An update on CMIP and the WGCM/WGNE Metrics Panel

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Talk outline

- A very brief review of AMIP and CMIP

- The WGNE/WGCM climate metrics (and diagnostics) panel

- A surge of interest in climate model "metrics"

- A new paradigm for CMIP: *Diagnostic, Evaluation and Characterization of Klima (DECK experiments)*

- Community-based evaluation of climate models

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AMIP began with WGNE

1990:   AMIP initiated by PCMDI with WGNE oversight

1995 - 2000   AMIP2
                    CMIP1

2000 – 2003   CMIP2   gigabytes

2003 – 2009   CMIP3#   terabytes   *CF data conventions*

2009 – Present   CMIP5   petabytes   *Data becomes distributed*

CMIP simulations enable a large body of research assessed by the IPCC

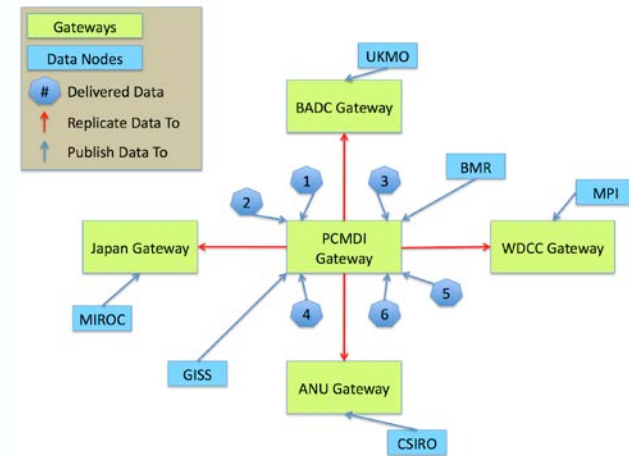# AMIP subsumed to be a part of CMIP (with links between WGNE and WGCM)

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Data accessibility for WCRP Climate Model Intercomparions (MIPs):

For CMIP3 (circa IPCC AR4) and earlier, data from CMIP and several other MIPs were centralized (at PCMDI)

Since CMIP5, data is now distributed via the Earth System Grid Federation (**ESGF**)

CMIP5 data ~5Pb

The conventions for **CF** (Climate and Forecast) metadata are used in the organization of all CMIP data

WGNE has encouraged objective tests of climate models

- WGNE formed a panel to identify performance metrics for climate models (2011)

- Panel is expanded and identified as a joint effort with WGCM/WGNE effort (2013)

Members selected by relevant and diverse experience, and potential for liaison with key WCRP activities:

Beth Ebert (BMRC) – JWGV/WWRP, WMO forecast metrics

Veronika Eyring (DLR Germany) – WGCM/SPARC/CMIP6, stratosphere, ESMs

Pierre Friedlingstein (U. Exeter) – IGBP, carbon cycle

Peter Gleckler (PCMDI), chair – WGNE/WGCM, atmosphere and ocean

Simon Marsland (CSIRO) – CLIVAR OMDP, WGCM, ocean

Robert Pincus (NOAA) – GEWEX/GCSS, clouds/radiation

Karl Taylor (PCMDI) – WGCM, atmosphere, CMIP

Keith Williams (U.K. Met Office) – WGNE, Transpose AMIP, clouds (new member)

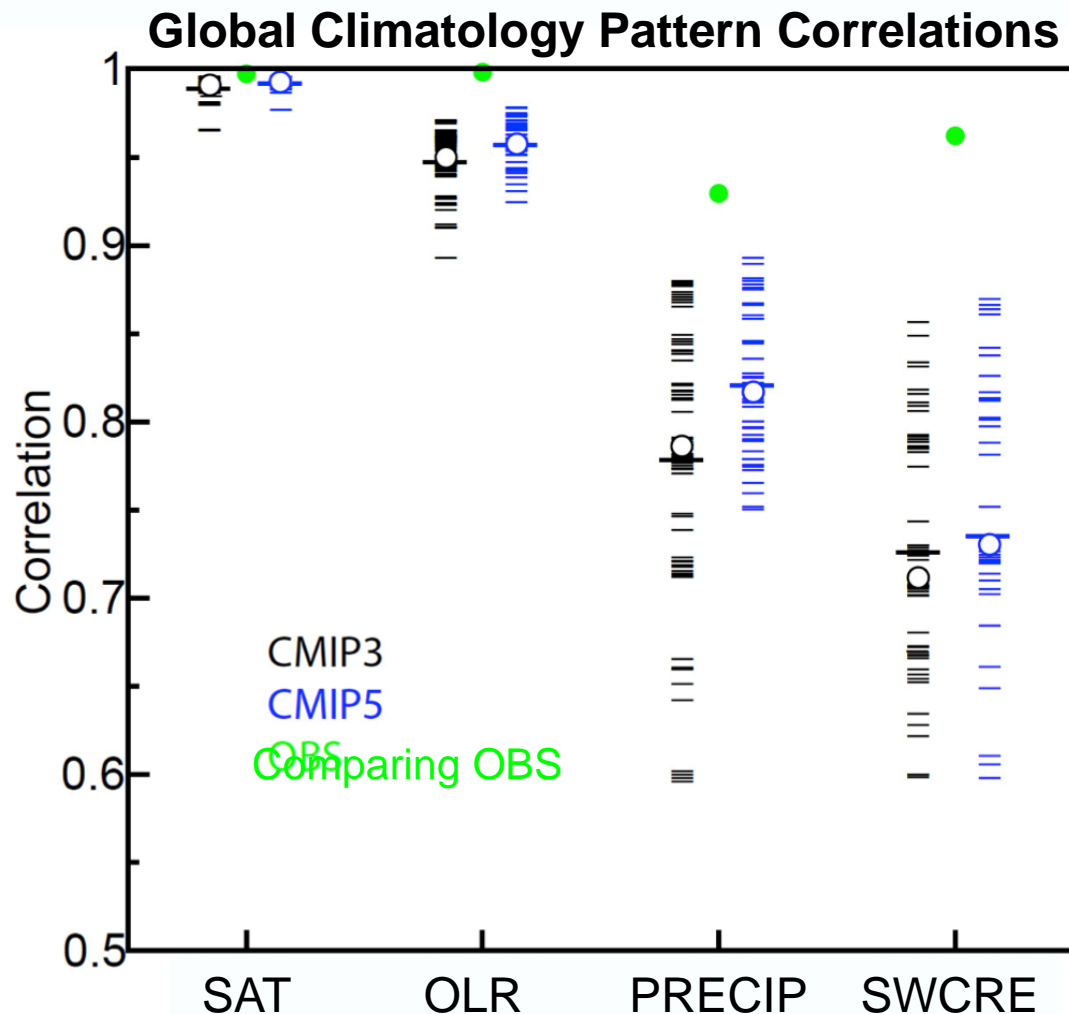http://www-metrics-panel.llnl.gov/wiki

Recent surge in research topics related to model metrics...

- <u>Succinct performance summaries, monitoring performance changes over time</u>

- Process-oriented metrics

- <u>Exploring the dependence between different models</u>

- Use in model tuning

- Comparing error characteristics of MME and PPE

- <u>Weighting model projections</u>

- "Emergent constraints"   <u>A few examples to follow</u>
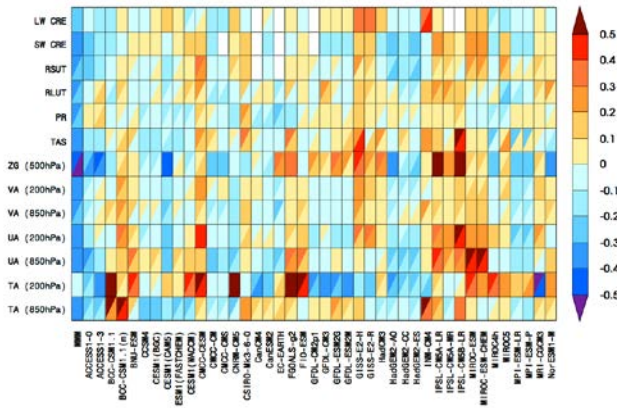
Are models improving?

Global Climatology Pattern Correlations

Many examples of incremental improvements since CMIP3

Improvement not uniform, but little evidence of performance deterioration

IPCC AR5 FAQ 9.6

Assessing model strengths and weaknesses relative to other models

Variables

Annual cycle

Models

AR5 WGI Figure 9.7

Variables

Extremes

Models

AR5 WGI Figure 9.7

Performance portrait examples
Annual cycle and extremes

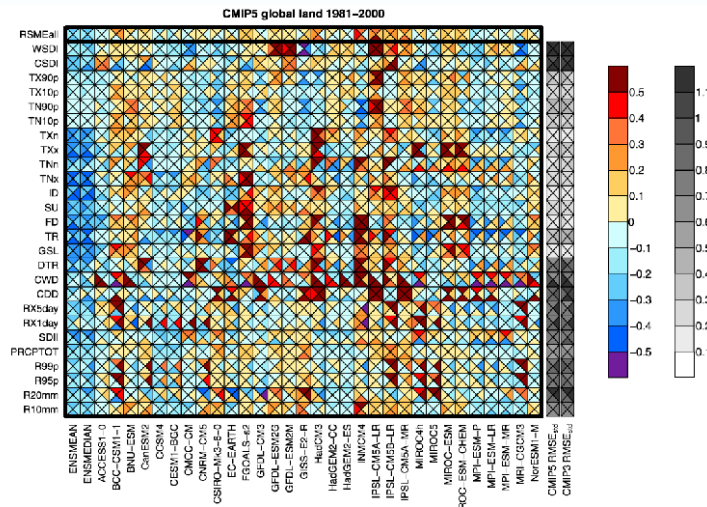Some models clearly simulating mean state and variability better than others

but

Which metrics to choose?

Some errors are correlated

Little relation to climate projections

Collapse to a single skill score?

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Model dependence
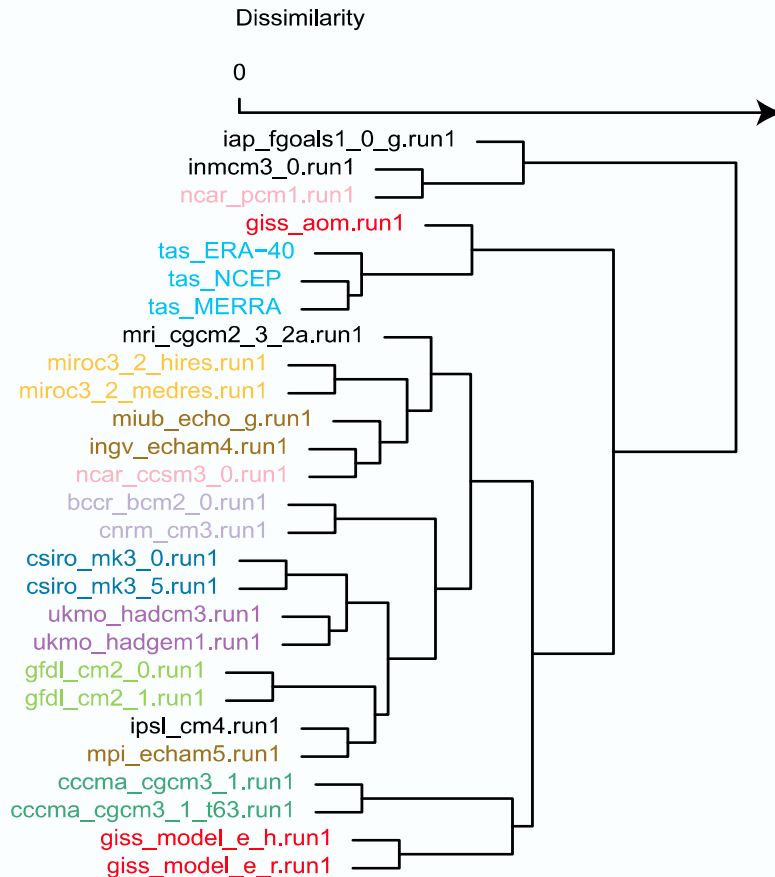
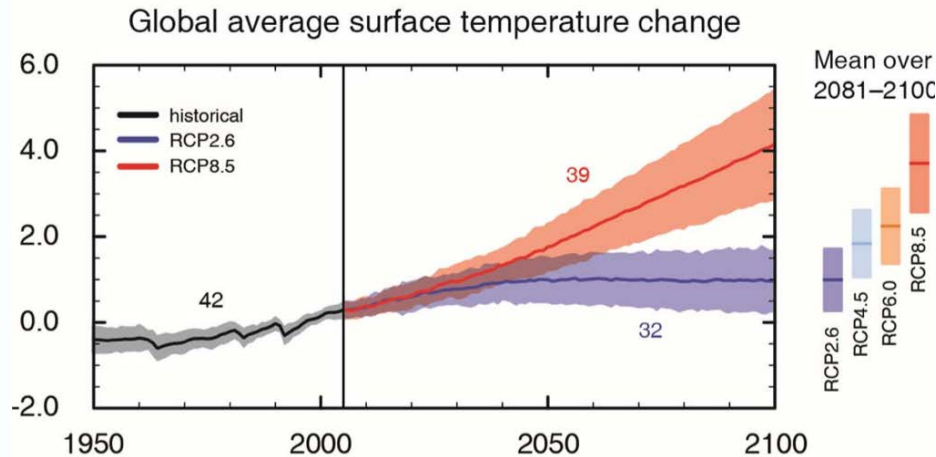**Masson and Knutti (2011), Knutti (2013)**

Quantifying the distance between control runs of two models, accounting for mean state, seasonal cycle, and interannual variations

Demonstrates a level of dependence between model pairs

Active area of research - how to use this information in producing multi-model projections?
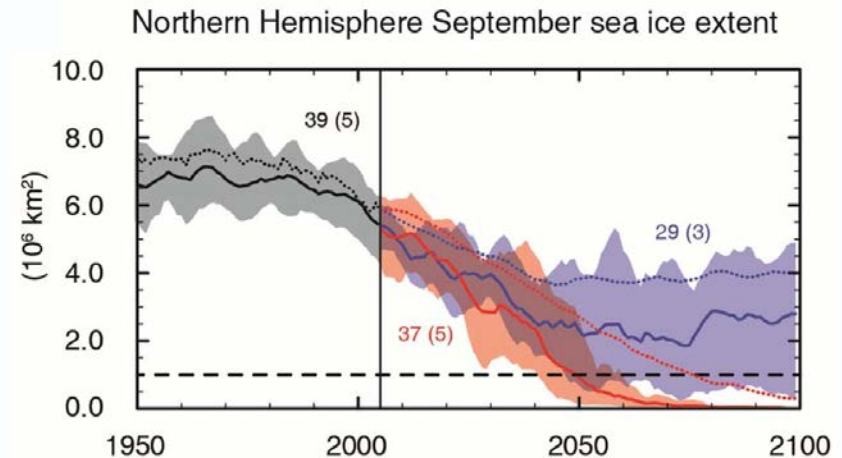
Multi-model projections: weighting model projections?
CMIP5 for different forcing scenarios

All models treated equally: standard IPPC approach

Subset of 5 models averaged together, selected by how well they simulate the present day annual cycle and observed trends (sea ice loss)
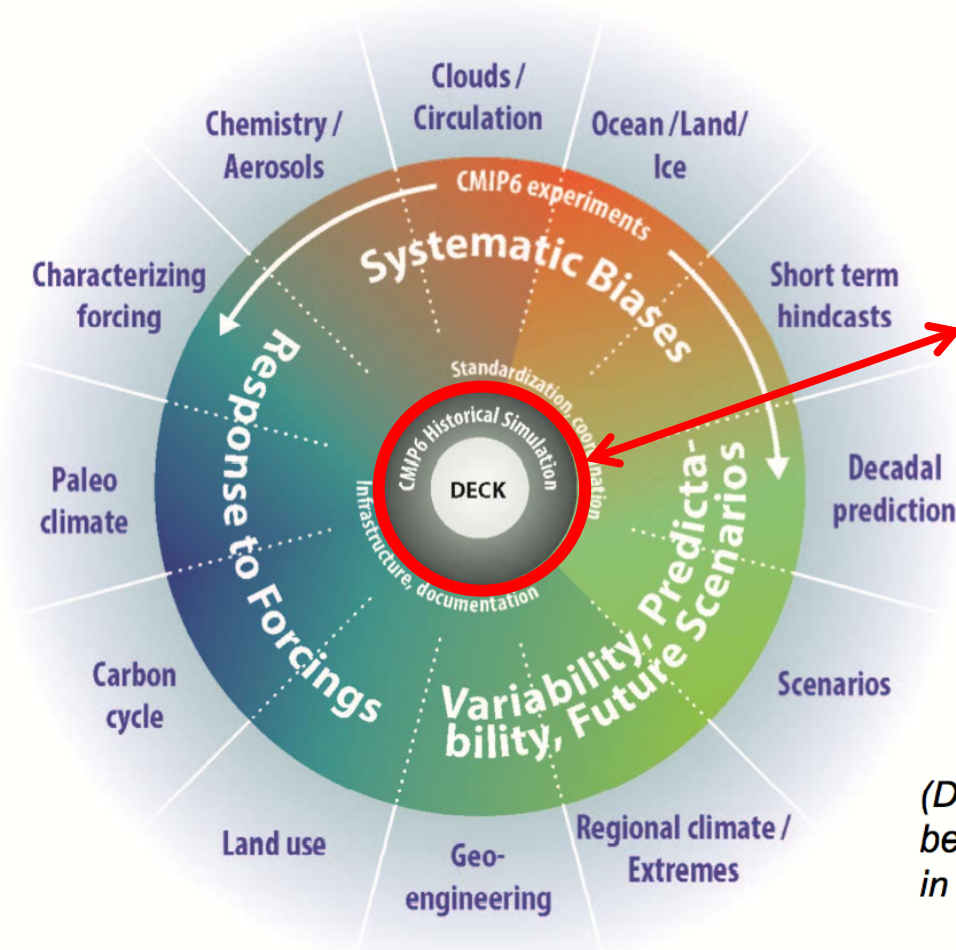**Weighting projections: A first in IPCC**

AR5 WGI Figure SPM.7a

AR5 WGI Figure SPM.7b

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Challenges for the Metrics Panel

- Limited opportunities to verify climate model simulations

- Metrics used for many purposes; appropriate set is application dependent

- Observations lacking for many processes believed important for climate change

- Identifying what is most important for ESM projections remains very much a research topic

- No consensus on a short list of metrics or how/if such a list should be used (e.g., in model tuning, weighting, …)

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CMIP6 and the future of CMIP

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"

DECK (entry card for CMIP)
i. AMIP simulation (~1979-2014)
ii. Pre-industrial control simulation
iii. 1%/yr CO_2 increase
iv. Abrupt 4xCO_2 run
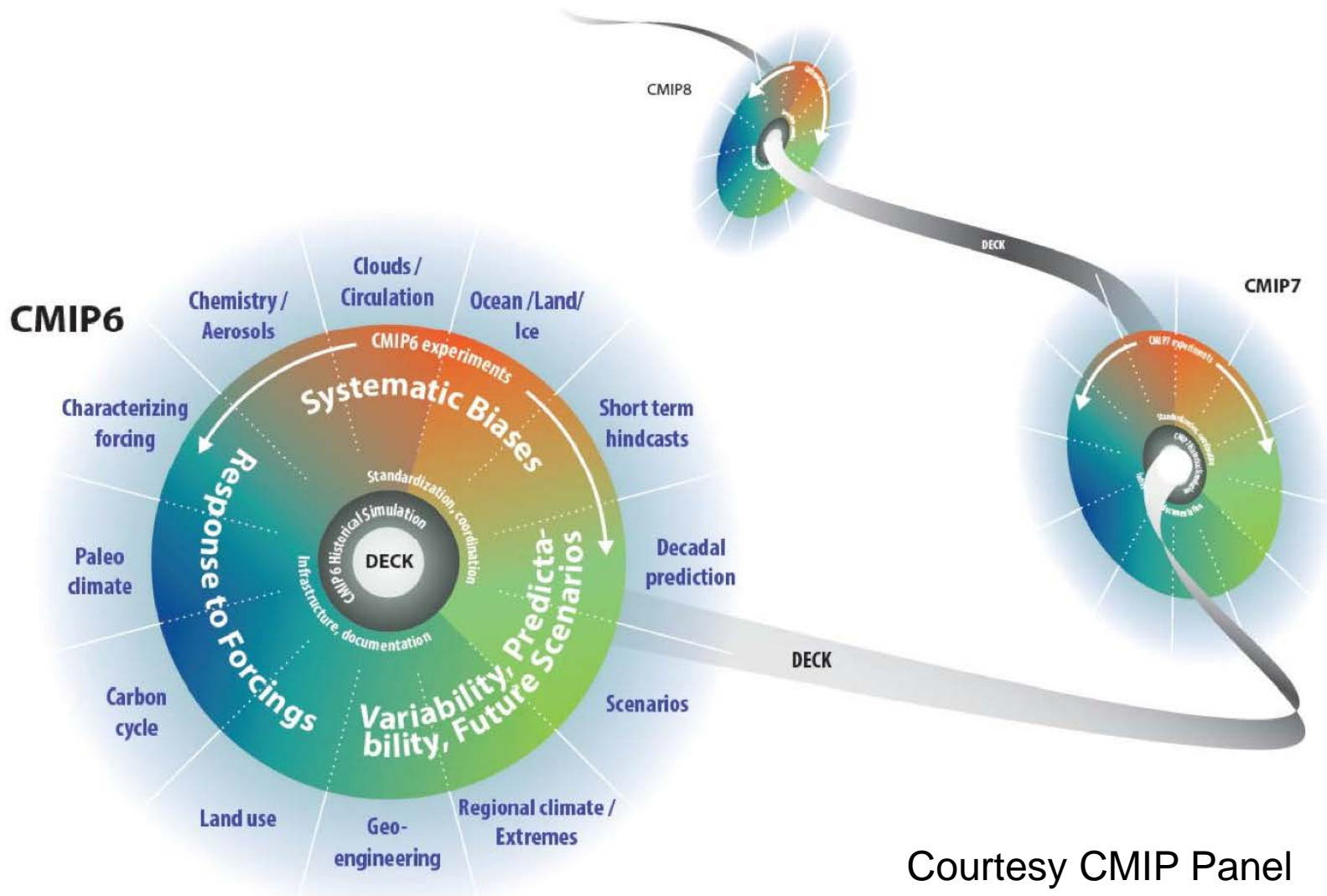
CMIP6 Historical Simulation (entry card for CMIP6)
v. Historical simulation using CMIP6 forcings (1850-2014)

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

With proto-DECK experiments (LMIP,OMIP etc.) in CMIP6 Tier1

WGCM CMIP Panel currently working to finalize CMIP6 design current

CMIP Continuity

Courtesy CMIP Panel

Minor revision of the Metrics Panel terms of reference to support advancement of the CMIP DECK and Historical Exps (under discussion)

- <u>Foster an environment to advance community-based routine evaluation of climate models</u>

- Coordinate with other WCRP/CLIVAR activities that are actively developing diagnostics and performance metrics

- Identify analysis routines and packages that may be of potential use to modeling groups and researchers, and encourage functionality with the CMIP data conventions

- Ensure that well-established capabilities are <u>applied to the CMIP DECK</u> and Historical experiments, with results made readily accessible

- Encourage and facilitate performance metrics research by identifying key areas needing work and possibly organizing workshops

- Progress and terms to be reviewed annually by both the WGNE and the WGCM.

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Panel beginning a catalog of developing capabilities of potential interest for the DECK   (a few examples)

Name	Scientific Analysis	Software tools required	Targets CMIP data	Intended users	Availability, Point of Contact	References	Comments
CFMIP Diagnostics Repository	A variety of analysis codes targeting cloud properties	MatLab@	mixed	Open	http://cfmip.metoffice.com/CFMIP_diag.html POC: Yoko Tsushima yoko.tsushima@metoffice.gov.uk	*Bodas-Salcedo et al.*, 2011	**To be made by the metrics panel**
Climate Variability Diagnostics Package **(CVDP)**	Interannual variability	NCL driven by python	Yes	Open	http://www2.cesm.ucar.edu/working-groups/ cvcwg/cvdp/data-repository POC Adam Phillips (asphilli@ucar.edu)	Phillips et al., 2014	
Earth System Model Validation Tool **(ESMValTool)**	Mean state, variability, trends, and processes for various aspects of ESM evaluation	NCL driven by python	Yes	Open, Dedicated Team	http://www.pa.op.dlr.de/ESMValTool/ (in preparation) POC: Veronika Eyring (Veronika.Eyring@dlr.de)	Righi et al. 2014	
International Land Model Benchmarking Project (ILAMB)	Land evaluation in CMIP ESMs	?	Yes	Dedicated Team	http://ilamb.org POC: Forrest Hoffman (forrest@climatemodeling.org)	Luo et al. [2012]	
PCMDI's Metrics Package **(PMP)**	Climatological analysis of atm, ocean, ice	A "light" installation of UV-CDAT (python)	Yes	Open, but primarily for modelers	Doutriaux et al. (2015). PCMDI Metrics Initial Release. DOI:10.5281/zenodo.13952	In prep.	

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Next steps

- Refine Terms of Reference in consultation with WGCM and WGNE

- Identify existing diagnostic/metrics capabilities, document their status and summarize their potential use for the DECK. Make this information available

- Identify synergies between efforts in attempt to strengthen collaborations

- Evaluate what is needed to improve a community-based DECK evaluation capability (e.g., a team devoted to developing coding best practices applicable to popular open-source tools currently in use by climate scientists)

A longer term goal: to ensure that community-based diagnostic and metrics capabilities are appropriately developed to ensure repeat/routine use for the CMIP DECK

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