obs4MIPs:

Origins, progress and plans

Peter J. Gleckler (PCMDI)

A partial list of contributors:

Advancing NASA products: Andy Manaster (RSS), Carl Mears (RSS), Greg Elsaesser (NASA/GISS)

PCMDI/LLNL: P. J. Durack, K. E. Taylor, J. Lee and C. Zhang, S. Ames, C. Mauzey

WCRP obs4MIPs Steering Panel

CMIP International Project Office

CERES Science Team Meeting
LLNL, B170
October 1-3, 2024

LLNL-PRES-869918-DRAFT

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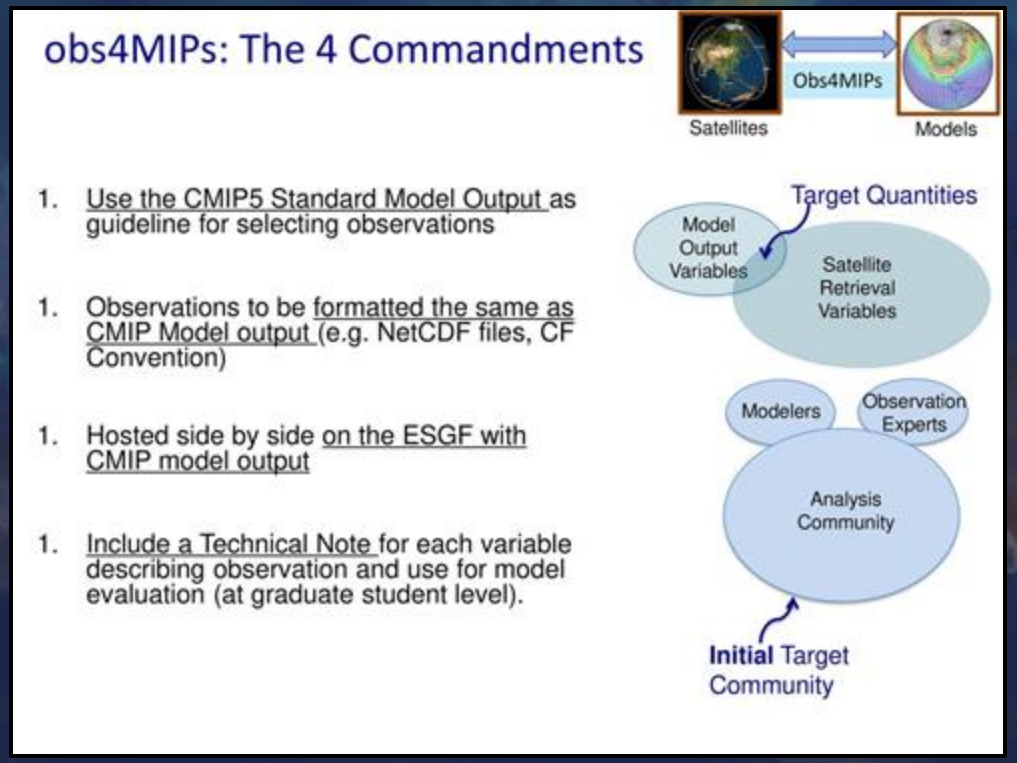
Contents

- Background
- Nuts and bolts
- What is new?
- Delivering CERES
- Benchmarking model performance
- Summary
- Possible discussion topics

A slide – still relevant - from the origins of obs4MIPs



obs4MIPs
Observations for Model Intercomparisons Project

PCMDI
Earth System Model Evaluation Project

Goal

To facilitate more effective use of observations for Earth System Model evaluation, research and development with the aim of accelerating model improvements …

Approach

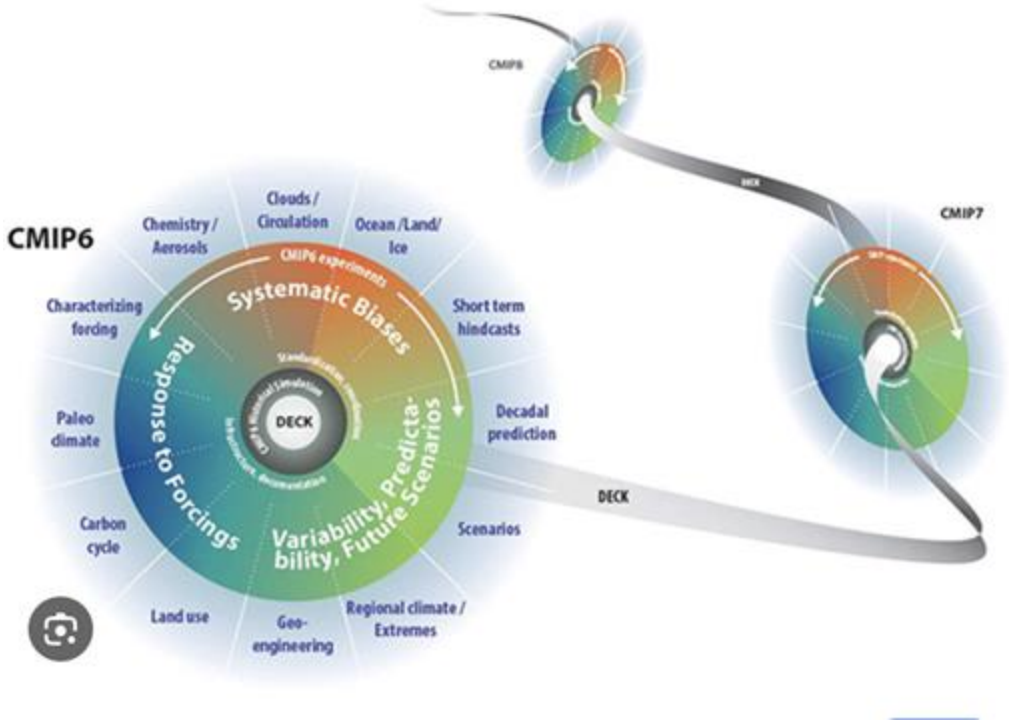
metadata/data technical alignment of CMIP output and observations

Data Standards

side-by-side delivery of both via the Earth System Grid Federation (ESGF)

Data Delivery

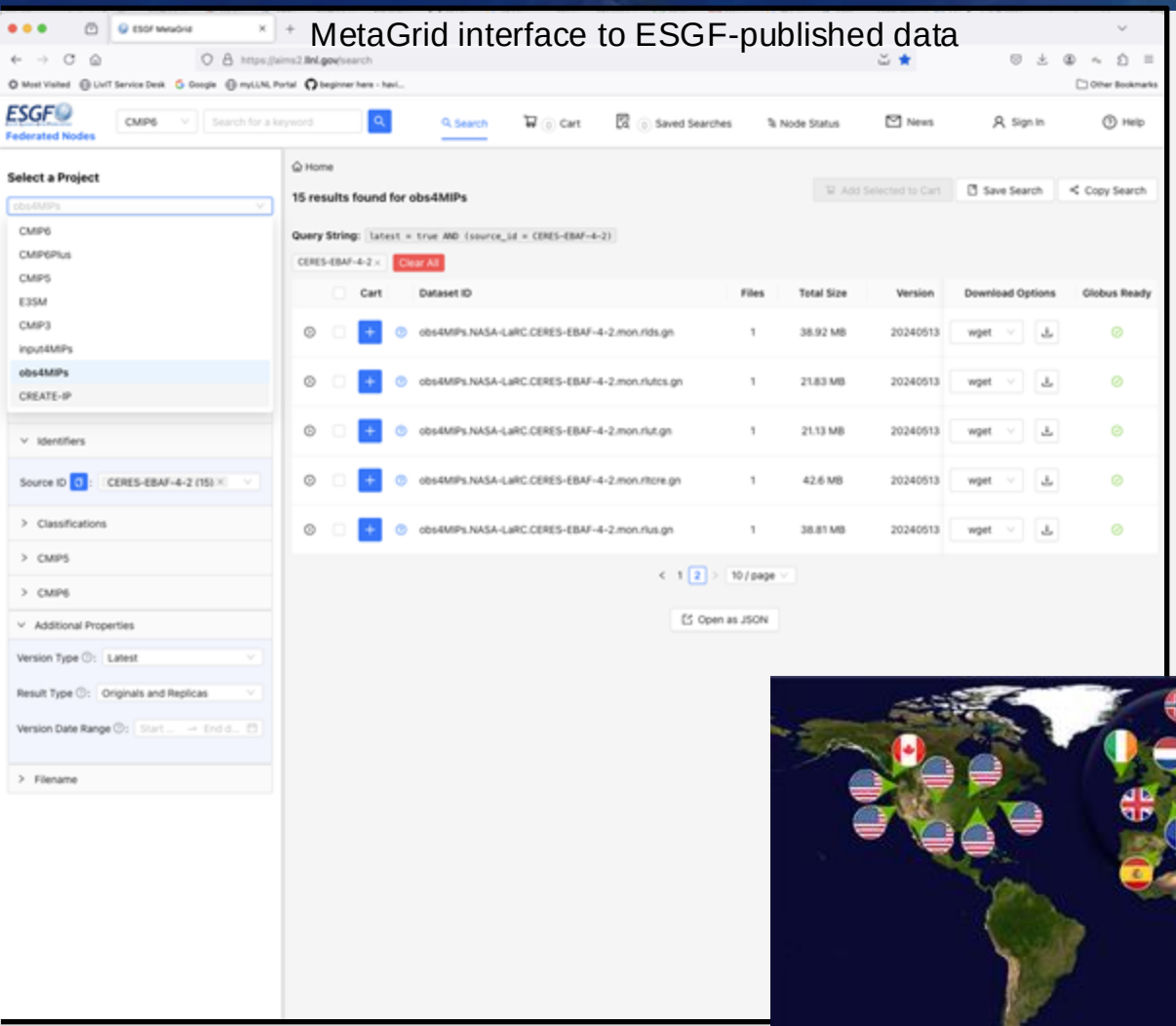
Coupled Model Intercomparison Project (CMIP)
Data standards and protocols



- Protocols for describing climate model output have bee advancing for over 30 years
- Hundreds of clearly defined variables are described in detail, and output at specific frequencies (monthly, daily 6hr, 3hr, 1hr, time-step)
- Via the MIPs, the modeling community has collectively embraced the Climate-Forecast (CF) conventions
- "Controlled Vocabulary" and "Registered Content" facilitate the organization of this data, via a specific application of the CF conventions

Earth System Grid Federation (ESGF)

Primary delivery mechanism of E3SM, CMIP, obs4MIPs, and related project data



MetaGrid interface to ESGF-published data

- ESGF has delivered 10's of petabytes of CMIP data (and related projects) to thousands of users
- A federated system of data nodes
- Well-defined project protocols makes this possible
- Preparations underway for a CMIP7
- **ESGF2** is being advanced via a consortium led by ORNL

CMIP6 data nodes

Obs4MIPs origins and evolution

Table 1. Initial set of obs4MIPs published and documented datasets (at date of submission). The datasets are 1 × 1 degree Lat-Lon monthly averages, with global coverage, unless otherwise noted. The temperature, specific humidity, and ozone datasets are also vertically stratified at the CMIP5 required pressure levels.

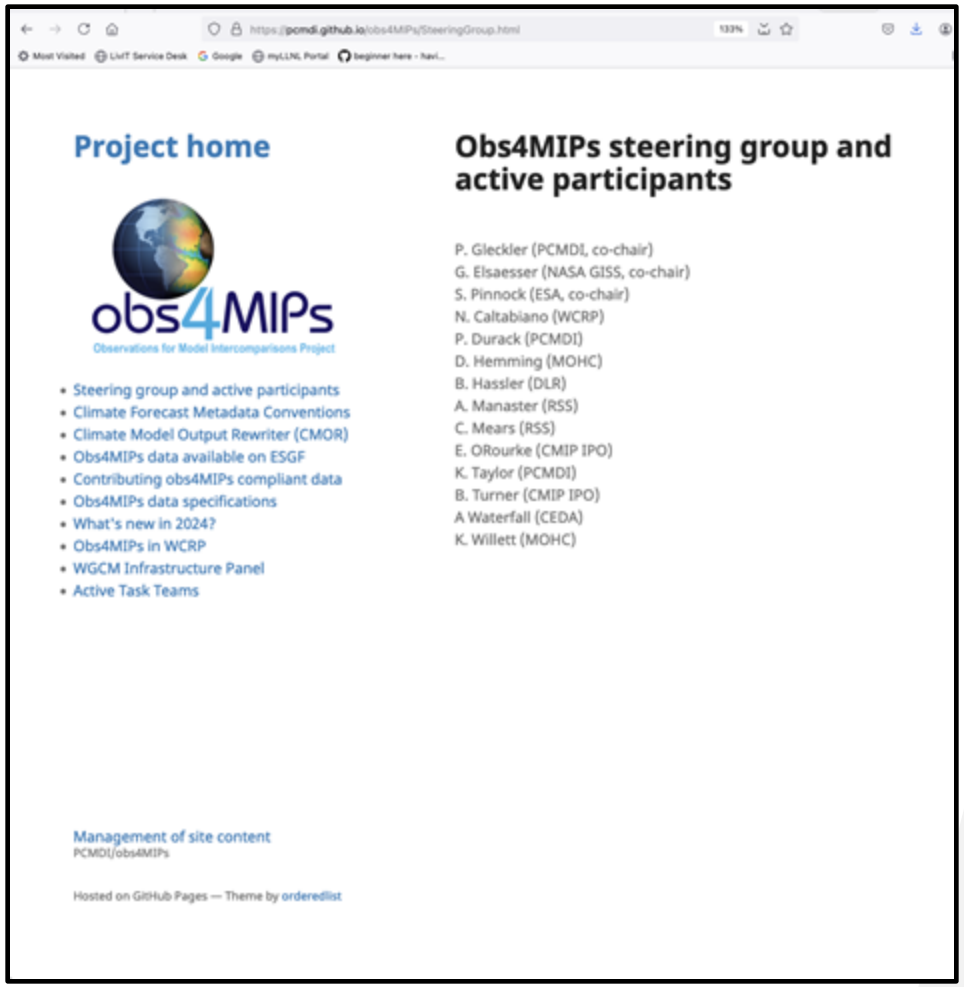
Data source	CMIP5 protocol variables	Time period (month/year)	Comments
AIRS (≥ 300 hPa)	Atmospheric temperature, specific humidity (*ta, hus*)	9/2002–5/2011	AIRS + MLS needed to cover all CMIP5 required pressure levels
MLS (< 300 hPa)	Atmospheric temperature, specific humidity (*ta, hus*)	8/2004–12/2010	2 × 5 degrees Lat-Lon AIRS + MLS needed to cover all CMIP5 required pressure levels
TES	Mole fraction of ozone (*tro3*)	7/2005–12/2009	2 × 2.5 degree Lat-Lon
AMSR-E	Sea surface temperature (*tos*)	6/2002–12/2010	
CERES	Top-of-the-atmosphere outgoing longwave and shortwave radiation, incident shortwave radiation fluxes (*rlut, rlutcs, rsut, rsutcs, rsdt*)	3/2000–6/2011	
MODIS	Total cloud fraction (*clt*)	3/2000–9/2011	
TOPEX/JASON series	Sea surface height above geoid (*zos*)	10/1992–12/2010	AVISO Product
TRMM	Precipitation flux (*pr*)	1/1998–6/2011	0.25 × 0.25 degree, 50°N–50°S Monthly averages and 3-hourly snapshots
QuikSCAT	Near-surface (10-m) winds (*sfcWind, uas, vas*)	8/1999–10/2009	Oceans only, excluding sea ice regions.

Initial set of NASA products included in obs4MIPs (Teixeira et al., 2014)

- Kickoff meeting @PCMDI with JPL and NASA science teams (Oct 2010; Gleckler et al, EOS), leading to …
- A team worked for several years to deliver selected NASA products to obs4MIPs (~2011-2014), leading to …
- WCRP Data Advisory Council advocating for internationalization of the project (2014)
- Community recommendations resulting from a workshop at NASA HQ (2014; Ferraro et al, BAMS, 2015)
- obs4MIPs status for CMIP6 (Waliser et al., GMD, 2020)

Obs4MIPs Steering Panel and the WCRP

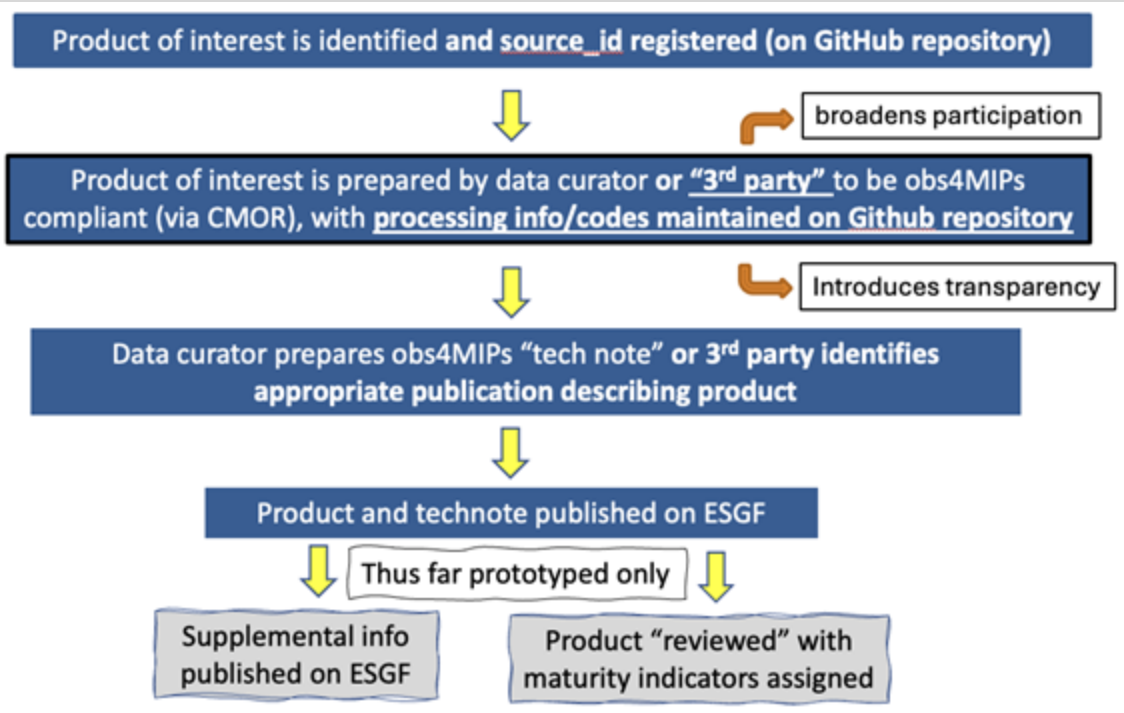
International collaboration



- Since 2022 obs4MIPs has been reinvigorated, with a steering panel supported by the CMIP International Project Office (IPO)
- Co-Chairs: P. Gleckler (PCMDI), G. Elsaesser (NASA/GISS), S. Pinnock (ESA)
- Obs4MIPs is a centralizing effort of ESMO (Earth System Modelling and Observations), a new core project of the World Climate Research Programme

Nuts and bolts

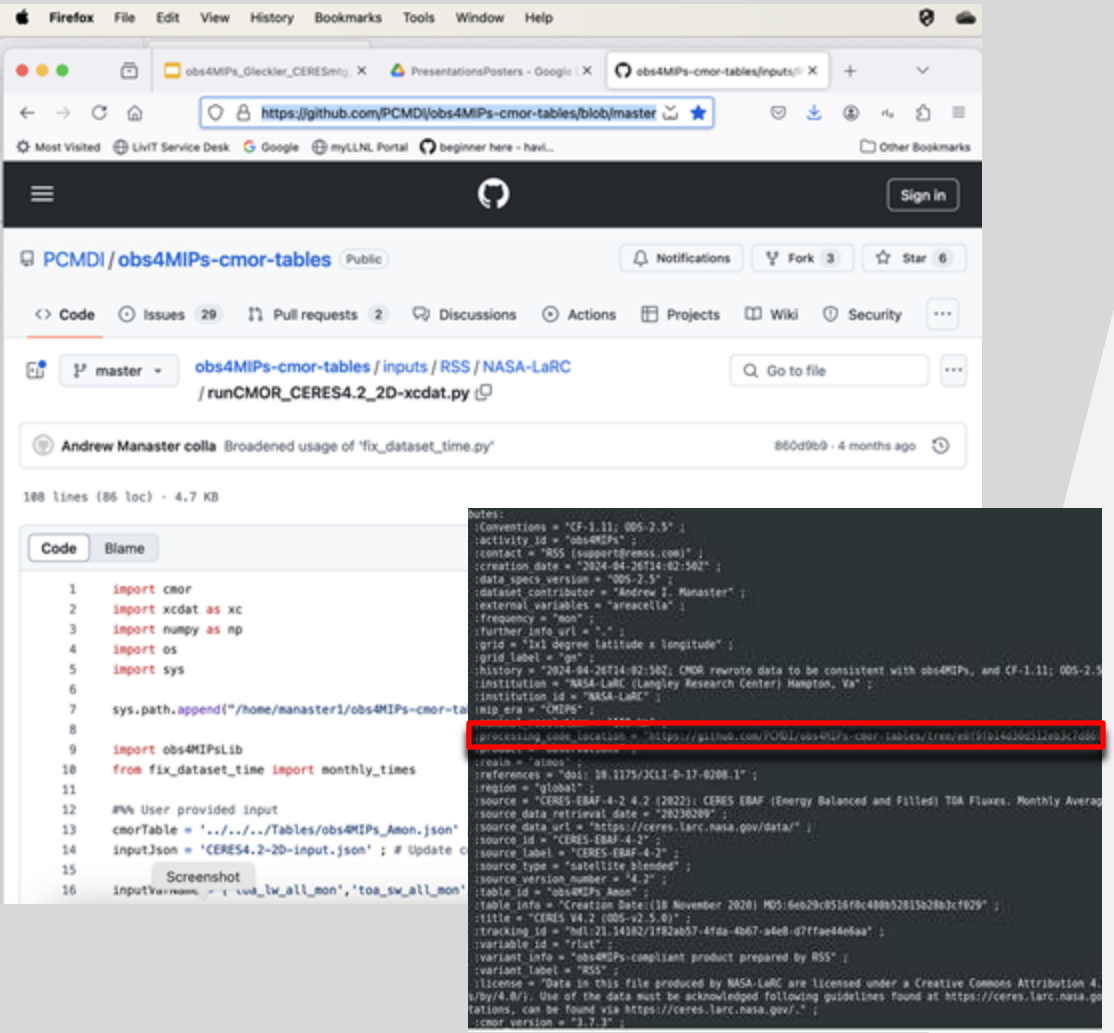
An improved and streamlined process



What is new?

- The utility to prepare data (CMOR) has been generalized for describing observational data
- obs4MIPs data specifications (ODS2.5) are technically aligned with CMIP updates
- Controlled vocabularies and unified version control of <source_id> (e.g., "CERES-EBAF-4-2")
- Transparency: processing workflow captured for each dataset
- Can be prepared by data curator or facilitated by a "3rd party"

obs4MIPs-compliant CERES-EBAF-4-2

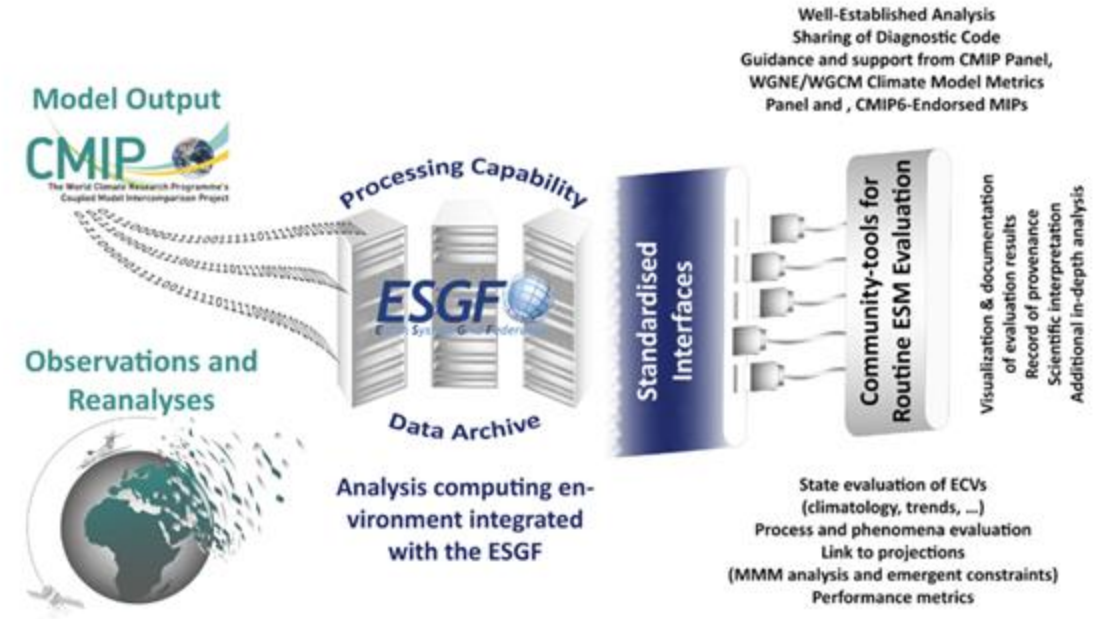


- obs4MIPs compliant CERES data (and other NASA products) have been prepared by Andy Manaster at Remote Satellite Systems (RSS) and published to ESGF-obs4MIPs
- A global attribute in the netCDF files points to the version controlled processing codes available on a github repository
- Most changes are to metadata
- Exception: associated bounds for time, lon and lat are added

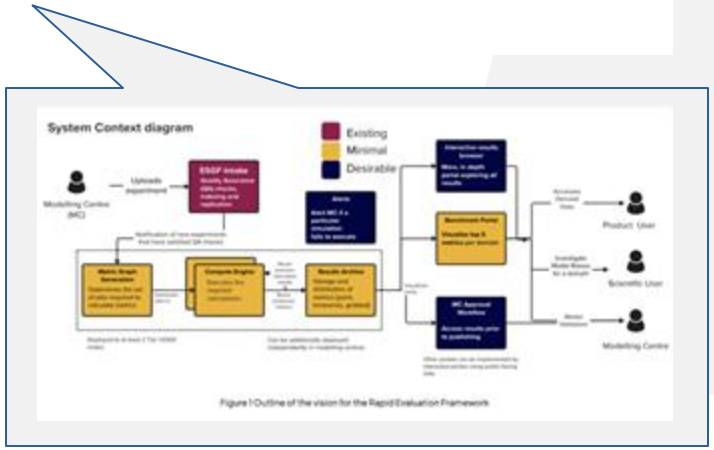
Sample file name
rlut_mon_CERES-EBAF-4-2_RSS_gn_200003-202310.nc

Rapid evaluation framework

WCRP CMIP Model Benchmarking Task Team



Eyring et al., 2016



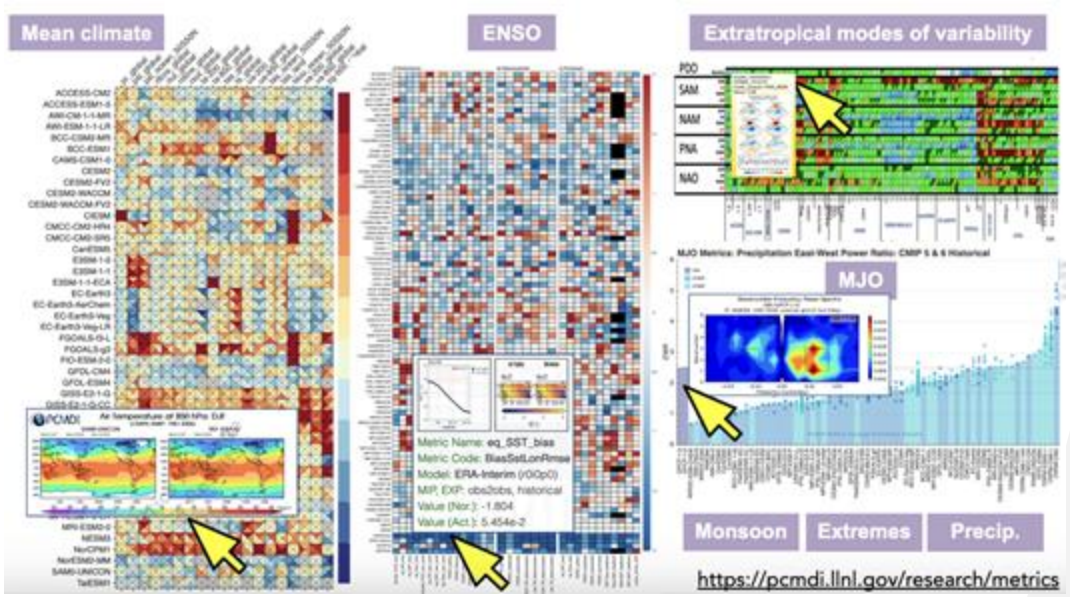
WCRP Task Team workflow development

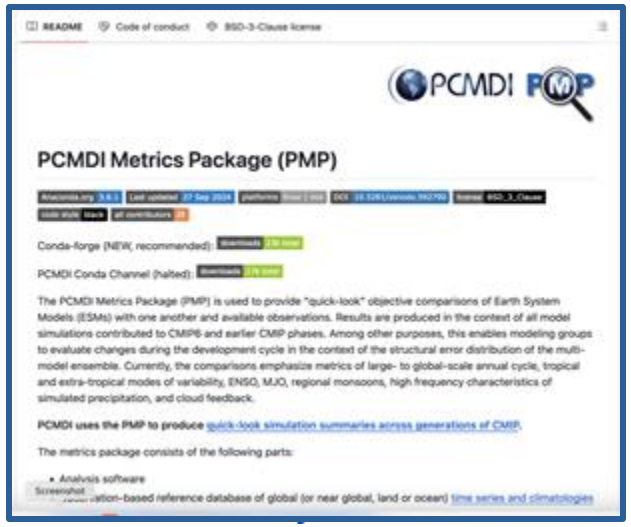
- Teams are advancing more efficient, quasi-operational capabilities for systematic evaluation of models
- Analysis via well-established evaluation tools, executed directly on data located at ESGF nodes, and public reporting of results

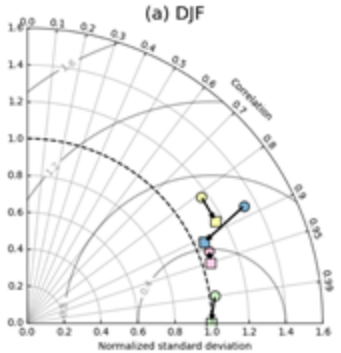
Example tool: The PCMDI Metrics Package (PMP)

Team lead by Jiwoo Lee

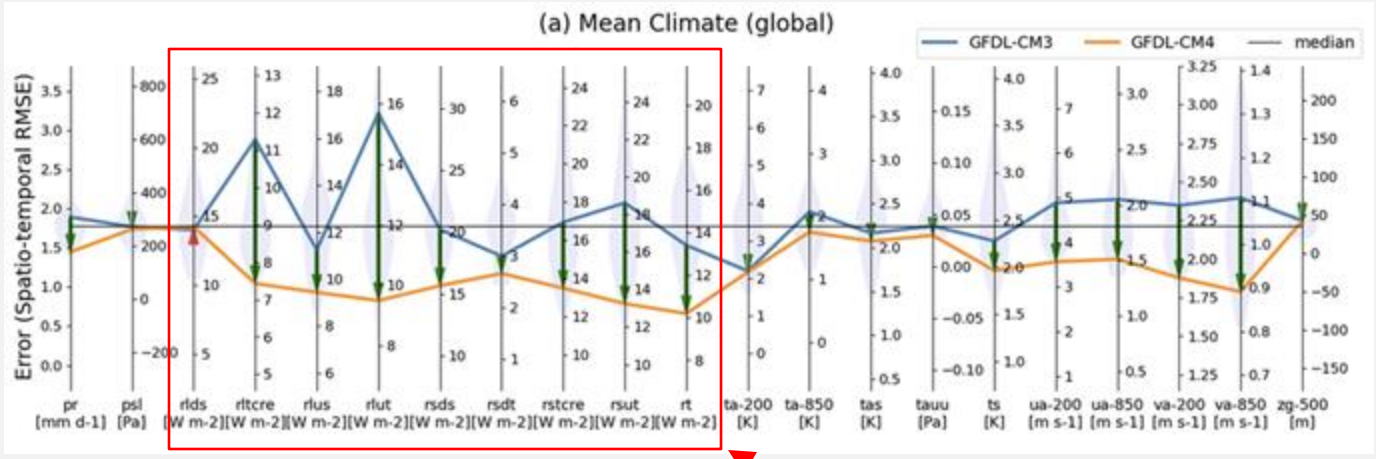
Lee et al doi: 10.5194/gmd-17-3919-2024







- PMP is used for gauging model performance in the evolving CMIP archive, and is now being generalized to target performance changes during the model development process
- Quick-look results are available via the PCMDI homepage



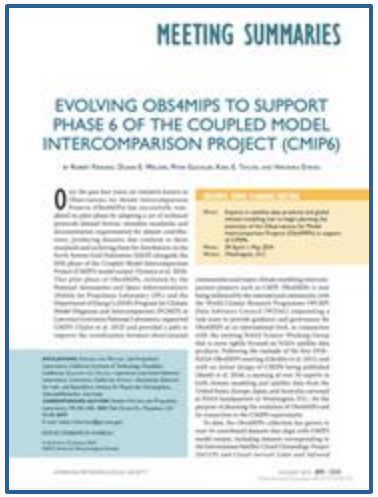
CERES-EBAF-4-2 TOA and sfc comparisons

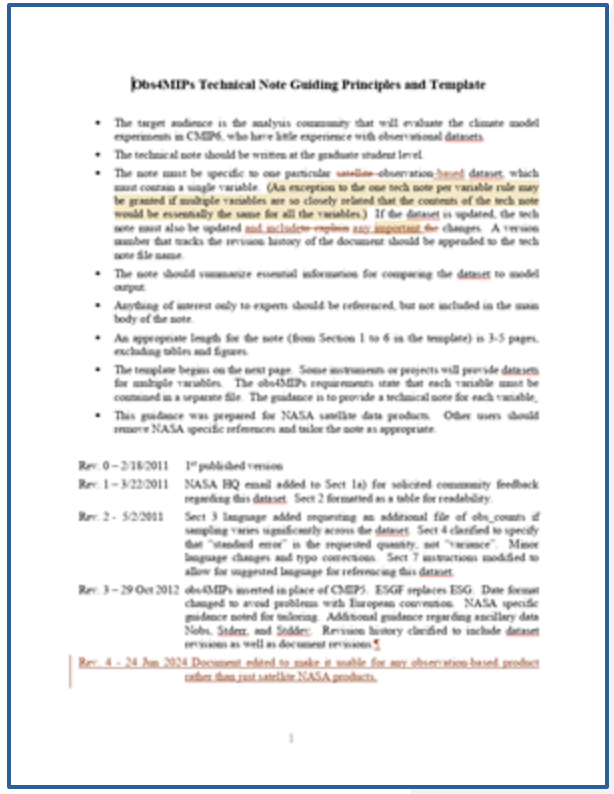
Summary

How do updates to an obs product impact judgements about model performance?

- obs4MIPs has recently been reinvigorated in preparation for CMIP7 and other modeling activities
- The process of preparing obs4MIPs-compliant data has been substantially improved
- In addition to serving the large community of CMIP users, obs4MIPs is being leveraged by organized teams striving to accelerate the systematic evaluation of models
- A pipeline now exists for delivering updated CERES products to obs4MIPs – increased automation is possible

Additional topics





Obs4MIPs Technical Note Guiding Principles and Template

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Rev: 4 - 24 Jun 2024	Document edited to make it usable for any observation-based product rather than just satellite NASA products.

- Efforts are underway to introduce a pathway for "exploratory products" into obs4MIPs (G. Elsaesser)
- Increasing emphasis on higher resolution, process-relevant products
- Delivery of "tech notes" and ancillary data/metadata
- "Suitability Indicators"
- Monitoring usage of obs4MIPs datasets
  - ESGF download statistics
  - Reporting from dedicated benchmarking teams?

Resources

obs4MIPs homepage

obs4MIPs github (codes and CMOR tables)

obs4MIPs ESGF-published data available through Metagrid

Climate Model/observations Output Rewriter (CMOR)

WCRP benchmarking task team

Presentation references

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Supporting Slides

Lawrence Livermore National Laboratory

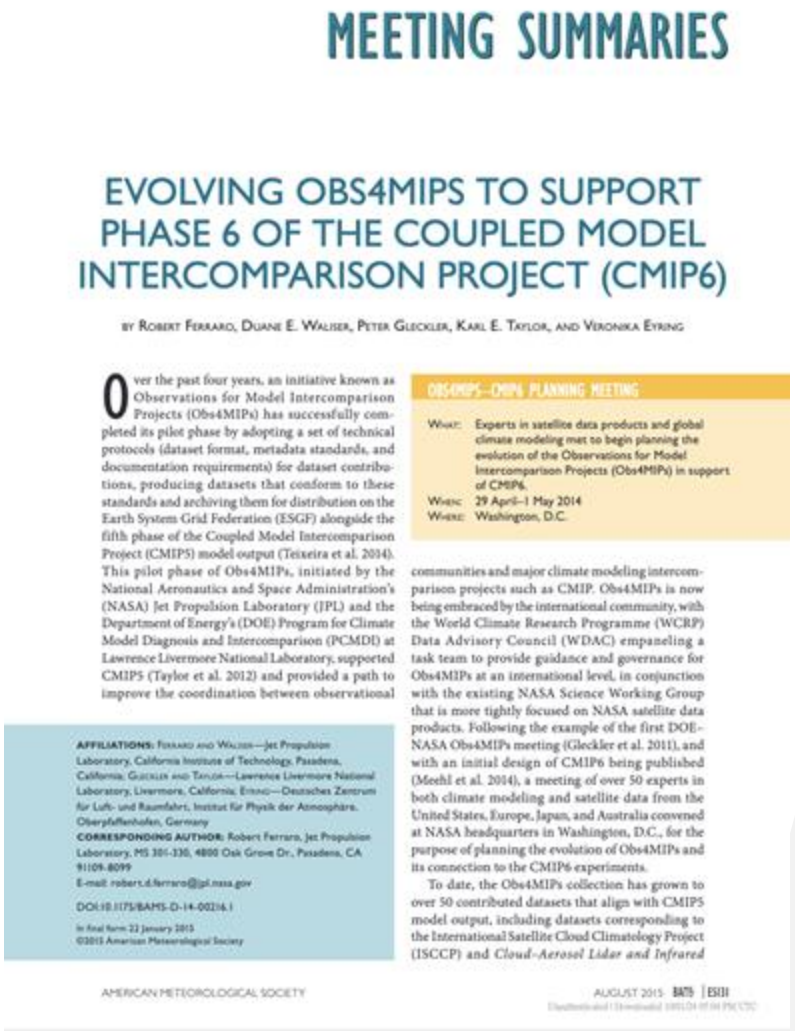
obs4MIPs dataset suitability indicators

(a) Technical requirements		Dataset suitability and maturity			Comparison complexity
Meets obs4MIPs data technical requirements	Includes obs4MIPs technical note information	Closeness or robustness of measurement to observed reference quantity	Maturity with respect to climate model evaluation	Provision for robust uncertainty information	Complexity of model observation comparison
Data suitably processed with CMOR and/or consistent with obs4MIPs standards	Complete technical note information provided	Measurement approach provides a very close relationship to observation quantity	Multiple peer-reviewed examples of application to climate model evaluation	Uncertainty information provided per retrieval/grid point	Comparison can be made directly with CMIP model output variable
Largely complete with minor metadata inconsistencies	Technical note information incomplete and/or could be improved	Measurement approach requires complex and/or non-linear retrieval methods and/or subjective inferences/definitions	One peer-reviewed example of application to climate or component model evaluation.	General uncertainty information given relative to the methodology and dataset as a whole - backed by actual field/in-situ validation exercises	Comparison requires some simple post processing of CMIP output variable(s) (e.g. vertical integral or ratio of two variables)
Non-compliant. Should be removed from database!	Technical note not provided	Measurement approach requires significant use/influence from complex or weakly constrained model and/or has significant ambiguity in definition(s)	No peer-reviewed examples of application to model evlauation	No uncertainty information provided	Comparison requires complex processing of CMIP output (e.g. "simulator", budget calculation)

Waliser et al., 2020

- Provide users with an overview of key features of a given dataset's suitability for model evaluation
  - Does the dataset adhere to obs4MIPs requirements?
  - How complex is the model-obs comparison?
- Allow for a wider spectrum of observations to be included in obs4MIPs

Recommendations from obs4MIPs 2014 meeting



MEETING SUMMARIES

EVOLVING OBS4MIPS TO SUPPORT PHASE 6 OF THE COUPLED MODEL INTERCOMPARISON PROJECT (CMIP6)

BY ROBERT FERRARO, DUANE E. WALISER, PETER GLECKLER, KARL E. TAYLOR, AND VERONIKA EYRING

Over the past four years, an initiative known as Observations for Model Intercomparison Projects (Obs4MIPs) has successfully completed its pilot phase by adopting a set of technical protocols (dataset format, metadata standards, and documentation requirements) for dataset contributions, producing datasets that conform to these standards and archiving them for distribution on the Earth System Grid Federation (ESGF) alongside the fifth phase of the Coupled Model Intercomparison Project (CMIP5) model output (Teixeira et al. 2014). This pilot phase of Obs4MIPs, initiated by the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory (JPL) and the Department of Energy's (DOE) Program for Climate Model Diagnosis and Intercomparison (PCMDI) at Lawrence Livermore National Laboratory, supported CMIP5 (Taylor et al. 2012) and provided a path to improve the coordination between observational communities and major climate modeling intercomparison projects such as CMIP. Obs4MIPs is now being embraced by the international community, with the World Climate Research Programme (WCRP) Data Advisory Council (WDAC) empaneling a task team to provide guidance and governance for Obs4MIPs at an international level, in conjunction with the existing NASA Science Working Group that is more tightly focused on NASA satellite data products. Following the example of the first DOE–NASA Obs4MIPs meeting (Gleckler et al. 2011), and with an initial design of CMIP6 being published (Meehl et al. 2014), a meeting of over 50 experts in both climate modeling and satellite data from the United States, Europe, Japan, and Australia convened at NASA headquarters in Washington, D.C., for the purpose of planning the evolution of Obs4MIPs and its connection to the CMIP6 experiments.

To date, the Obs4MIPs collection has grown to over 50 contributed datasets that align with CMIP5 model output, including datasets corresponding to the International Satellite Cloud Climatology Project (ISCCP) and *Cloud–Aerosol Lidar and Infrared*

OBS4MIPS–CMIP6 PLANNING MEETING

WHAT: Experts in satellite data products and global climate modeling met to begin planning the evolution of the Observations for Model Intercomparison Projects (Obs4MIPs) in support of CMIP6.
WHEN: 29 April–1 May 2014
WHERE: Washington, D.C.

AFFILIATIONS: FERRARO AND WALISER—Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California; GLECKLER AND TAYLOR—Lawrence Livermore National Laboratory, Livermore, California; EYRING—Deutsches Zentrum für Luft- und Raumfahrt, Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany
CORRESPONDING AUTHOR: Robert Ferraro, Jet Propulsion Laboratory, MS 301-330, 4800 Oak Grove Dr., Pasadena, CA 91109-8099
E-mail: robert.d.ferraro@jpl.nasa.gov
DOI:10.1175/BAMS-D-14-00216.1
In final form 22 January 2015
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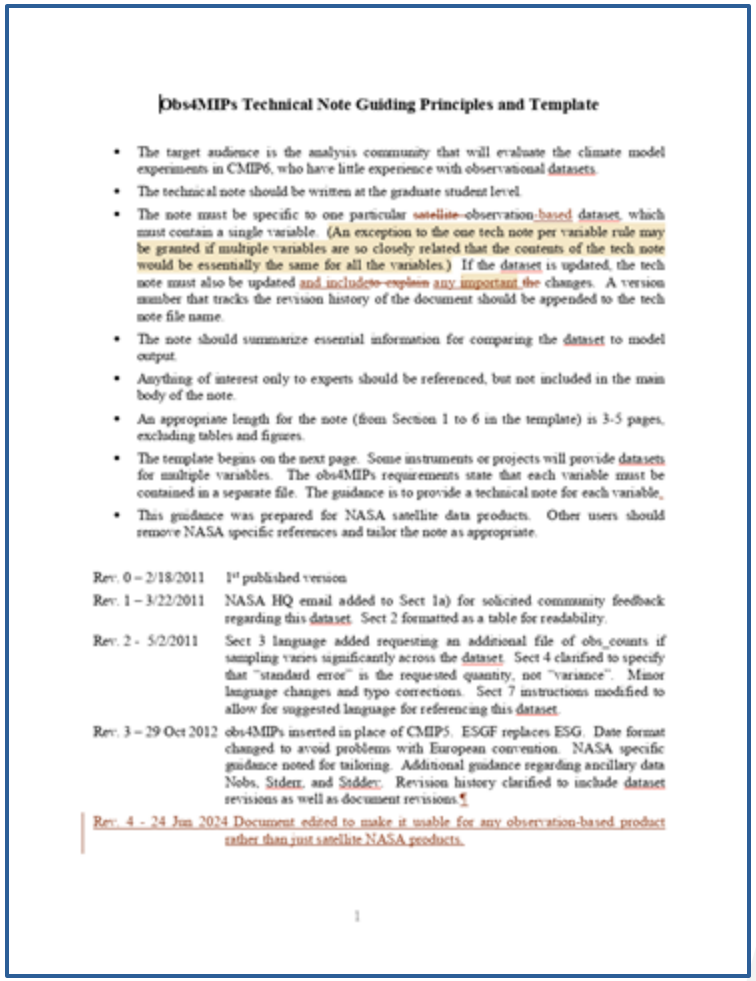
- Expand the inventory of datasets (including beyond CMIP variables)
- Include higher-frequency datasets and higher-frequency model output
- Reliable and defendable error characterization estimation
- Include datasets in support of off line simulators
- Selected reanalysis fields that are suitable as reference to compare with models (e.g., state fields)

Tech Note Template



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- originally designed specifically for satellite products
- CERES_EBAF_Ed4.2 Data Quality Summary is close to this template
- Currently being generalized by the obs4MIPs Steering Panel
- A report series for obs4MIPs?