CMIP

Coupled Model Intercomparison Project

CMIP Annual Report
2022-2023

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Authorship and publisher's notice

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Acknowledgements

Foreword

The last year has seen a rapid evolution in CMIP project organization, new activities, and community co-creation, with the establishment of the CMIP International Project Office (IPO) and the beginning of formal planning for the next phase, CMIP7. The IPO provides a key CMIP organisational hub, supporting the scientific and technical experts, and ensuring effective communication throughout our broad and expanding international community.

The CMIP Panel leadership has been refreshed, prompted by the exit of the CMIP Panel Chair, Jean-François Lamarque (NCAR, USA), in September 2022. The WGCM co-chairs proposed Helene Hewitt (Met Office, UK), as the new Chair to the 25th Session of the WGCM in November 2022. This was accepted by the WGCM members, and Helene started in January 2023. A new governance structure, membership, and Terms of Reference (ToR) proposal was approved by the WGCM in March 2023. This included adding a co-chair, in line with other WCRP activities and to provide greater resilience, with John Dunne (NOAA-GFDL, USA) taking on this role in March 2023. The new CMIP Panel leadership complements existing WGCM Infrastructure Panel (WIP) co-chairs, Paul Durack (PCMDI/LLNL, USA) and Matthew Mizielinski (Met Office, UK). Following the CMIP Panel experience, a review of the WIP governance and ToR is currently underway, and once finalised will be aligned with the CMIP Panel as relevant. The structure and membership of these panels will undergo regular review to ensure they meet the requirements of the evolving CMIP landscape and include key representation from core contributors while promoting diversity and inclusion.

Planning for CMIP7 has continued apace with the establishment of CMIP Task Teams (TTs) to drive forward the definition and delivery of CMIP7 in an open, consultative, and collaborative manner. An open community call for nominations was launched in August 2022 and nearly 150 applications were received. Seven CMIP TTs are now active: Data Access, Data Citation, Data Request, Forcings, Model Benchmarking, Model Documentation and Strategic Ensemble Design. Each task team has two co-leads, with facilitation support from the IPO. Together, the IPO, the TTs, the CMIP Panel, and the WIP are working to deliver the CMIP7 experimental design and protocol paper in 2024, initiating the next phase along with revised supporting infrastructure commencing in 2025 onwards.

The infrastructure underpinning CMIP6 has continued to evolve through ongoing support and development. One of numerous highlights is the introduction of the new MetaGrid user interface for ESGF (https://aims2.llnl.gov). The request by modelling groups for ongoing support of the broadening CMIP activities is being met by CMIP6Plus, which aims to facilitate community MIPs on a timeline decoupled from the IPCC cycle and preceding the formal CMIP7 phase. A CMIP6Plus white paper has been drafted and will shortly be shared with WGCM membership, realizing the potential for CMIP infrastructure to enable responsive, reactive science.

A new "Fresh eyes on CMIP" working group is being established comprised of scientists, researchers, and practitioners in the early stages of their careers to sit alongside the CMIP7 task teams. This working group will provide a fresh perspective on CMIP, unconstrained by the current structure or composition, and inject new ideas, technologies, and aspiration into planning, in addition to further supporting enhanced global South engagement and participation. This initiative is another direct response to feedback and requests by modelling groups and the broader community to provide a more transparent and engaged development cycle for CMIP7.

In addition to facilitating the CMIP Panel, WIP and task teams in their work, the IPO strengthened by the addition of communications and technical expertise in early 2023, has driven enhanced

communication and engagement activities for the CMIP community and wider landscape of stakeholders and downstream end users. This includes: a new CMIP website; social media channels; regular virtual community drop-in sessions; forcings, priority variables, supporting infrastructure, and modelling centre readiness surveys; and engagement activities at events and conferences including EGU23 and AGU23 ensuring the CMIP7 development process is open, transparent, and responsive to broad international community feedback.

We look forward to continuing to work with the community in the year ahead as we facilitate community climate science through CMIP6Plus, finalise the CMIP7 experimental design and plans for supporting infrastructure, engage with the new IPCC leadership, and make efforts towards operationalising key components of CMIP to deliver the next phase.

The CMIP leadership

John Dunne,
CMIP Panel Co-chair

Paul Durack
WIP Co-chair

Helene Hewitt,
CMIP Panel Co-chair

Matt Mizielinski
WIP Co-chair

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1 CMIP Governance

1.1   The CMIP Panel

The CMIP Panel is a World Climate Research Program (WCRP) Working Group on Coupled Modelling (WGCM) subcommittee charged with overseeing the evolving design of Coupled Model Intercomparison Project (CMIP) and with coordinating the various activities contributing to the science and impact of CMIP. The Panel provides recommendations, proposals, and insight to the WGCM. The Panel works to empower modelling centres to deliver globally coordinated multi-model ensembles to further understanding of the climate system and provide foundations for climate mitigation and adaptation policy. The Panel will promote a transparent and open process to ensure equality of access to the process and of input to requirements and design choices.

In the past year, panel membership has seen many changes. Two new co-chairs have been appointed: Prof. Helene Hewitt OBE in 2022, and Dr. John Dunne in 2023. Together, Helene and John will provide leadership, vision, and drive to achieve the Panel's aims and objectives. Additionally, two new Panel members were appointed: Dr. Olivier Boucher and Prof. Tomoki Miyakawa. With this new Panel in place, WGCM approved an update to the CMIP Panel's ToR. This outlined a new, extended panel structure, with up to eight core panel members (including two co-chairs) augmented by the WGCM and WIP co-chairs, plus the leads of active CMIP Task Teams. The ToR also formalised the decision-making process for the Panel. Decisions are made by consensus and uploaded to a publicly available decision log for improved transparency.

Looking ahead to the next year, the goals for the CMIP Panel include:

- Recruiting two new core Panel members representing the Global South.
- Development, and effective communication, of process for MIPs in CMIP7 and for ongoing activities.
- Development of the CMIP7 experimental design and protocol.
- Development of CMIP7 science goals.
- Design of operational experiment stream to deliver to policy assessment, impacts and adaptation, and climate services end users.
- Making progress towards operationalisation of key components of CMIP delivery.
- Building the case for sustainable and globally aligned strategic funding for CMIP activities including engagement with key science and infrastructure funders, including European Commission and US Department of Energy, together with the WIP leadership.
- Sustainable CMIP activity to monitor and develop an action plan to reduce the carbon impact of future CMIP activities.
- Continuing the co-creation and co-development ethos with the CMIP community, wider WCRP activities, the global climate community and end users.

CMIP Panel Chairs

John Dunne	NOAA-GFDL	USA	2023-
Helene Hewitt	The Met Office	UK	2022-

CMIP Panel members

Julie Arblaster	Monash University	Australia	CMIP Panel Member	2020-
Olivier Boucher	IPSL	France	CMIP Panel Member	2023-
Tomoki Miyakawa	University of Tokyo	Japan	CMIP Panel Member	2023-
Robert Pincus	LDEO/Columbia University	USA	CMIP Panel Member	2020-
Paul Durack	PCMDI/LLNL	USA	WIP Co-chair, Climate Forcings co-lead	2020-
Matthew Mizielinski	Met Office	UK	WIP Co-chair	2020-
Gregory Flato	CCCma	Canada	WGCM Co-chair	2016-
Tatiana Ilyina	MPI-M	Germany	WGCM Co-chair	2021-
Vaishali Naik	NOAA	USA	Climate Forcings Co-lead	2022-
Atef Ben Nassar	IPSL	France	Data Access Co-lead	2023-
Sasha Ames	LLNL	USA	Data Citation Co-lead	2022-
Martina Stockhause	DKRZ	Germany	Data Citation Co-lead	2022-
Martin Juckes	STFC	UK	Data Request Co-lead	2022-
Chloe Mackallah	CSIRO	Australia	Data Request Co-lead	2022-
Birgit Hassler	DLR	Germany	Model Benchmarking Co-lead	2022-
Forrest Hoffman	ORNL	USA	Model Benchmarking Co-lead	2022-
David Hassell	NCAS	UK	Model Documentation Co-lead	2022-
Guillaume Levavasseur	IPSL	France	Model Documentation Co-lead	2022-
Ben Sanderson	CICERO	Norway	Strategic Ensemble Design Co-lead	2022-
Isla Simpson	NCAR	USA	Strategic Ensemble Design Co-lead	2022-
Cath Senior	Met Office	UK	Ex-Officio (ESMO)	2014-
Alex Ruane	NASA GISS	USA	Ex-Officio (VIACS AB)	2023-
Claas Teichmann	GERICS	Germany	Ex-Officio (VIACS AB)	2023-
Detlef van Vuuren	Utrecht University	Netherlands	Ex-Officio (ScenarioMIP)	2023-
Karl Taylor	PCMDI/LLNL	USA	Emeritus	2008-

1.2   The WGCM Infrastructure Panel

The objective of the WGCM Infrastructure Panel (WIP) is to provide guidance and oversee infrastructure development so that it will be fit for its purpose and meet the scientific needs of CMIP and other MIP projects. The mission of the WIP is to promote a robust and sustainable global data infrastructure in support of the scientific mission of the WGCM. The WIP is co-chaired by Dr. Paul Durack and Dr Matthew Mizielinski.

In the past year the WIP membership has remained constant. In line with the CMIP Panel, there is ongoing development of a WIP Terms of Reference. The new Terms of Reference will formalise the WIP membership term length, clarify the duties of the WIP within CMIP development, and define the role of the WIP co-chairs. The Terms of Reference will also formalise the decision-making process for the Panel. Decisions are made by consensus and uploaded to a publicly available decision log for improved transparency.

The WIP has driven the design of CMIP6Plus, which aims to leverage existing infrastructure, enabling modelling groups to contribute to next-generation climate science with minimal additional investment before the CMIP7 infrastructure and experimental design comes online. To support CMIP6Plus, work expanding the Controlled Vocabularies (CVs) and MIP tables that define variables are being evolved. The WIP are working towards opening CMIP6Plus for submissions soon, in addition to facilitating coordinated testing of new forcing datasets by realizing the CMIP continuous DECK (and historical) experiments. The WIP continues to engage with the infrastructure providers, in addition to ongoing discussions with the ESGF development community which is primarily split between the US Department of Energy (DoE) and the ENES research infrastructure community in Europe, which has received funding through the European Commission framework programme IS-ENES projects.

Looking forwards, the WIP's goals for the upcoming year are:

- Revise and update CMIP6 infrastructure (Controlled Vocabularies and MIP tables) in coordination with CMIP technical Task Teams to enable ongoing projects.
- Finalize the CMIP6Plus infrastructure stack, and whitepaper documenting the path for contributions – opening CMIP6Plus for modelling group submissions in late 2023.
- Coordinate with the Forcing TT and CMIP6Plus contributing modelling groups to publish new simulations testing next generation forcing data to CMIP6Plus.
- Continue to work on building a case for sustainable funding to support ongoing CMIP infrastructure development and support.
- Continue to develop and extend infrastructure to meet the needs of the CMIP7 experimental design and protocol.

WIP Chairs

Paul Durack	PCMDI/LLNL	USA	2017, Co-chair 2021–
Matthew Mizielinski	Met Office	UK	2018, Co-chair 2020–

WIP Members

Sasha Ames	LLNL	USA	2019–
Yuqi Bai	Tsinghua University	China	2018–
Katharina Berger	DKRZ	Germany	2021–
David Hassell	NCAS	UK	2019–
Martin Juckes	STFC	UK	2014–
Slava Kharin	CCCma	Canada	2014–
Andrea Lammert	DKRZ	Germany	2021–
Grigory Nikulin	SMHI	Sweden	2021–
Martina Stockhause	DKRZ	Germany	2019–
Karl Taylor	PCMDI/LLNL	USA	2014–

2 CMIP International Project Office

In recent years, the use of CMIP outputs has grown significantly to support, not only global climate negotiations, but also national climate assessments. climate services and private sector, impacts and adaptation planning and mitigating potential exposure to future risk due to climate change. Therefore, due to CMIP's growth in both scale and scope, coordination of its elements required dedicated secretariat support.

In March 2022, the CMIP International Project Office opened, hosted by ESA's Climate Office at its European Centre for Space Applications and Telecommunications (ECSAT) facility in Oxfordshire, United Kingdom.

"The first year of the new CMIP IPO has been very busy, establishing itself in the community, making the link to their main stakeholder and preparing the new CMIP7 cycle. The high professionalism and expertise of the core team is impressive and has made the first year of the CMIP IPO a real success. The team has grown as well to add additional expertise necessary to address the tasks ahead." – Susanne Mecklenburg, Head of ESA Climate Office

The IPO is run by staff from HE Space Operations under contract to ESA.

"The report concludes a successful first year of HE Space's staffing of the CMIP IPO. Our founding staff have worked hard to build a quality service that is required and needed by both the CMIP Panel and WIP as well as being hosted at ESA. The team have achieved a lot to ensure the service is fully engaged with the CMIP community. The team has also grown responding to providing a quality service. Via our staff, HE Space remains committed to supporting the continued development of CMIP." – Jason Maroothynaden, UK Managing Director, HE Space Operations Ltd

The role of the CMIP IPO is to:

- Provide administrative support and support organization of the activities of the CMIP panel and WIP, including relevant sessions, meetings, workshops, conferences, and training sessions.
- Support coordination, planning, development, and implementation of the CMIP experimental design, data archiving and dissemination, and associated observational reanalysis, forcings, scenarios and modelling efforts.
- Facilitate international coordination and communication with related WCRP and other international programmes as well as active liaison between the climate observations and modelling communities.
- Prepare reports, correspondence, and publications.
- Coordinate CMIP scientific communication, dissemination, and outreach.

The CMIP IPO also collaborates closely with related WCRP, other international programmes, funding agencies and wider stakeholders. **Fig. 1** shows the CMIP IPO's position within the broader WCRP landscape.
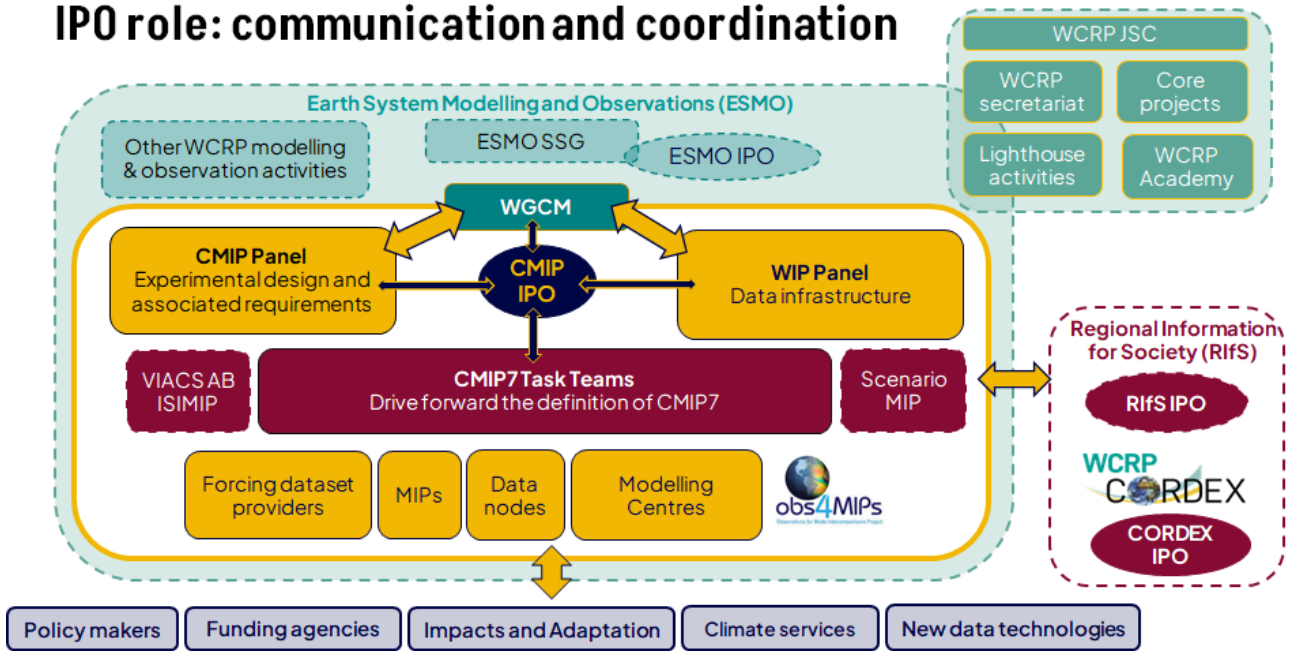
Fig. 1: The CMIP International Project Office within the wider WCRP landscape
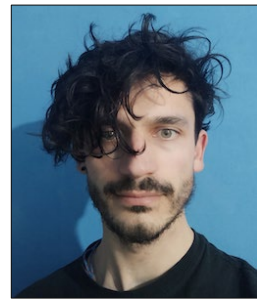
2.1 Staff

Eleanor O'Rourke, Director

Briony Turner, Programme Manager

Beth Dingley, Science and Communications Officer

Daniel Ellis, Technical Officer

Alice Kolesnikov, Part-time Administrative Support

Christopher Goddard, Part-time C3S-CMIP Liaison Officer

3 The CMIP7 Task Teams

The CMIP7 Task Teams have been established to:

1. Increase CMIP's scientific and societal relevance,
2. Improve accessibility and widen participation,
3. Support the design, scope, and definition of the next phase of CMIP,
4. Support the evolution of CMIP infrastructure and future operationalisation.

In the past year, open membership calls for all seven of the task teams were launched. Applications were reviewed by evaluation panels made up of CMIP Panel and WIP members plus the relevant task team co-leads with successful task team members notified shortly afterwards. 75% of applicants (both total and accepted applications) work in either Europe or North America. Additionally, 28% of applicants were women, with this proportion rising slightly to 33% when calculating the number of women accepted onto Task Teams. The CMIP Panel and WIP are very aware of the continuing imbalance in CMIP activities and will continue to work to promote enhanced diversity and inclusion.

As of June 2023, all seven Task Teams have regular meetings and are beginning collaborative work with short term and longer-term goals under development. Below is a short summary from the Task Teams co-chairs, on the work their teams have already initiated and their plans for the upcoming year.

3.1   Data Access Task Team

The data access task team, formed in March 2023, seeks to identify barriers to provisioning and using CMIP-related data and to gather ideas for lowering those barriers where possible. To this end, the task team is broadly constituted of members with expertise in data provisioning, data distribution, and data use; membership is drawn from academia, research, NGOs, and the commercial sector. The task team has two associated stakeholder groups, one focused on data provisioning and one on data distribution, whose purpose is to represent the wider community.

Initial meetings of the task team have focused on information gathering and especially on understanding the many models for data distribution which have developed since CMIP6. The team expects to complete its initial surveys by Autumn 2023 and to identify concrete goals at that time.

The Data Access Task Team is co-led by Robert Pincus (Columbia University, USA) and Atef Ben Nasser (ISPL, FR). Full Task Team membership is available on their website: https://wcrp-cmip.org/cmip7-task-teams/data-access/.

3.2   Data Citation Task Team

The Data Citation TT aims at transforming the existing data citation service into a sustainable, scalable and better-integrated service for CMIP7 with the option to offer it for WCRP projects beyond CMIP7. The current data citation service is a one-person effort, which cannot be continued into CMIP7. The concrete objectives of the TT are:

- to define options for a future citation service with information on functionality, advice on federated implementation, costs/risks and benefits as basis for attracting partners willing to contribute to the future citation service; and

- to define a governance structure overseeing the implementation and the compliance to standards and functionality.

The Citation TT has discussed and classified functionalities of a citation service and used this to define two basic options: minimal/required and desired options. Next steps are the investigation of federating options to share effort and costs of implementation, maintaining and supporting the solutions outlined in the two options. Technical experts will be invited to share their approaches and their experiences with the team.

As a second issue, the TT discussed on changes of the CMIP CVs to better serve the needs of the data citation. A subgroup composed of TT members, WIP members associated with other TTs, and IPO's technical officer to ensure that all CMIP7 infrastructure components benefit from the CV changes.

The Data Citation Task Team is co-led by Martina Stockhause (DKRZ, DE) and Sasha Ames (LLNL, USA). Full Task Team membership is available on their website: https://wcrp-cmip.org/cmip7-task-teams/data-citation/.

3.3   Data Request Task Team

The focus of the Data Request task team is to oversee the creation of the CMIP7 Data Request. The Data Request will provide participating modelling centres with full details of CMIP7 output requirements from participating science teams, helping to ensure that the CMIP7 output requirements accurately reflect the ambition of the science teams, the constraints of the data managing services, and the resources of the modelling centres.

An open call for member nominations was announced in August 2022 and closed in October 2022. The Data Request task team is made up of 18 members from 14 countries. The first meeting of the task team took place in December 2022. To date there have been five task team meetings.

A primary aim of the Task Team is to mitigate CMIP pressures on modelling and data centres, and to avoid unwarranted environmental impacts of excessive data storage, while both supporting the data needs of the CMIP community and avoiding unnecessary barriers of entry for data producers and users. The Task team has developed terms of reference and established six thematic sub-groups. Considering the CMIP6 survey results, the task team is seeking to build upon, whilst avoiding the bottlenecks of, the CMIP6 data request. Two drop-in workshops, with 93 registered delegates, were run in June 2023 to initiate engagement with MIPs and modelling centres on the data requirements for the CMIP7 cycle.

The task team co-leads have also developed a strategic approach document outlining key elements of the proposed CMIP7 data request which was circulated for comment across CMIP Panel and the WIP. A concept focus Gate 1 Form has now been submitted to CMIP Panel and the WIP for approval.

The Data Request Task Team is co-led by Martin Juckes (STFC, UK) and Chloe Mackallah (CSIRO, AUS). Full Task Team membership is available on their website: https://wcrp-cmip.org/cmip7-task-teams/data-request/.

3.4   Forcings Task Team

An open call for member nominations was announced in August 2022, with 20 applications received. The first round of member invitations was sent in November 2022, with a second round required to resolve missing connections in March 2023. The TT has 17 members, and six stakeholders, with

complete coverage over the CMIP DECK/historical forcing dataset providers, and five of the CMIP6-era contributing modelling groups.

The TT has met four times, with the initial kick-off in January 2023. The TT launched the "CMIP Forcings Survey" in February 2023, receiving feedback from 85 respondents covering forcing dataset providers, modelling groups, MIP chairs and data analysts. A Forcings Drop-in Session was also held on June 7, 2023, covering two time-zones to facilitate broad attendance. The session was attended by 52 participants: TT members, modelling centre representatives, data analysts and the broader CMIP community. The fifth TT meeting is scheduled for 19 July 2023.

Since its inception the TT has accomplished the following:
- Defined four core goals for CMIP7 and beyond. The mission is to identify and implement next generation forcings for current and future generations of Earth System models.
- The "CMIP Forcings Survey" was developed and conducted to support the goal "Evaluate and document the CMIP6-era forcing collection and identify issues, coverage gaps, or omissions through an open community survey". Survey results have contributed to the identification of individual DECK/Historical forcings improvements, new and updated data needs of modelling centres/users, and data providers challenges, with lack of funding a primary concern.
- The TT produced a timeline for revised forcings in support of CMIP7. The initial mid-2024 release will extend and update CMIP6-era datasets, extended to December 2021. Forcings data will be published into the input4MIPs "CMIP6Plus" MIP era as they are available, with the first published in May 2023. Datasets will be revised in 2026 extending to 2022-2024 where possible.
- An AGU Fall Meeting 2023 session proposal "Climate forcing: quantifying the roles and responses of anthropogenic and natural climate drivers" co-convened by Paul Durack, Vaishali Naik and Stephanie Fiedler has been accepted.
- During meetings, TT members have discussed issues related to forcing testing and related tools, data format, availability and access, documentation and community engagement via the online discussion platform, online meetings and the TT homepage. The TT is also actively interacting with other TTs to coordinate on overlapping remits.

The Forcings Task Team is co-led by Paul Durack (PCMDI/LLNL, USA) and Vaishali Naik (GFDL/NOAA, USA). Full Task Team membership is available on their website: https://wcrp-cmip.org/cmip7-task-teams/forcings/.

3.5   Model Benchmarking Task Team

The objectives of the Model Benchmarking TT are to identify and understand multi-model evaluation, model-data intercomparison, and benchmarking activities that were successful in CMIP6 and other modelling activities. In addition, the TT will consider the design and development of systematic and comprehensive model evaluation approaches for CMIP7, employing a diversity of observational data and reanalysis. The Model Benchmarking TT has met four times, and TT members are working toward producing two papers. The first paper will offer a review of model evaluation and benchmarking methods and tools used in prior CMIP activities, identify strengths and weaknesses of different approaches, and attempt to define best practices for model benchmarking. The second paper will be forward-looking, and outline suggested systematic benchmarking methods that could be deployed for CMIP7. One goal is to determine if a system can be designed for producing diagnostics and scoring models for a variety of variable and characteristics in an automated fashion as relevant simulations are submitted to the Earth System Grid Federation (ESGF) to better inform analysts about recent historical

model performance before the researcher downloads or uses the model output. TT members are currently developing three working documents:

1. Key references from the previous CMIP phases regarding model benchmarking.
2. Information about different benchmarking tools used in previous CMIP phases.
3. Ideas on what would be most useful/helpful/necessary to provide a comprehensive benchmarking framework for CMIP7.

Finally, TT co-leads Birgit Hassler (DLR, DE) and Forrest Hoffman (ORNL, USA) submitted an abstract to the WCRP Open Science Conference, and it was selected for an oral presentation at the meeting in Kigali, Rwanda, in October 2023.

Full Task Team membership is available on their website: https://wcrp-cmip.org/cmip7-task-teams/model-benchmarking/.

3.6   Model Documentation Task Team

The aim of this TT is to devise a practical and sustainable documentation strategy for CMIP7 based on the centralized CMIP documentation that was undertaken during the fifth and sixth phases under the banner of ES-DOC (Earth System Documentation).

After selecting the members of the group representing different user communities and ES-DOC engineers, the kick-off meeting was held in January 2023. Following a presentation of each member, the group's objectives and a detailed presentation of the existing ES-DOC infrastructure, the first action was to identify some typical use cases for the model documentation.

Particular attention was also paid to the errata service and the management of the CMIP controlled vocabulary underlying the documentation. A second meeting dedicated to these issues highlighted two needs:

- The errata service needs to be more visible on the ESGF interface, with a kind of "quality flag" system.
- The integration of a CV management system is essential.

At a third meeting in April 2023, several links were highlighted with the other CMIP7 task teams, in particular: the Benchmarking, the Ensemble Design, the Forcings and the Data Access teams.

Finally, on the basis of the list of use cases, a strawman proposal was validated in order to identify the major challenges that the group should address as a priority. As a result, sub-working groups were formed on the following themes:

- Model CV: Enhanced source_id CV to provide a guaranteed minimum cover of model descriptions.
- Documentation Detail: Look to reduce the amount of documentation requested, whilst not reducing usefulness. Generate a use case for every question to provide the context for asking it.
- Data Accessibility: Versioning, further_info_URL, integration with ESGF, command line API.
- Experiments Documentation: Interactions with MIPs early. Possibly MIP members creating their own docs?

The next meeting is scheduled for the end of June, with an initial progress report from the sub-groups.

The Model Documentation Task Team is co-led by David Hassell (NCAS, UK) and Guillaume Levavasseur (IPSL, FR). Full Task Team membership is available on their website: https://wcrp-cmip.org/cmip7-task-teams/model-documentation/.

3.7   Strategic Ensemble Design Task Team

The Strategic Ensemble Design Task Team membership is comprised of 22 representatives from across academia and national modelling centres. This membership is complemented by four stakeholder groups which provide additional expertise from: climate finance and industry; integrated assessment modelling, scenarios, and policy; impacts, adaptation and climate services; and modelling centres.

The Strategic Ensemble Design Task Team has met four times since early December and has held a drop-in session to obtain feedback from the broader community. The task team has discussed and made recommendations on a number of issues. One issue that was discussed extensively was the potential change in start date of standard CMIP simulations from 1850 to 1750 motivated by results from one modelling group. This was discussed within the CMIP Panel and at the broader drop-in session and an overall recommendation was made that this should be proposed as a MIP as opposed to making a mandatory change of start date so that it can first be demonstrated what the impacts are across a broader range of models and to avoid increasing the computational burden on modelling centres that choose not to participate. The other primary topic that the task team has addressed has been the issue of which simulations (if any) should be added to the DECK and which should be prioritized as part of the fast stream groups to be completed on IPCC timelines. This has been discussed within the task team and with the climate services stakeholder group which led to a preliminary proposal for where experiments should be placed, and the task team has now sent this out for feedback. Finally, the task team has spent some time considering the enhanced use of emissions driven simulations in CMIP7 and a perspective on this topic is being drafted, led by task team co-lead Ben Sanderson.

The Strategic Ensemble Design Task Team is co-led by Ben Sanderson (CICERO, NO) and Isla Simpson (NCAR, USA). Full Task Team membership is available on their website: https://wcrp-cmip.org/cmip7-task-teams/ensemble-design/.

3.8   Fresh Eyes on CMIP

In the CMIP6 Community Survey, it was frequently raised that CMIP should nurture the future CMIP community and promote young and global South scientists. Historically, the CMIP decision making process has been opaque, and membership on the central decision-making teams was dominated by senior scientists. However, solving problems as difficult as those in climate science requires having representation of all voices at the table. Researchers, scientists, and practitioners early in their career provide a unique insight into climate science and have the potential to offer a fresh perspective on CMIP. Early Career Researchers (ECRs) regularly undertake the, often time consuming, task of generating, downloading, processing, and analysing data from CMIP and have a unique, working insight into the successes and flaws of CMIP phases.

Therefore, the CMIP IPO have launched Fresh eyes on CMIP. This is a new working group comprised of scientists, researchers, and practitioners in the early stages of their careers to sit alongside the CMIP7 Task Teams. Fresh Eyes on CMIP will also work to significantly increase collaborations with scientists

working in the global south. This group will directly integrate the voices of ECRs into CMIP through participation in CMIP Panel, WIP, and Task Team meetings and will provide invaluable insight into the generation, access, and analysis of CMIP data. On launching Fresh Eyes on CMIP at the European Geosciences Union Annual Meeting in April 2023 (EGU23), Helene Hewitt commented

"We see this group as providing invaluable insight into the generation, access, and analysis of CMIP data. We want to improve our ways of working by promoting inclusivity and diversity and ensuring greater representation of ECR voices in the future CMIP. It's so important when we're looking to solve big problems in climate science that we have everyone's voice at the table." – Helene Hewitt, CMIP Panel Co-chair

The first of three membership calls closed at the start of June and was a huge success. 161 applications were received, with multiple applications received from each continent (excluding Antarctica). In total, 39% of applications were received from applicants working outside of Europe and North America. Also, 58% of applicants identified as male, 39% as female, and 3% identifying as either non-binary or other. The membership call was launched at the European Geosciences Union (EGU) General Assembly in April 2023. The next call will be launched at the WCRP Open Science Conference, held in October 2023 in Kigali, Rwanda. We are hoping to increase the proportion of applications from the Global South, especially Africa, from that call.

From the applicant pools, a steering group and two co-chairs will be selected to act as liaisons to the Task Teams, CMIP Panel, and WIP, with the remaining applicants invited to join topic specific subgroups.

4 Scientific Highlights

The data from existing CMIP phases continues to be heavily used throughout the community. CMIP6 data publication began in 2019 and much of the data publication was completed in 2022. Below are selected highlights by the CMIP IPO's Science and Communications Officer, from high-impact science journals which have made use of the CMIP data.

4.1   Climate change increases cross-species viral transmission risk.

This study warns that mammals who are forced to move to cooler climates due to climate change are already spreading their viruses more widely. The authors highlight that this will have undoubtable impacts for human health.

Due to changes in climate and land use, there will be more opportunities for virus species which have historically only circulated wild mammals to spread to a wider group of species. Carlos et al., used projections of the future climate in 1970 from nine CMIP6 global circulation models (GCMs) and four SSP-RCP combinations, along with a phylogeographical model of the mammal-virus network to simulate potential future hotspots of viral sharing. Using this, the authors predict the areas which will have high amounts of viral sharing. They also show that bats drive the majority of novel virus sharing and, in particular, are likely to spread viruses on evolutionary pathways which could facilitated viral emergence in humans.

This paper was ranked first on Carbon Brief's *The climate papers most featured in the media in 2022* and was mentioned 716 news stories by 558 outlets around the world, including the Guardian, New York Times, Agence France-Presse, Al Jazeera and New Delhi Times.

Carlson, C.J., Albery, G.F., Merow, C., Trisos, C.H., Zipfel, C.M., Eskew, E.A., Olival, K.J., Ross, N. and Bansal, S., 2022. Climate change increases cross-species viral transmission risk. Nature, 607(7919), pp.555-562, [doi:10.1038/s41586-022-04788-w](doi:10.1038/s41586-022-04788-w).

4.2   Exceeding 1.5°C global warming could trigger multiple climate tipping points.

Climate tipping points are thresholds which, when crossed, lead to large, often irreversible changes in the climate system. In this paper, Armstrong McKay et al., provide an assessment of the most important tipping points. They find nine "core" tipping elements which significantly contribute the Earth system functioning, and seven additional regional "impact" tipping elements, which have a large impact on human welfare or are unique features of the Earth system. Many of the thresholds have significant implications for climate policy, with six tipping points becoming likely within the Paris Agreement range of 1.5-2 °C.

Thresholds for key climate-related tipping points

● <2C ■ 2-4C ▲ >4C
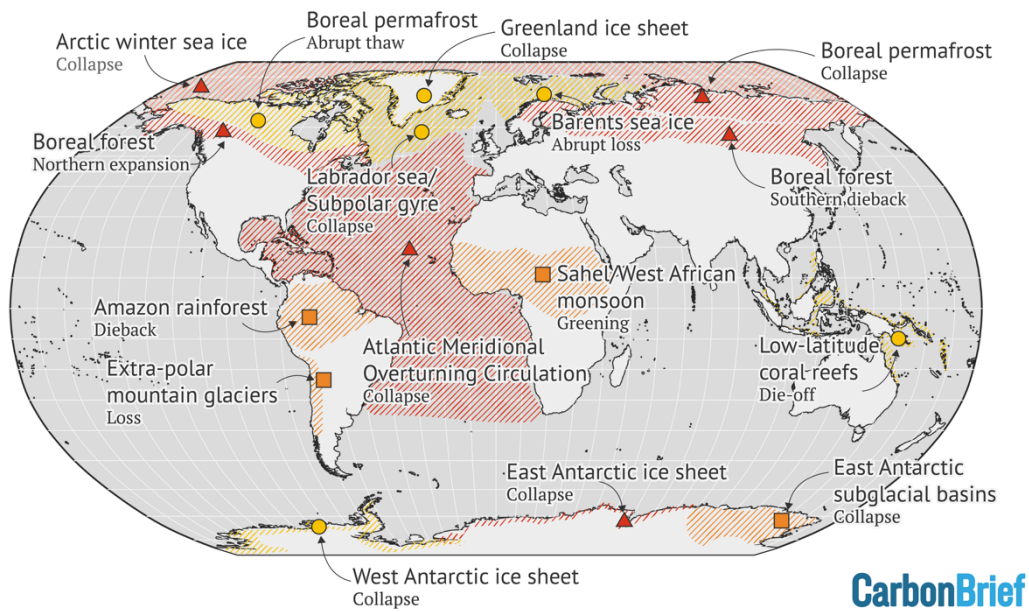
Fig. 2 The location of the Earth's tipping points and when they are likely to be crossed. Credit: CarbonBrief, map by Tom Prater, based on McKay et al (2022).

This paper was also ranked second on Carbon Brief's *The climate papers most featured in the media in 2022* and was mentioned in 667 news stories from 397 outlets – including the Guardian, New Scientist and BBC News.

Armstrong McKay, D.I., Staal, A., Abrams, J.F., Winkelmann, R., Sakschewski, B., Loriani, S., Fetzer, I., Cornell, S.E., Rockström, J. and Lenton, T.M., 2022. Exceeding 1.5 C global warming could trigger multiple climate tipping points. Science, 377(6611), p.eabn7950, DOI:10.1126/science.abn7950.

4.3   Human-induced weakening of the Northern Hemisphere tropical circulation.

The Hadley circulation impacts the spatial patterns of precipitation and temperature at lower latitudes. Historically, models and observations have disagreed on whether the Northern Hemisphere Hadley circulation will strengthen or weaken with climate change. In this paper, Chemke and Yuval use constrained recent sea-level pressure changes to verify that the circulation has weakened in recent decades, in agreement with CMIP6 simulations. The authors further attribute these changes to anthropogenic emissions.

Chemke, R. and Yuval, J., 2023. Human-induced weakening of the Northern Hemisphere tropical circulation. Nature, pp.1-4.

4.4 Selecting CMIP6 GCMs for CORDEX Dynamical Downscaling: Model Performance, Independence, and Climate Change Signals.

Dynamical downscaling of GCM simulations resolves region climates better, and therefore is useful for guiding regional climate policy. However, downscaling is computationally expensive, and therefore careful decisions must be made when selecting a subset of CMIP models. In this paper, Di Virgilio et al., identify a suitable subset for analysing regional climate over Australia. The assessed models against three criteria: performance simulating daily climate variable distributions; model independence; climate change signal diversity. Their evaluations identified 11 GCMs which performed "consistently poorly" across their metrics, and another 13 GCMs which showed "adequate-to-good" performance.
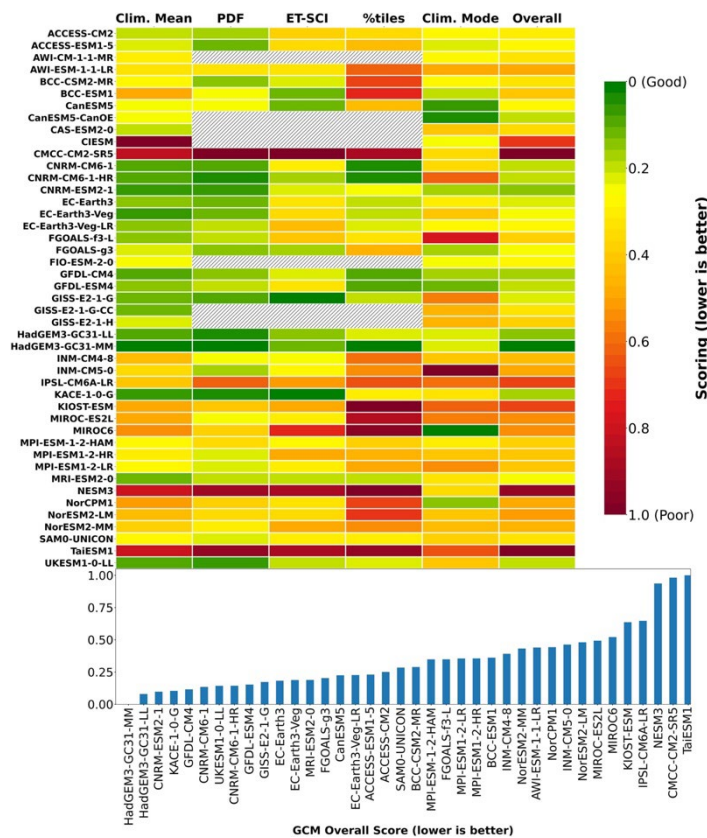
Fig. 3 CMIP6 GCM performances per climate stream/statistic, and overall performances across all climate streams/statistics assessed (far right column) over Australia. Hashing indicates GCMs (N = 7) that did not have data available to enable assessment (i.e., an absence of daily data); Bottom: overall scores for the subset of CMIP6 GCMs that were assessed across all climate streams/statistics (i.e., excluding the N = 7 that lacked daily data). Source: Di Virgilio et al., 2022.

Di Virgilio, G., Ji, F., Tam, E., Nishant, N., Evans, J.P., Thomas, C., Riley, M.L., Beyer, K., Grose, M.R., Narsey, S. and Delage, F., 2022. Selecting CMIP6 GCMs for CORDEX dynamical downscaling: model performance, independence, and climate change signals. Earth's Future, 10(4), doi: 10.1029/2021EF002625.

4.5   Observationally-constrained projections of an ice-free Arctic even under a low emission scenario.

The latest IPCC Assessment Report (AR6) estimated that the Arctic is projected to be mostly ice-free in September by mid-century under mid- and high-emission scenarios, but not under low-emission scenarios. In this paper, Kim et al., show that the influence of greenhouse gases on Arctic sea ice area is underestimated in CMIP6 models. The authors show that, when CMIP6 models are scaled to best match the observed trend in sea ice area, the Arctic is projected to be ice-free in September in all emission scenarios, not just the mid- to high-emission scenarios.
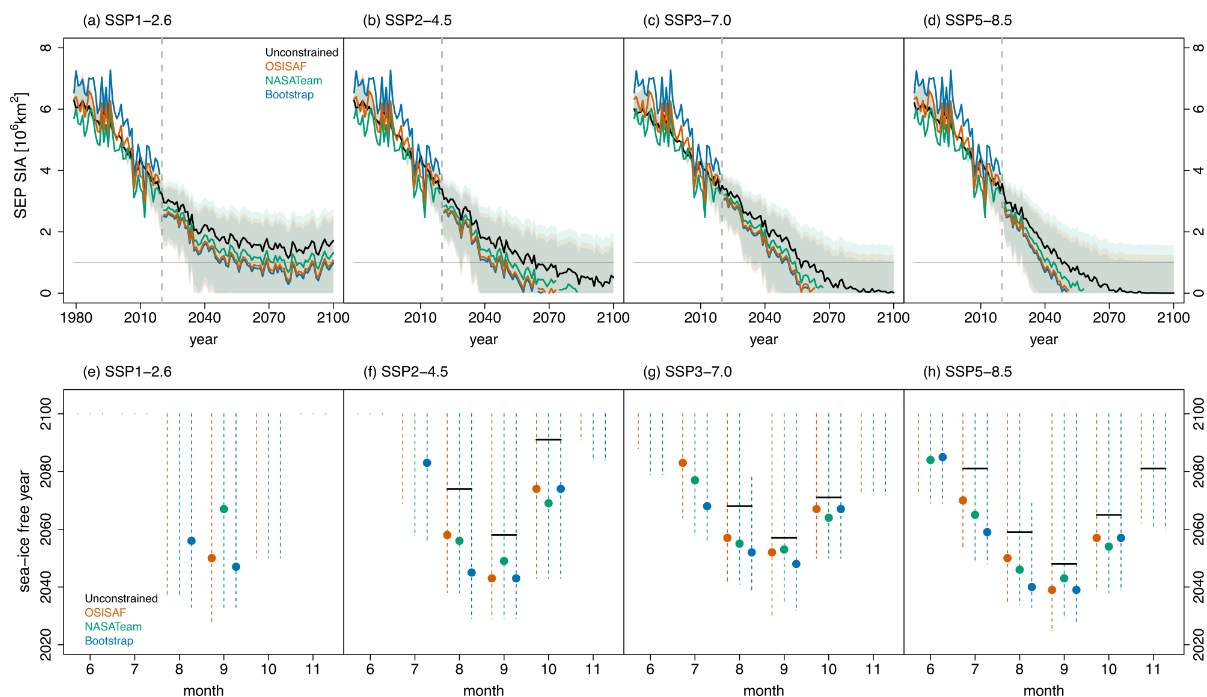
Fig. 4 Time series of Arctic sea ice area (SIA) in September over the period 1979–2100 from three sets of observations (OSISAF, NASATeam, and Bootstrap) and Coupled Model Intercomparison Project Phase 6 (CMIP6) multi-model means of the **a** Shared Socioeconomic Pathway (SSP) 1–2.6, **b** SSP2-4.5, **c** SSP3-7.0, and **d** SSP5-8.5 scenario simulations. Coloured lines indicate observations for the historical period (1979–2019) and observationally-constrained projections for the future period (2020–2100) which are obtained by scaling raw projections (black lines) with GHG scaling factors (see Fig. 2). Coloured shading indicates the uncertainty ranges (5–95%) of observationally-constrained projections (based on 5–95% ranges of GHG+ scaling factors). **e–h** CMIP6 projected sea ice-free years (defined as the year when monthly mean multi-model mean SIA drops below 1×10^6 km2 for the first time) for different SSP scenarios. Marks and vertical dashed lines indicate the best estimate and 5–95% ranges, respectively, of constrained projection results based on GHG scaling factors for three observations. Horizontal lines indicate results from unconstrained projections. Source: Kim et al., 2023.

Kim, Y.H., Min, S.K., Gillett, N.P., Notz, D. and Malinina, E., 2023. Observationally-constrained projections of an ice-free Arctic even under a low emission scenario. Nature Communications, 14(1), p.3139, doi:10.1038/s41467-023-38511-8.

5 Engagement activities

5.1 Sustainable CMIP

CMIP is an accumulation of international scientific effort. This includes a multitude of activities that have an emissions footprint, such as from computing and meeting travel. The science of CMIP is important, but we must be conscious of the carbon footprint this work is associated with. WCRP has committed to reducing its carbon footprint across all activities. Within the CMIP community, we are focusing on four key areas of reduction:

- eliminate unnecessary data duplication,
- network and data transmission optimisation,
- intentional decision making on CMIP design (experiments, computation, and storage),
- activities of the CMIP community (Scope 3 emissions).

We are currently working on the experimental design of CMIP7 through a series of Task Teams. All recommendations emerging are reviewed regarding implications for, and efforts that can be made, to improve data efficiency and use at every stage of its life cycle.

Work is ongoing to determine the carbon footprint from CMIP6. There has been some work through the EU Horizon 2020 project, IS-ENES3, which has revealed that the CMIP6 experiments at a range of modelling centres in Europe were between 24 and 868 tonnes of CO_2. To put this in perspective, a return flight London to New York is just under a tonne of CO_2. This work is continuing, and we will develop a more robust estimate which will be used as a benchmark on which a monitoring and action plan for CMIP7 can be developed.

5.2 Events

LPS 2022

The Living Planet symposium in 2022 took place in Bonn, Germany 23-27 May. It was attended by over 5000 in-person attendees from 76 countries. ESA's Biennial Living Planet Symposia are amongst the biggest Earth observation conferences in the world. Their focus is on use of Earth observation by scientists to understand Earth's environment and climate and its role in building a sustainable future and a resilient society.

Following a warm welcome from ESA's Director of EOP Earth Observations, Simonetta Cheli, WCRP Joint Scientific Council Chair, Detlef Stammer, opened the CMIP IPO at a dedicated launch event which took place at the conference on Monday 23 May. The event included talks from the CMIP Panel Chair and WIP co-chairs, the Head of the ESA Climate Office and Director of the newly established IPO.

The IPO Director was also involved in convening and chairing responsibilities at the session on Observations & Modelling: shedding light on climate futures which took place on the dedicated Climate Day on Wednesday 25 May. Panel guests included Jörg Schulz (EUMETSAT), Irene Lake (Director, International Project Office for CORDEX), Susann Tegtmeier (University of Saskatchewan, ESMO Interim SSG Co-Chair), Carlo Buontempo (ECMWF), Axel Lauer (DLR) and Simon Pinnock from the ESA Climate Office.

During the conference the IPO staff had a number of in-person meetings to explore with staff from WCRP CORDEX IPO and various European organisations at the interface between observations and climate modelling, including ECMWF, EUMETSAT, the leads for the Copernicus Climate Change Service and ESA's Climate Modelling User Group initiative.

GCOS 2022

The 2nd Global Climate Observing System (GCOS) conference took place in Darmstadt, Germany in October 2022. GCOS 2022 was held to assess how the current global climate observing system can be improved to better support current and near-term user needs for climate information.

The CMIP IPO facilitated a hybrid World Café event at GCOS 2022, focused on developing community ideas to strengthen the observational-modelling interface towards meeting near term and emerging scientific needs critical to our understanding of climate change. The event was chaired by Jörg Schulz (EUMETSAT). Discussion was vibrant and brought out many ideas for actions to further enhance collaboration and co-development across the modelling, observation, and user communities.

The event participants discussed current bottlenecks in the observation-modelling interface in different breakout groups across the session:

- Developing climate observation networks.
- Urgent action at international and national scale to ensure open access climate data for all.
- Transforming climate data into information relevant for decision making.
- Building and sustaining climate data records.

At the end of the event, it was concluded that action is required by GCOS and WMO communities to urgently address open access data for climate science. There are crucial gaps in access, important for both the observation and modelling communities.

To learn about the event and its conclusions in more detail, the event report is available at https://wcrp-cmip.org/cmip-reports/.

EGU23

The European Geophysical Union's General Assembly in 2023 (EGU23) took place in Vienna at the end of April. EGU23 welcomed over 15,000 in-person attendees from 107 countries with over 1400 people also joining online. CMIP was well represented in submitted abstracts, featuring in 50 presentations and 12 sessions. Four members of our governing panels and four members of the International Project Office (IPO) were also able to attend.

The IPO was delighted to host two Townhalls during the week, and four informal drop-in sessions with over 100 attendees. Eleanor O'Rourke led the sessions alongside Helene Hewitt (CMIP Panel co-chair), Julie Arblaster (CMIP Panel member), Martina Stockhause (WGCM Infrastructure Panel member, Data Citation Task Team co-lead), and Birgit Hassler (Model Benchmarking Task Team co-lead).

The first Townhall – 'Co-creating the future CMIP' – included discussion on the scientific and infrastructure priorities for CMIP7. The second Townhall – 'Early Career Researchers' (ECRs) reflections from CMIP' – was designed to give ECRs the chance to feedback on their CMIP6 experiences and highlight improvements to be addressed in the planning of future CMIP activities. Guest contributor, Marisol Osman, provided perspectives from the Young Earth System Scientists community closing

on the need to engage more ECRs in leadership roles. In the ECR Townhall, Helene Hewitt also launched 'Fresh Eyes on CMIP' – a new working group for ECRs, designed to directly integrate their voices into the CMIP design and governance.

During the conference, the IPO held a social lunch to encourage networking and discussion about CMIP as well as a series of lunch time themed drop-ins at the European Space Agency's (ESA), the host institution of the CMIP IPO, stand.   The drop-in sessions were led by CMIP Panel and WIP members as well as guest speakers. The session on Tuesday proved particularly popular with a talk and discussion session led by Stefan Sobolowski (NORCE Research), on CMIP Downscaling in EURO-CORDEX, the European domain of the international CORDEX initiative.

At the end of the conference, the CMIP IPO director Eleanor O'Rourke commented:

"Our events were filled with enthusiasm for CMIP but also importantly offered an open platform for some important issues, questions, and highly constructive feedback to be raised. This included challenges around data access and documentation and also the important scientific questions to be addressed by the future CMIP. The IPO team was also delighted to hear the very positive feedback on its support and facilitation of the CMIP community." – Eleanor O'Rourke, CMIP IPO Director

ScenarioMIP workshop

On June 20-22, 2023, the first meeting of the ScenarioMIP project under the new phase of the Coupled Model Intercomparison Project, CMIP7, was held in Reading, UK supported by the IPO and kindly hosted by the University of Reading Meteorology Department. The meeting was led by the ScenarioMIP Co-chairs Detlef van Vuuren (PBL, NL), Claudia Tebaldi (JGCRI/PNNL, USA), and Brian O'Neill (JGCRI/PNNL, USA).

This workshop brought together the re-established ScenarioMIP community with the key CMIP Task Teams, scenario-relevant MIPs and their invited scientific experts, representatives of modelling centres and CMIP leadership to look at lessons learned from CMIP6/AR6, current scenario development progress, and the key questions and experimental design priorities towards CMIP7/AR7 generation scenarios. There was a mix of plenary and breakout sessions during this three-day hybrid format workshop offering both in-person and online participation. 78 people attended the meeting, with 37 in person and 41 online. In advance of the workshop a ScenarioMIP community survey was launched and has received over 100 responses. A summary of the responses submitted in advance of the workshop was presented at the opening plenary.

The agenda of the meeting was organized around three themes:

1. Taking stock of ScenarioMIP past phase (under CMIP6) and of current activities and plans in other scenario-related MIPs.
2. Discussing different ideas and criteria about the choice of the new ScenarioMIP design, and
3. Agreeing on a way forward. Future steps involve a process that will result in the publication of a peer-reviewed article describing the new design, and the approval of such design by the appropriate level of WCRP. It will have a focus on ensuring openness and inclusivity of a wide and diverse community.

The meeting successfully achieved all three themes.

A meeting report will be circulated to participants in July 2023 and further information of the community engagement process will be added to the new ScenarioMIP webpages at https://wcrp-

cmip.org/model-intercomparison-projects-mips/scenariomip/. The meeting report includes a draft proposal for scenario choices and a process for further elaboration of the final proposal.

Drop-in sessions

Following feedback from CMIP6, the scientific community requested that CMIP7 should enhance active community input to the experimental design process (see CMIP6 Community Survey section below). Speaking to this, a series of regular drop-in sessions was launched in early 2023, facilitated by the CMIP International Project Office (CMIP IPO), to cover key aspects of CMIP7 design and development and promote community feedback to the CMIP governance and Task Teams. These sessions are open to all with attendance by modelling centre and MIP representatives strongly encouraged. Three such sessions have been held thus far, with each summarised below. Each drop-in session is held at two different times to enable participation from those in all time zones across the world.

MODELLING CENTRE DROP-IN

This inaugural pair of drop-in sessions were held in February 2023 and were chaired by Helene Hewitt (CMIP Panel co-chair), Paul Durack (WIP co-chair and Forcings Task Team co-lead), and Ben Sanderson and Isla Sanderson (Strategic Ensemble Design Task Team co-leads). The sessions were well received, and they were attended by almost 100 people. The topics discussed were focussed on the overall experimental design of CMIP7, including which experiments should be prioritised, a community proposal on extending the start date of CMIP experiments back to 1750 (in CMIP6 the start date was 1850), and how to incorporate MIPs within CMIP's structure moving forwards. Overall, representatives from modelling centres were keen to ensure that the number of required experiments and ensemble members is kept to a minimum in CMIP7, but also that these decisions should be made through consultations across the entire modelling community, to ensure that the design suites as many purposes as possible. Many of the other questions and their answers from these sessions can be found on the CMIP Q&A Forum at the following link: bit.ly/CMIP-faq.

VARIABLES DROP-IN

The first pair of CMIP Variables drop-in sessions were held in June 2023 on two separate days, with different timeslots to enable participation globally. Sessions were chaired by one of John Dunne (CMIP Panel Co-chair) or Julie Arblaster (CMIP Panel member) and led by one of the Data Request Task Team co-leads, Martin Juckes (STFC) or Chloe Mackallah (CSIRO). The events' objectives were to gain an understanding of the community's data aspirations and understand the challenges the community foresees during CMIP7. Registration was open to all, with those involved with MIPs and modelling centres particularly encouraged to attend. In total, 93 people registered for the event (of which 47 attended) across both sessions.

The sessions opened with an update on the current planning for CMIP7 and some polls to help the conveners understand which communities were represented, and their knowledge about the CIMP6 data request. Full slides presented during the sessions are available online at https://doi.org/10.5281/zenodo.8042186. Participants then split out into breakout groups based on their climate 'realms' of interest: oceanography; cryosphere; atmosphere, clouds, and aerosols; land surface; and impacts, mitigation and downscaling. Discussions within breakout groups covered attendees' aspirations for the CMIP7 data request and their concerns and reservations. There was excellent discussion during both sessions. The full details can be read in the event report at https://wcrp-cmip.org/cmip-reports/. Questions raised during the session will be added to the CMIP Q&A Forum in due course. This can be accessed at bit.ly/CMIP-faq.

FORCINGS DROP-IN

The first CMIP Forcings drop-in sessions were held in June 2023 across two timeslots to support equitable global participation. These sessions aimed to facilitate community discussion on the development and use of forcing datasets. Each session was chaired by one of the CMIP Panel Co-chairs, John Dunne (GFDL/NOAA) and Helene Hewitt (Met Office) and led by the Forcings Task Team co-leads, Paul Durack (PCMDI/LLNL) and Vaishali Naik (GFDL/NOAA), with input from the wider members of the task team. Participants were introduced to the task team's members and stakeholders together with the core goals they are seeking to address. Further, feedback received in the recent Future CMIP Forcings Community Survey was outlined and how the task team is addressing the issues raised to deliver to CMIP7 and tackle longer term scientific challenges, before opening the session for an interactive dialogue with participants.

Registration was open to anyone with an interest in CMIP forcing datasets through the wcrp-cmip.org website. There were 88 registered participants (of which 52 attended) across the two online sessions from across the globe representing data users, Model Intercomparison Projects (MIPs), forcing dataset providers, and particularly strong attendance from modelling centres.

The agenda for the sessions covered the CMIP Forcings Task Team, reflections from CMIP6 forcings, developing the forcing dataset update timeline, plans for dataset testing, and plans for communication, tools, and engagement. Full slides presented during the sessions are available online at https://doi.org/10.5281/zenodo.8042162. Both sessions provided a wealth of insightful questions, comments, and discussion on these topics. The event report can be found at https://wcrp-cmip.org/cmip-reports/ and questions raised during the session have been added to the CMIP Q&A Forum in due course. This can be accessed at bit.ly/CMIP-faq.

5.3   Engaging with our scientific community

Community surveys

CMIP6 COMMUNITY SURVEY

In early 2022 the WGCM and CMIP Panel launched the "**CMIP Community next steps survey**" to gather views on the positive aspects and challenges they faced in CMIP6, and how they would like to see future phases of CMIP structured and delivered.

A total of 318 responses were submitted and the CMIP IPO completed an analysis facilitating discussion and reflection within the CMIP Panel and WIP. Overall, the response was positive; however, delays in forcing datasets, the pressure to meet IPCC AR6 deadlines, and the high number of MIPs and experiments putting a huge burden on modelling centres were key areas of dissatisfaction. Respondents raised the following suggestions for improvements towards CMIP7:

- An evolution from CMIP6 but no major structural changes.
- Retain alignment to IPCC in some form.
- Reduce the huge burden on modelling centres.
- Need for greater focus on climate impacts and adaptation relevant experiments (including updated scenarios).
- Need for operationalisation of critical elements (e.g., forcing).
- Build on substantial CMIP6 data infrastructure progress to support improved data access.

- Need for a smaller, simpler Data Request and comprehensive review of ES-DOC and errata service.
- Continue and enhance active community input to the experimental design process.
- Nurture the future CMIP community and promote young and global South scientists.

One of the key outcomes of the survey was to initiate the establishment of the CMIP7 task teams to address the issues raised, evolve existing and develop new approaches, and encourage wider community involvement in designing the future CMIP.

CMIP FORCINGS SURVEY

The CMIP Forcings Task Team, led by Paul Durack (LLNL) and Vaishali Naik (GFDL), supported by the CMIP IPO, initiated a CMIP Forcings Survey in February/March 2023 to inform the CMIP forcings development timeline and anticipated updates from providers. In addition, the survey sought to identify needs for modelling centres/MIPs to run the simulations. This survey was targeted at those who were involved in either dataset preparation (forcing dataset providers) or their use (modelling groups and MIPs) in CMIP6, or plan to be as we look towards CMIP7. There was also an opportunity for CMIP data users to feedback on problems/issues with the forcing datasets and suggestions for the future development. There were 85 responses in total, which have provided the task team with information to develop a provisional forcings update/extension timeline and highlighted key issues and challenges to be addressed to ensure problems faced during CMIP6 are avoided as far as possible.

CMOR SURVEY

The WGCM Infrastructure Panel (WIP) initiated the CMOR Users and Developers survey in March/April 2023, to collect experiences from CMIP6 as well as aiding the WIP in defining CMOR requirements and plan forwards for the next generation of MIPs. This survey was targeted at MIP data contributors and other infrastructure users. There were 35 responses in total from 23 different modelling centres, most of whom used both CMOR and PrePARE in their data preparation workflows. Overall, respondents found CMOR and PrePARE useful and appreciated the documentation and guidance available, although some feedback suggested more user guidance would aid the process of preparing data. Some suggestions included developing several 'How to…' user guides and more example codes.

MODELLING CENTRE CMIP7 READINESS SURVEY

The CMIP6 survey and other community engagement provided valuable feedback on the way forward to which the CMIP Panel is responding in its planning, and critical to this planning is developing a realistic timeline. Some of the CMIP7 constraints come from the availability of the forcings (both for the historical period and scenarios) as well as the data request and are being addressed through our respective CMIP7 Task Teams. Also critical to planning is knowing when the modelling centres anticipate being ready, in advance of information around the IPCC AR7 timeline, expected later in 2023, and therefore a community survey was released in June 2023. The results will support further timeline development and engagement with the new IPCC Bureau, once elected in July 2023.

MIP registration

To reduce duplication of effort across MIPs and modelling centres and to foster collaboration, we launched MIP registration in March 2023.

The CMIP IPO continues to encourage all ongoing and new MIPs (CMIP6-endorsed MIPs and others) to register. This register acts as a source of information for CMIP governance to consider when discussing the design of CMIP7, as well as information for the climate science community on the activities going

on globally. MIP activities are publicly available on the CMIP website to facilitate collaboration opportunities.

Since the registration process was launched, to date 24 MIPs have registered at varying stages of development, from a registration of an initial idea, through to MIPs which already have simulations underway. A dynamically updated list of the registered MIPs are available on the CMIP website at https://wcrp-cmip.org/model-intercomparison-projects-mips/.

Priority variables consultation

The CMIP Data Request Task Team, led by Martin Juckes and Chloe Mackallah, are establishing a process to address the challenges presented by having too many variables listed as top priority while meeting the needs of both data providers and users. It is envisaged that a core set of variables can form a baseline for exchange of climate model data, in any intercomparison project, in accordance with FAIR data and Open Science principles.

In spring 2022, members of the CMIP community were engaged in a survey and two workshops on the proposed methodological approach and a paper publication process to devise an agreed list of core variables. The two workshops, held in May 2022, were based upon the 32 responses to the survey issued by the CMIP IPO in April 2022 to Modelling Centre and Data Request Leads, and the MIP Chairs.

The key outcomes of the consultation were:

- Broad support for the proposed objective to establish an agreed list of core variables to be archived for exchange of climate model data.
- Early engagement is vital for the planned expert elicitation process. Further consideration required as to whether to take a top-down or bottom-up approach to expert elicitation.
- Inclusion of an additional first task for authors to refine the objective, particularly in establishing clarity on purpose, function and intended (current and future) users of the core set of variables.
- Authors will need to consider and make recommendations on proposed implementation, in close collaboration with key stakeholders (WCRP, WGCM, modelling centres, MIP chairs etc.).
- Variable selection criteria are contentious and will require further iterative community engagement. Suggestions made of consideration of a matrix rather than list approach and further thought regarding the prioritisation approach regarding issues such as potential bias and choice of metrics for variable selection criteria and how to serve a wide range of users.

A paper is currently in preparation for publication in GMD in the second half of 2023 summarising the conclusions of the consultation and recommendations for a set of WCRP baseline variables.

CMIP6 Data Licence relaxation

In October 2022, the CMIP6 data license for all 131 contributing model configurations was relaxed to CC BY 4.0 (Creative Commons Attribution). The CMIP6 license relaxation enables a broader use the CMIP archive, facilitating the expansion of climate data usage across research, industry, and policy communities.

Internal communication channels

The IPO set up a community collaboration platform to support activities of the CMIP and WIP Panels, in accordance with a set of key considerations agreed by the CMIP Panel. The platform selected was

ONLYOFFICE and the IPO were successful in their application for the package for non-profit organisations. Currently the platform facilitates transparent interaction and development of ideas and proposals by 146 community members, comprising the panels and their task teams, including stakeholder groups.

5.4   Wider engagement activities

Community presentations

The CMIP Panel, WIP, task team members and IPO have been active in presenting at a wide range of meetings across the CMIP community and beyond including:

- CMIP reports at the WCRP Joint Scientific Committee 43rd (June 2022) and 44th (May 2023) Sessions.
- CMIP and WIP presentations and planning sessions at the 25th Session of the WGCM (November 2022).
- WIP presentations at the 9th joint ESGF-IS-ENES meeting (January 2023).
- Australian National CMIP7 Workshop (February 2023).
- Safe Landing Climates Lighthouse Activity meeting (March 2023).
- The Decadal Climate Prediction Project (DCPP) panel of WCRP (March 2023).
- US Climate Modelling Summit (April 2023).
- World Meteorological Organization Congress (May 2023).
- EU Horizon 2020 and Horizon Europe project meetings e.g., OptimESM, CRiceS and ESM2025.

Mailing lists and social media

With the new CMIP International Project Office (IPO) opening, there is more resource for developing CMIP than in previous years. Therefore, the IPO is working hard to make CMIP a more open, inclusive community. Part of this work is focussing on our communications so that we can advertise our opportunities, news, and events to anyone who might interested. To achieve this, the IPO have set up new mailing lists which are open to everyone.

In total, there are nine mailing lists. The CMIP Community News mailing list is the IPO's primary list for sending out communications across the CMIP network. On here, opportunities for getting involved with CMIP7 and give feedback on previous phases of CMIP are advertised, CMIP events are promoted, and news is shared from colleagues around the CMIP community. The other mailing lists are available for specific task team information, and for keeping up to date with efforts to make CMIP more sustainable.

The response from the community to developing this mailing lists has been very positive. In four months, almost 800 people have signed up for the CMIP Community News list.

The IPO also manages social media accounts for CMIP on both Twitter (@wcrpcmip) and LinkedIn (wcrp-cmip). These platforms are useful for reaching different communities and spreading the word on CMIP and its activities. The reach of these accounts is growing, with strong content engagement, especially on posts highlighting events and new vacancies within the CMIP organisational teams.

A new CMIP website

In 2023, a new CMIP website was launched, with a significant amount of new information on both past and future CMIP phases. The website is designed to be a central resource, pooling together information and links to the wide range of CMIP materials that can be found across the internet. The webpages will be continuously updated as the planning for CMIP7 advances. This website will be the primary place to find the most up-to-date information on CMIP and can be accessed at www.wcrp-cmip.org.

5.5   Looking ahead

Continuing and enhancing community engagement

Going forward the CMIP IPO, CMIP Panel, WIP and task teams are committed to continuing to actively engage and co-create with the community and wider stakeholders as the CMIP7 experimental design and implementation planning develops.

The regular drop-in sessions have been received very positively and will be continued providing timely opportunities for feedback on aspects of the design, components of the CMIP infrastructure, and highlighted specific user needs, as well as modelling centre and infrastructure constraints.

The new website will be continually updated as the CMIP7 science goals, experimental design, and protocol are developed to keep the community well-informed and to ensure that modelling centres and infrastructure providers have as much time as possible to prepare for the next phase of CMIP. Some features on the website are in an early stage of development (such as the Question & Answer bank, CMIP Document Library and the CMIP7 Task Team webpages). The CMIP IPO will continue to build on these resources in the coming year. Additionally, new webpages will be developed to provide information on CMIP for different communities. In particular, the CMIP IPO is looking to develop Information for Policy Makers and CMIP Tools webpages. Alongside this, the IPO will develop other new resources to aid data providers and users. This will include explainer videos, guides, and a recorded webinar series. These resources will help to disseminate invaluable knowledge across the entire CMIP community.

WCRP Open Science Conference 2023

The 2nd WCRP Open Science Conference will take place in Kigali, Rwanda in October 2023. Three members of the CMIP IPO will attend, alongside CMIP Governance and Task Teams members. WCRP hopes that, by holding the conference on the African continent it will promote strong engagement with the climate and environment communities with those in Rwanda and across Africa. The outcomes of the conference sessions will culminate with a statement, termed the 'Kigali Declaration', which will be submitted to the 28th Conference of Parties (COP28) happening in November 2023.

In total, the IPO is helping to facilitate four events during the conference:

1. CMIP Data Access session,
2. Joint CMIP-CORDEX climate data evaluation and analysis tools session,
3. Panel discussion on addressing barriers to a diverse and inclusive climate modelling community,
4. World café focussed on strengthening the observation-modelling interface.

AGU23

The American Geophysical Union's General Assembly in 2023 (AGU23) will take place in San Francisco, USA in December 2023. There will be a strong CMIP presence across the conference. There are four sessions accepting abstracts which are being co-convened by those on CMIP Task Teams:

1. *Climate forcing: quantifying the roles and responses of anthropogenic and natural climate drivers.* This session will be convened by Forcings Task Team co-leads Paul Durack and Vaishali Naik and Task Team member Stephanie Fiedler.
2. *Improvements in Regional and Global Air Pollutant and GHG Emissions Inventories.* This session is convened by Forcings Task Team members Rachel Hoesly and Stephen Smith alongside Brian McDonald and Kenna Rewcastle.
3. *Systematic Benchmarking of Earth System Models.* This session is convened by Model Benchmarking Task Team co-lead Forrest Hoffman, Task Team member Jiwoo Lee, obs4MIPs co-chair Peter Gleckler, alongside Paul Ullrich.
4. *Open Earth and Environmental Data Advance Scientific Discovery.* This session is convened by Forrest Hoffman and Paul Durack, alongside Shreyas Cholia and Justin Hnilo.

Additionally, the CMIP IPO is facilitating two townhall events to mirror those held at EGU23. Both sessions, 'Co-creating the future CMIP' and 'Early Career Researchers' reflections from CMIP' will be chaired by CMIP Panel co-chair John Dunne alongside additional speakers from the Panel, WIP and CMIP7 Task Teams.