MU–MIP
Model Uncertainty – Model Intercomparison Project
WGNE update

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WGNE 37, 9 November 2022, Boulder, USA

Background

- Joint initiative of the WGNE and PDEF[1] working group

- At the joint WGNE/PDEF meeting in Tokyo, October 2018, a coordinated activity was proposed to evaluate model error across a number of forecast models, and is since led by Hannah Christensen (Oxford University)

- Some key scientific questions:

  Stochastic parametrisation

  - How should model uncertainty (random error) be best represented?
  - Should stochastic parametrisations be model dependent?
  - Are current approaches justified? How can they be improved?

  Systematic errors

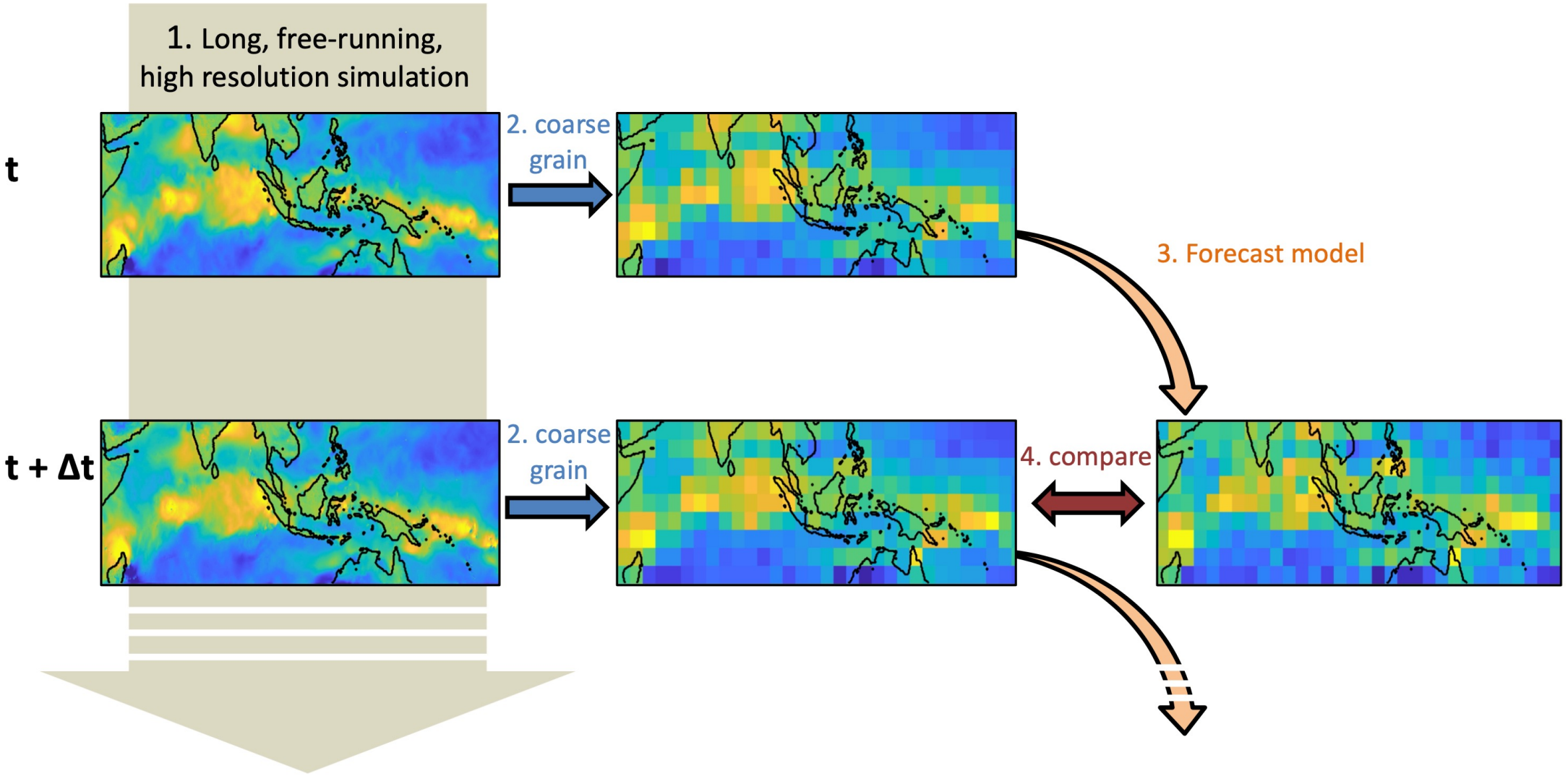
  - How structurally diverse are deterministic parametrisations?
  - How different are systematic errors on short timescales?

  High-resolution simulations

  - Can we use coarse-graining as a validation tool for high-resolution models?

[1] Predictability, Dynamics and Ensemble Forecasting

Protocol: use high-resolution simulations as ‘truth’

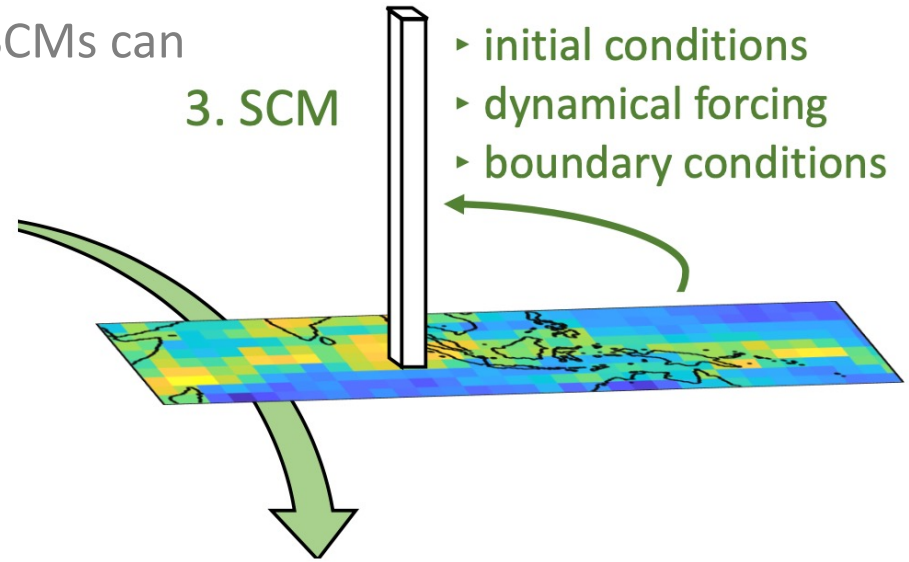


Christensen et al. (2018, JAMES), Christensen (2020, QJRMS)

Use SCM as forecast model

Why use SCMs?

- Supply dynamical tendencies allows to target uncertainty in the parametrizations
- SCMs are computationally cheaper and more portable than full models
- Few models can be run over a limited domain, while independent SCMs can be used to tile the targeted limited domain



Thus use coarse-grained high-resolution simulation to prescribe

- Initial conditions
- Forcing: advective tendencies, geostrophic winds, vertical velocity
- Boundary conditions: surface sensible and latent heat fluxes, skin temperature

Short-term SCM simulations (a few hours), discard first hour as spin-up

Christensen et al. (2018, JAMES), Christensen (2020, QJRMS)

What information do we get?

From high-resolution dataset:

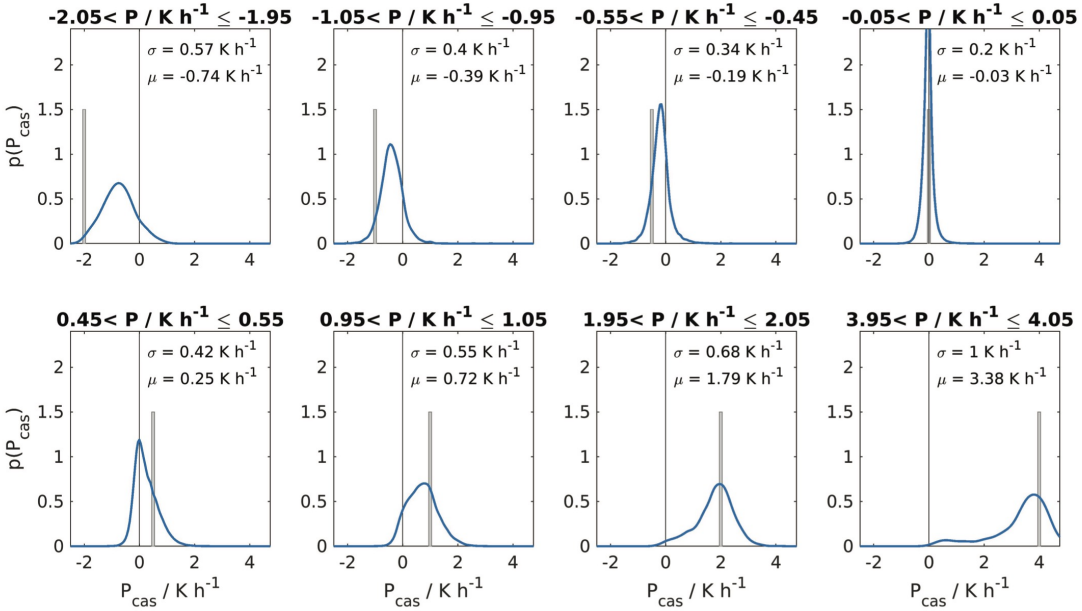
- **Total change in (T, q, u, v)** as a function of model level, location and start date/time
- Coarse-graining provides ***large-scale (dynamical) and sub-grid-scale total tendencies***

From SCMs:

- ***Change in (T, q, u, v) from dynamics and individual parametrisations***
  as a function of model level, location and start date/time

➢ ***Model error statistics as a function of space and time***

Proof of concept in Christensen (2020, QJRMS):
UKMO limited area high-resolution simulations (CASCADE)
vs. OpenIFS SCM



Christensen (2020, QJRMS)

Partners

Representatives of WGNE and PDEF WG

- Nils Wedi, Romain Roehrig
- Judith Berner, John Methven, Mark Rodwell

Modeling groups / SCMs

- NCAR/NOAA DTC CCPP
- IFS (University of Oxford)
- UM (UKMO, University of Exeter)
- Météo-France
- CSIRO

Benchmark high-resolution simulations

- DYAMOND (ESIWACE) ICON (MPI)

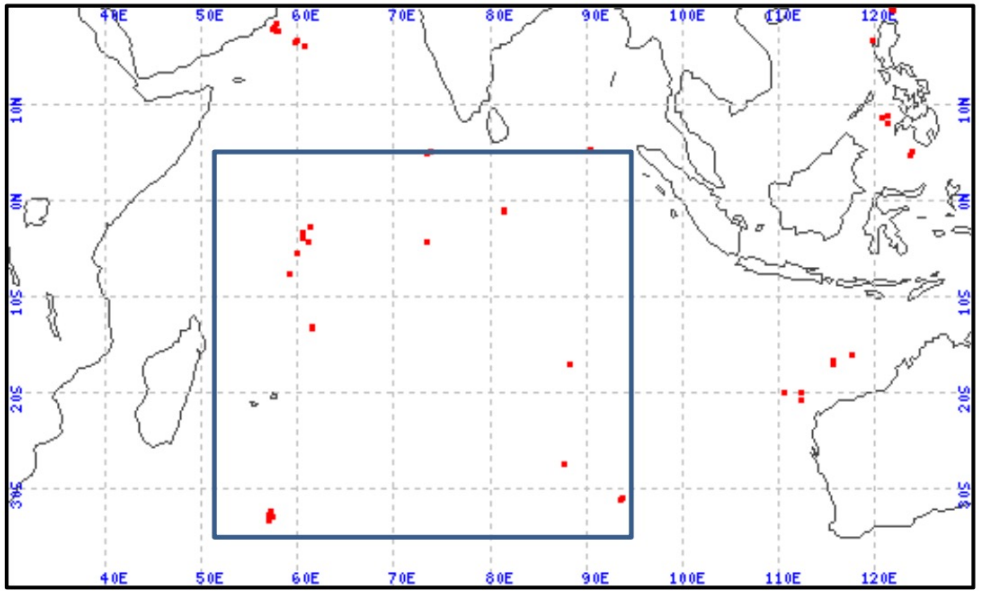
Analysis

- All

Knowledge transfer

- ECMWF, NOAA, UKMO, Météo-France

Progress



Meetings, since launch in September 2020

- 4 in total, 1 since WGNE 36

Coarse-grained SCM input datasets (HC lead)

- Initial resolution: 0.2° (~22 km)
- Initial domain: Indian Ocean
- 30 days
- Version 2.0 available (September 2022)

Making input DEPHY format usable by modeling groups

- IFS, Météo-France, CCPP: complete
- CSIRO, UKMO: in progress

Common output decided (format and variables)

Funding

- NCAR/NOAA DTC 3-year proposal accepted, started May 2021 (led Mike Ek and Ligia Bernardet)
- UK Leverhulme Trust proposal accepted, started July 2023
  - Hannah Christensen (Oxford) lead
  - Co-Is Romain Roehrig (MF), Hugo Lambert (Exeter), Judith Berner (NCAR)
  - 3 PDRA

DTC participation in MU-MIP

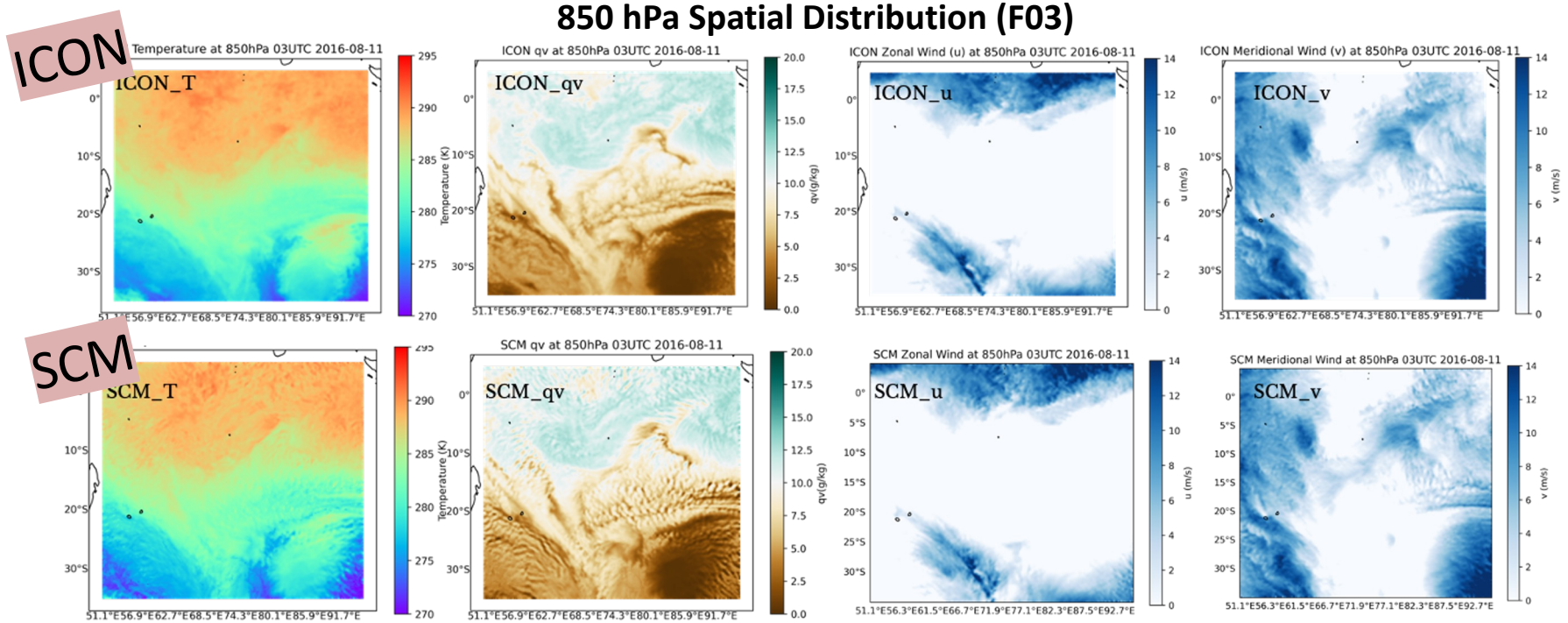
Developmental Testbed Center (DTC) funding from NOAA to participate in MU-MIP

- DTC Team: Xia Sun, Kathryn Newman, Ligia Bernardet, Mike Ek
  - SMEs: Hannah Christensen, Judith Berner, Lisa Bengtsson
- Conduct runs using the Common Community Physics Package (CCPP) Single Column Model (SCM) with physics relevant to NOAA
- Initial experiments using coarse-grained ICON DYAMOND data, followed by coarse-grained 3-km NOAA Unified Forecast System (UFS)

Initial simulations using an array of CCPP SCMs forced by coarse-grained ICON high-resolution runs revealed a bug in the surface fields for the ICON v1.0 forcing dataset, fixed for ICON v2.0 forcing

Good agreement between ICON coarse-grained forcing data and array of CCPP SCMs for T, qv, u, v (right)

850 hPa Spatial Distribution (F03)



*ICON=coarse-grained forcing data

https://mumip.web.ox.ac.uk/home

Model Uncertainty - MIP

Home

Welcome to the Model Uncertainty - Model Intercomparison Project (MUMIP)

An initiative of the WCRP Working Group for Numerical Experimentation and the WWRP Predictability, Dynamics and Ensemble Forecasting Working Group

Introduction

MU-MIP is an international project which seeks to characterise systematic and random component of model error across many different climate models. This is the first coordinated intercomparison of random model error, and will be used to inform stochastic parametrisation development.

Some key questions:

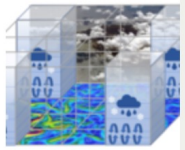
- How should we best represent model uncertainty/random error using stochastic approaches?
- To what extent should this representation be model specific or a fundamental property of atmospheric models?
- Are current approaches justified? How can they be improved?
- Can a coarse-graining approach be used to validate and compare high-resolution simulations and their behaviour across scales?

Contact

The MU-MIP team consists of scientists from 10+ institutes spanning three continents. Please get in touch by emailing Judith Berner on berner 'at' ucar.edu if you would like to get involved!

We also have a mailing list for communicating information about upcoming meetings, new code and data releases, and so on.

News



SCM forcing files v2.0 available

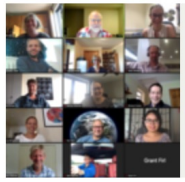
7 September 2022

Leverhulme Trust funding for MUMIP work

30 June 2022

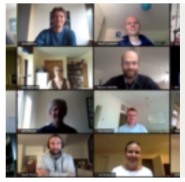
MUMIP meeting 3

22 June 2022



Technical discussion meeting

26 August 2021



MUMIP Meeting 2

23 June 2021

Second MUMIP Team meeting scheduled

20 May 2021

1 2 next last

Next steps

All groups running SCMs with version 2.0

- Possibly test different types of SCM forcing (lots of discussions during last meeting)
- Share SCM output (best way to be defined)

Conducting analyses

- Systematic and random errors

Continuing to recruit new participants

- e.g., MU-MIP was advertised at ECMWF Model Uncertainty workshop in May 2022