

This document summarizes obs4MIPs status and plans, identifies key opportunities/challenges, and considers possible coordination with the ESMO SSG to plan an obs4MIPs future that best meets the needs of the research community and WCRP.

Overview

Overarching goal of obs4MIPs

To *enable* the research community to more effectively use observational products for Earth System Model (ESM) Evaluation, Research and Development (ERD) and to facilitate stronger and more frequent interactions between observationalists and modellers with the aim of accelerating model improvements.

Approach

Obs4MIPs facilitates ESM ERD via technical alignment of gridded observational products with CMIP protocols. The technical alignment is accomplished by open source metadata/data integration of the two projects, facilitating side-by-side delivery of both via the Earth System Grid Federation (ESGF, [Williams et al., 2016](#)) and enabling data access for the research community. Much like CMIP, the obs4MIPs framework makes data products available without quality judgments, exposing them to scrutiny by the research community.

Background in brief

Obs4MIPs originated from a collaboration between PCMDI and NASA ([Gleckler et al., 2011](#); [Teixeira et al., 2014](#)). Following the encouragement of the WGCM, obs4MIPs was internationalized via the WCRP Data Advisory Council (WDAC). A workshop helped identify key community recommendations to advance obs4MIPs ([Ferraro et al., 2015](#)), many of which are still relevant and being addressed today. A detailed status of obs4MIPs during the CMIP6 evaluation phase was documented in [Waliser et al. \(2020\)](#).

More recently, broad recognition of the project's potential has led to a reinvigorated effort, benefiting from the lessons of past experiences and the ability to expedite progress via adoption of open-source methods (e.g., GitHub). As plans for a CMIP7 emerge, obs4MIPs continues to be closely aligned with CMIP protocols via close collaboration with the WGCM's Infrastructure Panel (WIP). Additionally, since mid-2022 the obs4MIPs Steering Panel has been working with the CMIP IPO to advance the project. Before widely promoting the renewed effort, the priority has been to first re-establish a presence with demonstrated improvements and to recommence the delivery of data. Recent investments have paid off via substantial work over the last year (~1.5 FTE), with support of the PCMDI/DOE, NASA, ESA and

the CMIP-IPO. And, although there is still infrastructure that could be developed to strengthen the effort (see below), the obs4MIPs Steering Panel is now prepared to engage with the broader community, starting with the ESMO SSG.

Current Status

During the past 18 months, efforts to revamp obs4MIPs have included: 1) modernizing the technical alignment with CMIP, and 2) improving the process for preparing obs4MIPs-compliant products (e.g., making all software publicly available and version controlled via GitHub). This investment has continued to focus on delivering *CMIP-aligned* obs4MIPs-compliant products, i.e., those that closely match a CMIP standard model output variable and time-coordinate (3hr, daily, or monthly). Although the framework for delivering CMIP-aligned products can be further improved and is likely to be finessed as CMIP7 takes shape, it is now well-established and is enabling the ramp-up of data delivery in 2024.

For a variety of reasons, contributions of obs4MIPs products have been limited in recent years, with some existing products now outdated, and there are many widely used datasets in model evaluation that are yet-to-be included. Nonetheless, with the infrastructure advancements that have been made during 2023 (see TT1-TT2 below), the Steering Panel is confident that in 2024 the availability of well-established CMIP-aligned products will yield benefits that have long been envisioned for obs4MIPs.

What has changed?

A longstanding challenge that obs4MIPs has faced has been to streamline the effort required to prepare an obs4MIPs-compliant product, and, subsequently to publish it on ESGF. In 2022-2023, significant progress was made in data preparation by adopting a fully open-source framework. All metadata and processing scripts used are now required to be archived, providing a transparent knowledge base that can be exploited as templates to expedite the inclusion of new data. Additionally, recent updates to the obs4MIPs Data Specifications (the technical alignment with CMIP) enables “3rd parties” to conform existing observational datasets to obs4MIPs standards when the original data provider is unable to do so. This pathway facilitates broader involvement of the community and could potentially substantially broaden the obs4MIPs contributor pool.

Beyond the baseline delivery of CMIP-aligned products

Since the inception of obs4MIPs, delivery of large- to global- scale CMIP-aligned gridded products has been the priority, but with CMIP related research increasingly focusing on regional scales, higher resolution, and process relevant evaluation, it is expected that inclusion of higher frequency and regional products will become an increasing obs4MIPs priority (see recommendations from Ferraro et al., 2015). To address this need, with the assistance of the CMIP IPO and the WGCM WIP, the obs4MIPs Steering Panel has partitioned its ongoing effort into the following task teams (TTs):

TT1: [Obs4MIPs data specifications \(ODS\)](#). Responsible for detailing the technical specifications ensuring alignment with CMIP model output. ODS are now quite mature but may need to be further refined as CMIP7 is defined.

TT2: [Workflow efficiency](#). Improving workflow to prepare/deliver obs4MIPs-compliant data.

TT3: *Inclusion of ancillary information*. Intended to establish a template to enable inclusion of additional information with an obs4MIPs-compliant product (e.g., supporting documentation or data, uncertainty characterization, a forward model to facilitate comparison with standard model output).

TT4: *Oversight of dataset suitability indicators*. As described in Waliser et al. (2020, Fig 2A) the intent is to provide information on how well products are technically aligned with CMIP, and how readily they can be used to compare with model output.

TT5: *Pathways for integrating reanalyses into obs4MIPs*. A few variables from atmospheric reanalysis are routinely used in model evaluation (e.g., state fields) and will continue to be made available via obs4MIPs. With additional support, the obs4MIPs framework could accommodate making reanalysis more broadly available as obs4MIPs products, or the framework could be leveraged by another effort intended to focus on reanalysis products.

TT6: *Inclusion of satellite-based exploratory datasets*. Fundamental to a possible expansion of obs4MIPs beyond CMIP-aligned products, this effort involves identifying pathways for including data that are not a close match to existing CMIP standard output, but with additional work/analysis could be valuable for advancing model evaluation, research and development.

TT7: *Prototyping the inclusion of in-situ (site) data*. As with exploratory datasets, site data does not fit the original paradigm of obs4MIPs which focused on gridded datasets. However, recommendations for including high frequency site data have been longstanding, and thus a team is currently examining how this could be technically integrated into obs4MIPs.

TT8: *Guidance and capacity building*. Preparation by Steering Panel of content to encourage new dataset proposals and use of obs4MIPs datasets. The CMIP-IPO supports communication and outreach of this content.

TT1-2 are core to delivering obs4MIPs-compliant CMIP-aligned gridded products, i.e., those that closely align with the CMIP standard model output by matching a CMIP variable and time-coordinate (3hr, daily, or monthly). TT3-TT4 are intended to improve the information available to characterize the CMIP-aligned products - both efforts require more attention before they can be integrated with the ESGF delivery system. TT5 emphasizes a limited set of fields from atmospheric reanalysis that are well-established in ESM evaluation. More information on the TTs is available in the Appendix.

Until now, the focus of obs4MIPs has been on large- to global- scale CMIP-aligned products, but with modeling related research increasingly focusing on regional scales, higher resolution, and process relevant evaluation, it is expected that inclusion of higher frequency and regional products will begin to be a priority for inclusion obs4MIPs. TT6-TT7 represents possibilities for broadening the effort to help deliver new and innovative products to better understand model behavior. More detail on each of the task teams is provided in Appendix I.

The obs4MIPs Steering Panel, CMIP IPO and WGCM WIP will continue to work on advancing obs4MIPs as a framework to deliver products for model evaluation, research and development. While infrastructure work continues, in 2024 the priority has turned to preparing and delivering (via ESGF) obs4MIPs-compliant products, with accessibility through [MetaGrid](#), a rapidly developing utility that integrates access to CMIP, obs4MIPs and other projects hosted by ESGF. At this stage the selection

of which datasets to prepare is not difficult - there are many products that are well-established and routinely used for model evaluation that are not yet included in obs4MIPs. The limited agency support (notably DOE, NASA and ESA) is helping build a database that will help make obs4MIPs a centralizing resource for CMIP, and the introduction of “3rd party” ad hoc contributions provide an avenue to accelerate the comprehensiveness of obs4MIPs as a resource.

As the obs4MIPs federated database is populated with well-established CMIP-aligned products over the next 1-2 years, it will become increasingly useful to entrain broader expertise to enhance the value of obs4MIPs.

Possible Synergies with the ESMO SSG

The diverse scientific priorities and expertise of the WCRP core projects further advance the science and systematic evaluation of ESMs via the CMIP experimental protocols. We believe that the obs4MIPs framework can be leveraged by the WCRP core projects to enhance the delivery of observational products to accelerate ESM evaluation, research and ultimately development. In addition to making use of obs4MIPs as a resource, the core projects may engage by identifying and contributing data products they prioritize for model evaluation or product intercomparisons (e.g., comparisons of multiple precipitation or surface flux data sets).

In 2024, key priorities for the obs4MIPs Steering Panel include leveraging the [updated data specifications](#) to accelerate the inclusion of CMIP-aligned products, and via TT6 and TT7 to establish protocols for including data products that don't readily match the CMIP standard output but have the potential to substantially advance how observations are used in model evaluation and research. During this period, the Steering Group welcomes interaction with the ESMO SSG and WCRP core projects to explore possibilities that best meet the needs of the research community.

Recommendations for ESMO SSG:

- Appoint an SSG representative to liaise with the OSP.
- Assist obs4MIPs outreach/collaborations with other WCRP core projects.
- Relay to the OSP any additional user requirements or priorities that could align with the goals of obs4MIPs (e.g., a class of data not yet under consideration by the OSP TTs).

The obs4MIPs Steering Panel would also like ESMO SSG to note that:

- Obs4MIPs facilitates ESM research via technical alignment of CMIP protocols; inclusion of the scientific/observational needs of other WCRP projects within obs4MIPs can be explored via interactions with the OSP.
- Obs4MIPs is a federated community project and relies on external parties to prepare, deliver and store data on behalf of obs4MIPs.
- Given the good progress made over the last year, the OSP appreciates continued support of the CMIP-IPO, while also exploring/developing possible links with ESMO.
- Under current resourcing, the OSP is not positioned to respond to requests for new products to be included in obs4MIPs, however, it can offer support to guide others in the preparation and delivery of obs4MIPs-compliant products.

- Resources supporting obs4MIPs have, and continue to be, provided by PCMDI/DOE, NASA, ESA and the CMIP-IPO.

References

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Appendix I: Task Team additional information

TT1: [Obs4MIPs data specifications \(ODS\)](#). This provides the underlying technical alignment with CMIP model output, including the description of the data (metadata) as well as spatial and temporal coordinates. Many of the attributes used in CMIP are well-suited for describing observations and thus are used in obs4MIPs. In some cases, however it is necessary to modify the use of the attributes to be more relevant for describing observations or to add new attributes that are helpful for describing observations but not relevant to model output. A priority in the latest version (ODS V2.5) is to provide a provenance trail of how the obs4MIPs-compliant dataset was prepared, including where/when the original data was obtained and a pointer to the processing code that was used to make the data obs4MIPs compliant. ODS are now quite mature but will likely require updates as the CMIP7 experimental protocol is established or as “exploratory products” (see TT6 below) are considered for inclusion in obs4MIPs.

TT2: *Workflow efficiency*. This team strives to improve the start-to-finish process of preparing an obs4MIPs-compliant dataset and publishing it to ESGF. Substantial progress has been made over the

last 18 months in the data preparation which is now fully transparent and open source. However, work is needed to improve the review and monitoring of new products, the inclusion of ancillary information (TT3), and the federated ESGF-publication of new data products.

TT3: Exploring options to include “ancillary information”. There is considerable interest in enabling additional information to be accessible alongside obs4MIPs-compliant datasets. Examples include additional documentation or data, uncertainty information, or inclusion of a forward model to facilitate comparison with standard model output). Several prototypes were tested with earlier versions of ESGF portal software (e.g., Fig 2b in Waliser et al., 2019), however, apart from establishing a “Tech Note” template, to date a framework for bundling a diversity of metadata and/or data has yet to be defined. The goal of TT3 is to define how best to organize this supplementary data, and how to make it readily available with the data products as they are retrieved from ESGF.

TT4: Oversight of dataset indicators. The intent of this task team is to define a pathway for providing high level information on how well obs4MIPs products are technically aligned with CMIP, and how readily they can be used to compare with model output. The indicators proposed in Fig. 2A of Waliser et al., 2020, encapsulate this goal without targeting data quality which is beyond the scope of the Steering Panel. The challenge at hand is to establish a process for monitoring products introduced to obs4MIPs, assigning values for the dataset indicators, and making this evolving information publicly available. As with many of the other task teams, this requires an ongoing effort.

TT5: Pathways for integrating reanalyses into obs4MIPs. A few variables from atmospheric reanalysis are routinely used in model evaluation (e.g., state fields) and will continue to be made available via obs4MIPs. With additional support, the obs4MIPs framework could accommodate making reanalysis more broadly available as obs4MIPs products, or the framework could be leveraged by another effort intended to focus on reanalysis products as did CREATE-IP.

TT6: Inclusion of satellite-based exploratory datasets. This effort is fundamental to a possible expansion of obs4MIPs. It involves identifying pathways for including data that are not a close match to existing CMIP standard output, but with additional work/analysis could be valuable for advancing model evaluation, research and development. This entails continuing to rely on ODS to technically align data with model output, where possible, while at the same time relaxing a minimal number of constraints to enable the exploratory data to be accessible via the framework. Exploratory products will typically require a user to do additional work to objectively compare the data with model output. It is difficult to encapsulate what this involves because of the many different ways a prospective dataset can be technically inconsistent with CMIP model output. Common inconsistencies involve differences in the observed and simulated quantity involved, or its temporal sampling. Whereas many of the products included in obs4MIPs are sufficiently aligned with CMIP to justify routine model-obs difference maps, use of obs4MIPs exploratory products is expected to be more complex and research driven. TT6

is currently working on prototyping several example exploratory datasets to help establish a path forward to include data that is traditionally more complex to use in model evaluation but nonetheless considered as a potential path towards inspiring more process-relevant model evaluation.

TT7: *Prototyping the inclusion of in-situ (site) data.* As with exploratory datasets, site data does not fit the original obs4MIPs paradigm. However, recommendations for including high frequency site data in obs4MIPs have been long standing, particularly as higher resolution simulations make comparisons between site data and model grid cells more tractable. During CMIP5, CFMIP-2 proposed archival of high frequency model output (e.g., temperature and humidity budget terms) at targeted “cfsites”, representing 120 locations around the globe. This task team is currently prototyping how best to incorporate site data into obs4MIPs.

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