

HighResMIP-EERIE workshop 8th Nov 2023 1400-1700 CET (Central European Time), 1-4pm GMT

Purpose: To inform and motivate ongoing writing of new HighResMIP protocol paper. To generate new science questions and ideas for future work. To discuss links to CMIP DECK via metrics/process understanding and idealised simulations. To discuss experimental design issues, diagnostics and how to address them.

3 hours. Webex, link is at bottom of document.

Main questions 4x30 mins

Quickfire 2x10 mins

Each topic will be kicked-off with brief (~3 min) introductions from speakers before general discussion.

1400-1410 Brief introduction to workshop - Malcolm Roberts

1410 – 1440

1. New science questions and novelty for HighResMIPv2 compared to CMIP6

HighResMIP co-leads: Qing Bao - IAP, China

Enrico Scoccimarro - CMCC, Italy. Recorded:

https://drive.google.com/file/d/1AUYYkxnMB80qTXM7OWR5HJRM8AUgo6sM/view?usp=drive_link

Qing works at IAP on climate system modelling and subseasonal to decadal prediction. What was the impact of HighResMIP on GCMs common biases, e.g. double ITCZ, MJO, too many tropical depressions and too few strong tropical cyclones, diurnal cycle, regions where orography is important. Science areas for HighResMIP - convection, scale-aware parameterisations, towards km-scale, dynamics-physics coupling, physics-informed machine learning (ML) parameterisations. Applications for HighResMIP simulations - both stakeholders and end-users, disaster reduction, carbon neutrality, training data for ML.

Ocean eddies are a key addition from HighResMIP simulations, we have some related questions in the evolving protocol paper.

Make sure we revisit science questions in original HighResMIP and assess where we are, as well as new questions/models/outputs.

Enrico - the role of extreme events in modulating the climate system. An example is tropical cyclones (TCs), which can have an important role as a source of stochastic forcing, triggering and modulating different climate models of variability. Another example would be westerly wind bursts influencing ENSO initiation. We can only look at such processes with global, coupled models with sufficient resolution to represent such extreme events (and ideally intensity spectrum of such extremes, such as Cat 5 TCs). Models around 25km may be sufficient. Lots of work looking at large-scale and influence on extremes, less on upscale impacts - energy dissipated by ENSO vs by TCs. Suggestion to have additional experiments, for example to suppress TCs and look at impact. Other papers e.g. TCs over western North Pacific interacting with tropical circulation, TCs and water vapour export to Europe, TCs and

triggering/amplification of midlatitude Rossby wave packets to force high impact weather (Scoccimarro et al., 2020, 2018; Keller et al., 2019; and others).

Scale-interactions and diagnostics to understand those processes - distinguish from regional downscaling. Data access, volumes, on-the-fly diagnostics with agreed packages? Output at lower resolution, coarse-grain? **Should we start a working group on these issues?**

What can HighResMIP say about abrupt changes? Ice sheets, Amazon etc. It seems like the speed at which extremes are accelerating may be faster than expected. Issues about benchmarking models to understand relationship with lower resolution models (which can produce larger ensembles etc).

1440 - 1510

2. Problems people have had in running long simulations with HighResMIP/CMIP experimental designs at high resolution, learn lessons

Jon Seddon/Mario Acosta/Pablo Ortega (PRIMAVERA) - Met Office, UK/BSC, Spain.

<https://docs.google.com/presentation/d/1NN-l2tmqz3qVww8zEp7SsRuCJcOLmKdz/edit?usp=sharing&oid=106958588699932550226&rtpof=true&sd=true>

Jon talked about the PRIMAVERA groups producing HighResMIP simulations. Having data on the same platform was very important (take analysis to data). Developed Data Management Tool to manage data and disk space. Develop tools to enable faster model evaluation - standard metrics, packages.

Mario and Pablo - Model computational performance in HighResMIP simulations - found bottlenecks at higher resolution around coupling, IO, global MPI communications, domain decomposition tools. Had to change supercomputer platform (tests for equivalent model climatology important), balance between energy and time-to-solution options, data output costs increase dramatically at higher resolution, model throughput can be much lower than theoretical due to queues, errors, complex experiments.

IO tools e.g. XIOS - sharing experiences are important, different settings.

Groups hitting storage and data serving limits to community - to enable others to access data. **CMIP task team on data access (no one was involved in meeting, Robert Pinkus leads)**. Issues with ESGF.

1510 - 1520 Break

1520-1540 Quickfire sessions

1520 - 1530

3. Development of metrics from simulations – both idealised (e.g. p4K) and Tier 1 (drift, variability etc), to measure model performance and link to CMIP

Helene Hewitt - CMIP panel co-chair.

Paul Ullrich - LLNL - recorded:

https://drive.google.com/file/d/1G_8vt8Dgy0ubA2MwC_wpYl4wQvXVHTDY/view?usp=drive_link

Helene had some thoughts on HighResMIP for CMIP7. Why a need for CMIP7? Proven way to test and validate models, process understanding, test new hypotheses using new, updated, extended climate simulations, new opportunities with observational campaigns to develop diagnostics and new MIPs, CMIP is a key international climate service, gap in CMIP delivery could result in poorer quality climate information. CMIP7 high level objectives - fundamental understanding of the climate system, prediction of near-term evolution, long-term response (e.g. overshoots), bridging climate science and society. Evolving design - more continuous approach, CMIP fast track (subset of simulations, not the Disneyland ride!), allow MIPs to have more flexible timescales. Link CMIP and HighResMIP - metrics to link low resolution to higher resolution models (e.g. ECS from first 20 years of 4xCO₂, TOA, SST error patterns, ocean T&S trends, variability metrics). Try to link to km-scale via 1 year simulations in HighResMIP. Data request task team have been defining data request for CMIP7 (though noted that some different variables accessed differently from HighResMIP, **perhaps contact Martin Jukes about this**). Which scenarios to use - **engage with ScenarioMIP (high, medium, low, and/or overshoot and/or ramp up-down experiments) - may want to consider which of these should be core HighResMIP scenarios**. May come up in CMIP panel meeting. **Overshoots- minimum set of years?**

Many groups will have less resources for CMIP7 than they had for CMIP6, so some prioritisation would be useful anyway.

Paul - US capabilities for benchmarking climate models relevant to high resolution models. Flagship efforts - PCMDI metrics package (PMP) and International Land/Ocean Model benchmarks (ILAMB/IOMB), Model Diagnostics Task Force (MDTF), Climate variability diagnostics package (CVDP), Climate model assessment tool (CMAT). PMP can look at mean climate metrics across variables and produce website to be browsed, can also include aspects of variability such as MJO. MDTF has broader range of diagnostic tools from community. Impacts-relevant metrics via PCMDI and Hyperfacets. Suite of IPCC metrics, including as part of the IPCC atlas. TempestExtremes package can do feature tracking for TC, ETC, AR, blocking and MCS, and the outputs can be used in the Coastal storm metrics package to look at fraction of precip associated with such processes. Need data to be CF-compliant, and then workflows mentioned should be straightforward. Need to decide on recommended reference datasets for common fields (temperature and precip particularly).

1530 - 1540

4. Diagnostics, time-slice periods of simulations with enhanced outputs and/or number of ensembles, what science questions and analysis can they enable

Anne Marie Treguier - CNRS, France.

Joakim Kjellsson - GEOMAR. 20 year ORCA12 run including model tendency terms - what we learned.

Anne Marie talked about ocean diagnostics. Need to evolve from monthly 3D ocean output - but what can we afford - daily 3D, or every 3/5 days. Second moments e.g. uT , uv etc. Online diagnostics. Daily at some levels, time slices maybe ~10 years long. Knowing about use of OMIP data would be useful, but this was not uniformly CMORised so not really possible. Coordinate with time periods if e.g. want to force CORDEX models. Data compression, coarse graining (though this might compromise e.g. budget analysis)? Need well defined questions for what such large data volumes might be used for - e.g. Lagrangian particle tracking. Common strategies to facilitate joint analyses - choice of time slices (e.g. after ARGO), online computation of trajectories (e.g. eddies and TCs), ensembles. Maybe more coordination/collaboration with OMIP. For tracking, need to propose common tools, thresholds etc. Other metrics e.g. MJO.

Joakim talked about some new GEOMAR high resolution global simulations. Noted reduced Southern Ocean biases, so tried to do budgets (monthly 350GB per SY, very large).

1540-1610

5. What to do about ocean spin-up in coupled simulation, both in terms of experiments and when analysing. Trade-offs - longer spin-up vs non-zero TOA, ocean initial conditions, subtract control-1950 from hist-1950?

Gokhan Danabasoglu - NCAR.

ESMO with others (WGNE, Digital Earth, Ocean group) have formed a group on ocean spin-up (led by Baylor Fox-Kemper) - how the physical ocean model is initialised. For all model simulations of many types - piControl, seasonal, subseasonal etc. Planning a paper summarising methods currently used. For HighResMIP, starting in a period with non-zero TOA is not ideal - since a longer spin-up will warm the ocean more. Not all analyses from HighResMIP removed the trend from the control-1950 simulations when looking at the hist-1950, **so we should make some recommendation in the protocol paper**. What science questions we are interested in may influence whether these drifts, non-zero TOA etc are important. Methods to short-cut, e.g. extrapolate trends from short periods in spin-up, revisit old acceleration techniques.

When checking ocean (quasi-)equilibrium in all models, need to look at regional trends, exchanges etc, not just global trends.

1610-1620 Break

1620-1650

6. Talk(s) from groups who have previously run eddy-rich simulations and are producing new analyses

Ping Chang said someone from iHESP/MESACLIP can talk - Texas A&M

Brief results from Qing Bao and Pier Luigi Vidale.

Ping talked about ongoing ensembles of CMIP-style CESM high resolution global coupled simulations, aiming for 10 members of historical from 1920. Look for forced response from an ensemble of simulations from ensembles of low and high resolution simulations - signal-to-noise optimised PC1. Then regress this timeseries onto SST, SLP and precipitation. Patterns in HR models look much more like observed than LR models (DiNezio et al, in prep). Ensemble of HR HighResMIP simulations also capture features such as the observed recent Eastern Pacific/Southern Ocean trend, though individual models differ in performance. Given that the signals are seen in ensembles of simulations, it suggests this is an externally forced trend. Southern Ocean may also be important for mid-latitudes via teleconnections. Whether the HR models are capturing the trends for the right reason is still under question, but the fact that no LR models capture such a trend is interesting.

Qing showed some recent simulations with a 12.5km AMIP-style simulation (no tuning), showing significant improvements in TC performance in terms of intensity and frequency. Pier Luigi similarly showed an ensemble of 10km AMIP-style simulations in which the intensities seem to match the observations very well, even if the rate of wind intensification is still slower than observations.

AOB including actions from workshop

1700 Close

These two topics had fewer votes in the poll but are still important - we'll leave them out this time due to time constraints, but try and put together some text on them with relevant parties.

7. EERIE partners and others present plans and progress on new HighResMIP simulations

EU EERIE is a project aimed at better understanding of the role of the ocean mesoscale in climate. Three EERIE modelling groups are running coupled HighResMIP simulations, initially using the v1 protocol, and then v2 in 18 months or so. The models are: ICON, IFS-FESOM2 and IFS-NEMO, all running at around 10km or higher, and the models and progress are documented on the EERIE website: <https://eerie-project.eu/research/modelling/>. These coupled simulations to 2050 are expected to be completed around the end of 2024. The data is planned to be published though exact details of that are still under discussion.

In addition, ECMWF and Met Office are testing the new HighResMIPv2 highresSST-present (atmosphere-only) simulation design, 1980-2022 using ESA CCI SST and sea-ice forcing, with ECMWF planning to run this at 9 and 36km resolutions (Met Office at 60, 20km). In EERIE, these simulations will form the baseline to some sensitivity studies where the ocean eddy (time-varying mesoscale) signatures within the SST forcing will be removed (using the GCM-Filters package, <https://gcm-filters.readthedocs.io/en/latest/>), in order to investigate the role of these features on climate. These simulations are also planned to be completed by end-2024.

Within EERIE we agreed a Data Request for our model output, which can be viewed here: https://github.com/eerie-project/dreq_tools.

We are using some standard assessment tools and packages: py-eddy-tracker for eddy tracking (<https://py-eddy-tracker.readthedocs.io/en/latest/index.html>), TempestExtremes for storm tracking and atmospheric rivers (<https://github.com/ClimateGlobalChange/tempestextremes>).

8. Links to other communities, outreach to CORDEX, others e.g. RIfS, km-scale

I had an email discussion with Naomi Goldenson, who leads RIfS. Currently they are more focussed on requirements gathering and guidance than providing a platform for data outputs (apart from CORDEX). They may be able to advise what outputs are most useful to the community and enable connections between communities. Perhaps there is scope for agreeing useful derived diagnostics that can be produced as the models run. Guidance on model process-based metrics could also be useful, to allow users to figure out what data are trustworthy for their region.

It is difficult, but we may need to find some concrete and specific actions we can take (on both sides) to start up these collaborations between communities, it cannot just come from the HighResMIP side.

How can we link up with CORDEX in terms of processes and resolution, metrics.

We also have links to DYAMOND-long groups and simulations, who themselves also have good links to observational campaigns, either in the past or planned e.g. EARTHCARE.

Webex link - we will use Webex unless something catastrophic happens:

Über den Meeting-Link beitreten

<https://awi.webex.com/awi/j.php?MTID=mf5030a85482f147673f0dc3ece84e3fb>

Mit Meeting-Kennnummer beitreten

Meeting-Kennnummer (Zugriffscode): 2734 566 3700

Meeting Passwort: 6fAJqg7mZp3

