



Modelling wave–ice–ocean interactions in ACCESS-OM3

NCAR Polar Group Workshop 2026

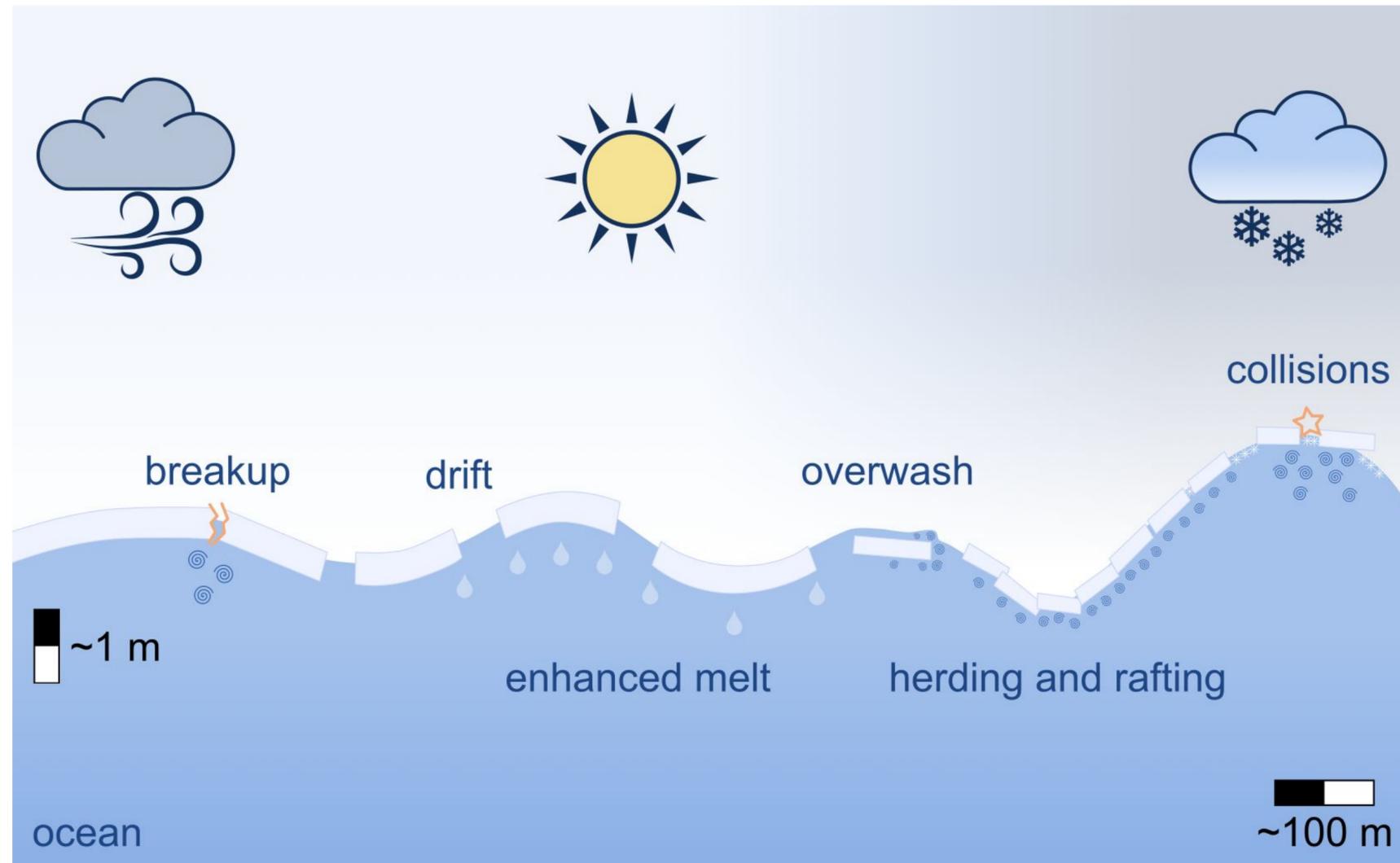
Noah Day, Luke Bennetts, Siobhan O’Farrell, Ezhilsbareesh Kannadasan, Alex Fraser, Alberto Meucci and others

Credit: Nathan Teder



Wave–sea ice processes in global climate models

All of these processes can take place within a 1° cell*



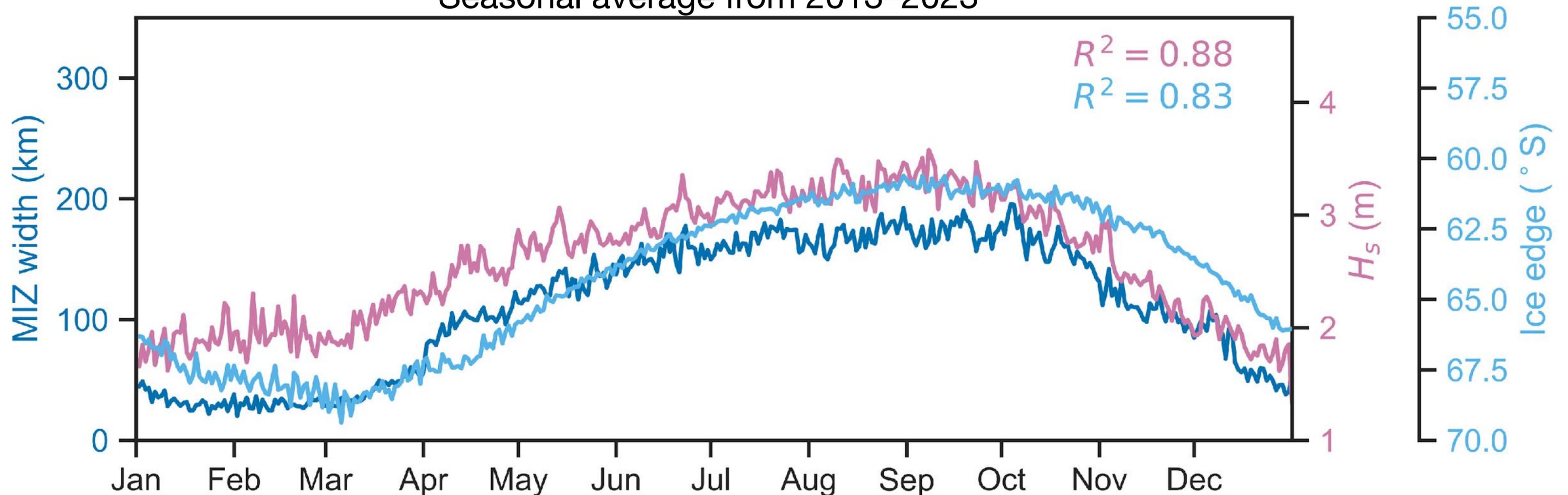
- Ocean surface waves interact with sea ice in the marginal ice zone (MIZ)
- Waves fracture the ice cover, producing smaller, more mobile floes
- Sea ice attenuates wave energy, controlling the extent of fracture
- These processes occur over sub-grid scales, making it challenging for climate models

* Bennetts, et al. (2024). *Closing the loops on Southern Ocean dynamics: From the circumpolar current to ice shelves and from bottom mixing to surface waves*. *Reviews of Geophysics*, 62(3).

Remote sensing of the Antarctic marginal ice zone

- A climatology of Antarctic MIZ widths (i.e., wave penetration distances into sea ice) derived from satellite altimetry has recently been produced*
- The seasonal **MIZ width** is highly correlated with both **significant wave heights** and the **latitude of the ice edge**

Seasonal average from 2013–2023*

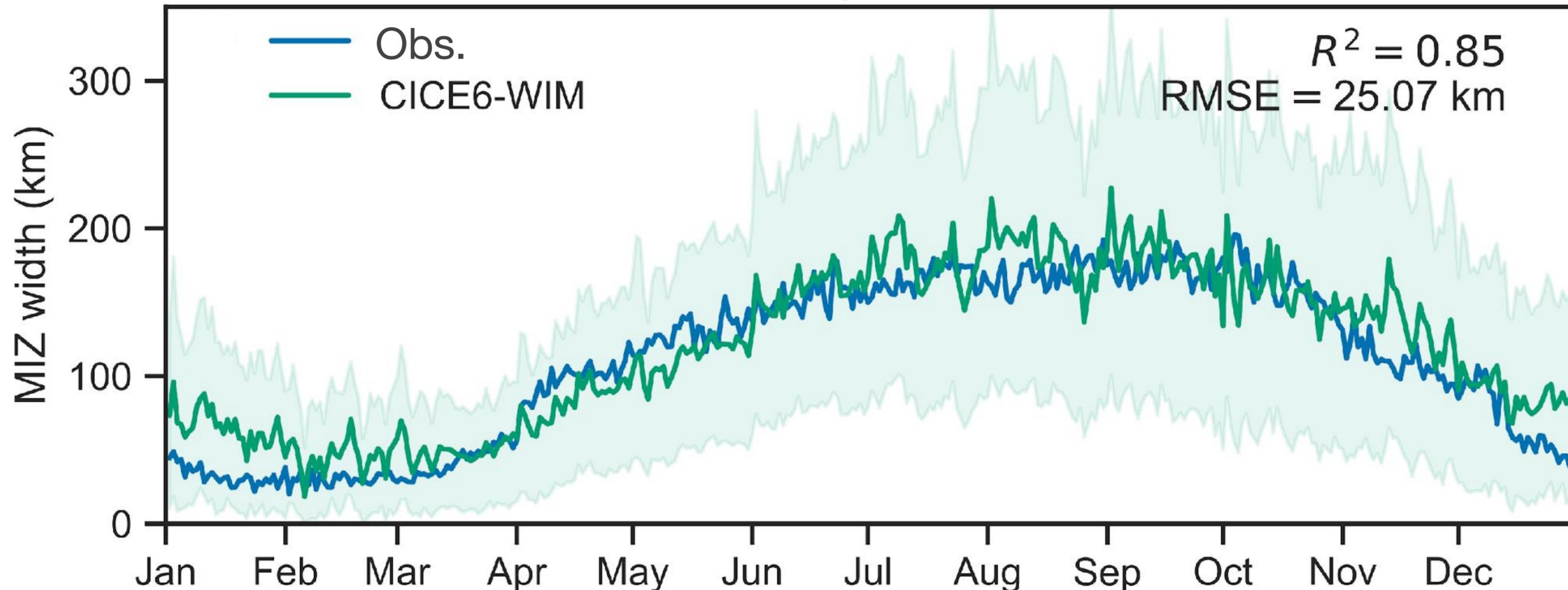


* Fraser, Day, et al., *Revealing the Antarctic marginal ice zone: a decade-long wave-in-ice climatology*. [In review].

Remote sensing of the Antarctic marginal ice zone

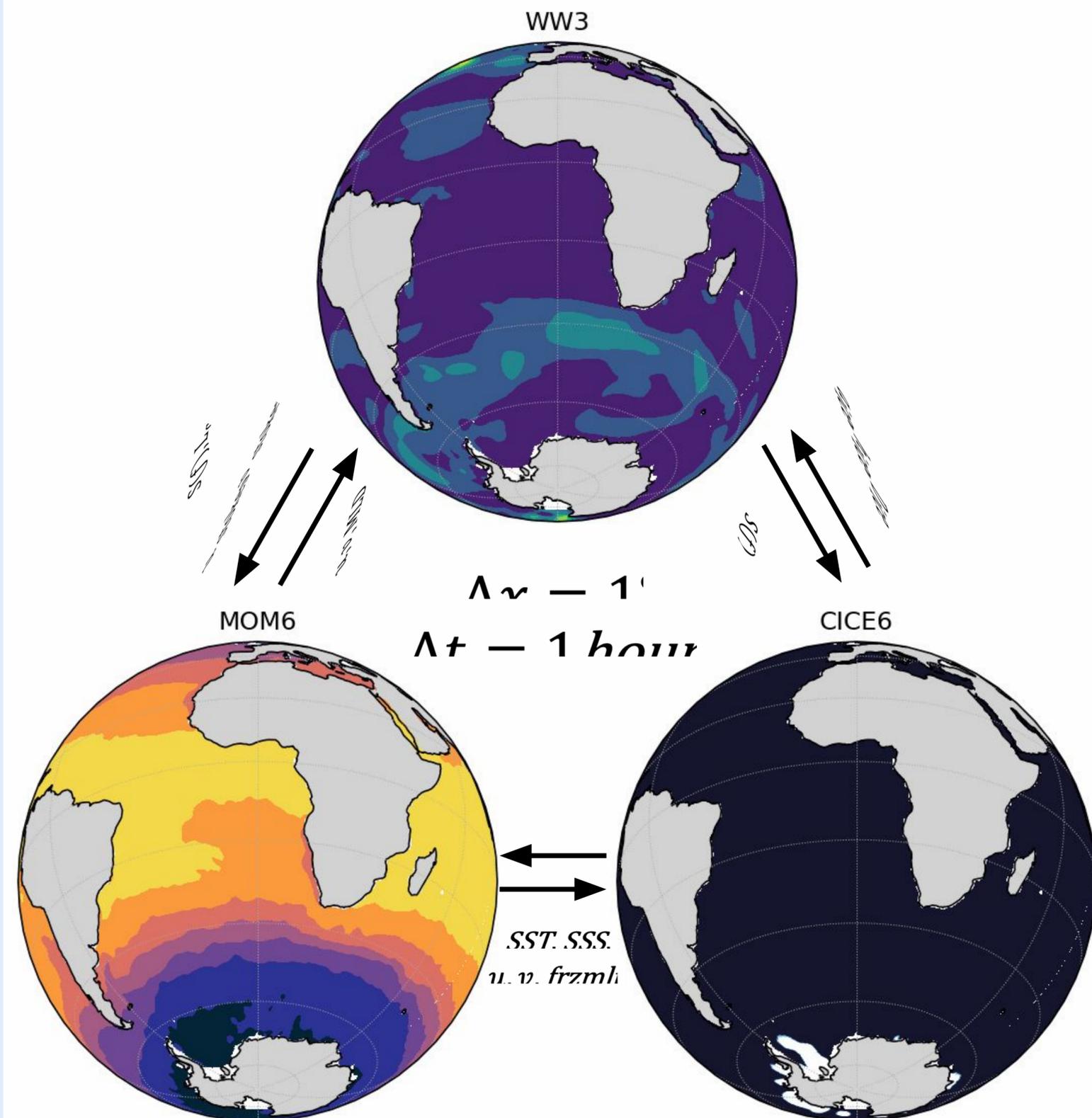
- **Observed MIZ widths** are also highly correlated outputs from **CICE with a simple wave-ice module** (CICE6-WIM at 0.25° resolution)
- The strength of key MIZ processes (attenuation, breakup, etc.) remains poorly constrained; so, we are developing a coupled ocean-sea ice-wave model

Seasonal average from 2013–2023*



* Fraser, Day, et al., *Revealing the Antarctic marginal ice zone: a decade-long wave-in-ice climatology*. [In review].

Ocean–Sea ice–Wave Coupling in ACCESS-OM3



🚧 **ACCESS-OM3:** Australia's next-generation ocean–sea-ice model is currently being developed

🧊 **CICE:** Floe size and thickness distribution (FSTD)

- Wave-induced breakup and new floe size formation (depends on $S(f)$)

🌊 **WW3:** Wave attenuation

- Currently using IC4M8^[1] (depends on $a_{ice}, h_{ice}, D_{ice}$)

🌍 **MOM6:** Wave-induced mixing

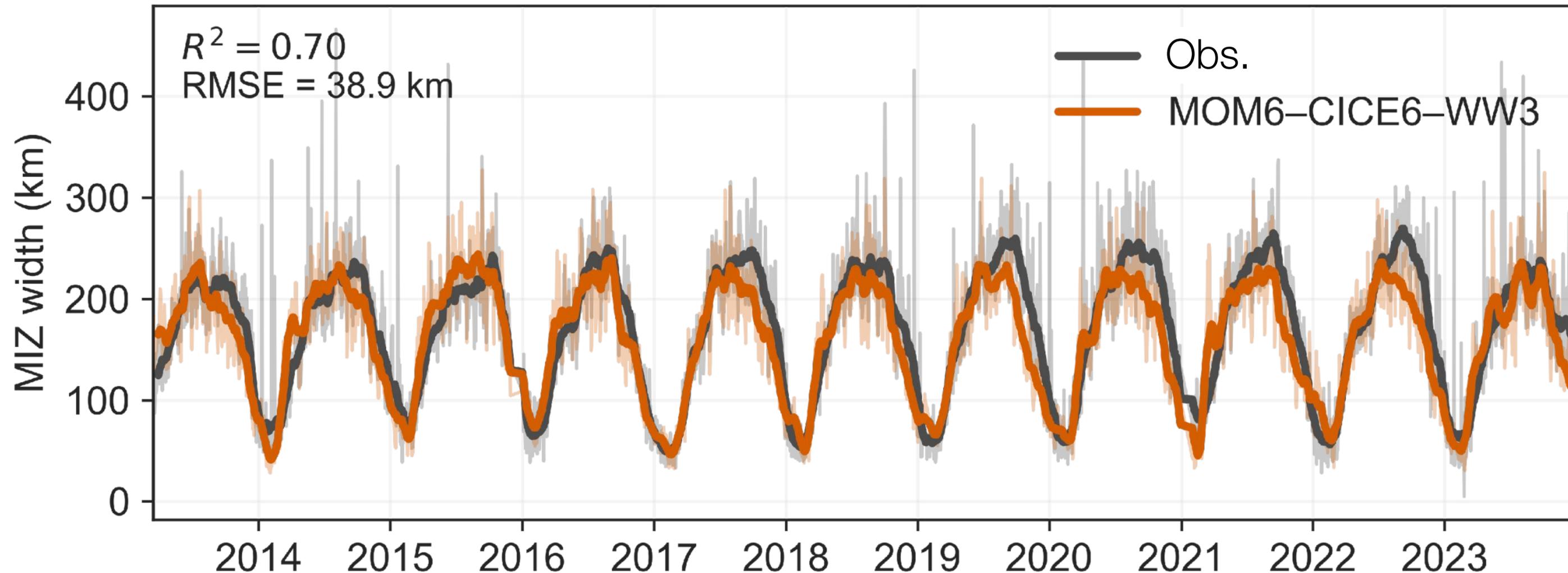
- Currently using the KPP scheme with an enhancement factor^[2]

^[1] Meylan, et al. (2021). *A floe size dependent scattering model in two-and three-dimensions for wave attenuation by ice floes*. *Ocean Modelling*, 161, 101779.

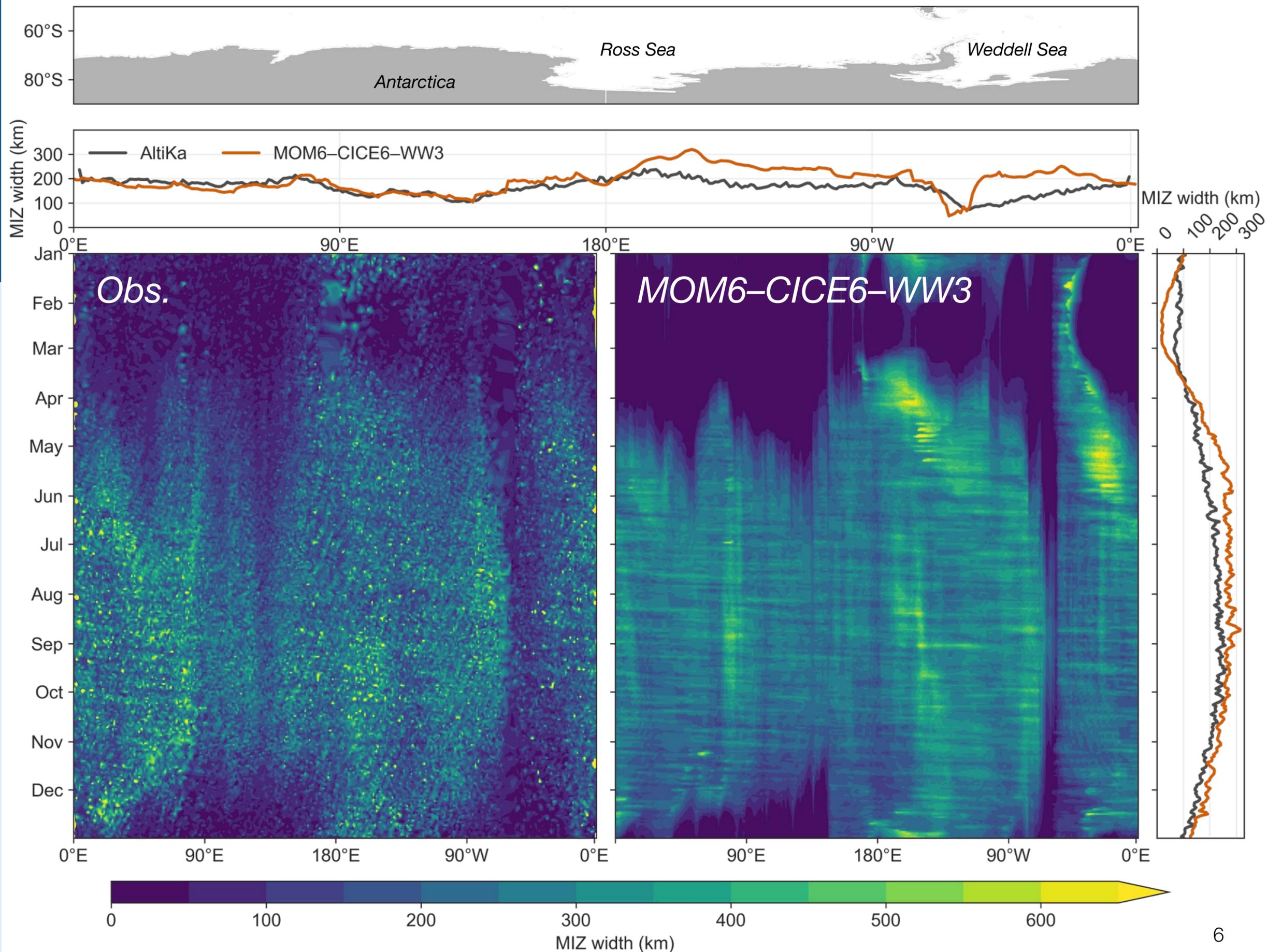
^[2] Li, et al. (2016). *Langmuir mixing effects on global climate: WAVEWATCH III in CESM*. *Ocean Modelling*, 103, 145–160.

Preliminary Results: MOM–CICE–WW3 vs Obs.

- With standalone CICE at 0.25° , correlations were high for the climatology but not for time series ($R^2 \approx 0.5$)
- Now time series correlations are $R^2 \approx 0.7$, even at 1° resolution



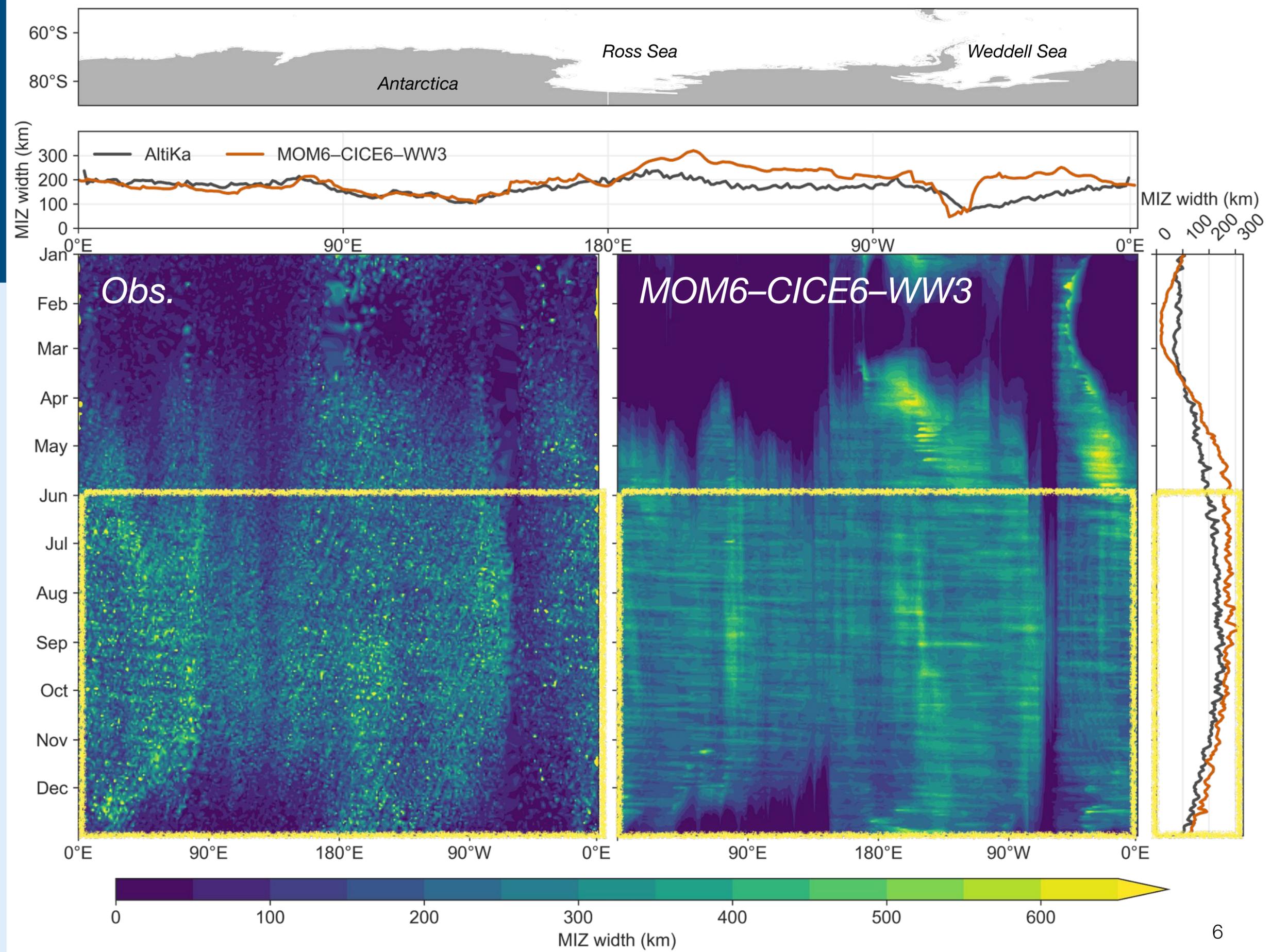
Preliminary Results: Climatology (2013–2023)



Preliminary Results: Climatology (2013–2023)

Agreement:

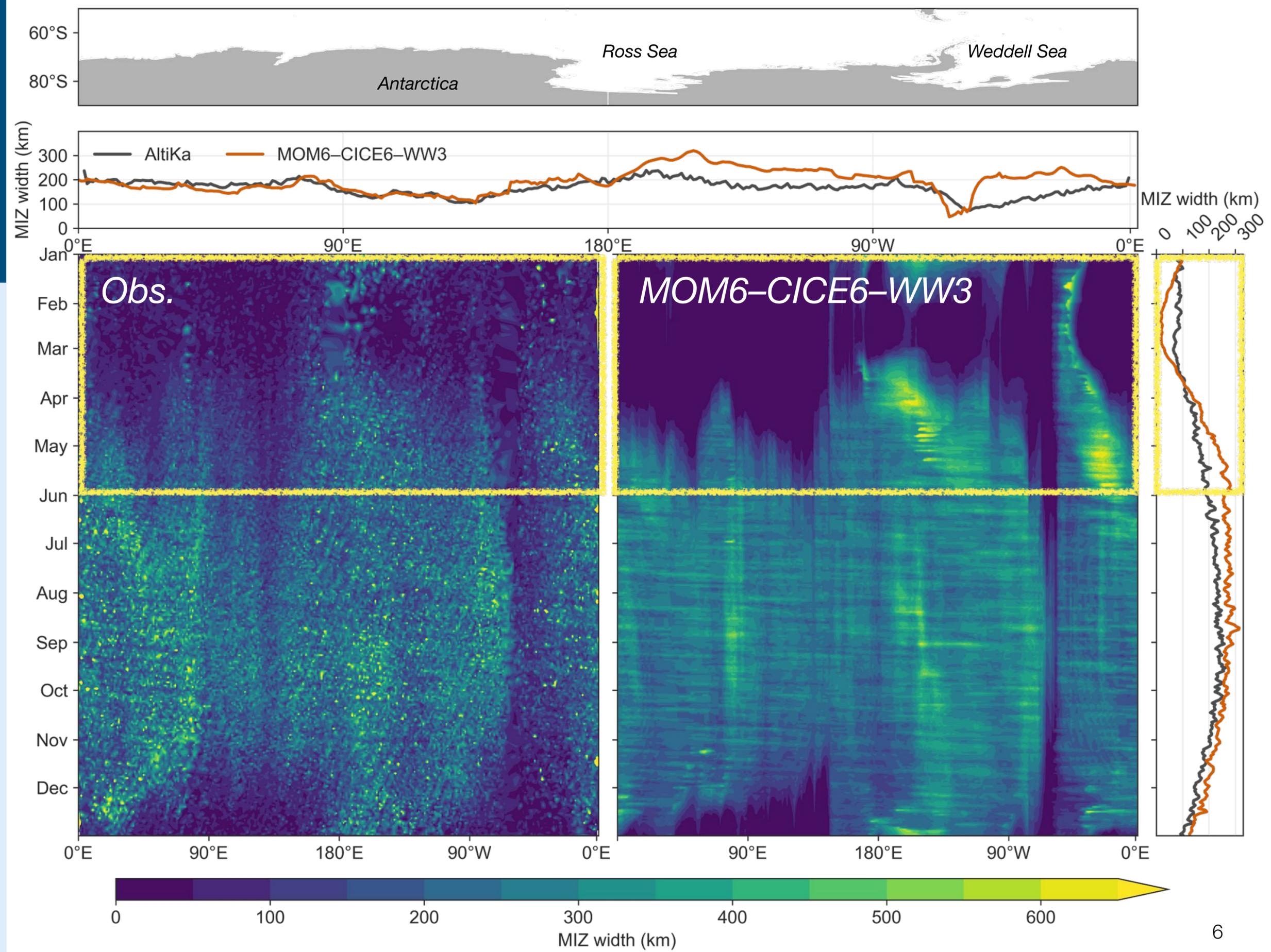
- Winter → Summer ✓



Preliminary Results: Climatology (2013–2023)

Agreement:

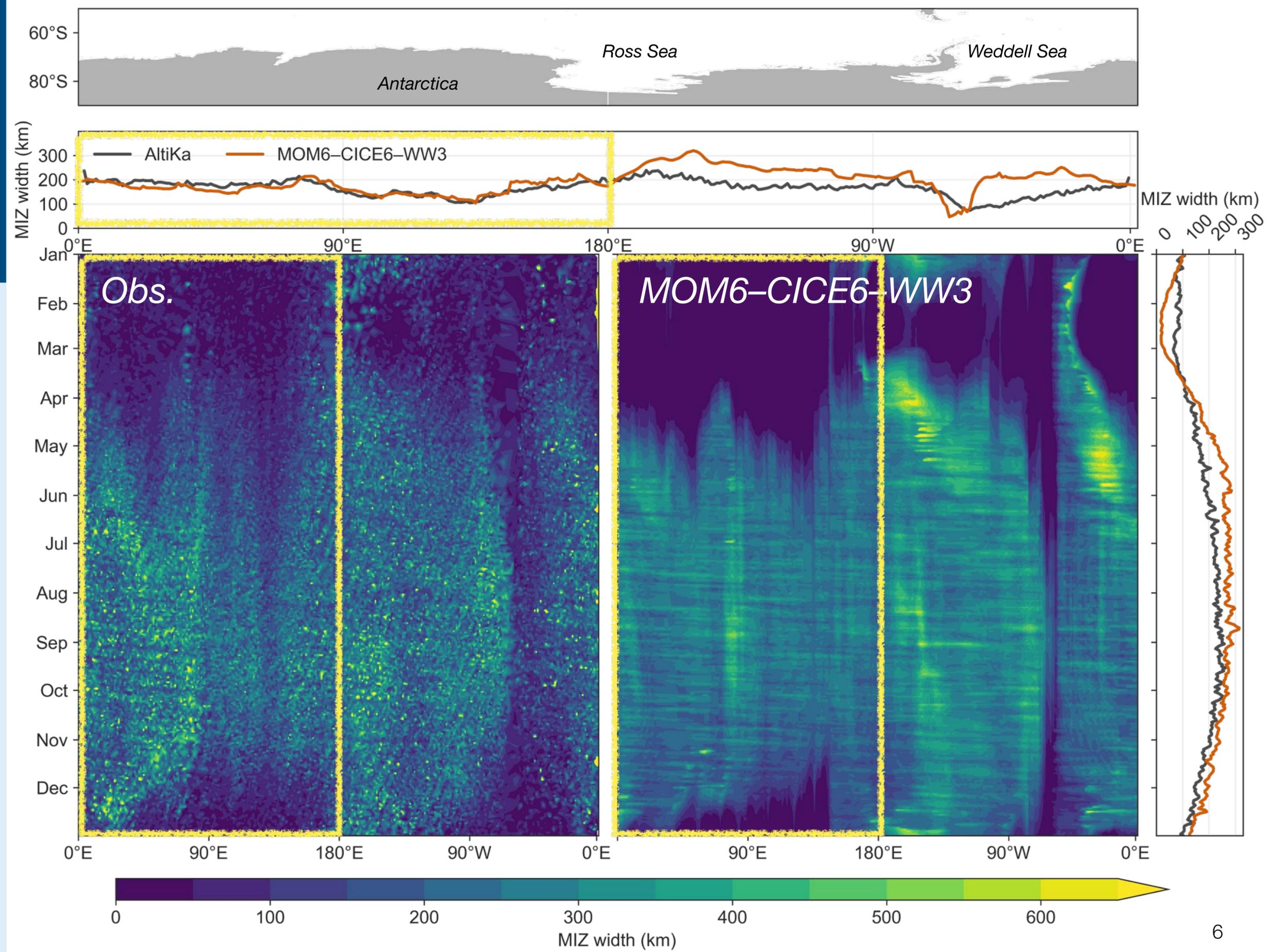
- Winter → Summer ✓
- Summer → Winter ?



Preliminary Results: Climatology (2013–2023)

Agreement:

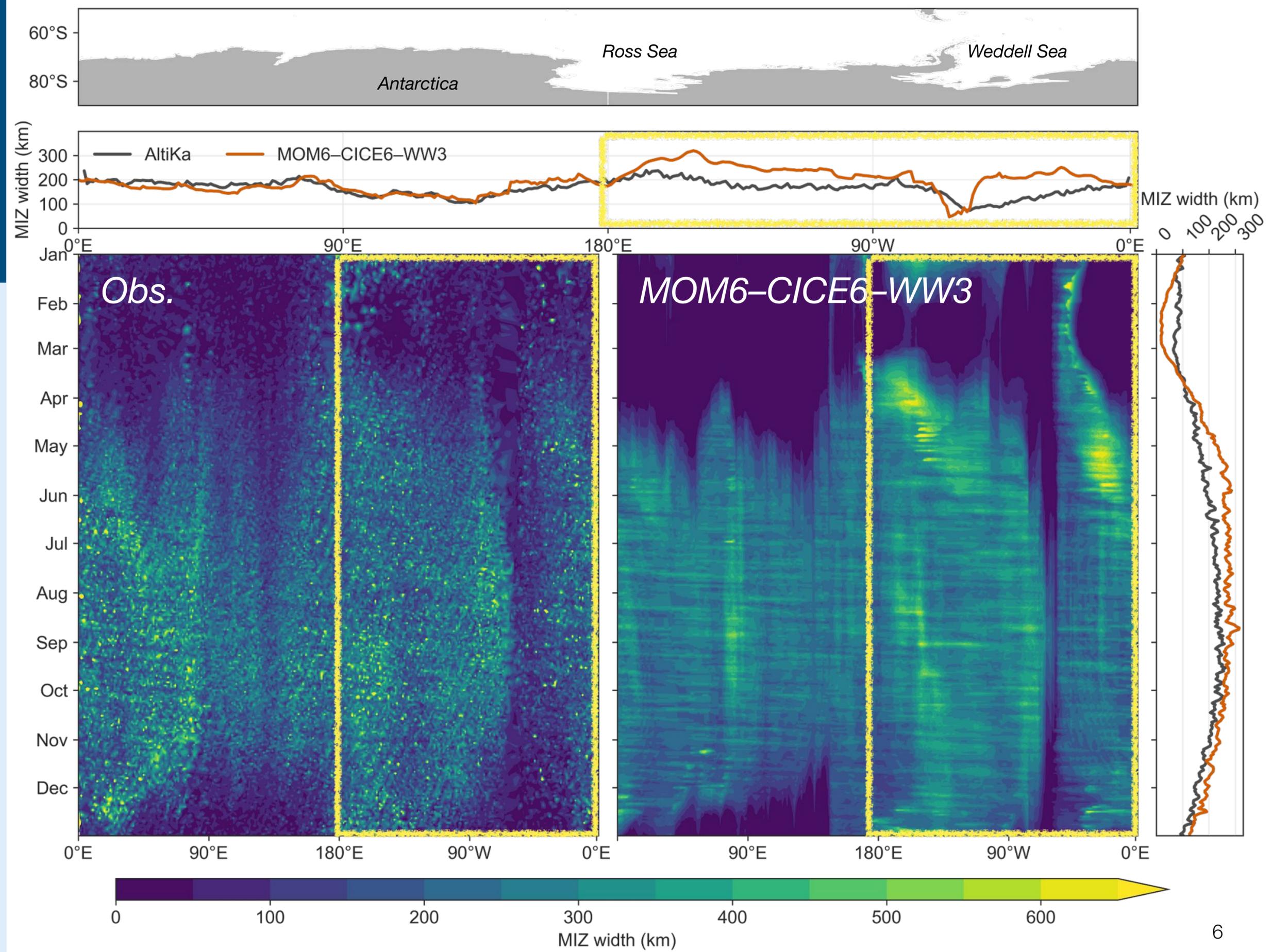
- Winter → Summer ✓
- Summer → Winter ?
- East Antarctica ✓



Preliminary Results: Climatology (2013–2023)

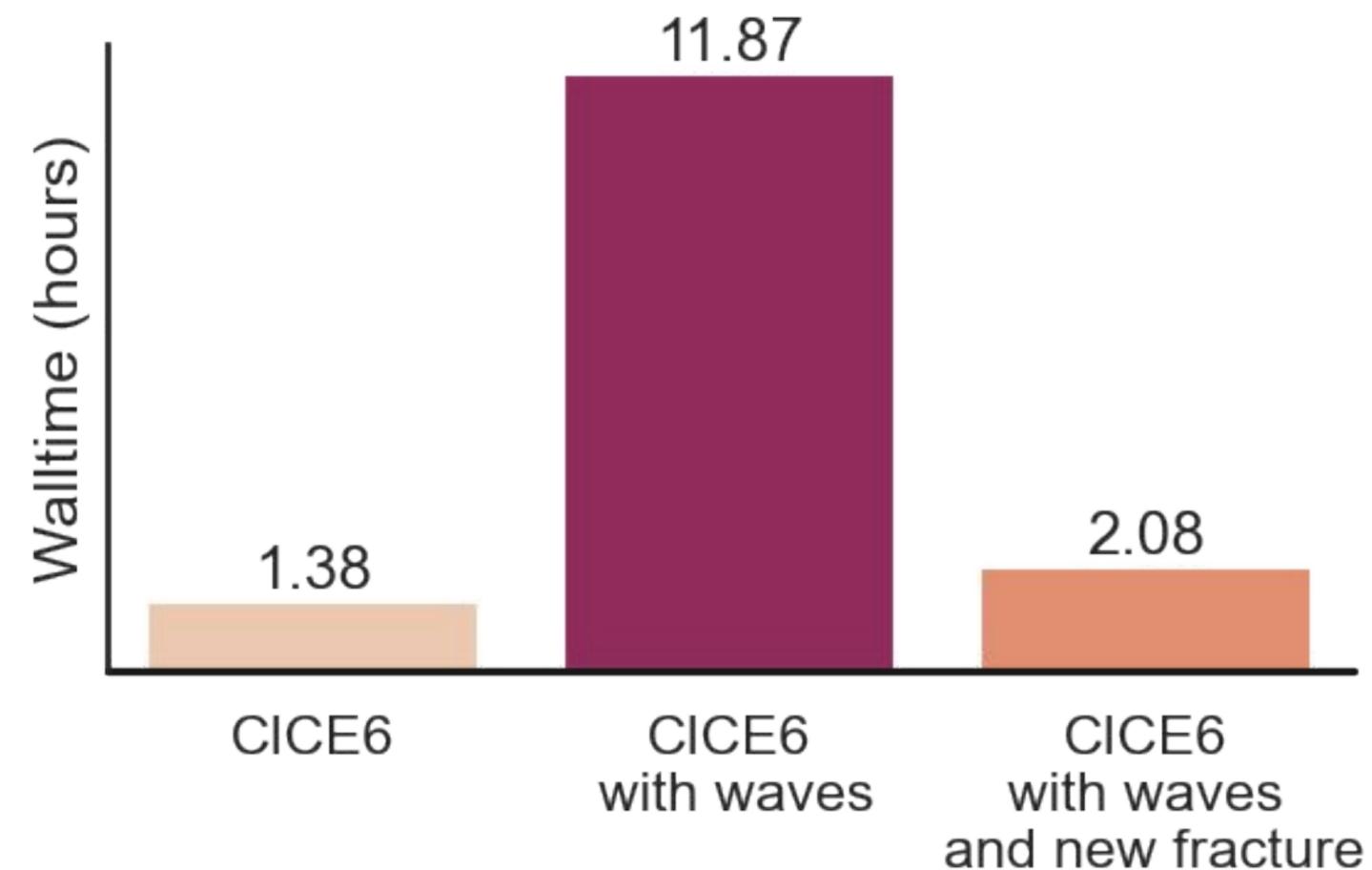
Agreement:

- Winter → Summer ✓
- Summer → Winter ?
- East Antarctica ✓
- West Antarctica ?



Technical challenges and future work

1 model year on 24 CPUs



- The wave-induced breakup algorithm in CICE is quite expensive
- Using known distributions for the fracture histogram show a considerable speed-up, trading some physical detail for efficiency
- WW3 is also very expensive making 0.25° configurations challenging



Thank you

noah.day@unimelb.edu.au

Immediate improvements in model outputs

- Standalone sea-ice models poorly reproduce Antarctic sea ice extent, and therefore misrepresent the ice-edge location
- MOM6–CICE6–WW3 is currently being calibrated, including tests of wave impacts on sea-ice extent

