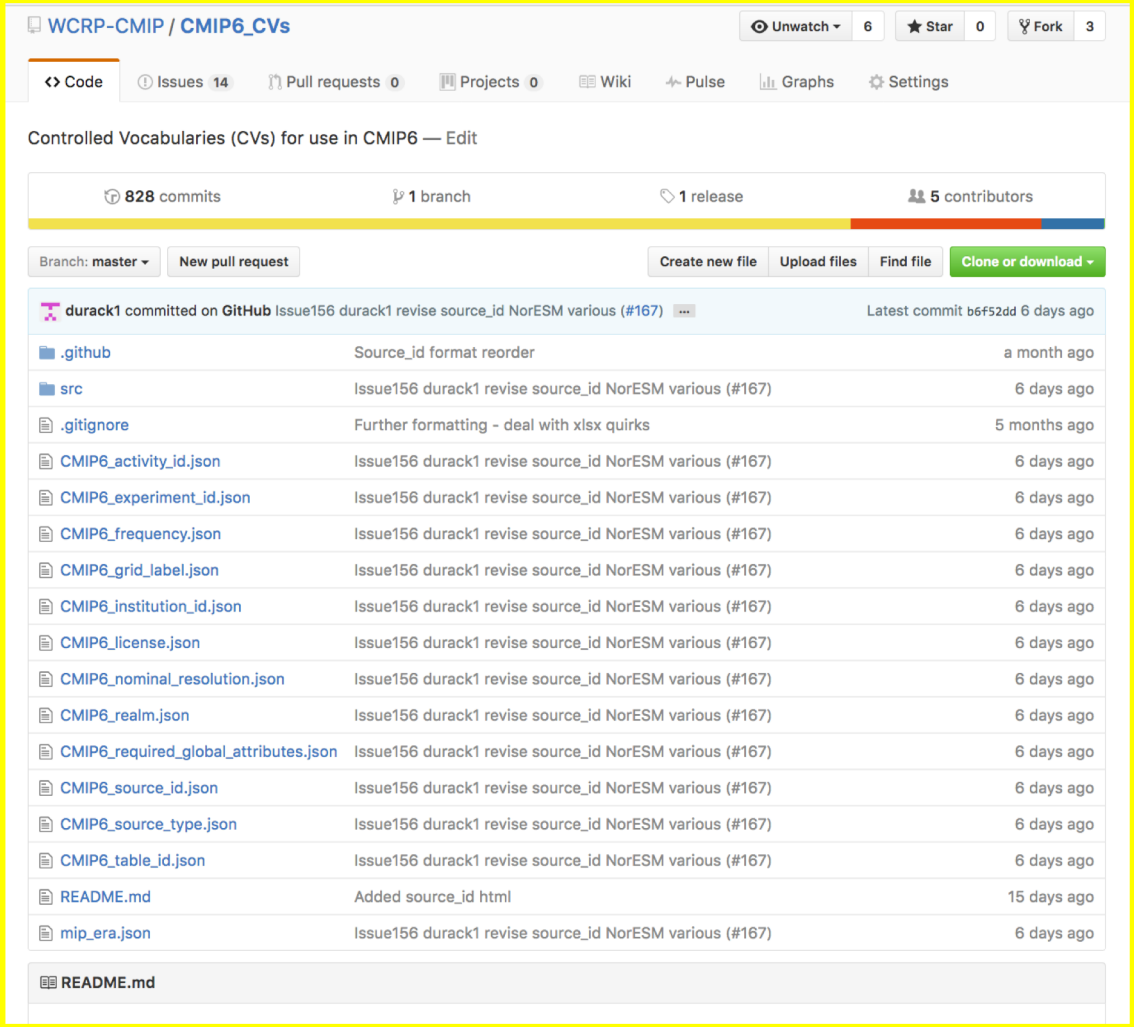
Infrastructure components and dependencies



Reference ”controlled vocabularies” (CVs)

- CVs allow users and individual infrastructure elements to communicate.
- Recorded in JSON files
- For “institution” and “source” vocabularies are registered by participating groups
- Dictionaries record allowed relationships (e.g., which sub-experiments are associated with a given experiment)
- Status: all needed CV’s defined, including activity, Institution, model, experiment, sub-experiment, realm, frequency, …..

https://github.com/WCRP-CMIP/CMIP6_CVs



Institutions and models must be registered in CVs

Status: Operational

CMIP6_CVs

https://github.com/WCRP-CMIP/CMIP6_CVs

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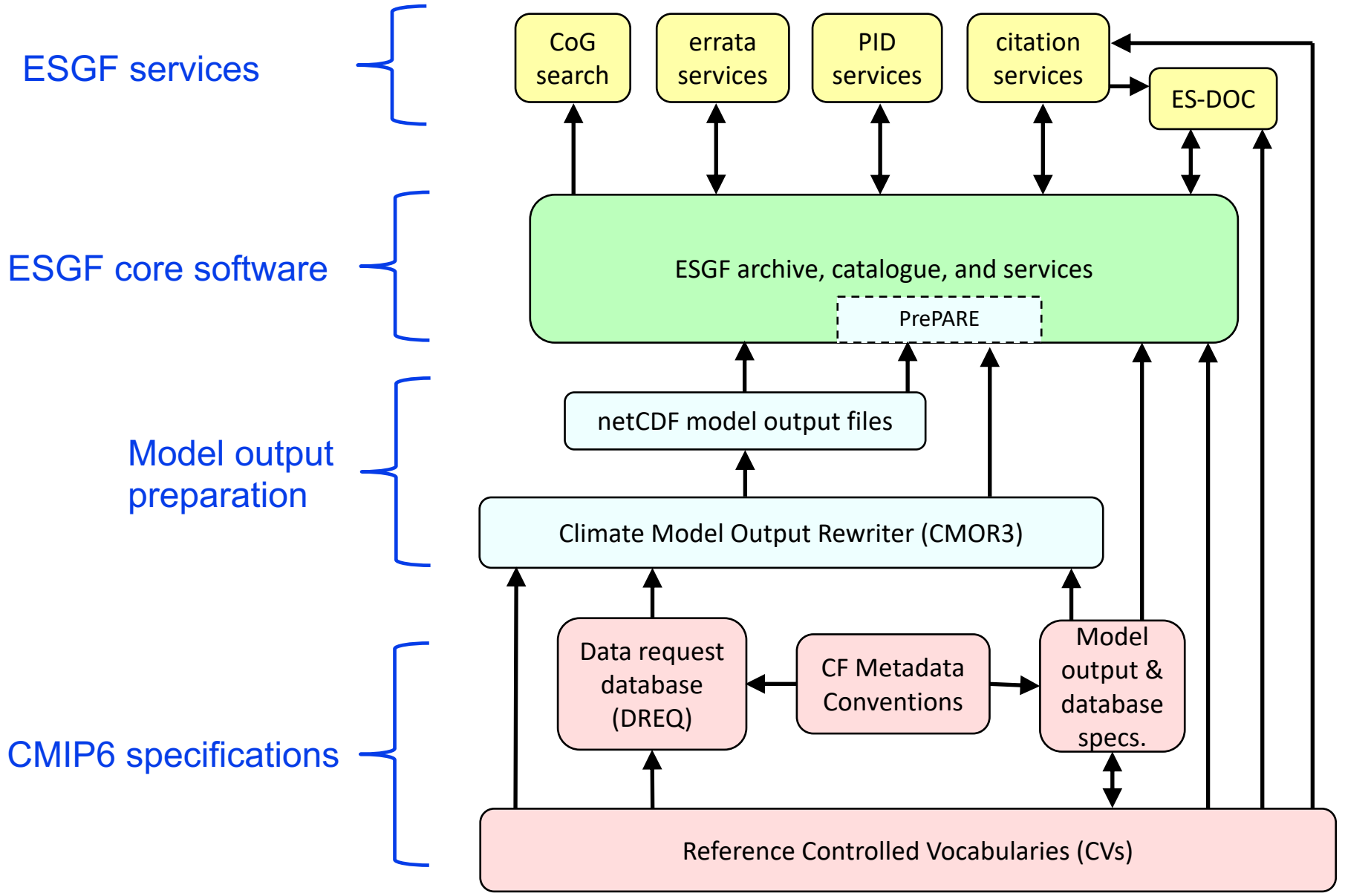
Infrastructure components and dependencies



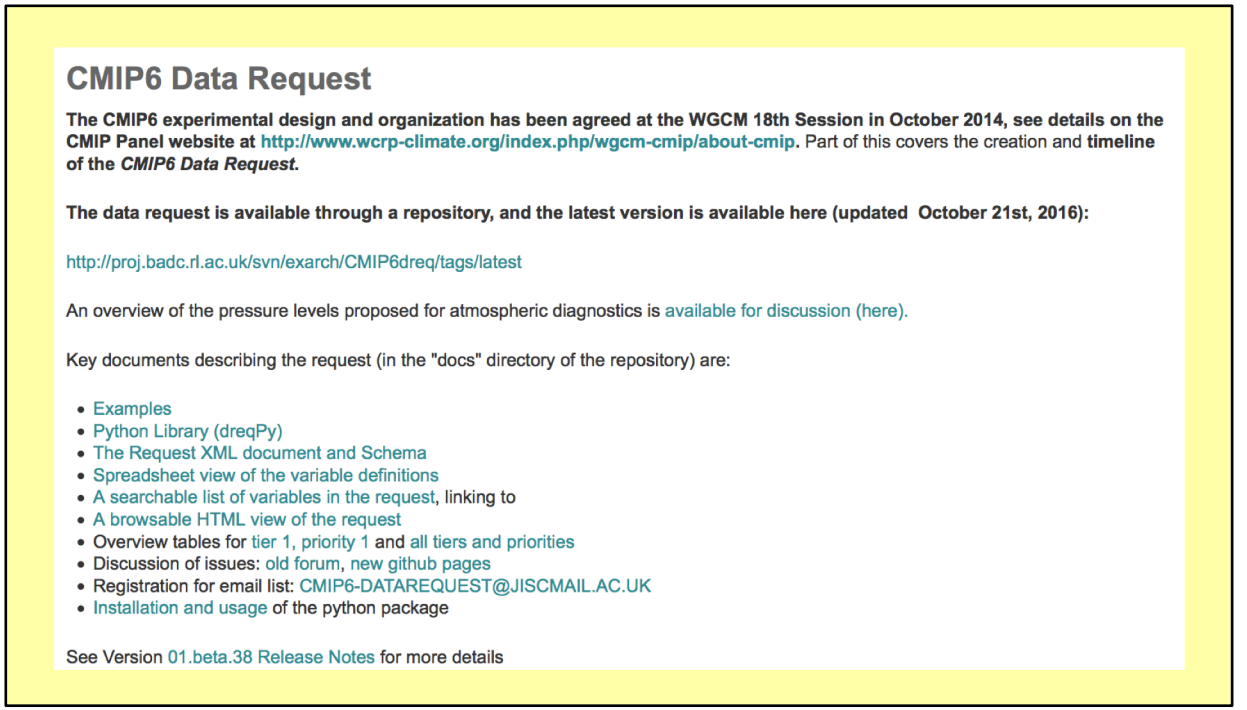
CMIP data request tools and documentation (DREQ; Martin Juckes)

PCMDI

Specifies:

- Which variables should be saved for a given experiment and time period, and at what frequency.
- What variable-specific metadata should be included in output files.

See WIP CoG site →



CMIP6 Data Request

The CMIP6 experimental design and organization has been agreed at the WGCM 18th Session in October 2014, see details on the CMIP Panel website at http://www.wcrp-climate.org/index.php/wgcm-cmip/about-cmip. Part of this covers the creation and **timeline of the *CMIP6 Data Request*.**

The data request is available through a repository, and the latest version is available here (updated October 21st, 2016):

http://proj.badc.rl.ac.uk/svn/exarch/CMIP6dreq/tags/latest

An overview of the pressure levels proposed for atmospheric diagnostics is available for discussion (here).

Key documents describing the request (in the "docs" directory of the repository) are:

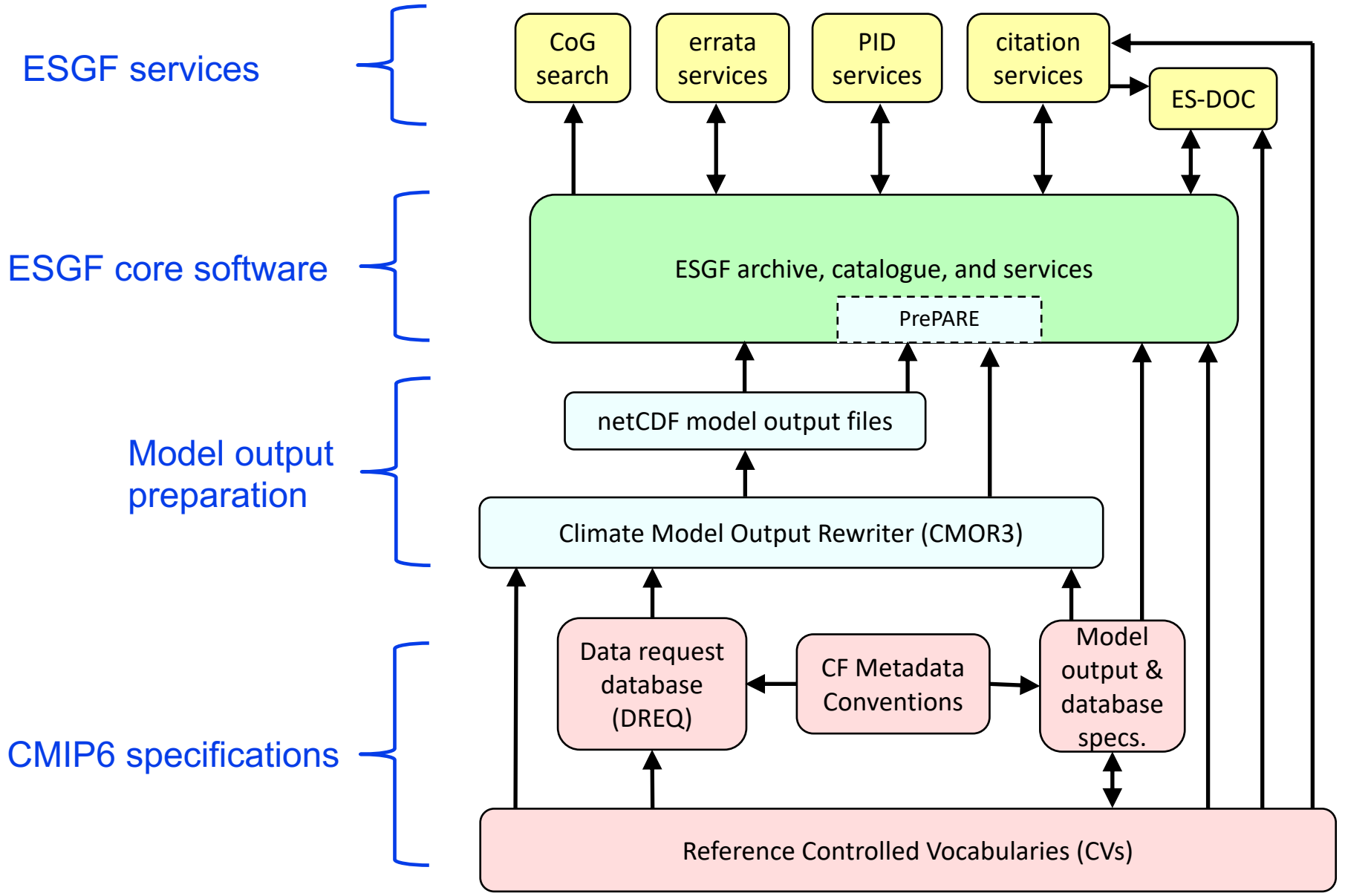
- Examples
- Python Library (dreqPy)
- The Request XML document and Schema
- Spreadsheet view of the variable definitions
- A searchable list of variables in the request, linking to
- A browsable HTML view of the request
- Overview tables for tier 1, priority 1 and all tiers and priorities
- Discussion of issues: old forum, new github pages
- Registration for email list: CMIP6-DATAREQUEST@JISCMAIL.AC.UK
- Installation and usage of the python package

See Version 01.beta.38 Release Notes for more details

Status: In place and in use!

- ”Cosmetic” refine-ments still being made
- New releases undergo review

Infrastructure components and dependencies



Climate Model Output Rewriter (CMOR3)

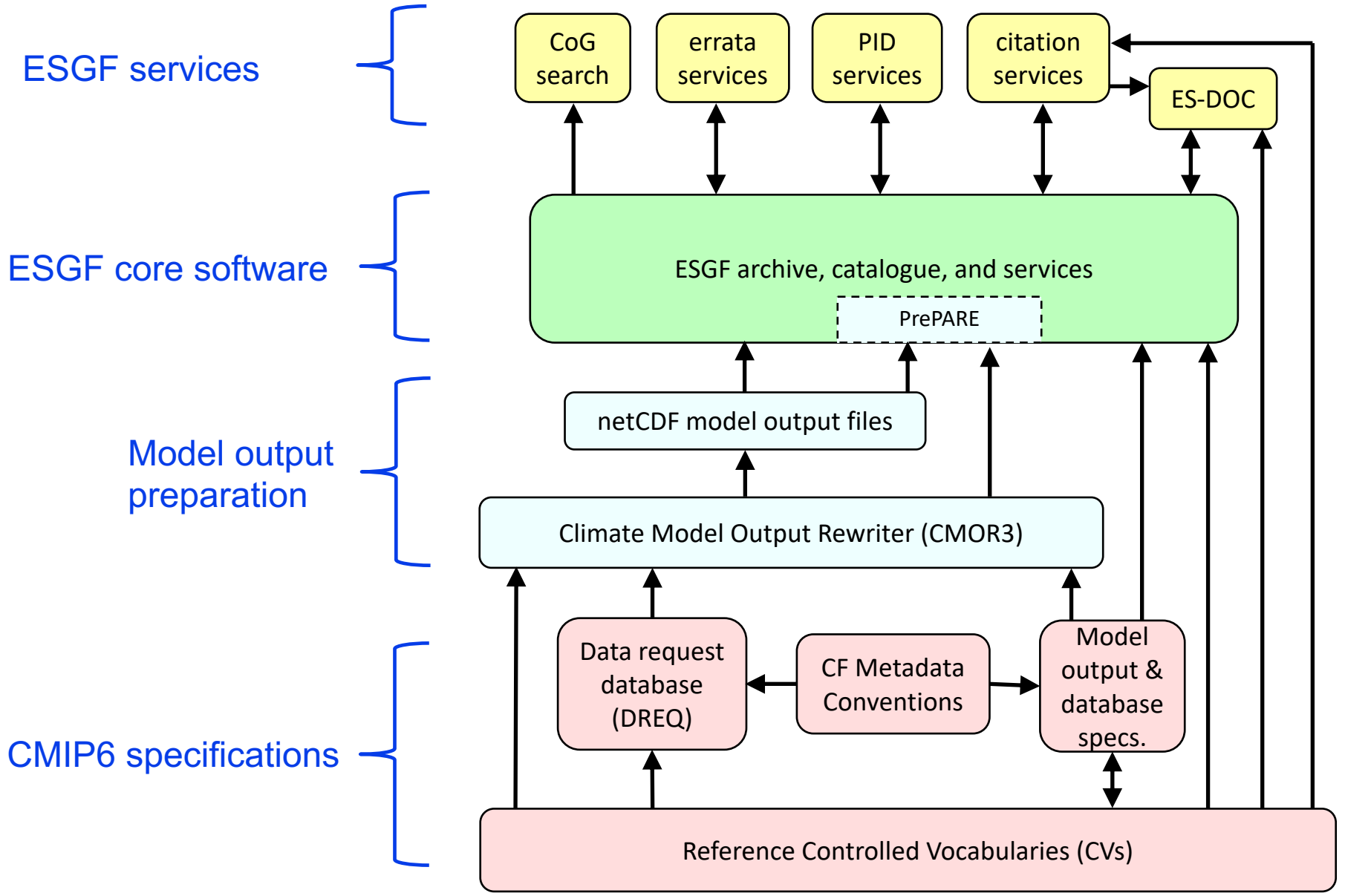
- Facilitates (and checks) conformance of files to CMIP6 requirements

- Status: in place and in use!
  - Code available at https://github.com/PCMDI/cmor
  - Documentation available at http://cmor.llnl.gov/
  - Development phase is complete
  - Bugs corrected when discovered

Pre-Publication Attribute Reviewer for ESGF (PrePARE)

- Checks conformance of files to CMIP6 requirements
  - Available for use by groups not relying on CMOR
  - Included as part of the publication job stream
- Status: in place and in use (??)
  - Code is part of the CMOR build (??)
  - Development phase is complete
  - Bugs corrected when discovered
  - Certain checks of variable attributes are currently too stringent and will be relaxed.

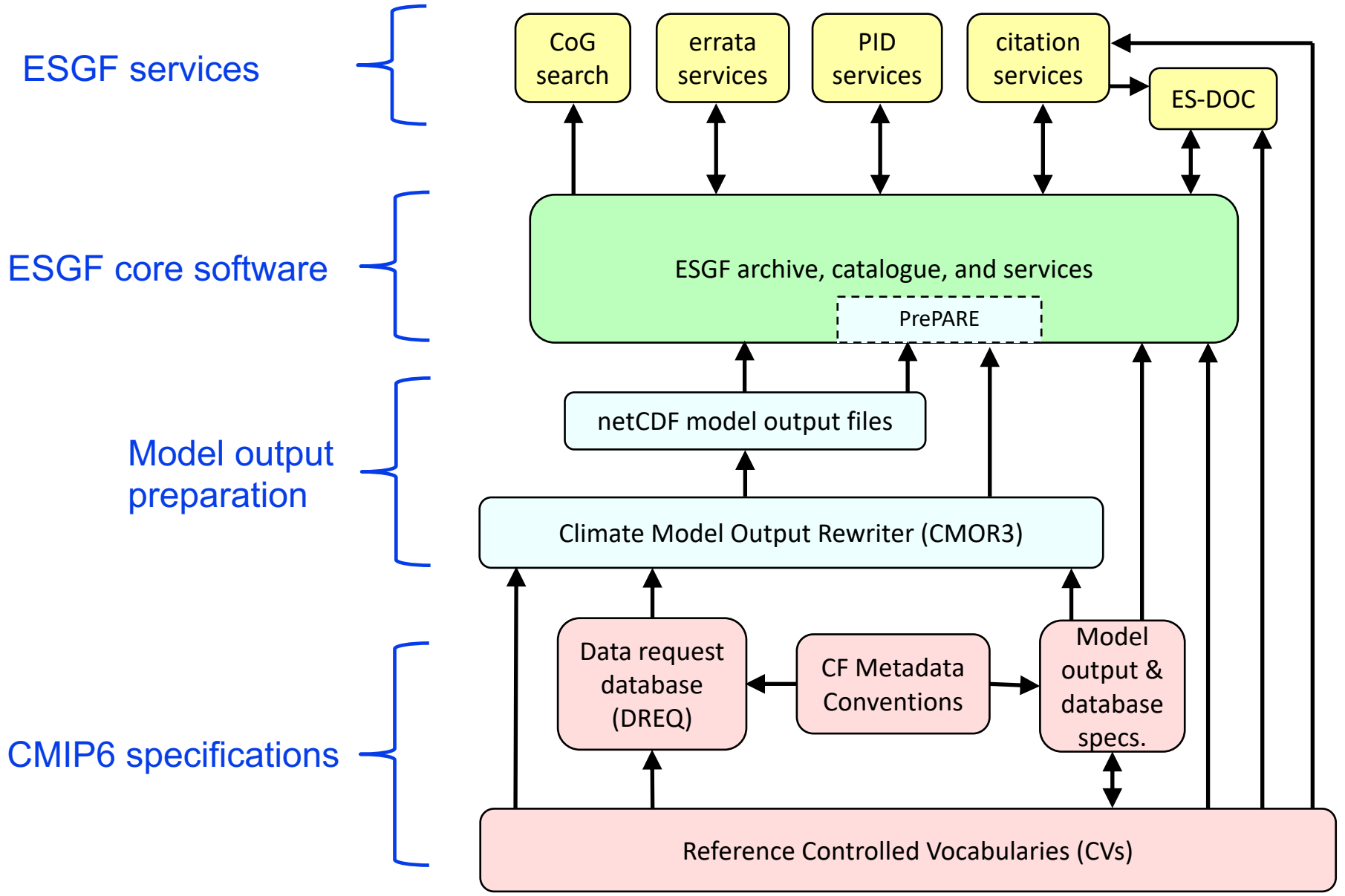
Infrastructure components and dependencies



ESGF core software stack

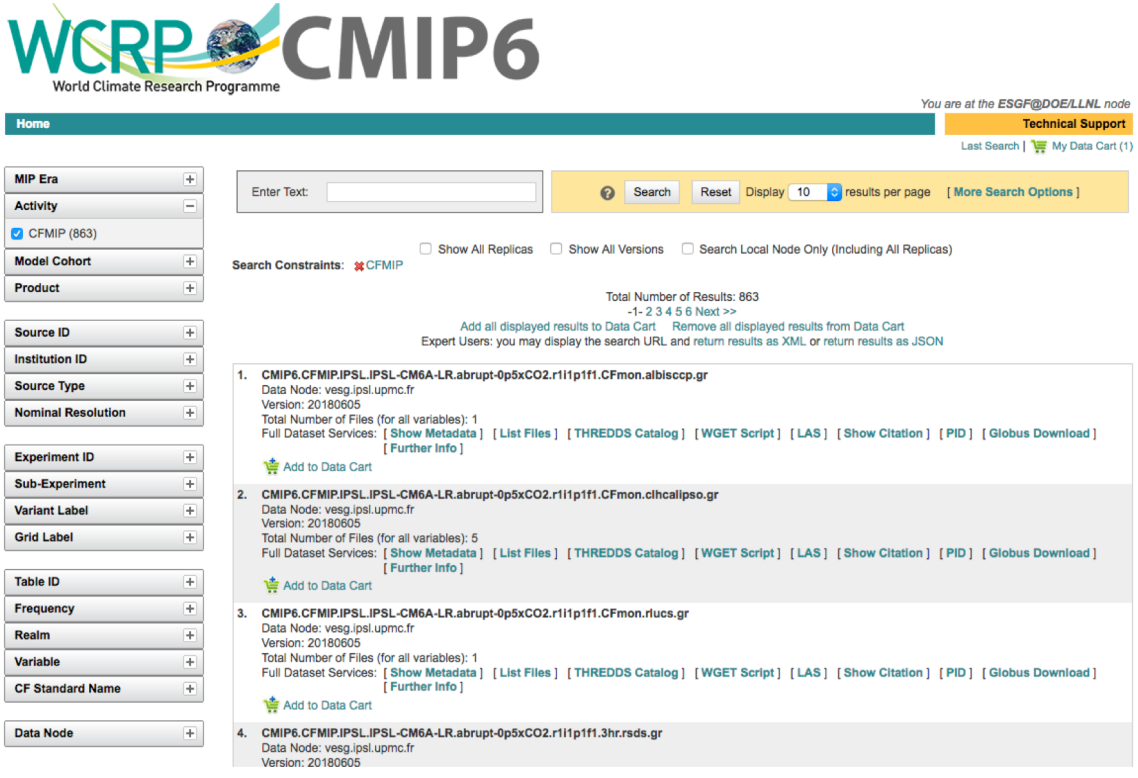
- Supports a federated data archive hosting the CMIP6 data
- Status: In place and operational!
  - Output from 6 models and 19 experiments now available
  - Served through 5 CMIP6 CoG data portals
- The work of the project scientists and the CDNOT in performing the "data challenge" tests ensured a smooth launch of ESGF for CMIP6. THANK YOU!
- Replication procedure is working
  - PCMDI has replicated ~65% of available; DKRZ ~10%.
- To do (high priority): enable Globus grid ftp at all sites for all datasets.

Infrastructure components and dependencies



ESGF services: CoG

- Provides users with an interface to browse and download data
- Status: All CMIP6 data now available via any one of 5 CoG sites
- All sites should have identical look and feel
  - Rules and format are given at https://goo.gl/P1e18T
  - IPSL, PCMDI/LLNL, and CEDA are in full compliance, and GFDL and DKRZ have been asked to make minor modifications.



Data citation services

Show Citation

1. **CMIP6.CFMIP.IPSL.IPSL-CM6A-LR.abrupt-0p5xCO2.r1i1p1f1.CFmon.albisccp.gr**
   Data Node: vesg.ipsl.upmc.fr
   Version: 20180605
   Total Number of Files (for all variables): 1
   Full Dataset Services: [Show Metadata] [List Files] [THREDDS Catalog] [WGET Script] [LAS] [Show Citation] [PID] [Globus Download] [Further Info]
   Add to Data Cart

Citation page

Metadata for 'CMIP6.CFMIP.IPSL.IPSL-CM6A-LR.abrupt-0p5xCO2'

General Information

General Information

Name CMIP6.CFMIP.IPSL.IPSL-CM6A-LR.abrupt-0p5xCO2

Abstract Coupled Model Intercomparison Project Phase 6 (CMIP6) data sets.
These data includes all datasets published for 'CMIP6.CFMIP.IPSL.IPSL-CM6A-LR.abrupt-0p5xCO2' according to the Data Reference Syntax defined as
'mip_era.activity_id.institution_id.source_id.experiment_id.member_id.table_id.variable_id.grid_label.version'.

The Earth System Model IPSL-CM6A-LR, released in 2017, includes the components:
atmos: LMDZ (NPv6, N96; 144 x 143 longitude/latitude; 79 levels; top level 40000 m), land: ORCHIDEE (v2.0, Water/Carbon/Energy mode), ocean: NEMO-OPA (eORCA1.3, tripolar primarily 1deg; 362 x 332 longitude/latitude; 75 levels; top grid cell 0-2 m), ocnBgchem: NEMO-PISCES, seaIce: NEMO-LIM3.
The model was run by the Institut Pierre Simon Laplace, Paris 75252, France (IPSL) in native nominal resolutions: atmos: 250 km, land: 250 km, ocean: 100 km, ocnBgchem: 100 km, seaIce: 100 km.

Project: These data have been generated as part of the internationally-coordinated Coupled Model Intercomparison Project Phase 6 (CMIP6; see also CMD Special Issue: http://www.geosci-model-dev.net/special_issue590.html). The

Cite this data

Citation **(2018)**. *IPSL IPSL-CM6A-LR model output prepared for CMIP6 CFMIP abrupt-0p5xCO2*. Earth System Grid Federation.
http://cera-www.dkrz.de/WDCC/meta/CMIP6/CMIP6.CFMIP.IPSL.IPSL-CM6A-LR.abrupt-0p5xCO2

BibTeX RIS

Model and experiment documentation

1. **CMIP6.CFMIP.IPSL.IPSL-CM6A-LR.abrupt-0p5xCO2.r1i1p1f1.CFmon.albisccp.gr**
   Data Node: vesg.ipsl.upmc.fr
   Version: 20180605
   Total Number of Files (for all variables): 1
   Full Dataset Services: [Show Metadata] [List Files] [THREDDS Catalog] [WGET Script] [LAS] [Show Citation] [PID] [Globus Download]
   [Further Info]
   Add to Data Cart

Further Info

Model and experiment documentation by es-doc

es-doc
Earth System Documentation

CMIP6 Further Information v0.5.0.0 Support Help

Further Info URL: https://furtherinfo.es-doc.org/CMIP6.IPSL.IPSL-CM6A-LR.abrupt-0p5xCO2.none.r1i1p1f1

ES-DOC Documentation

MIP Era	CMIP6
Institution	IPSL
Model	IPSL-CM6A-LR
Experiment	abrupt-0p5xCO2
Ensemble Description	N/A
Machine Performance	N/A

Dataset Documentation

Dataset ESGF Search	N/A
Dataset Errata	N/A
Dataset Citation(s)	https://cera-www.dkrz.de/WDCC/meta/CMIP6/CMIP6.CFMIP.IPSL.IPSL-CM6A-LR.abrupt-0p5xCO2

Other Documentation

WCRP CMIP6 Homepage	https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6
ES-DOC CMIP6 Homepage	https://es-doc.org/cmip6

Summary:

- The major infrastructure elements enabling scientists to access data are in place and working satisfactorily.

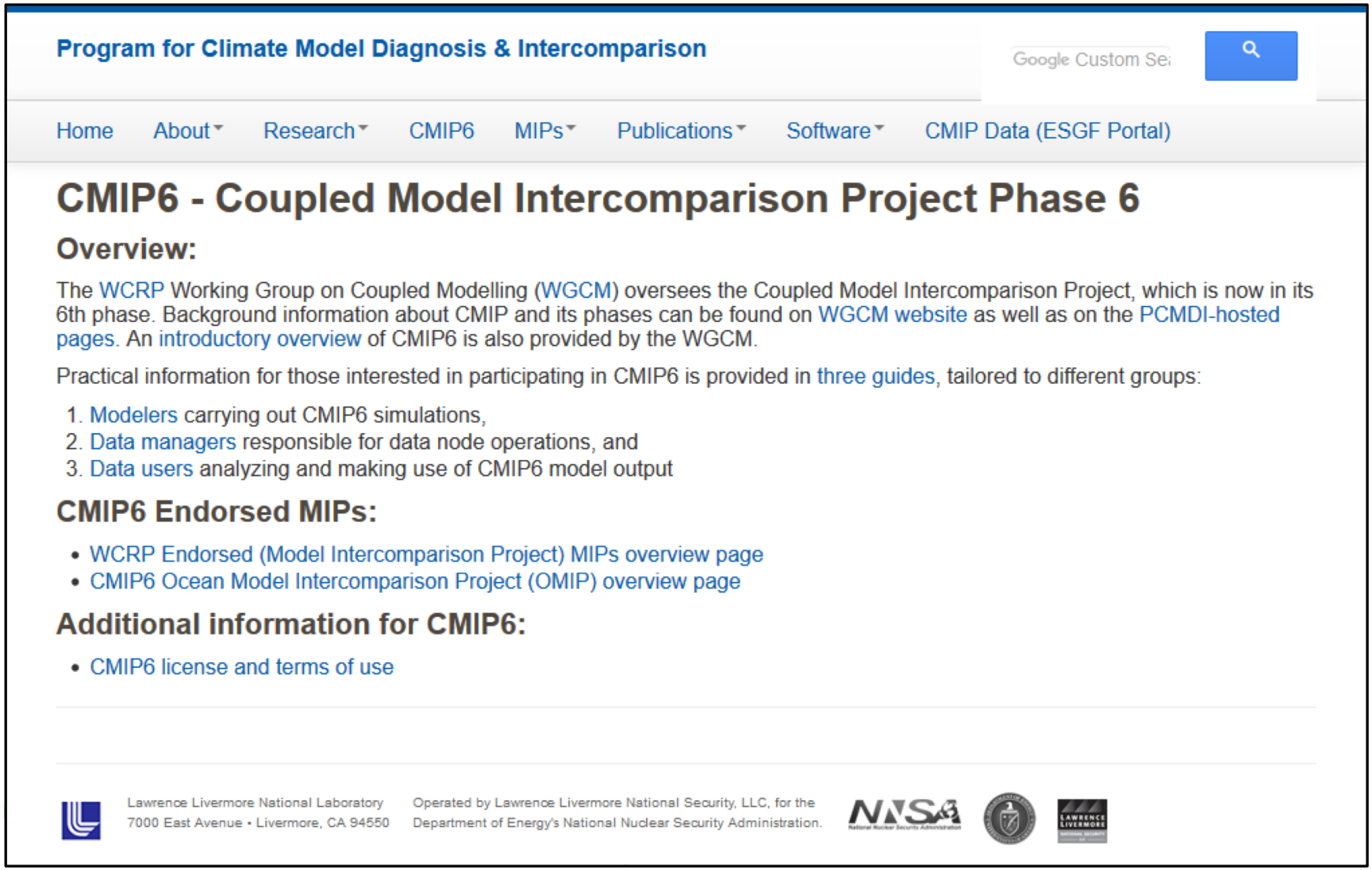
- Users continue to complain that
  - Globus gridftp is unavailable at some nodes
  - Server-side computation capability is missing
    - subsetting
    - simple reduction (climatology, zonal mean, etc.)

- The ES-DOC software has advanced considerably, but modeling groups have not yet provided content.

- Better documentation (and tutorials) across the infrastructure should help us make up for our lack of user support

CMIP6 website provides practical guidance for all parties interested in CMIP

CMIP6 Guide: https://pcmdi.llnl.gov/CMIP6/



Program for Climate Model Diagnosis & Intercomparison

Google Custom Sea

Home | About | Research | CMIP6 | MIPs | Publications | Software | CMIP Data (ESGF Portal)

CMIP6 - Coupled Model Intercomparison Project Phase 6

Overview:

The WCRP Working Group on Coupled Modelling (WGCM) oversees the Coupled Model Intercomparison Project, which is now in its 6th phase. Background information about CMIP and its phases can be found on WGCM website as well as on the PCMDI-hosted pages. An introductory overview of CMIP6 is also provided by the WGCM.

Practical information for those interested in participating in CMIP6 is provided in three guides, tailored to different groups:

1. Modelers carrying out CMIP6 simulations,
2. Data managers responsible for data node operations, and
3. Data users analyzing and making use of CMIP6 model output

CMIP6 Endorsed MIPs:

- WCRP Endorsed (Model Intercomparison Project) MIPs overview page
- CMIP6 Ocean Model Intercomparison Project (OMIP) overview page

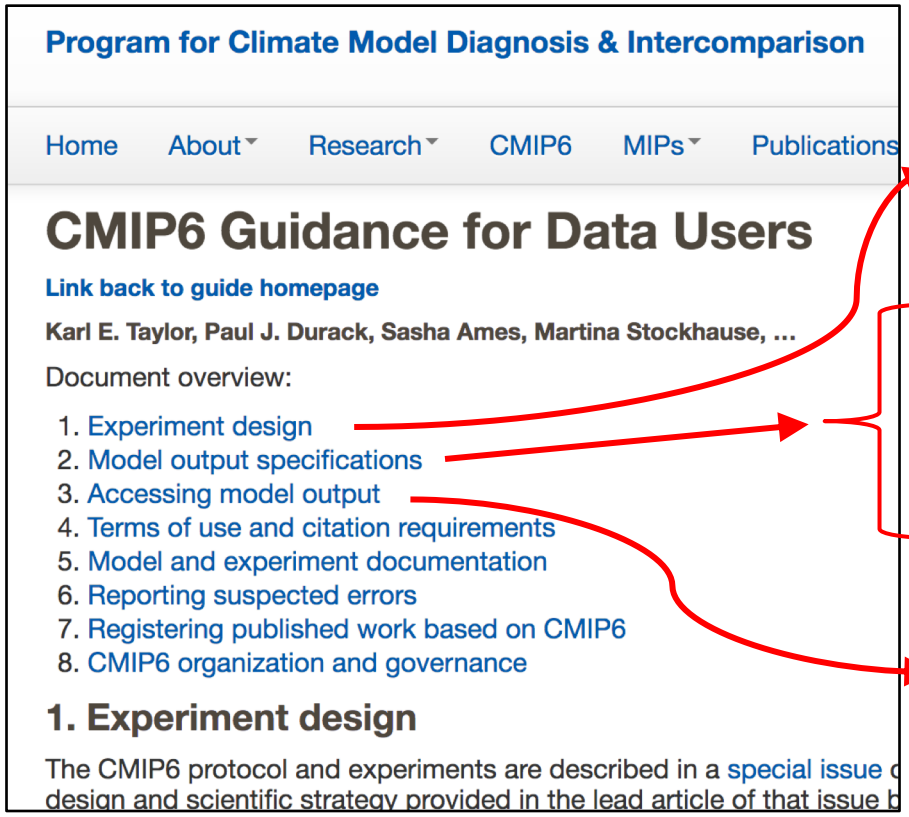
Additional information for CMIP6:

- CMIP6 license and terms of use

Lawrence Livermore National Laboratory
7000 East Avenue • Livermore, CA 94550

Operated by Lawrence Livermore National Security, LLC, for the Department of Energy's National Nuclear Security Administration.

Example: Guidance document for data users



- Points to information on experimental design
- Describes and links to controlled vocabularies
- Documents essential model output specifications
- Describe how to access output

https://pcmdi.llnl.gov/CMIP6/Guide/dataUsers.html

Remarks on longer-term issues

- Despite growing international investment in climate modeling infrastructure, it remains fragile: "single points of failure" need to be addressed because they can lead to enormous disruptions
  - Some individuals are irreplaceable
  - Some software is not well documented
- ESGF has become essential to the climate research community:
  - CMIP, input4MIPs, obs4MIPs, etc.
  - Modeling groups have invested in it
- Given resource constraints, we should
  - Treat ESGF as part of an *operational* climate research enterprise; it must be reliable
  - Avoid pursuing revolutionary changes, even when promising, if that would threaten or weaken support for the working infrastructure. [Beware of the cloud!]