

Coupled Model Intercomparison Project Phase 6 (CMIP6)

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Date: 10 June 2015

Please see the CMIP Panel website for additional information and updates:

<http://www.wcrp-climate.org/index.php/wgcm-cmip/about-cmip>

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The final CMIP6 Design, possibly with small modifications to the here presented figures and wording, will be published in a GMD Special Issue together with a description of the CMIP6-Endorsed MIPs and the forcing datasets. This Special Issue opens 30 April 2015.



2013: Given the success of the 2006 AGCI session in formulating CMIP5, it was decided to convene an AGCI session in 2013 to plan CMIP6 bringing together climate scientists, IAM modelers and IAV researchers



Eos, Vol. 95, No. 9, 4 March 2014

EOS

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

VOLUME 95 NUMBER 9
4 March 2014
PAGES 77–84

Climate Model Intercomparisons: Preparing for the Next Phase

PAGES 77–78

Since 1995, the Coupled Model Intercomparison Project (CMIP) has coordinated climate model experiments involving multiple international modeling teams. Through CMIP, climate modelers and scientists from around the world have analyzed and compared state-of-the-art climate model simulations to gain insights into the processes, mechanisms, and consequences of climate variability and climate change. This has led to a better understanding of past, present, and future climate, and CMIP model experiments have routinely been the basis for future climate change assessments made by the Intergovernmental Panel on Climate Change (IPCC) [e.g., IPCC, 2013, and references therein].

CMIP has developed in phases, with the simulations of the fifth phase, CMIP5, now mostly completed. Though analyses of the CMIP5 data will continue for at least several more years, science gaps and outstanding science questions have prompted preparations for the sixth phase of the project (CMIP6). This brief overview of the initial proposed design of CMIP6 is meant to inform interested research communities and to encourage discussion and feedback for consideration in the evolving experiment design (see Figure 1). A more complete description and further information are available at [http://www.wgcm-cmip/wgcm-cmip6](http://www.wcrp-climate.org/index.php/wgcm-cmip/wgcm-cmip6) and in the additional supporting information in the online version of this article.

Scientific Focus and Structure

The proposed scientific backdrop for CMIP6 consists of the six grand challenges of the World Climate Research Programme

climate variability, climate predictability, and uncertainties in scenarios?

Within this scientific framework, a more distributed organization for CMIP6 than in previous phases of CMIP is proposed. This would fall under the oversight of the CMIP Panel (see Figure 1), wherein an ongoing activity, CMIP, is distinguished from a particular phase of CMIP, now CMIP6. This structure involves two basic components.

First, CMIP (inner part of Figure 1) would be composed of two elements: in one, researchers would run a small set of standardized

New aspects of CMIP6:

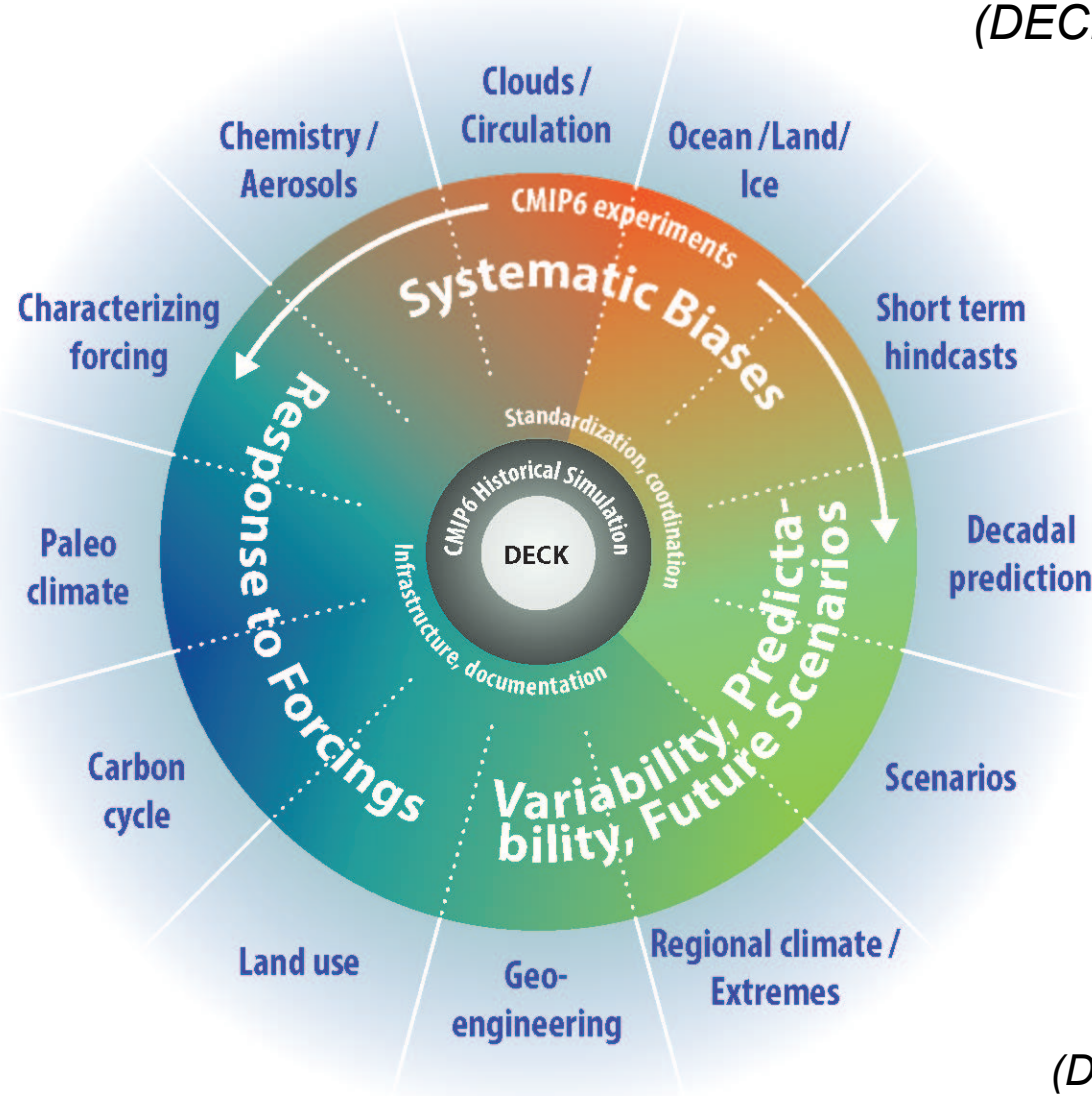
--Much input from many communities and individuals

--Better-defined scientific framework

- The **scientific backdrop** for CMIP6 is the six **WCRP Grand Challenges**, and an additional theme encapsulating questions related to **biogeochemical forcings and feedbacks**.
 1. Clouds, Circulation and Climate Sensitivity
 2. Changes in Cryosphere
 3. Climate Extremes
 4. Regional Climate Information
 5. Regional Sea-level Rise
 6. Water Availability
 7. Biogeochemical forcings and feedbacks (AIMES & WGCM)
- The specific experimental design is focused on **three broad scientific questions**:
 1. How does the Earth System respond to forcing?
 2. What are the origins and consequences of systematic model biases?
 3. How can we assess future climate changes given climate variability, predictability and uncertainties in scenarios?

New aspects of CMIP6: a distributed better-defined structure of multiple MIPs, and:

Ongoing Diagnosis, Evaluation, and Characterization of Klima (DECK) Experiments



DECK (entry card for CMIP)

- i. AMIP simulation (~1979-2014)
- ii. Pre-industrial control simulation
- iii. 1%/yr CO₂ increase
- iv. Abrupt 4xCO₂ run

CMIP6 Historical Simulation (entry card for CMIP6)

- v. Historical simulation using CMIP6 forcings (1850-2014)

(DECK & CMIP6 Historical Simulation to be run for each model configuration used in the subsequent CMIP6-Endorsed MIPs)

Note: The themes in the outer circle of the figure might be slightly revised at the end of the MIP endorsement process

Criteria for DECK and CMIP6 Historical Simulation

(1) What are the criteria for the DECK?

The DECK experiments are chosen

1. to provide continuity across past and future phases of CMIP,
2. to evolve as little as possible over time,
3. to be well-established,
4. to be part of the model development cycle.

(2) What are the criteria for the CMIP Phase X Historical Simulation?

The CMIP Phase X Historical Simulation is chosen

1. to serve as a benchmark for CMIP6-Endorsed MIPs
2. to use the specific forcings consistent with Phase X of CMIP
3. to be decoupled from model development cycle if needed.

CMIP6-Endorsed MIPs

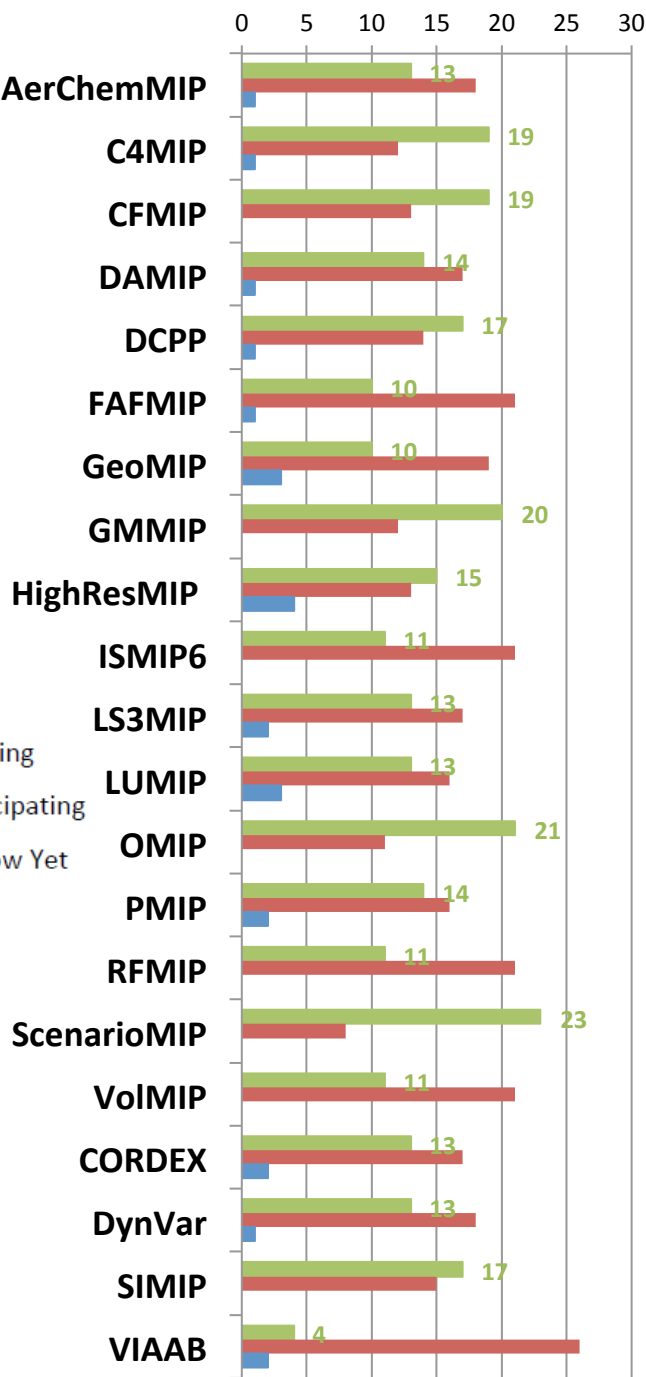
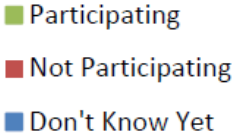
Main Criteria for Endorsement

1. The MIP and its experiments address at least one of the key science questions of CMIP6.
2. The MIP demonstrates connectivity to the DECK experiments and the CMIP6 Historical Simulation.
3. The MIP adopts the CMIP modeling infrastructure standards and conventions.
4. All experiments are tiered, well-defined, and useful in a multi-model context and don't overlap with other CMIP6 experiments.
5. Unless a Tier 1 experiment differs only slightly from another well-established experiment, it must already have been performed by more than one modeling group.
6. A sufficient number of modelling centers (~8) are committed to performing all of the MIP's Tier 1 experiments and providing all the requested diagnostics needed to answer at least one of its science questions.
7. The MIP presents an analysis plan describing how it will use all proposed experiments, any relevant observations, and specially requested model output to evaluate the models and address its science questions.
8. The MIP has completed the MIP template questionnaire.
9. The MIP contributes a paper on its experimental design to the CMIP6 Special Issue.
10. The MIP considers reporting on the results by co-authoring a paper with the modelling groups.

* For "Diagnostic-MIPs" only non-experimental criteria apply

Proposals from CMIP6-Endorsed MIPs & Model Groups' Commitments to Participate in each MIP

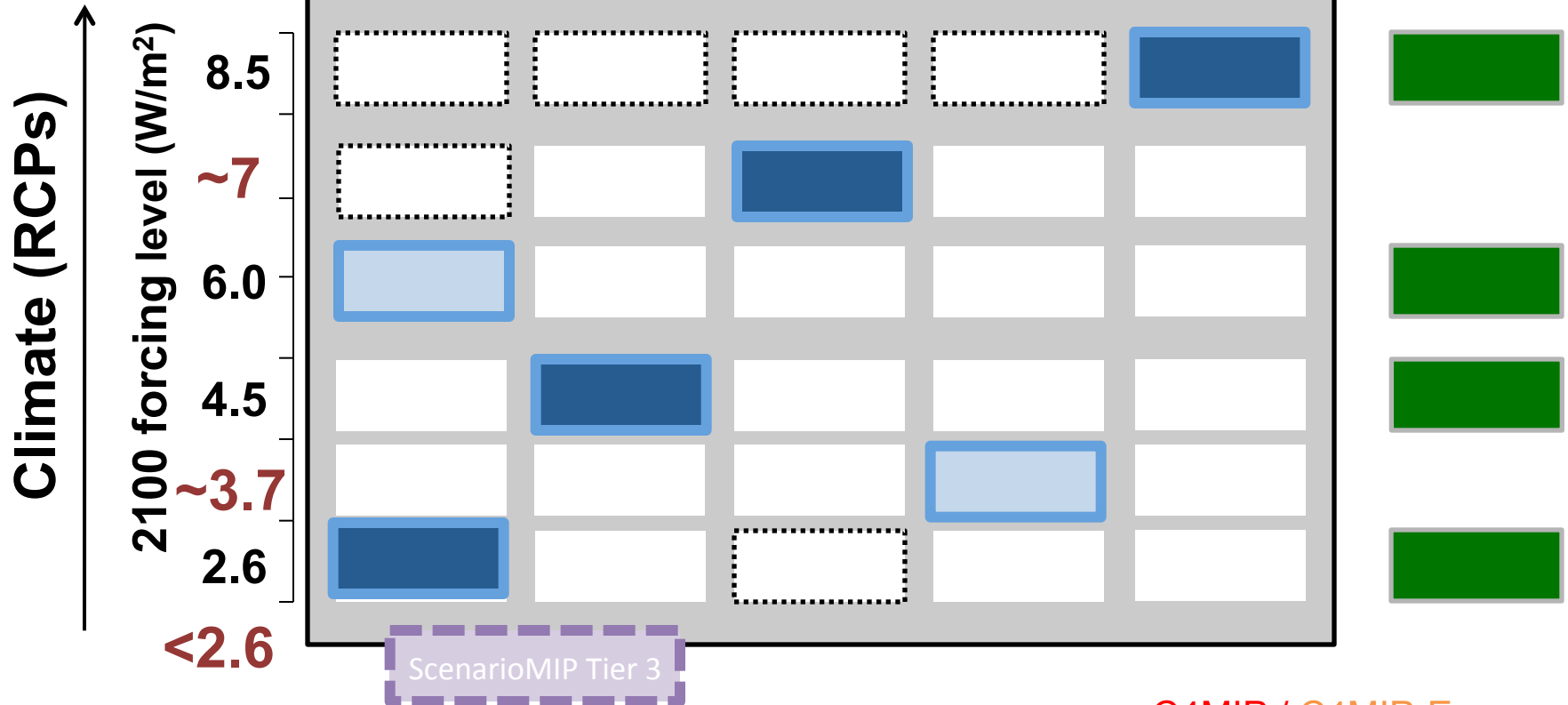
	Long Name of MIP (Short Name of MIP)
1	Aerosols and Chemistry Model Intercomparison Project (AerChemMIP)
2	Coupled Climate Carbon Cycle Model Intercomparison Project (C4MIP)
3	Cloud Feedback Model Intercomparison Project (CFMIP)
4	Detection and Attribution Model Intercomparison Project (DAMIP)
5	Decadal Climate Prediction Project (DCPP)
6	Flux-Anomaly-Forced Model Intercomparison Project (FAFMIP)
7	Geoengineering Model Intercomparison Project (GeoMIP)
8	Global Monsoons Model Intercomparison Project (GMMIP)
9	High Resolution Model Intercomparison Project (HighResMIP)
10	Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6)
11	Land Surface, Snow and Soil Moisture MIP (LS3MIP)
12	Land-Use Model Intercomparison Project (LUMIP)
13	Ocean Model Intercomparison Project (OMIP)
14	Palaeoclimate Modelling Intercomparison Project (PMIP)
15	Radiative Forcing Model Intercomparison Project (RFMIP)
16	Scenario Model Intercomparison Project (ScenarioMIP)
17	Volcanic Forcings Model Intercomparison Project (VolMIP)
18	<i>Coordinated Regional Climate Downscaling Experiment (CORDEX)</i>
19	<i>Dynamics and Variability of the Stratosphere-Troposphere System (DynVar)</i>
20	Sea-Ice Model Intercomparison Project (SIMIP)
21	Vulnerability, Impacts, and Adaptation Advisory Board (VIA AB)



Future Scenarios in CMIP6 (Current Proposal)

Shared Socioeconomic Pathways

SSP1 Sustainability	SSP2 Middle of the Road	SSP3 Regional Rivalry	SSP4 Inequality	SSP5 Fossil-fueled Development	CMIP5 simulations
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ScenarioMIP Tier 1

ScenarioMIP Tier 2

CORDEX
DAMIP
DCPP
RFMIP

AerChemMIP
LUMIP (switch
LU SSP1-2.6)
HighResMIP

C4MIP / C4MIP-E

GeoMIP

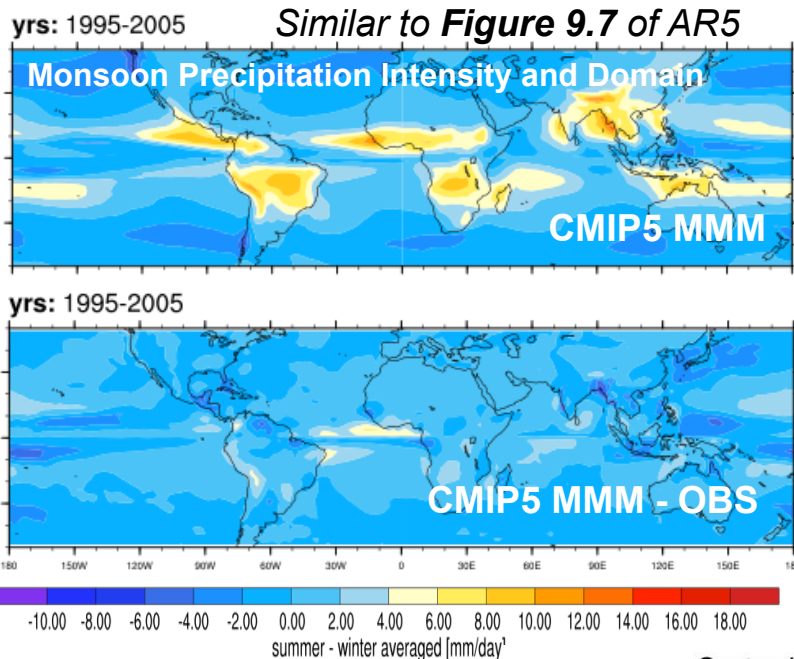
ISMIP6-E

HighResMIP

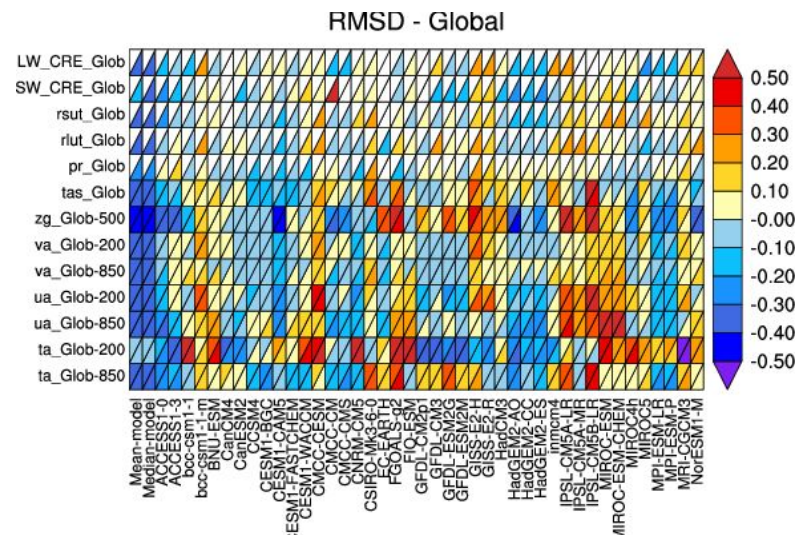
LS3MIP, ScenarioMIP-E

New for CMIP6: Routine Benchmarking and Evaluation

CMIP evaluation tool to produce well-established analyses as soon as model output becomes available
e.g., Community-developed Earth System Model Evaluation Tool <http://www.pa.op.dlr.de/ESMValTool>
and PCMDI metrics package - *Link to WGNE/WGCM Climate Model Metrics Panel*

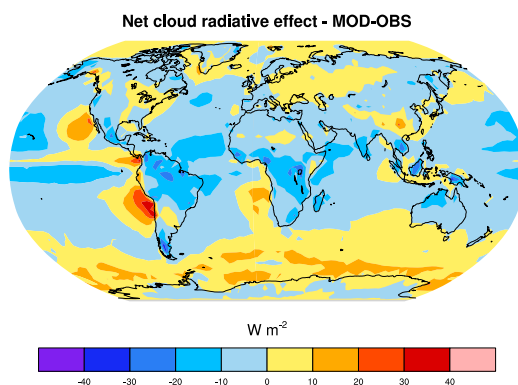


Running
along-
side the
ESGF

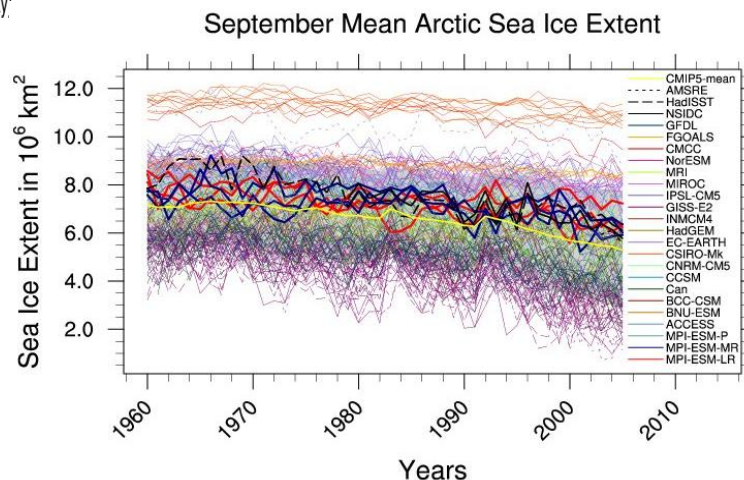


Similar to Figure 9.7 of AR5

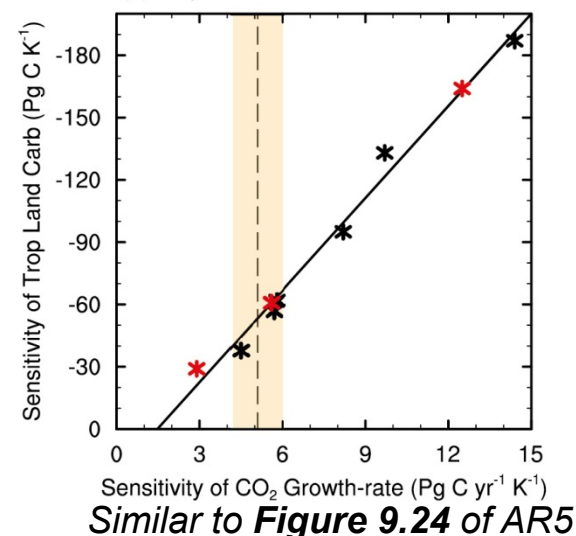
Link to projections
(b) Tropical Land carbon feedback



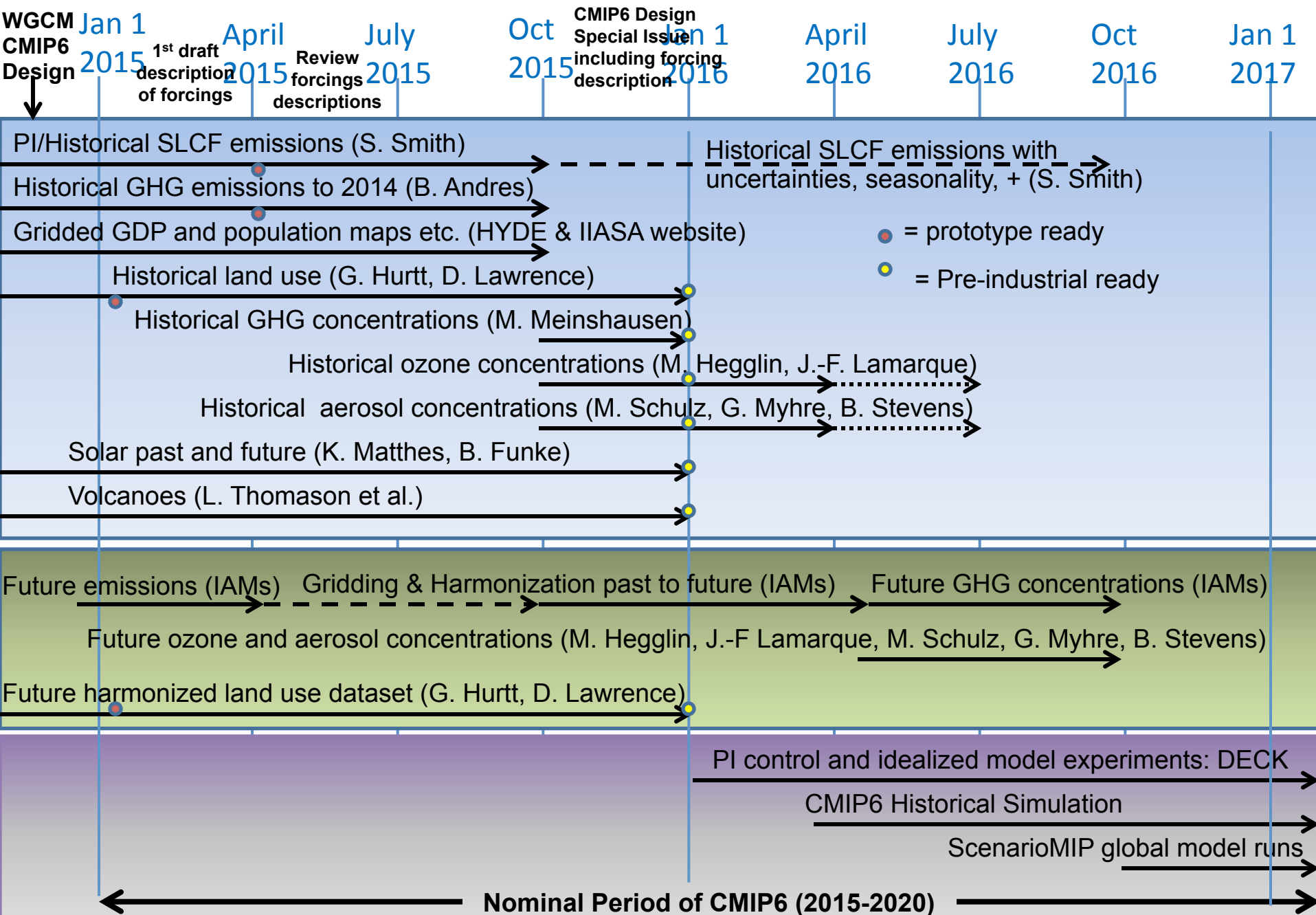
Similar to Figure 9.5 of AR5



Similar to Figure 9.24 of AR5



CMIP6 Timeline



Summary and Outlook

CMIP6 Status

- CMIP6 Organization and Design finalized
- CMIP6 MIP endorsement nearly finalized
- Timelines in place for forcing datasets
- CMIP6 Simulation Period (2015-2020)
- Infrastructure in preparation (including data request)



CMIP6 Evaluation and Scenarios

- Climate model evaluation central part of CMIP6, research on emergent constraints ongoing, including uncertainty assessments in projections.
- New scenarios span the same range as the RCPs, but fill critical gaps for intermediate forcing levels.
- Several scenarios (but not all) of the SSP/RCP matrix will be run with coupled climate models, but some in Tier 2 or 3; need to justify the choices well and consider the selection in our interpretation.

Workshops/meetings

- 18-20 October 2015: WGCM-19 (Dubrovnik, Croatia)
- 20-23 October 2015: WCRP/FP7 EMBRACE Workshop on CMIP5 Model Analysis and Scientific Plans for CMIP6 (Dubrovnik, Croatia)

Geosci. Model Dev. Special Issue on CMIP6 (April 2015 - December 2016)

- Overview of the CMIP6 Design and Organization (submission asap)
- Experimental design from all CMIP6-Endorsed MIPs (submission by end of 2015)
- Description of the CMIP6 forcing data

Coupled Model Intercomparison Project (CMIP)

- Organized by the WCRP Working Group on Coupled Modelling (WGCM) -

Objective: Understanding of past, present and future climate variability and change through a coordinated multi-model experiment design.

Overseen by CMIP Panel (sub-committee of WGCM)

Coordinated across multiple climate science communities within WCRP and beyond (e.g., AIMES, IAMC)

- Since 1995, **CMIP** has coordinated climate model experiments involving multiple international modeling teams.
- CMIP has led to a better understanding of past, present and future climate change and variability.
- CMIP has developed in phases, with the simulations of the fifth phase, CMIP5, now mostly completed.
- Though analyses of the CMIP5 data will continue for at least several more years, science gaps and outstanding science questions have prompted preparations to get underway for the **sixth phase of the project (CMIP6)** already in 2013.

CMIP regularly supported IPCC Assessment Reports with a coordinated set of multi-model simulations

Relative to the 1986-2005 average

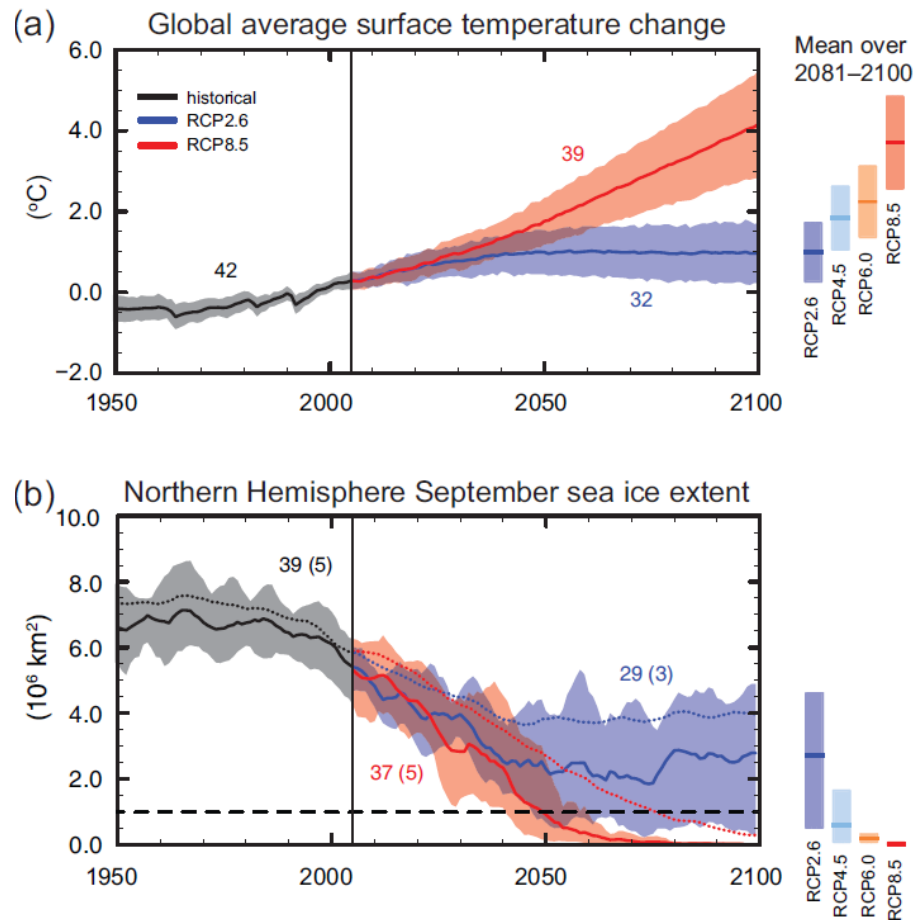


Figure SPM.7

WG I AR5

Process Understanding

Chapter 6: Carbon and other Biogeochemical Cycles

Chapter 7: Clouds and Aerosols

From Forcing to Attribution of Climate Change

Chapter 8: Anthropogenic and Natural Radiative Forcing

Chapter 9: Evaluation of Climate Models

Chapter 10: Detection and Attribution of Climate Change: from Global to Regional

Future Climate Change and Predictability

Chapter 11: Near-term Climate Change: Projections and Predictability

Chapter 12: Long-term Climate Change: Projections, Commitments and Reversibility

Integration

Chapter 13: Sea Level Change

Chapter 14: Climate Phenomena and their Relevance for Future Regional Climate Change

Process understanding and projections including uncertainty estimates also relevant for WG II & III

CMIP6 Organization

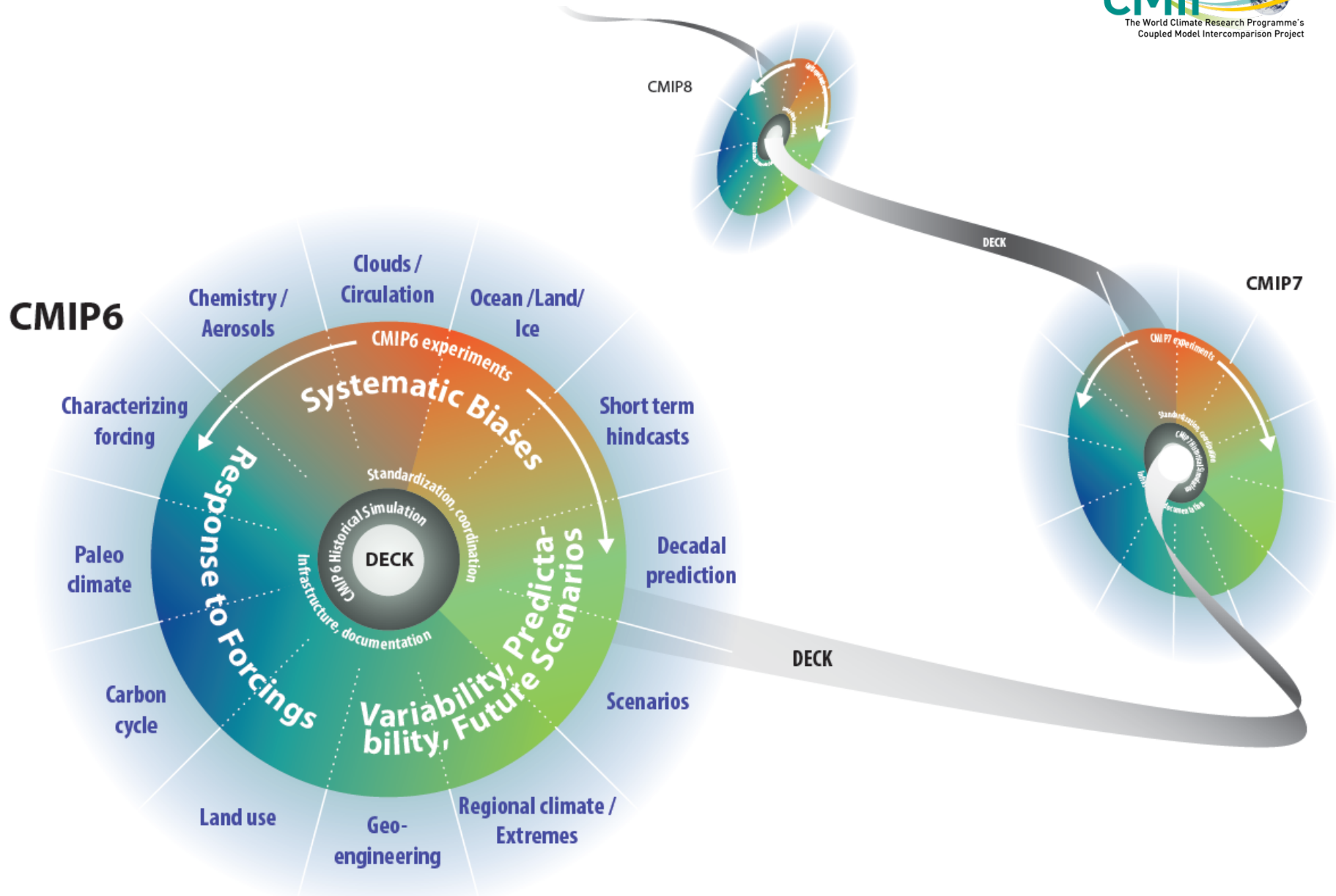
- **CMIP Panel** (V. Eyring (chair), J. Meehl, B. Stevens, R. Stouffer, K. Taylor) which is responsible for direct coordination of CMIP and overseeing the whole CMIP process.
- Sub-committee of **WCRP's Working Group of Coupled Modelling** (WGCM, co-chairs S. Bony and C. Senior).
- **WGCM Infrastructure Panel** (WIP, co-chairs V. Balaji & K. Taylor): Establishes standards and policies for sharing climate model output; puts the data request together technically (M. Juckes).

CMIP6 Design

- Based on the summer 2013 CMIP5 survey and Aspen & WGCM/AIMES 2013 meetings
- Initial proposal for the design of CMIP6 (Meehl et al., EOS, 2014).
- Feedback on this initial CMIP6 proposal has been solicited over the year from modeling groups and model analysts until September 2014.
- The WGCM and the CMIP Panel have then finalized the CMIP6 design at the WGCM 18th session (October 2014, Grainau) in consultation with the model groups and MIP co-chairs.

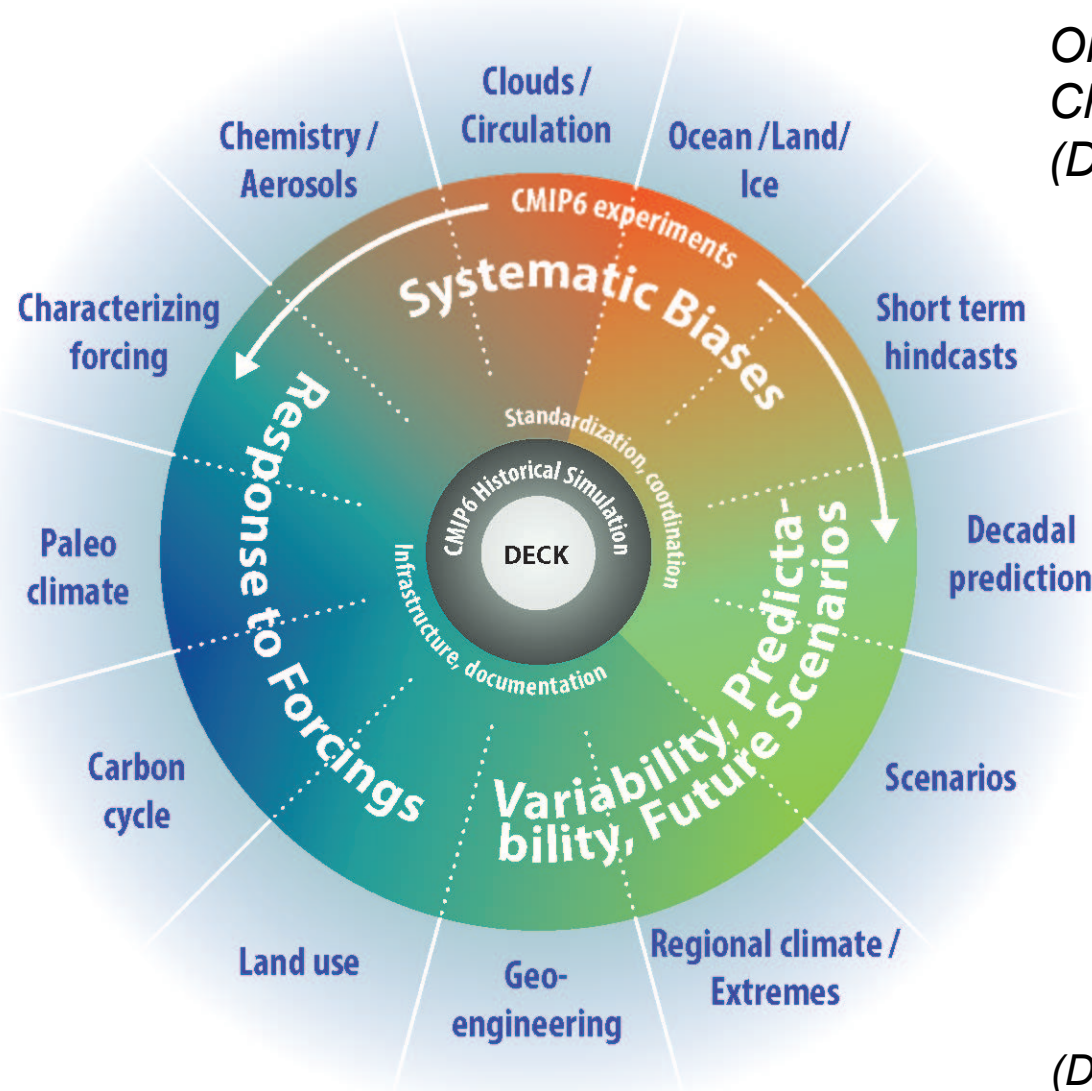


CMIP Continuity



Note: The themes in the outer circle of the figure might be slightly revised at the end of the MIP endorsement process

WCRP Grand Challenges: (1) Clouds, circulation and climate sensitivity, (2) Changes in cryosphere, (3) Climate extremes, (4) Regional climate information, (5) Regional sea-level rise, and (6) Water availability, plus an additional theme on “Biogeochemical forcings and feedbacks”



Ongoing Diagnosis, Evaluation, and Characterization of Klima (DECK) Experiments

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CMIP and CMIP6 Cycle

CMIP Cycle

1. **Coordination of Data Request DECK** (coordinated and technically overseen by WIP, scientifically overseen by CMIP Panel, in close collaboration with modelling groups)
2. **ESGF Data Archive and Related Functionality** (overseen by WIP)
3. **Register Model for CMIP and Run and Submit DECK Experiments** (model groups)
4. **Documentation of Models and Simulations** (WIP in collaboration with model groups)

CMIP6 Cycle

1. **Defining the MIP set:** open call for MIP proposals
2. **Harmonization Phase:** WGCM reviews and harmonizes experiments across the MIPs for synergies and similar experimental design in collaboration with MIP co-chairs
3. **Endorsement of MIPs by CMIP Panel + WGCM co-chairs**
4. **Coordination of CMIP6 Data Request (DECK+)** (coordinated and technically overseen by WIP, scientifically overseen by CMIP Panel, in close collaboration with modelling groups)
5. **Preparation of Forcings** (“Forcing Group” and overseen by CMIP Panel)
6. **Documentation of CMIP6 Experimental Design in a Special Issue** Overview (CMIP Panel + WGCM Co-chairs) + Papers from CMIP6-Endorsed MIPs + Papers on Forcing Datasets)
7. **Model Execution CMIP6 Historical Simulation** (DECK & CMIP6 Historical Simulation to be run for each model configuration used in the subsequent CMIP6-Endorsed MIPs)
8. **Routine Model Evaluation:** as soon as output from CMIP6 Historical Simulation is submitted
9. **Model Execution MIP experiments and submission to ESGF** (model groups)
10. **Additional Model Analysis:** by wider community

CMIP Organization and Governance

WGCM (co-chaired by S. Bony and C. Senior)

<http://www.wcrp-climate.org/index.php/wgcm-overview>

- Ensures good communication between the modelling groups and the WGCM panels (CMIP Panel, WIP)
- Facilitates communication between the CMIP Panel and WCRP Grand Challenges + Theme of collaboration on “Biogeochemical forcings and feedbacks”, and WCRP core projects
- Organizes the review of MIP proposals for CMIP6 endorsement

CMIP Panel (V. Eyring (chair), J. Meehl, B. Stevens, R. Stouffer, K. Taylor)

<http://www.wcrp-climate.org/index.php/wgcm-cmip/about-cmip>

- Sub-committee of the WGCM which is responsible for direct coordination of CMIP
- Oversees the whole CMIP process
- Coordinates the DECK activity and the CMIP Phase X Historical Simulation
- Coordinates and approves endorsement of CMIP6 MIPs
- Oversees and approves scientific content of the CMIP data request
- Facilitates communication between the MIPs, modeling groups and the WIP

WGCM Infrastructure Panel (WIP, co-chaired by V. Balaji & K. Taylor)

<https://www.earthsystemcog.org/signal/list/wip/>

- Establishes standards and policies for sharing climate model output and ensure consistency across WGCM activities
- Extends standards as needed to meet evolving needs.
- Reviews and provides guidance on requirements of the infrastructure (e.g. level of service, accessibility, level of security)
- Oversees technical part of the CMIP6 data request and puts it together (**M. Juckes**)