Observations for Climate Model Evaluation

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Program for Climate Model Diagnosis and Intercomparison, LLNL

PCMDI

Talk outline

- Some context: WCRP coordinated climate model experimentation
- Evaluating climate models: observational challenges
- Obs4MIPs and WDAC oversight
- Seeking common ground

WCRP's Coordinated Climate Modeling Experimentation:

The MIPs

WCRP Climate Model Intercomparisons (MIPs)

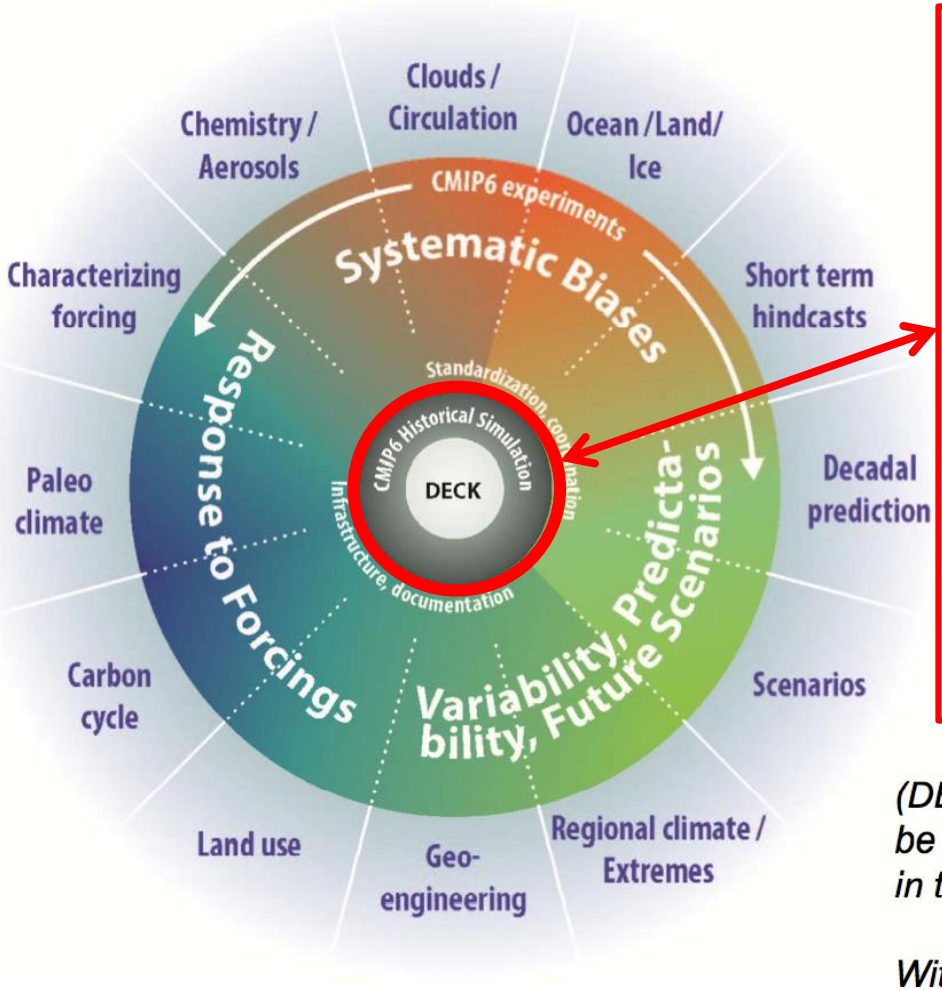
1990 - 1995	Atmospheric Model Intercomparison Project (AMIP)		
1995 - 2000	Coupled Model Intercomparison Project (CMIP) AMIP2		
2000 – 2003	CMIP2 PMIP, CFMIP…	*gigabytes*	
2003 – 2009	CMIP3	*terabytes*	***CF data conventions***
2009 – Present	CMIP5[#]	*petabytes*	***Data becomes distributed***

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

[#]AMIP, CFMIP and PMIP become coordinated with CMIP

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)

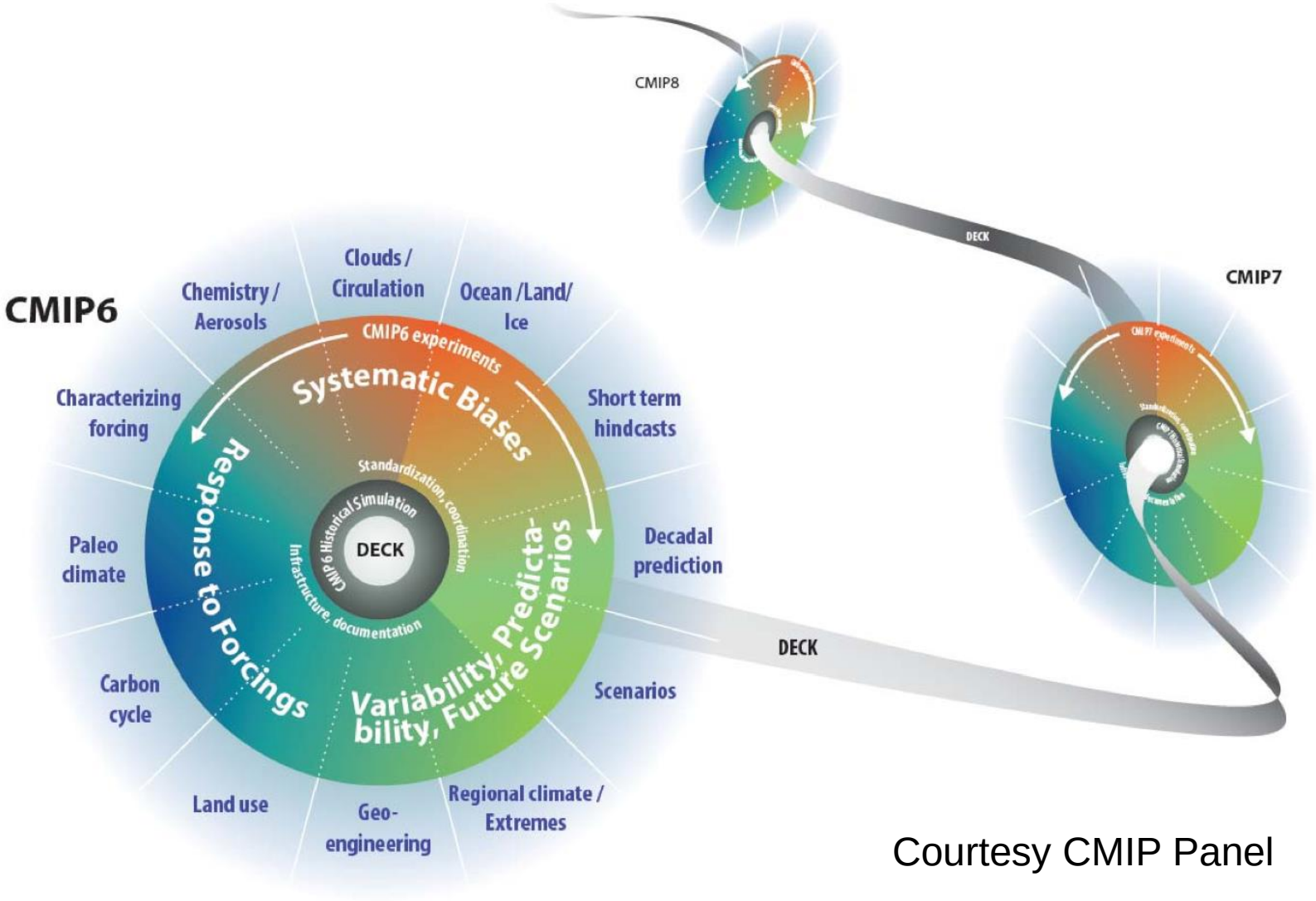
v. Historical simulation using CMIP6 forcings (1850-2014)

(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

CMIP Continuity



Courtesy CMIP Panel

CMIP Infrastructure
"Nuts and bolts"

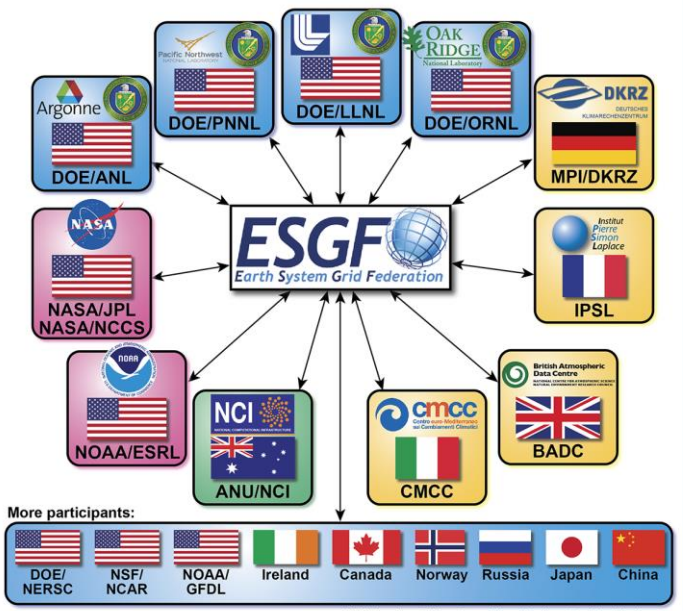
- Experiment protocol (AMIP, Historical, PIControl, etc.)
- Climate Forecast (**CF**) Convention (as applied in CMIP)
- Software to ensure data is compliant: CMOR, CF-checker
- Distribution: Earth System Grid Federation (ESGF); targets CF
- Earth System CoG: Interface to ESGF, well suited for coordinated projects

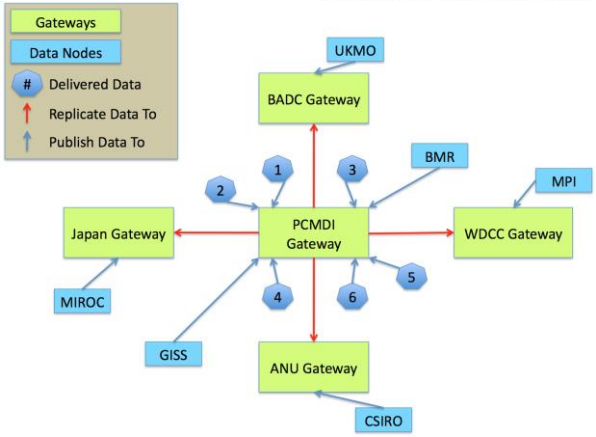
Data accessibility for WCRP Climate Model Intercomparions (MIPs):

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

ESGF is open source and its use its steadily expanding

Numerous efforts underway to expand capabilities (e.g., sub-setting data and server side calculations)





Observational for climate model evaluation

Established use of ECVs for model evaluation

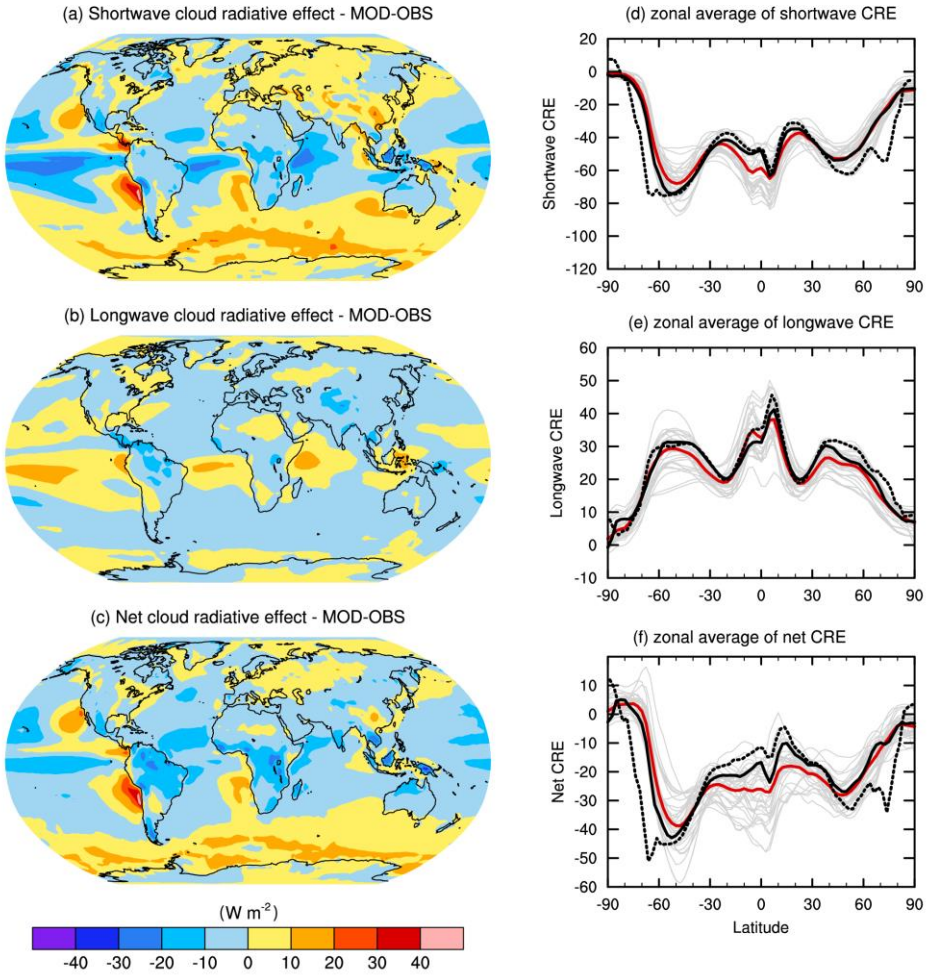


Figure 9.5, IPCC AR5 WGI

<u>Example</u>

Cloud radiative effects

A first order issue for climate models

Substantial biases persist

Often of use in tuning procedures

ECVs for climate model evaluation and development

- Many ECV products are valuable for climate model evaluation and research (i.e., already being used)
- Some existing underutilized data may become more useful for model evaluation with additional work/processing
- Multiple estimates (e.g., alternate instrument) are usually helpful
- A great deal of interest in ECV “observational ensembles”
- ECVs not designed to target model development

Challenges: Improved use of observations for climate model evaluation

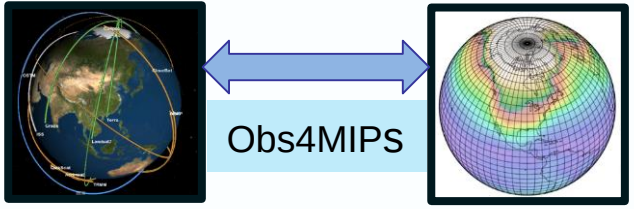
- Quantitative estimates of measurement/processing/sampling uncertainties becoming increasingly important – generally this very hard
- Often a fair (model-to-observation) comparison is difficult
- Many observational data sets can be useful for model evaluation but how does one choose which to use? Systematic evaluation is one approach
- Targeting key processes is especially helpful but data is lacking in many cases
- Accuracy of some measurements may already be good enough; many are not

Obs4MIPs

Obs4MIPs

Objective: To make observational data more accessible for evaluation of CMIP class simulations

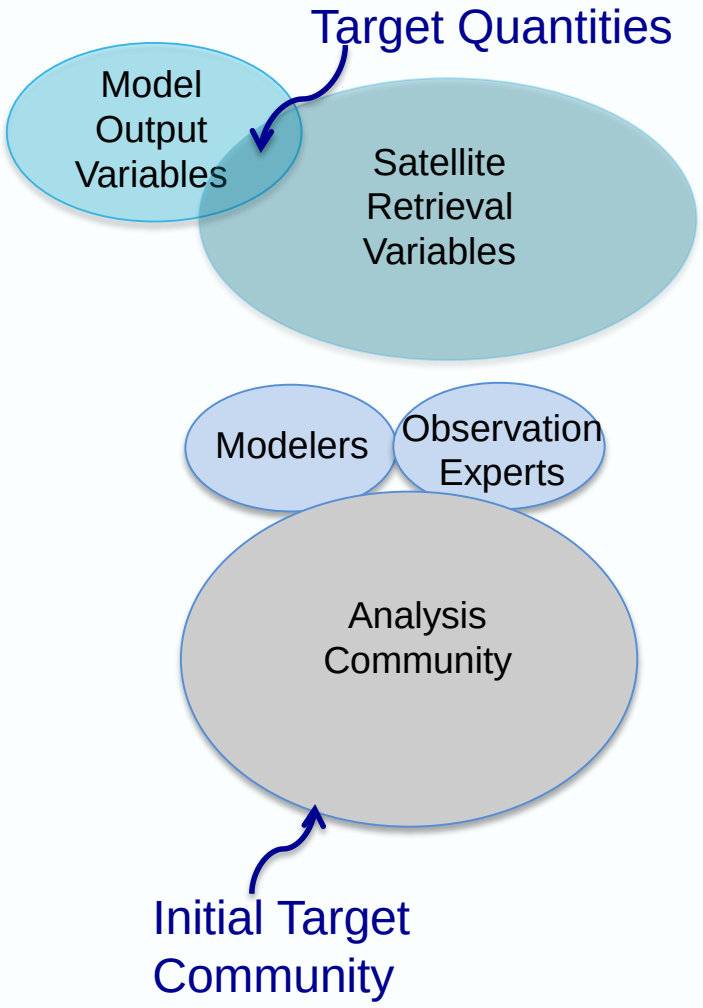
obs4MIPs: The 4 Commandments



Began as a NASA pilot project, now expanding as a WCRP project with WDAC oversight

1. Use the CMIP Standard Model Output as guideline for selecting observations.
2. Observations to be structured the same as CMIP Model output (e.g. NetCDF, CF Convention).
3. Hosted on the ESGF side by side with CMIP model output.

1. Include a Technical Note for each variable describing observation and use for model evaluation (at graduate student level).



obs4MIPs: Current Set of Satellite Observations

Sorted by CF Variable *Long Name*

Air Temperature
Ambient Aerosol Optical Thickness at 550 nm
CALIPSO 3D Clear fraction
CALIPSO 3D Undefined fraction
CALIPSO Clear Cloud Fraction
CALIPSO Cloud Fraction
CALIPSO High Level Cloud Fraction
CALIPSO Low Level Cloud Fraction
CALIPSO Mid Level Cloud Fraction
CALIPSO Scattering Ratio
CALIPSO Total Cloud Fraction
Cloud Fraction retrieved by MISR
CloudSat 94GHz radar Total Cloud Fraction
CloudSat Radar Reflectivity CFAD
Fraction of Absorbed Photosynthetically Active Radiation
ISCCP Cloud Area Fraction (Joint histogram of opt thickness and CTP)
ISCCP Mean Cloud Albedo (Cloud-fraction weighted & daytime)
ISCCP Mean Cloud Top Pressure (Cloud-fraction weighted & daytime)
ISCCP Mean Cloud Top Temperature (Cloud-fraction weighted & daytime)
ISCCP Total Cloud Fraction (daytime only)
Leaf Area Index
Mole Fraction of O3

Many contributions from CFMIP-OBS

and NASA

Near-Surface Wind Speed
PARASOL Reflectance
Precipitation
Sea Surface Height Above Geoid
Sea Surface Temperature
Specific Humidity
Surface Downwelling Clear-Sky LW
Surface Downwelling Clear-Sky SW
Surface Downwelling LW
Surface Downwelling SW
Surface Upwelling Clear-Sky SW
Surface Upwelling LW
Surface Upwelling SW
TOA Incident SW
TOA Outgoing Clear-Sky LW
TOA Outgoing Clear-Sky SW
TOA Outgoing LW
TOA Outgoing SW
Total Cloud Fraction
Water Vapor Path

WDAC Observations for Model Evaluation Task Team

Terms of Reference

1. Establish data/metadata standards for observational and reanalysis data sets that are consistent with standards used in major climate model intercomparison efforts (e.g., CMIP)

2. Encourage the application of these standards to well-established observational datasets that have demonstrated utility for model evaluation.

3. Provide guidance and oversight to obs4MIPs, including the organization of data hosted on ESGF. Establish criteria and a process by which contributed datasets are accepted for inclusion.

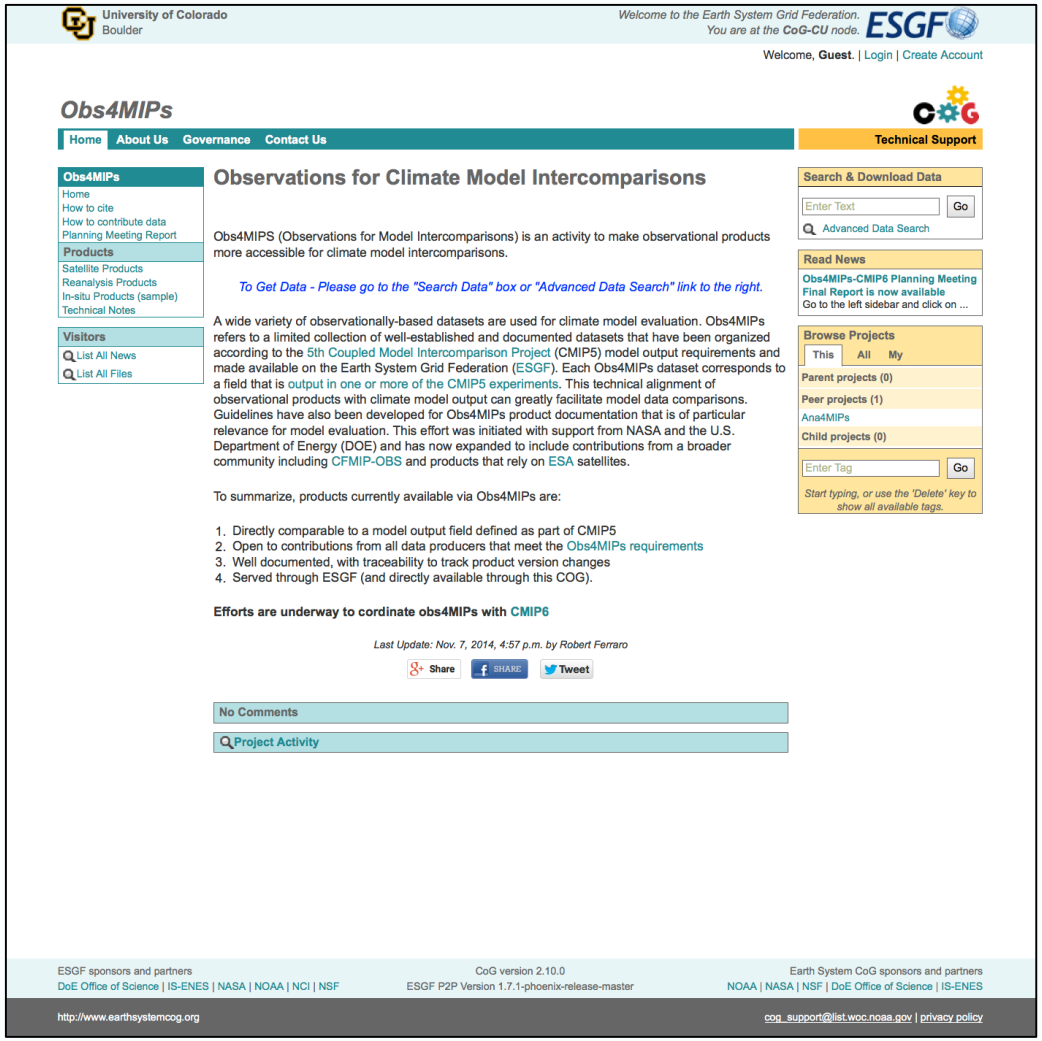
5. Seek community input and feedback on the value of products conforming to the standards, and refine and extend the standards, as necessary, to meet any additional or evolving needs.

6. Coordinate above activities with major climate model intercomparison efforts (e.g., CMIP) and liaise with other related WCRP bodies

WDAC Observations for Model Evaluation Task Team Membership

Peter Gleckler, co-chair, PCMDI
Duane Waliser, co-chair, JPL/NASA
Sandrine Bony, IPSL
Mike Bosilovich, GSFC/NASA
Helene Chepfer, IPSL
Veronika Erying, DLR
Robert Ferraro, JPL/NASA
Pierre-Phillipe Mathieu, ESA
Roger Saunders, UKMO
Jörg Schulz, EUMETSAT
Karl Taylor, PCMDI
Jean-Noël Thépaut, ECMWF

Data access and project connectedness



obs4MIPs data are available through the CoG

The CoG is directly connected to ESGF

CMIP6 is expected to be hosted on the CoG along with many related projects (e.g., ana4MIPs and CREATE-IP)

obs4MIPs planning for CMIP6 – future "requirements"

Meeting (NASA HQ) in 2014, facilitated discussion between experts in model development and evaluation, and experts in satellite data products. Selected consensus recommendations that applied to all of the meeting topic areas:

- Expand the inventory of included datasets
- Include higher frequency satellite data and model output. Could be limited to an observationally-rich "golden period"
- Reliable and defendable error characterization/estimation of observations is a high priority, and obs4MIPs should press harder for the improvements
- Include datasets in support of off-line simulators (prime example: COSP—Cloud Feedback Model Intercomparison Project [CFMIP] Observation Simulator Package)
- Collocated observations, including sparser in-situ datasets, are particularly valuable for diagnosing certain processes - inclusion in obs4MIPs should therefore be encouraged
- Precise definitions of data products (what's actually being reported), including biases, and precise definitions of the model output variables are required.

Ferraro et al., BAMS *in press*

Seeking common ground

WDAC TOR's relevant to Copernicus and obs4MIPs

To promote

- coordinated assessment and comparison of climate-data products, including those from reanalyses
- research for continuing improvement in the processing and reprocessing of climate data
- development of mechanisms for archival and preservation of, access to and analysis of data, and associated meta data
- standards for product generation, including global and regional reanalyses

Personal perspective

- There are many challenges associated with organizing a diverse suite of observations and making them easily accessible
- We should strive to not re-invent too many wheels
- Ideally we would have a common foundation from which to build on for multiple and diverse purposes

Can we adopt and build on a common language? (the secret to CMIP's success)

Based on more than a decade of grass roots development

Demonstrated success for multiple purposes

Worth exploring how it could be adopted to meet additional needs or…

At a minimum, alternate solutions should be mapped to the CF conventions where possible