Regional Modelling with MOM6

The East Australian Current as a test-bed

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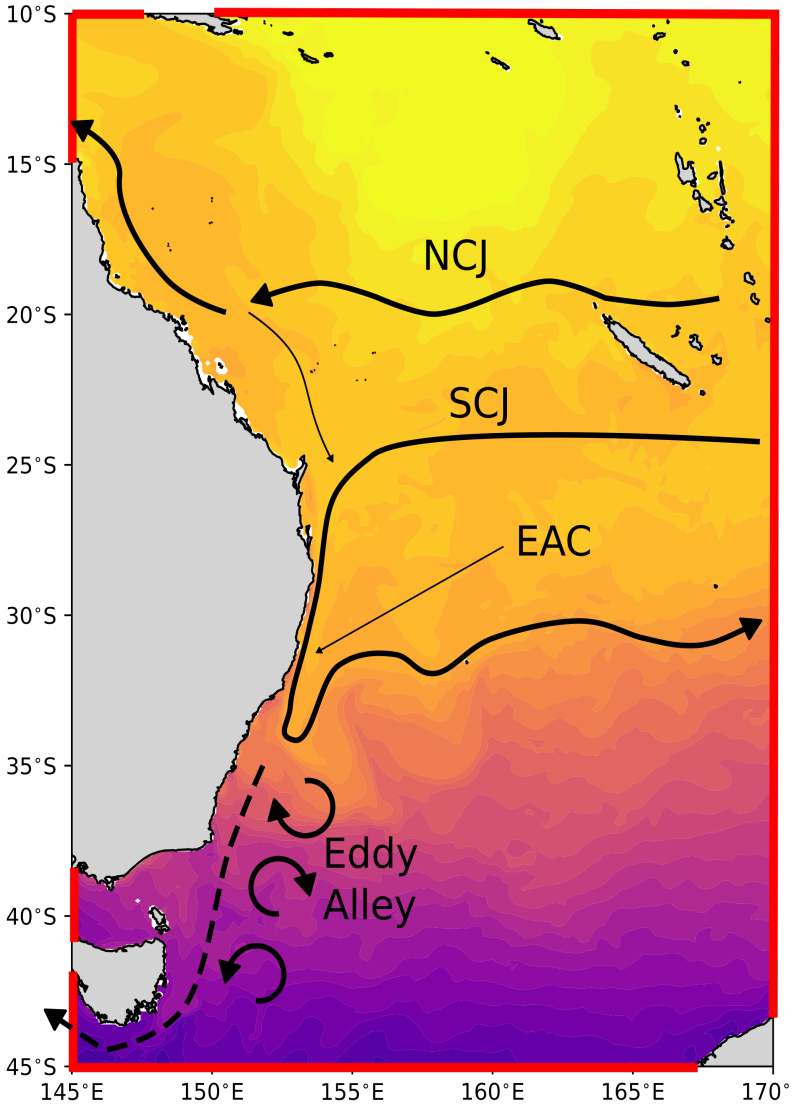
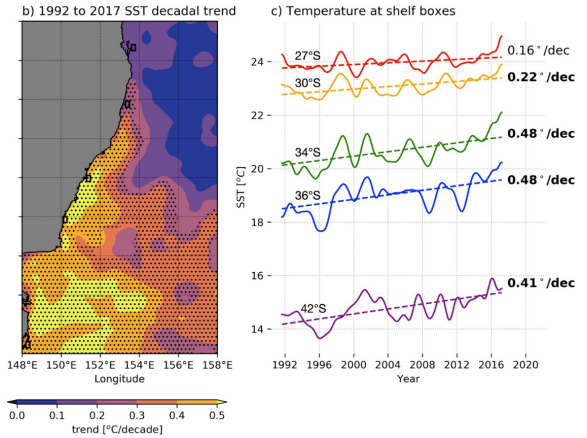
The EAC – a primer

- The western boundary current for the South Pacific Gyre;
- Highly variable:
  - *"The flow patterns in the East Australian Current are so complex and variable that it is often difficult even to decide whether a single continuous current exists"* (Godfrey et al. 1980)
- Influences heat, salt, nutrients, etc for the east coast;
- **Warming ~4x global average rate!**





SST trends (Malan et al. 2020)

Tropical coral growing near Manly, NSW (Booth & Sear 2018)

The EAC Transport array

- CSIRO/IMOS mooring program from 2012 to 2022 (gap from 2013-2015);
- **Transport from *60 Sv* southwards (~Gulf Stream) to *5 Sv* northwards (reversal!);**
- Evidence that EAC transport influenced by remote drivers (Sloyan & O'Kane 2015, Bull et al. 2020) and
- Also evidence suggesting local influences (Chapman et al., in revision)

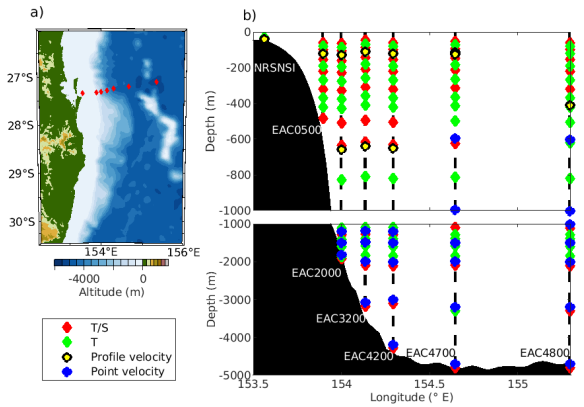
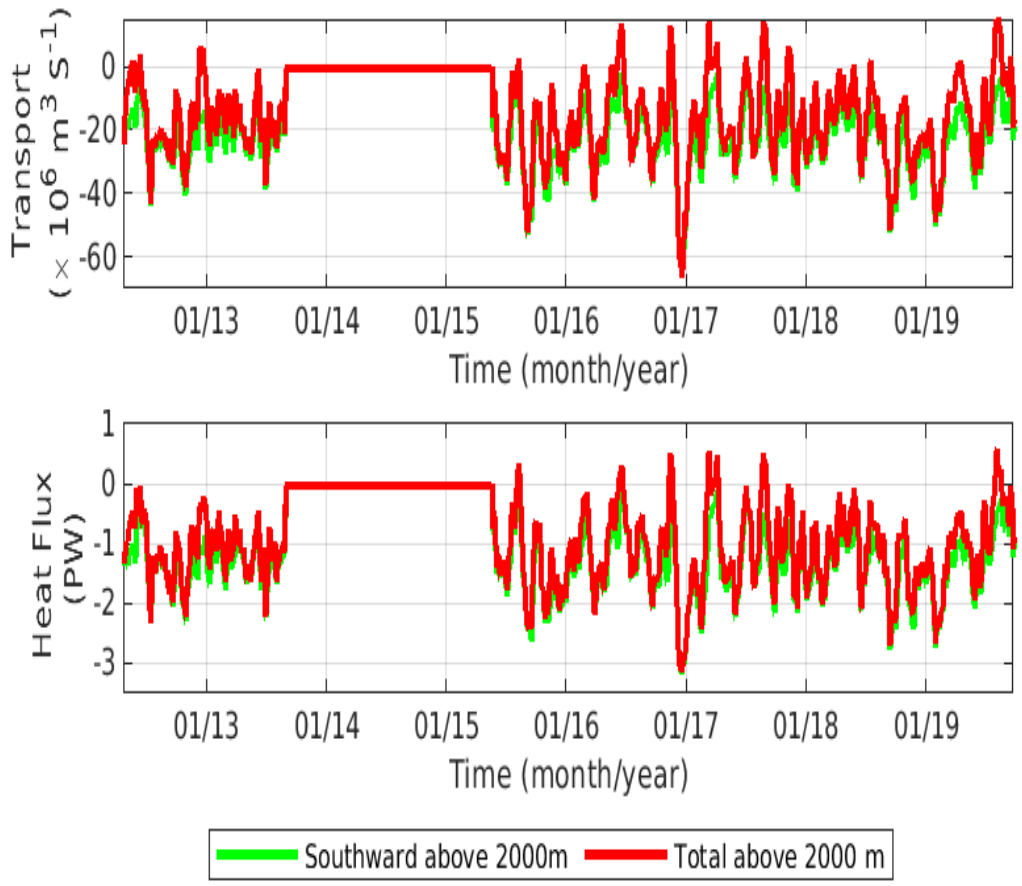


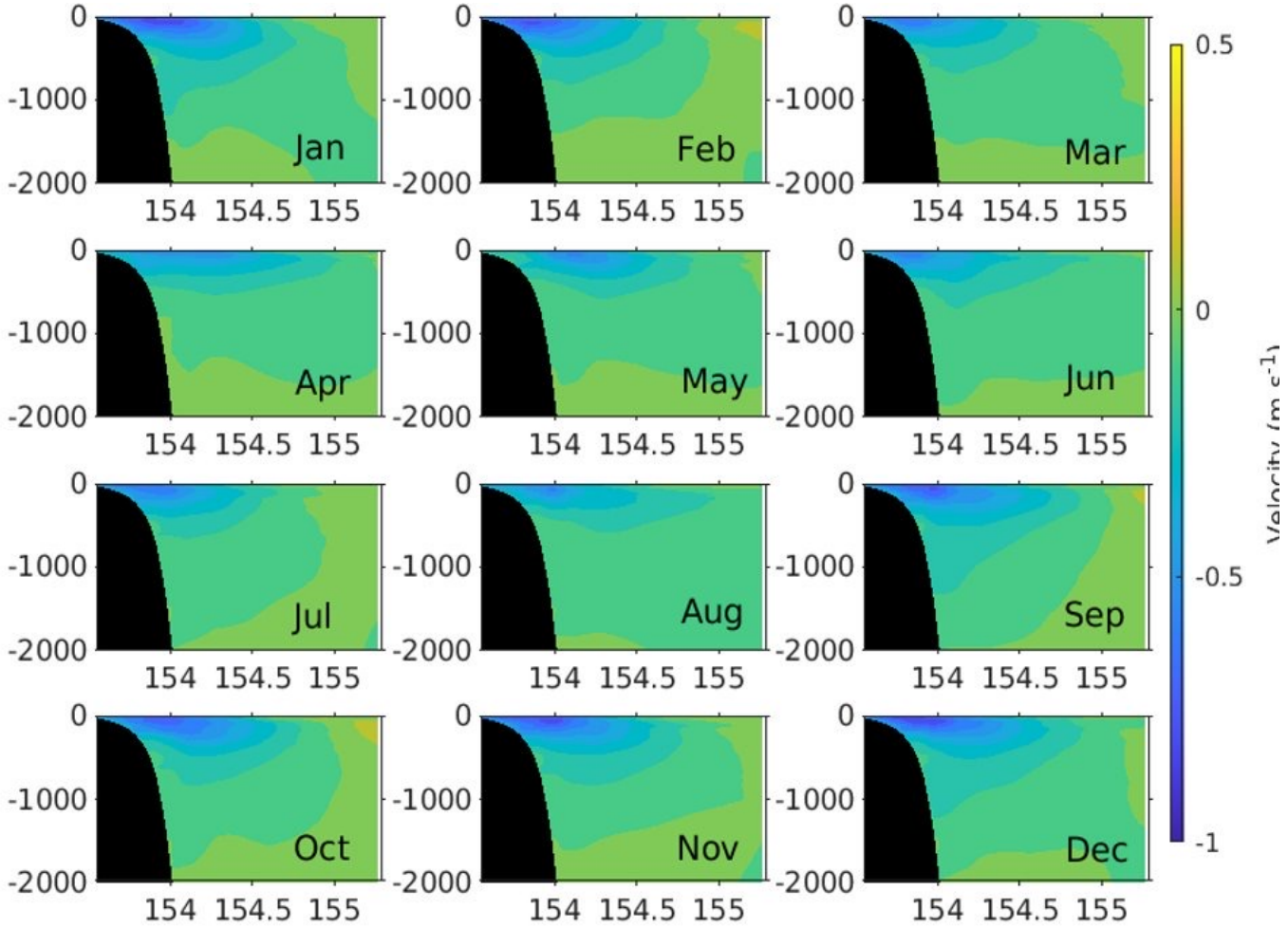
Photo by Thomas Moore



Sloyan et al. (in review)

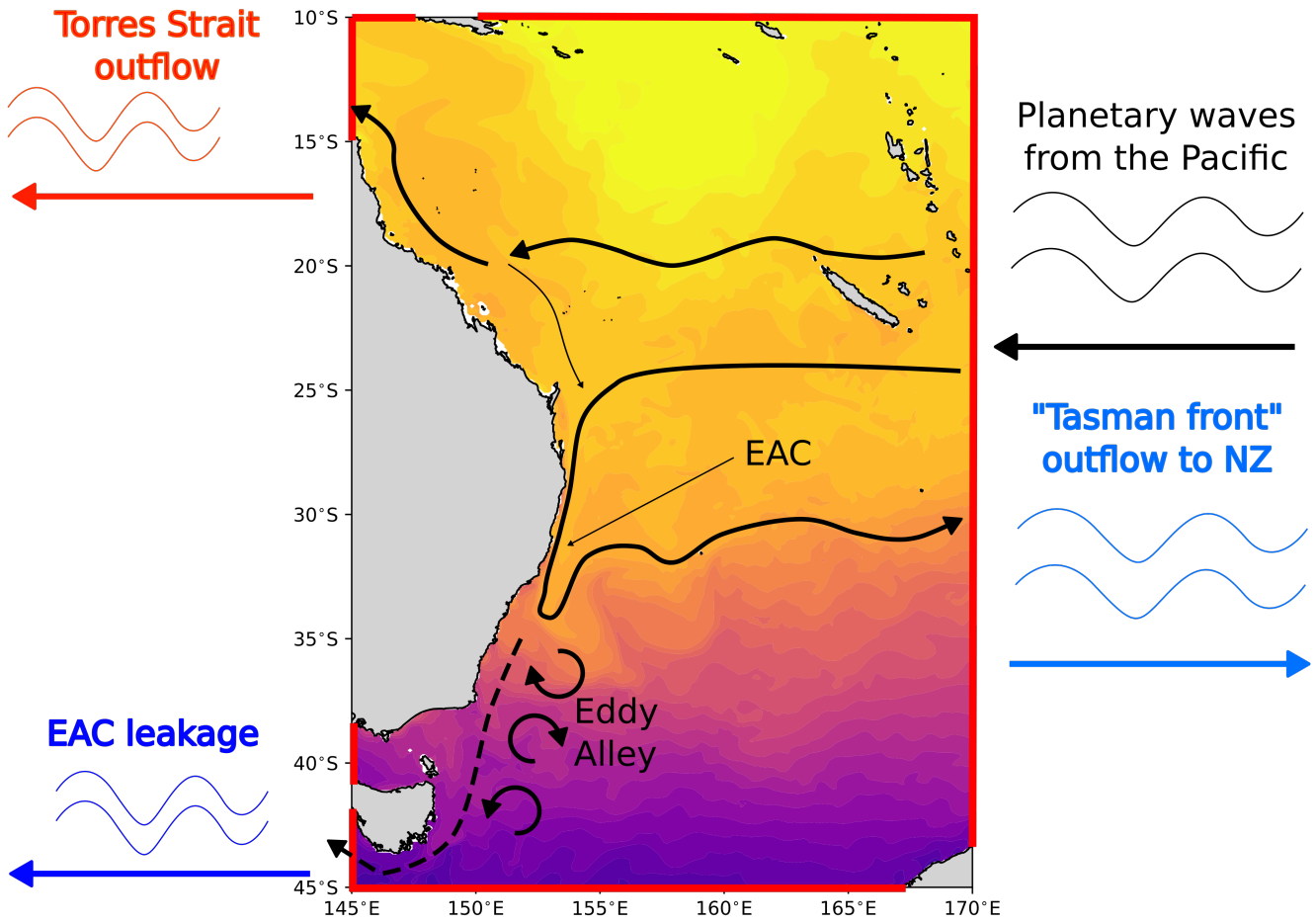
The EAC Transport array

- Moorings show strong evidence of **maximum current strength at depth**
- Seasonality – stronger in summer, weaker in Autumn



Regional Ocean Modelling – more complex than you think!

- Outgoing waves need to exit without spurious reflection;
- Incoming waves need to propagate with appropriate phase speeds;
- Simple boundary conditions (Dirichlet, Neumann, etc…) can yield unphysical values;
- **Inappropriate boundary conditions affect the interior solution!!!**

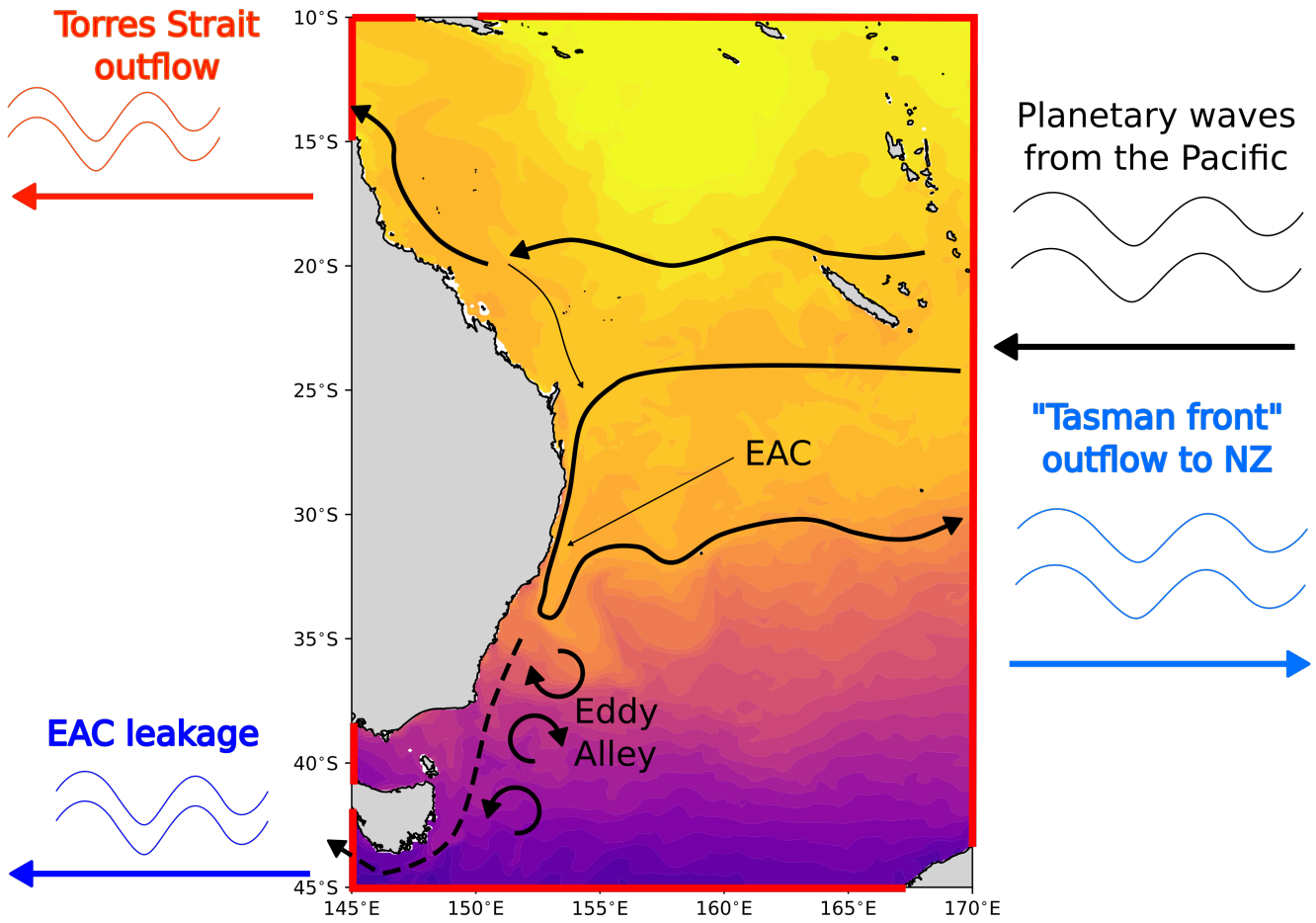


Regional Ocean Modelling – more complex than you think!

- Radiation boundary conditions generally employ the Sommerfeld condition:

$$\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial n} = 0$$

- Schemes differ by how they compute phase speed *c*



MOM6 – EAC a test-bed for regional modelling

- A regional (PNG to Tasmania, East Coast to New Zealand) MOM6 configuration
- Repeat neutral year (1991) - surface forcing from 3 hourly JRA, boundary forcing specified from final cycle of ACCESS-OM01 RYF
- Currently using *z** vertical coordinates – (ALE tests are on the too-do list)
- 1/10° horizontal grid spacing, 75 vertical levels
- Test cases:
  - Long (30 year) run with **Orlanski Radiation OBCs**
  - Short (5 year) cold start run with **Raymond & Kuo OBCs**
  - Short (5 year) warm start run with **Raymond & Kuo Boundary OBCs**
  - Other runs (repeat ENSO year, ensemble generation,)

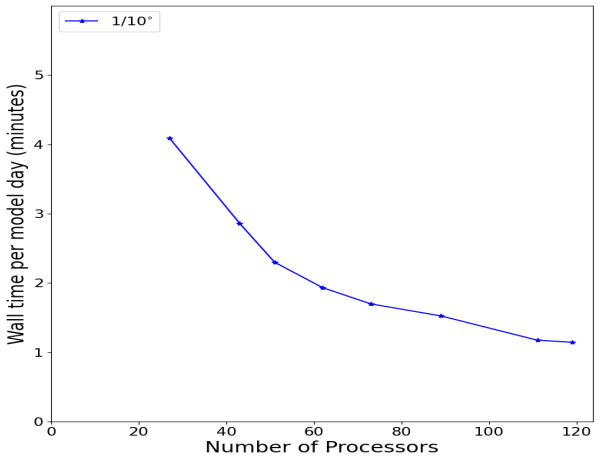
Intermezzo – Pawsey Supercomputing Center and *Setonix*

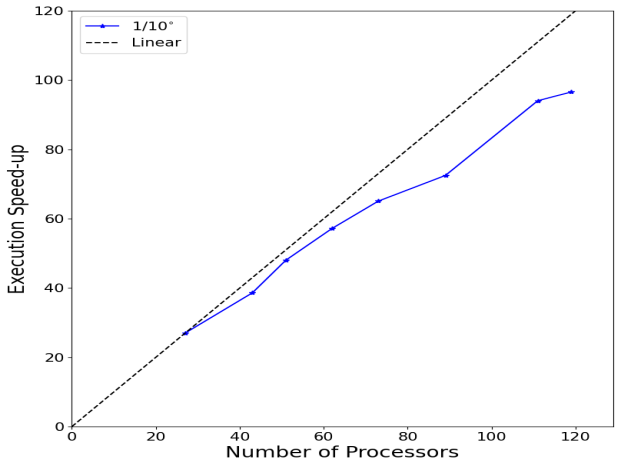
- These runs were NOT performed on Gadi but on the Pawsey machine Magnus;
- New machine, Setonix, coming on line within months;
- Gadi equivalent with some caveats:
  - Cray arch with AMD processors (limits intel complier suite)
  - *Slurm* workload manager (required modification to *Payu)*
  - Object file system in-place of group store (cloud-like… takes some getting used to)

MOM6 EAC – scaling

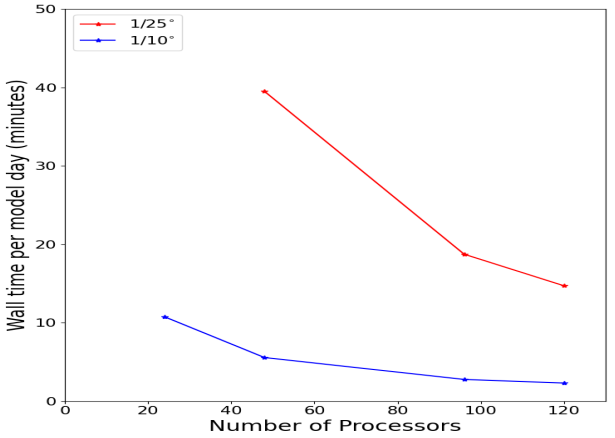
- Results from tests on *Magnus (Pawsey)* - we expect similar on *Setonix;*
- Linear scaling to ~80 cores (somewhat concerning – although no tuning);
- Good throughput per node;
- Performs similarly to MIT-GCM (runs with same domain on same machine.

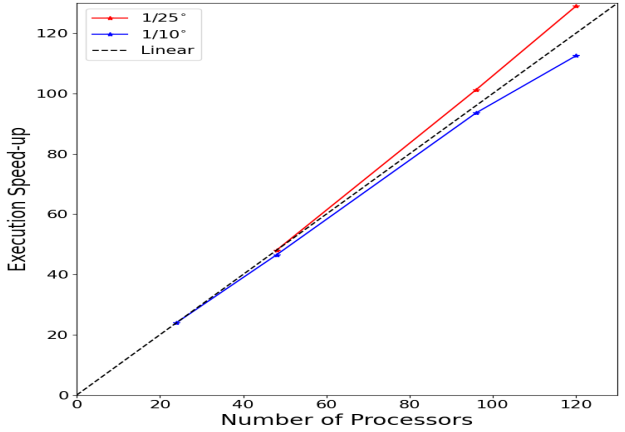
MOM6





MIT-GCM

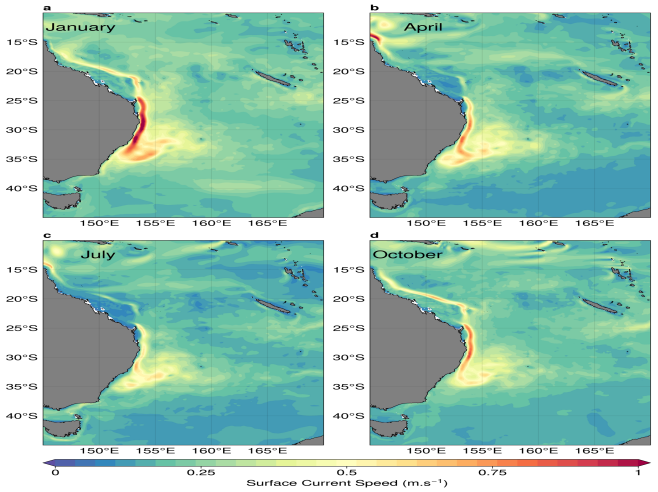




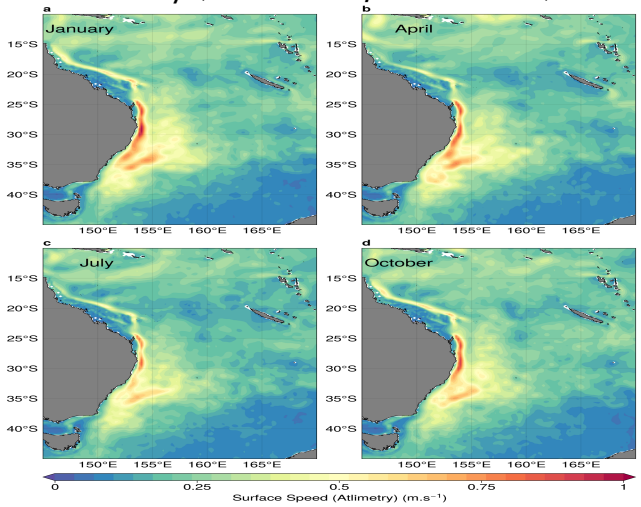
Basic validation

- Seasonal cycle (strongest in summer, weakest in winter) well captured
- Too strong in summer, too weak in winter
- EAC core too far north and too far offshore

MOM6 EAC (20 year)



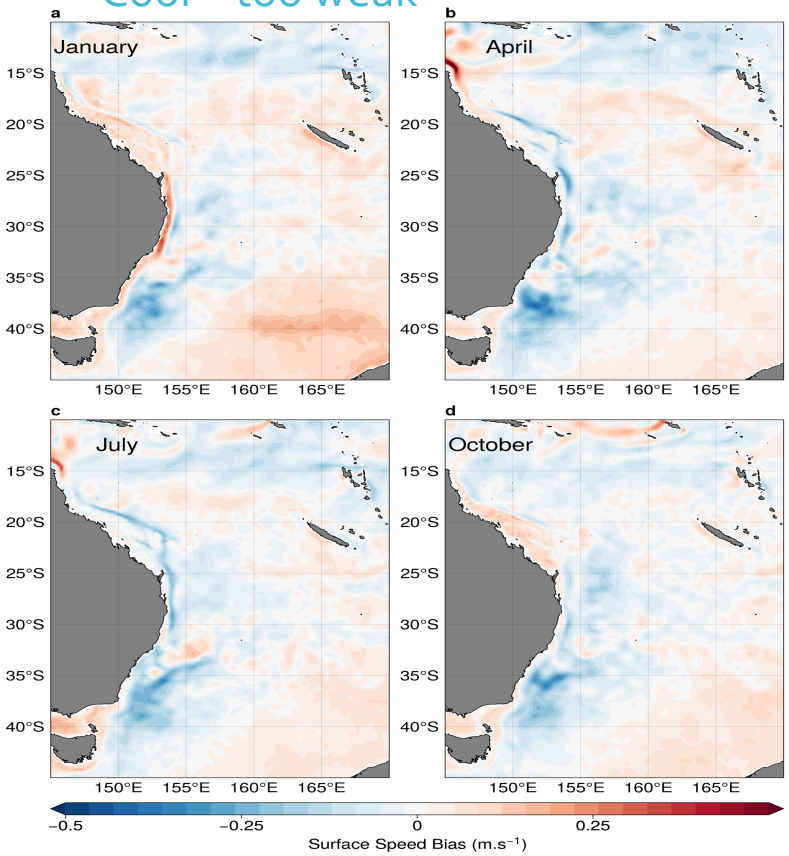
Altimetry (2001-2021, detrended)



Bias (model-obs)

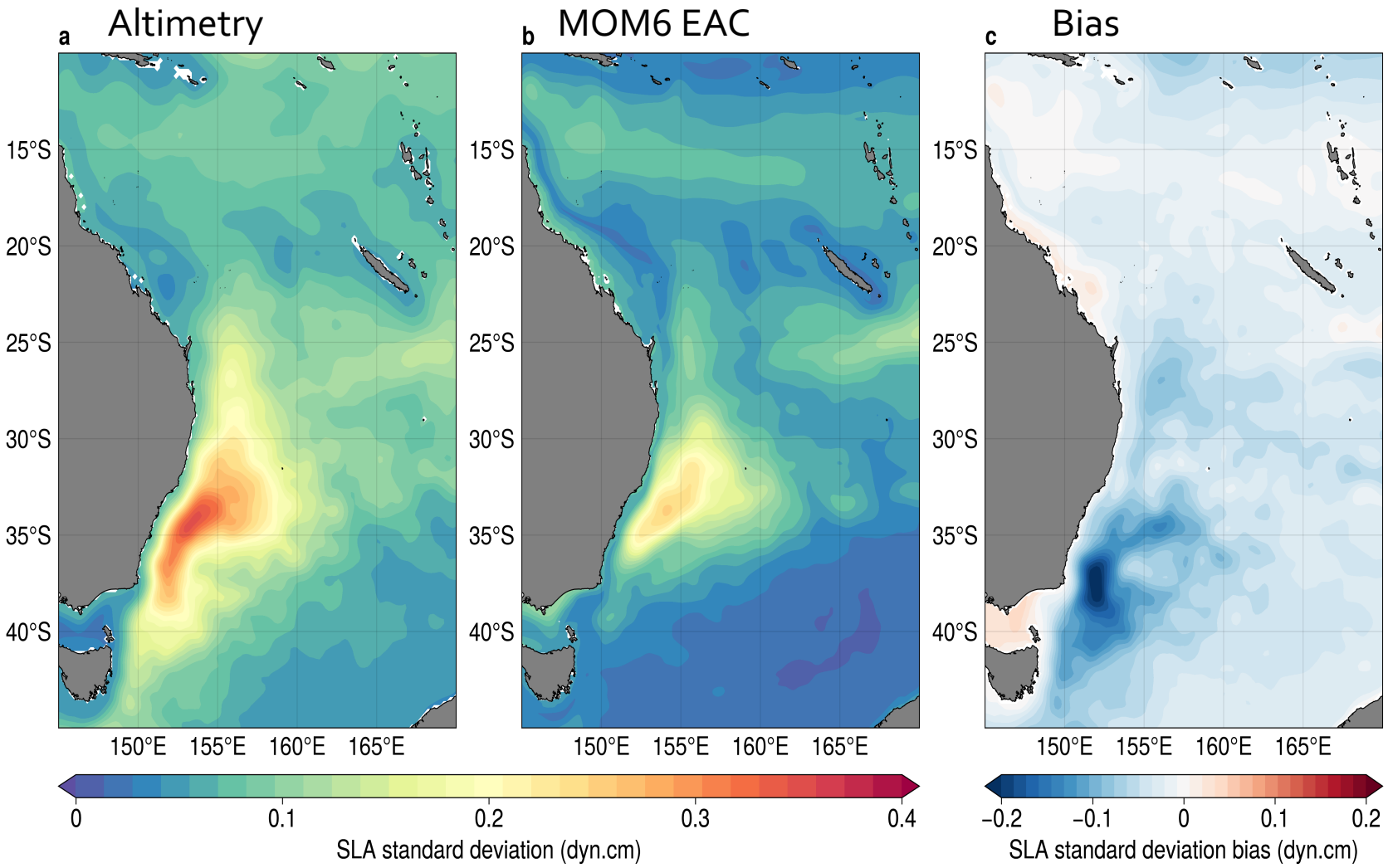
Warm = too strong

Cool = too weak



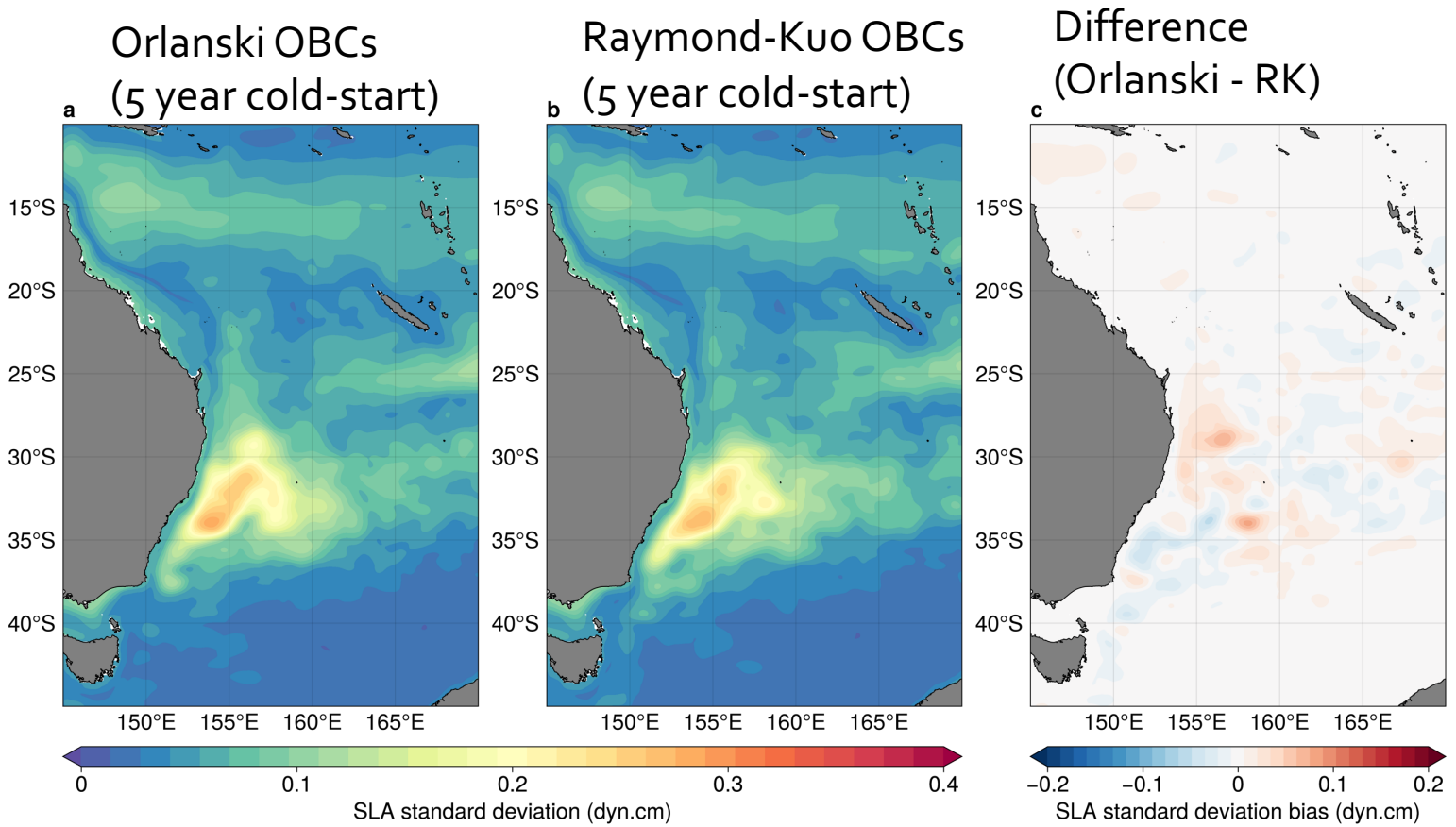
Basic validation

- Variability is *generally* in the right place and right order of magnitude.
- Too weak and too confined between 35
- Too strong near the Torres Strait



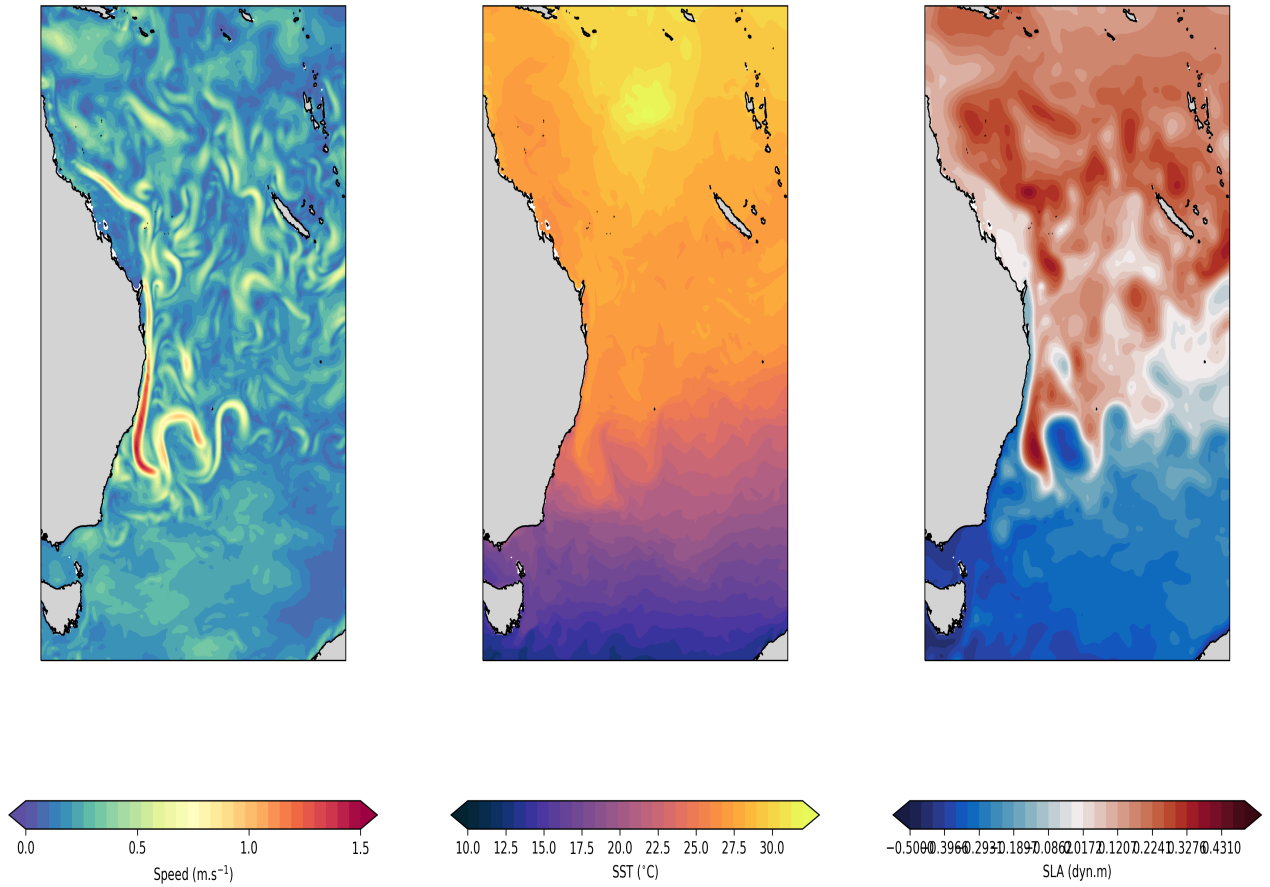
Sensitivity to OBC scheme

- Test two OBC radiation schemes – Orlanski 1976, and Raymond & Kuo (1984);
- Raymond and Kuo are (technically) more sophisticated;
- Minimal effects on the interior solution, no craziness at boundaries
- Other schemes exist, but require implementation



Take home message

- A regional MOM6 implementation for the Tasman Sea
- Further validation is ongoing
- Model gives good scientific results – room for improvement
- Scaling is a bit concerning
- This is a test-bed – the number applications is (approximately) limitless!



Work in progress and future plans

- Early days (side project for most participants);
- Strong demand from stakeholders;
- Further developments need planning – ad hoc is bad;
- **Community buy-in is key! We need you!**

Activity	Progress
Ensemble system (à la OCCIPUT)	Almost there
Different domains	DONE!
IAF runs	Almost there
High resolution	In progress
Compiler/layout tuning	In pipeline
Hybrid vertical coordinates	In pipeline
Projection (CMIP) downscaling	Wishlist
Couple atmosphere/ocean	Wishlist

Thanks!