Interesting bugs I have had with MetROMS

and how I fixed them

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Climate Change Research Centre

ARC CENTRE OF EXCELLENCE FOR CLIMATE SYSTEM SCIENCE

ACE CRC
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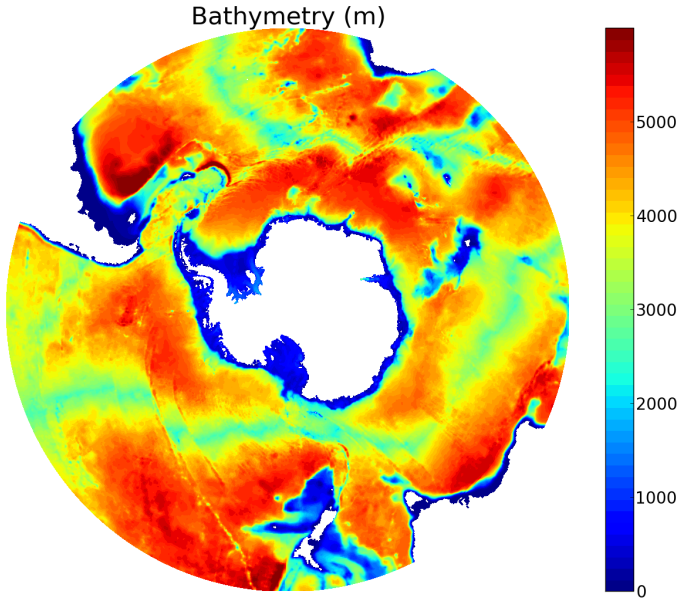
MetROMS

- ROMS + CICE + MCT
- Coupled by the Norwegian Meteorological Institute
- Separate processors for ROMS and CICE
- 28% overhead in walltime, 44% in CPU hours compared to standalone ROMS with no sea ice

Circumpolar Antarctic domain

- Quarter-degree; northern boundary at 30S
- Atmospheric forcing: ERA-Interim (6-hourly winds, monthly averages otherwise)
- Northern boundary conditions: ECCO2 (monthly averages)
- Ice shelf thermodynamics code from Galton-Fenzi et al., 2012

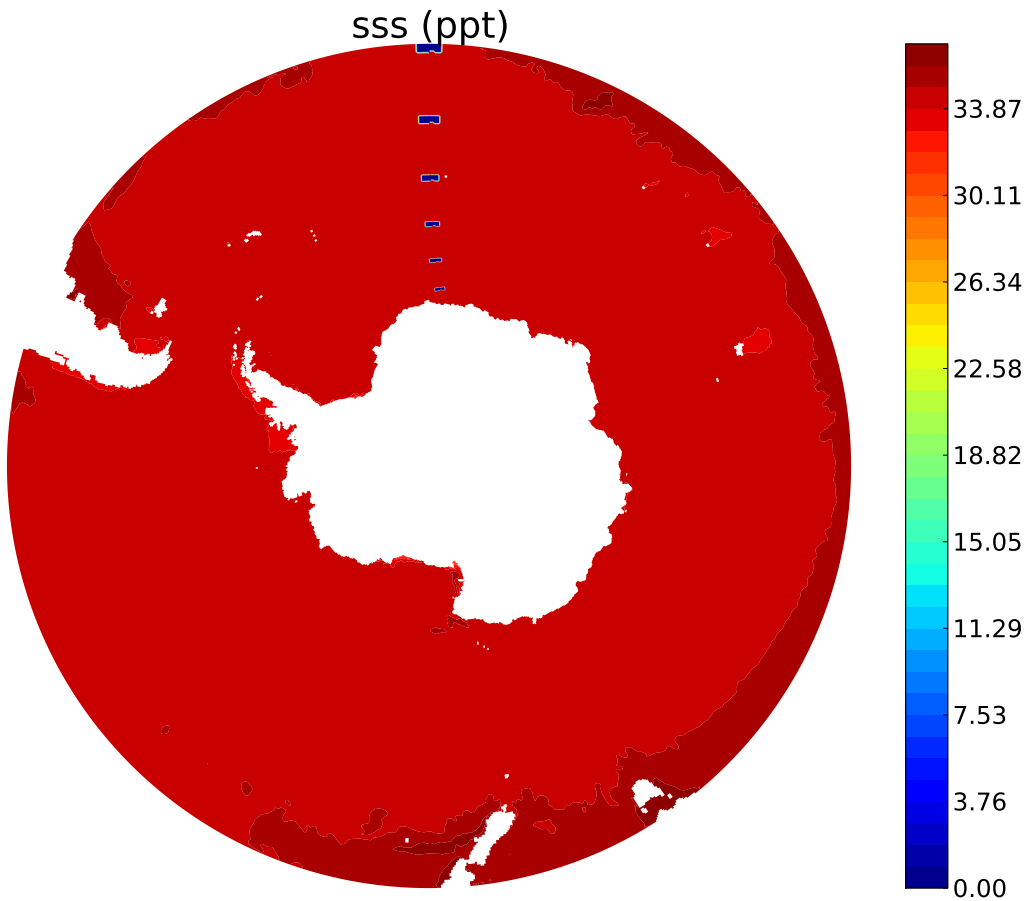


Why Talk about Bugs?

- If you don't have anything else to talk about yet
- More accurate view of the model development process
- Helps others save time in the future

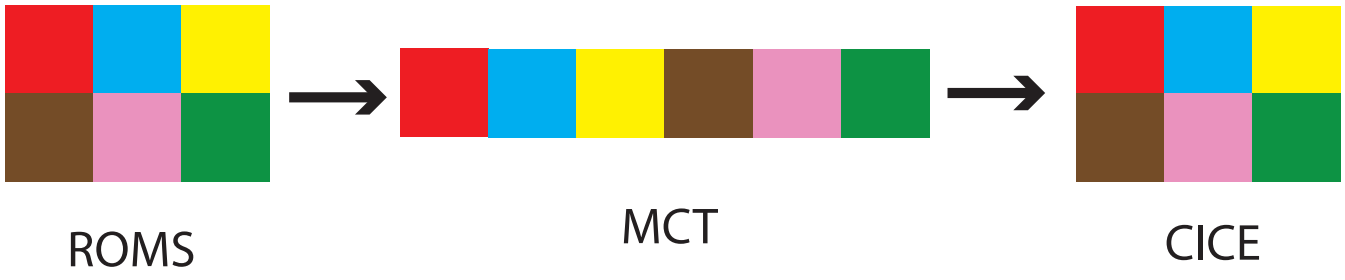
The Patches of Zeros Bug

Patches of zeros in all ROMS-to-CICE coupling fields



Sea surface salinity as seen by CICE

The Patches of Zeros Bug

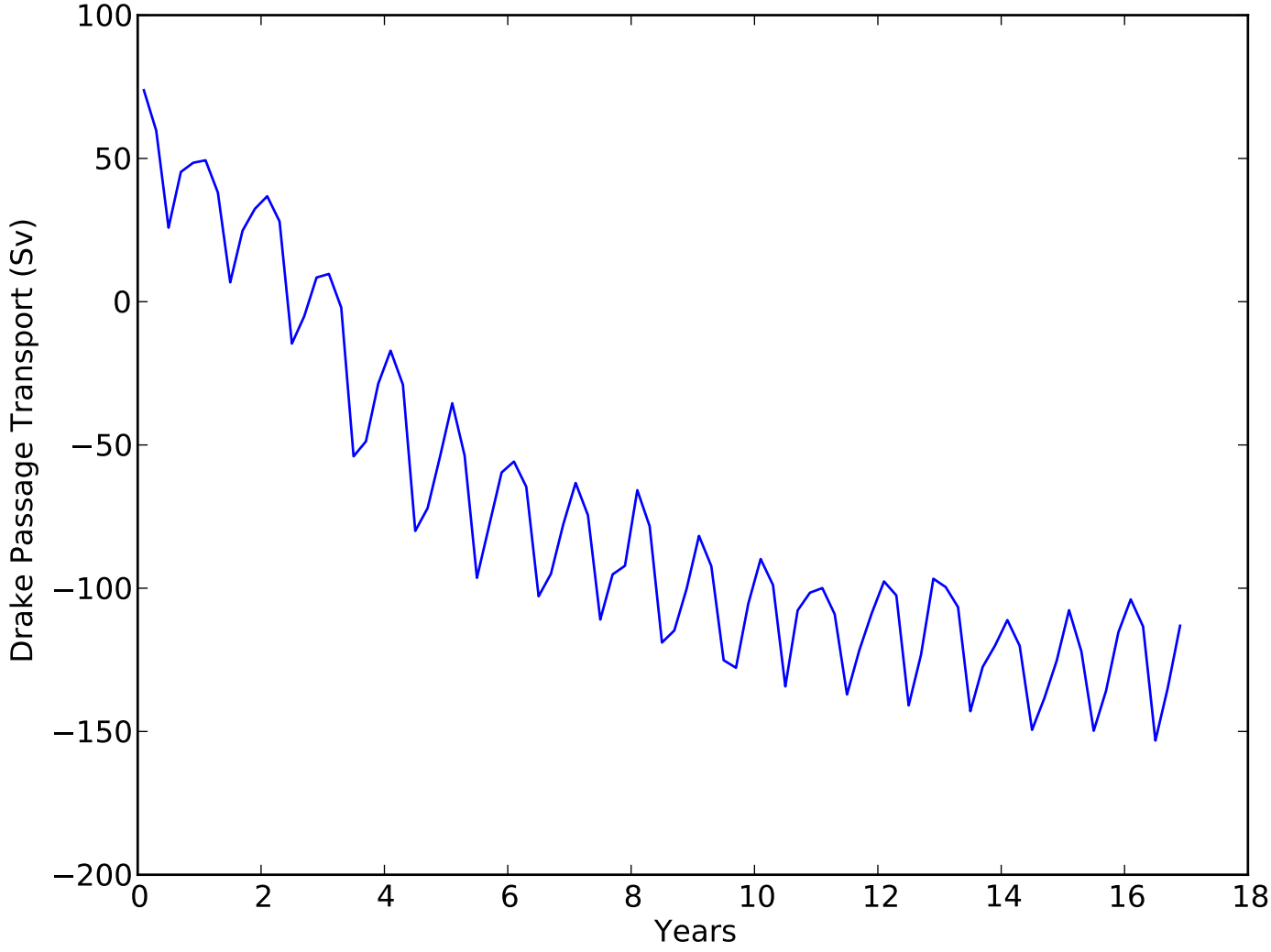


How MCT transfers a 2D field

The Patches of Zeros Bug

- `ocean_coupler.F`: local definitions for `IstrR`, `IendR`, `JstrR`, `JendR`
- `roms_export.F`: sets these variables with `include set_bounds.h`
- If there is a periodic boundary, these two definitions don't match up
- Some indices in MCT's 1D array are never updated from zero

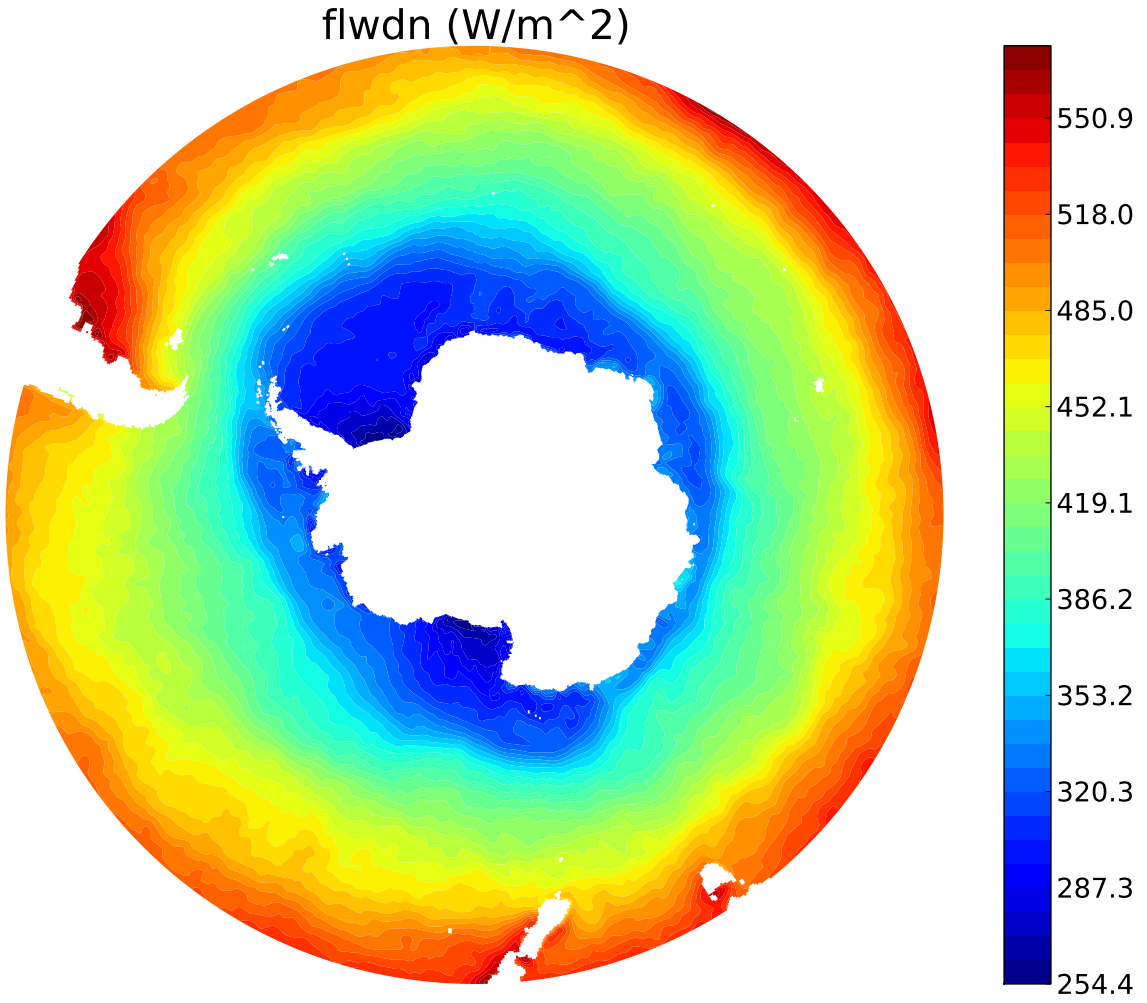
The Backwards Drake Passage Transport Bug



The Backwards Drake Passage Transport Bug

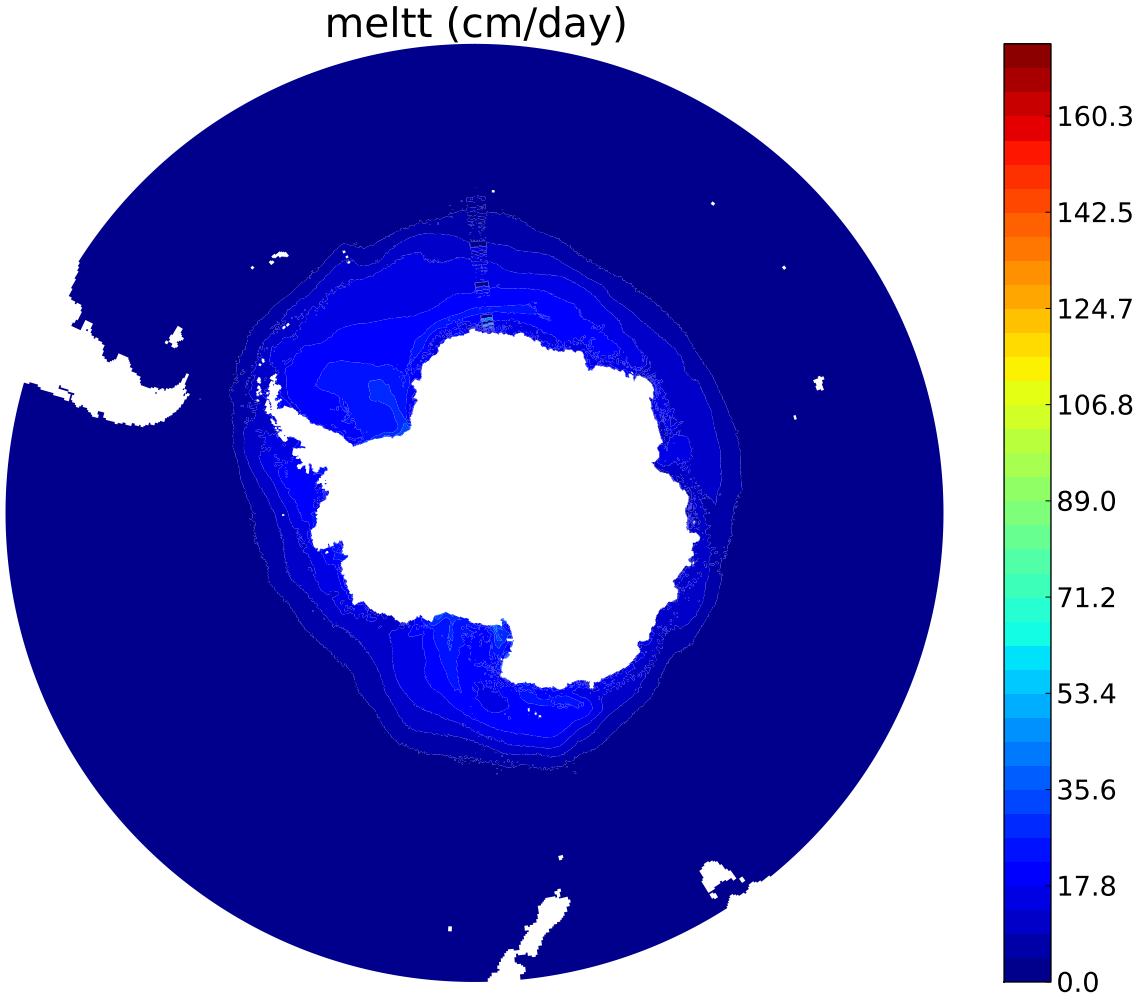
- CICE wants specific humidity
- ROMS wants relative humidity
- Relative humidity is $\sim 10^3$ times greater than specific humidity

The Backwards Drake Passage Transport Bug



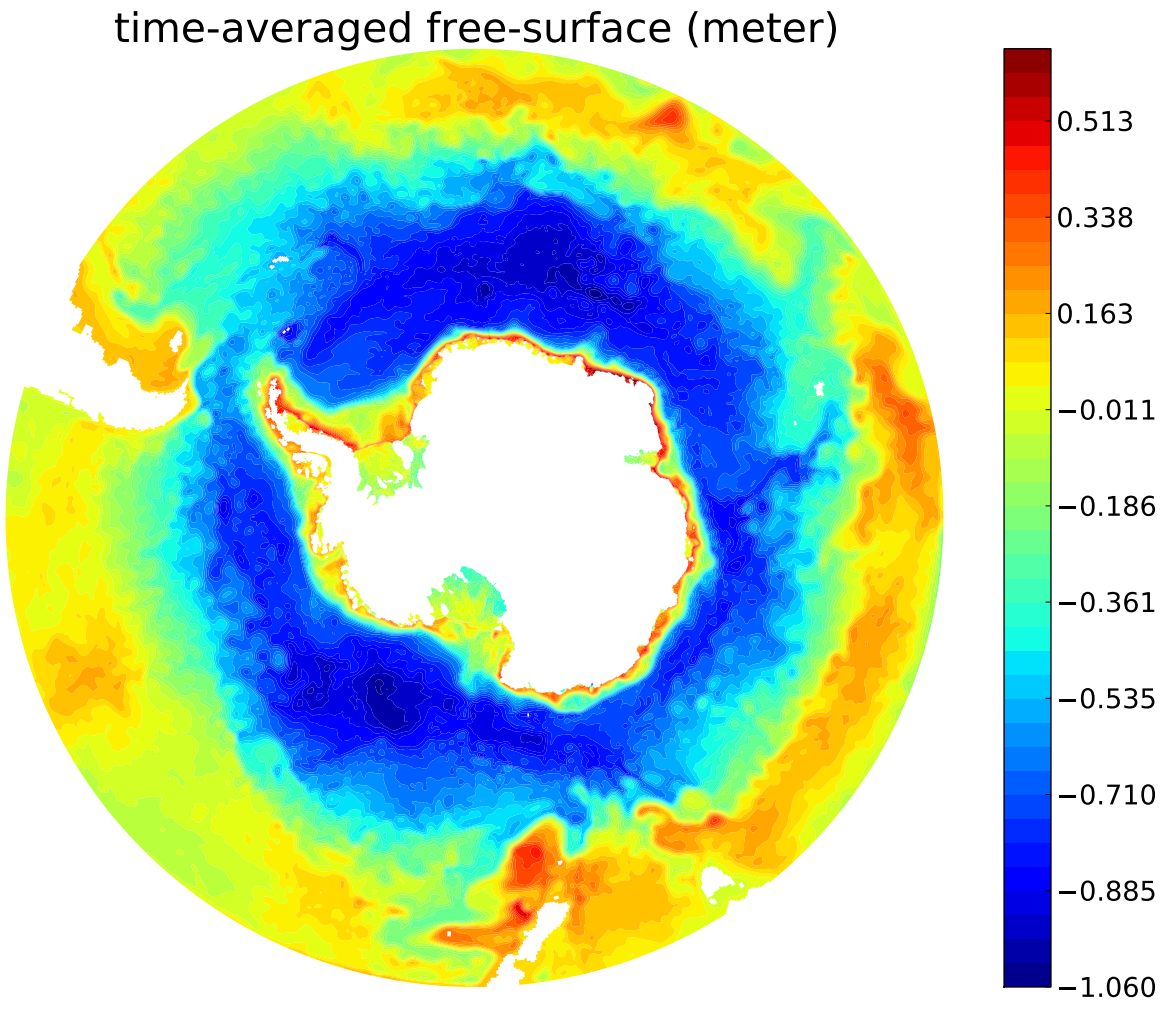
Incoming longwave radiation, calculated by CICE

The Backwards Drake Passage Transport Bug



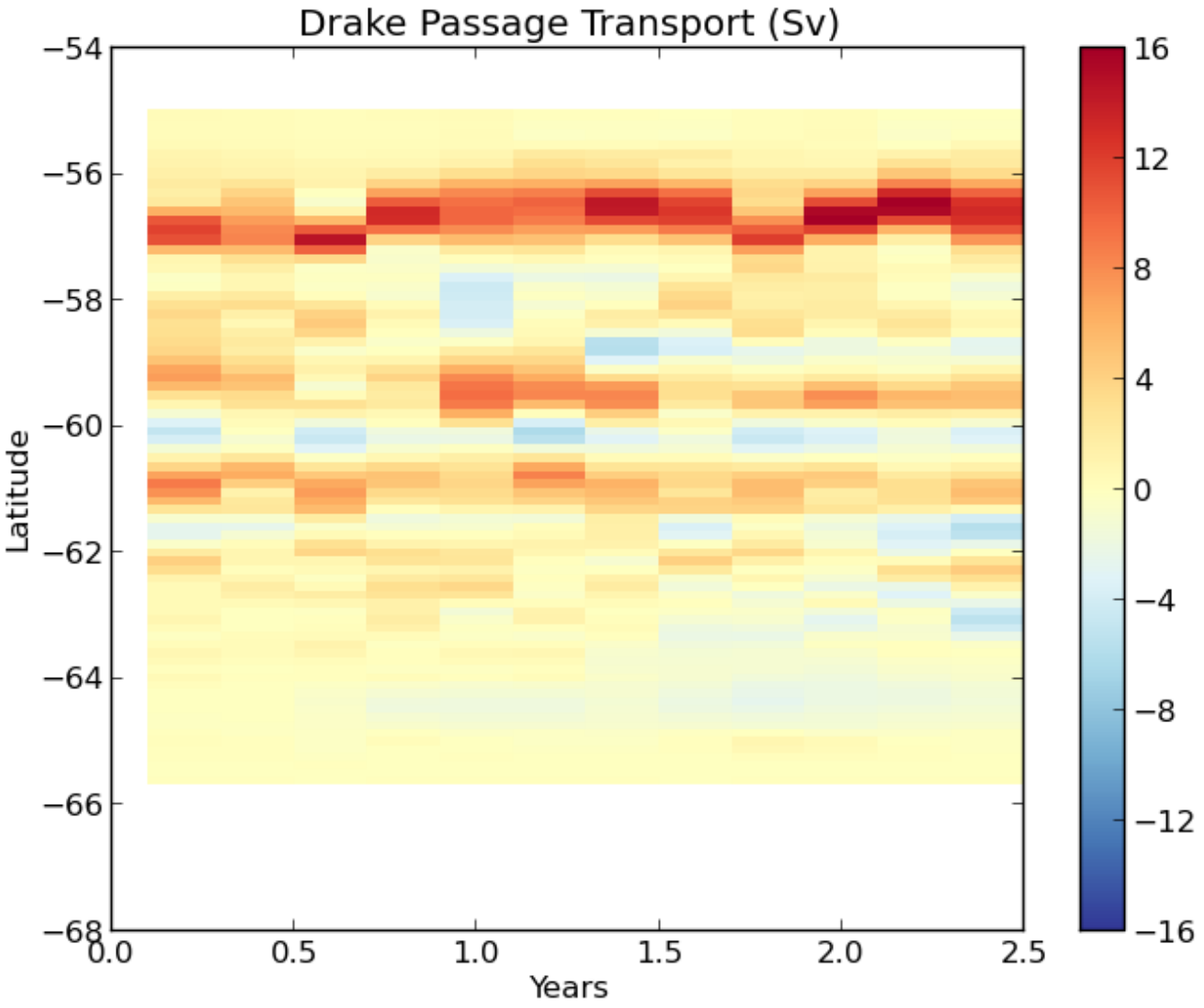
Sea ice top melt

The Backwards Drake Passage Transport Bug



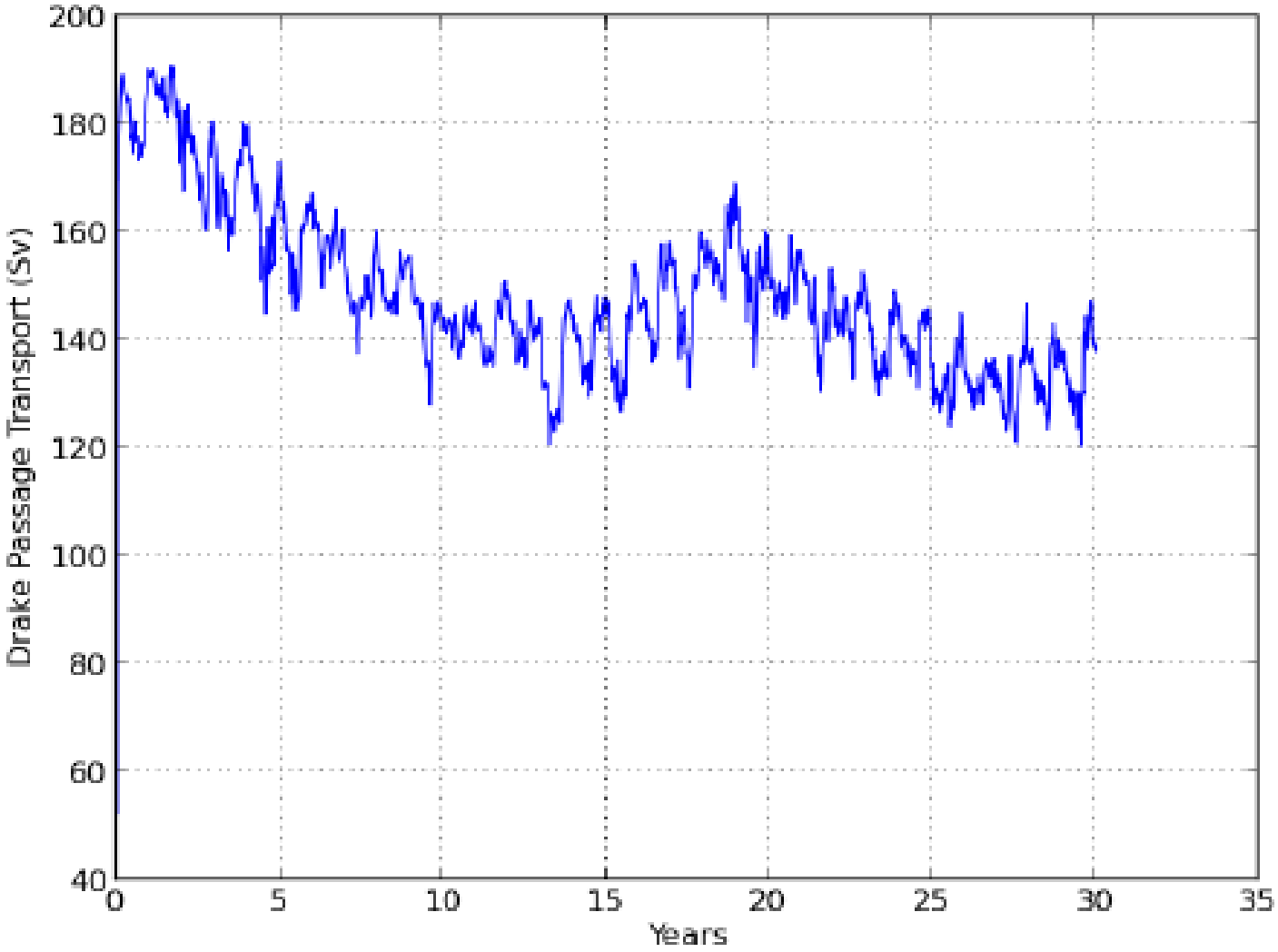
Elevated sea surface $\Rightarrow$ westward transport

The Backwards Drake Passage Transport Bug



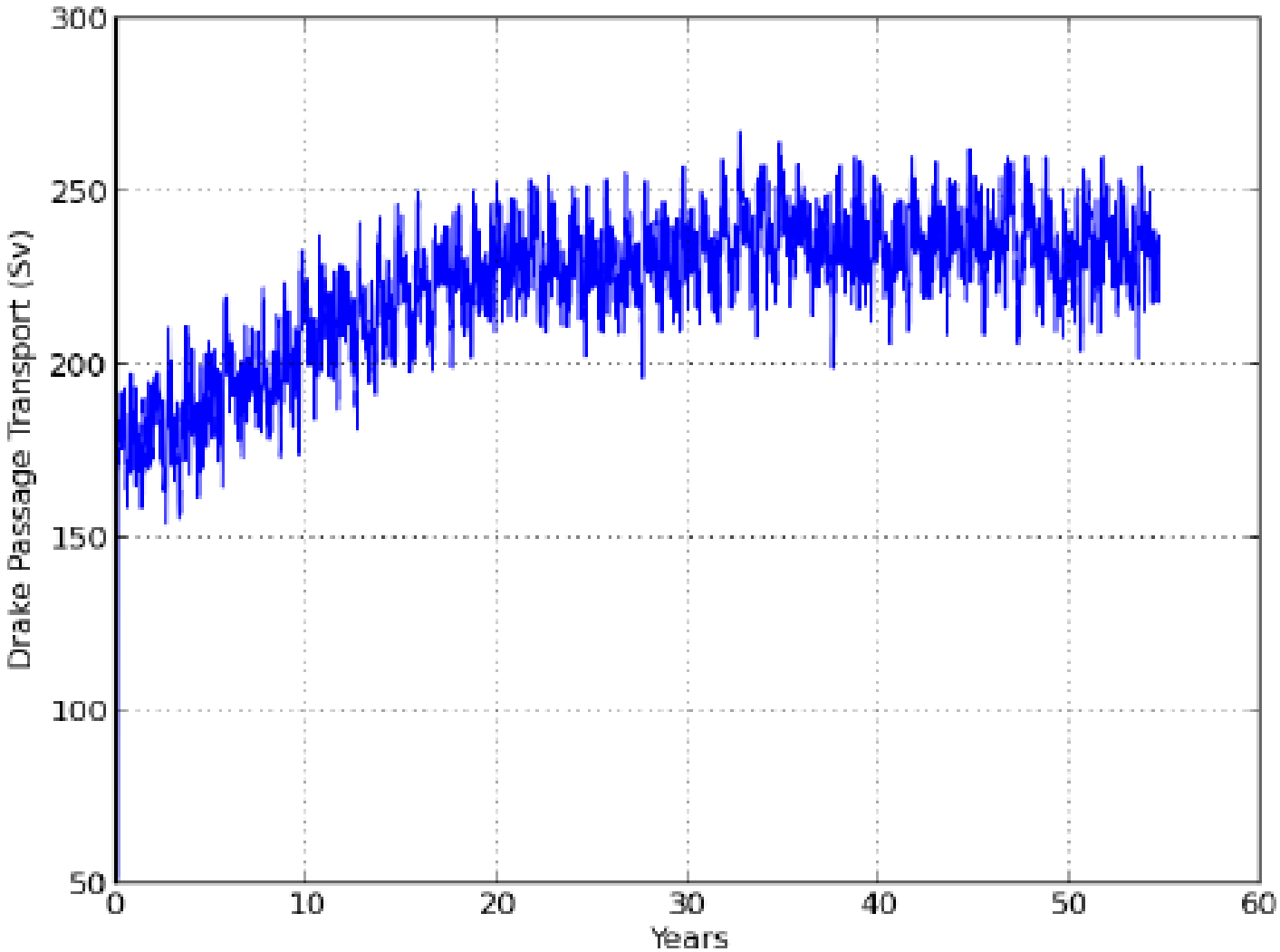
Drake Passage transport without north-south integral

The Backwards Drake Passage Transport Bug



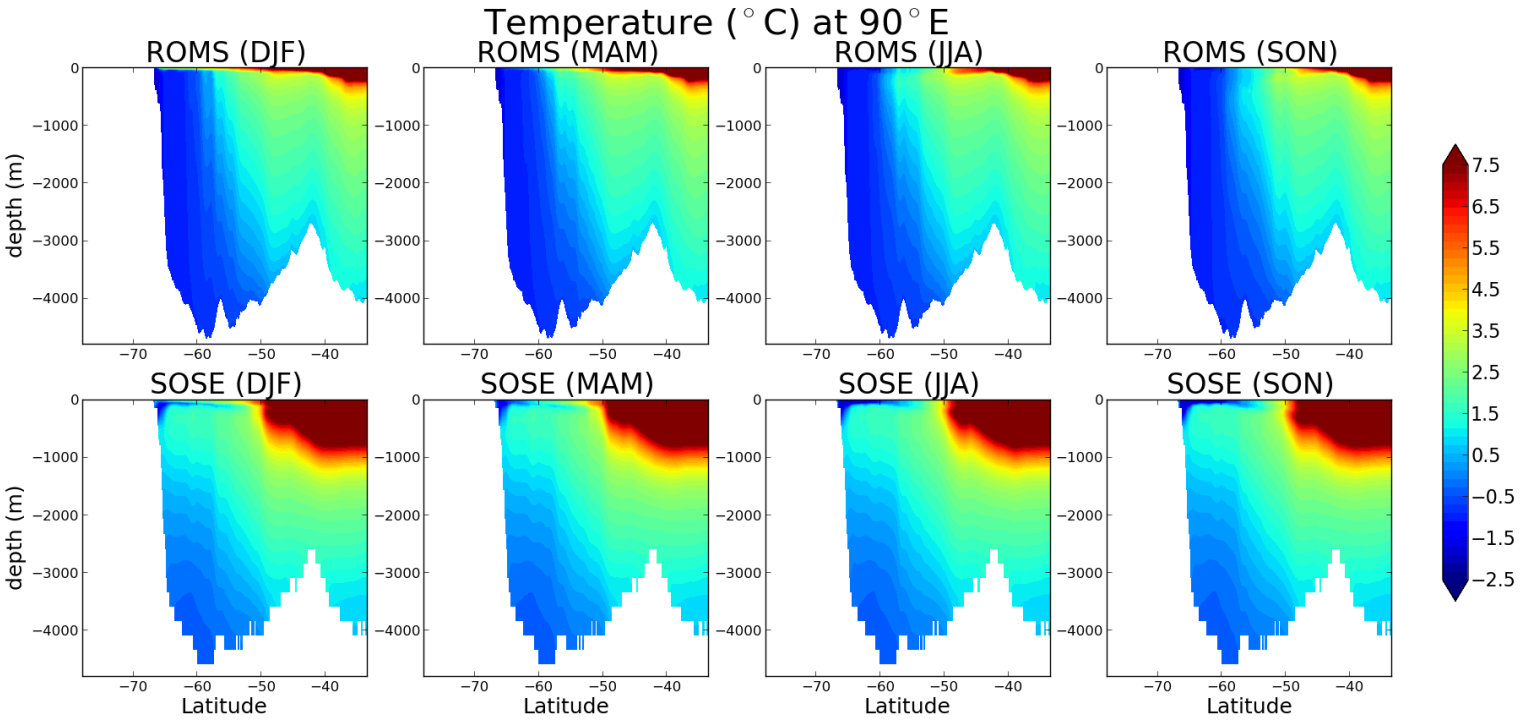
Fixed!

The Too-Strong Drake Passage Transport Bug



Switching from monthly to 6-hourly winds almost doubles transport

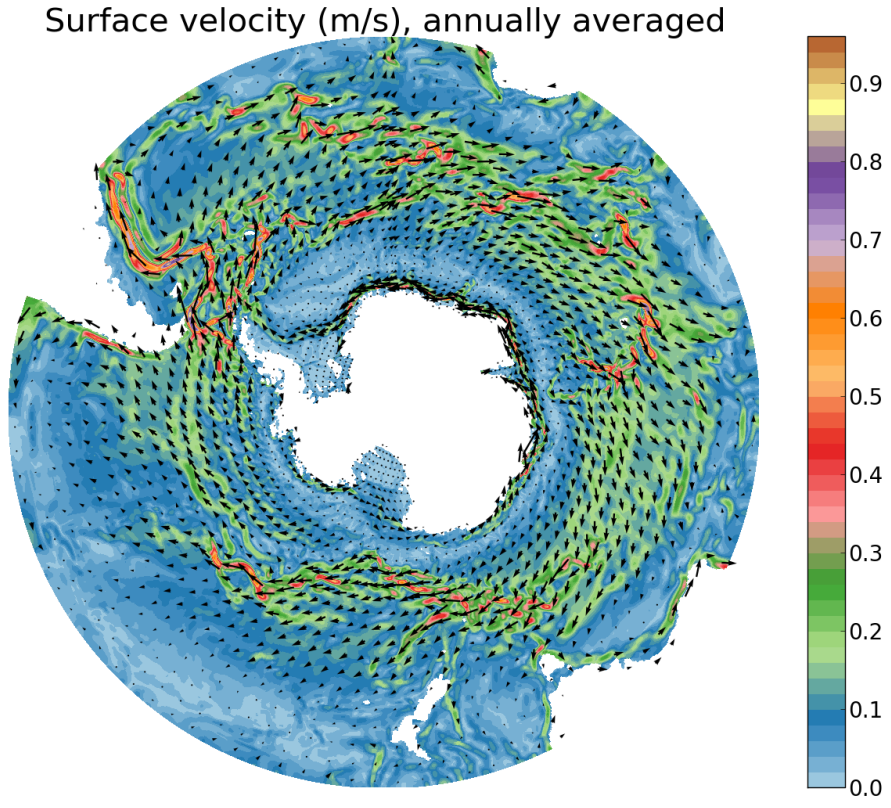
The Too-Strong Drake Passage Transport Bug



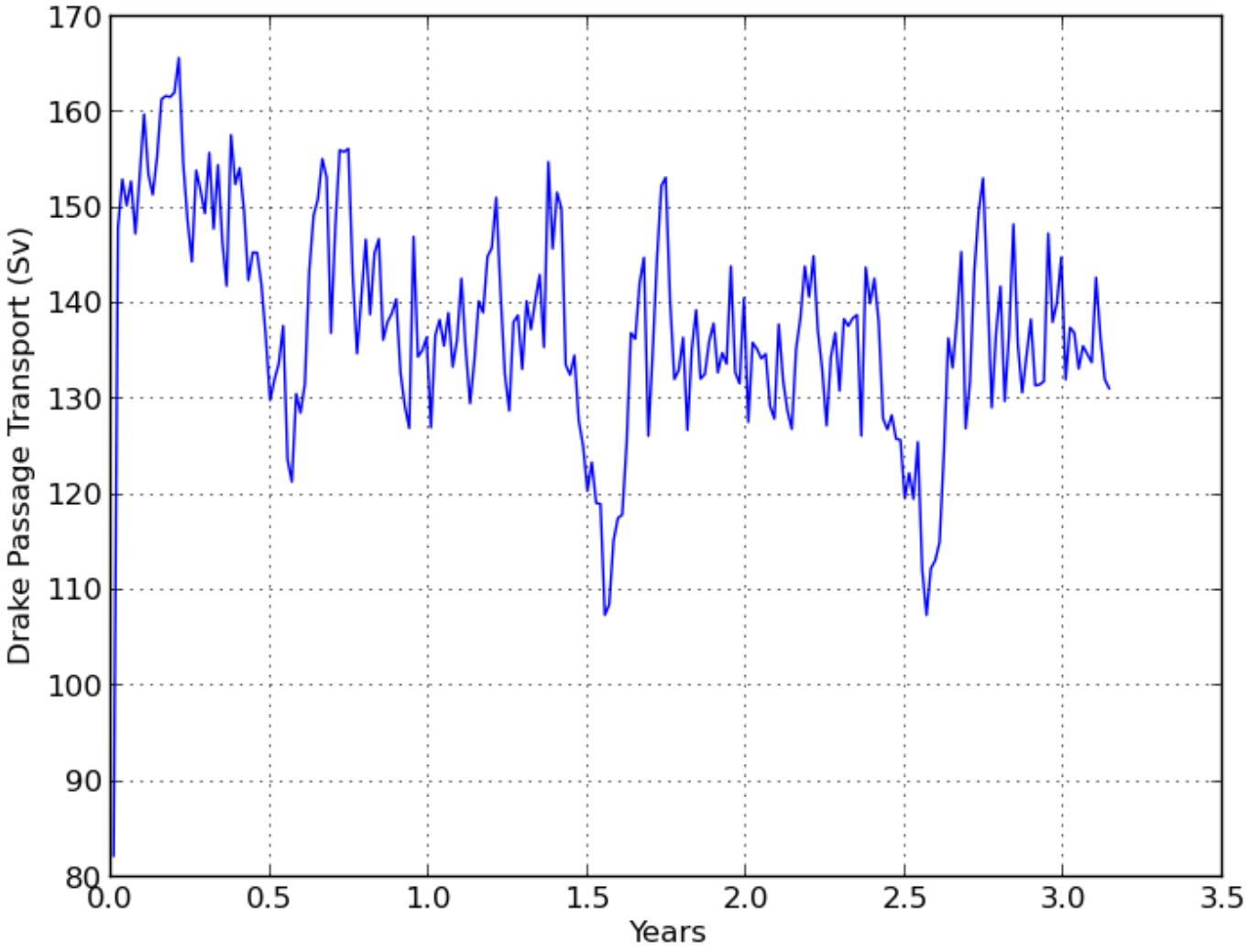
ACC is too strong for CDW to upwell in Southern Ocean

The Too-Strong Drake Passage Transport Bug

- `UV_VIS2`: suppresses baroclinic instability
- ACC jets don't break into eddies
- Need to use `UV_VIS4` instead

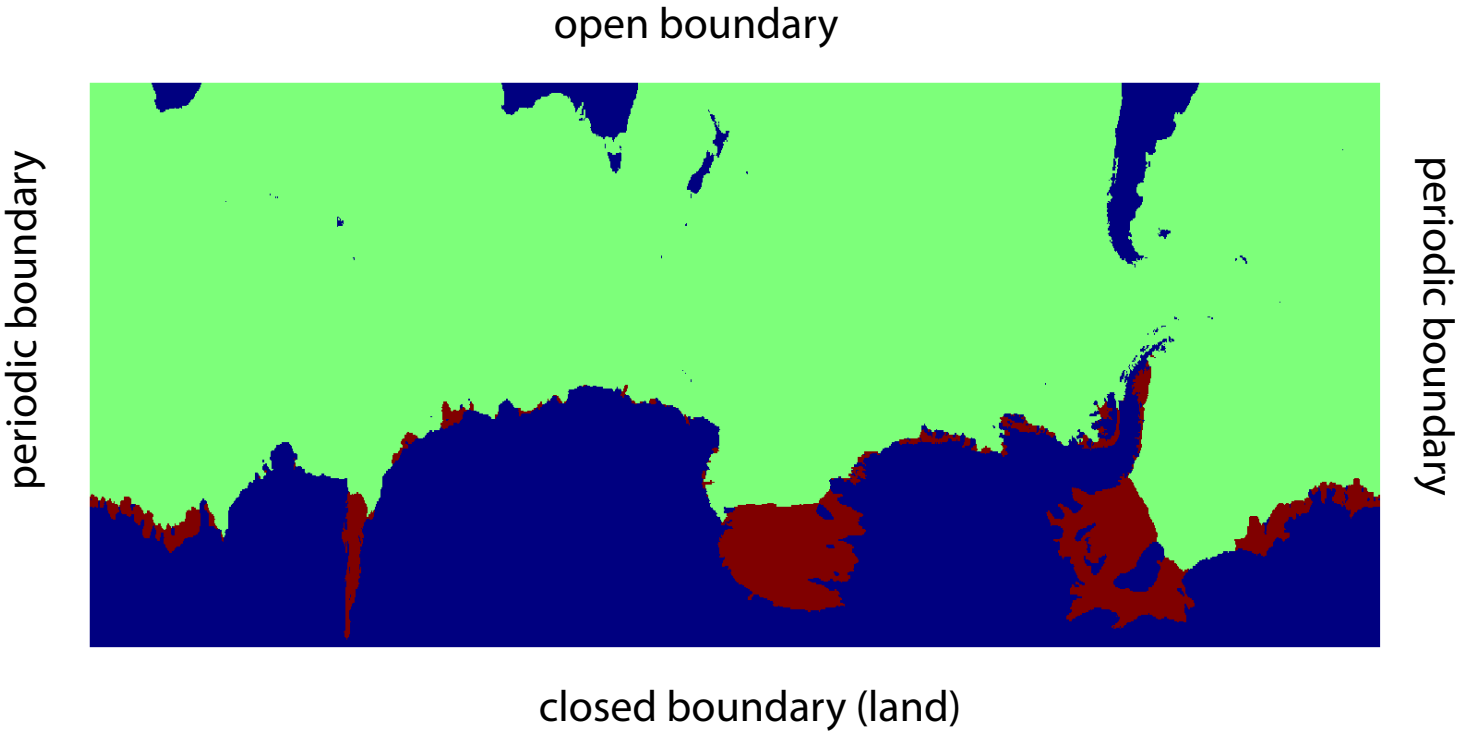


The Too-Strong Drake Passage Transport Bug



Using `UV_VIS4` instead of `UV_VIS2`

The Unstable Open Boundary Bug

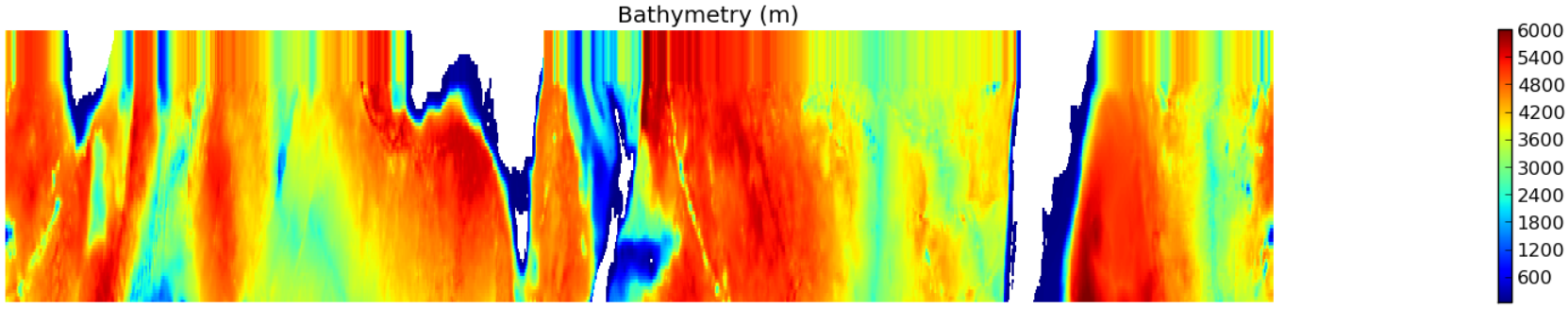


Open boundaries are prone to instabilities

The Unstable Open Boundary Bug

Matt Mazloff's method:

1. `u` and `ubar` clamped to zero at northern boundary
2. Set $\frac{\partial h}{\partial y} = 0$ for northernmost 3°



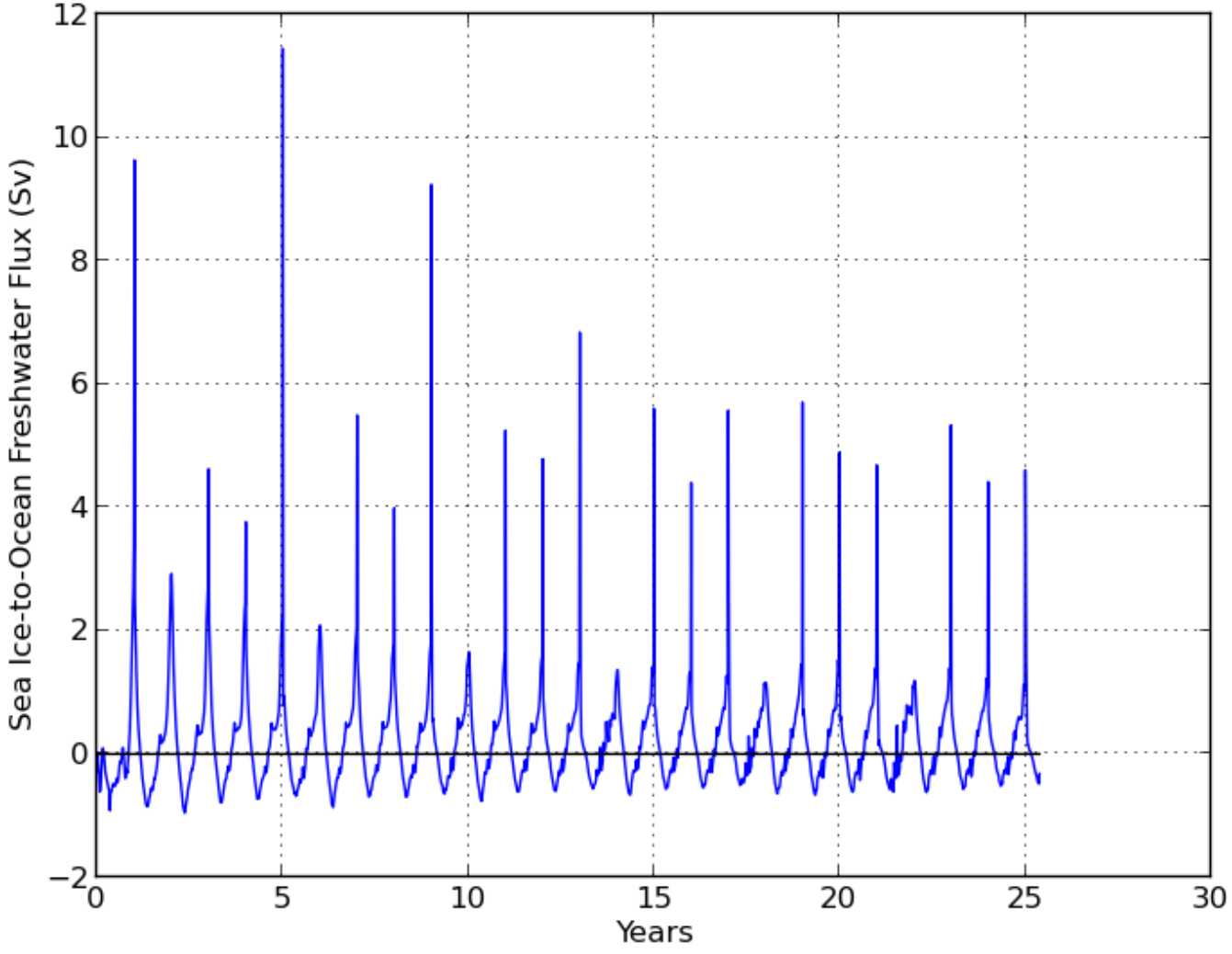
3. Sponge layer over northernmost 3°

The Unstable Open Boundary Bug

Boundary conditions I use:

Variable	**West**	**South**	**East**	**North**
`zeta`	Periodic	Closed	Periodic	**Chapman**
`ubar`	Periodic	Closed	Periodic	**Clamped**
`vbar`	Periodic	Closed	Periodic	**Flather**
`u`	Periodic	Closed	Periodic	**Clamped**
`v`	Periodic	Closed	Periodic	**RadNud**
`temp`	Periodic	Closed	Periodic	**RadNud**
`salt`	Periodic	Closed	Periodic	**RadNud**

The Leap Year Bug

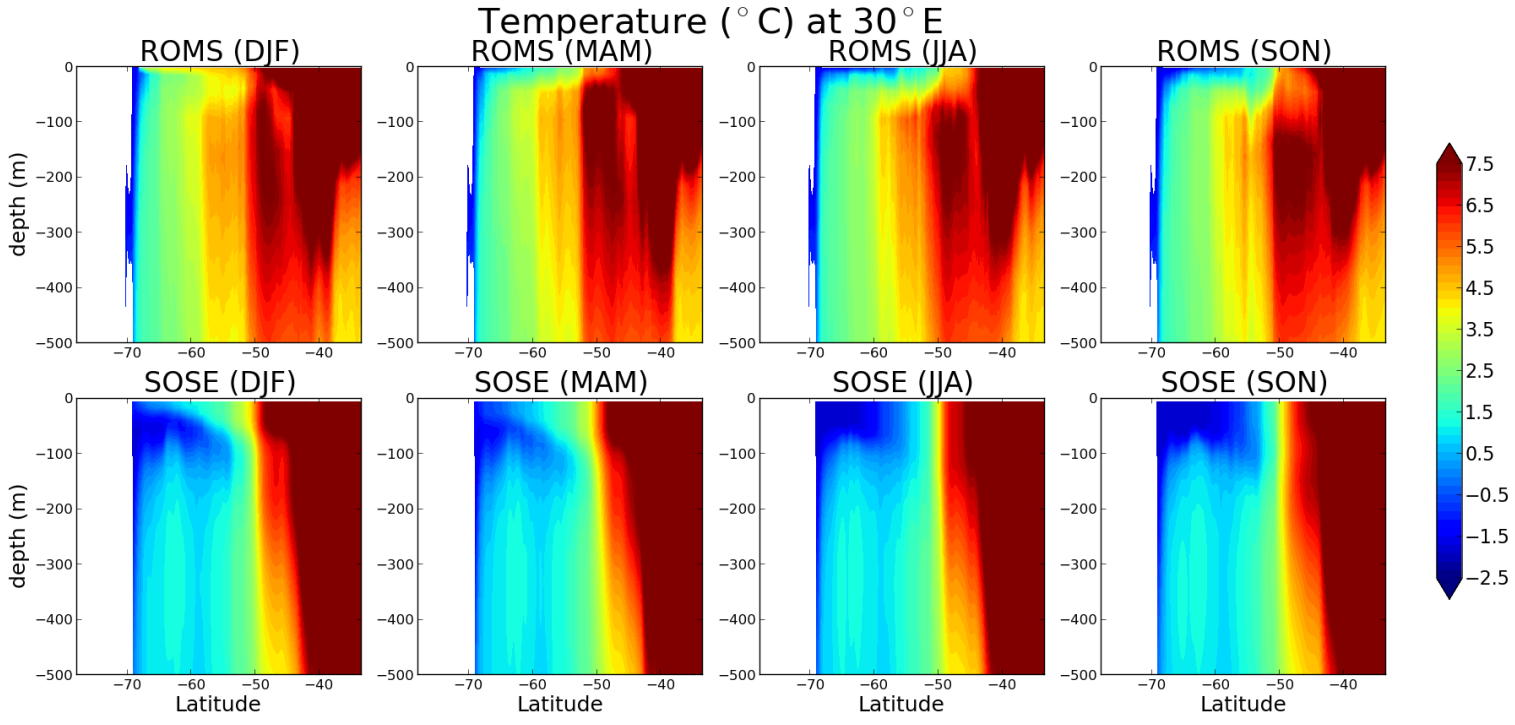


4 year cycle in sea ice melt

The Leap Year Bug

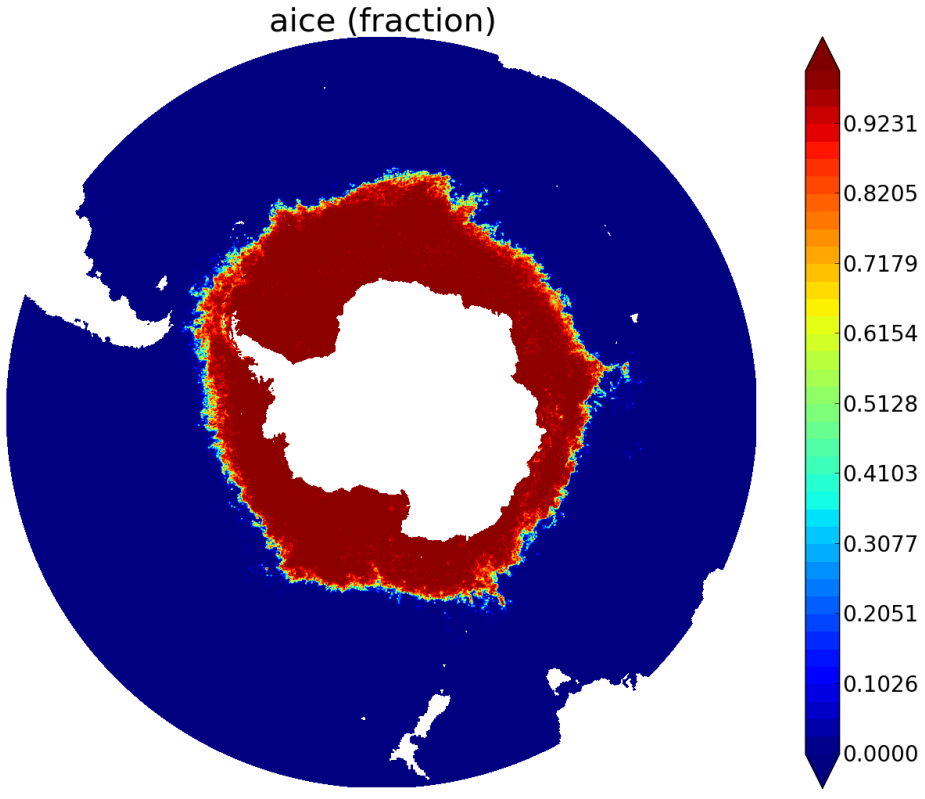
- CICE forcing code for monthly fields
- Assumes number of days per year is constant - but I'm running with leap years!
- Time-interpolation coefficients go crazy whenever it's not a leap year
- Giant spike in air temperature (and all other forcing fields) for a couple of days

The Supercooling Bug



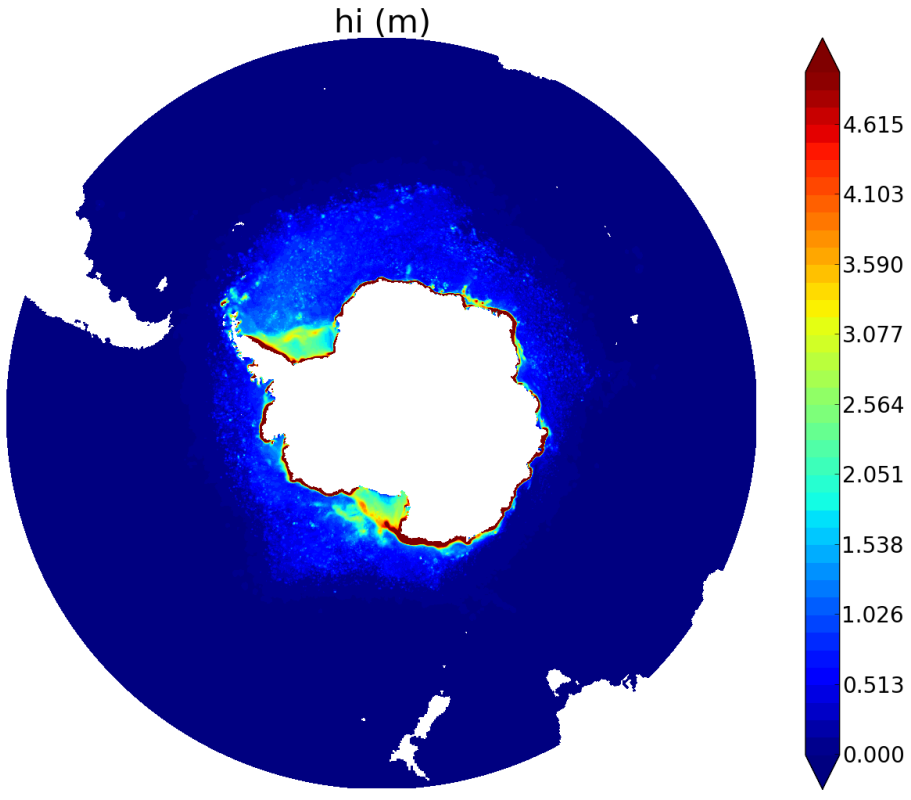
There is no Winter Water

The Supercooling Bug



5-day average at the end of July, first year of simulation
There are no coastal polynyas

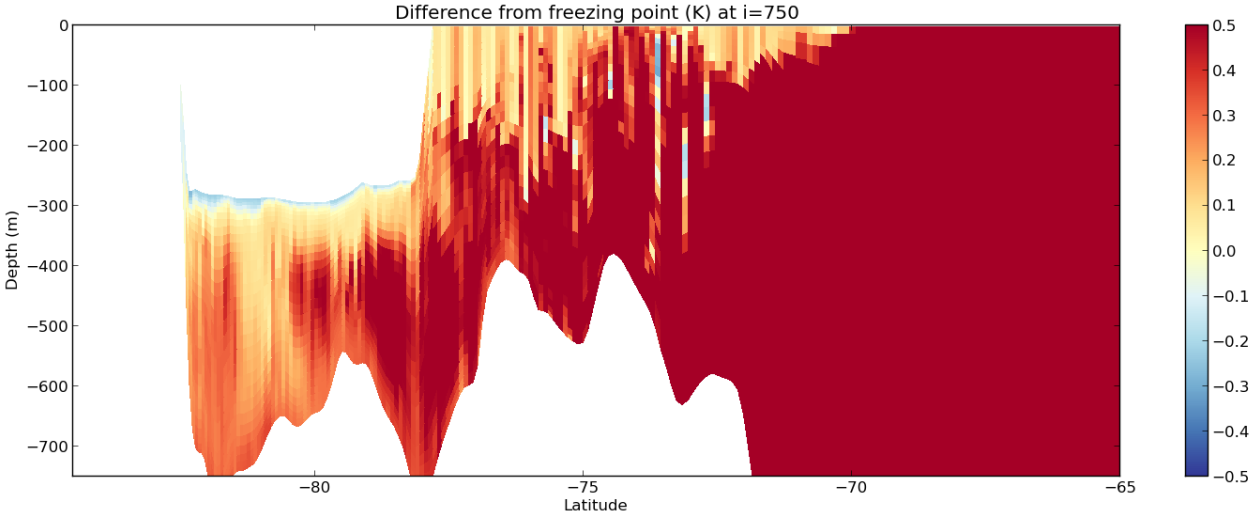
The Supercooling Bug



5-day average at the end of September, third year of simulation

$\sim$ 4 times thicker than observations

The Supercooling Bug



Spurious supercooling caused by advective errors

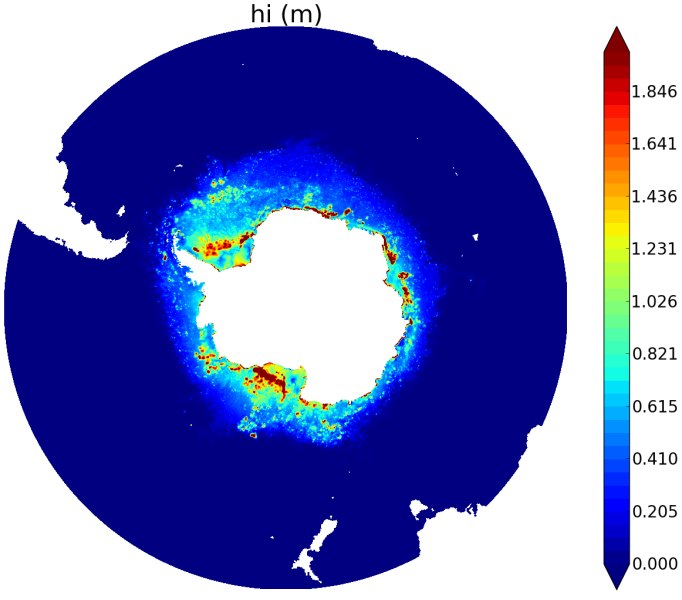
The Supercooling Bug

Suppresses polynyas in two ways:

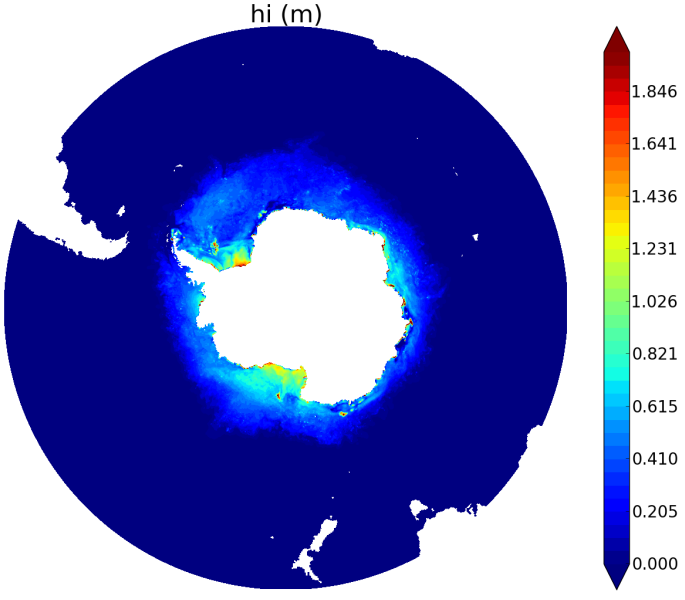
- Dynamic: Thick sea ice over continental shelf break has a buttressing effect
- Thermodynamic: Sea ice immediately melts and stratifies the water column

The Supercooling Bug

TS_C4HADVECTION + TS_C4VADVECTION



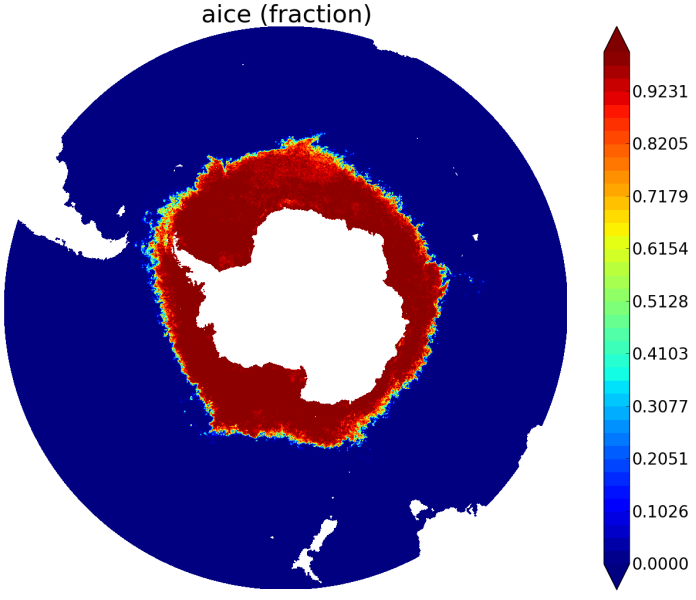
TS_U3HADVECTION + TS_C4VADVECTION



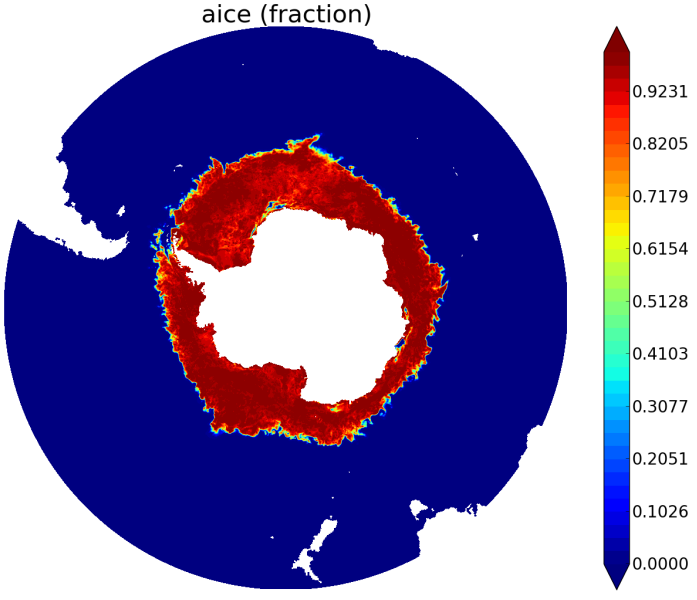
After 6 months (initialised with no ice)

The Supercooling Bug

`TS_C4HADVECTION` + `TS_C4VADVECTION`



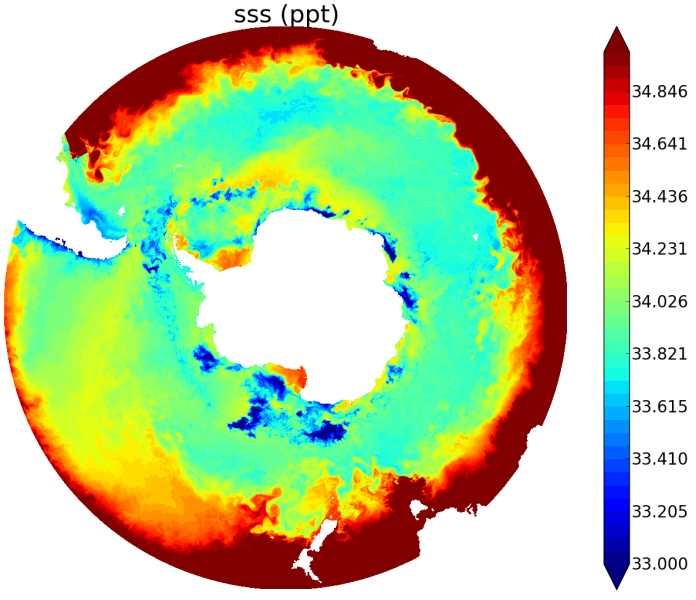
`TS_U3HADVECTION` + `TS_C4VADVECTION`



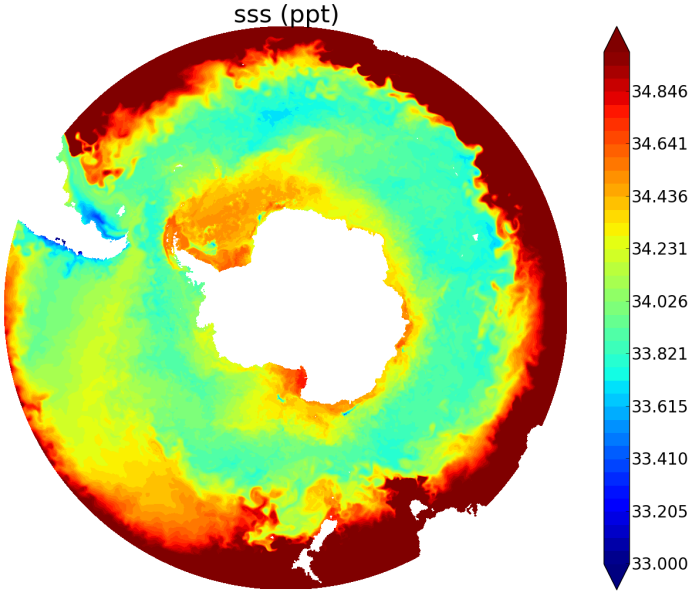
After 6 months (initialised with no ice)

The Supercooling Bug

TS_C4HADVECTION + TS_C4VADVECTION



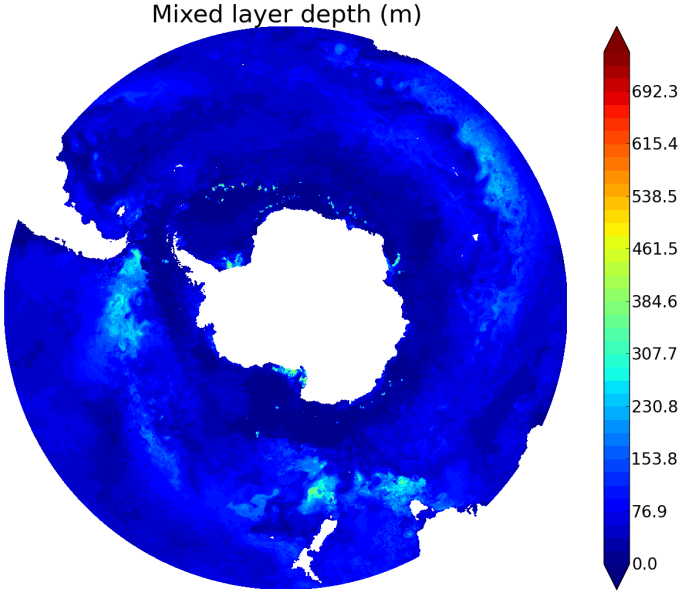
TS_U3HADVECTION + TS_C4VADVECTION



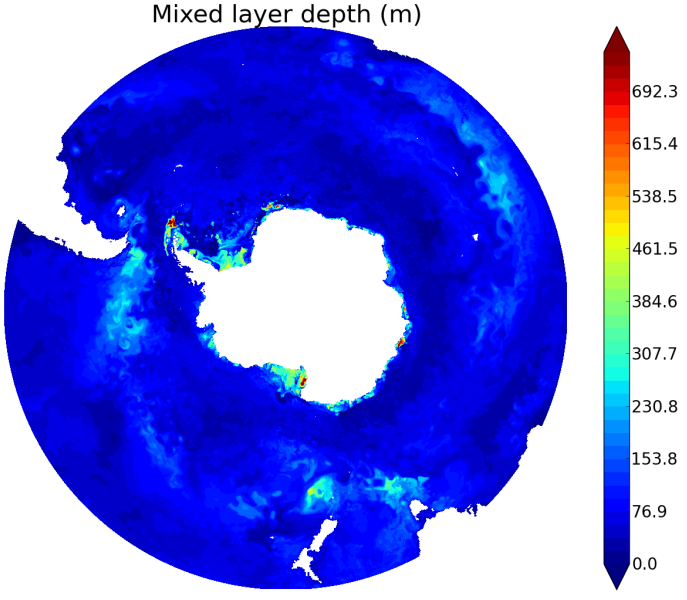
After 6 months (initialised with no ice)

The Supercooling Bug

`TS_C4HADVECTION` + `TS_C4VADVECTION`



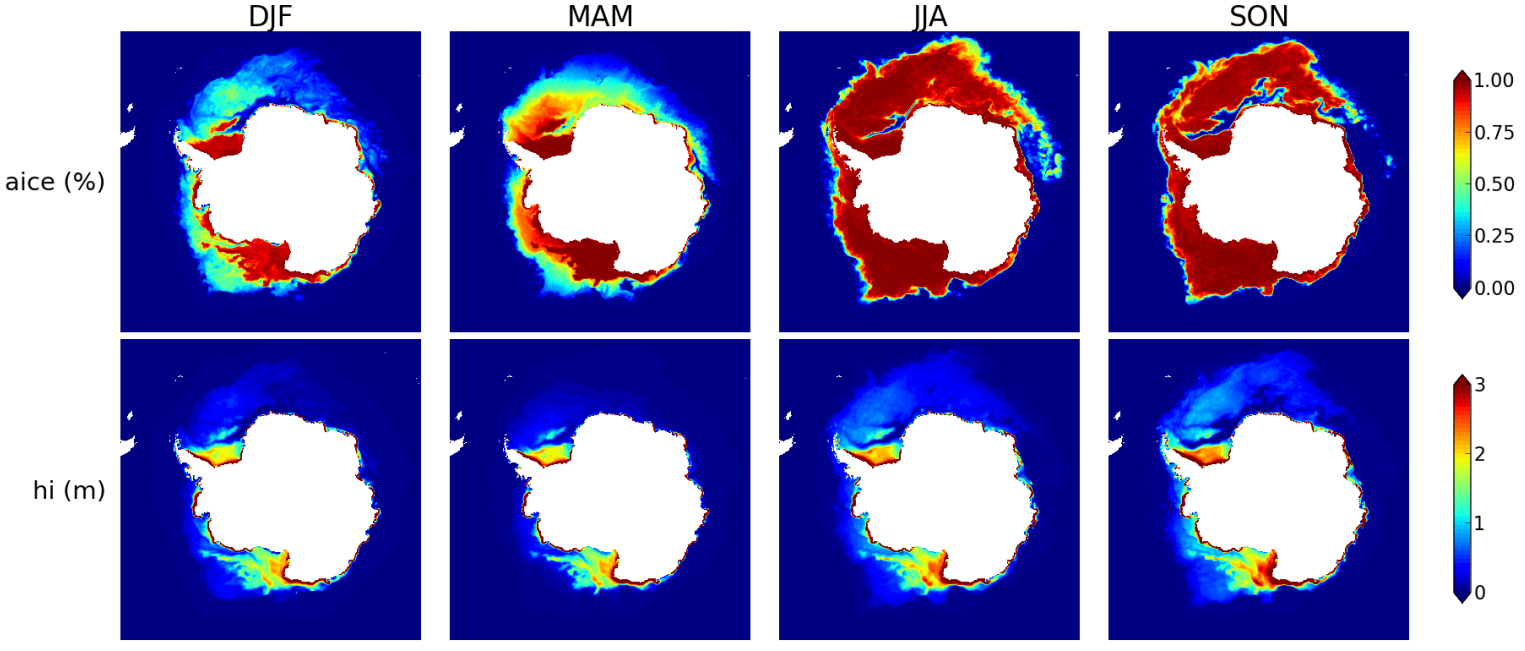
`TS_U3HADVECTION` + `TS_C4VADVECTION`



After 6 months (initialised with no ice)

The Weird Sea Ice Bug

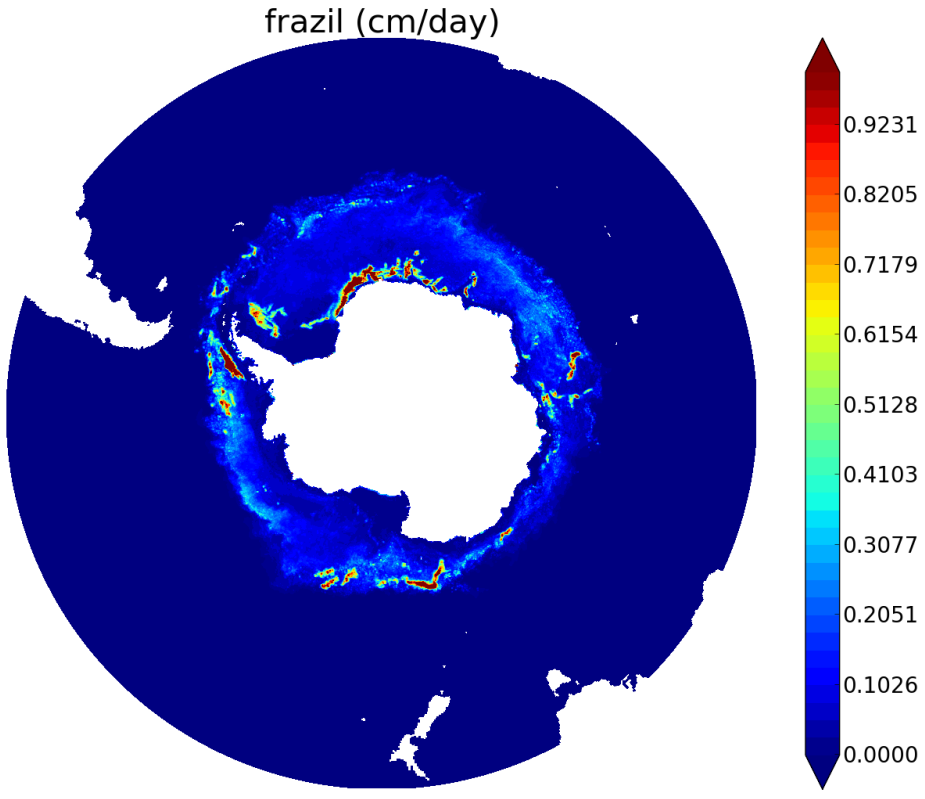
Run for a few more years...



The Weird Sea Ice Bug

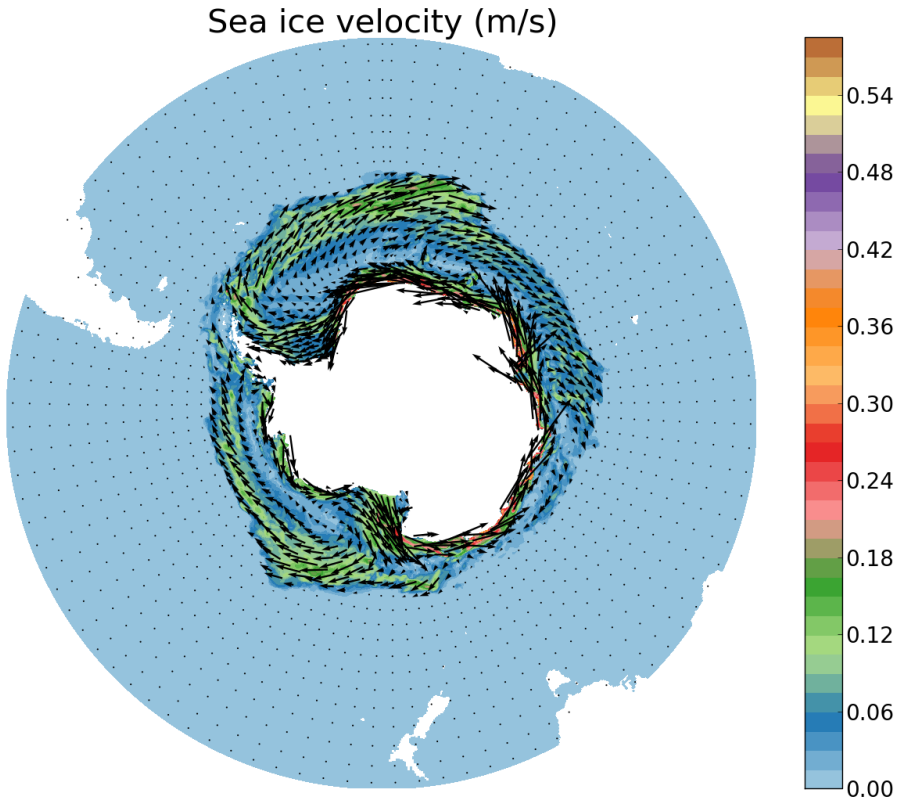
- Still advective errors?
- Use `TS_A4HADVECTION` + `TS_A4VADVECTION`
- Strong explicit mixing with `TS_DIF2` (`TNU2` = 600, scaled with grid size)
- Not much difference

The Weird Sea Ice Bug



Averaged over second year of simulation

The Weird Sea Ice Bug



Averaged over second year of simulation

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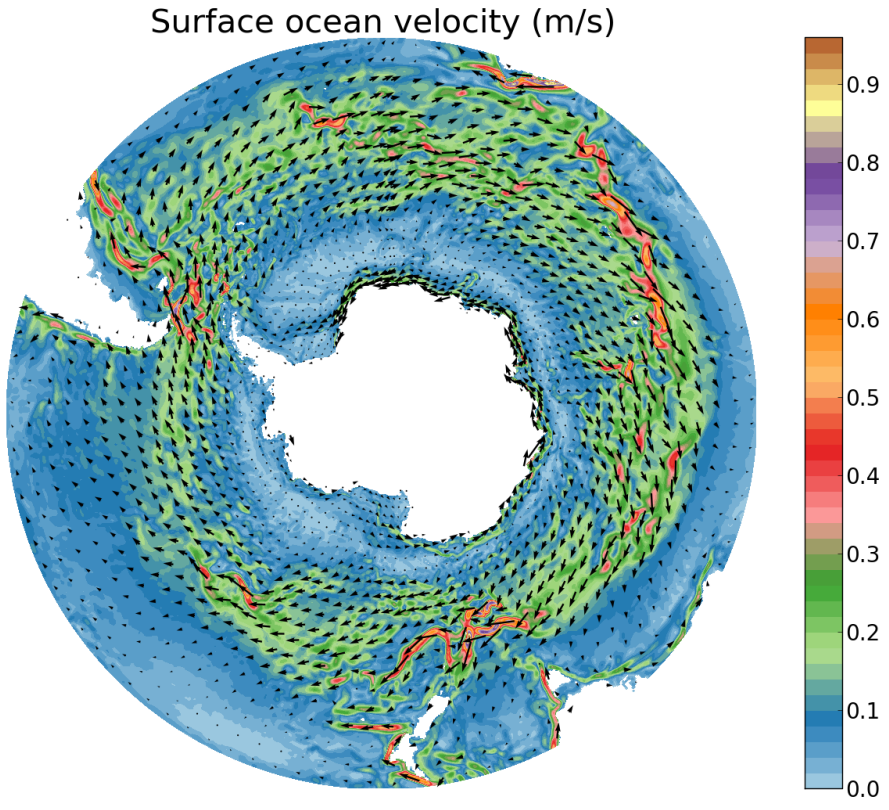

Averaged over second year of simulation

Thanks for coming! Any questions?

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