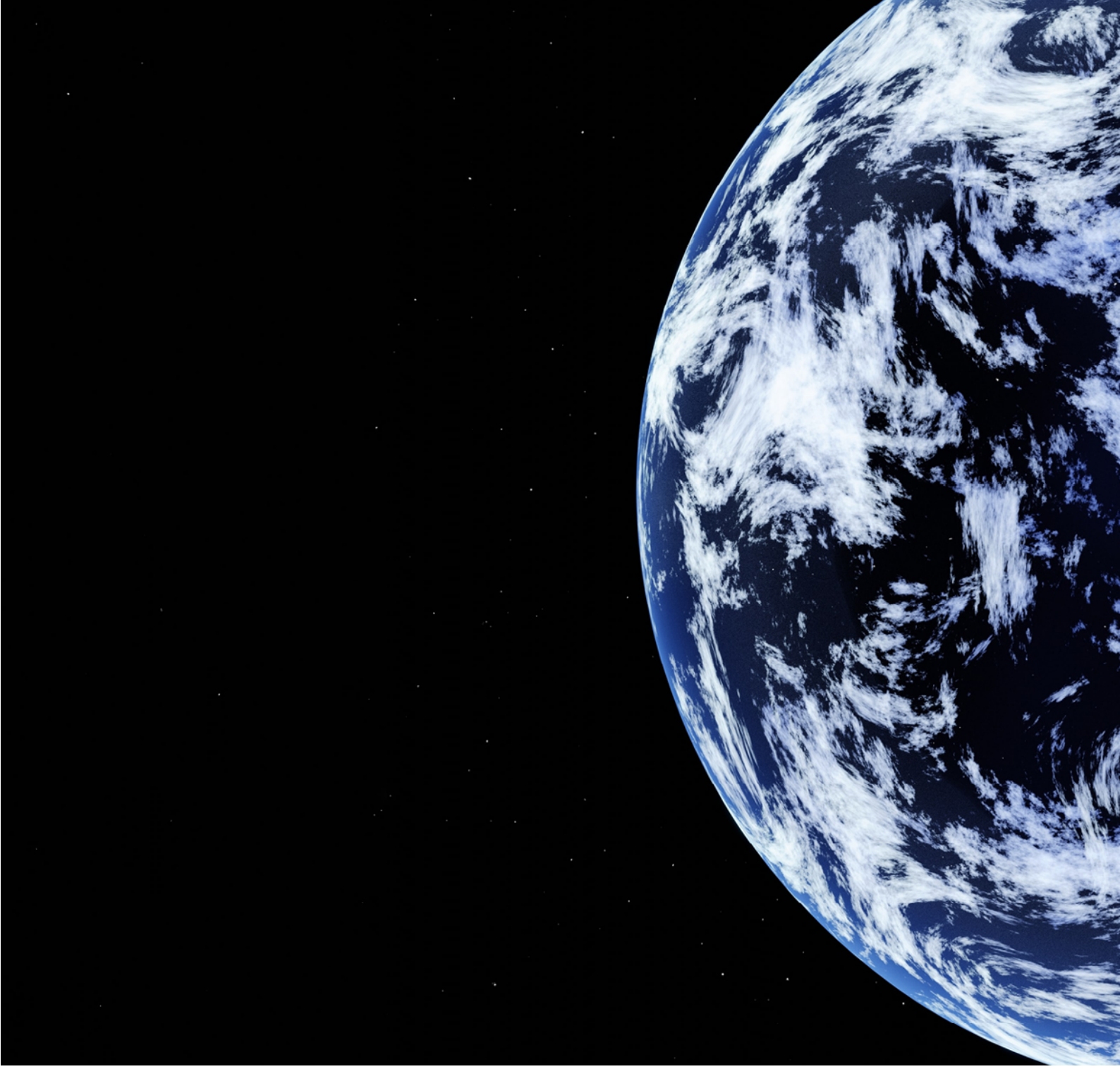

CMIP26 – CMIP COMMUNITY WORKSHOP

Session abstracts

May 2025

Contents

The CMIP Community Workshop

The CMIP Community Workshop (hereafter CMIP26) will take place 9-13 March 2026 at the Kyoto International Conference Centre, Japan. CMIP26 will bring together a growing, and increasingly diverse, community of Earth system scientists, partners, and stakeholders. It will be an opportunity to discuss the latest developments in Earth system and coupled modelling, leverage the wealth of the CMIP6 analyses and explore the updated forcings and early results from CMIP7 simulations, including new experimental designs and MIPs. It will also highlight the expanding observation-modelling interface, address strategies for streamlining the climate information chain, and forge a vision and global partnerships to deliver sustained and high-quality climate information to all users. The workshop will also provide ample opportunities for networking, collaboration, and knowledge exchange, fostering new partnerships with the CMIP community. In addition, there will be an Early-Career Scientist hackathon, designed and developed by our Fresh Eyes on CMIP community.

Workshop format, hosts and funding

The Workshop will have both in-person and remote participation options to ensure inclusion and engagement while minimizing our carbon footprint.

In-person participation will be kindly hosted by the Japanese SENTAN project and the Advanced Institute for Marine Ecosystem Change (AIMEC) in Kyoto, Japan at the Kyoto International Conference Centre. In addition, the European Space Agency is providing generous event funding as host of the CMIP International Project Office.

Workshop themes

Theme 1: Progress in understanding historical climate variability and change

- Improvements and biases in model performance
- Characterising model behaviour
- CMIP Rapid Evaluation Framework (REF)
- Use of observations and proxies for evaluating models
- Natural and anthropogenic climate forcing and attributing causes of change in the historical record

Theme 2: Understanding climate system responses, feedbacks and thresholds

- Patterns of sea surface temperature change
- Changing weather patterns
- Water-carbon-climate nexus
- Points of no return/ratcheting including tipping points and overshoots
- Uncertainty quantification in climate projections
- Regional applications
- Impacts on social-ecological systems

Theme 3: Synthesising information across the multiverse of models

- Making data accessible for users and stakeholders
- Models at high resolution
- Emulators of CMIP models
- Applications of artificial intelligence and machine learning in CMIP
- Impacts and extremes
- Evaluating risk under different storylines

Scientific Organising Committee

1. Helene Hewitt (workshop co-chair; Met Office, UK)
2. John Dunne (workshop co-chair; NOAA-GFDL, US)
3. Julie Arblaster (Monash University, Australia)
4. Tim Andrews (Met Office, UK)
5. Qing Bao (IAP, China)
6. Paul Durack (PCMDI/LLNL, US)
7. Cheikh Modou Noreyni Fall (UCAD, Senegal)
8. Sedat Gözlet (GEOMAR, Germany)
9. Mujtaba Hassan (IST, Pakistan)
10. Birgit Hassler (DLR, Germany)
11. Saurabh Kelkar (Watershed Organization Trust, India)
12. André Lanfer Marque (INPE, Brazil)
13. Yiwen Li (China University of Geosciences, China)
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15. Tomoki Miyakawa (University of Tokyo, Japan)
16. Bette Otto-Bliesner (UCAR, US)
17. Juliano Palacios (UBC, Spain)
18. Natassa Romanou (NASA, US)
19. Ankur Srivastava (IITM, India)
20. Ranjini Swaminathan (University of Reading, UK)
21. Maureen Wanzala (WCRP Secretariat)

Local Organising Committee

1. Tomoki Miyakawa (University of Tokyo)
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5. Yu Kosaka (University of Tokyo)
6. Chie Yokoyama (University of Tokyo)
7. Michio Kawamiya (JAMSTEC)
8. Hiroaki Tatebe(JAMSTEC)
9. Tomohiro Hajima (JAMSTEC)
10. Chihiro Kodama (JAMSTEC)
11. Ryusuke Masunaga (JAMSTEC)
12. Hideaki Kawai (MRI)
13. Nagio Hirota (NIES)
14. Nobuhito Mori (Kyoto University)

Workshop website

The latest information and announcements can currently be found at https://wcrp-cmip.org/event/cmip26/ . A dedicated workshop website is under development.

Call for abstracts

This document provides details of the sessions approved by the CMIP Community Workshop (hereafter CMIP26) Scientific Organising Committee (SOC). The call for abstracts was launched on 23 May 2025 and the **deadline for submissions is 08:00 UTC, 13 August 2025**.

For further information and link to the abstract submission system see https://wcrp-cmip.org/cmip26-call-for-abstracts/

In the following pages you will find the titles, list of conveners and abstract for each session organized by theme. The session titles and abstracts can also be searched online here. The lead convener/s for each session are highlighted in **bold**.

Theme 1: Progress in understanding historical climate variability and change

ID	Session title
1	Earth System Forcings: CMIP7 and beyond
2	Confronting Earth System Model Trends with Observations
3	Understanding reactive gases, aerosols, and land use for air quality and climate change
4	Exploring Radiative Forcing in Models and Observations to Understand Climate Change
5	Confronting models with observed changes in the Earth's energy imbalance
6	The role of fire in the Earth System
7	Gridded Population Data and CMIP: Challenges and Opportunities
8	Evaluating models at regional scales using novel methods and multi-source observations
9	Persistent Biases in Climate Model Performance: Insights from CMIP5 to CMIP6
10	The CMIP Rapid Evaluation Framework - first results and applications
11	Precipitation observations for model assessment of precipitation types, scales, and processes: advances, methods, and current needs
12	Improvements and challenges in simulating precipitation in CMIP-class models
13	Past to Future: Integrating paleo archives to inform CMIP7 model evaluation and insights
14	Observations for coupled model evaluation: Uncertainties and opportunities

Theme 2: Understanding climate system responses, feedbacks and thresholds

ID	Session title
15	Clouds, circulation and climate sensitivity
16	AMOC in CMIP: Progress, Challenges, and Tipping Point Risks
17	Modelling Earth system tipping points, extreme outcomes, and the Tipping Points Modelling Intercomparison Project.
18	Progress in modelling solar radiation modification through GeoMIP
19	Global land carbon cycle dynamics: Understanding and constraining uncertainties
20	C4MIP scientific plans for CMIP7
21	Assessing TCRE and ZEC in CMIP7 simulations
22	Emission-driven ESMs for CMIP7 and beyond: analysis, performance and comparison with concentration-driven simulations
23	Modelling Carbon Dioxide Removal (CDR)

Theme 3: Synthesising information across the multiverse of models

ID	Session title
24	Impacts and Adaptation Data and Applications
25	Marine ecosystem projections: improving mechanistic understanding to reduce uncertainty
26	Extreme Events: Observations and Modelling
27	Emergence and Projection of Extreme Events: from Forcing/Teleconnection and from Tropical to Polar Regions
28	Advancing climate modelling and science through high-resolution simulations
29	Can we emulate CMIP now or in the future?
30	Emerging technologies in ESM and changes in observational data requirements
31	Science requirements for next generation model evaluation: from observations to advanced diagnostics and AI.
32	Responsible Use of CMIP Data in Regional Decision Contexts
33	Growing the connectivity between CMIP with the Coordinated Regional Climate Downscaling Experiment (CORDEX)
34	Understanding the South American Monsoon System's Response to Climate Change: Feedbacks, Thresholds, and Evolving Circulation Patterns in Observations and CMIP Models
35	What can we learn from single model large ensembles (SMLEs)?

Please note that some merging of sessions may occur, in consultation with session proposers, following the review of submitted abstracts.

Theme 1: Progress in understanding historical climate variability and change

ID 1: Earth System Forcings: CMIP7 and beyond

Conveners: Man Mei Chim (University of Exeter), Paul J. Durack (LLNL), Claire Macintosh (European Space Agency), **Vaishali Naik (NOAA GFDL)**, Zebedee Nicholls (Climate Resource)

Earth system variability and change arise from shifts in atmospheric composition that affect the top-of-atmosphere energy balance, from land use changes that alter surface albedo, and from changes to ocean surface temperature and sea ice among other "forced" perturbations. These natural or anthropogenic drivers of change are collectively referred to as Earth System forcing agents. Regular updates to forcing datasets are necessary to advance scientific understanding underpinning attribution and prediction of Earth System changes. We invite contributions across all aspects of forcing research, including the development of historical and future forcing datasets and their regular updates, idealized analyses, single- or multi-model frameworks, or observational methods to assess their influence on Earth system responses and feedbacks We are especially interested in studies examining responses to forcing over time, using next-generation (CMIP7), or earlier CMIP phases (CMIP6/CMIP6Plus). Submissions that explore interactions across multiple components of the Earth system—ocean, atmosphere, cryosphere, land surface and subsurface, and biosphere—and provide evidence of linked or coherent forced responses are highly encouraged.

ID 2: Confronting Earth System Model Trends with Observations

Conveners: Leandro Díaz (University of Buenos Aires), Yen-Ting Hwang (National Taiwan University), Tiffany Shaw (University of Chicago), Isla Simpson (National Center for Atmospheric Research), **Robert Jnglin Wills (ETH Zurich)**

Anthropogenically forced climate change signals are emerging from the noise of internal variability in observations, and the impacts on society are growing. For decades, Climate or Earth System Models have been predicting how these climate change signals will unfold. The climate science community and the CMIP community in particular are now in a position to confront the signals, as represented by historical trends, in models with observations.

We welcome contributions that take stock of the ability of models to capture recent trends across all Earth system components from global to regional scales and seek to answer questions such as: What are we getting right? What are we getting wrong? Why? What have we not yet paid enough attention to and where might surprises lie? Contributions could, for example, highlight successes or discrepancies in CMIP-model trends, demonstrate robust procedures for confronting observed and modeled trends, advance understanding of the origins of historical trends in the observational record and/or models (including, for example, DAMIP simulations), or employ cutting-edge methods (e.g., machine learning, kilometer-scale models, hindcasts such as those contributed to DCPP) to identify sources of model discrepancies or separate forced signals from internal variability.

ID 3: Understanding reactive gases, aerosols, and land use for air quality and climate change

Conveners: Florence Brown (ETH Zurich), Stephanie Fiedler (University of Heidelberg), Paul Griffiths (Bristol University), **Fiona O'Connor (Met Office Hadley Centre)**, Duncan Watson-Parris (Scripps Institution of Oceanography)

The second phase of the Aerosol and Chemistry Model Intercomparison Project (AerChemMIP2), part of the Coupled Model Intercomparison Project phase 7 (CMIP7), builds on the first phase of AerChemMIP (Collins et al., 2017), the Chemistry-Climate Model Initiative (CCMI), Hemispheric Transport of Air Pollution (HTAP) and previous multi-model activities. It has strong links in approach, experimental design and data request with other MIPs listed for CMIP7 such as the Radiative Forcing Model Intercomparison Project (RFMIP), ScenarioMIP, and the Detection and Attribution MIP. AerChemMIP2 aims to understand the climate and air quality impacts of aerosols and chemically reactive gases from the pre-industrial to present day and projected into the future. The experimental protocol of AerChemMIP2 closely aligns with the CMIP7 core experimental design and its registered MIPs. AerChemMIP2 experiments for attributing changes in the historical period and in future scenarios to short-lived climate forcers (SLCFs), as well as the radiative forcing experiments for individual SLCFs are listed in the CMIP7 fast track.

This session requests submissions for results from global atmospheric chemistry and aerosol climate models and/or Earth system models, e.g., from AerChemMIP, RFMIP, DAMIP and other CMIP7 simulations, and aims to bring together scientists with an interest in:

- quantifying the impact of emissions changes on atmospheric composition and radiative forcing over the period 1850-2100.
- evaluating reactive gases and aerosols in CMIP7 models against observations.
- exploring chemistry-climate interactions in CMIP7 models, with a focus on the climate response to changes in trace gas and aerosol concentrations.
- understanding components of radiative forcing.
- discussion of new analyses to address the scientific gaps and challenges arising from CMIP6.

ID 4: Exploring Radiative Forcing in Models and Observations to Understand Climate Change

Conveners: Tim Andrews (UK Met Office), **Ryan Kramer (NOAA/GFDL)**, Chris Smith (Vrije Universiteit Brussel)

Radiative forcing is the initial energy imbalance caused by a perturbation to the state or composition of the Earth system. All anthropogenic climate change is a response to the radiative forcing. Consequently, diagnosing radiative forcing is crucial to most CMIP research applications, and will continue to play a prominent role in CMIP7 through the continuation of the Radiative Forcing Model Intercomparison Project (RFMIP) and the addition of RFMIP-like, fixed-SST simulations to the CMIP7 DECK.

Despite being a fundamental metric, the definition of radiative forcing and how we quantify it continues to evolve. Since CMIP6, novel approaches have been introduced to diagnose radiative forcing in both models and observations, including through the use of machine learning techniques, line-by-line and parameterized radiative transfer schemes, simple models, and satellite data and satellite simulators. Likewise, the quantification of radiative forcing has been used to study an ever-expanding variety of climate research topics that are dependent on Earth's energy budget. In this session, we aim to highlight these recent efforts to diagnose radiative forcing for the purpose of model evaluation, constraining uncertainty, or improving understanding of the climate response more generally. We welcome any study focused on radiative forcing and hope to build a valuable community of practice ahead of CMIP7.

ID 5: Confronting models with observed changes in the Earth's energy imbalance

Conveners: Timothy Andrews (Met Office &University of Leeds), Norman Loeb (NASA Langley Research Center), Gavin Schmidt (NASA GISS), Benoit Meyssignac (LEGOS, Université de Toulouse)

The Earth's energy imbalance (EEI) refers to an imbalance between how much solar radiant energy is absorbed by Earth and how much thermal infrared radiation is emitted to space. It is a key metric of the climate system and a driver of climate change and associated impacts. Continuous monitoring of the Earth's energy budget has revealed a steadily increasing EEI (by ~ 0.5 Wm-2 per decade) since the early 2000s, seen in both satellite (e.g. CERES) and in-situ (e.g. ARGO) observations. An increasing EEI is to some extent expected from our knowledge of forcing (e.g. increased GHGs and reduced aerosol emissions), climate feedback and heat uptake process, yet the exact causes and implications are uncertain. Moreover, climate models struggle to simulate the magnitude of this trend. The reason why climate models understate this trend is unknown, and the consequences not fully understood.

In this session, we aim to explore and quantify the historical drivers of the observed increase in EEI and compare these against climate model simulations. We welcome a broad range of studies since the EEI trend is expected to depend on many processes across different timescales, including changes in forcing (both anthropogenic and natural), climate feedbacks such as trends in cloudiness and their interaction with sea-surface-temperature patterns, and natural variability such as El Niño events. Of particular relevance will be any early results from CERESMIP simulations, and we aim to build a community aimed at updating these simulations annually.

ID 6: The role of fire in the Earth System

Conveners: Man Mei Chim (University of Exeter), Meghna Soni (University of Exeter), , **Fang Li (Institute of Atmospheric Physics, Chinese Academy of Sciences)**, Matthew Kasoar (Imperial College London), **Vichawan Sakulsupich (University of Cambridge**)

Fire is the primary terrestrial ecosystem disturbance and a key Earth system process. Its frequency and intensity are expected to increase across most regions in the future, posing significant challenges for ecosystems, the carbon cycle, and society. Fire research is rapidly expanding across disciplines, emphasizing the need to advance our understanding of its interactions with climate, the biosphere, and human systems.

This session invites contributions that investigate the role of fire in the Earth system across any spatio-temporal scale, using field and laboratory observations, proxy records, remote sensing, statistical (including AI) and process-based models, and data-model fusion techniques.

We encourage abstracts addressing fire's interactions with biosphere and atmosphere: including (1) biogeochemical cycles, (2) vegetation composition and structure; (3) fire-induced trace gas and aerosol emissions; (4) wildfire plumes; and (5) atmospheric circulation, composition, and chemistry in both the troposphere and stratosphere.

We also welcome submissions exploring fire's interactions with climate, cryosphere, and society, such as (6) meteorological factors (e.g., temperature, humidity, precipitation, wind speed), (7) energy and water budgets, (8) permafrost and sea ice, and (9) human health, land use and management, conservation, and livelihoods.

Additionally, we invite submissions focusing on fire dynamics, including: (10) spatio-temporal changes in fire in the past, present, and future, (11) fire products and models, and their validation, error/bias

assessment and correction, and (12) analytical tools designed to enhance situational awareness for fire practitioners and to improve fire early warning systems.

ID 7: Gridded Population Data and CMIP: Challenges and Opportunities

Conveners: Ian Coady (University of Southampton), Jessica Espey (University of Southampton), Jen Gaskell (University of Southampton), **Laurence Hawker (University of Bristol)**

Gridded estimates of resident human population play a vital role in a range of climate modelling tasks—from driving climate models and gridding emission data, to informing detailed climate impact assessments. As demand for accurate and consistent population datasets grows, there is an urgent need to develop harmonised historical, present-day, and future population maps that capture changing demographics and employ robust, transparent methodologies for spatial allocation.

This session will focus on the current challenges and future directions in production and use of gridded population data, particularly in the context of climate modelling. While high-resolution (e.g., 100m) gridded datasets of current population distributions and demographics are commonly used in present-day planning and impact analyses, future-oriented population grids remain underutilised due to a lack of available data and complexity in interpretation. Integrating future population scenarios—especially those aligned with the Shared Socioeconomic Pathways (SSPs)—requires not only technical innovation but also careful communication of the assumptions and uncertainties underpinning these projections.

We invite contributions that address methodological, technical, and conceptual advances in this space, with the aim of fostering a CMIP-focused community dialogue around best practices and emerging opportunities. In particular, we welcome presentations on the following topics:

- Harmonization Across Time: Strategies to ensure consistency between historical, current, and future scenario gridded population maps.
- Innovative Methodologies: Advances in spatial, temporal and demographic disaggregation techniques, uncertainty estimation, and the integration of socio-economic indicators into population grids.
- Emerging Datasets: Introduction and evaluation of new population and socio-economic datasets, with a focus on their relevance for climate science.

ID 8: Evaluating models at regional scales using novel methods and multi-source observations

Conveners: Lisa Alexander (UNSW Sydney), Lincoln Muniz Alves (Instituto Nacional de Pesquisas Espaciais - INPE, Brasil), Faye Abigail T. Cruz (Manila Observatory), **Phuong Loan Nguyen (UNSW Sydney)**

Observational datasets are essential for the robust evaluation of global and regional climate models (including CMIP and CORDEX), as they enhance our understanding of historical climate variability and change and underpin the robustness of future climate projections. However, in many regions like Southeast Asia, South America, and Africa, observations are sparse and have large uncertainties, especially for rainfall and other less well-observed variables, like wind and humidity. These limitations pose significant challenges for model evaluation and selection. This session invites contributions that address innovative methods for dealing with observational uncertainties, benchmarking climate models, and constraining model outputs using multiple observational sources, including in situ, satellite-derived, and reanalysis datasets, at both global and regional scales. Contributions are welcome on, but not limited to: (1) quantifying inconsistencies across in situ, satellite-derived, and reanalysis-based observational products; (2) assessing the impacts of observational uncertainty on

model performance assessments and model selection, especially at regional scales; (3) constraining model outputs using multiple observational datasets; and (4) developing/implementing standardized frameworks and novel approaches that incorporate observational uncertainty into model assessment.

This session aims to promote discussion on best practices for model assessment by examining how the choice of datasets and metrics could impact evaluation outcomes, build confidence in climate projections, and ultimately support informed decision-making at regional scales. We especially encourage participation from researchers in model development and evaluation, especially from the global South, as well as those from observational dataset development.

ID 9: Persistent Biases in Climate Model Performance: Insights from CMIP5 to CMIP6

Conveners: Florence Alice Brown (ETH Zürich), Sabine Bischof (GEOMAR Helmholtz Centre for Ocean Research Kiel), Robert Fajber (McGill University), **Sifan A. Koriche (University of Alabama),** Ankur Srivastava (Indian Institute of Tropical Meteorology)

Despite advancements in climate modeling from CMIP5 to CMIP6, several persistent biases continue to challenge the accuracy of climate projections. This session provides a platform to present and discuss persistent biases in model performance, examining their influence and focusing on their implications for model fidelity and future development. We invite contributions that explore the following:

- Comparative analyses of model biases across CMIP3, CMIP5, and CMIP6, focusing on key climate variables throughout all earth system components.
- Investigations into regional biases, including those over complex terrains, southeast tropical Atlantic, Greater Horn of Africa (short-long rain), North Pacific (Cold Temperature Biases).
- Individual model studies on reasons and possible solutions for persistent model deficiencies such as the double ITCZ bias, the Amazonian dry bias, the representation of the Pacific cold tongue or the stratospheric polar vortex, etc.
- Discussions on the implications of model biases for future model development and climate prediction accuracy.
- By synthesizing findings from various studies, this session seeks to enhance our understanding of persistent model biases and inform strategies for their resolution in upcoming model iterations.

ID 10: The CMIP Rapid Evaluation Framework - first results and applications

Conveners: Birgit Hassler (DLR), Forrest M. Hofmann (ORNL), Ranjini Swaminathan (University of Reading), Briony Turner (CMIP International Project Office)

The Rapid Evaluation Framework (REF) is a new CMIP led initiative to support the routine evaluation of new simulations, and to improve the availability and access to the obtained evaluation results. The REF is being deployed at Earth System Grid Federation (ESGF) nodes, where it will be automatically run to evaluate simulations as they are published and the results are made available to researchers and the public. In its initial version, the REF contains several different diagnostics, calculated by four different open-source evaluation software packages, from five different realms. These diagnostics were selected due to their importance in helping to understand the simulated Earth System and some realm-specific processes.

In this session, we invite abstracts that focus on the use and the application of REF results within the CMIP and also the wider climate communities. Topics of interest include but are not limited to:

- Analysis of results provided by the REF diagnostics.
- Applications of the REF results to advance scientific studies.
- Utilization of the REF results to further downstream applications.
- Application of the REF results for IPCC AR7 analyses.

ID 11: Precipitation observations for model assessment of precipitation types, scales, and processes: advances, methods, and current needs

Conveners: Lincoln Muniz Alves (Centro de Ciência do Sistema Terrestre - CCST/INPE), **Charlotte DeMott (Colorado State University),** Ruby Leung (Pacific Northwest National Laboratory), Akiyo Yatagai (Hirosaki University), Ming Zhao (NOAA Geophysical Fluid Dynamics Laboratory),

Precipitation is a critical component of the water cycle. Accurate measurements of precipitation across scales remains a challenge, limiting process understanding and modelling, including predictions and projections. The Global Precipitation Experiment (GPEX) is a new WCRP Lighthouse Activity that aims to reduce knowledge gaps in measurement and modeling of precipitation across scales and improve precipitation predictions around the world. One objective of GPEX is to leverage existing and newly curated precipitation datasets, storm tracking tools and datasets for improvements in process understanding in support of model evaluation.

This session welcomes studies that highlight the utility or limitations of current precipitation datasets, reanalyses, and proxy datasets for model assessment of precipitation types, scales, processes, and storm types in CMIP6 and/or early CMIP7 model output. Examples of topics appropriate for this session include studies focused on:

- Advances in observing precipitation intensity, phase, and duration for understanding connections between model precipitation errors and precipitation projections.
- Advancing homogenization of long-term datasets, particularly in data sparse regions, to enable observational data constraints on CMIP projections.
- Assessing the sensitivity of model errors in precipitation and related-storm characteristics to benchmark precipitation products and for different storm tracking methods as applied to, e.g., atmospheric rivers, mesoscale convective systems, tropical cyclones, and monsoons.
- Using high-resolution observational datasets for assessment of high-resolution simulations (e.g., HighResMIP, DYAMOND).
- Developing precipitation metrics that enable like-for-like comparisons of observed and simulated precipitation characteristics and their connections to the environments.
- Using observations of precipitation and states to constrain modeling of precipitation, particularly in data sparse regions (e.g., polar, mountains).
- Strategies for filling data gaps identified in the IPCC AR6 Atlas, especially for polar and remote regions, including as well as the use and limitations of reanalysis products as proxy observations.
- Addressing challenges of measuring solid precipitation, especially in high latitudes and mountainous regions.

ID 12: Improvements and challenges in simulating precipitation in CMIP-class models

Conveners: Annalisa Cherchi (Institute of Atmospheric Sciences and Climate (CNR-ISAC)), Maria Laura Bettolli (Ciudad Universitaria Pabellón), Ayantika Dey Choudhury (Indian Institute of Tropical

Meteorology), **Hayley Fowler (Newcastle University)**, Hui Su (Hong Kong University of Science and Technology)

Modelling and prediction of precipitation over land and oceans is still a big challenge in climate research. Understanding and accurately modeling precipitation associated with high-impact weather systems such as Atmospheric Rivers (AR), Mesoscale Convective Systems (MCSs), Monsoons, and Tropical Cyclones remains a major challenge for the CMIP community. These phenomena are the main focus of the WCRP Lighthouse Activity, Global Precipitation Experiment (GPEX), which aims to reduce knowledge gaps in measurement and modeling of precipitation across scales and improve precipitation predictions around the world. This session aims to bring together researchers investigating how these phenomena are represented in current and upcoming-generation climate models. How large-scale circulation is linked with such regional precipitation patterns is of paramount importance in climate models, as CMIP-class models still misrepresent the strength, timing and spatial imprint of large-scale remote drivers like ENSO, MJO, IOD and AMV on regional precipitation, with clear implications for the precipitation projected response.

Contributions to this session could include the assessment of models' skill in simulating precipitation, exploring the underlying physical processes producing precipitation, identifying the sources of major biases, and proposing strategies for improvements in simulation. Studies that address how these precipitation systems, extremes and global versus regional precipitation patterns may change under future climate, their uncertainties, and regional impacts are also encouraged. We welcome contributions leveraging high-resolution modeling, machine learning, novel diagnostics and using novel constraints on projections. The session will also serve as a forum for discussing coordinated efforts to improve precipitation modeling, prediction and process understanding in future CMIP activities with strong contributions and linkages to GPEX.

ID 13: Past to Future: Integrating paleo archives to inform CMIP7 model evaluation and insights

Conveners: Chris Brierley (University College London), Ran Feng (University of Connecticut), Masa Kageyama (LSCE), Louise Sime (British Antarctic Survey), **Christian Stepanek (AWI)**, Masakazu Yoshimori (University of Tokyo)

Paleoclimate simulations and proxy data offer a critical but underused resource for evaluating and improving Earth System Models (ESMs). As CMIP7 focuses on fast-track experiments supporting IPCC AR7, paleoclimate studies can directly inform its guiding questions. Proxy records and simulations of past warm periods—such as the Pliocene, Miocene, Eocene, Last Interglacial and Holocene— but also of the Last Glacial Maximum can constrain patterns of environmental change, especially the co-evolution of tropical and high-latitude regions, in particular with regard to sea surface temperature and weather patterns. Paleoclimate model intercomparison studies and model-proxy comparison bring ESMs out of their modern comfort zone and support identification of model uncertainty that may be overlooked if focusing on the observational period alone. High-resolution paleodata also captures the frequency and intensity of extreme weather events across millennia, providing essential context for modern extremes, and let us explore thresholds for abrupt climate change and its dynamics. Long-term carbon cycle feedbacks observed during glacial-interglacial transitions help test and refine model behavior under emission-driven scenarios, directly supporting CMIP7's focus on the water-carbon-climate nexus. Finally, the paleorecord reveals real-world tipping points—such as abrupt climate shifts and ice sheet collapse—that are vital for testing early warning indicators and understanding irreversibility. This session invites abstracts that use paleoclimate data and simulations to evaluate, constrain, or design CMIP7 experiments, including contributions from PMIP, model-data comparisons, long transient simulations, and the use of machine learning or data assimilation in paleoclimate applications. We aim to bring together the paleoclimate and CMIP communities to ensure that the deep-time record informs our understanding of future climate risks and system

behavior. We particularly encourage submissions connecting model responses to the WhatIfMIP experiments with their paleoclimate counterparts.

ID 14: Observations for coupled model evaluation: Uncertainties and opportunities

Conveners: Swen Brands (CSIC), Demiso Daba (Arba Minch University), Dora Hegedus (STFC), Jerry Tjiputra (NORCE)

As the complexity, resolution, and experimental diversity of coupled climate model simulations continue to grow, so does the need for observational datasets that are suitable for model evaluation and initialization across all components of the climate system and experimental setups. However, observational datasets have spatial and temporal limitations and become increasingly sparse further back in time. Additionally, a scale mismatch exists between in-situ measurements and the spatial-temporal resolution of models. These and other factors introduce uncertainties that must be considered and addressed in the practice of climate model evaluation. This session aims to explore these challenges and invites abstracts on topics including but not limited to:

1. Presentation of observational datasets, including reanalysis and remotely sensed products, across all components of the coupled climate system
2. Bridging the scale gap between observations and model representations
3. Documentation of observational uncertainties, inconsistencies, or errors in commonly used datasets relevant to climate model evaluation
4. Regional observational datasets for high-resolution model evaluation
5. Process-based evaluation and intercomparison of observational datasets
6. Synergies between observational dataset development and climate model advancement
7. Metadata conventions in observational datasets that enhance their utility for model evaluation
8. Datasets for initialized climate prediction (decadal and seasonal)
9. Initial shocks in initialized climate prediction systems
10. Best practices for addressing observational uncertainties in model evaluation and initialized climate prediction

We also welcome poster abstracts presenting exploratory research ideas on synthesizing quantification of observational uncertainty and integrating them into model evaluation frameworks. This is done to foster discussion in the community and as a way for authors to get feedback on proposed research.

Theme 2: Understanding climate system responses, feedbacks and thresholds

ID 15: Clouds, circulation, and climate sensitivity

Conveners: Timothy Andrews (Met Office), Paulo Ceppi (Imperial College London), **Yen-Ting Hwang (National Taiwan University)**, Sarah Kang (MPI Meteorology), Masahiro Watanabe (University of Tokyo)

Clouds and convection play a central role in shaping Earth's weather and climate, yet many of the underlying processes remain uncertain. This session invites contributions that address the fundamental physical mechanisms governing cloud and convective processes and their interactions with atmospheric dynamics, radiation, and climate feedbacks. Studies examining the two-way coupling between sea surface temperature patterns and radiative feedbacks, often referred to as the "pattern effect", are also encouraged, extending our understanding of the ocean's role in modulating cloud feedbacks and climate sensitivity.

We welcome studies that explore:

1. Climate feedbacks and sensitivity: How do clouds respond to external perturbations? How do clouds influence climate sensitivity and patterns of change?
2. Energy Imbalance: How do we measure, model, and understand the factors controlling Earth's energy imbalance?
3. Convection: What processes control shallow and deep convection including organization, and how do these interactions affect climate and weather?
4. Circulation and climate dynamics: How do clouds couple to circulations and what role does this coupling play in weather and climate?

The analysis may include idealized experiments, such as abrupt 4xCO_2 and 1% per year CO_2 increase experiments, CFMIP experiments, realistic historical and future projection scenarios, as well as comparisons with observational and reanalysis data, all of which fall within the scope of the session.

ID 16: AMOC in CMIP: Progress, Challenges, and Tipping Point Risks

Conveners: Marius Årthun (Nansen Environmental and Remote Sensing Center), **Marion Devilliers (Danish Meteorological Institute),** Aixue Hu (National Center for Atmospheric Research), Torge Martin (GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel), Ilana Schiller-Weiss (Danish Meteorological Institute)

The Atlantic Meridional Overturning Circulation (AMOC) is a critical component of the global climate system, transporting heat and carbon, shaping regional climate variability and sea level change. Emerging evidence suggests that the AMOC may be weakening, raising concerns about a potential tipping point under global warming. While CMIP-class models remain essential for understanding the past and future evolution of the AMOC, their ability to accurately represent fundamental processes, such as dense overflows, water mass transformation, and AMOC sensitivity to climate change remain questioned. Are these models suitable for assessing the risk of abrupt AMOC transitions?

This session invites contributions that explore the representation, variability, sensitivity and predictability of the AMOC in CMIP5, CMIP6, and upcoming CMIP phases. We welcome studies that:

- Evaluate model performance against observations and reanalyses.
- Analyze future AMOC projections under various emission scenarios.
- Investigate model spread, uncertainties, and key feedback mechanisms.
- Assess early-warning indicators and tipping point precursors.
- Examine the role of grid resolution, parameterizations, and freshwater forcing.
- Propose or apply new diagnostics for the AMOC and related processes including novel machine learning and other AI-based methods.

We particularly encourage submissions that link AMOC behavior to broader climate system dynamics -- including Arctic freshwater export, Southern Ocean processes, ocean-atmosphere interaction, as well as studies proposing coordinated analyses or experimental designs for future CMIP activities. This session aims to bring together the modeling, observational, theoretical, and AI/ML communities to critically assess current CMIP model capabilities on skillfully simulating the AMOC, identify critical knowledge gaps, and discuss pathways towards improved model representation of the AMOC and tipping risk assessment. We hope to foster collaborative efforts that support the development of targeted experiments and diagnostics for CMIP7 and beyond.

ID 17: Modelling Earth system tipping points, extreme outcomes, and the Tipping Points Modelling Intercomparison Project

Conveners: Donovan Dennis (Potsdam Institute for Climate Impact Research (PIK)), Jonathan Donges (PIK), Sina Loriani (PIK), **Bette L Otto-Bliesner (NSF NCAR),** Anastasia Romanou (NASA Goddard Institute for Space Studies), Ricarda Winkelmann (Max Planck Institute of Geoanthropology (MPI-GEA), Tokuta Yokohata (National Institute for Environmental Studies)

Tipping elements in the Earth system—such as the Greenland and Antarctic ice sheets, the Atlantic Meridional Overturning Circulation (AMOC), high-latitude permafrost, and major terrestrial biomes—may respond abruptly, rapidly, and irreversibly to anthropogenic forcing. Capturing potential tipping points, critical thresholds, and high-impact shocks in climate models remains a major challenge and source of uncertainty in projections of future climate change. This is due in part to limitations in current model structures and the complexity of simulating thresholds, feedbacks, and abrupt transitions across scales.

This session solicits contributions on the modelling and consequences of tipping points in the Earth system, including:

- coupled and process-based simulations of abrupt change.
- advances in model development for nonlinear systems.
- multi-model comparisons.
- theoretical analyses, Machine Learning Artificial Intelligence emulators.
- strategies to improve representation of tipping dynamics in Earth system models.
- storylines of extreme outcomes in the future.
- cascading global and regional impacts of potential Earth system tipping points, large-scale, critical thresholds, or high-impact shocks after their triggering.
- broader consequences across the climate system, ecosystems, and societies.

We anticipate many contributions from community members involved in the Tipping Points Modelling Intercomparison Project (TIPMIP), a CMIP-registered initiative designed to systematically explore and

constrain tipping dynamics in coupled Earth system models as well as standalone domain models. However, we warmly welcome modelling teams already involved in TIPMIP as well as other efforts, including but not limited to, national and EU projects (e.g. TipESM, ClimTip, OptimESM), and other MIPs (e.g. ISMIP, LUMIP, C4MIP, PMIP, NAHosMIP, HighResMIP).

ID 18: Progress in modelling solar radiation modification through GeoMIP

Conveners: Ewa Bednarz (NOAA), Temitope Egbebiyi (University of Cape Town), **Matthew Henry (University of Exeter)**, Daniele Visioni (Cornell University), Lili Xia (Rutgers University),

Solar Radiation Modification (SRM, also known as sunlight reflection methods or solar geoengineering), is a set of proposals to temporarily modify Earth's radiation budget in order to mitigate the adverse impacts of climate change. The Geoengineering Model Intercomparison Project (GeoMIP), which has been part of the Coupled Model Intercomparison Project (CMIP) since CMIP5, has proposed multiple modelling experiments to understand the physical mechanisms underlying the potential climatic impacts of SRM, and to understand sources of agreement and disagreement across different climate models. Most recently, the project expanded with the new G6-SAI-1.5K experiment for Stratospheric Aerosol Injection, which has been designated as a CMIP7 Assessment Fast Track experiment. Moreover, there are ongoing efforts towards developing a similar experimental protocol for marine cloud brightening (MCB), thus broadening GeoMIP's scope by comparing contrasting mechanisms of radiative perturbation. In this session, we welcome recent results relevant to GeoMIP, including the assessment of inter-model differences in recent experiments, new findings on MCB protocols, as well as new analyses of downstream impacts of SRM targeting vulnerable and underrepresented communities who may be disproportionately affected. We also encourage studies focusing on the development of SRM scenarios to be included in future GeoMIP experiments, downscaling efforts, and methodologies to facilitate analyses of GeoMIP results by leveraging cloud-based computing.

ID 19: Global land carbon cycle dynamics: Understanding and constraining uncertainties

Conveners: Rosie A. Fisher (CICERO Center for International Climate Research), Julia K. Green (University of Arizona), David M. Lawrence (NSF National Center for Atmospheric Research), **Lina Teckentrup (Barcelona Supercomputing Center)**, Alexander J. Winkler (Max-Planck-Institute for Biogeochemistry, Jena)

Land removes around a third of anthropogenic CO_2 emissions and is therefore crucial in mitigating climate change. However, the simulated land carbon uptake in CMIP-type models for the historical period and in future projections is linked to large uncertainty, with uncertainty in the i) sign and magnitude of trend, ii) strength of interannual variability, iii) the partitioning of carbon among ecosystem pools, and iv) different sensitivities to key processes and drivers.

For this session, we invite contributions that address uncertainty in the terrestrial carbon cycle and offer solutions for future development. We particularly welcome submissions on

1. Challenges in current modeling approaches
We welcome contributions that identify key sources for biases and uncertainty in existing carbon-cycle-enabled CMIP models, such as uncertainty in parameterization, model assumptions, and sensitivities to forcings and processes, with a focus on quantifying the biases

2. Using observations to constrain model predictions
Contributions that explore how observational data (e.g., satellite data, flux tower measurements, remote sensing) can be used to better constrain land carbon simulations, e.g. challenges in evaluating model predictions to observations and/ or methods for integrating observational data into models.

3. Novel modeling approaches to reduce uncertainty and biases

We welcome contributions on innovative methods to reduce uncertainty and biases in land carbon predictions and projections, including hybrid models that combine process-based and data-driven techniques, machine learning methods to enhance model calibration, and methods for uncertainty quantification.

ID 20: C4MIP scientific plans for CMIP7

Conveners: Vivek Arora (Environment and Climate Change Canada), Pierre Friedlingstein (University of Exeter), Tatiana Ilyina (Universität Hamburg), Chris Jones (UK Met Office)

Quantification and understanding of the response of land and ocean C cycles to increasing atmospheric CO_2 concentration, the resulting climate change associated with increasing CO_2 and other GHGs, and other drivers of C cycle including nitrogen deposition are key to projecting future airborne fraction of anthropogenic emissions and therefore the resulting changes in climate. Enhancing this understanding has been the core purpose of the Coupled Carbon Cycle Climate Model Intercomparison Project (C4MIP) through the last two phases of the Coupled Modelling Intercomparison Project (CMIP). Primary C4MIP analyses through the last two CMIP phases have been based on concentration-driven Earth System model (ESM) simulations, although a smaller number of emissions-driven simulations were also performed. The seventh phase of CMIP places a higher focus on emissions-driven ESM simulations, and C4MIP analyses need to evolve to able to use emissions-driven simulations and characterize land/ocean C cycle responses using metrics that are less scenario dependent than they have been in the past. The response of land/ocean C cycles in scenarios of decreasing and negative emissions, and our understanding of the response of fires, permafrost C feedback, nutrient dynamics, and dynamic changes in marine biology and in geographical distribution of vegetation in response to changes in climate and other environmental drivers also need to be quantified. Quantification of the C cycle response of these processes feeds directly in the calculation of the transient climate response to cumulative emissions (TCRE). This session invites submissions that will help lay the groundwork for novel analyses for better quantification/characterization of these processes in coupled ESMs participating in CMIP7.

ID 21: Assessing TCRE and ZEC in CMIP7 simulations

Conveners: Chris Jones (Met Office Hadley Centre), Roland Seferian (CNRM), Pierre Friedlingstein (University of Exeter), Tatiana Ilyina (Universität Hamburg), Ben Sanderson (CICERO)

The IPCC AR6 quantification of the remaining carbon budgets (RCB) consistent with global warming level such as 1.5°C or 2°C is fraught with such a large uncertainty that it is hardly useful for decision-making. The remaining carbon budget for 1.5°C is very likely to be between 300 and 900 billion tons CO_2. This large uncertainty primarily comes from the Transient Climate Response to cumulative Emissions (TCRE), as it is the primary determinant of the RCB. IPCC AR6 assessment of TCRE showed a large uncertainty (0.27 to 0.63°C per 1000 billion tons CO_2 emitted). The Zero Emissions Commitment (ZEC) also plays a vital role in determining the remaining carbon budget but also the ability of the world to stabilise climate and to inform action needed to achieve overshoot and recovery scenarios. Information on reversibility and symmetry is sorely lacking.

It is important to draw on CMIP7 output to assess new understanding on TCRE and ZEC, with special focus on the newly design flat10 suite of experiments. The goal of the session is to bring together the multiple strands of evidence and expertise which are needed to make a substantial advance in our understanding of TCRE and ZEC, and how these can inform RCB estimates.

Specific topics will include:

- Understanding TCRE and ZEC components, frameworks for investigating the processes and contributions to TCRE, ZEC, and identifying where uncertainty comes from, focus on Land/Ocean processes (e.g., CO_2 fertilization, permafrost; ocean co-uptake of heat/CO_2)
- Observational or Emergent constraints.
- Use of simple models/emulators and model hierarchy.

ID 22: Emission-driven ESMs for CMIP7 and beyond: analysis, performance and comparison with concentration-driven simulations

Conveners: Tomohiro Hajima (JAMSTEC), Birgit Hassler (DLR), Colin Jones (Leeds University/NCAS), **Roland Séférian (CNRM)**, Nicolas Vuichard (LSCE)

While being established over the last decades, the use of Earth system models (ESMs) running with anthropogenic emission of CO_2 remains marginal in CMIP exercises. This is changing in CMIP7 where the use of these emission driven model configurations has been promoted across a number of key experiments (flat10, historical reconstructions, ScenarioMIP, TIPMIP) in order to better capture the full range of uncertainties and feedbacks (from emission to climate change), providing a benchmark for simple climate models and also offering an avenue to assess the geophysical realism of mitigation pathways by representing internally carbon dioxide removal technologies.

To date the body of literature assessing the performance of these model configurations is rather small compared to that of the traditional approach to perform climate simulation — driven by CO_2 concentration. Thus, the knowledge on both the performance of these models' configurations and on the Earth system feedbacks within these ESMs is still limited.

The goal of the session is to bring together the community of model developers, experts in model-data evaluation and related communities to assess the performance of the latest generation of emission-driven ESMs contributing to CMIP7 and beyond, including differences relative to their concentration-driven counterpart. The session will also discuss the consequences of both an emission- and concentration- driven projection ensembles in CMIP7, and how to best combine these for estimating future GHG budgets and warming targets.

Additionally, this session also welcomes applications of advanced Earth system model development incorporating modeling of non-CO_2 greenhouse gases such as methane or nitrogen and process-based representation of carbon removal options.

ID 23: Modelling Carbon Dioxide Removal (CDR)

Conveners: Raffaele Bernardello (Barcelona Supercomputing Center), Anna Harper (University of Georgia), **Nadine Mengis (GEOMAR Helmholtz Center for Ocean Research)**, Jörg Schwinger (NORCE Norwegian Research Centre)

Most future scenarios that limit global warming to below 2°C by 2100 rely on the large-scale implementation of carbon dioxide removal (CDR) measures. While CDR is increasingly recognized as a key component of climate change mitigation, its representation in Earth system models (ESMs) remains limited and often lacks the details required to capture key processes and feedbacks. This constrains our ability to assess the efficacy, side effects, and system-wide implications of CDR within climate mitigation pathways.

A new phase of the Carbon Dioxide Removal Model Intercomparison Project (CDRMIP) is now being launched for CMIP7. It aims to address key scientific questions including:

1. How effective are (explicit) CDR implementations in terms of removal efficiency, what carbon–climate feedbacks do they trigger, and what are their expected side effects including biophysical effects; and how does this vary under net-positive, net-zero and net-negative emissions?
2. What are the discrepancies between integrated assessment model (IAM) scenarios, typically based on reduced-complexity climate models, and fully coupled ESMs when CDR is explicitly represented? How do these mismatches affect assessments of additionality and interactions among different CDR options within mitigation portfolios?
3. This session will introduce the aims and design of the upcoming CDRMIP phase and present the experimental protocol for CDRMIP. The session is meant to offer a platform to share and discuss early CDR implementation examples. We invite contributions focusing on CDR representation in IAM and ESMs, results from the previous CDR model intercomparison, example for challenges in CDR implementation, and experiences from the IAM–ESM chain, when it comes to CDR. The session will also provide space to discuss coordination needs for the success of CDRMIP and opportunities for community collaboration moving into CMIP7.

Theme 3: Synthesising information across the multiverse of models

ID 24: Impacts and Adaptation Data and Applications

Conveners: Xiaomao Lin (Kansas State University), **Alex Ruane (NASA)**NASA, Wan-Ling Tseng (National Taiwan University)

This session will describe the CMIP7 Impacts and Adaptation (I&A) Theme Data Request and highlight Vulnerability, Impacts, Adaptation and Climate Services (VIACS) applications across society.

Recognizing the increasingly vital role of impacts and adaptation work in demonstrating the value of CMIP work, the VIACS Advisory Board was created in CMIP6 and carried into CMIP7, where it fed directly into the process by which CMIP7 determined model outputs requested by model user communities. Feedback from those communities underscored the need for foundational Earth System Model (ESM) outputs upon which dynamical and empirical downscaling, bias-adjustment, impacts models, and emulators all fed into information products that support climate action planning across sectors and around the world. This included requests for specific sets of variables that enable the calculation of climatic impact-driver indices and tolerance thresholds that determine ecosystem and societal risk, as well as variable groups describing ESM outputs that could be processed into input data for impacts models.

The I&A Data Request Team identified several mechanisms to prioritize resources given ESM group constraints, resulting in more targeted guidance for ESM groups seeking to produce outputs that will inform planning for agriculture, water resources, forestry, biodiversity, human health, cities, infrastructure, and other systems. The session will also highlight applications of ESM outputs for sectoral impacts and adaptation studies, inviting participants to share their experiences applying CMIP6 outputs as well as pilot applications of the newest CMIP7 outputs as they become available.

ID 25: Marine ecosystem projections: improving mechanistic understanding to reduce uncertainty

Conveners: Daniele Bianchi (University of California Los Angeles), Filippa Fransner (University of Bergen), Yong-Yub Kim (Institute for Basic Science Center for Climate Physics, Busan), Colleen Petrik (Scripps Institute of Oceanography), **Keith Rodgers** (Advanced Institute for Marine Ecosystem Change, Tohoku University)

What are the key processes that are responsible for the well documented uncertainty in marine ecosystem projections under climate change, ranging from primary production to fish? Critical progress has been made over the last two decades in the joint application of both Earth system models (ESMs) and Marine Ecosystem models (MEMs) to identify uncertainty in future projections, with this reflected in synthesis efforts with ESMs (Kwiatkowski et al., 2020) and MEMs (Tittensor et al., 2021). However, to date the underlying mechanisms are often not understood. Thus, there is an urgent need moving forward to investigate underlying processes that sustain uncertainty, as a means to improve community confidence in projections.

This session welcomes abstracts on topics that span lower trophic levels (LTLs) to upper trophic levels (UTLs), both from modeling and from observations, that can contribute to elucidating key process

understanding that can serve to benefit community modeling efforts to project anthropogenic changes in projected ecosystems. For ESMs and their representation of LTLs, this would include investigations into primary production, biomes-related quantities, as well as oxygen cycling. For MEMs and UTLs, this would include both process-focused model experiments and regional analyses that highlight model strengths and weaknesses, as well as consideration of potential emergent constraints for future change building on understanding derived from contemporary observations.

ID 26: Extreme Events: Observations and Modelling

Conveners: Bin Chen (Chinese Academy of Meteorological Sciences), Pawan Kumar Chaubey (Nanyang Technological University), Mohan Kumar Das (National Oceanographic And Maritime Institute), **Sridhara Nayak (Japan Meteorological Corporation)**, T. P. Sabin (Indian Institute of Tropical Meteorology), Yuan Tian (Lingnan Normal University), **Yang Zhao (Ocean University of China)**,

In recent years, intensifying flash floods, droughts, mesoscale convective systems, heatwaves, cold waves, tropical cyclones, storm surges, thunderstorms, atmospheric rivers and other high impact hydrometeorological hazards have stressed the urgent need to explain scientific advances into practical tools that protect societies and save lives.

This session aims to deepen our understanding of the spatial and temporal characteristics of these extreme events, including the impact of human activities on the evolving behavior of extremes, and to improve their predictability using observational data and numerical model simulations. We particularly encourage studies that use CMIP or CMIP downscaled data to investigate extreme events in both historical simulations and future climate projections, including near-term (e.g., 30 years) and long-term (e.g., 100 years) period to support policymakers in creating more resilient societies by providing robust projections for risk mitigation and adaptation strategies. Abstracts that aim to assess how various climate models capture the frequency, intensity, and distribution of extreme events under different climate change scenarios are highly welcomed.

We also welcome abstracts that focus on evaluating how well climate models simulate extreme events, as well as studies that aim to improve confidence in future climate projections to support risk management and decision-making.

ID 27: Emergence and Projection of Extreme Events: from Forcing/Teleconnection and from Tropical to Polar Regions

Conveners: Huang-Hsiung Hsu (Academia Sinica), Eun-Soon Im (The Hong Kong University of Science and Technology), Yu Kosaka (University of Tokyo), Yu-Chiao Liang (National Taiwan University), **Min-Hui Lo (National Taiwan University)**

As global warming intensifies, the frequency and severity of extreme events - heatwaves and droughts, cold surges from tropics to the poles - are increasing, revealing the growing crisis in the Earth's climate system. These extremes are shaped not only by local forcings but also by large-scale teleconnections and internal climate variability, including evolving El-Niño Southern Ocean dynamics and tropical-polar linkages, whose behavior under anthropogenic influences are engaging climate research field. This session invites contributions that investigate the emergence, evolution, and projection of extreme events, with particular emphasis on the underlying physical and dynamic mechanisms. We welcome studies that explore the interactions between anthropogenic forcings and teleconnection patterns across spatial and temporal scales, from the tropics to the poles. We encourage submissions that use satellite observations, advanced climate modeling, and AI-assisted approaches to uncover hidden relationships and physical processes, assess cascading impacts on hydrological systems, and support

climate adaptation and governance strategies. By fostering interdisciplinary dialogue among hydrologists, climate scientists, and Earth system modelers, this session aims to advance our mechanistic understanding of extreme event formation and propagation under anthropogenic global change, offering actionable insights for both science and policy.

ID 28: Advancing climate modelling and science through high-resolution simulations

Conveners: Qing Bao (Institute of Atmospheric Physics, Chinese Academy of Sciences), Jung-Eun Chu (City University of Hong Kong), Chihiro Kodama (Japan Agency for Marine-Earth Science and Technology), Ja-Yeon Moon (IBS Center for Climate Physics), **Sun-Seon Lee** (IBS Center for Climate Physics), **Kevin A. Reed (Stony Brook University)**, Malcolm J. Roberts (Met Office), Axel Timmermann (IBS Center for Climate Physics)

The potential for increasing spatial resolution to improve process representation in all Earth system components continues to be of great interest to the scientific community. Advancing projections and predictions of climate variability and change, particularly at regional scales, relies on the adequate simulation of processes and feedbacks across a range of spatial scales. Recent advances in high-resolution modeling, such as those completed as part of the High-Resolution Model Intercomparison Project (HighResMIP), have demonstrated potential changes in both large-scale aspects and the regional responses of the ocean and atmospheric circulations due to climate change, in addition to improvements in representations of small-scale processes and extremes. This session welcomes submissions that document recent advances of high-resolution global models or analyze large-scale, regional, and/or local-scale responses to climate change in high-resolution simulations. For the purposes of this session, high-resolution is defined to be atmospheric and ocean model component grid spacings of 25 km or less, including global cloud-resolving model and high-resolution Earth system models. Studies that make use of HighResMIP phase 2 protocols and other kilometer-scale climate simulations to further advance our understanding of the role of horizontal resolution in state-of-the-art simulations are particularly encouraged. We invite studies that (1) evaluate if high-resolution can reduce key structural uncertainties in future climate projections, (2) identify resolution-dependent atmospheric or oceanic processes that are missing from standard-resolution CMIP models that might impact recent or future climate simulations, and (3) uncover new scientific insights through the explicit representation of small-scale processes such as convective systems, tropical cyclones, and mesoscale dynamics in the atmosphere and ocean, combine information from high-resolution and lower resolution models, together with other data sources and processing, to inform future adaptation and climate risk planning. Work that makes use of progress from recent WCRP-led hackathons focusing on high-resolution are also of interest.

ID 29: Can we emulate CMIP now or in the future?

Conveners: Helene Hewitt (Met Office), **Baylor Fox-Kemper (Brown University)**, Shruti Nath (University of Oxford), **Yann Quilcaille (ETH Zurich),** Katsumasa Tanaka (LSCE), Duncan Watson-Parris (UCSD), Christopher Womack (MIT)

While CMIP models remain crucial for Earth sciences, climate emulators calibrated on CMIP models and/or on observations can complement the CMIP process in many ways, often at a lower computational cost than direct applications of CMIP models would. Using emulators together with CMIP models enables new science: especially accelerated computation of future scenarios and linking to other modelling frameworks, data assimilation, or new interpretation frameworks. While all emulators simplify the modelling using various techniques based on physics, statistics, and more recently machine learning and artificial intelligence, the emulators come with different focuses. For instance, global-level reduced dimension simple climate models focus on emissions & land-use scenarios to project global climate, domain emulators focus on specific components of the Earth

system (e.g., ice sheet or ocean emulators), and spatial climate emulators build on simple climate models to provide spatial climate fields. Emulators combined with CMIP models enables new science: (1) accelerated computation of new scenarios to get a "sneak peek" of results on more regular intervals than formal CMIP release; (2) linking to other modelling frameworks for instance to model the feedbacks between human and natural systems; (3) exploring uncertainties and natural variability; (4) and more, such as data assimilation, new interpretation frameworks, establishing ensemble ranges at lower costs, enabling deeper time exploration, etc.

In this session, we would like to explore the breadth of approaches that are being investigated and the benefits that they will bring to the CMIP endeavour, including (1) the research of such tools, whether based on physics, statistics, machine learning, hybrid or other approaches; (2) the calibration and validation on CMIP models; (3) the applications of such tools for the exploration of climate scenarios, maybe including linking to economic and integrated assessment variables; (4) new co-development approaches where CMIP experiments might be complemented with emulator assistance to access new scientific questions (e.g., volcanism); and (5) contributions that address the limitations of emulators. We invite contributions across all the domains that CMIP covers.

ID 30: Emerging technologies in ESM and changes in observational data requirements

Conveners: Fanny Adloff (ESMO International Project Office), Swen Brands (CSIC), Amy Doherty (Met Office), Birgit Hassler (DLR), Forrest M. Hoffman (ORNL), Claire Macintosh (European Space Agency), Yuhan Douglas Rao (NCSU), Ranjini Swaminathan (University of Reading)
Jerry Tjiputra (NORCE Norwegian Research Centre)

New and emerging technologies are increasingly impacting all methods of operation in climate science. Advanced modelling efforts seeking to represent the global Earth system in ever finer detail are targeting cloud-resolving, km-scale resolutions. Earth System Models (ESMs) serve as digital twins of our climate system, providing projections of future changes under various scenarios. Machine Learning and Artificial Intelligence approaches are now often integrated into Earth System Models and used in the handling of the data outputs. Increasingly complex atmospheric, ocean, land surface and biogeochemical processes are being implemented across the Earth System Modelling landscape, and require new observational data streams, including curated efforts like Obs4MIPs. The anticipated increase in the number and complexity of ESMs in the upcoming Coupled Model Intercomparison Project (CMIP7) will improve understanding but also increase the spread and uncertainty of projections. On the other hand, the interdependencies among ESMs can lead to similarities in behavior, necessitating novel methodologies to improve model-data evaluations. The trend towards increased resolution and more complex process representation has implications for observations that are required to initialise, evaluate, develop, and constrain projections of traditional ESMs. These shifts in ESM landscapes affect the observational community in several ways, including the need to expand and evolve existing frameworks like Obs4MIPs to support higher resolution, more process-rich models. New data requirements for training, validating, and critically assessing biases in AI models increasingly incorporate contemporary observable mechanisms and diverse Earth Observation (EO) data. Further, improvements in model processes will help reveal the efficacy of observations and identify ideal targets for the next generation of observational platforms and the re-evaluation of existing mission data. In this session, we invite speakers to describe the changing requirements of observation users and implications of emerging ESM technologies for observations, and how WGORC and Obs4MIPs can ensure better model-observation integration in this context, including constraining future projections.

ID 31: Science requirements for next generation model evaluation: from observations to advanced diagnostics and AI.

Conveners: Rebecca Beadling (Temple University), Swen Brands (CSIC), Birgit Hassler (DLR), Forrest Hoffman (Oak Ridge National Laboratory), **Ranjini Swaminathan (University of Reading)**,

Coupled Earth system models have both evolved in complexity and in modelling capabilities with each successive generation. Improved process representations, higher resolutions, novel parameterization schemes using ML and AI are some of the advancements planned for the next generation of models. In this session, we invite abstracts that address the challenges of evaluating these scientific advancements in CMIP7 models. Topics of interest include but are not limited to :

1. Observational data set requirements, handling observational uncertainty in model evaluation, novel observations for novel processes in models.
2. Process based evaluation: cross-domain interactions, diagnostics where observations are lacking or limited, for instance future scenario projections.
3. Causality and teleconnections across time, space and scale.
4. AI and ML methods and emulators including explainability that show novelty in capturing model behavior or fidelity to observations beyond traditional approaches to evaluation.
5. Generational changes across models.
6. Model biases and uncertainties.
7. Effects of internal variability on model errors.
8. Synoptic or regional-scale model evaluation.
9. Best practices and considerations to evaluate ML and AI methods embedded in coupled models.
10. Strategies for scoring model fidelity.

We also welcome exploratory research ideas and prototype frameworks as poster abstracts to promote discussion in the community and as a way for authors to get feedback on proposed research.

ID 32: Responsible Use of CMIP Data in Regional Decision Contexts

Conveners: Louis-Philippe Caron (Ouranos), Bruce Hewitson (University of Cape Town), Douglas Maraun (University of Graz), Genito Maure (Universidade Eduardo Mondlane), Monica Morrison (National Center for Atmospheric Research),

The Coupled Model Intercomparison Project (CMIP) is currently the basis of a large number, if not most efforts to plan for future climate on scales that are not always well-resolved in GCMs, often via derived products that claim to add value at regional scale. The provision and use of actionable climate information are fundamental for addressing climate change risks, but often there is a misalignment between the available information and the needs of regional decision makers. The research aims of the original CMIP effort have resulted in standardized datasets, that are often used in ways that were not originally intended by the modeling centers. Information that is not fit-for-purpose and is not contributing to reducing decision risk can introduce the potential of maladaptation. The responsible generation, analysis, and delivery of climate information needs to recognize the ethical role of the actors when the decision maker, in acting on the information, carries accountability for consequences. Aligned with the World Climate Research Programme's RIfS project, this session has three major goals. 1) To underscore the depth of what is entailed in context-specific actionable information and stakeholder engagement to inform global coupled model experiment design, 2) to discuss how GCMs can be optimally – both directly and via downscaling and postprocessing - used in contributing to the construction of regional climate information, and 3) to provide an opportunity for the CMIP community to engage in the conversations around the current practice in the downstream user community and identify ways to better align the generation and delivery of information with the responsible adoption in policy and decisions.

ID 33: Growing the connectivity between CMIP with the Coordinated Regional Climate Downscaling Experiment (CORDEX)

Conveners: Melissa Bukovsky (University of Wyoming), Dominique Paquin (Ouranos), **Stefan Rahimi (University of Wyoming),** Michelle Reboita (Universidade Federal de Itajubá), Ali Shaukat (Hospital for Sick Children (SickKids), Toronto),

The Coordinated Regional Climate Downscaling Experiment (CORDEX) contributes to the broader CMIP modeling multiverse by providing complementary, coordinated, high-resolution regional climate information that extends the utility of global Earth system model (ESM) outputs to decision-relevant scales across 14 regions and all continents. This session invites abstracts that showcase the breadth of ongoing CORDEX activities - aimed at advancing understanding of historical and future climate, modeling capabilities, coordination, and knowledge exchange - including CORDEX-CMIP6, the CORDEX-CMIP7, Flagship Pilot Studies, and Task Force efforts. We also encourage submissions that explore evolving relationships between CORDEX and other CMIP initiatives. We are particularly interested in abstracts addressing emerging data needs to support regional Earth system modeling, such as high-resolution forcings (e.g., emissions, land cover), 3-D ocean temperatures, and sea ice, as well as those highlighting how downscaled outputs can inform ESM development by improving representation of regional processes and feedbacks. While CORDEX has made substantial progress in coordinating regional modeling, challenges persist in generating and distributing high-resolution information for some regions. The next phase of CORDEX-CORE is actively working to address these gaps; however, we welcome abstracts that engage with this effort or propose collaborative approaches to expand regional coverage, including integration with other CMIP initiatives such as HighResMIP. More broadly, this session aims to foster dialogue between the global and regional modeling communities, enhance coordination and accessibility of high-resolution climate information, and provide a forum for discussing the latest developments within the CORDEX community of practice—all in support of the broader CMIP agenda.

ID 34: Understanding the South American Monsoon System's Response to Climate Change: Feedbacks, Thresholds, and Evolving Circulation Patterns in Observations and CMIP Models

Conveners: Tércio Ambrizzi (University of São Paulo), **Glauber Willian de Souza Ferreira (Federal University of Itajubá)**, Helber Barros Gomes (Federal University of Alagoas), Michelle Simões Reboita (Federal University of Itajubá), Rosmeri Porfírio da Rocha (University of São Paulo)

The South American Monsoon System (SAMS) and its associated South Atlantic Convergence Zone (SACZ) are critical drivers of regional hydroclimate, yet understanding their response to climate change remains challenging due to complex multi-scale interactions and model limitations. This session aims to foster collaboration and knowledge exchange by bringing together observational and modeling experts to advance our comprehension of SAMS variability and change, leveraging insights from CMIP6 analyses and anticipating challenges for CMIP7. We invite contributions exploring the intricate processes influencing SAMS, focusing on bridging the crucial observation-modeling interface:

- Feedbacks: Investigating the roles of land use/land cover change and their impacts on the regional energy and water cycles as represented in observations and models.
- Responses and Thresholds: Analyzing observed and simulated changes in precipitation characteristics (mean, extremes, seasonality), and monsoon onset/demise.
- Teleconnections: Assessing the fidelity of CMIP models in capturing key influences from ENSO, MJO, Atlantic/Pacific decadal variability, and understanding how these interactions modulate SAMS weather patterns under different climate states.

- Model Evaluation and Innovation: Critically assessing progress and persistent biases (e.g., precipitation magnitude, SACZ, and ITCZ representation) in CMIP6 simulations and defining key evaluation metrics for CMIP7. It also includes exploring the application of artificial intelligence and machine learning (AI/ML) for tasks such as identifying complex patterns of change, bias correction, process diagnostics from large datasets, and enhancing uncertainty quantification in projections. We also encourage contributions using diverse observational datasets for robust model evaluation.

This session seeks to synthesize recent observational findings, diagnostic analyses of CMIP simulations, and insights from novel modeling and analysis techniques (including AI/ML). We aim to collectively improve the understanding of SAMS dynamics, responses, and feedbacks under changing climate conditions, ultimately refining projections of future circulation patterns and contributing to the climate information chain for regional stakeholders.

ID 35: What can we learn from single model large ensembles (SMLEs)?

Conveners: Jenny Mecking (National Oceanography Centre), Yu-heng Tseng (National Taiwan University)

CMIP model simulations often rely on very few and commonly only one ensemble member per model. Some modelling centres have since extended their contributions with larger ensembles, sometimes incorporating slight modifications to the original model. Having a limited number of ensemble members is often not based on reluctance but due to limitations including but not limited to compute power and data storage. However, single-model large ensembles (SMLEs) can offer valuable insights into internal versus forced variability, signal-to-noise, ensemble sizes limitations, etc.

This session welcomes submissions employing SMLEs across all components of the Earth systems (e.g. atmosphere, ocean, sea ice, land, biogeochemistry) and all types of SMLE (e.g. initial condition, perturbed physics, boundary condition). We do not have a strict definition of the minimum size to be considered a SMLE.

The session aims to facilitate exchange among researchers and to explore how SMLEs can complement multi-model frameworks in advancing our understanding of climate variability and change.