Wind– and sea-ice–driven interannual variability of Antarctic Dense Shelf Water formation

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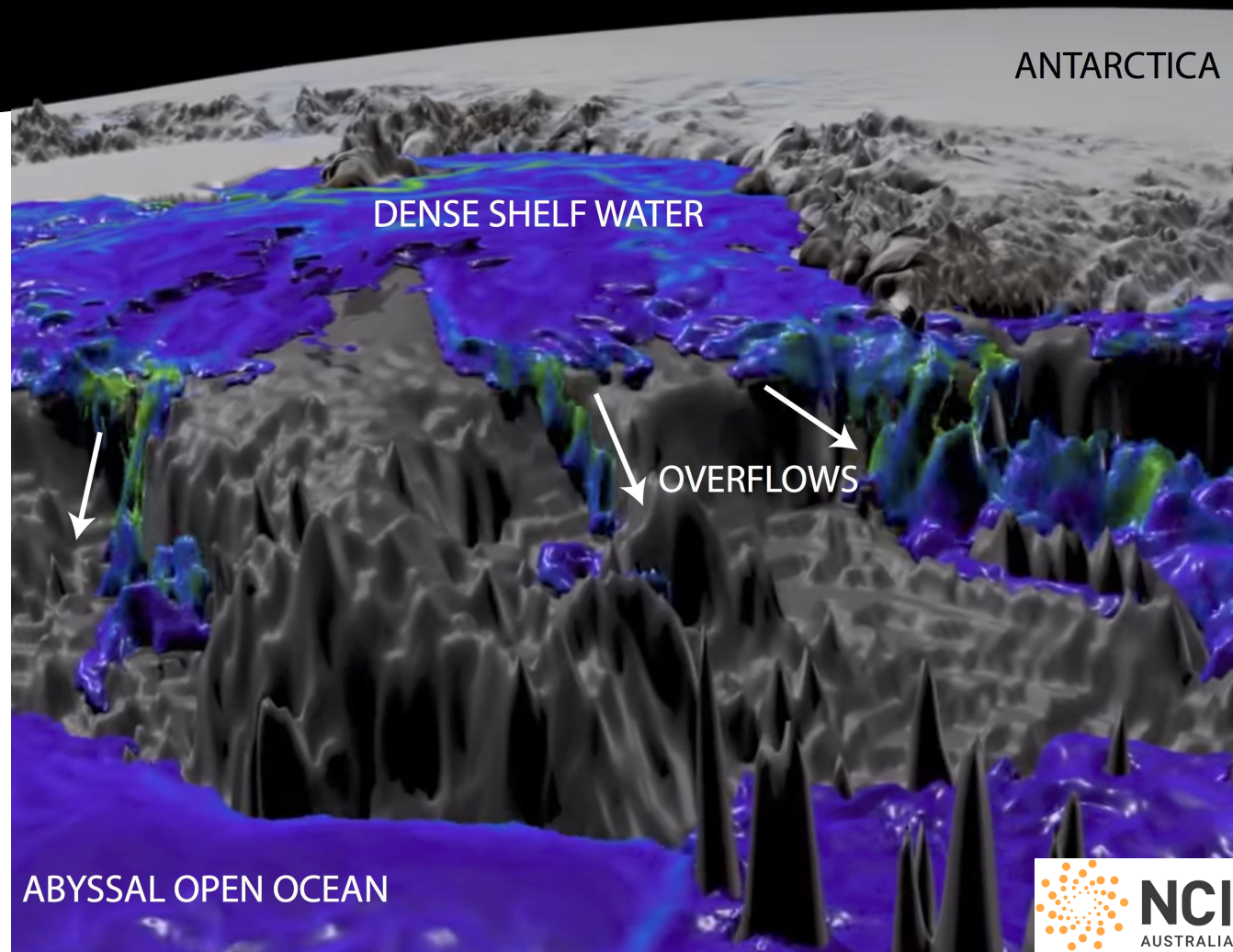
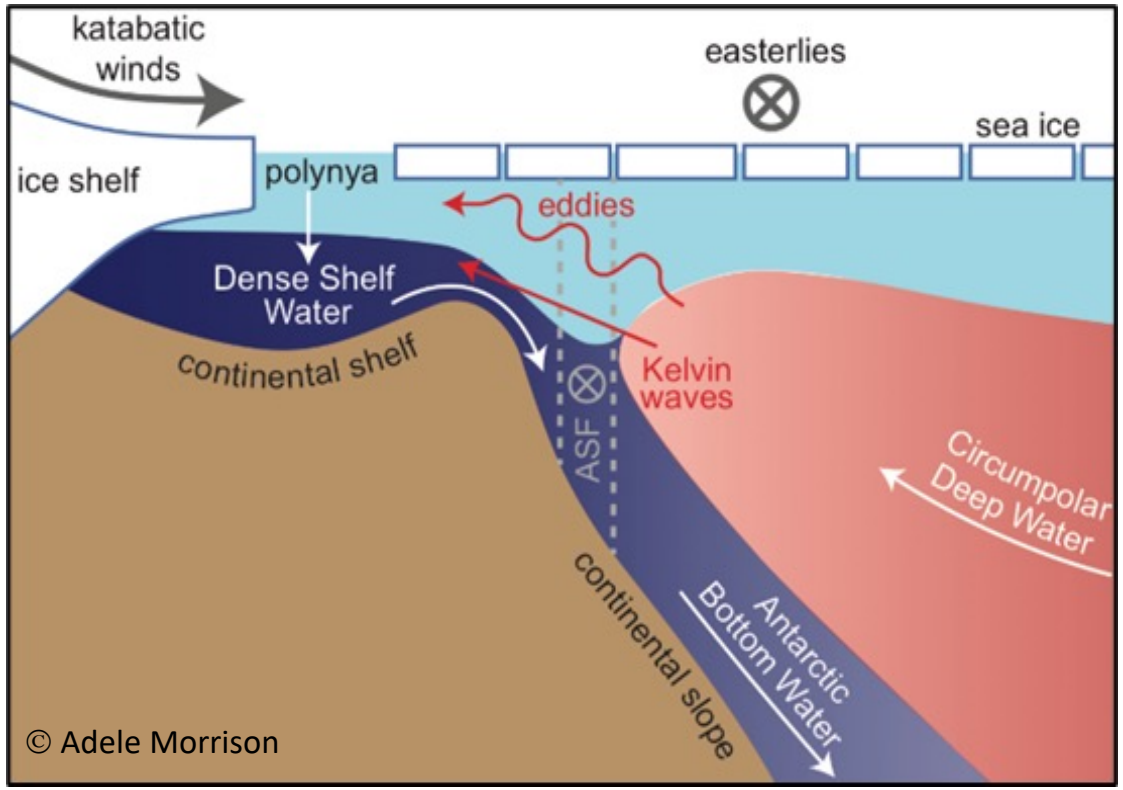


NCI AUSTRALIA

The formation of Antarctic Bottom Water

- Antarctic Bottom Water (AABW) is a major component of the ocean's meridional overturning circulation.
- AABW is formed in coastal polynyas in four regions around Antarctica.
  → offshore transport of 8.1±2.6 Sv (Orsi et al., 1999, 2002)
- Most global ocean and climate models are not simulating this correctly.



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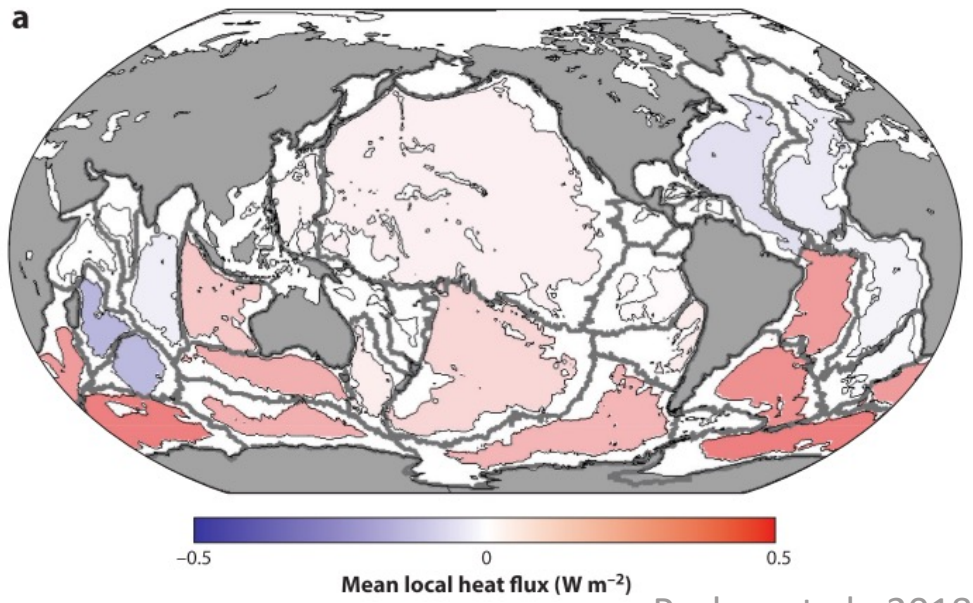
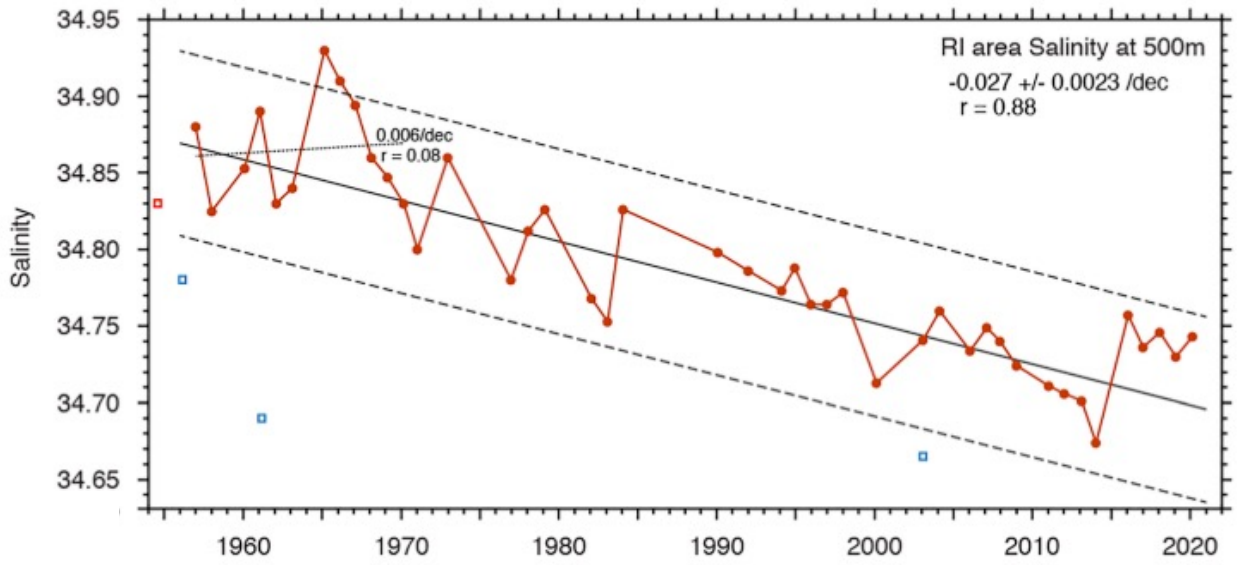
Trends and variability of AABW



Purkey et al., 2018



summer (DJF) salinity at 500 m near Ross Island (Jacobs et al., 2022)

- AABW has warmed, freshened and its volume has declined in recent decades.
- large interannual variability in Antarctic dense shelf water properties

  → processes remain poorly understood

How did the formation and export of AABW vary in the last decades?

What are the drivers of this variability?

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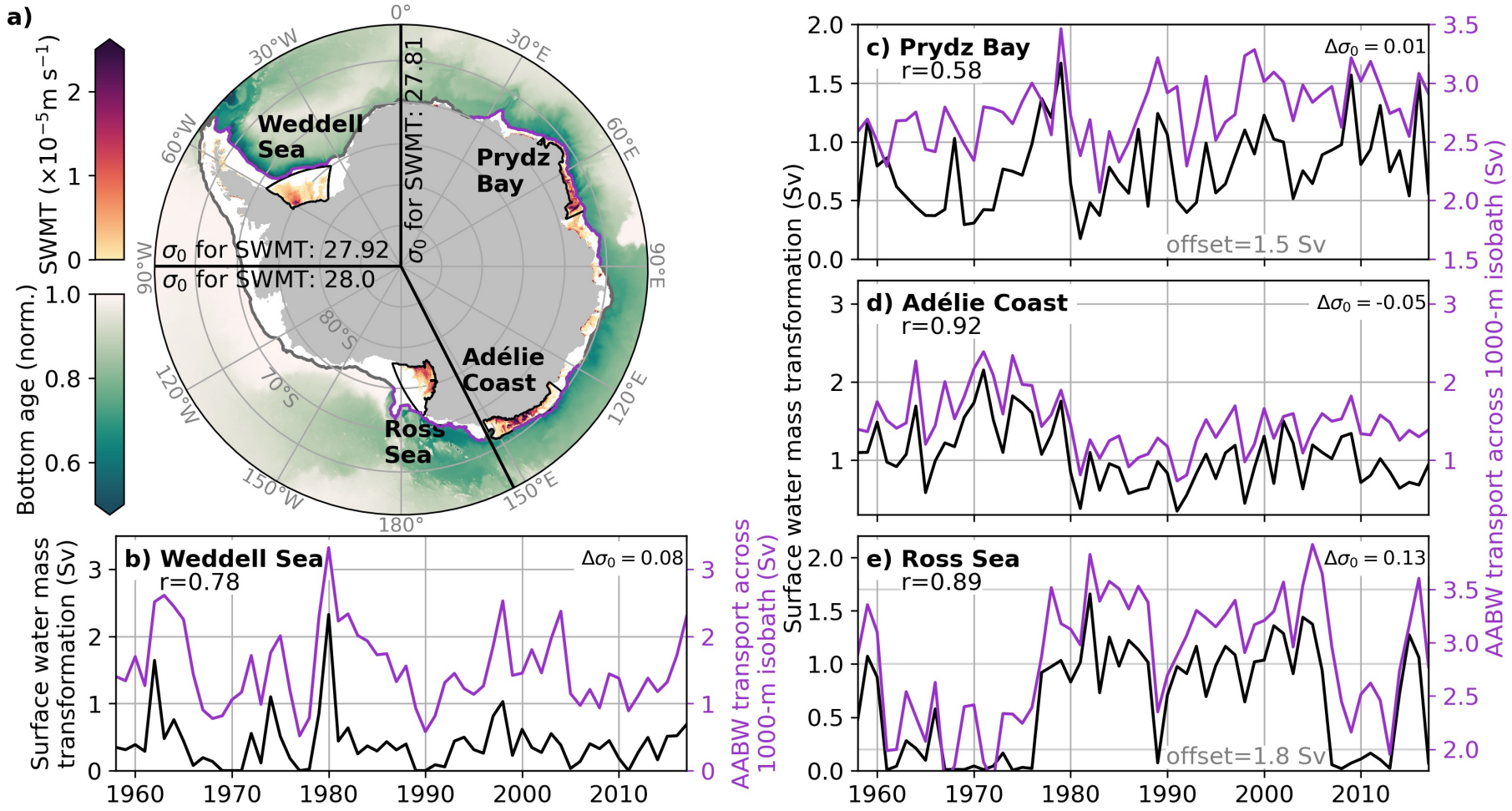
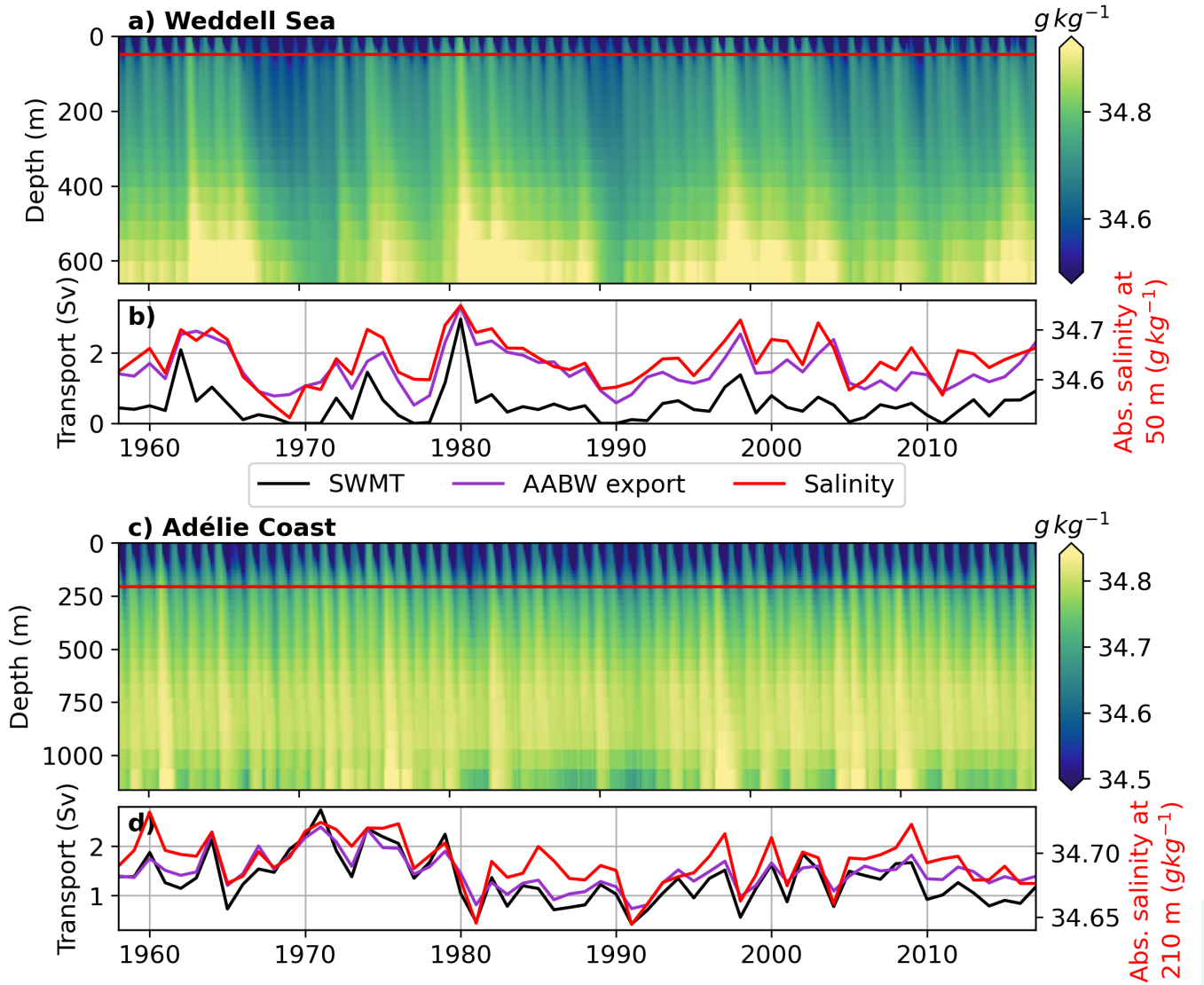
Variability of AABW formation and export

- strong inter-annual variability, not correlated between most formation regions
- mean AABW export of 8.6±0.9 Sv



Variability of salinity in DSW formation region

- Weddell and Ross Sea: Reservoirs of very dense waters at depth after strong events of SWMT can lead to higher AABW export for up to a decade.
- Adélie Coast and Prydz Bay: No reservoirs of very dense waters due to narrower shelf extent



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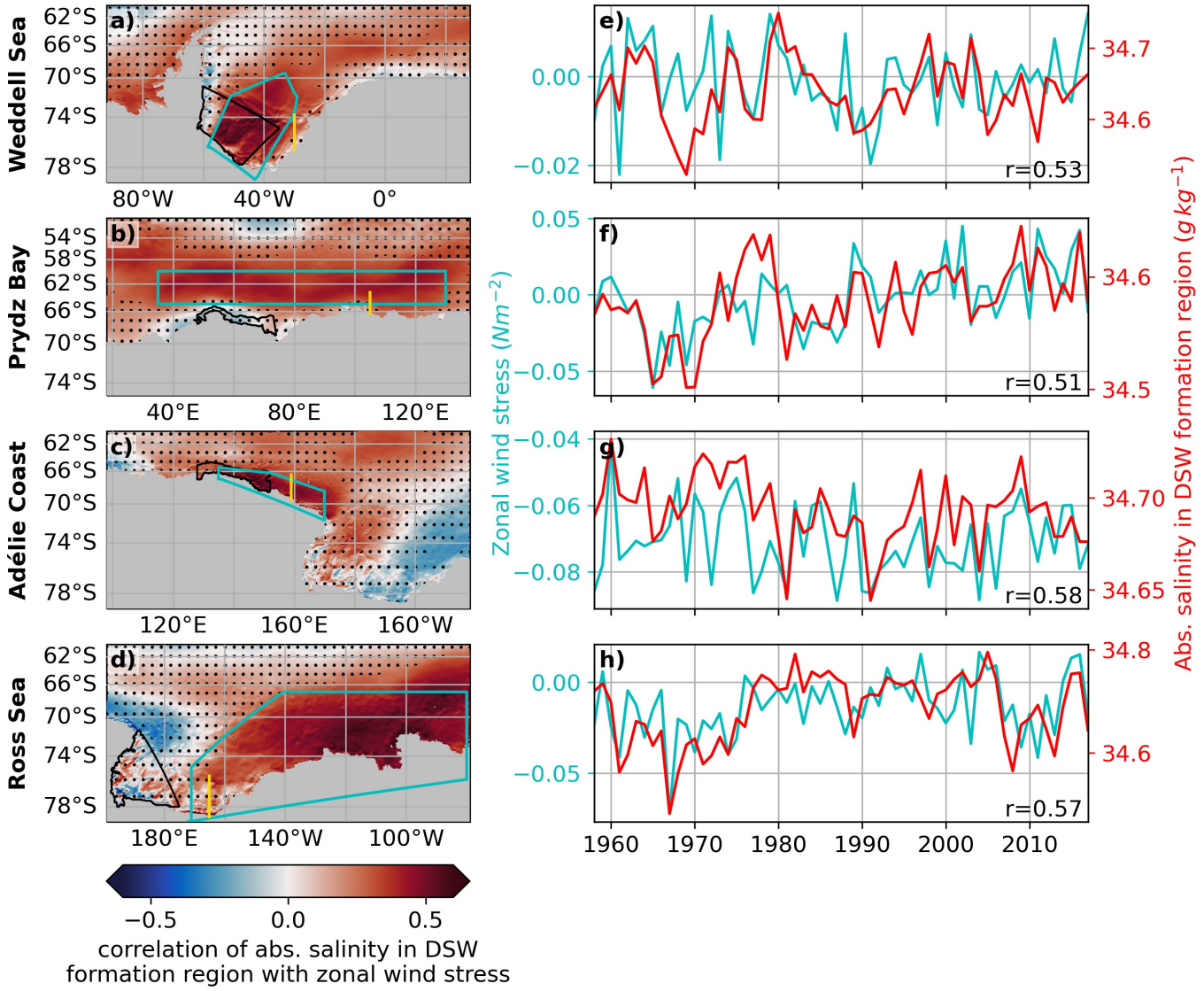
Drivers of the variability: zonal wind

- higher salinity of DSW due to weaker easterlies upstream of DSW formation region



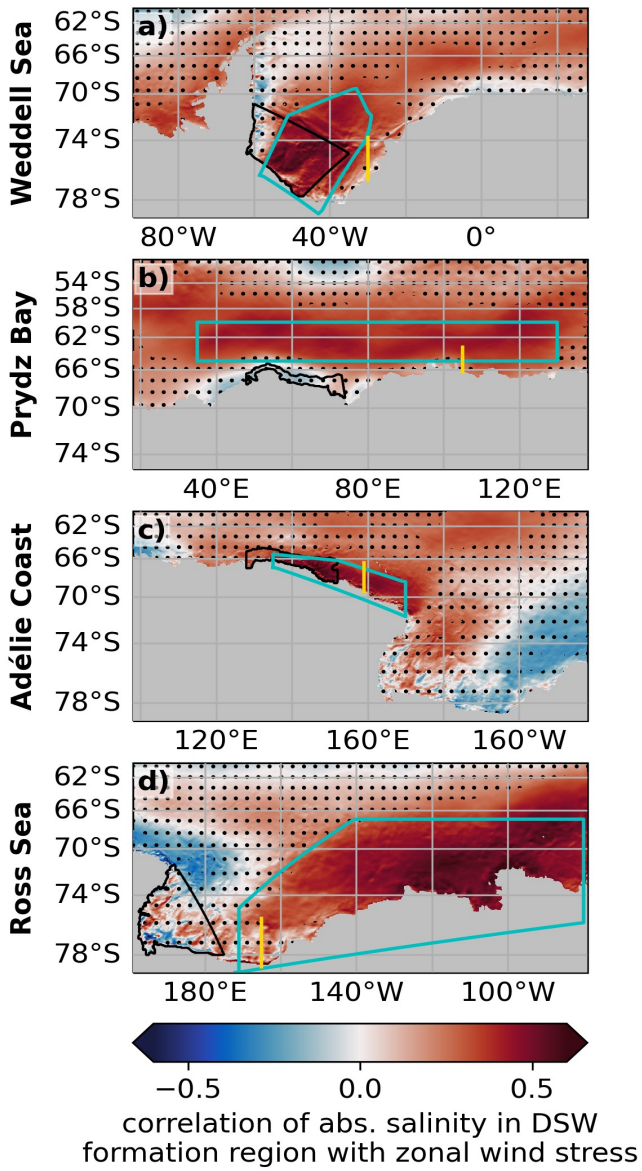
Drivers of the variability: sea ice

– weaker easterlies upstream of DSW formation region

→ reduced sea ice transport into DSW formation region

→ increased area of open water and hence likelihood of polynyas

→ increased AABW formation and export



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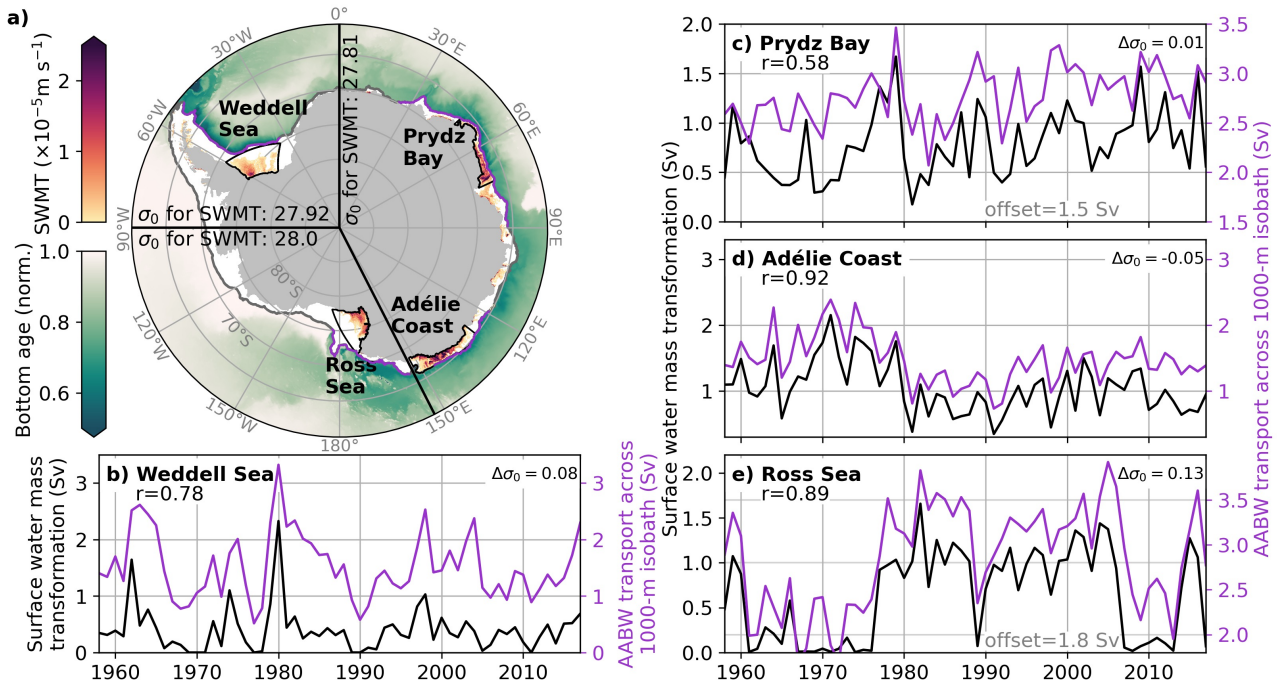
Key points

How did the formation and export of AABW vary in the last decades?

- strong interannual variability
- reservoirs of very dense waters can feed AABW export for up to a decade

What are the drivers of this variability?

- zonal winds
- sea ice formation and import



Outlook: new PanAntarctic-005 configuration

- MOM6 + SIS2
- regional model south of 37°S
- horizontal resolution of 1/20°
- surface forcing: JRA55v13 RYF

→ My scientific question: How is the formation and export of AABW affected by the resolution of bathymetry?

→ expressions of interest: christina.schmidt@unsw.edu.au

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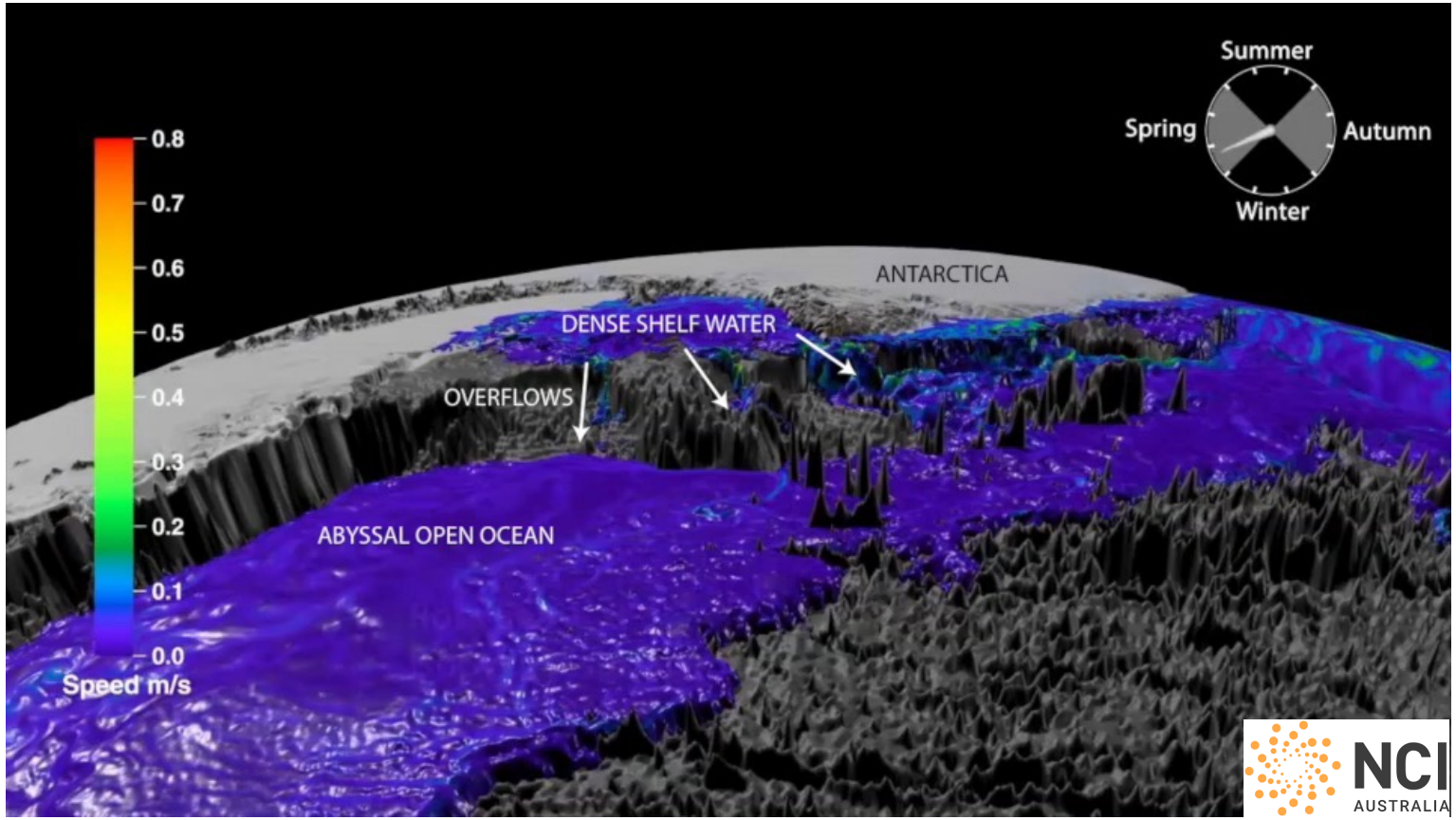
Appendix

Ocean–sea-ice model ACCESS-OM2-01



- Global ocean–sea-ice model ACCESS-OM2-01 (Kiss et al., 2020) with a horizontal resolution of 1/10°
- 75 z* vertical levels with a layer thickness of 1-200 m
- JRA55-do v1.4 atmospheric forcing for 1958-2018
- No ice shelf cavities, tides, and increasing melt water input

→ Processes and regions of AABW formation are accurately simulated (Moorman et al., 2020, Morrison et al., 2020).

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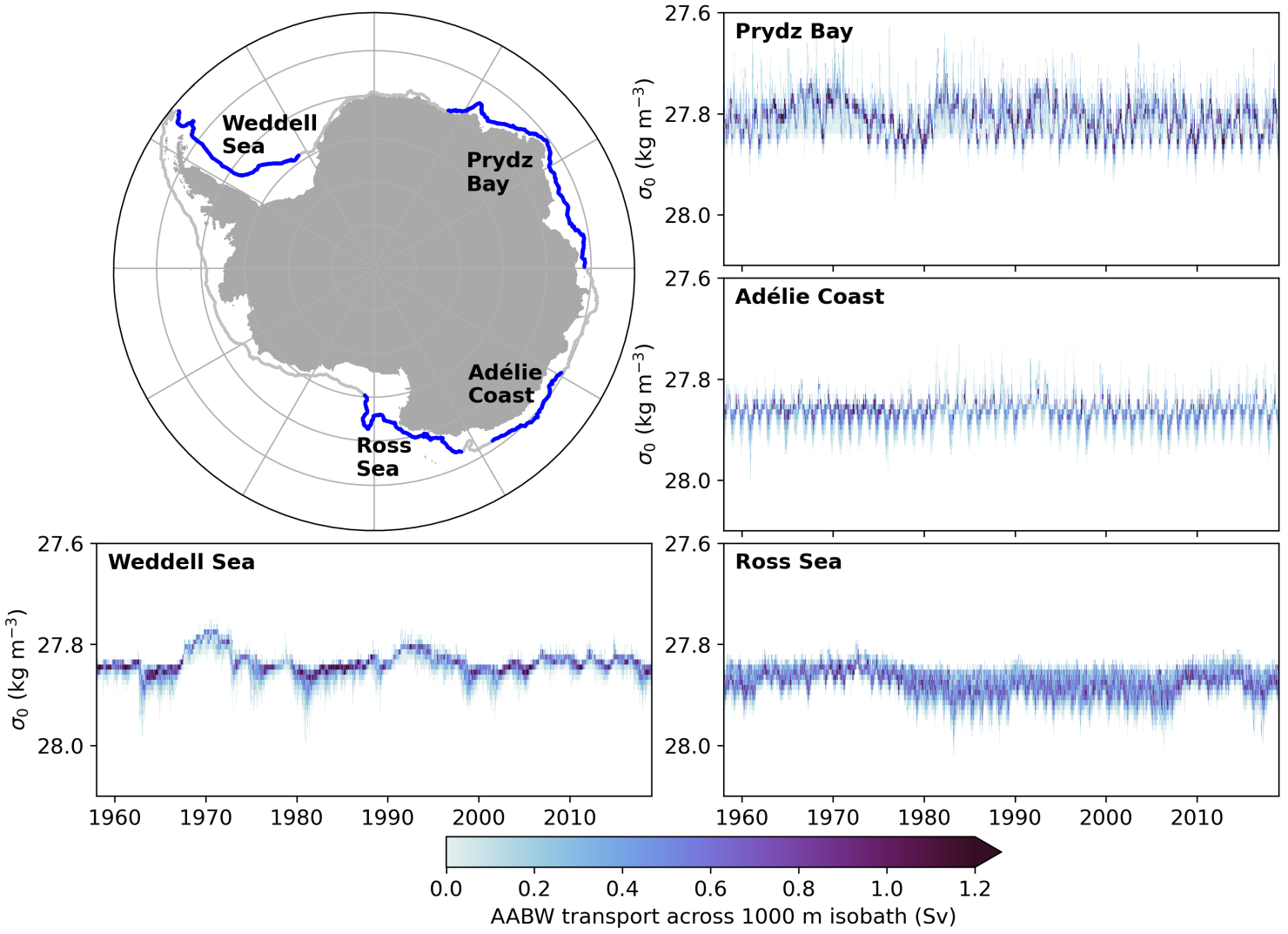
AABW export across the 1000-m isobath

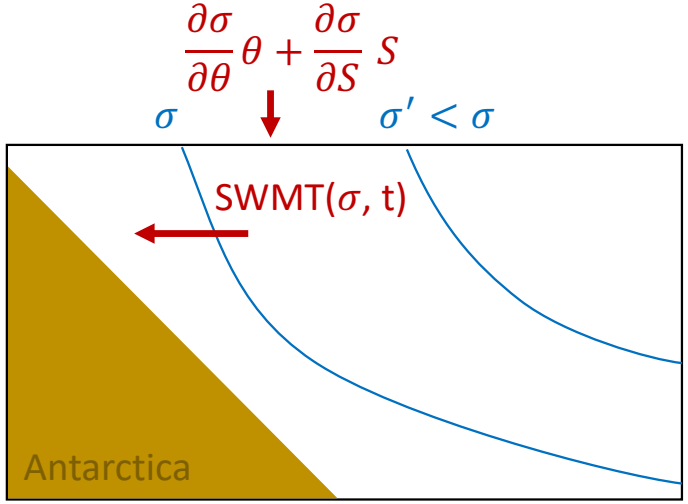
AABW export is the offshore transport across the 1000-m isobath in regions of AABW formation.



Surface water mass transformation (SWMT)

Volume flux into a density class (σ) from lighter density classes ($\sigma' < \sigma$) due to surface buoyancy forcing (Abernathey et al., 2016; Newsom et al. 2016)

$$\mathrm{SWMT}(\sigma, t) = \frac{\partial}{\partial \sigma} \iint\limits_{\sigma' < \sigma} \left(\frac{\partial \sigma}{\partial \theta} \theta + \frac{\partial \sigma}{\partial S} S \right) dx\, dy$$



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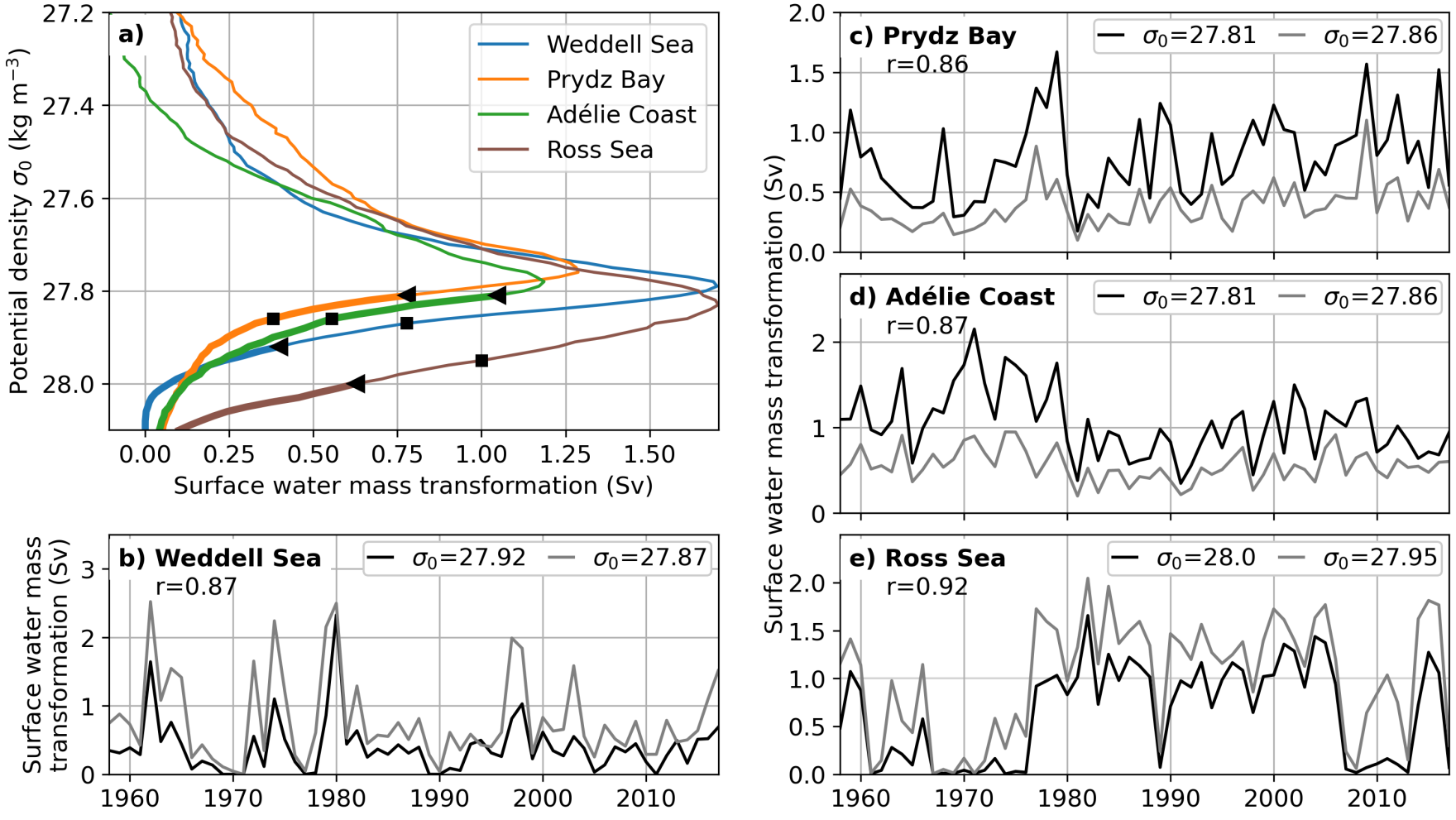
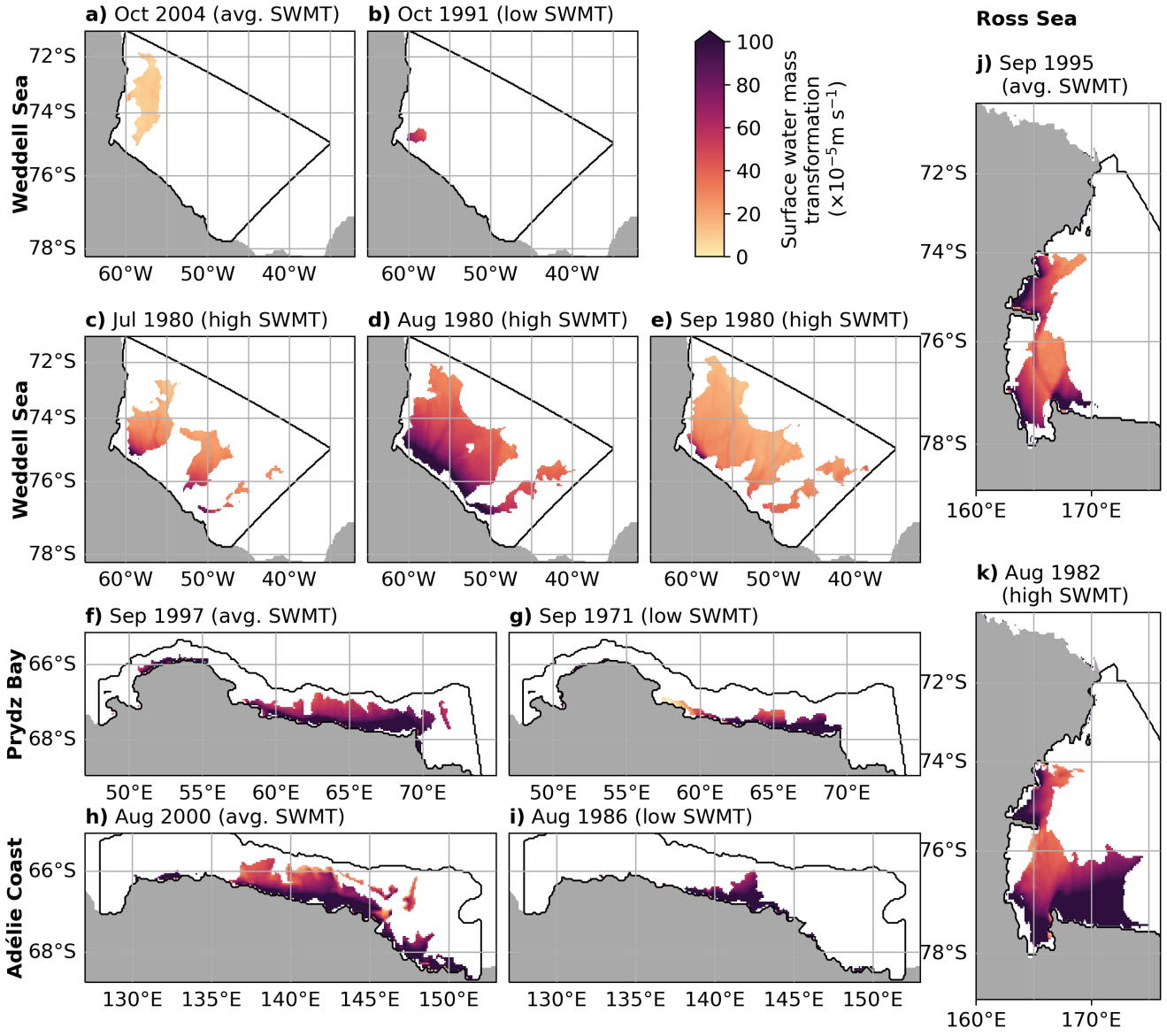


Variability of the SWMT area



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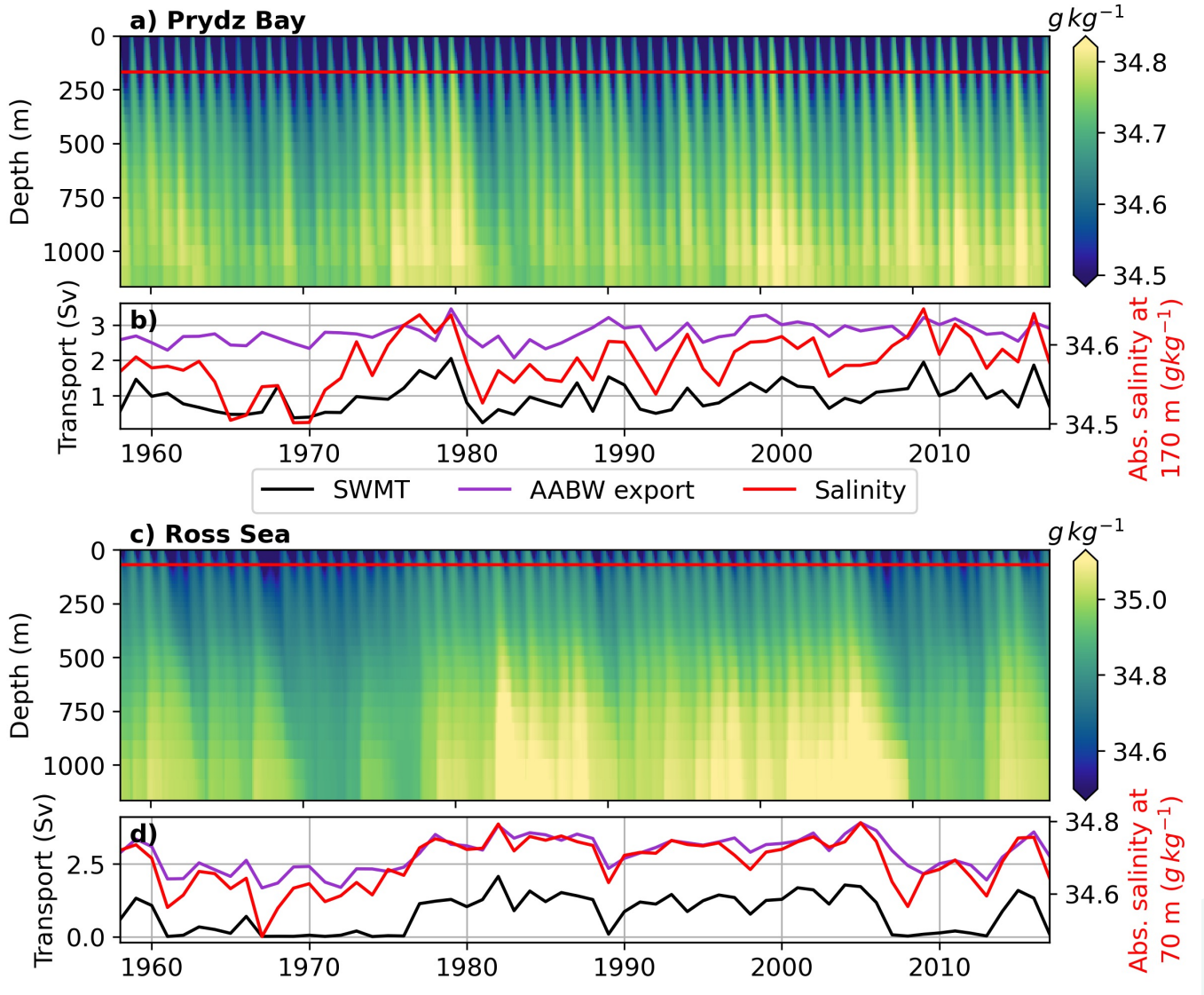

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→ increased salinity in DSW region

→ increased AABW formation and export

	Zonal wind stress	Salinity in DSW region	Ice transport
Ice transport			
Weddell Sea (Sep-Feb)	**-0.44**	**-0.47**	
Prydz Bay (May-Jun)	(-0.1)	-0.3	
Adélie Coast (Jul-Sep)	**-0.56**	**-0.41**	
Ross Sea (Feb-Apr)	**-0.51**	**-0.48**	
Area of open water			
Weddell Sea (May-Jun)	0.28	**0.60**	**-0.48**
Prydz Bay (Sep-Oct)	0.31	**0.56**	**-0.37**
Adélie Coast (May-Nov)	0.35	**0.50**	**-0.43**
Ross Sea (Apr-Jun)	0.43	**0.56**	**-0.40**

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