

Australia's ACCESS-OM3 ocean model suite

Andrew Kiss, Andrew Hogg, Micael Oliveira, Dougal Squire, Ezhilsabareesh Kannadasan, Anton Stekete, Minghang Li, Martin Dix, Kieran Ricardo, Adele Morrison, Ashley Barnes (ANU), Navid Constantinou (U. Melbourne), Pearse Buchanan, Siobhan O'Farrell (CSIRO)

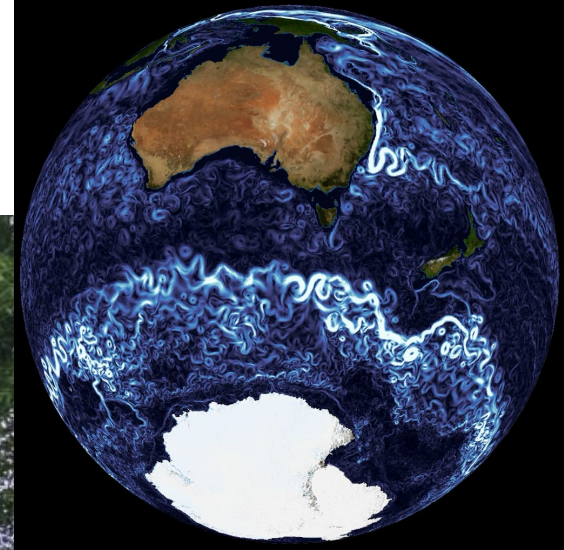
CESM Workshop, 10 June 2024



The Consortium for Ocean-Sea Ice Modelling in Australia
cosima.org.au

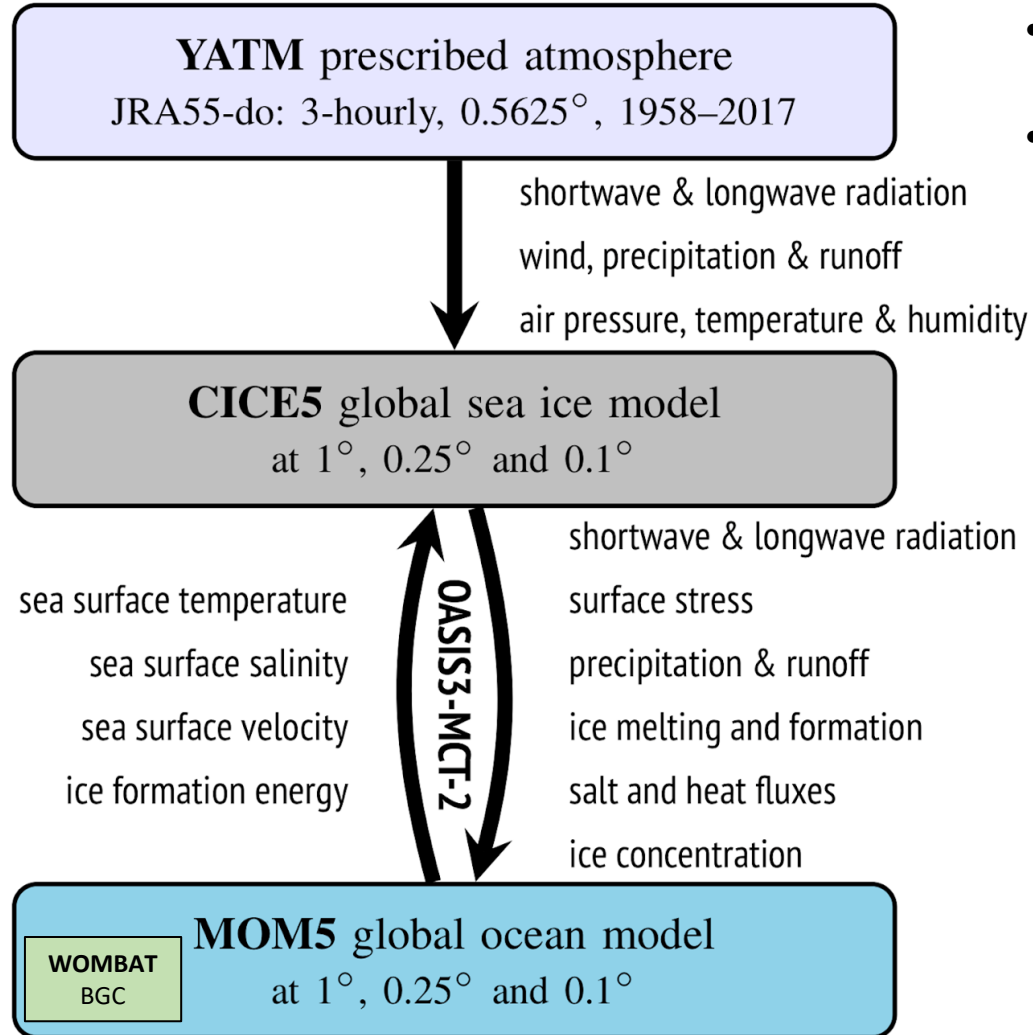
Australian ocean & sea ice modelling community

2022 COSIMA workshop: >90 attendees

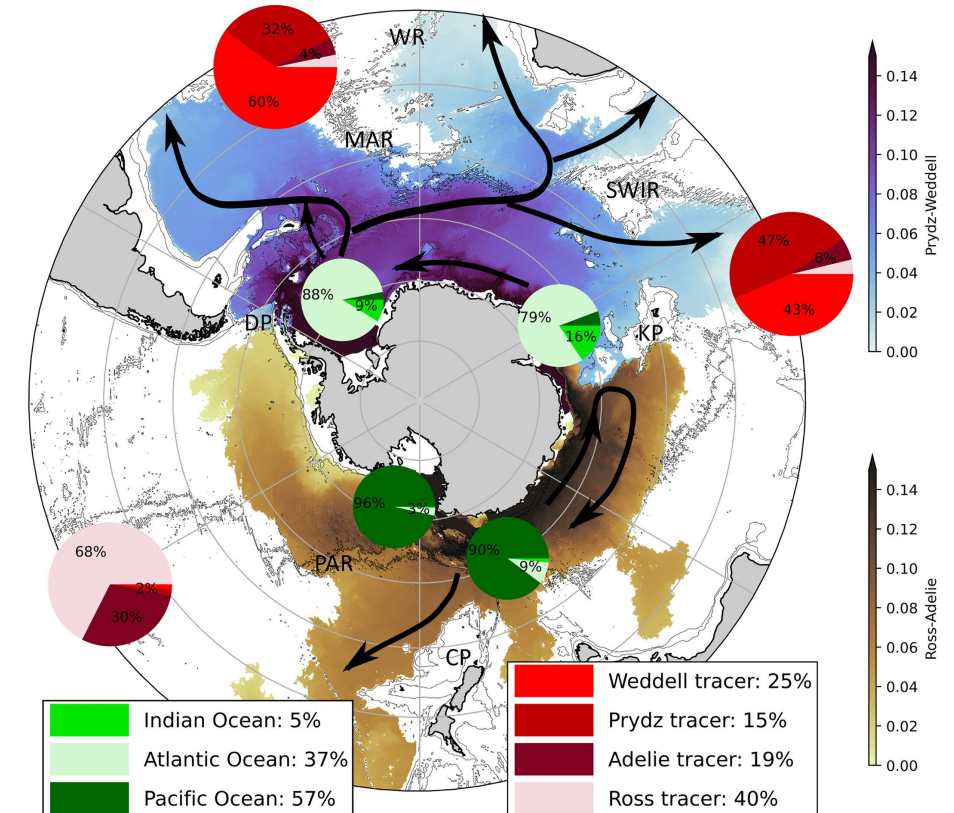


- **>180** researchers from ANU, UNSW, U Sydney, U Adelaide, U Melbourne, Monash, U Tasmania, UWA, CSIRO, BoM, AAD, etc.
- **ACCESS-OM2** (MOM5-CICE5) underpinned **>75 publications** since 2019, with **>1400 total citations**
 - 1° config used in the **ACCESS-CM2** climate model for CMIP6, and 0.25° for **ACCESS-CM2-025**
 - 0.1° config used by BoM & CSIRO for the next Bluelink global **ocean and sea ice forecasting system**

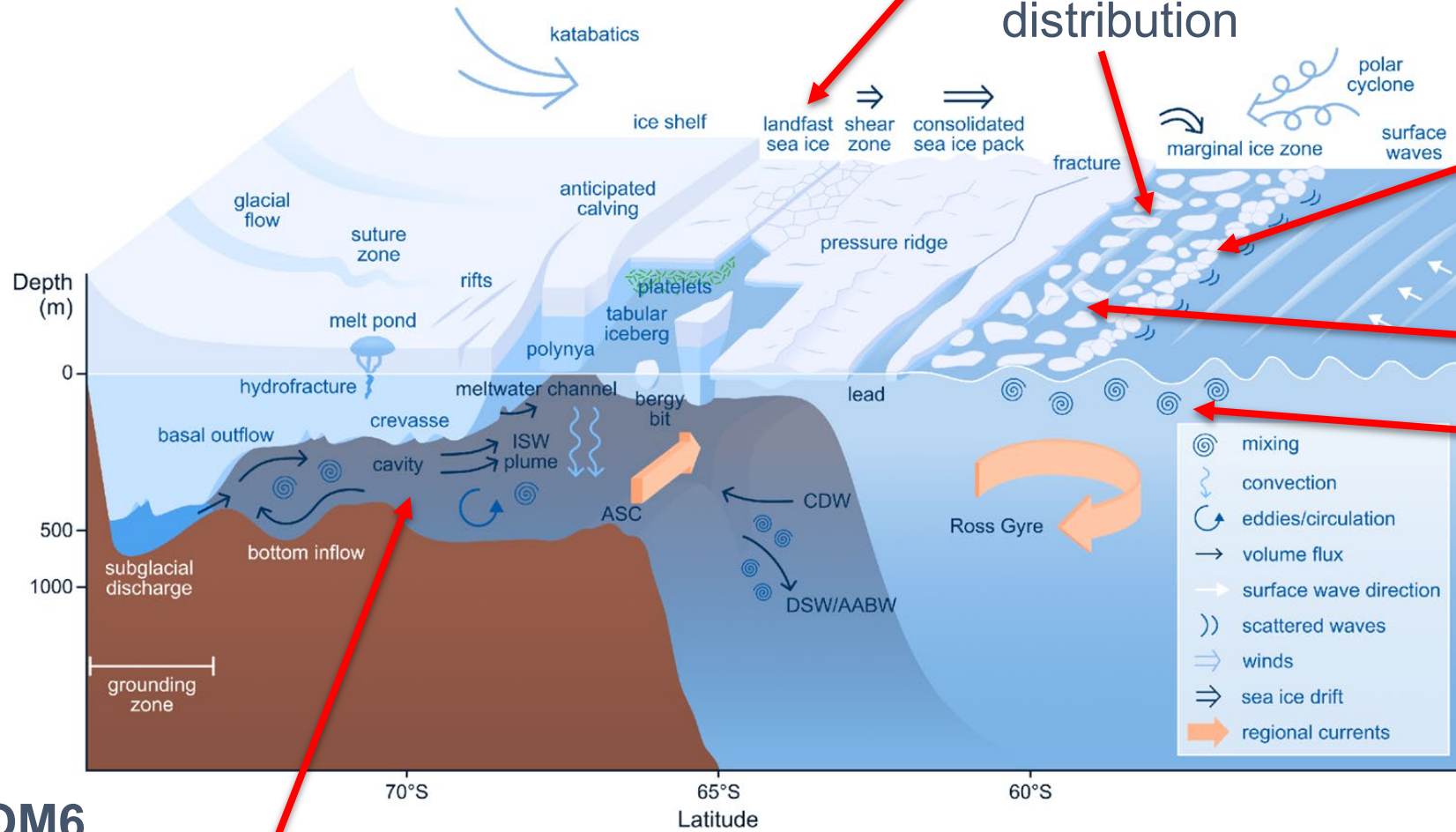
ACCESS-OM2



- Global MOM5-CICE5 configurations at 1°, 0.25° and 0.1°; OASIS3-MCT coupler; JRA55-do forcing
- >75 publications since 2019 →
- Realistic Antarctic Bottom Water formation at 0.1°



New processes in ACCESS-OM3



CICE6

- Landfast Ice
- Floe size distribution

WaveWatch III

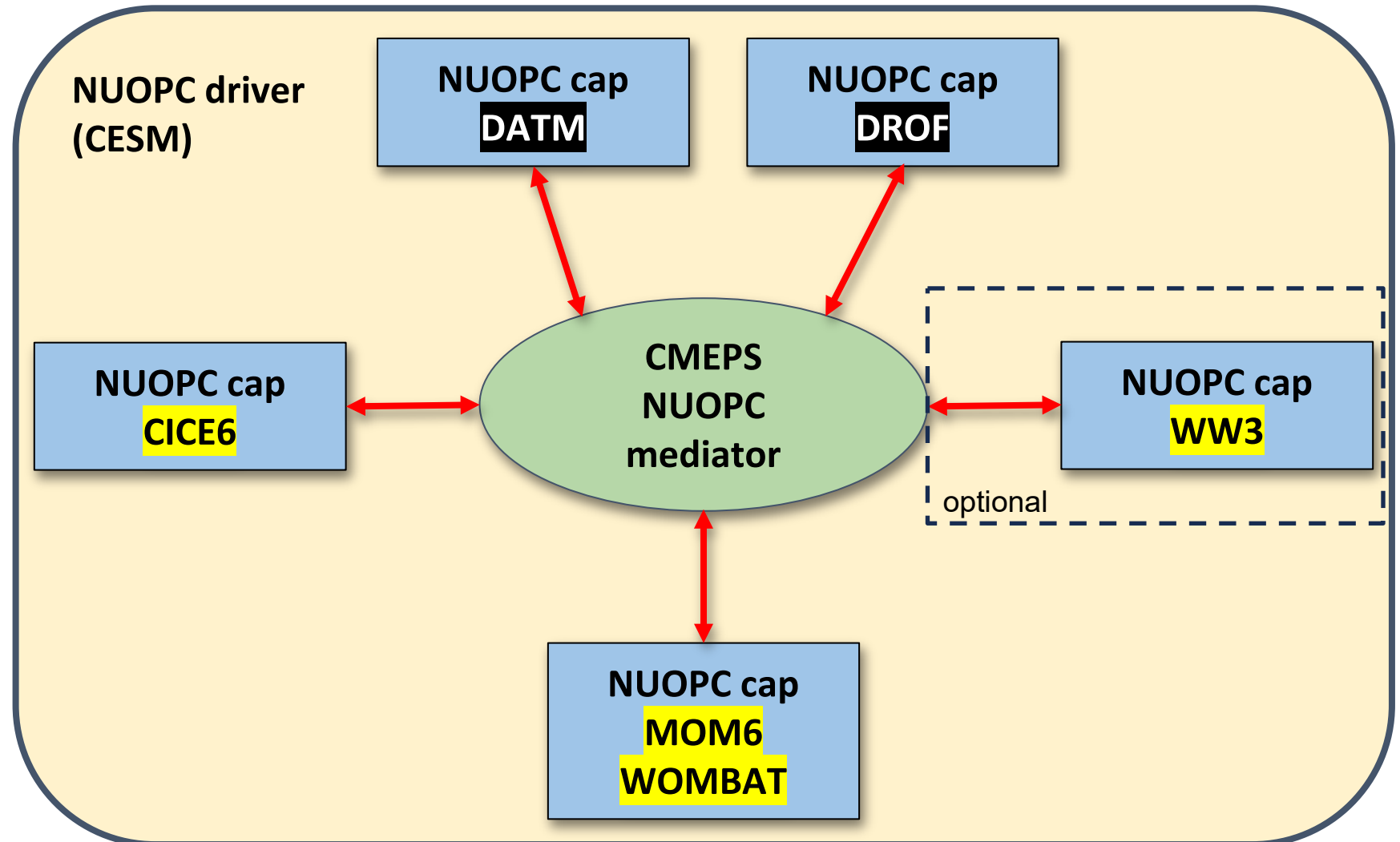
- wave induced breakup in the marginal ice zone
- floe size dependent wave damping
- surface mixing

MOM6

- Ice shelf cavity circulation impacts sea ice and global overturning

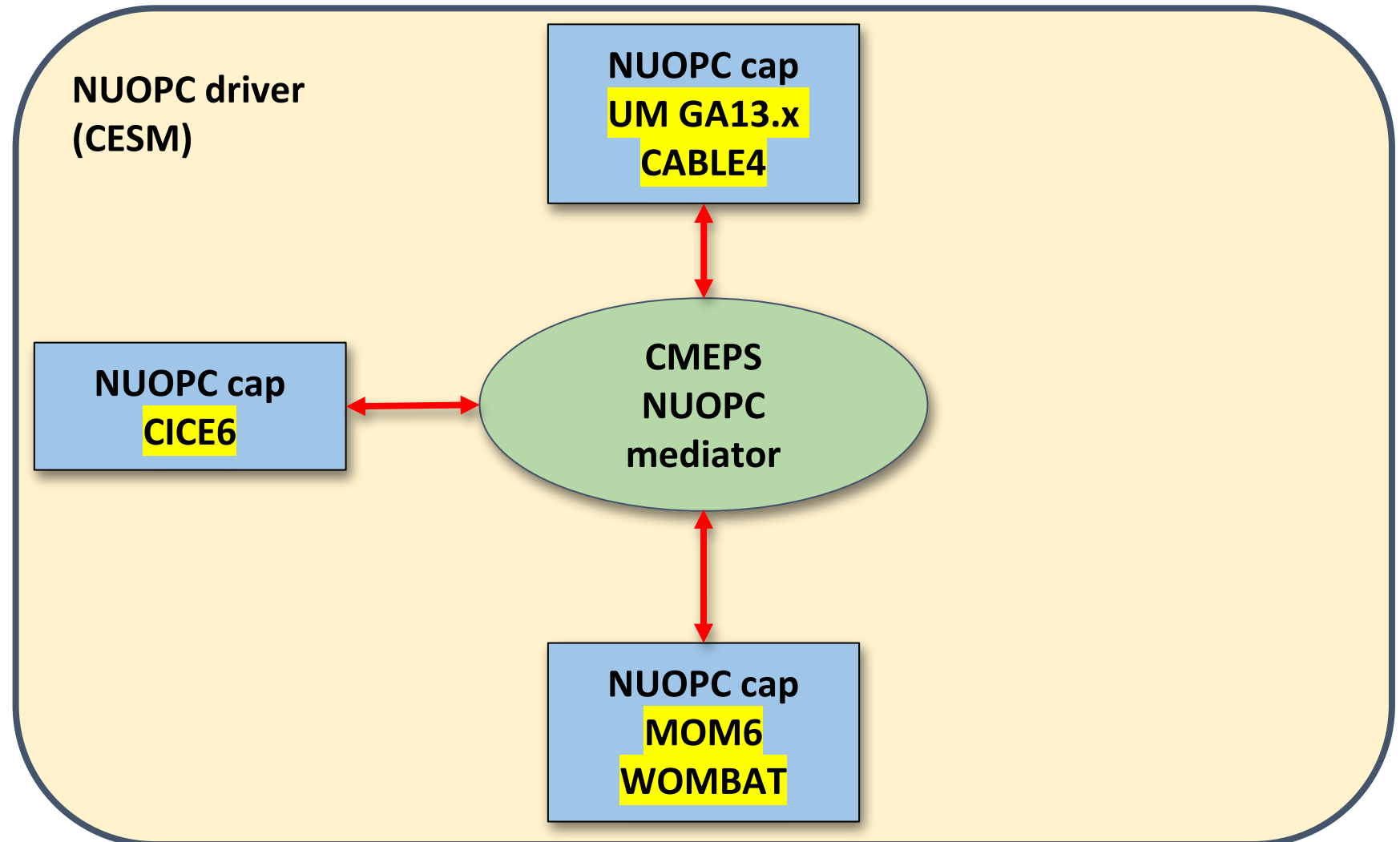
ACCESS-OM3: MOM6-CICE6(-WW3)

- Upgrade to **CICE6** and **MOM6**
- Add **WW3** (optional)
- **NUOPC coupling**
 - **CMEPS NUOPC mediator**
 - **CESM NUOPC driver**
 - CDEPS **DATM** & **DROF**
- **2-way CICE6-WW3 and MOM6-WW3 coupling** enabled, testing underway (Ezhilsabareesh Kannadasan)
- Testing & tuning underway
 - **1° configs running**, with and without WW3
 - **0.25° running** without WW3
 - Improving parallel scaling
- Next steps
 - **C-grid CICE**
 - Work towards **0.1°, 0.04° res**
 - **WOMBAT BGC** being improved and ported to MOM6 (Dougie Squire, Pearse Buchanan – see next talk)

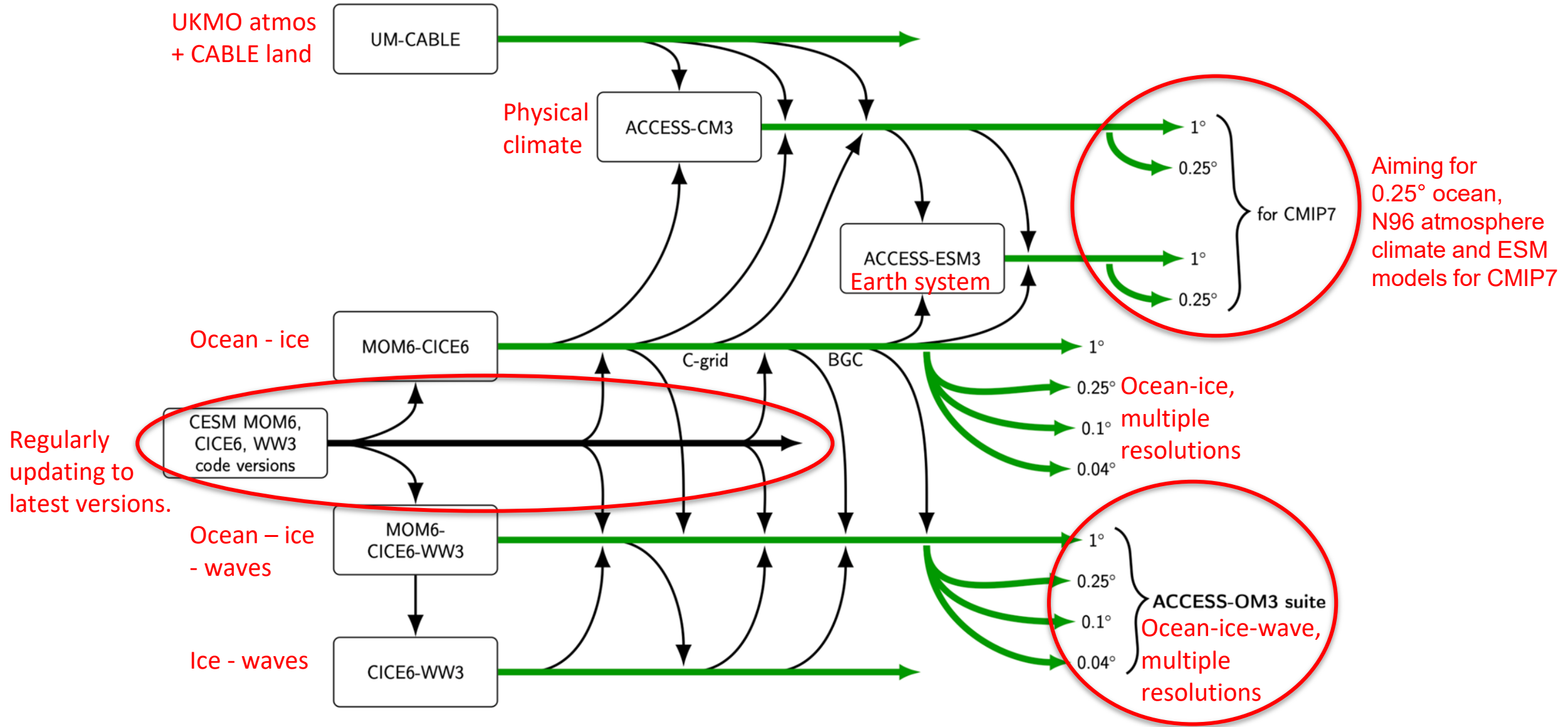


ACCESS-CM3 and ACCESS-ESM3 (target configuration)

- Couple MOM6, CICE6 to UKMO **UM GA13.x** atmos and **CABLE4** land surface
- No WW3
- New **NUOPC cap for UM** (Martin Dix, Kieran Ricardo)
- **Test config running at 1°**
 - UM 13.0 + JULES land (will try CABLE soon)
 - Performance looks good
 - Sea ice cycle already ~ok
- **Aiming for 0.25° ocean, N96 atmosphere**



Coordinated development of global models



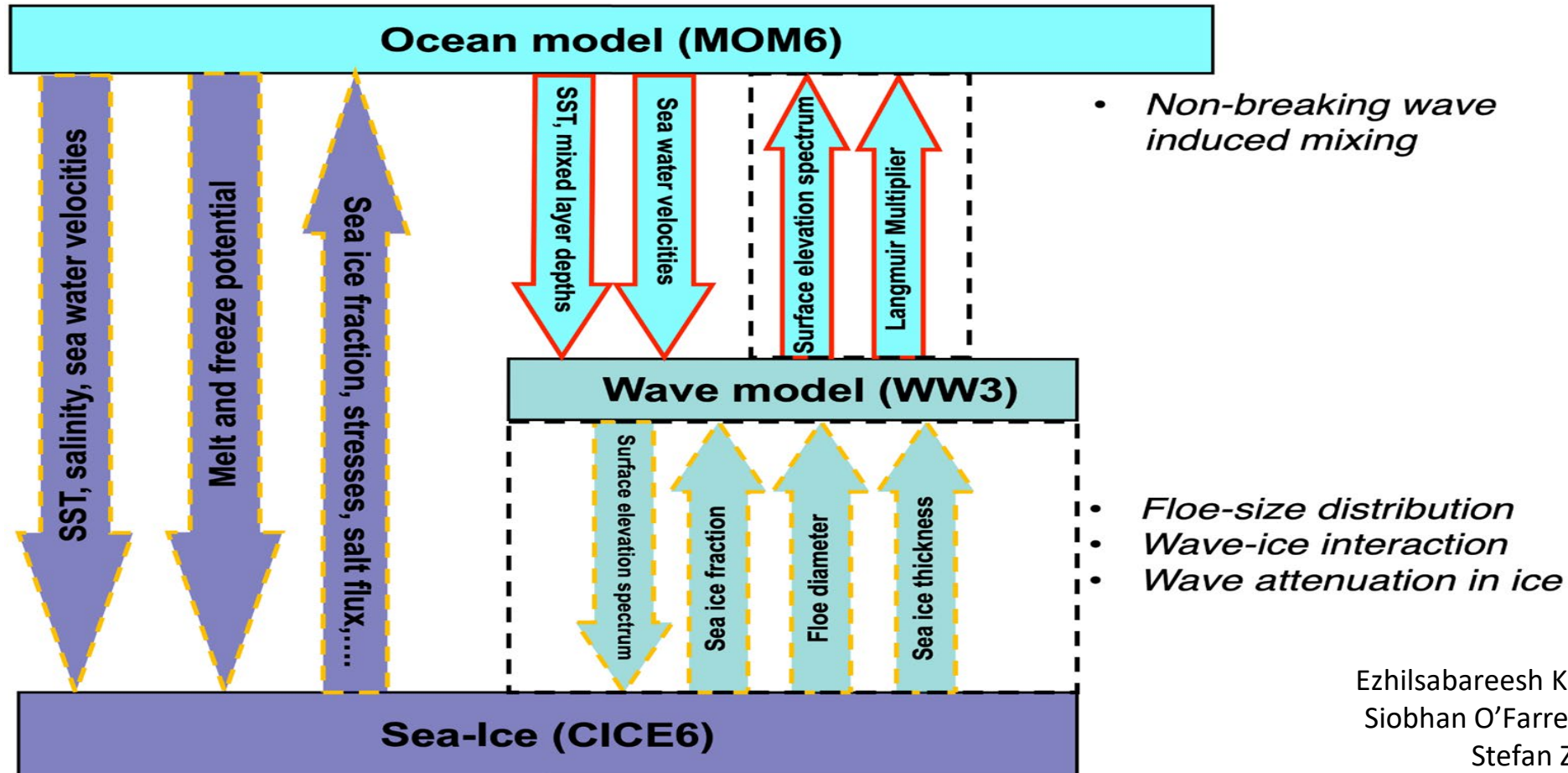
Preliminary results of 1° ACCESS-OM3 MOM6-CICE6-WW3 simulation

Developments:

- Two-way wave-ice and wave-ocean interaction
- **CICE6 floe size distribution** evolves in response to WW3 surface elevation spectrum
- **WW3 floe-size dependent scattering** using spatio-temporal floe size distribution from CICE6.

In progress:

- Testing different WW3 wave attenuation models (**Visco-elastic**, Wang & Chen, 2010 or **empirical**, Meylan et al., 2014) with floe-size dependent scattering
- **Next step:** Meylan et al. (2021) IC4M8 attenuation/scattering



Ezhilsabareesh Kannadasan, Anton Stekete, Siobhan O'Farrell, Noah Day, Luke Bennetts, Stefan Zieger, Shuo Li, Alex Babanin

Global 1° MOM6-CICE6-WW3 using **damping by visco-elastic sea-ice** (IC3, Wang and Shen, 2010)
and **floe-size dependent scattering** (IS2)

Surface waves
damped by
sea ice,
depending on
floe size

Waves
generate
floe size
distribution

Sea ice
concentration

Sea ice
thickness



Global 1° MOM6-CICE6-WW3 using **empirical damping by sea-ice** (IC4M2, Meylan et al., 2014) and **floe-size dependent scattering** (IS2)

Strongly damped waves outside the 15% sea ice concentration contour, reaching zero (NaN on log scale), unlike the IC3 case where damping occurs mainly within the contour.

Sea ice concentration

The reduced wave energy outside the 15% sea ice concentration contour may lead to the formation of large ice floes due to limited breakup potential

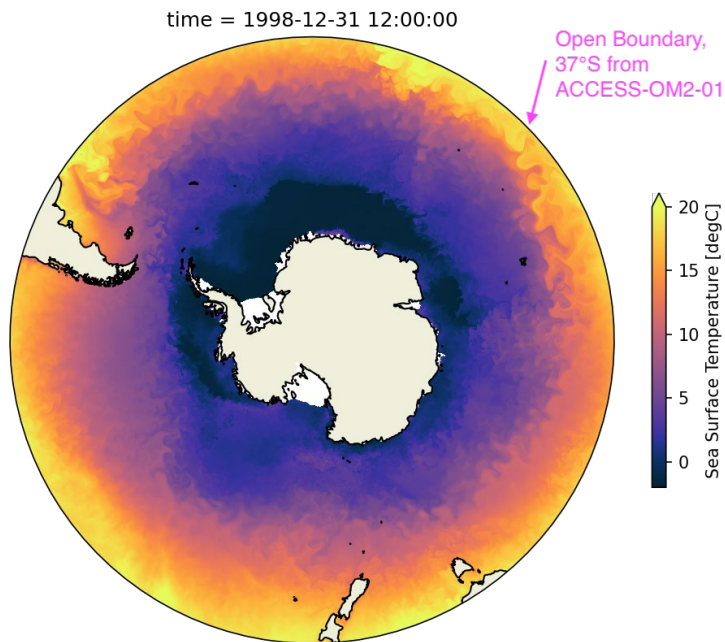
Sea ice thickness



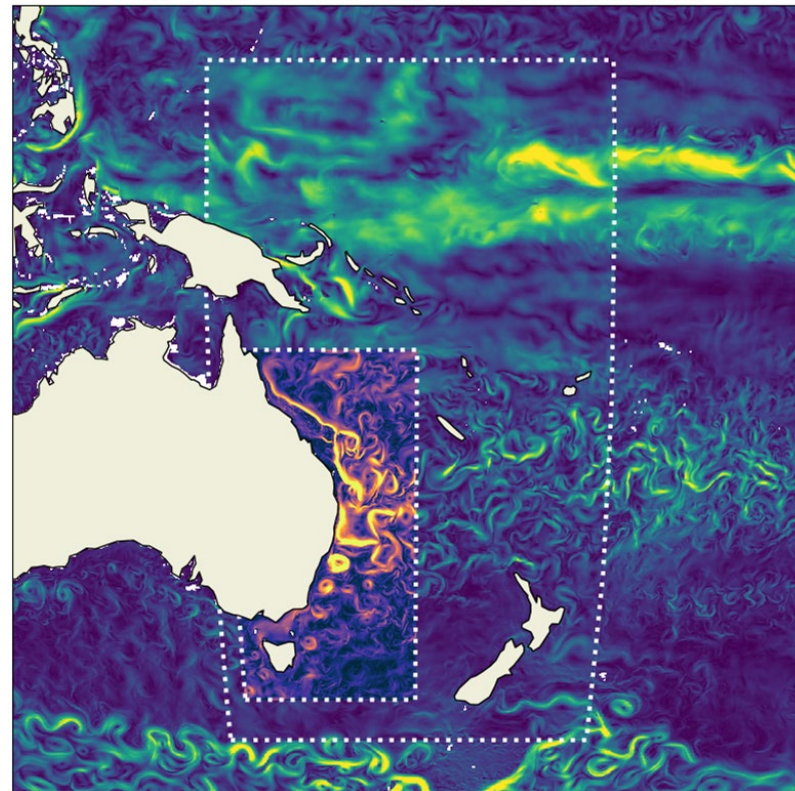
MOM6-SIS2 regional models

In parallel to global MOM6/CICE6 development, COSIMA members have developed a number of high resolution regional MOM6/SIS2 configs:

- Circumpolar, from Antarctica to 37°S
- East Australian Current region
- Tasman Sea tidal config



TWO-TIER MOM6 NESTING IN ACCESS-OM2-01



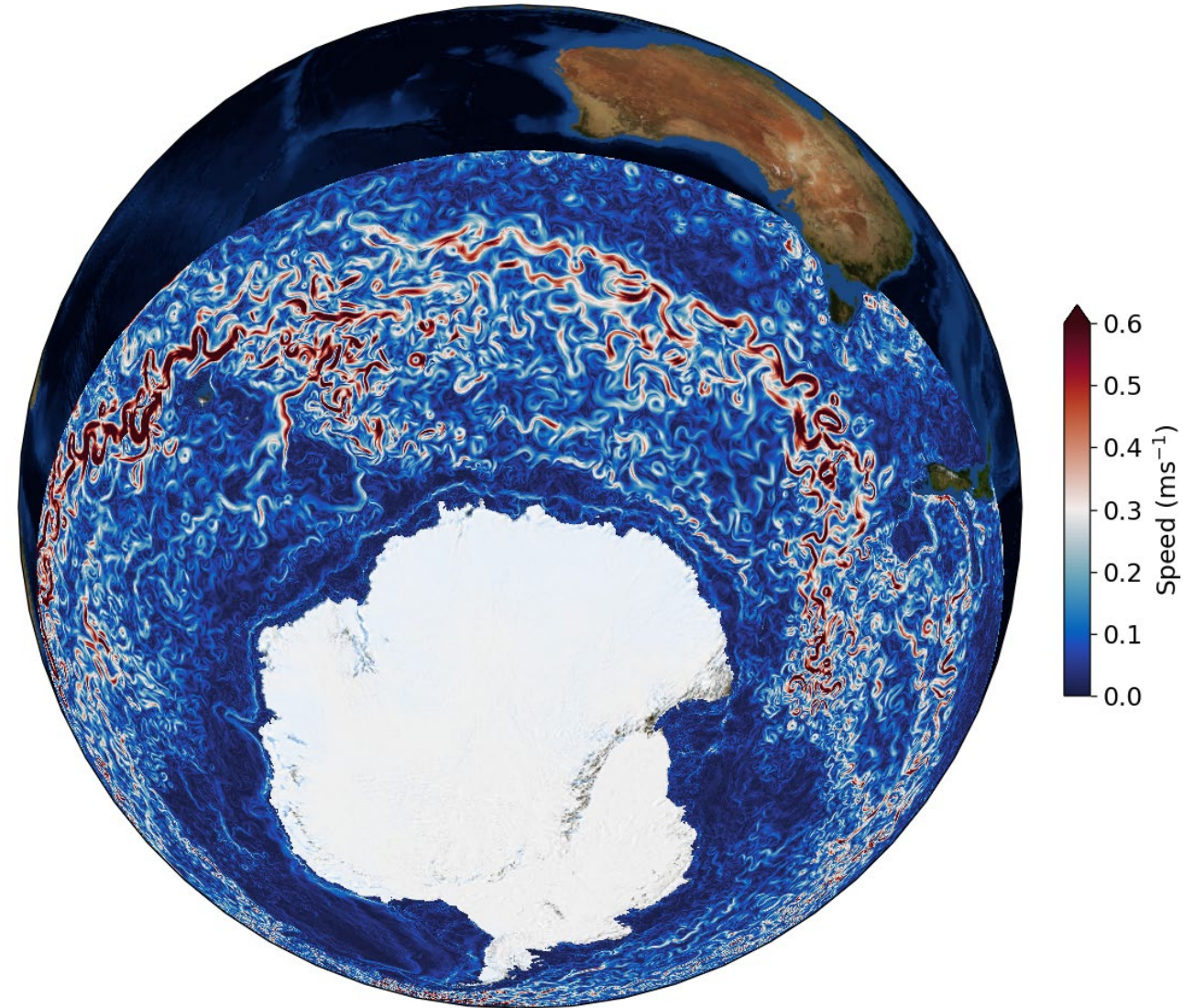
John Reilly

MOM6 regional model features:

- Non-reflective boundary conditions (Orlanski) without use of sponges/restoring.
- Velocity and tracer boundary forcing.
- Automatic vertical interpolation of boundary forcing.

Pan-Antarctic regional model

- Circumpolar, from Antarctica to 37°S
- 1/10°, 1/20° and 1/40° resolution
- 75 z* vertical layers
- Open boundary at 37°S driven by daily ACCESS-OM2-01 output, using tracer reservoirs (no sponges or restoring)
- JRA55-do surface forcing
- 12 years of each resolution complete



ANU: Adele Morrison, Andy Hogg, Angus Gibson, Wilton Aguiar, Micael Oliveira, Andrew Kiss
UNSW: Christina Schmidt, Matt England, Pedro Colombo, Fabio Dias
UTAS: Paul Spence, Matthis Auger

User-friendly MOM6 regional model configuration package

- <https://github.com/COSIMA/regional-mom6>
- **Python package to set up an entire experiment, including grids, surface and boundary forcing, initial conditions, bathymetry, tidal forcing**
- Development led by Ashley Barnes, ANU
- Paper in review at JOSS



README MIT license

regional_mom6

Python package for automatic generation of regional configurations for the [Modular Ocean Model 6](#).

repo status **Active** License **MIT** codecov **60%** docs **passing** code style **black**

Users just need to provide some information about where, when, and how big their domain is and also where raw input forcing files are. The package sorts out all the boring details and creates a set of MOM6-friendly input files along with setup directories ready to go!

The idea behind this package is that it should the user sidestep some of the tricky issues with getting the model to run in the first place. This removes some of the steep learning curve for people new to working with the model.

+ 2 releases

Contributors 5



Languages

Python 100.0%

EAC 1/80° regional MOM6

1/80° Tasman Sea
domain

Includes tides
(flickering)

Ashley
Barnes



Summary

- Large, active Australian ocean - sea ice – BGC – wave and climate modelling community has grown around existing MOM5-CICE5 models
- **Moving to MOM6-CICE6(-WW3) based models**
 - using CESM NUOPC components
 - **NUOPC cap for UKMO UM** atmosphere & CABLE land
 - Test configurations running, incl. with wave-ice coupling
 - Closer collaboration via CICE consortium and MOM6 node
- Regional MOM6 configuration tool
github.com/COSIMA/regional-mom6

