Joint winter meetings of the Ocean Model Working Group (OMWG) & Polar Climate Working Group (PCWG)

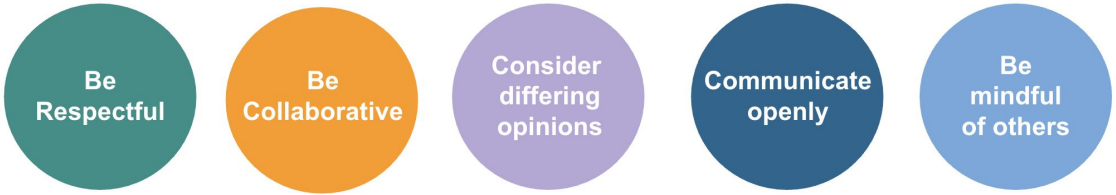
Feb.5-6, 2026

Gustavo Marques & Ian Grooms
OMWG Co-chairs

Alice DuVivier, Ed Blanchard-Wrigglesworth, & David Bailey
PCWG Co-chairs and Liaison

Welcome & Logistics

- Welcome in person and online!
- Code of Conduct
  - Give everyone equal opportunity to engage online and in person



- Wireless: UCAR Visitor is an open, unencrypted network that will require registration before full access is enabled.
- Contacts
  - Elizabeth Faircloth (faircloth@ucar.edu)
  - Alice DuVivier (duvivier@ucar.edu) & Dave Bailey (dbailey@ucar.edu)
  - Ian Grooms (ian.grooms@colorado.edu) & Gustavo Marques (gmarques@ucar.edu)

Meeting Structure

Time	Session	Location
Thursday		
8:30 – 10:30am	**Joint OMWG/PCWG:** Wave-Ice Interactions	Main Seminar Room (MSR)
10:30 – 11:00am	Break	
11:00am – 12:00pm	CGD Seminar	Main Seminar Room
12:00 – 1:25pm	Lunch	
1:25 – 3:00pm	**Joint OMWG/PCWG:** CESM3 development & plans	Main Seminar Room
3:15 – 4:30pm **3:30 – 4:50pm**	**PCWG session** **OMWG session**	**Damon Room (DR)** **Main Seminar Room**
4:30pm	Optional, self pay gathering	Southern Sun (bring cash)
Friday		
8:25am – 12:30pm **8:25am – 2:30pm**	**PCWG session** **OMWG session**	**Damon Room** **Main Seminar Room**

Facilities:

- Water Fountains around (stay hydrated!)
- Cafeteria sells lunch
- Restrooms:
  - Men's/Women's on first and second floors
  - Single use, accessible on second floor (go up and take a left)

Meeting Goals

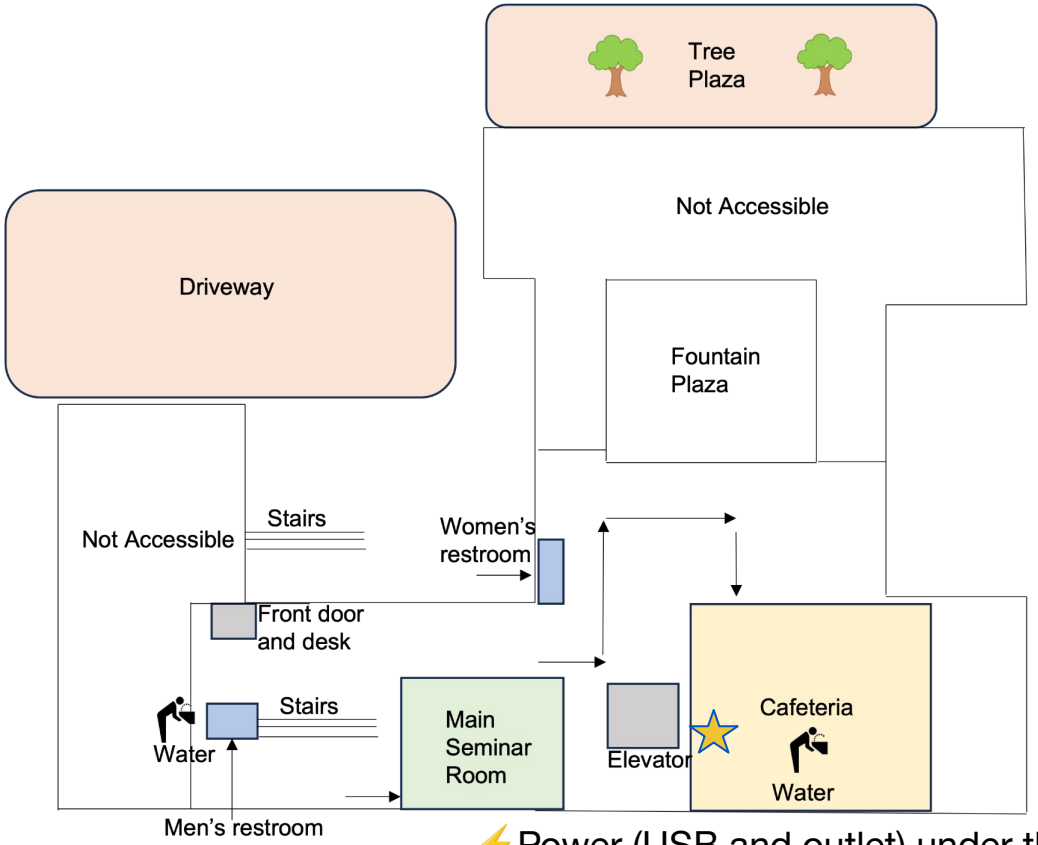
- Joint Sessions
  - Increase collaboration
  - Open new science opportunities
  - Get community input to inform model development and experiment design in CESM3 and beyond
  - Reduce meeting fatigue

- Individual Sessions
  - Discussion of traditional model component development
  - Community studies and results

- Meetings will be recorded

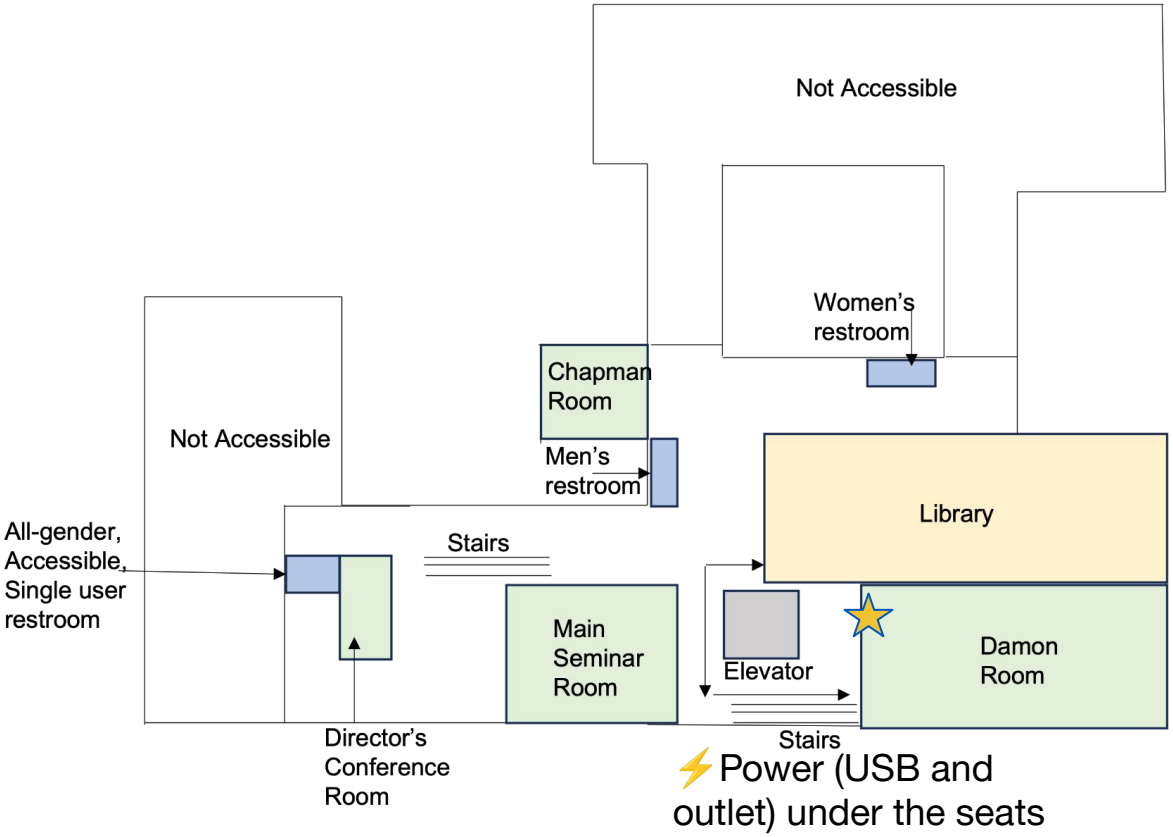
- Power under seats (MSR) or in center of table (DR)

- Please don’t touch the MSR screen!



Main floor

⚡Power (USB and outlet) under the seats



Second floor

⚡Power (USB and outlet) under the seats

CESM Communications:
https://www.cesm.ucar.edu/communications

Subscribe to the CESM Newsletter :
www.cesm.ucar.edu/news/newsletters

@ncar_cgd

@NCAR_CGD

NSF NCAR CGD

@ncar-cgd.bsky.social

OMWG/PCWG Joint Session Discussion
Wave-Ice interactions

Discussion topics

- Coordinated wave/ice experiments, etc.
- Regional ice/ocean/wave modeling
- Anything else…

CESM 3 Development Overview & Component Status

OMWG and PCWG co-chairs

CESM Tutorial

CESM Tutorial - July 6-10, 2026
At NSF NCAR Mesa Laboratory (in person), Boulder, CO

Application:
https://www.cesm.ucar.edu/events/tutorials/cesm

Deadline:
Tuesday, February 17, 2026 at 11:59 PM Mountain Time

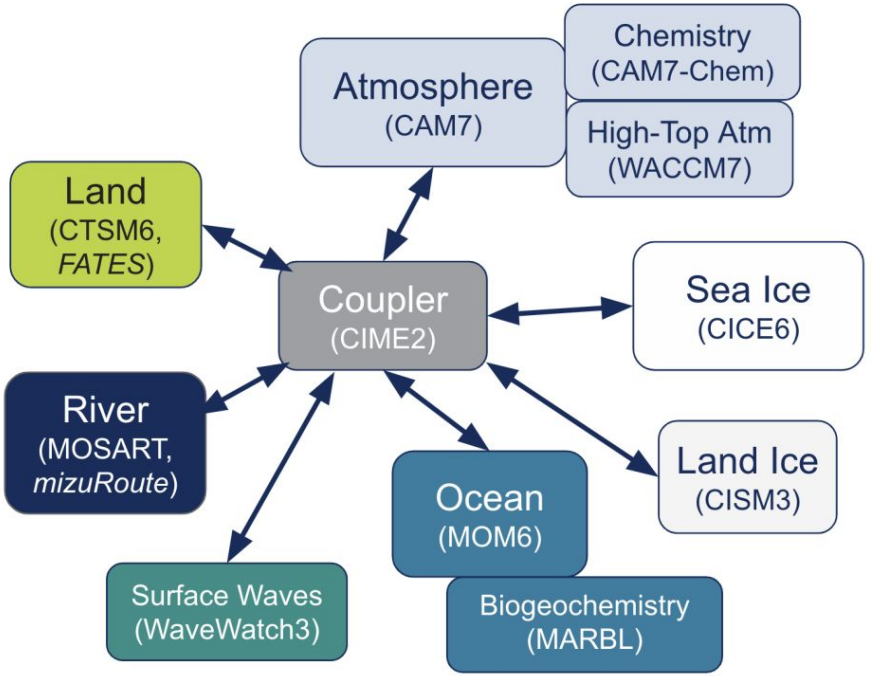
Cost:
No cost to attend. Travel support may be available (uncertain at this time).

Components of CESM3

Full list of changes
("what" and "why")

www.cesm.ucar.edu/news/community-earth-system-model-3-cesm3-plans-progress-timelines

Significant updates to all component models



Courtesy of David Lawrence

Development run database

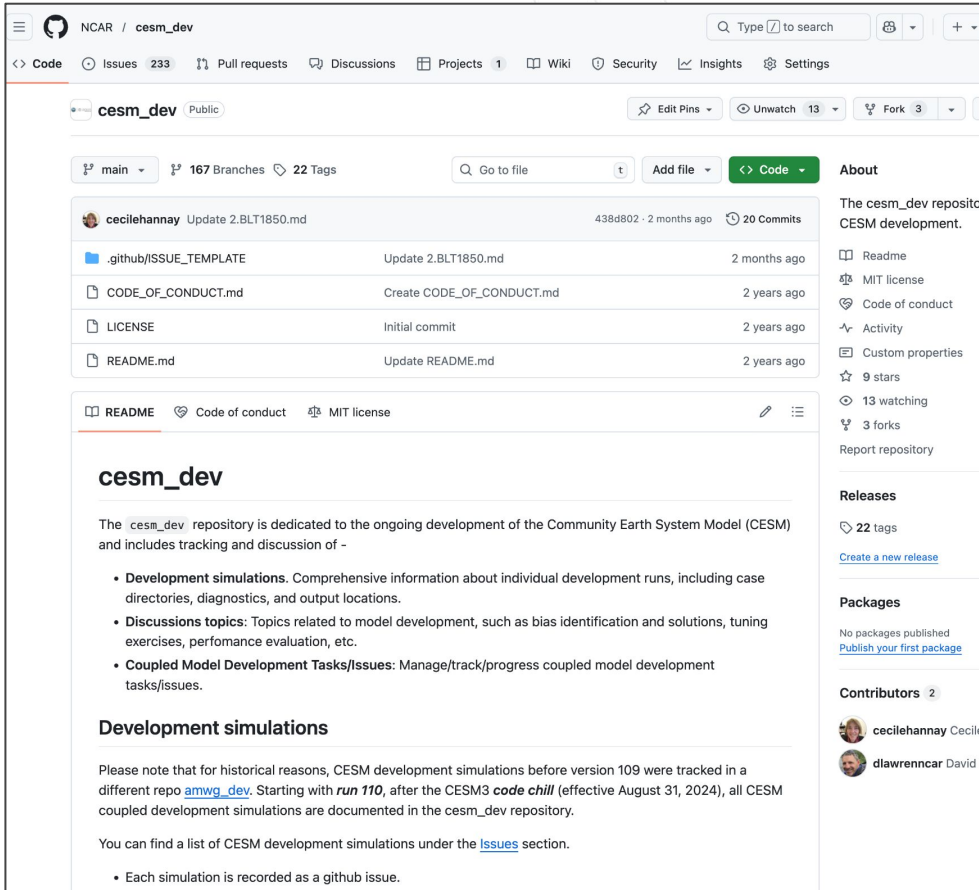
cesm_dev database

- We track of **all development simulations** in https://github.com/NCAR/cesm_dev/

What's available in cesm_dev database?

- Info about simulations
- Links to case directories
- Output availability (including some climos)
- Diagnostics
- Related discussions

Courtesy of Cecile Hannay



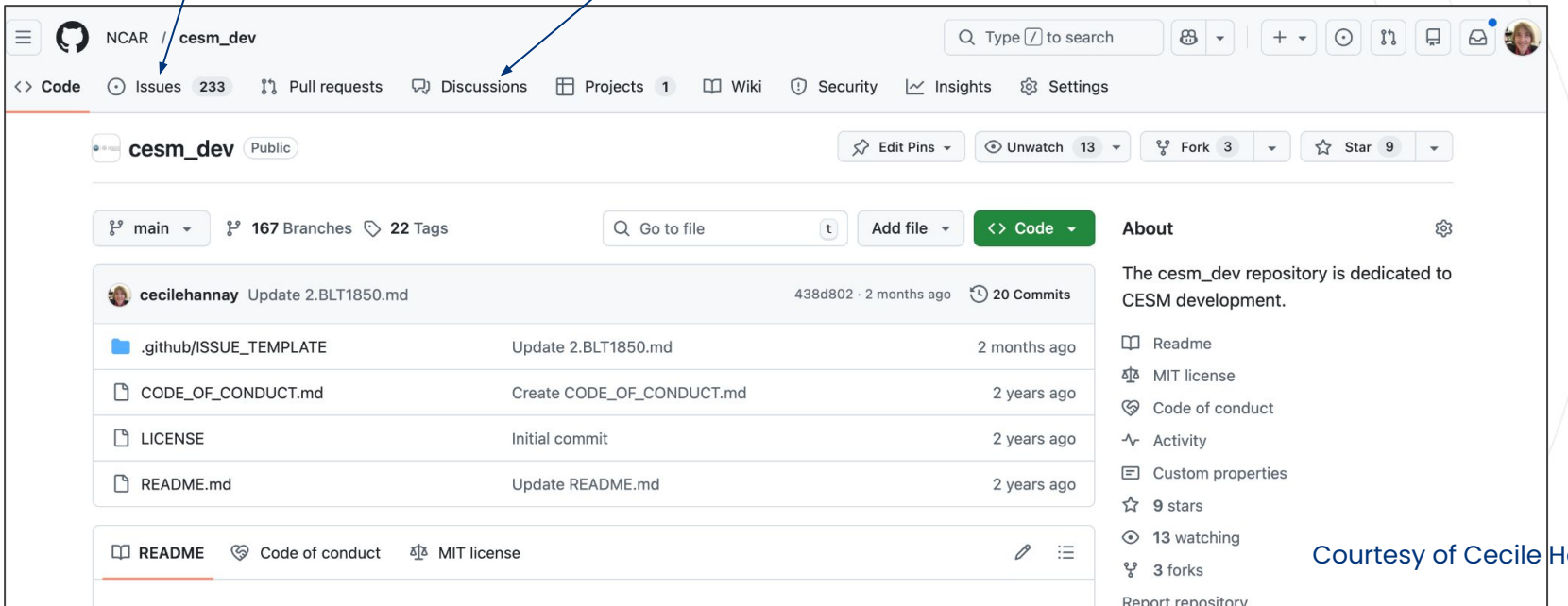
cesm_dev database

One issue = one simulation

- info about case directory, tag, diags
- Posts about plots, bug, etc…

Discussion

- discussion about specific issues
- Ex: Analysis of historicals, …



Courtesy of Cecile Hannay

The CESM development timeline and simulations

CESM2 release: June 2018

- Building timeline: 2010-2018
- 299 configurations

CESM3 release target date: …

- Building timeline: 2018-2026
- 302 configurations so far…

Courtesy of Cecile Hannay

The CESM development timeline and simulations

CESM2 release: June 2018

- Building timeline: 2010-2018
- 299 configurations

CESM3 release target date: June 2026

- Building timeline: 2018-2026
- 302 configurations so far…

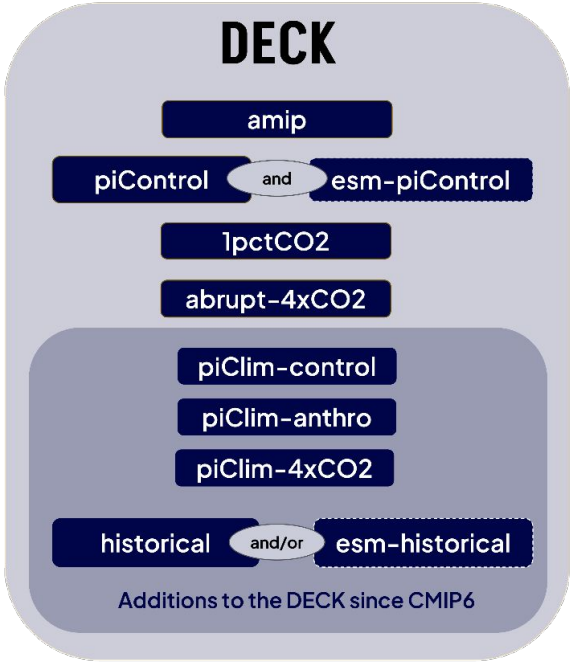
* We plan to do the CMIP7 DECK simulations

→ Necessary for model validation and assessment

* We will do other simulations if we have sufficient resources.

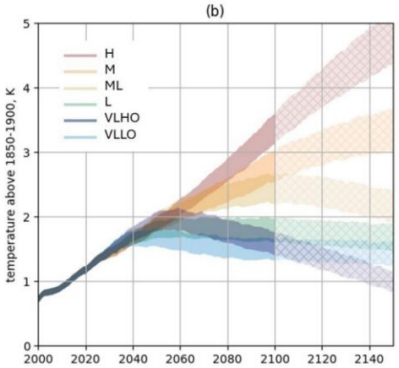
→ No decisions yet on which MIPS, scenarios, etc.

→ We welcome community input.



+

?



Challenges during CESM3 development

What has been slowing us down on the scenic highway to CESM3…

- ENSO characteristics
  => AMWG talk by Isla (Monday Feb.2, 2026)
- The Labrador Sea Freeze
  => PCWG talk!
- Antarctic Circumpolar Current (ACC) transport
  => OMWG talk!

Courtesy of Cecile Hannay

CESM 3 Sea Ice Model Status

Alice DuVivier & David Bailey
Polar Climate Working Group Co-chairs

Road map of the sea ice section

What's new in CICE in CESM3

- Floe Size Distribution
- Melt Ponds

Challenges during CESM3 development

- Labrador Sea • and many more…

Current sea ice status

- Look at two simulations - 271 and 287
- Diagnostics: https://webext.cgd.ucar.edu/BLT1850/b.e30_alpha07g.B1850C_LTso.ne30_t232_wgx3.287_ice/ice/html/ice/Hemis_seaice_visual_compare_contour.html
- CUPiD Diagnostics

PCWG Sea Ice Plans for CESM3 and beyond

Winter Working Group Meetings
February 2026

CESM3

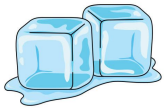
- Floe size distribution (FSD)

- Sea-level melt ponds

- Advanced snow physics (wind redistribution only)

All are in fully coupled system as default.

Spring/Summer 2026



CESM3 Code Mostly Frozen

Model tuning and finalization ongoing

CESM3 PI runs by June 2026 (hopefully!)

Beyond CESM3

CESM3+

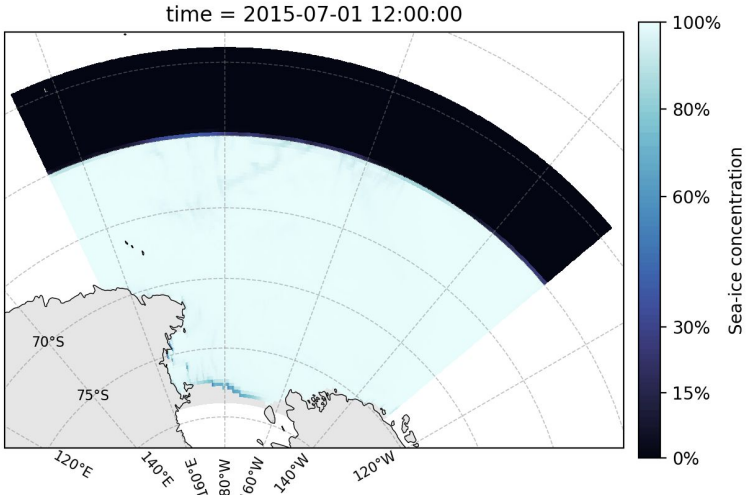
- Landfast ice subgridscale bathymetry
- CICE6-MOM6 Coupling on C-Grid
- Improved ice conduction
- New congelation growth

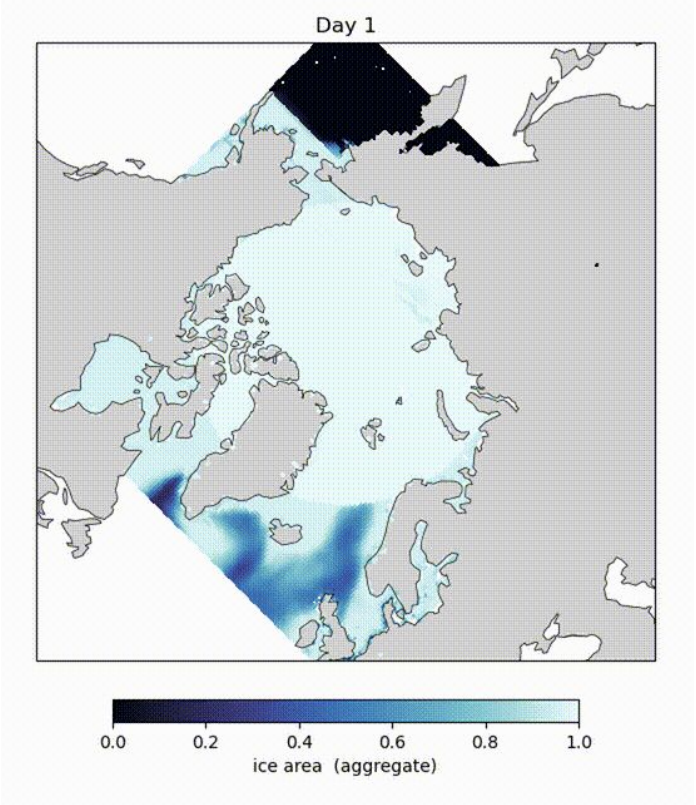
- Sea Ice Biogeochemistry
- Ice radiative transfer (5-band SNICAR)

- Machine Learning & FSD
- Regional ice/ocean modeling

Sea Ice and CROCODILE

CROCODILE: CESM Regional Ocean and Carbon cOnfigurator with Data assimILation and Embedding





Questions:

Cyclic vs. open boundaries

Waves

Sea Ice BGC

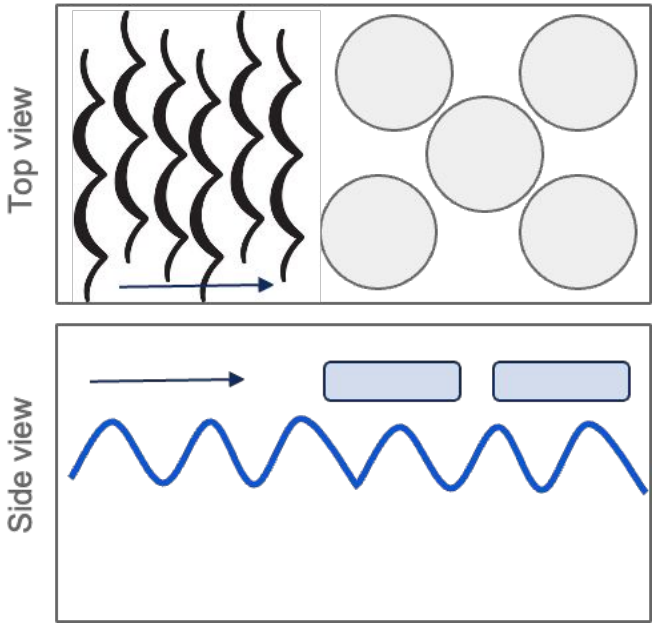
etc.

CROCODILE 2025 Workshop
Participant Show-and-Tell
NSF NCAR, 13-17 October

The prognostic floe size distribution (FSD)

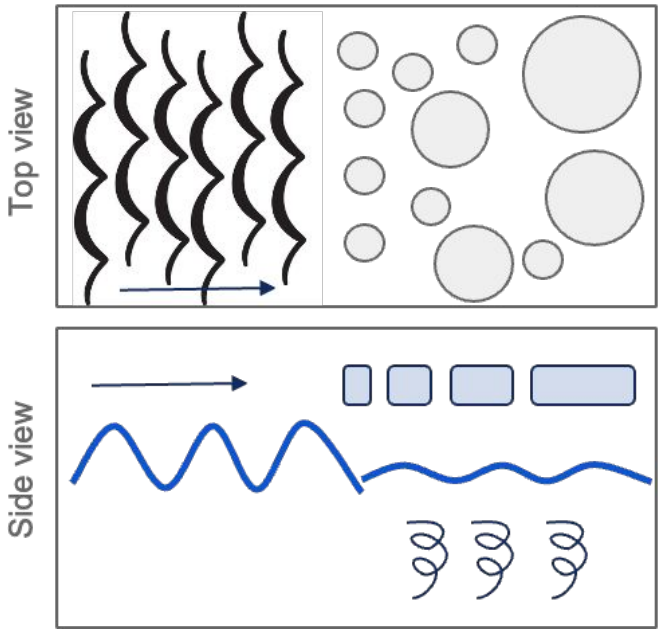
CESM2

Constant floe diameter: 300m
Ocean waves **not** damped by sea ice
Ocean mixing **not** impacted



CESM3

Prognostic joint floe size and ice thickness distribution
Ocean waves **are** damped by sea ice
Ocean mixing **is** impacted by waves

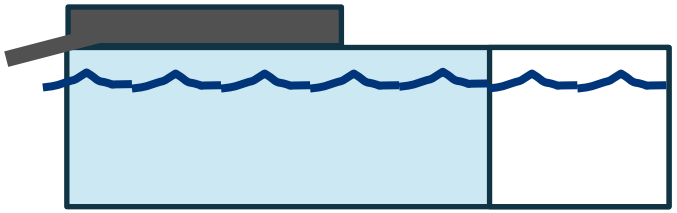


Impact on Ice

Wave breaks sea-ice
↓
More lateral melt
↓
More open water
↓
More waves

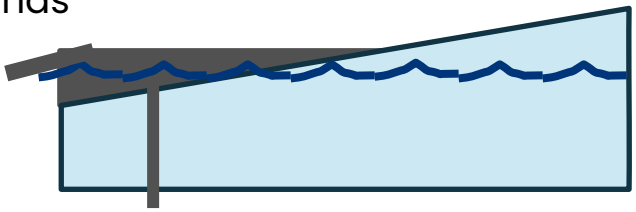
Sea Level Melt Ponds

CESM2
“level” ponds



- Ponds are sit on top of sea ice.
- Pond area and depth grow by fixed ratio. Drainage only reduces depth.
- Results in too extensive and too shallow melt ponds compared to observations.

CESM3
“sea level” ponds

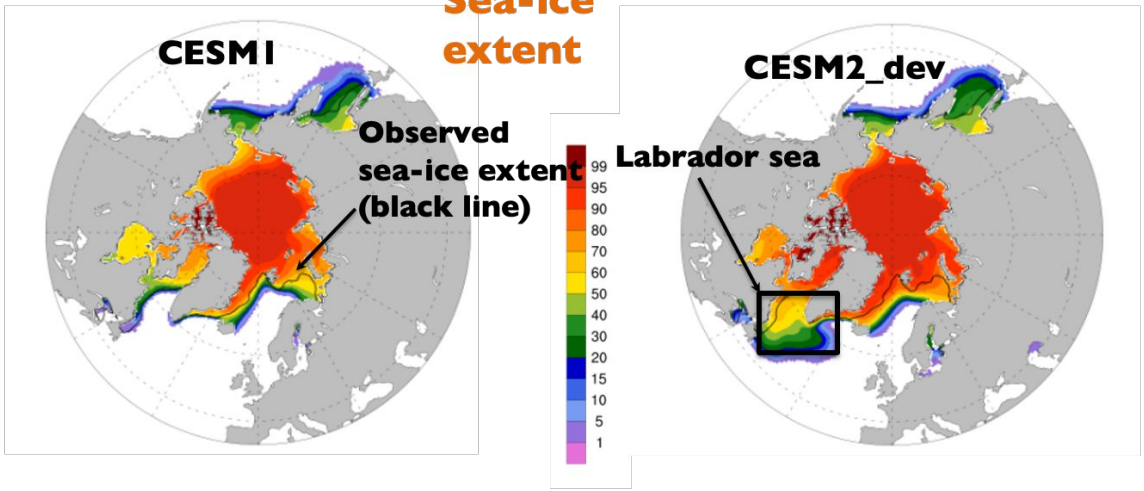


- Ponds account for sea level.
- Drainage reduces both depth and area based on elevation above sea level (hypsometry).
- Contact: David Clemens-Sewall David.Clemens-Sewall@colorado.edu

The Lab Sea Freeze: a long-time challenge in CESM

The Labrador Sea issue (CESM2 development, 2016)

- **The Labrador Sea was freezing in CESM2_dev.**



Sea-ice extent is close to obs. Labrador sea is ice free

Labrador sea is ice-covered.

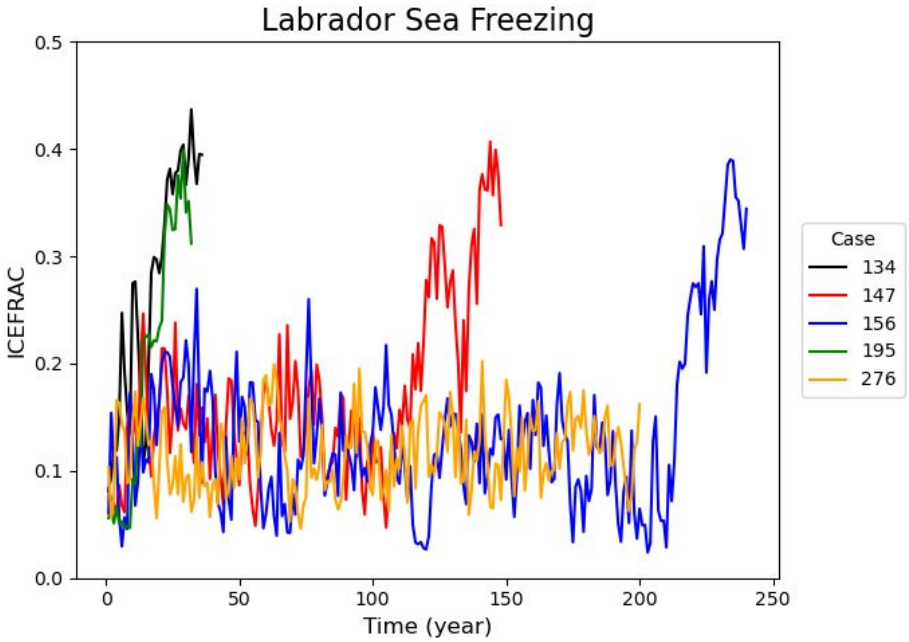
Courtesy of Cecile Hannay

The frozen Lab Sea Issue re-emerges in CESM3

Frozen lab sea is difficult problem

- Related to too much fresh water in Lab Sea
- Freezing can occur after long periods
- Freezing timing is unpredictable (can happen after 20, 100, or even 200 years)
- Lab sea freeze in 30% of development runs; in the remaining 70%, all we could say: the Lab is not frozen … yet.
- Once frozen, the Lab Sea stays frozen (*)

(*) this was true until …



Courtesy of Cecile Hannay

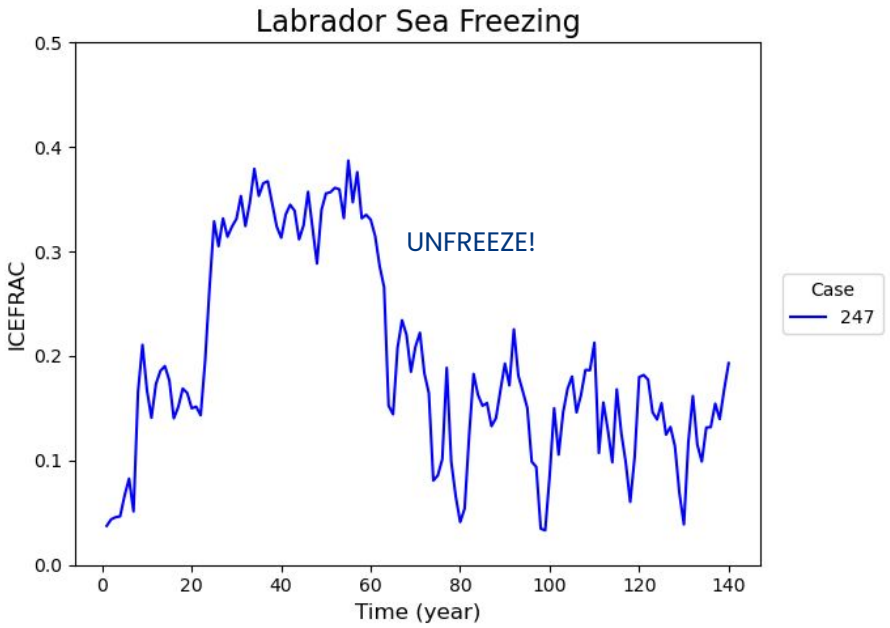
The frozen Lab Sea Issue re-emerges in CESM3

Frozen lab sea is difficult problem

- Related to too much fresh water in Lab Sea
- Freezing can occur after long periods
- Freezing timing is unpredictable (can happen after 20, 100, or even 200 years)
- Lab sea freeze in 30% of development runs; in the remaining 70%, all we could say: the Lab is not frozen … yet.
- ~~Once frozen, the Lab Sea stays frozen~~ (*)

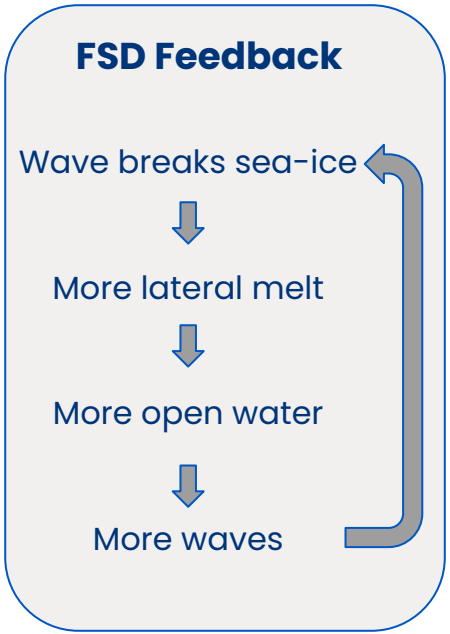
Two things impact the Lab Sea freezing:

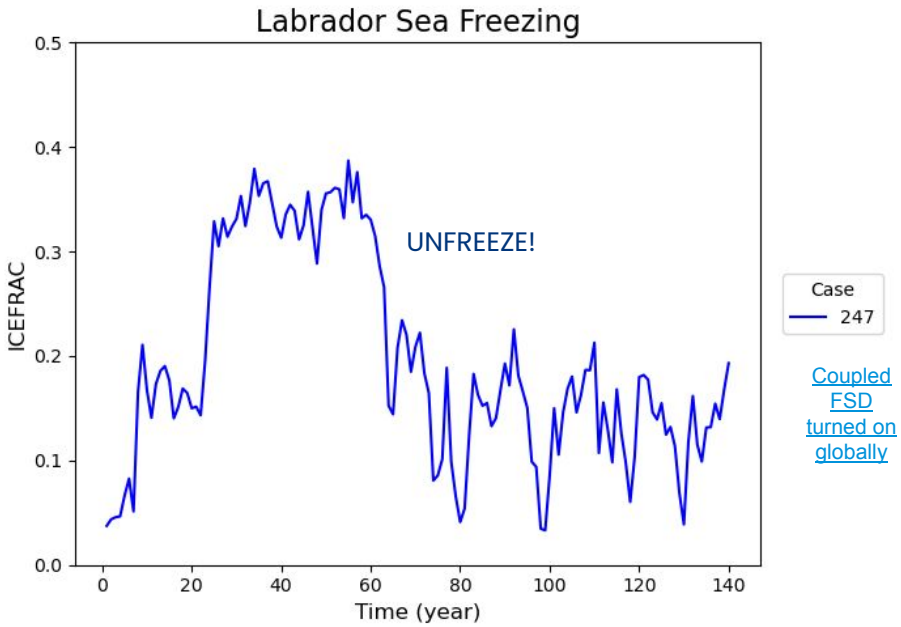
- The CICE floe size distribution (FSD) parameterization being fully coupled
- Turn OFF Bodner ocean parameterization in the Lab Sea Only



Courtesy of Cecile Hannay

Having full FSD is critical for unfreezing behavior





Coupled FSD turned on globally

Courtesy of Cecile Hannay

Impact of Bodner parameterization on Lab Sea

What is Bodner ?

- Bodner is a mixed-layer eddy (MLE) scheme
- It controls how strongly ocean restratifies the ML and it opposes deep mixing (convection).
- When ML depth increases the strength of the restratification increases.

Lab Sea = Deep ML

⇩

Bodner restratification too strong

⇩

Convection suppressed

⇩

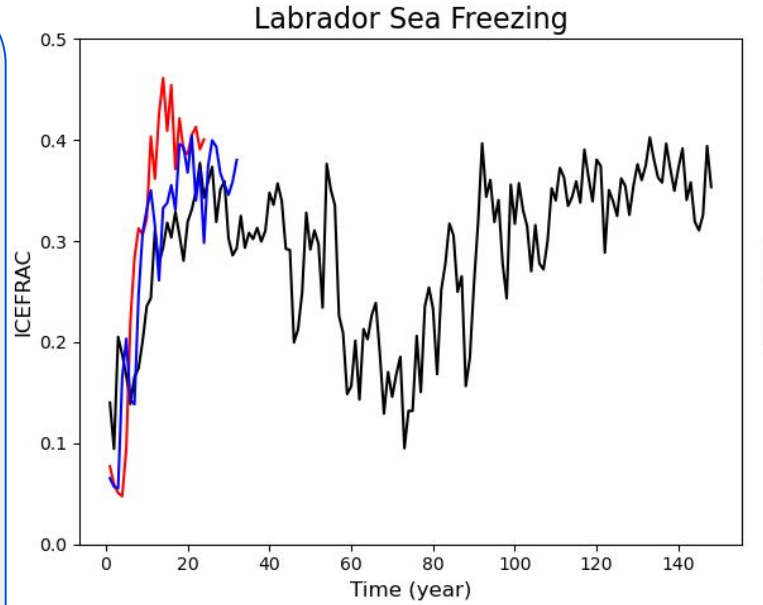
Heat trapped at depth

⇩

Cold surface

⇩

Sea Ice Growth



Tests to turn Bodner on in Lab Sea (unsuccessful)

Courtesy of Ian Grooms and Cecile Hannay

Sea Ice Status

So… how does the sea ice look in current development simulations?

Sea Ice Status

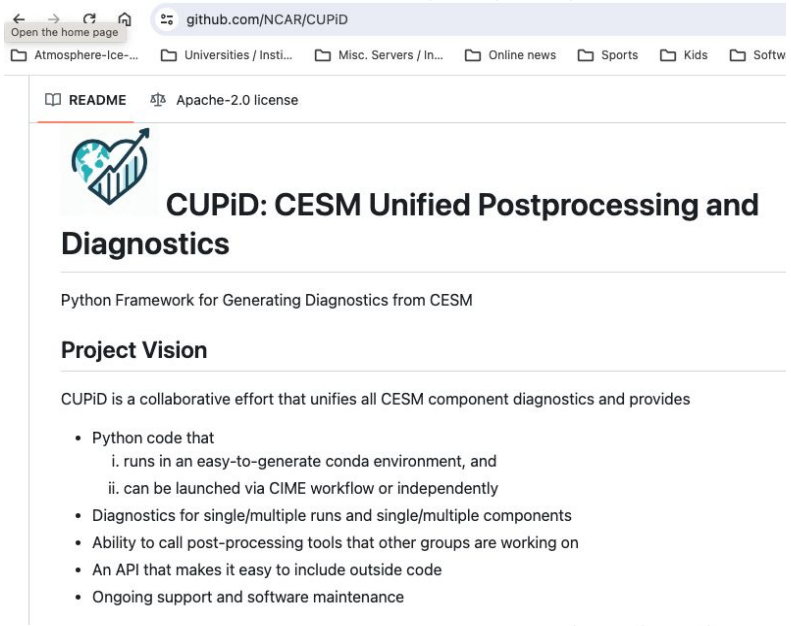
- Look at two simulations - 271 and 287
  - Diagnostics: https://webext.cgd.ucar.edu/BLT1850/b.e30_alpha07g.B1850C_LTso.ne30_t232_wgx3.287_ice/ice/html/ice/Hemis_seaice_visual_compare_contour.html

- A few caveats
  - 271 is the longest current simulation but has known issues with the ACC (see next talk)
  - 287 is the current “best” candidate for ocean configuration/settings.
  - Final atmosphere tuning is ongoing
  - Thus, while sea ice development is “done” some parameter tuning may be needed as response to other components finalization.

Sea Ice Status

- Look at two simulations - 271 and 287
  - Diagnostics: https://webext.cgd.ucar.edu/BLT1850/b.e30_alpha07g.B1850C_LTso.ne30_t232_wgx3.287_ice/ice/html/ice/Hemis_seaice_visual_compare_contour.html

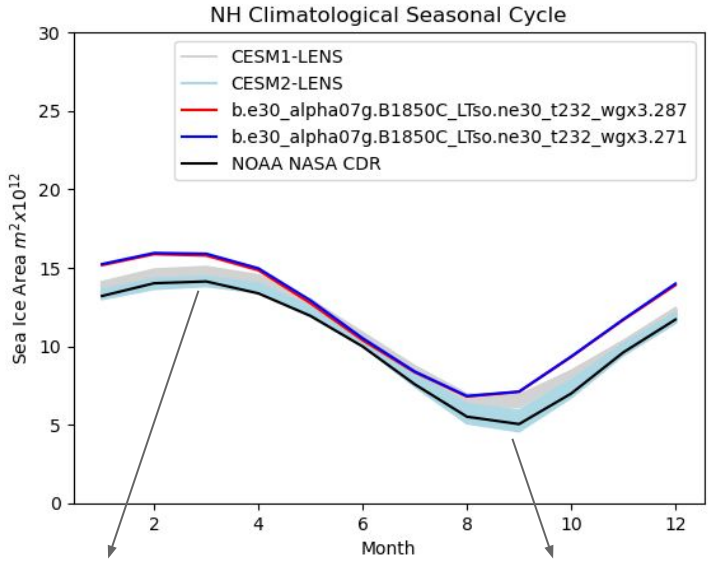
- A few caveats
  - 271 is the longest current simulation but has known issues with the ACC (see next talk)
  - 287 is the current "best" candidate for ocean configuration/settings.
  - Final atmosphere tuning is ongoing
  - Thus, while sea ice development is "done" some parameter tuning may be needed as response to other components finalization.

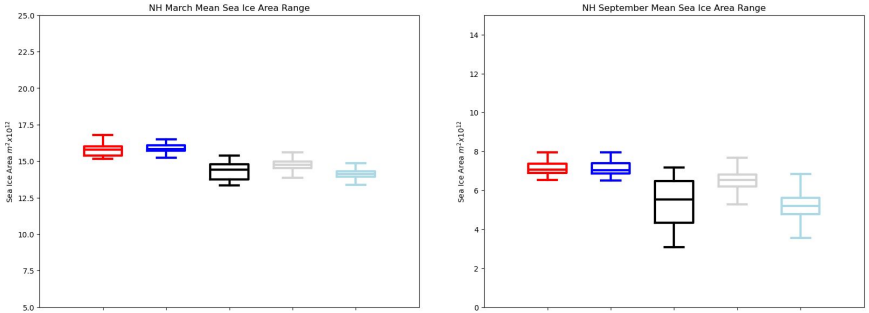


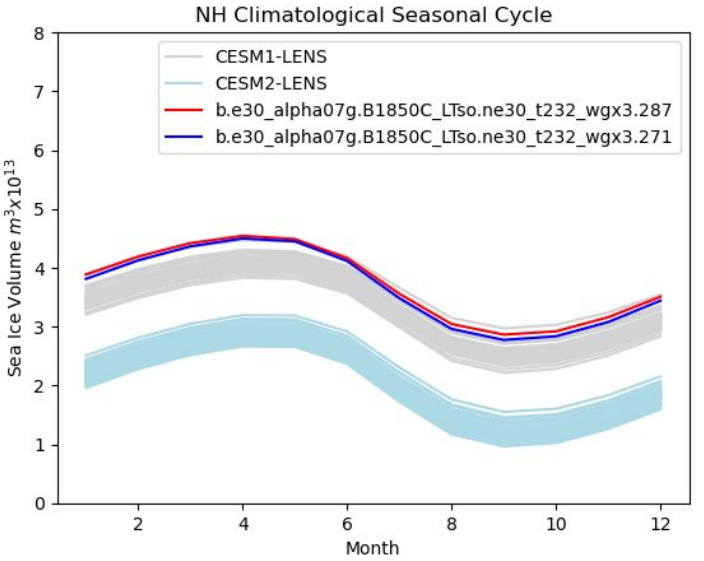
CUPiD Diagnostics

- Open to additions from community!

Arctic Sea Ice – Seasonal Cycle

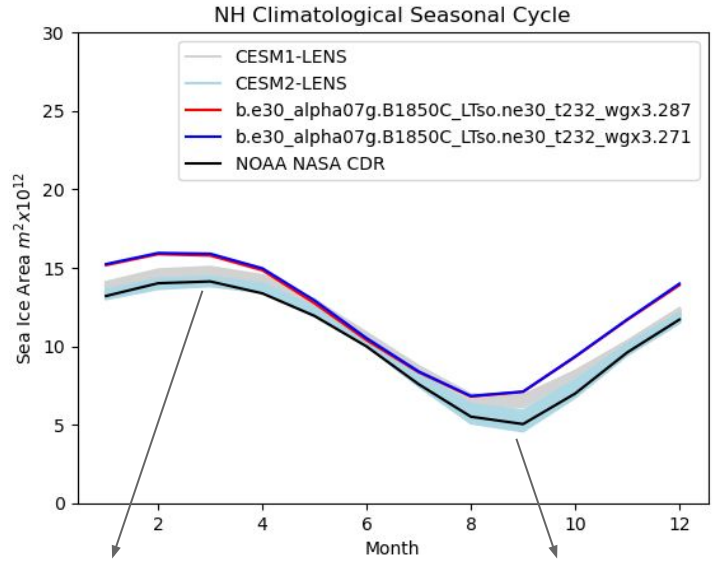


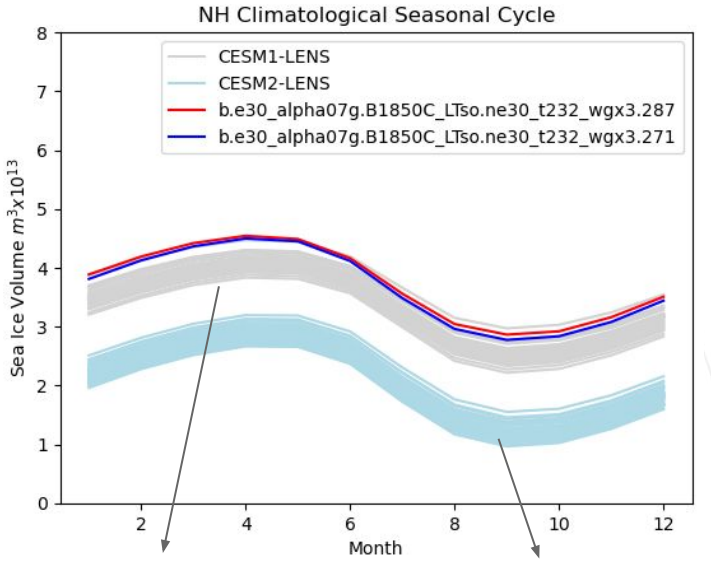


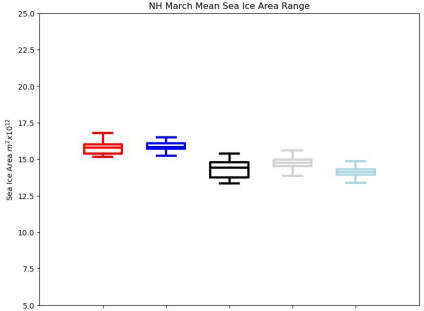


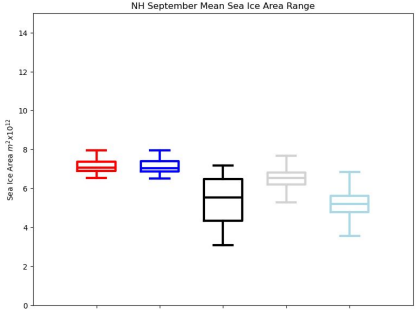
- SIC is higher than obs., but reasonable for a PI control.
- SIV is a bit higher than CESM1-LE, but is in the range we've been aiming for.

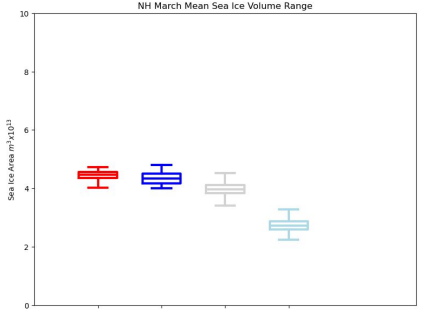
Arctic Sea Ice – Seasonal Cycle

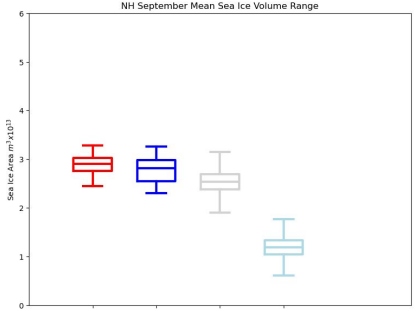




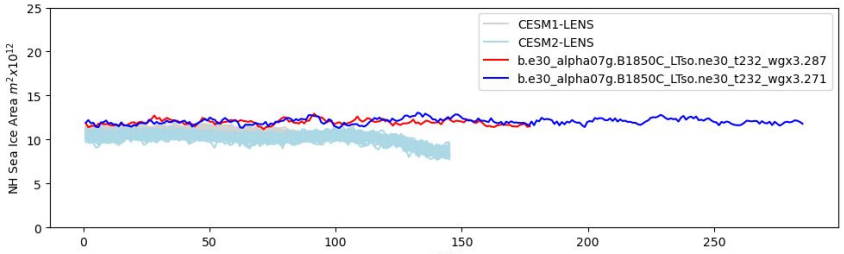


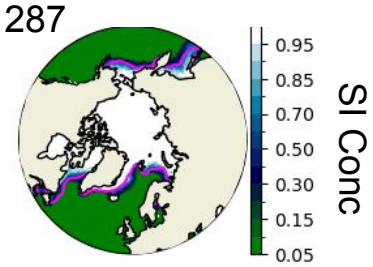






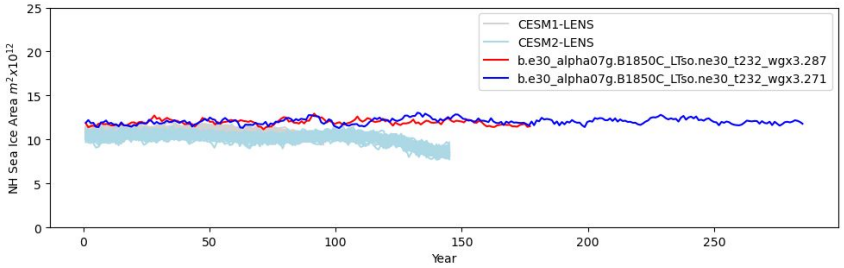
Arctic Sea Ice - Annual Means

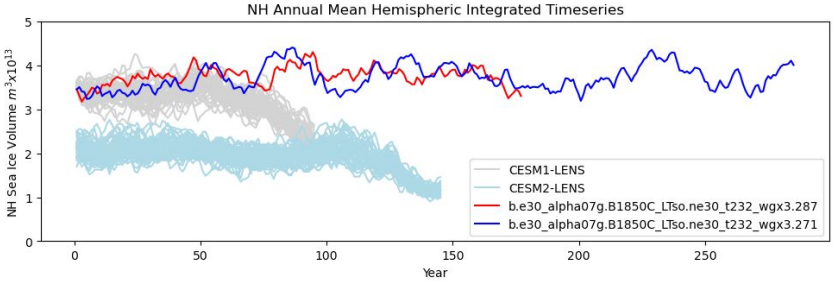


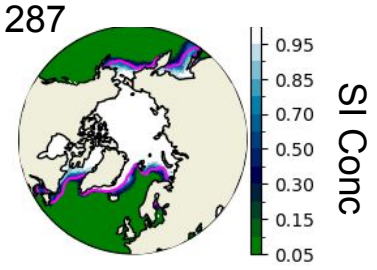


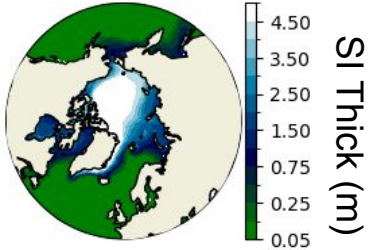
- PI SIA timeseries looks reasonable.
- PI SIConc extent similar to obs (magenta)

Arctic Sea Ice - Annual Means



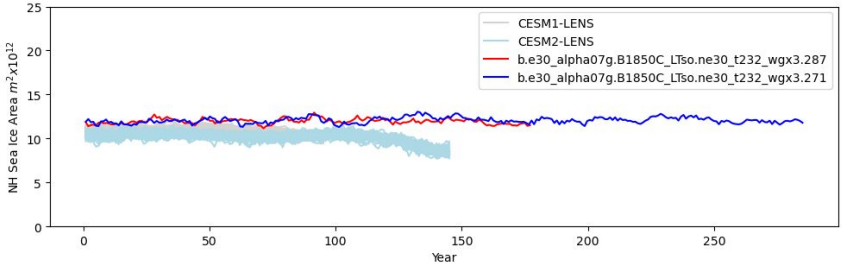


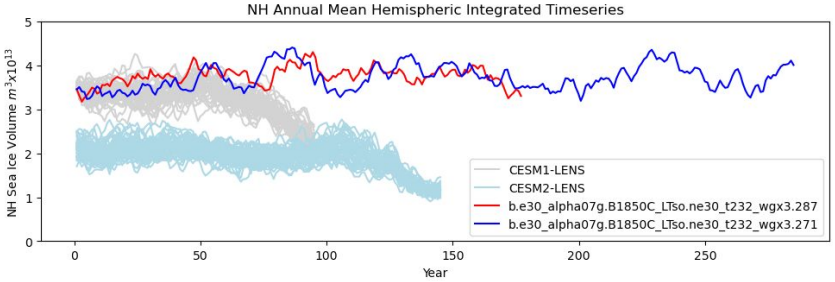


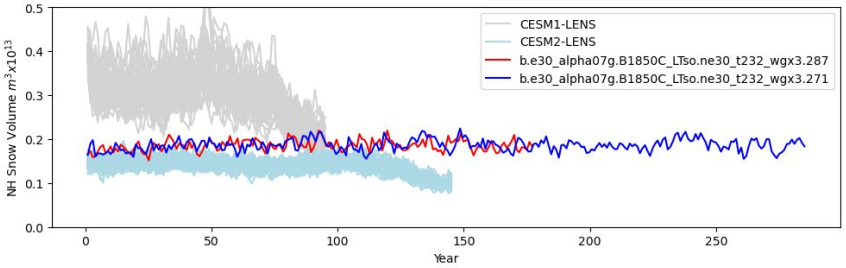


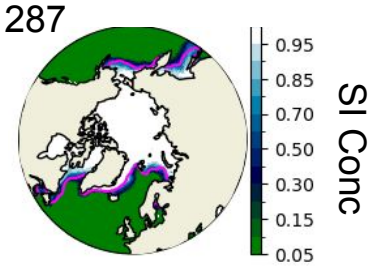
- PI SIA timeseries looks reasonable.
- PI SIConc extent similar to obs (magenta)
- PI SIV is closer to CESM1-LE range, which is what we're aiming for.
- Spatial pattern looks reasonable.

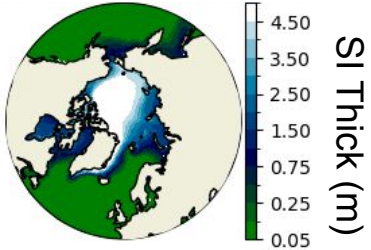
Arctic Sea Ice - Annual Means

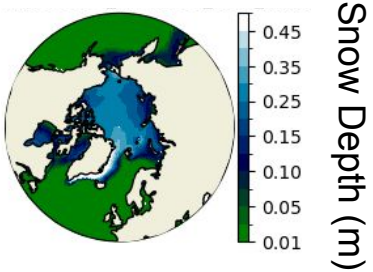












- PI SIA timeseries looks reasonable.
- PI SIConc extent similar to obs (magenta)

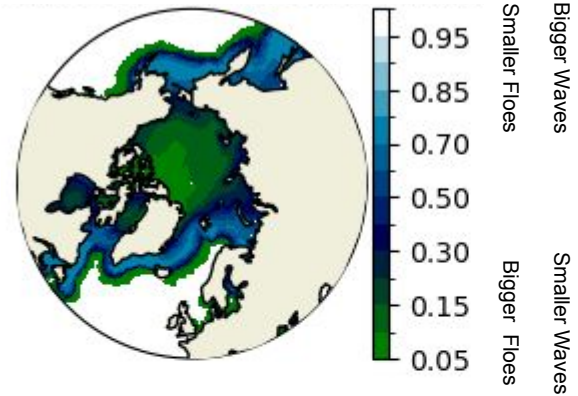
- PI SIV is closer to CESM1-LE range, which is what we're aiming for.
- Spatial pattern looks reasonable.

- Snow thickness range looks reasonable.
- Snow spatial distribution a little odd (see Webster et. al 2021 for obs).

Arctic Sea Ice

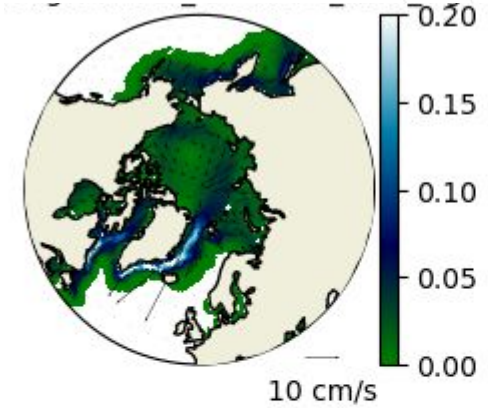
287

Floe size perimeter (1/m)



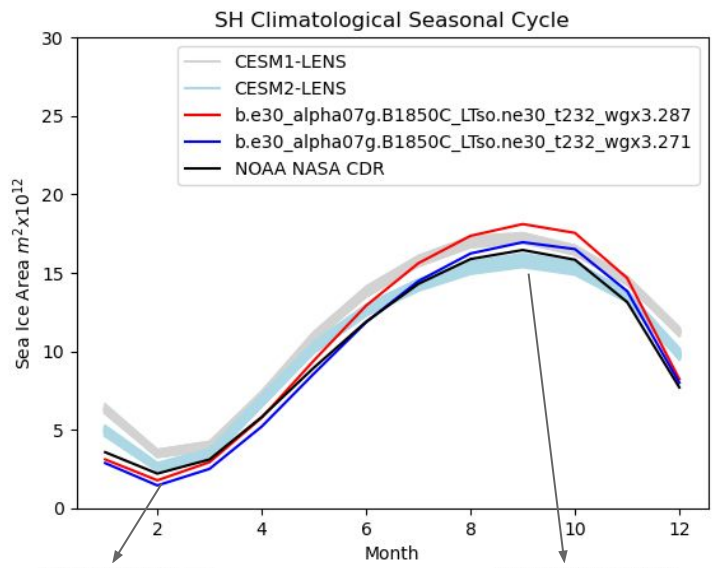
- Sea ice floes are smaller on margins, bigger in Central Arctic.
- Wave heights are biggest on margins and smallest in Central Arctic.

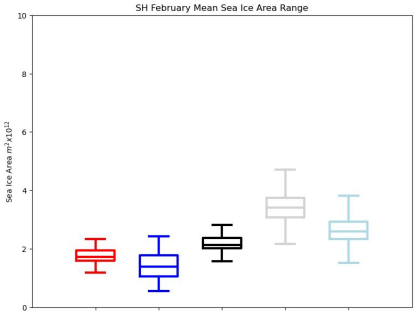
Ice Velocity (m/s)

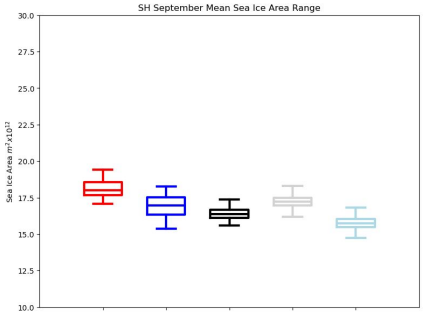


- Major features are present: Beaufort Gyre, transpolar drift, export through Fram Strait.

Antarctic Sea Ice – Seasonal Cycle

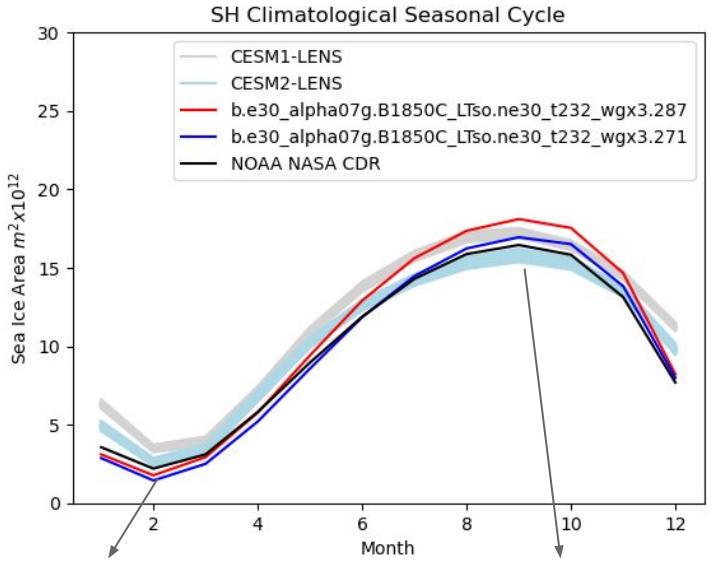


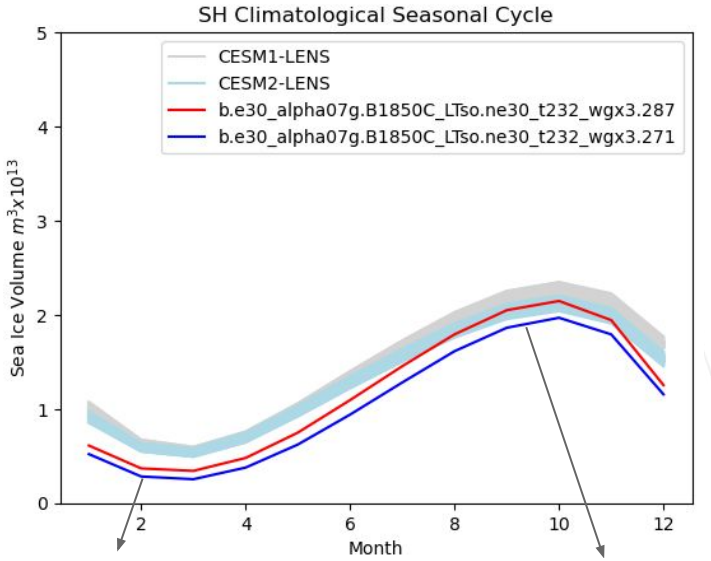


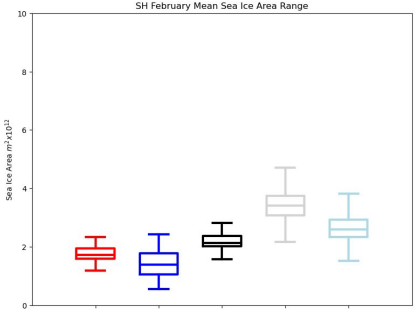


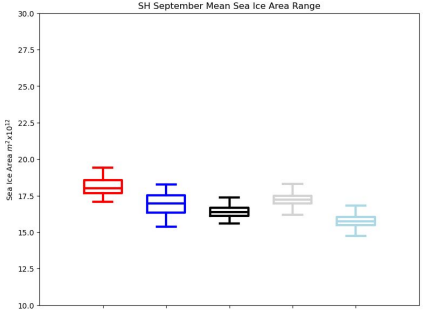
- Winter SIC is reasonable
  - BIG improvement from Winter 2025 meeting. Yay!
  - The winter extent is very sensitive to the mesoscale heat transport parameters (GM tuning).
- Summer SIC is very low
  - Maybe related to ice that is too thin (not shown) so doesn't last all summer?
  - No tuning has been able to address this issue.

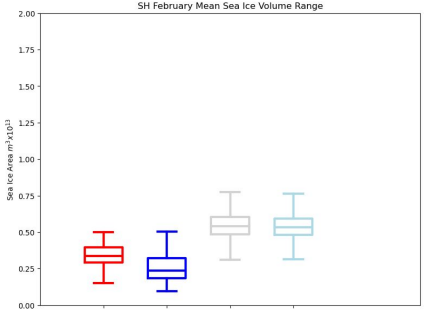
Antarctic Sea Ice – Seasonal Cycle

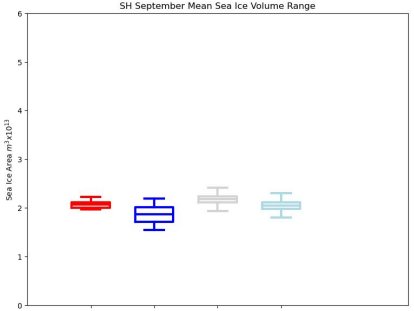




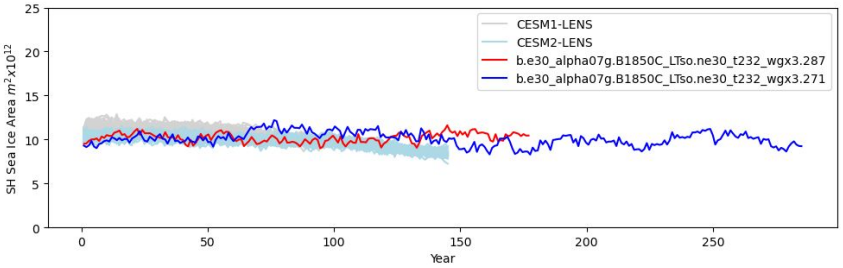




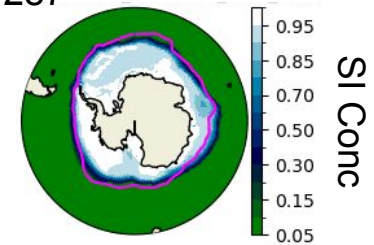




Antarctic Sea Ice – Annual Means

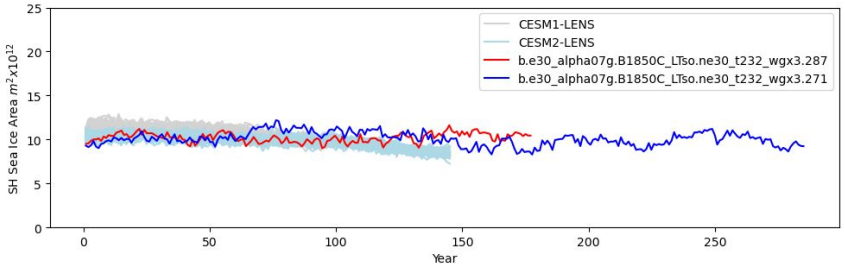


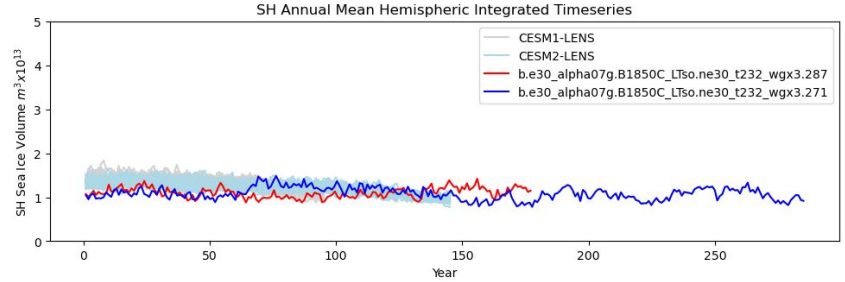
287

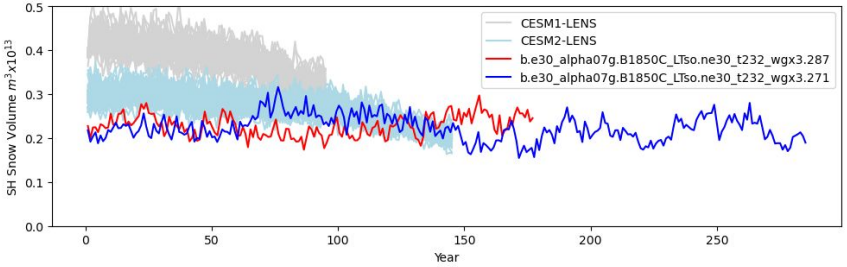


- Annual mean SIA is reasonable.
- 271 shows oscillation associated with ACC (mainly seen in Ross and Weddell Seas).

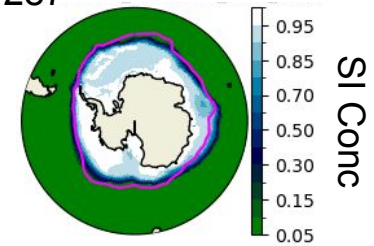
Antarctic Sea Ice – Annual Means







287



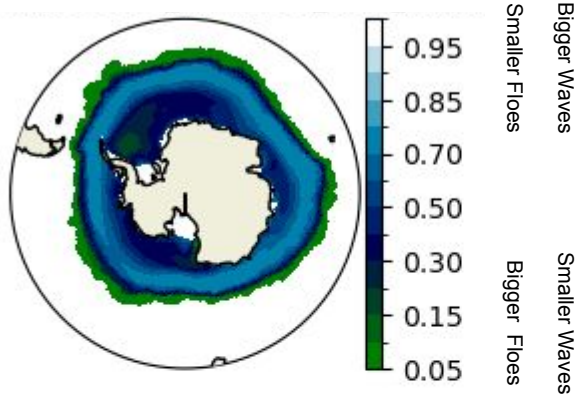
- Annual mean SIA is reasonable.
- 271 shows oscillation associated with ACC (mainly seen in Ross and Weddell Seas).

- SIV range is within CESM1-LE and CESM2-LE spread.
- Snow depth is smaller than either CESM1-LE or CESM2-LE.
  - Because of low summer extent?
  - Not totally understood.

Antarctic Sea Ice

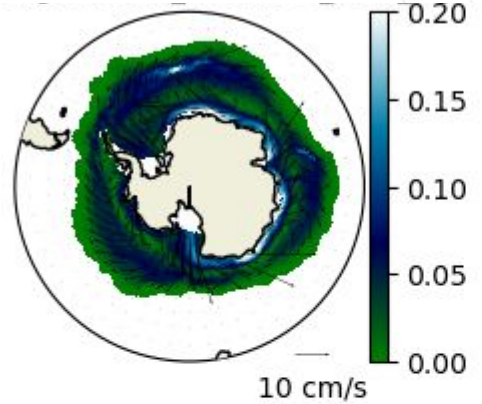
287

Floe size perimeter (1/m)



- Sea ice floes are smaller on margins, bigger near coast.
- Wave heights will diminish near coast and also reduce ocean mixing below ice.

Ice Velocity (m/s)



- Major features are present: Export from coast, coastal currents, ACC, etc.

CESM 3 Ocean Model Status

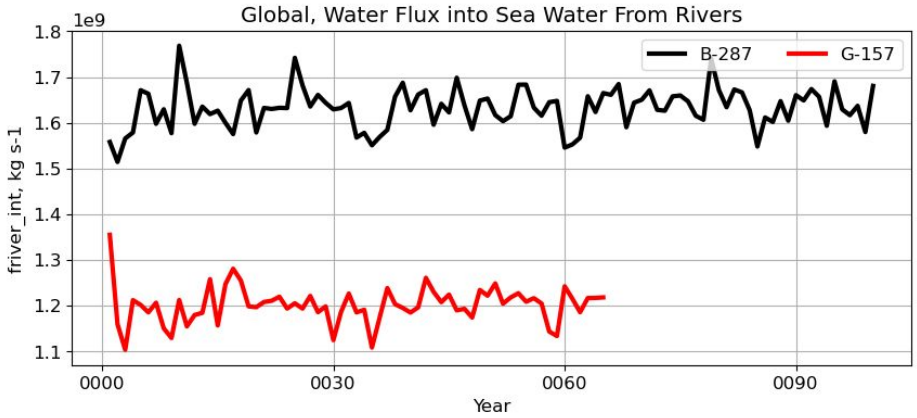
Ian Grooms & Gustavo Marques
Ocean Model Working Group Co-chairs

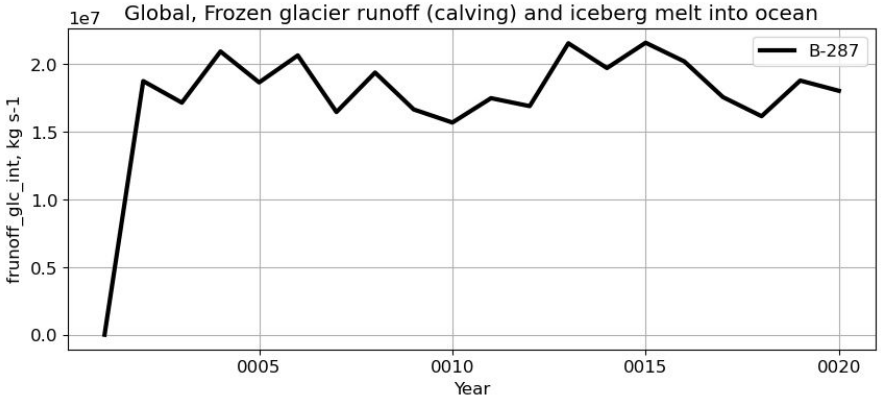
More than 159 forced (G) simulations in 2025!

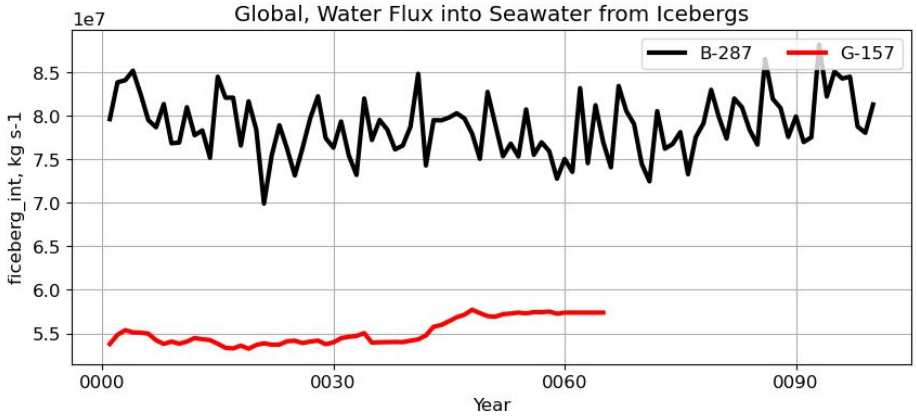
Key Differences Between POP2, MOM6-GFDL, MOM6-CESM Configurations

	POP2	MOM6-GFDL (OM4p5 cf ESM4.1)	MOM6-CESM3
Horizontal Grid	1.125° with equatorial refinement	0.5° with equatorial refinement	0.67° with equatorial refinement
Vertical Coordinate and Grid	Z coordinate, 60 levels, 10m @ surface	Hybrid coordinate, 75 levels, 2m @ surface	Hybrid coordinate, 75 *different* levels, 2.5m @ surface
Vertical Mixing	KPP with Langmuir	EPBL & Jackson (2008)	KPP with Flux-Profile-Mixing and Stokes Similarity
GM/Redi	Marshall N^2 scaling	MEKE with mixing-length scaling	MEKE with GEOMETRIC scaling
Submesoscale	FFH with constant length scale	FFH with constant length scale	Bodner (2023) with wave coupling
Horizontal Viscosity	Anisotropic Laplacian	MEKE harmonic + biharmonic Smag	Biharmonic Leith+E backscatter
Other parameterizations	Overflows, estuary box model	geothermal heating	Stochastic GM+E, stochastic eqn of state, geothermal heating
Sea level rise	Constant volume ocean	Ocean volume can change	Ocean volume can change

Excess liquid and frozen runoff in coupled runs (Global)

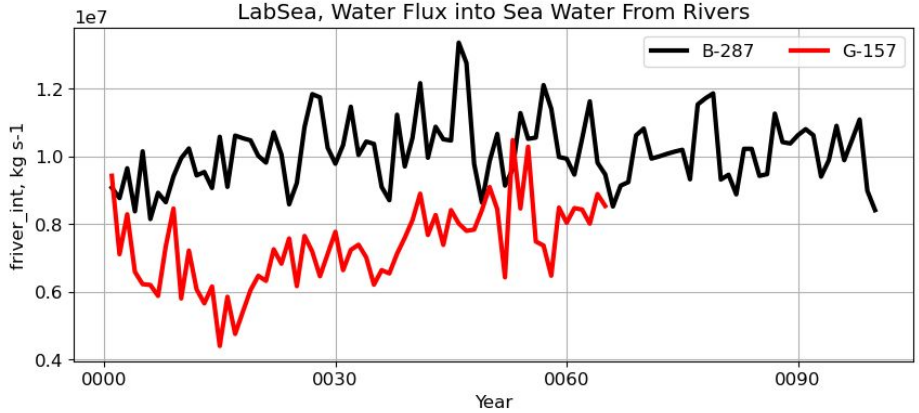




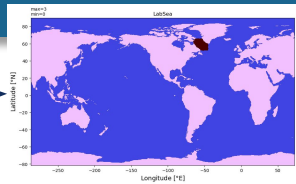


Globally, coupled runs deliver **~40% more liquid runoff** and **~ 80% more frozen runoff** to the ocean than forced (JRA) simulations.

Excess liquid and frozen runoff in coupled runs (Lab Sea)

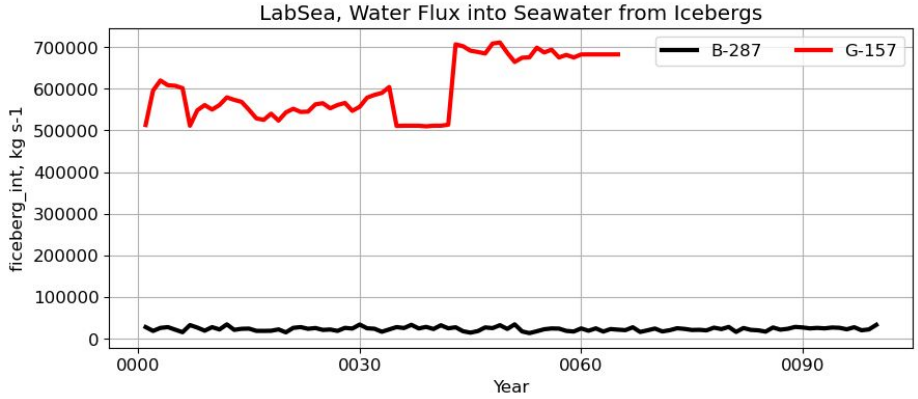


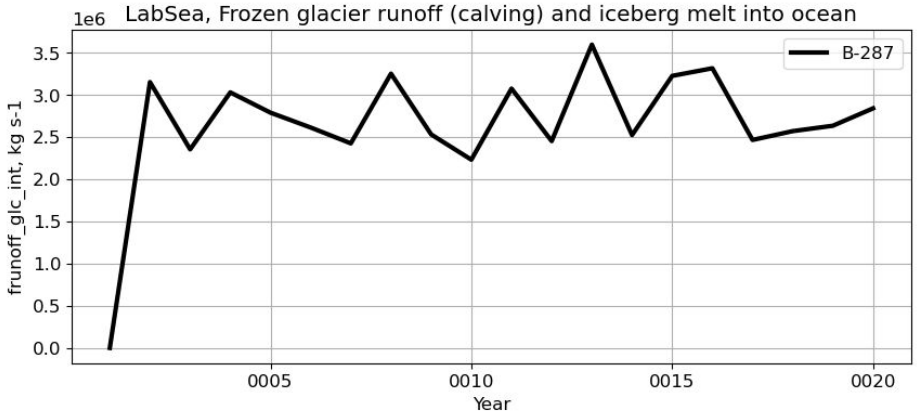
Lab Sea mask →



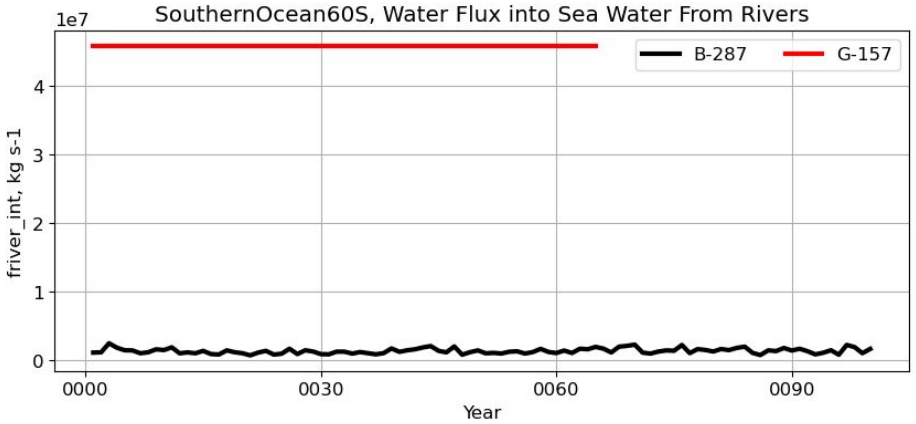
~25 % more **liquid runoff** in coupled runs

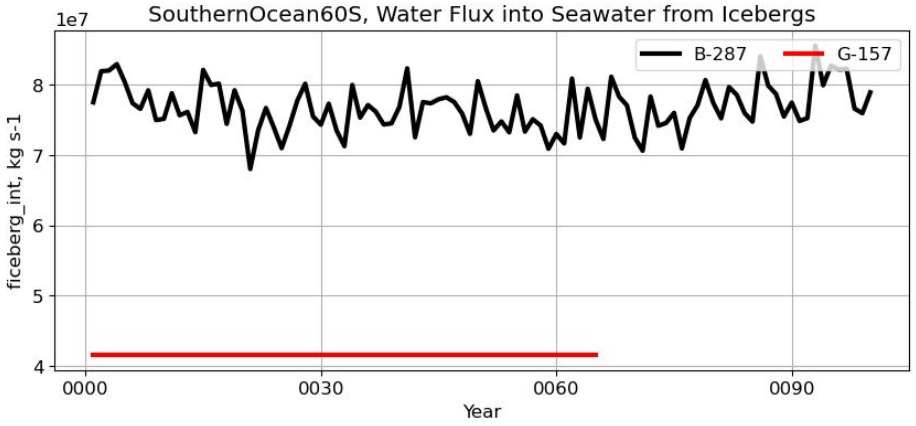
~ 500 % more **frozen runoff** in coupled runs



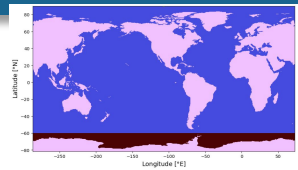


Excess liquid and frozen runoff in coupled runs (Southern Ocean)





Southern Ocean
(south of 60S) mask



~ **500%** more l**iquid runoff** in forced runs

~ **100%** more **frozen runoff** in coupled runs

Combined frozen + liquid runoff is similar in forced and coupled

Submesoscale: transition to Bodner (2023) with wave coupling

Mixed layer eddies (MLE): FFH and Bodner restratify the ocean mixed layer by an overturning streamfunction that flattens isopycnals.

$$\Psi = C_e \frac{\Delta s}{L_f} \frac{H^2 \nabla \overline{b}^z \times \mathbf{z}}{\sqrt{f^2 + \tau^{-2}}} \mu(z) \Rightarrow C_r \frac{\Delta s |f| h H^2 \nabla \overline{b}^z \times \mathbf{z}}{(m_* u_*^3 + n_* w_*^3)^{2/3}} \mu(z)$$

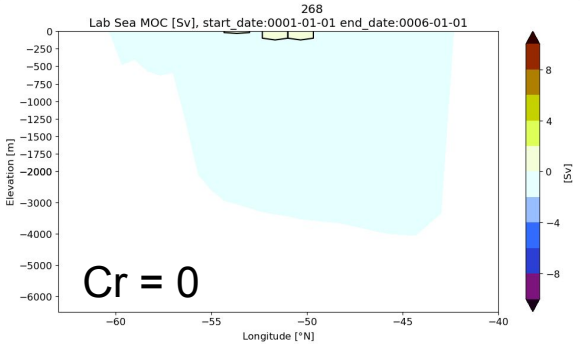
Reasons for going with Bodner23

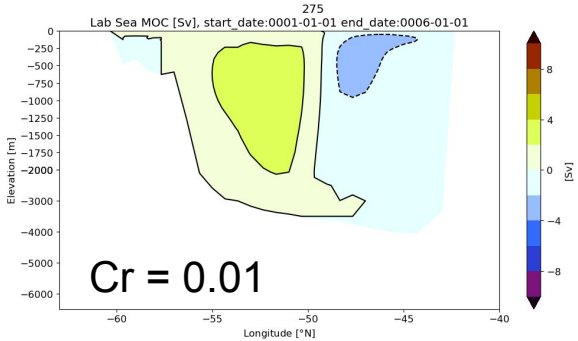
- Prognostic frontal length scale (Lf)
- We added the option to enhance **u*** using surface gravity wave information

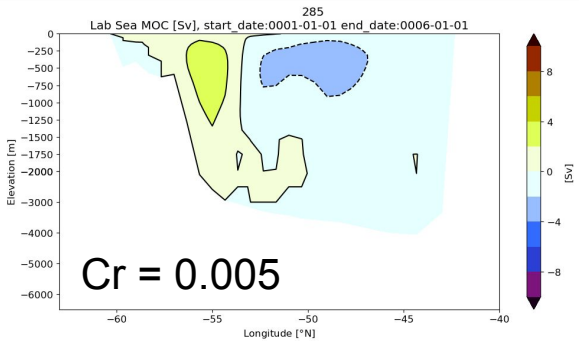
MLE and Lab Sea freezing

- Ψ increases rapidly with the boundary layer depth **h**, the mixed layer depth **H**, and lateral buoyancy gradients $\nabla \mathbf{b}$
- Deep h and H, and large $\nabla \mathbf{b}$ lead to excessive restratification, shutting off convection and resulting in Lab Sea freeze

MLE overturning streamfunction in the Lab Sea (coupled runs)

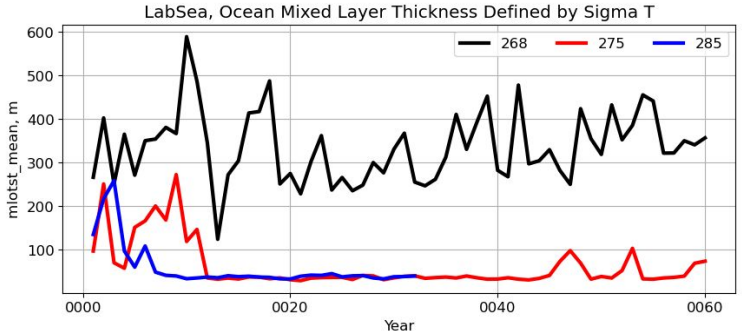






$$\Psi = C_e \frac{\Delta s}{L_f} \frac{H^2 \nabla \overline{b}^z \times \mathbf{z}}{\sqrt{f^2 + \tau^{-2}}} \mu(z) \Rightarrow C_r \frac{\Delta s |f| h H^2 \nabla \overline{b}^z \times \mathbf{z}}{(m_* u_*^3 + n_* w_*^3)^{2/3}} \mu(z)$$

The overturning response to Cr is highly non-linear, making the MLE Bodner scheme risky in the Labrador Sea due to a high likelihood of freezing



Updates to KPP with Flux-Profile-Mixing and Stokes Similarity

Us = Stokes drift

- Add explicit surface wave effects (e.g. Langmuir turbulence)
  - Remove implicit wave effects (existing CESM2 is NOT **U**s = 0)
  - Rebalance compensating errors
- Add Cross-Gradient (non-local) momentum flux (Flux-Profile-Mixing or FPMIX)

see Bill Large's 2024 OMWG talk

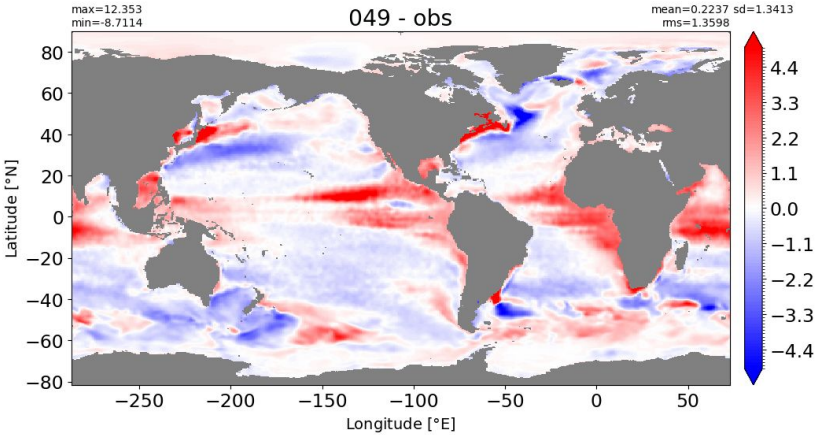
- Surface boundary layer calculation
  - Entrainment rule depth (Large et al., 2021), if surface non-solar buoyancy flux < 0
  - Otherwise, use original KPP Richardson Number method (Large et al., 1994)

Improve equatorial thermocline biases

Updates to the surface boundary layer formulation reduce equatorial thermocline biases

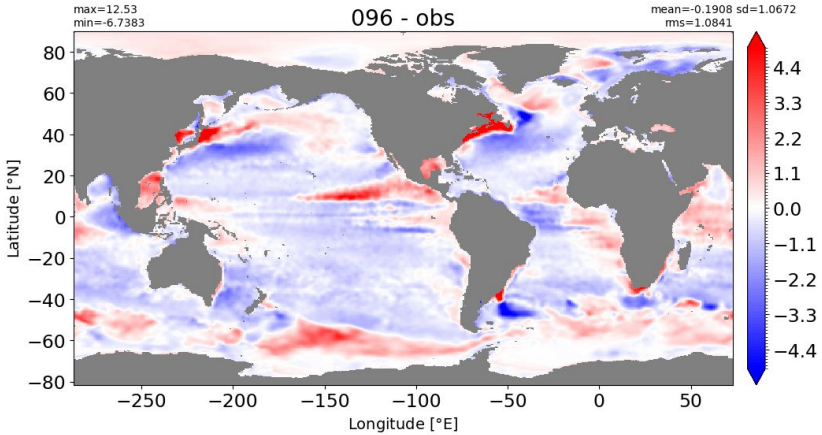
Ri # method

Temperature bias [C] at depth = 75.0 m (level = 5)

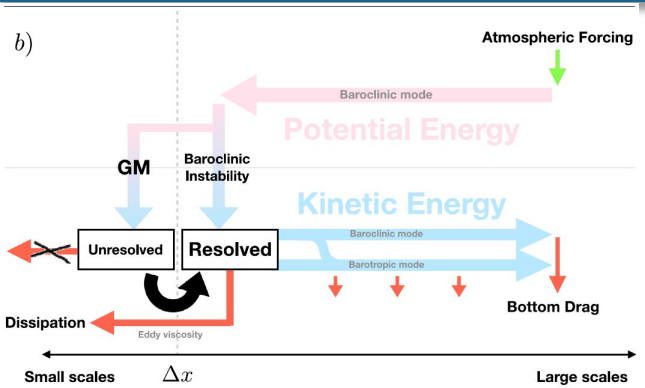


Ri # + entrainment rule methods

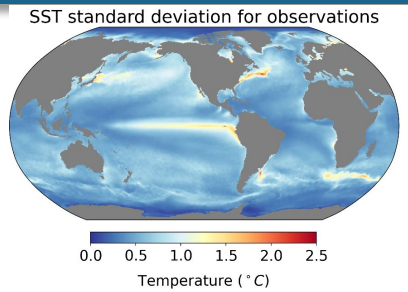
Temperature bias [C] at depth = 75.0 m (level = 5)

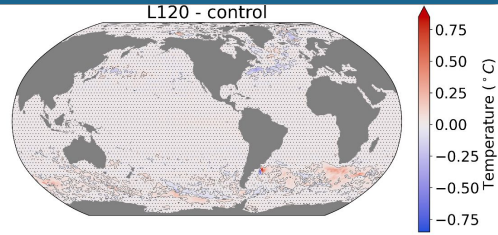


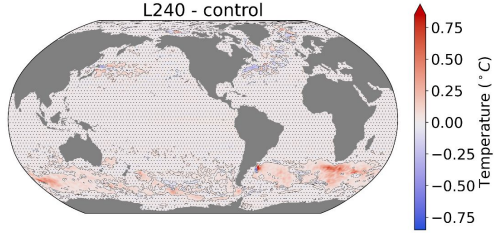
Stochastic backscatter

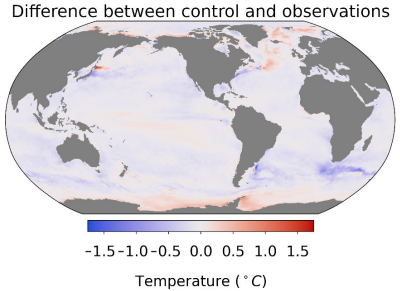


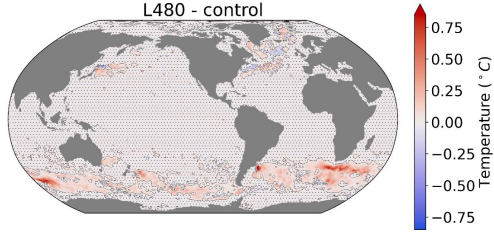
Left: Stochastic GM+E recycles some of the PE removed by GM into KE via backscatter



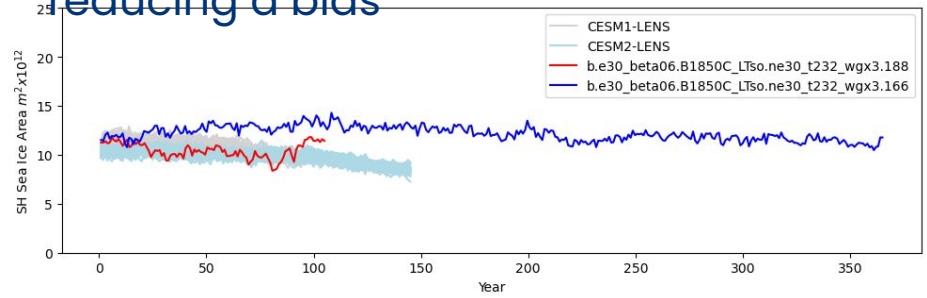








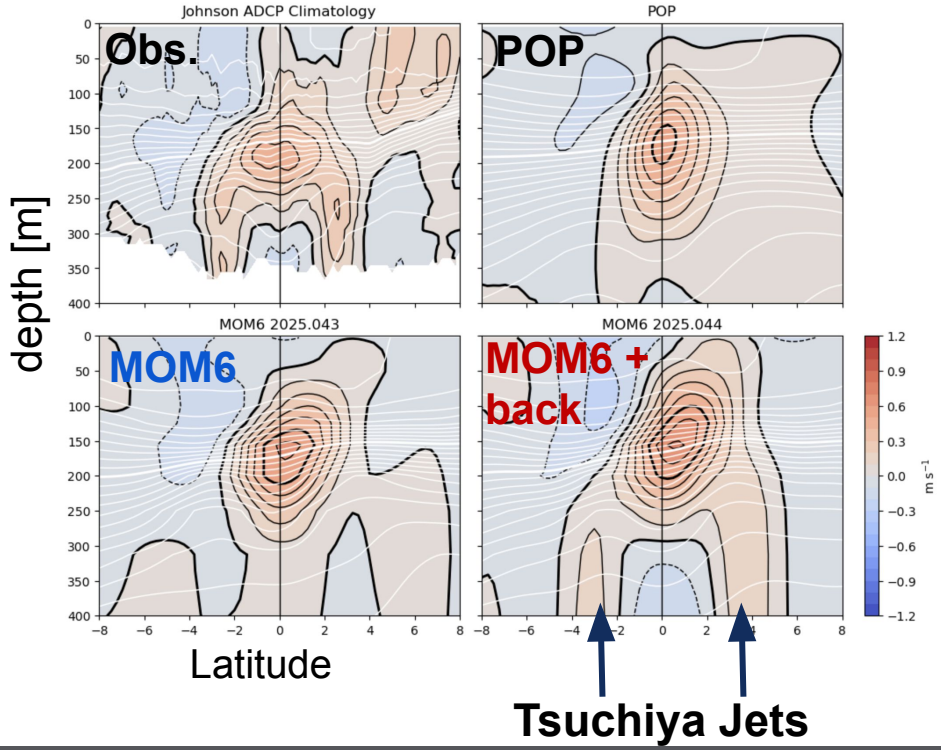
Below: Stochastic GM+E reduces southern hemisphere sea ice area, reducing a bias



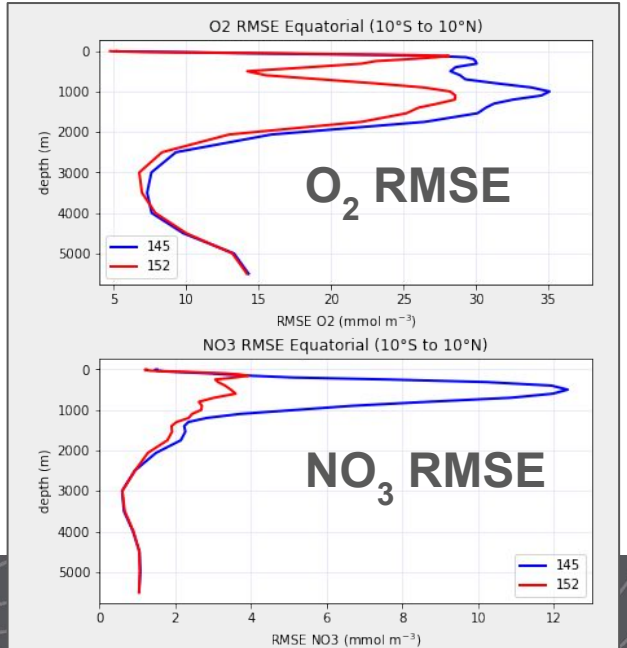
Above: SST variability is still too low compared to obs, but improves in SO

Improved Equatorial Ocean Processes via Kinetic Energy Backscatter

Transects of zonal velocity 165° E

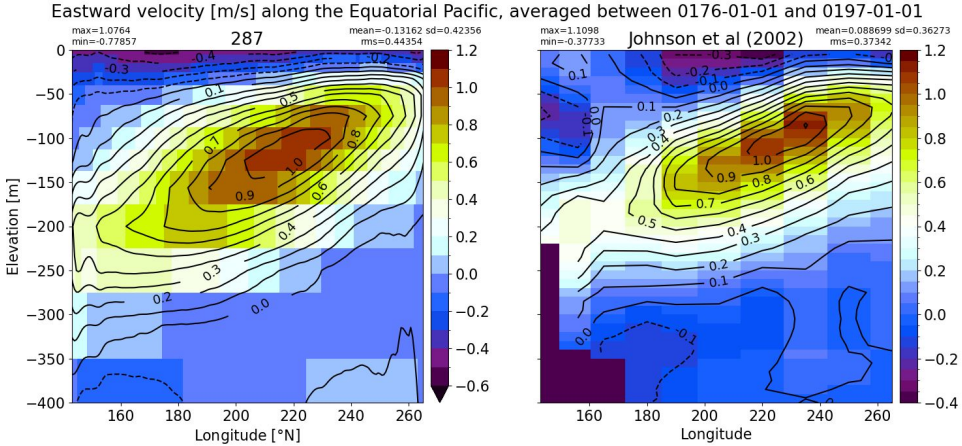


- Emergence of **Tsuchiya jets** when backscatter is applied
- These jets reduce biases in the extent of oxygen minimum zones, critical for ocean BGC processes

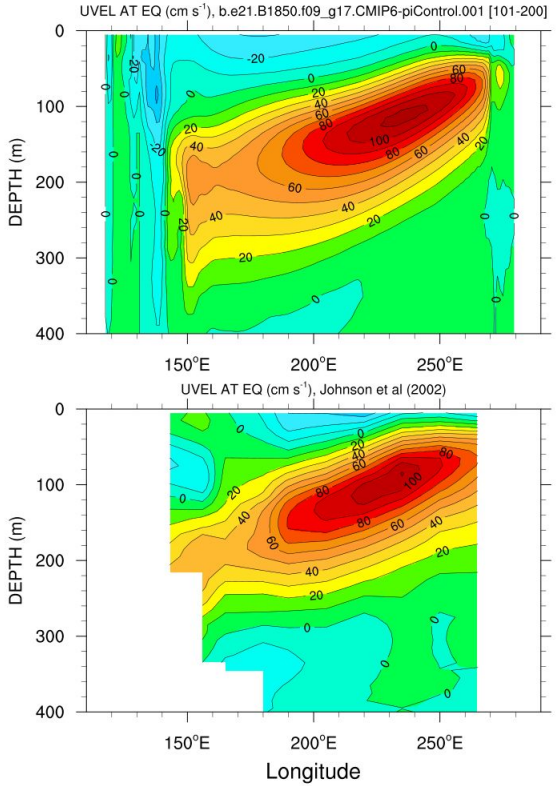


Pacific Equatorial Undercurrent (EUC) in coupled runs

CESM3 PI

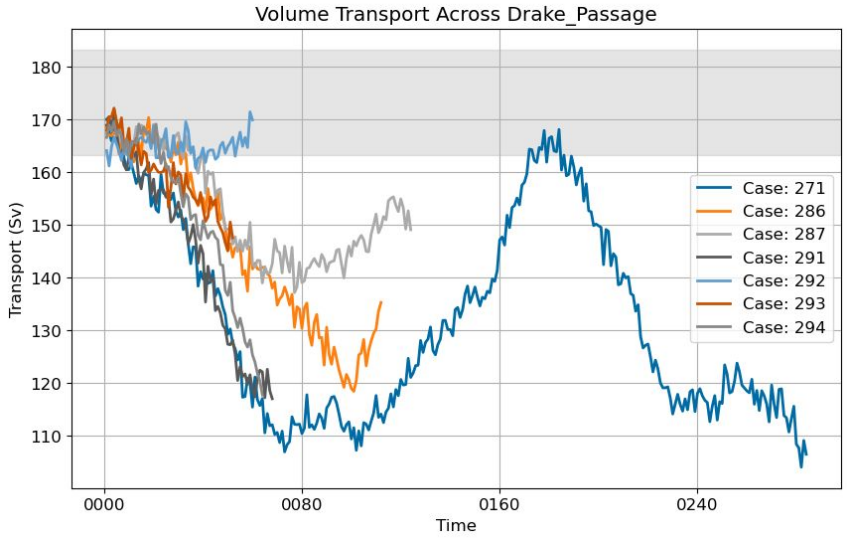


CESM2 PI

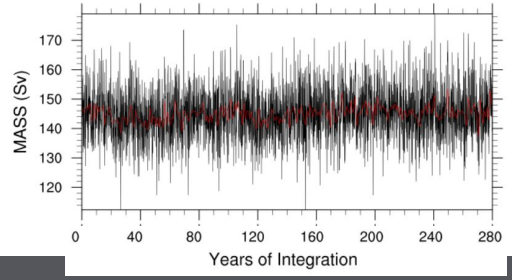


The structure and strength of the EUC are similar in CESM2 and CESM3; both exhibit an overly strong EUC on the western side compared to observations.

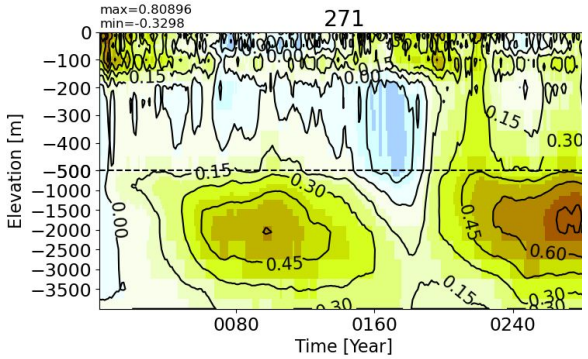
ACC strength and oscillations

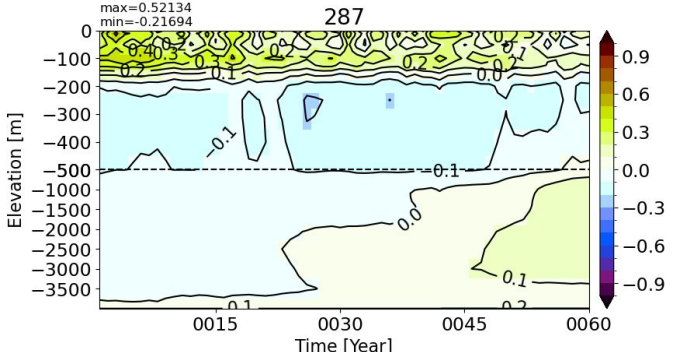


CESM2 PI



Tuning several ocean parameters to control ACC transport slow variability that impacts coupled climate

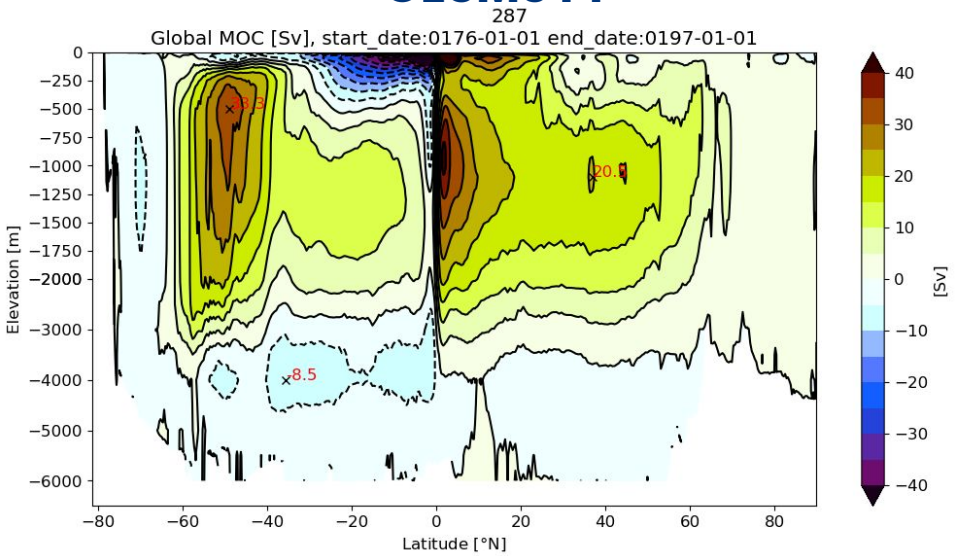




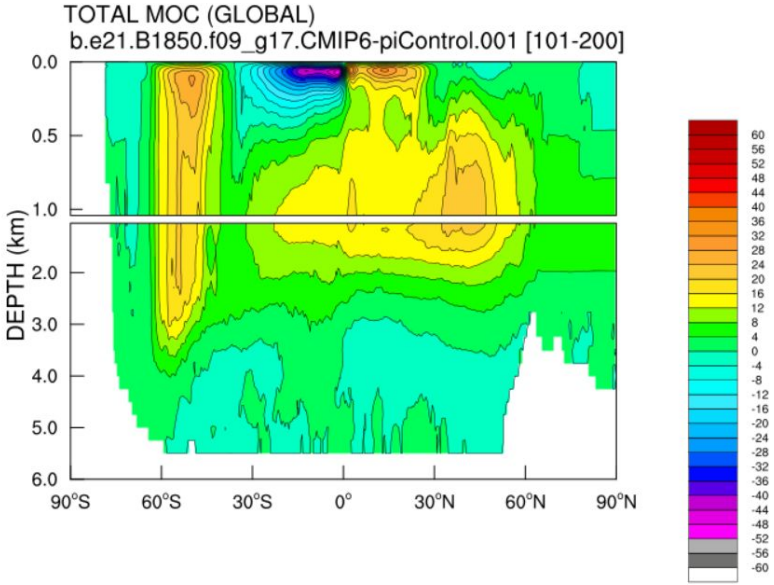
ACC variability appears to be associated with deep temperature anomalies around Antarctica

Global Meridional Overturning Circulation

CESM3 PI



CESM2 PI



The AABW cell is weak overall (though stronger than in CESM2) and oscillatory (not shown), and we are investigating a possible link between AABW export and ACC transport issues

Ocean model status summary

- Adopt Bodner as the MLE scheme based on improved physics and promising results in forced simulations; Lab Sea masked due to high freezing risk (excess runoff in coupled runs)
- Updates to the surface boundary layer formulation reduce equatorial thermocline biases
- Stochastic GM+E reduces Southern Hemisphere sea ice bias and improves Southern Ocean SST variability
- Kinetic energy backscatter improves equatorial processes (Tsuchiya jets), reducing biases in the extent of O_2 minimum zones critical to ocean BGC processes
- **In progress**: tuning several ocean parameters to control ACC transport slow variability that impacts coupled climate

OMWG/PCWG Joint Session Discussion
CESM3 and beyond

Discussion topics

- Questions about CESM3 release, CMIP7 plans, etc.
- CESM3 planned manuscripts
- Coordinated experiments and analysis, etc.
- Regional ice/ocean/wave modeling
- Anything else…