CMIP: A status update and future plans

Paul J. Durack, Karl E. Taylor, Sasha K. Ames,
Chris F. Mauzey and Jeff Painter

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Why does DOE support CMIP?

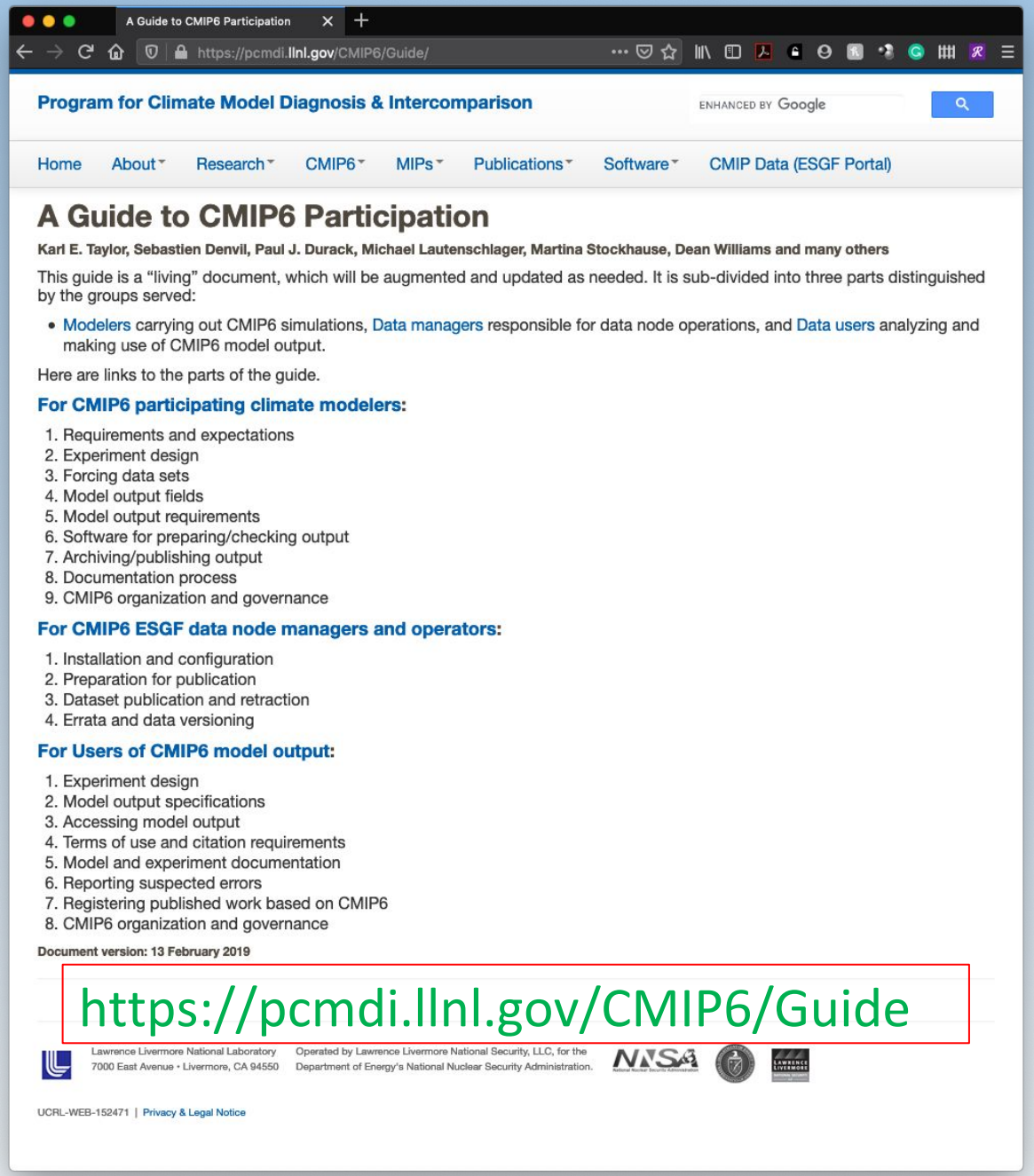
- Promote increased scientific scrutiny of models used to inform climate change mitigation and adaption policies
- Provide multi-model context for interpreting results
  - Lack of consensus across ensemble results calls for explanation, which leads to
    - Deeper understanding of results
    - Reduction in climate projection uncertainty
  - E3SM development efforts can be assessed
    - Development can be focused/prioritized, based on comparisons with CMIP ensemble
    - Provides international network for active collaboration
- Serve as a resource for DOE scientists, facilitating and expediting
  - Improved understanding of feedbacks
  - Identification of processes driving climate variability and change

PCMDI: CMIP leadership activities

- As WGCM CMIP Panel members, we
  - Structure and evolve CMIP design to maximize scientific impact relative to the effort/cost
  - Lead synergistic activities that enhance CMIP value, for example:
    - input4MIPs: development, documentation, and comparison of forcing datasets (Paul Durack)
    - obs4MIPs: coordination of effort to host and serve observational datasets conforming to CMIP data standards (Peter Gleckler)
- By chairing the WGCM Infrastructure Panel (WIP), we
  - Ensure coordination of international projects developing CMIP infrastructure
  - Develop data standards that facilitate use of MIP results (models and obs)
- Our CMIP leadership
  - Harnesses more than two decades of CMIP leadership experience
  - Synergistically relies on the DOE ESGF project, which develops the software at the core of the CMIP data archive storage and delivery

CMIP6 Guide

- CMIP6 user guide – starting point for engagement
- Focused information for
  - Climate modelers (data providers)
  - ESGF node managers (data distributors)
  - Users (data analysts)
- Provides information and links to other CMIP6 supporting material



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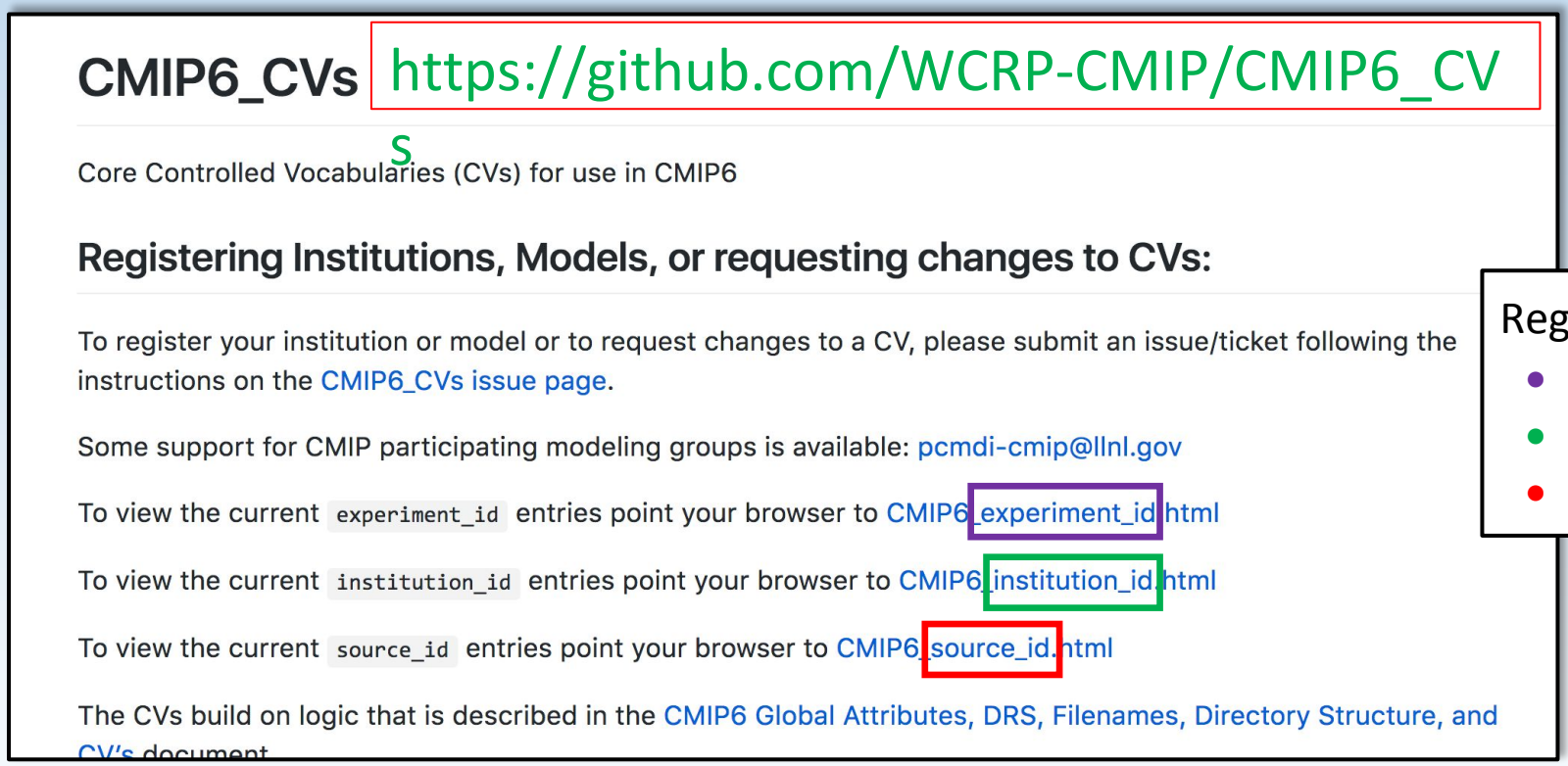
CMIP6 summary statistics

- 51 institutions/consortia (CMIP5: 31); 136 models (CMIP5: 59 models); 316 experiments, 104 tier 1 (CMIP5: 33, 14 tier 1)
- ~10 PB published to-date; 20–50 PB output expected (CMIP5: ~2 PB)
- PCMDI leads CMIP6 delivery (collaborates with partner institutions, see refs)



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

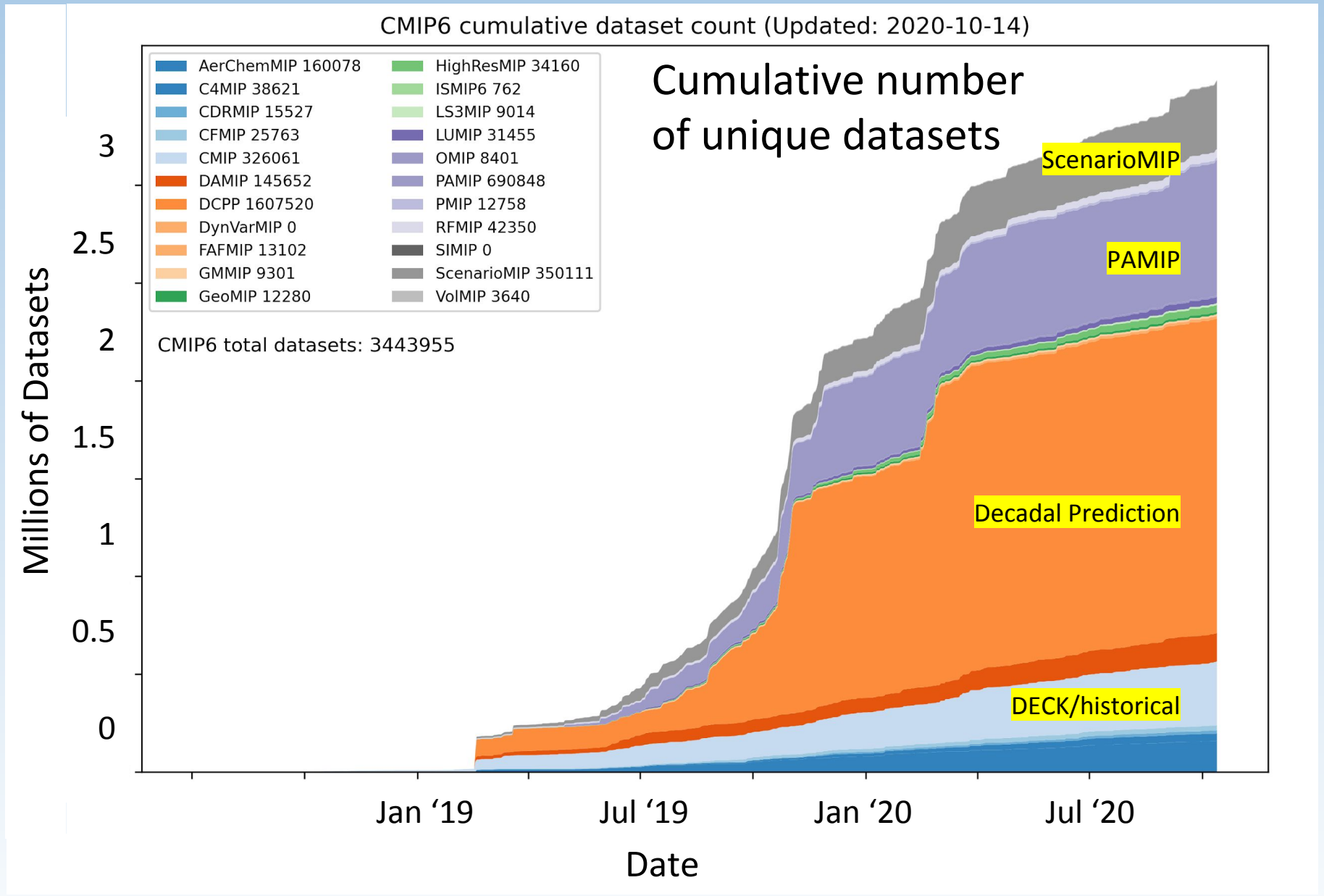
Registered:

- experiments
- institutions
- models

CMIP6 data archive growth

CMIP6: >9 PB

- PCMDI has replicated ~85% of the datasets
- Other data nodes have also replicated large fractions



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CMIP6 data availability

Complete CMIP6

More than 28 days | More than 7 days | Less than 7 days

Click on an activity name at the top of the tables to go to a page for that activity's data holdings.

Number of 'datasets' [variables x (# of simulations)] from each model in support of each CMIP6 activity.

Models

MIPs

model	# of activities	AerChemMIP	C4MIP	CDRMIP	CFMIP	CMIP	DAMIP	DCPP	FAFMIP	GMMIP	GeoMIP	HighResMIP	ISMIP6	LS3MIP	LUMIP	OMIP	PAMIP	PMIP	RFMIP	ScenarioMIP	VolMIP
# of models	375	36	17	10	13	61	13	11	9	16	5	34	1	14	17	20	8	17	29	42	2
4AOP-v1-5	1																		6		
ACCESS-CM2	5	999				2194			1500										560	3108	
ACCESS-ESM1-5	8	3152	2161	1082		11428	2155											158	708	11664	
ARTS-2-3	1																		8		
AWI-CM-1-1-HR	1											167									
AWI-CM-1-1-LR	1											168									
AWI-CM-1-1-MR	4	915				1258											65500			1464	
AWI-ESM-1-1-LR	2					868												1183			
BCC-CSM2-HR	1											404									
BCC-CSM2-MR	9		512		1031	2163	1481	36288		413				41	856					889	
BCC-ESM1	2	4417				1639															
CAMS-CSM1-0	5	153				763				183		63								765	
CAS-ESM2-0	3					1229			129							25					
CESM1-1-CAM5-CMIP5	1							378399													
CESM1-CAM5-SE-HR	1											345									
CESM1-CAM5-SE-LR	1											377									
CESM2	15		1367	136	4065	19263	3448		1407	294			762	890	4062	1546	74300	1070	808	8451	
CESM2-FV2	1					6957															
CESM2-WACCM	5	6740				7206					3322								223	14457	
CESM2-WACCM-FV2	1					7266															
CIESM	3					876				150										362	
CMCC-CM2-HR4	3					188						523				106					
CMCC-CM2-SR5	4	352				1639										236				1424	
CMCC-CM2-VHR4	1											525									
CMCC-ESM2	2													140	688						
CNRM-CM6-1	13	1950			3919	13518	4861	75697		832		6852		1488	153	116		172	575	6120	
CNRM-CM6-1-HR	5	227				1352				107		5066								927	

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CMIP6 data holdings – updated hourly

https://pcmdi.llnl.gov/CMIP6/ArchiveStatistics/esgf_data_holdings/

CMIP6 data availability

CMIP sub-MIP

More than 28 days | More than 7 days | Less than 7 days

Number of 'datasets' [variables x (# of simulations)] from each model in support of each CMIP6 CMIP experiment.

Experiments

Models

model	# of experiments	1pctCO2	abrupt-4xCO2	amip	esm-hist	esm-piControl	esm-piControl-spinup	historical	historical-cmip5	historical-ext	piControl	piControl-cmip5	piControl-spinup
# of models	293	51	50	47	13	13	1	56	1	1	57	1	2
ACCESS-CM2	5	273	274	521				802			324		
ACCESS-ESM1-5	7	278	278	588	3324	325		6306			329		
AWI-CM-1-1-MR	4	163	163					775			157		
AWI-ESM-1-1-LR	2							461			407		
BCC-CSM2-MR	7	142	142	455	570	144		568			142		
BCC-ESM1	5	183	173	468				644			171		
CAMS-CSM1-0	5	142	138	182				227			74		
CAS-ESM2-0	5	138	138	244				552			157		
CESM2	7	931	919	4124	372	993		10952			972		
CESM2-FV2	5	833	883	1217				3032			992		
CESM2-WACCM	5	923	841	1394				3042			1006		
CESM2-WACCM-FV2	5	946	892	1348				3067			1013		
CIESM	5	121	121	150				363			121		
CMCC-CM2-HR4	1							188					
CMCC-CM2-SR5	5	328	323	256				389			343		
CNRM-CM6-1	5	382	1808	491				10537			300		
CNRM-CM6-1-HR	5	275	268	230				301			278		
CNRM-ESM2-1	9	4304	1440	596	1324	554	279	5077			576		273
CanESM5	9	2014	650	2492	3009	310		17843	630		652	146	
CanESM5-CanOE	5	325			987	330		892			328		
E3SM-1-0	5	107	107	207				535			107		
E3SM-1-1	2							112			141		
E3SM-1-1-ECA	2							138			112		
EC-Earth3	5	195	345	269				8026			391		
EC-Earth3-LR	1										191		

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CMIP6 data holdings – updated hourly

https://pcmdi.llnl.gov/CMIP6/ArchiveStatistics/esgf_data_holdings/

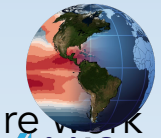
CMIP look back and ahead

- The MIPs have been steadily growing over the last 29 years

MIP era	Active Years	# Experiments	# Models	Data volume
AMIP1	1991	1	27 (atmosphere-only)	1 GB
AMIP2	1995	1	33 (atmosphere-only)	500 GB
CMIP1	1995-1997	1	17 (Coupled ocean-atmos)	1 GB
CMIP2	2000-2005	2	17 (Coupled ocean-atmos)	500 GB
CMIP3	2007-2010	11	24 (Coupled ocean-atmos)	50 TB
CMIP5	2011-2014	39	59 (Coupled, ESMs)	2 PB
CMIP6	2018-2022	316 (24 sub-MIPs)	136 (Coupled, ESMs, plus radiation codes)	>20 PB
CMIP7?	2025-2029?	-	-	-

CMIP7 planning is beginning

- Where can we simplify the structure to enable nimble responses to the creation of new MIPs to address new science questions?
  - Example: COVID-19 has inspired a possible "CovidMIP" (2020-2021)
    - to compare modeled and observed climate responses to changes in anthropogenic aerosols
    - ~10 modeling groups involved (including E3SM)
  - Example: Forcing datasets will continue to evolve
    - Can we continue to leverage the input4MIPs leadership to ensure datasets proposed for future work have been carefully vetted?
    - Volcanic forcing is a known issue for CMIP6 (Rieger et al., 2020 GMD)



- The challenge will be to provide flexibility while maintaining standards and procedures, which modeling groups and analysts now depend upon and which underlie model data delivery

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Input from CMIP users is invited

- What new infrastructure capabilities/tools should be developed to support CMIP-based research. For example
  - Regridding tools for easy comparison across models on different grids?
  - Alternative paths to CMIP output and documentation?
  - Methods by which data provenance can be easily recorded for journal articles?
  - Your ideas are needed!
- CMIP Panel survey will obtain feedback (within ~6 months)
  - Please share your opinions, suggestions for improving CMIP to serve the science
- Additional resources are being secured to aid CMIP-based research
  - CMIP international project office should be in place in 2021

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Publications

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Paul J. Durack
durack1@llnl.gov

Karl E. Taylor
taylor13@llnl.gov

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