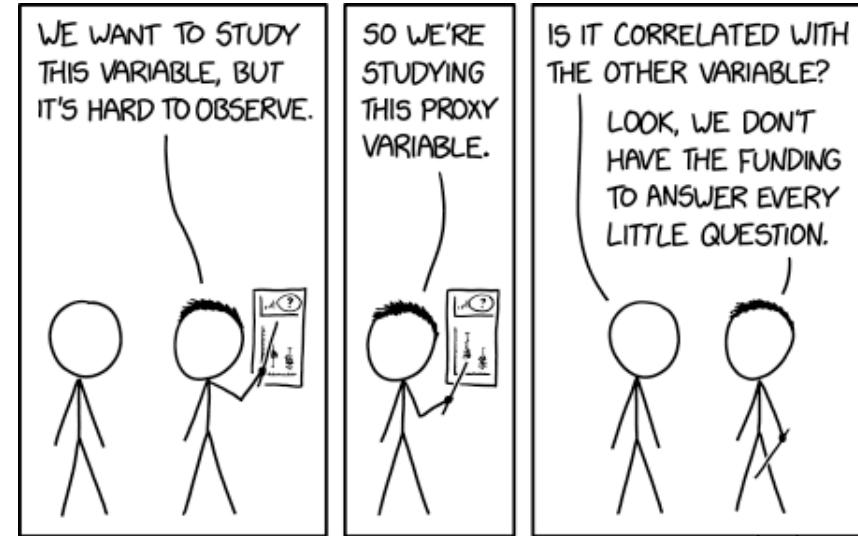




# Satellite observations of deep ocean currents



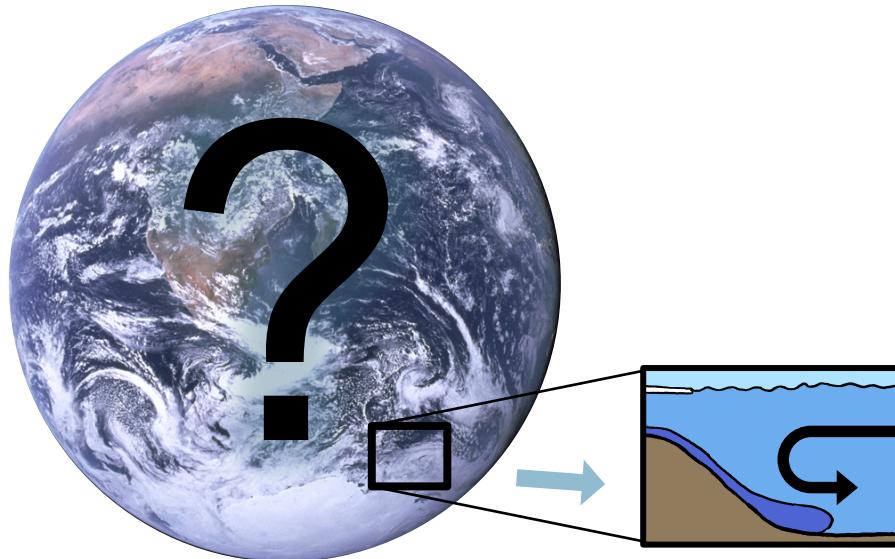
xkcd.com

Jemma Jeffree  
Andy Hogg  
Adele Morrison  
Aviv Solodoch  
Andrew Stewart

# Preview

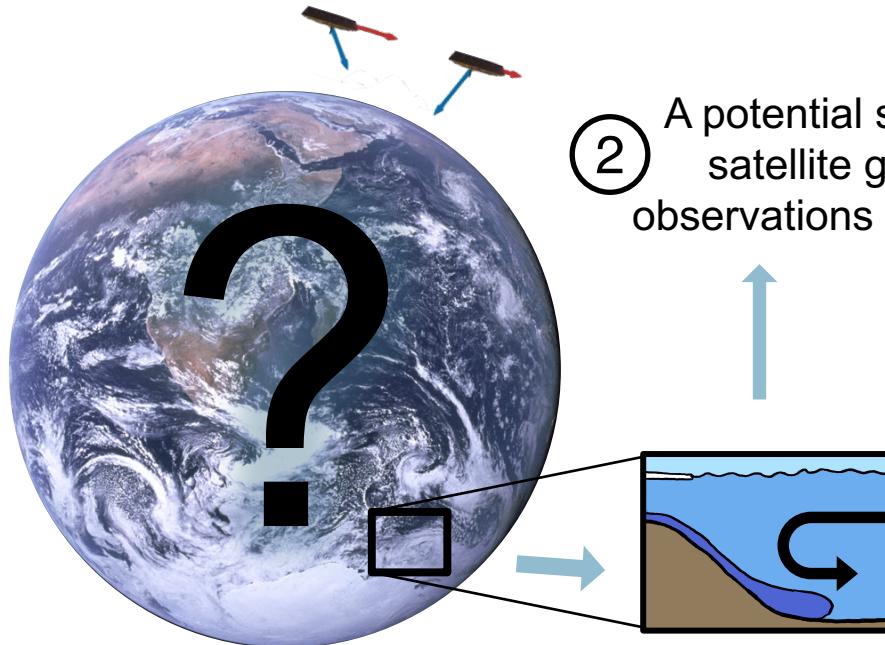


# Preview



① Unknown: Antarctic  
Bottom Water (AABW)

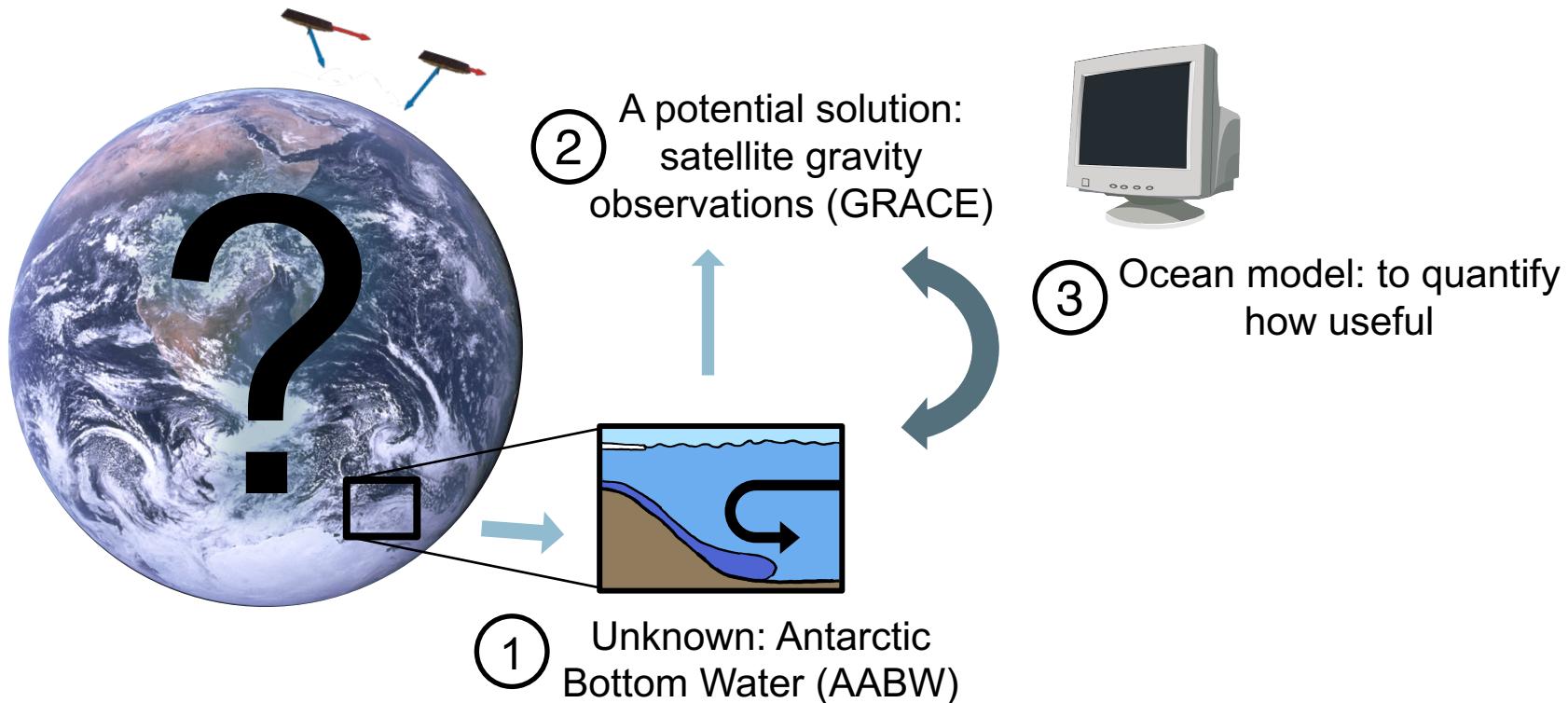
# Preview



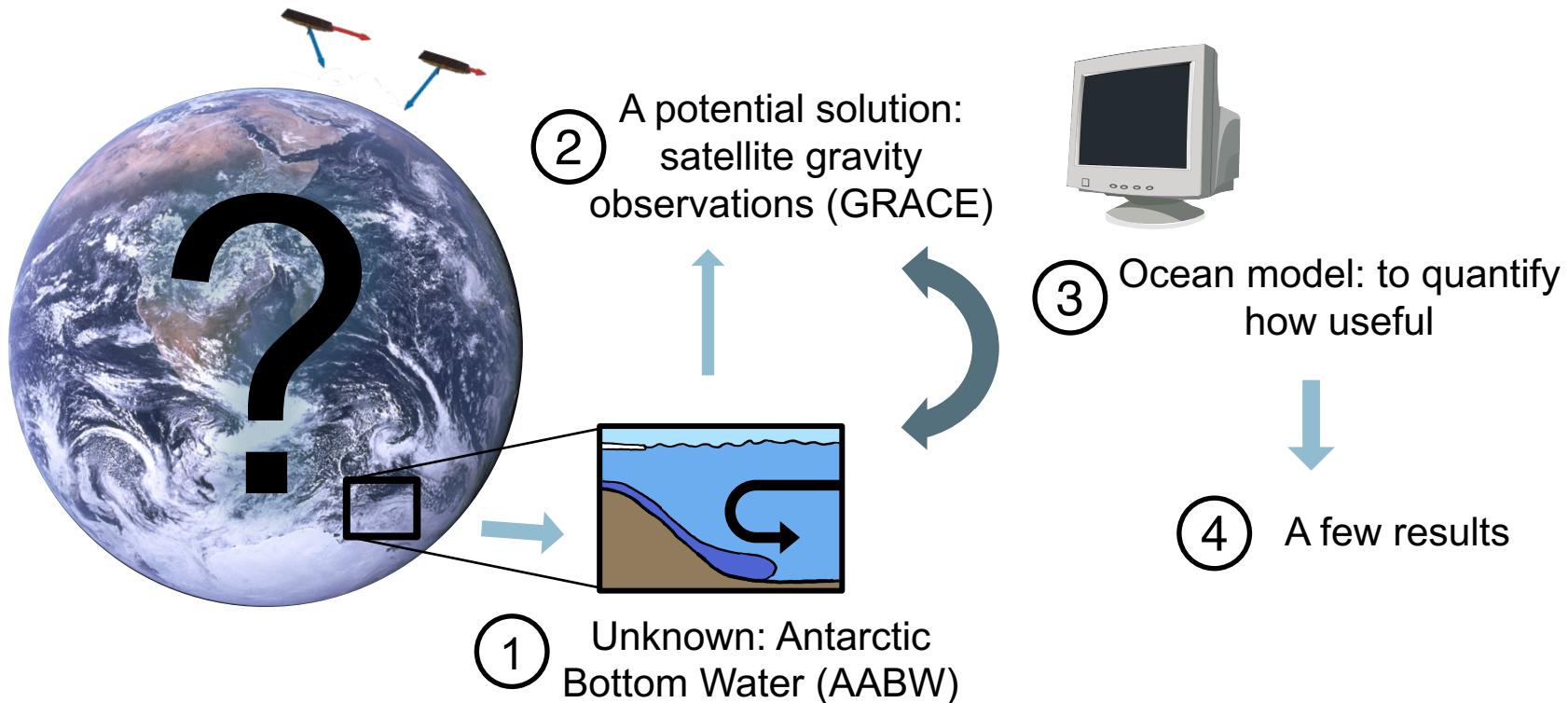
① Unknown: Antarctic  
Bottom Water (AABW)

② A potential solution:  
satellite gravity  
observations (GRACE)

# Preview

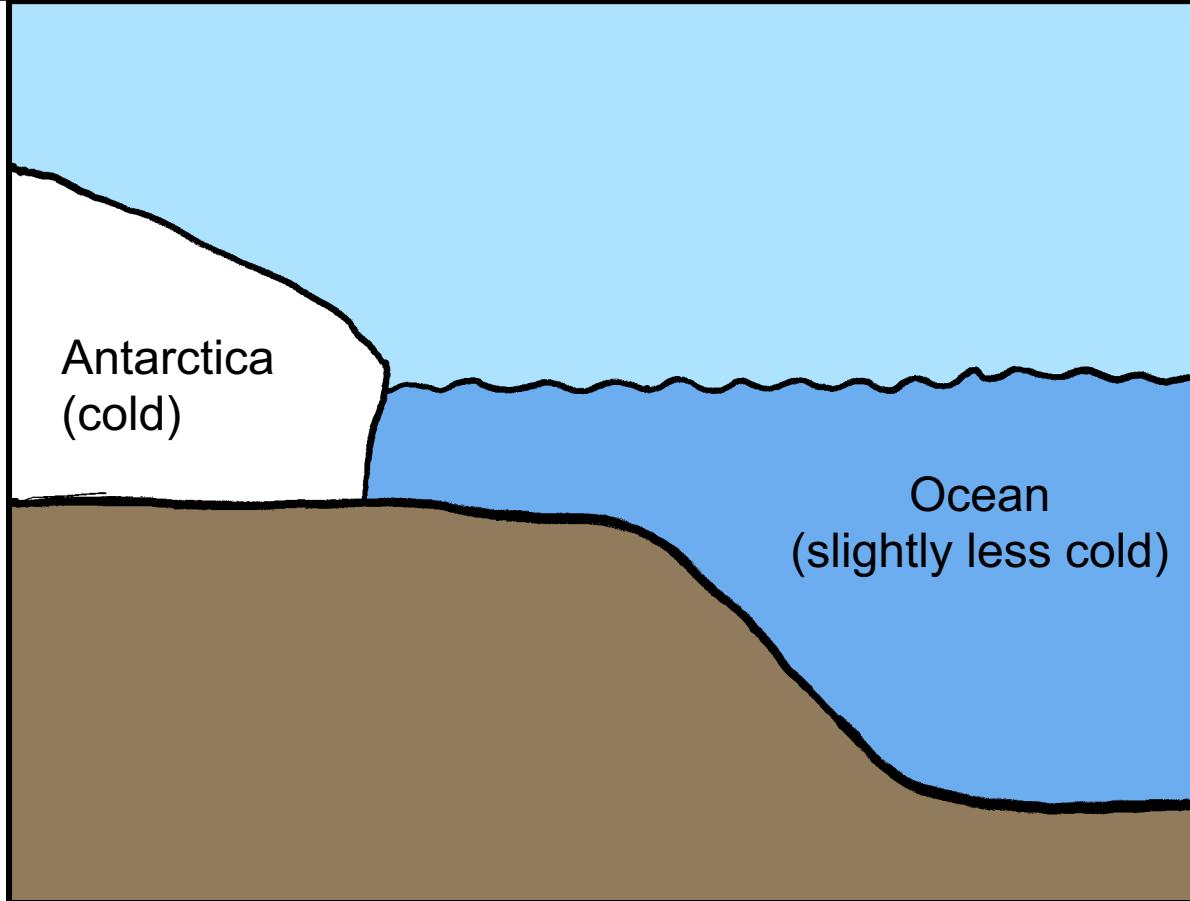


# Preview



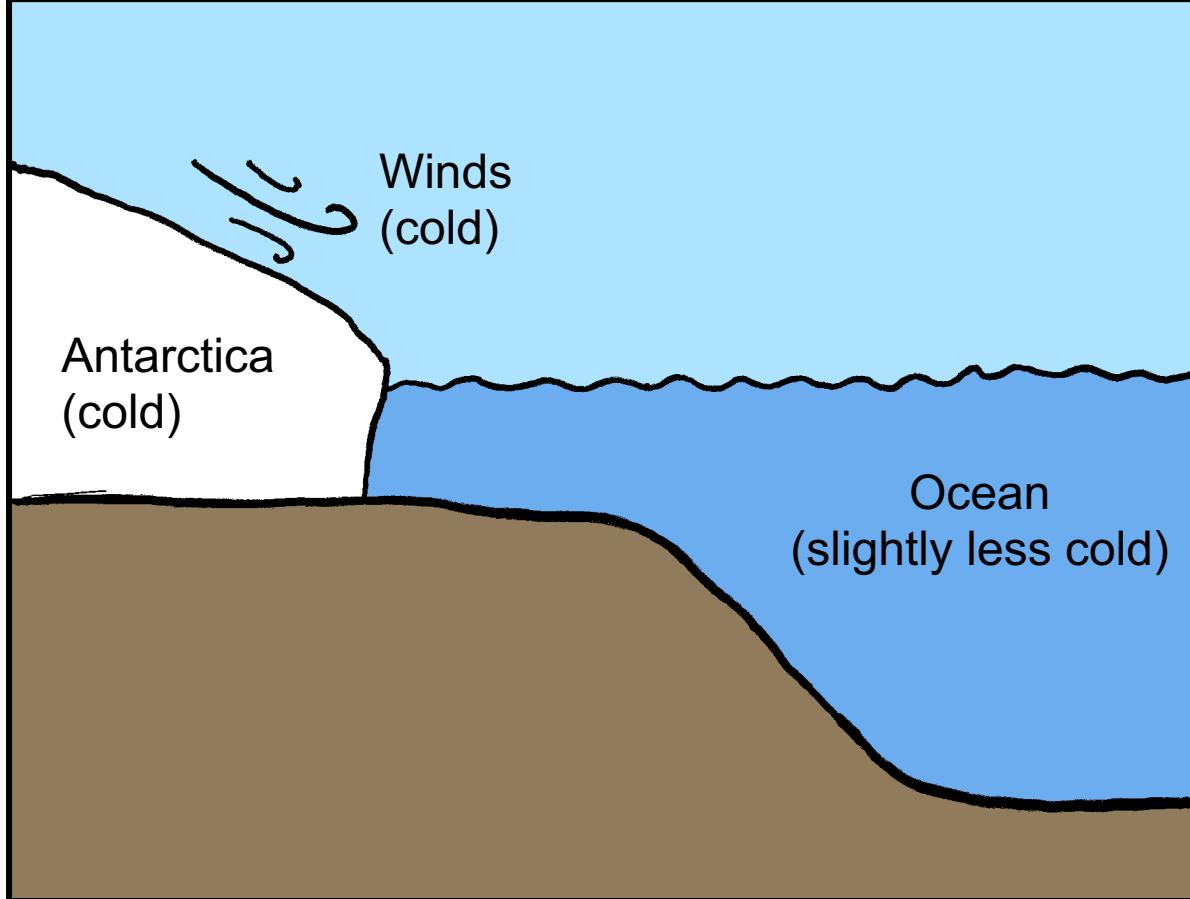
# AABW

(Antarctic  
Bottom  
Water)

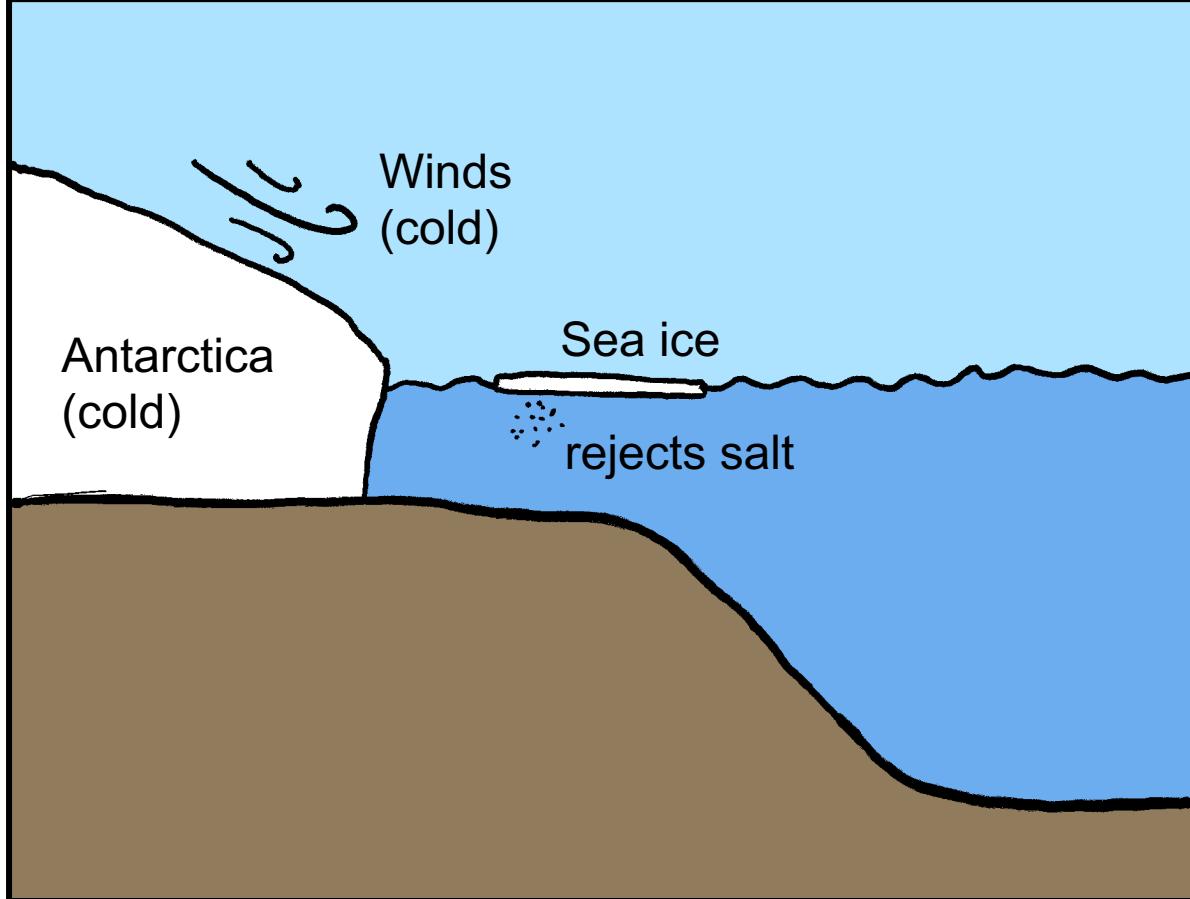


# AABW

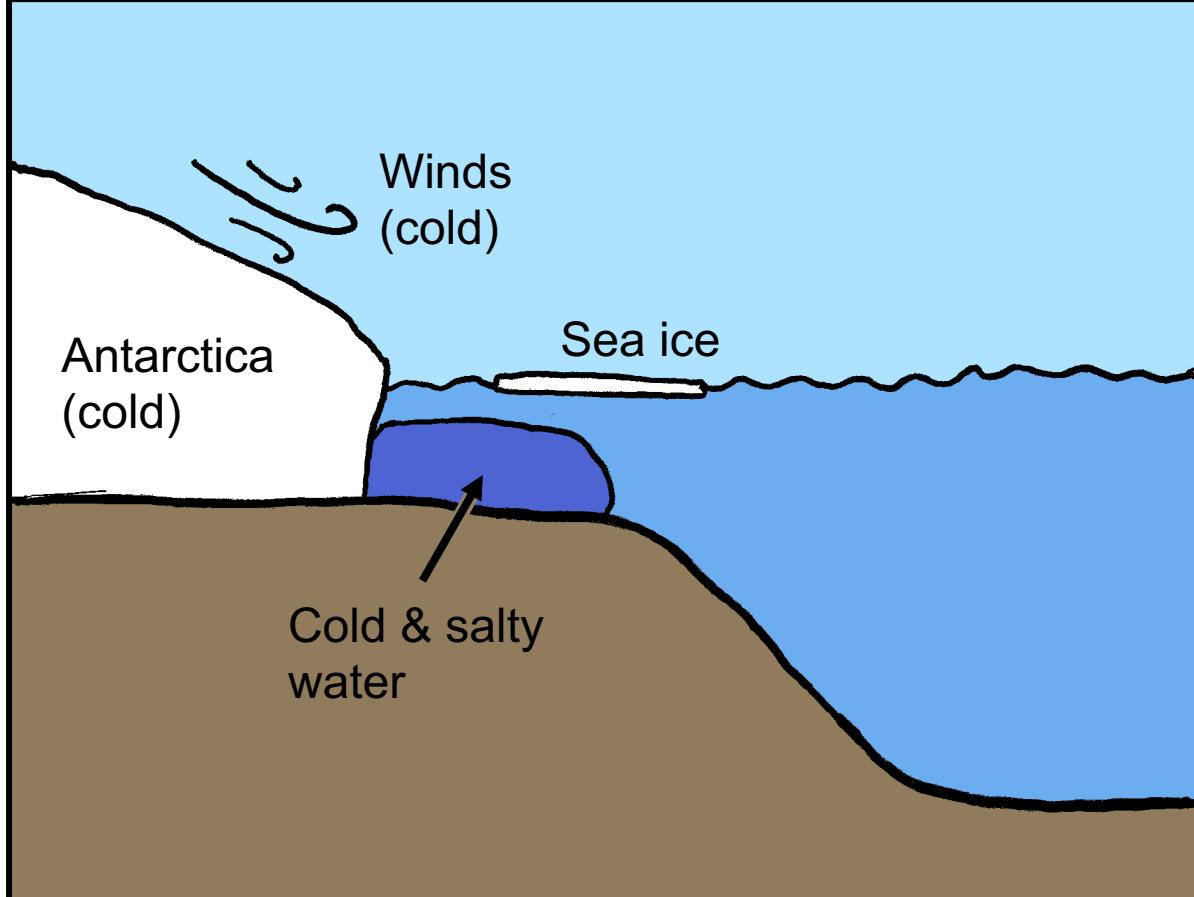
(Antarctic  
Bottom  
Water)



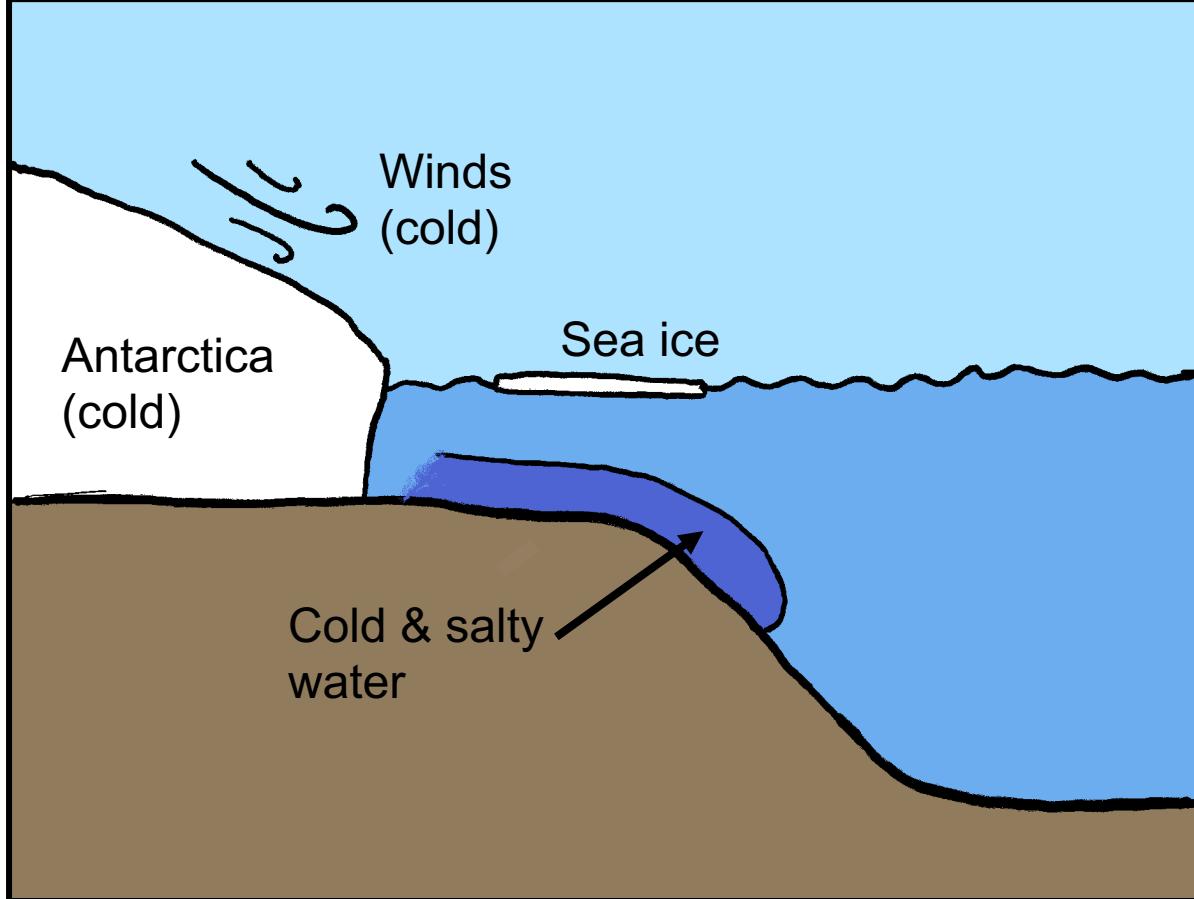
# AABW (Antarctic Bottom Water)



# AABW (Antarctic Bottom Water)

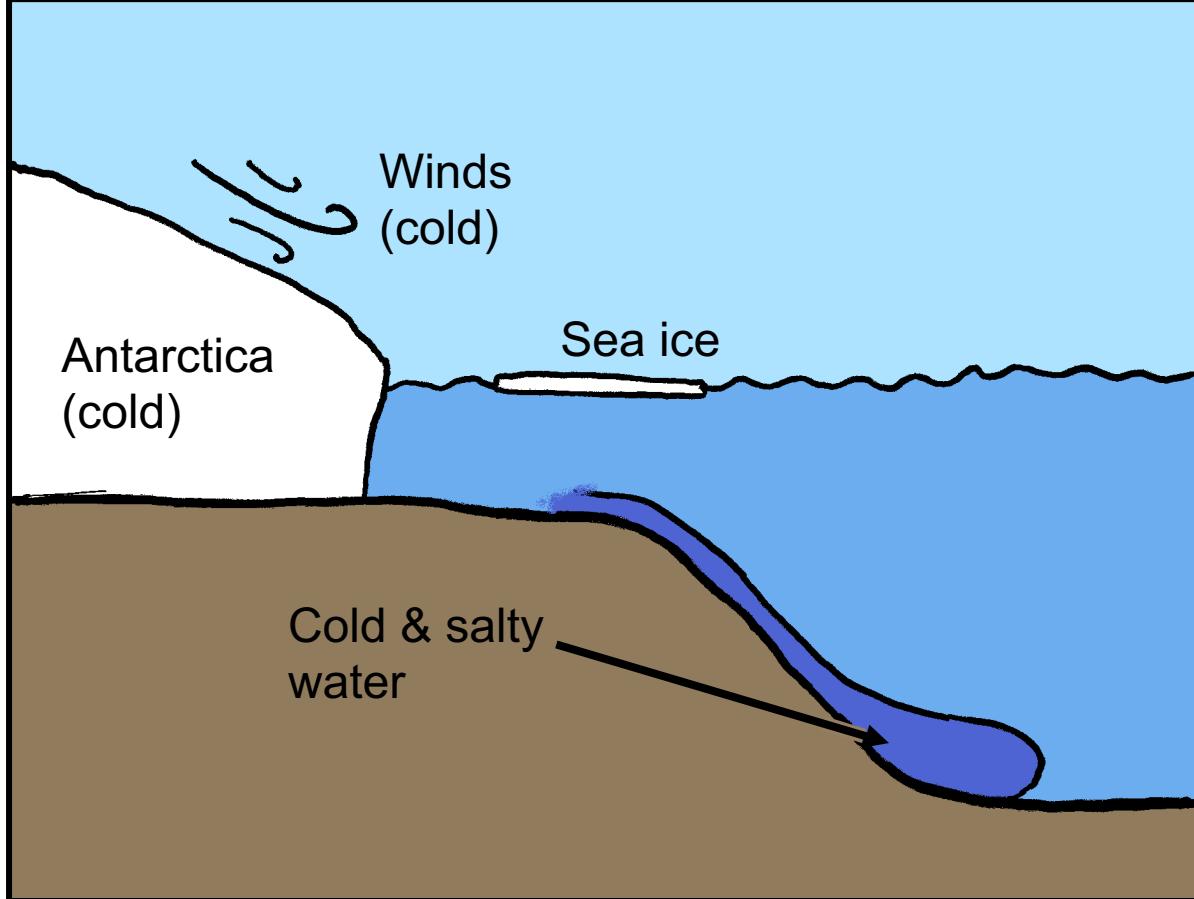


# AABW (Antarctic Bottom Water)



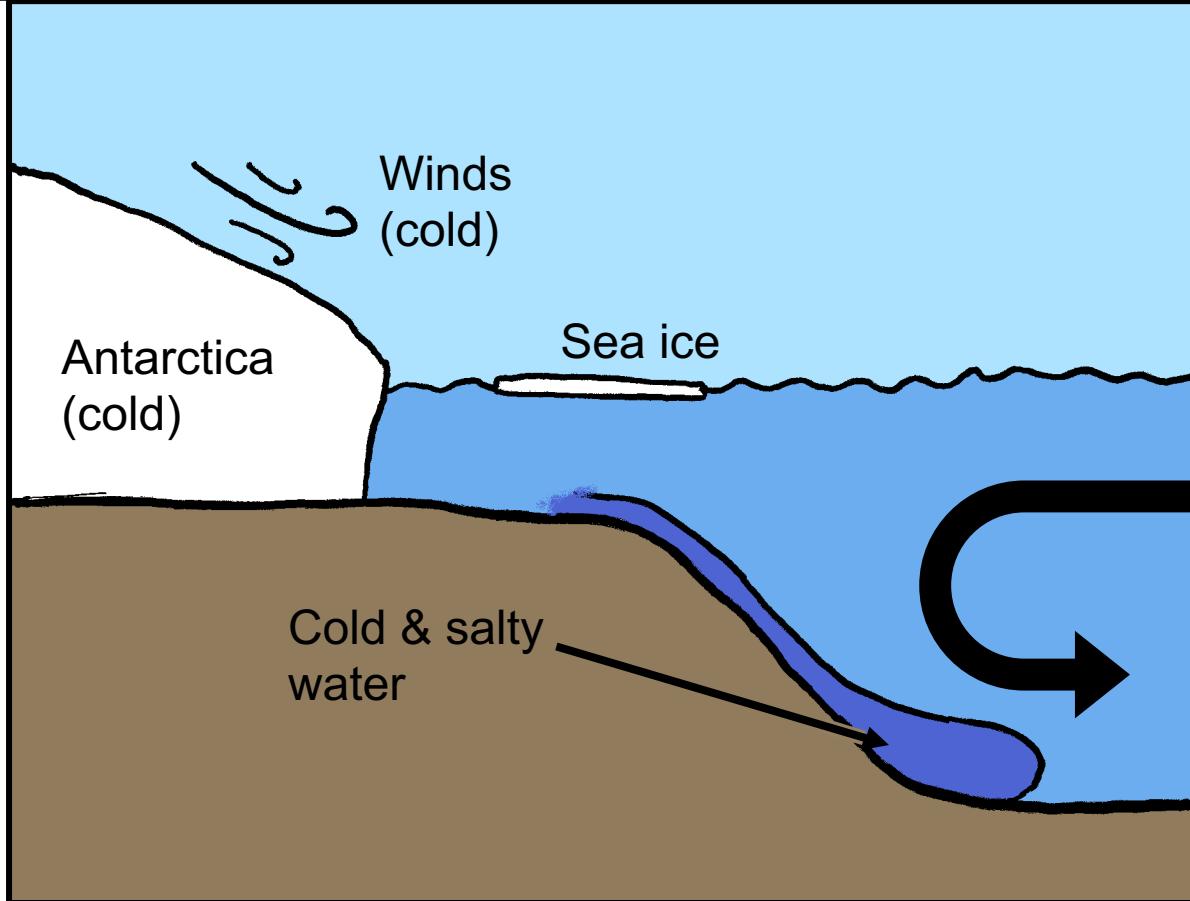
# AABW

(Antarctic  
Bottom  
Water)



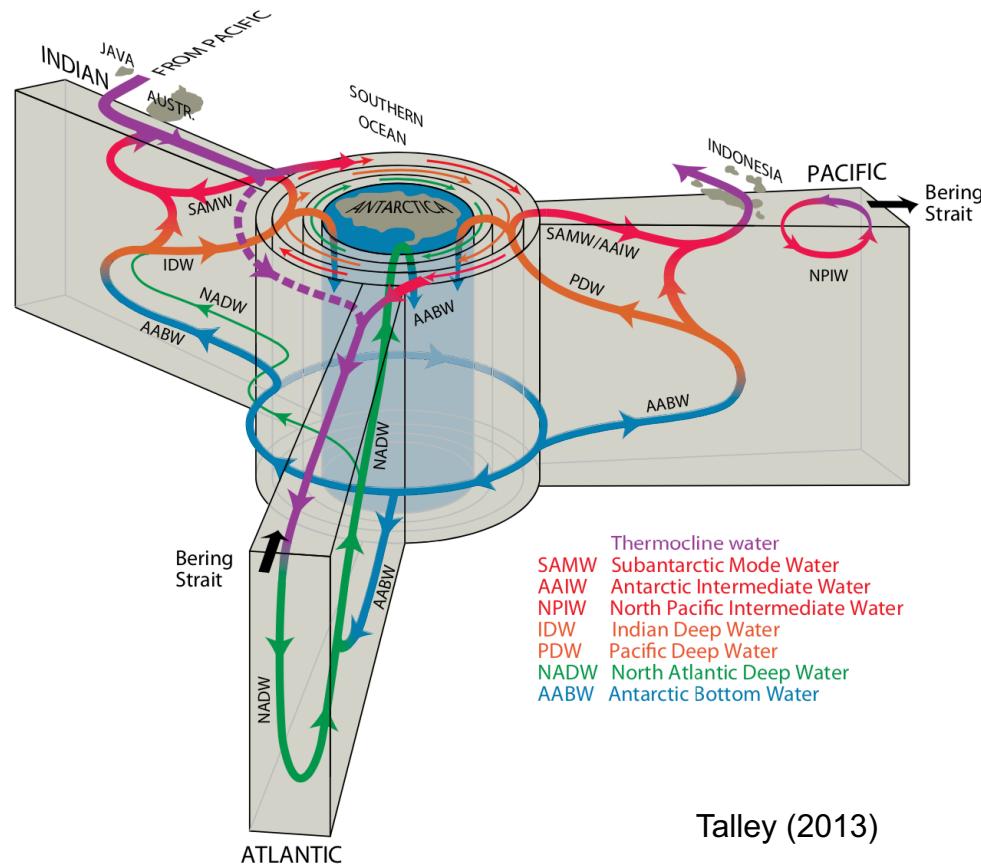
# AABW

(Antarctic  
Bottom  
Water)



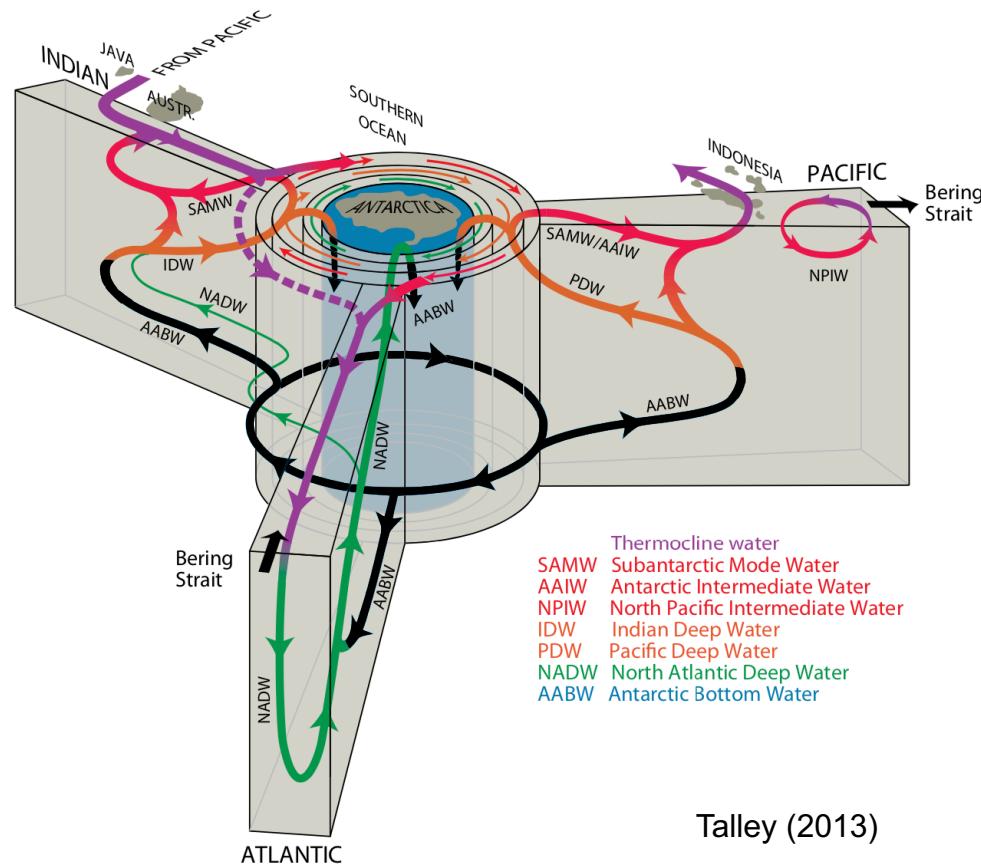
# AABW

## (Antarctic Bottom Water)



# AABW

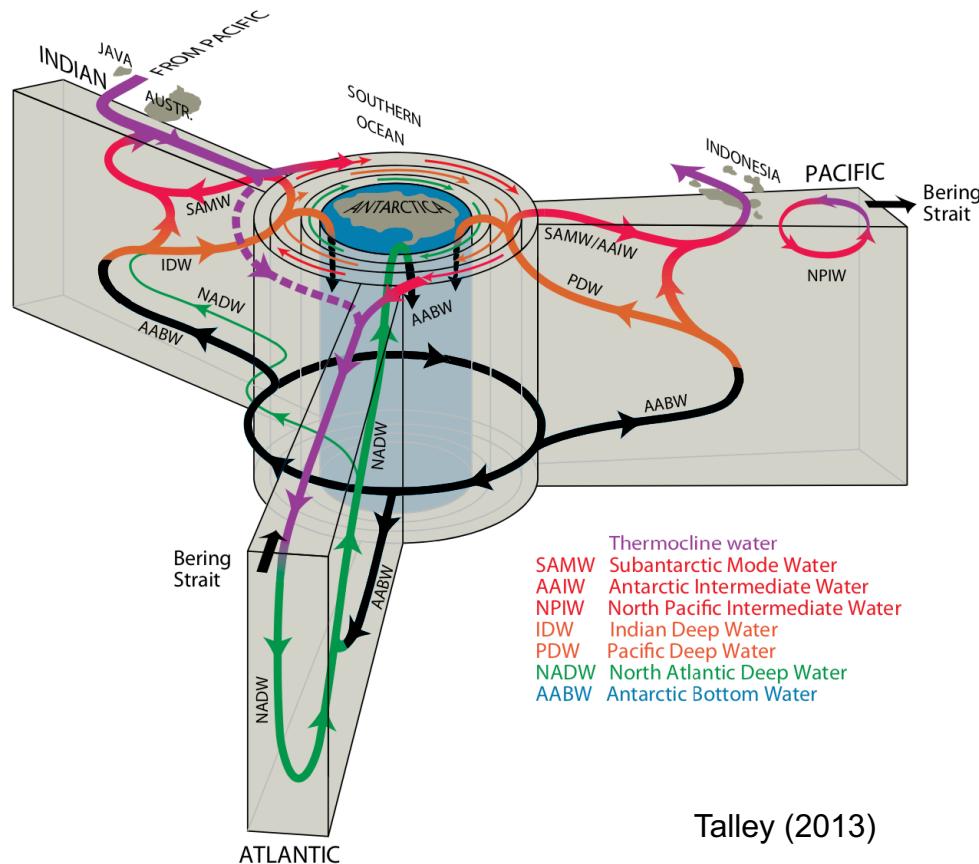
## (Antarctic Bottom Water)



# AABW

## (Antarctic Bottom Water)

- Impacts climate

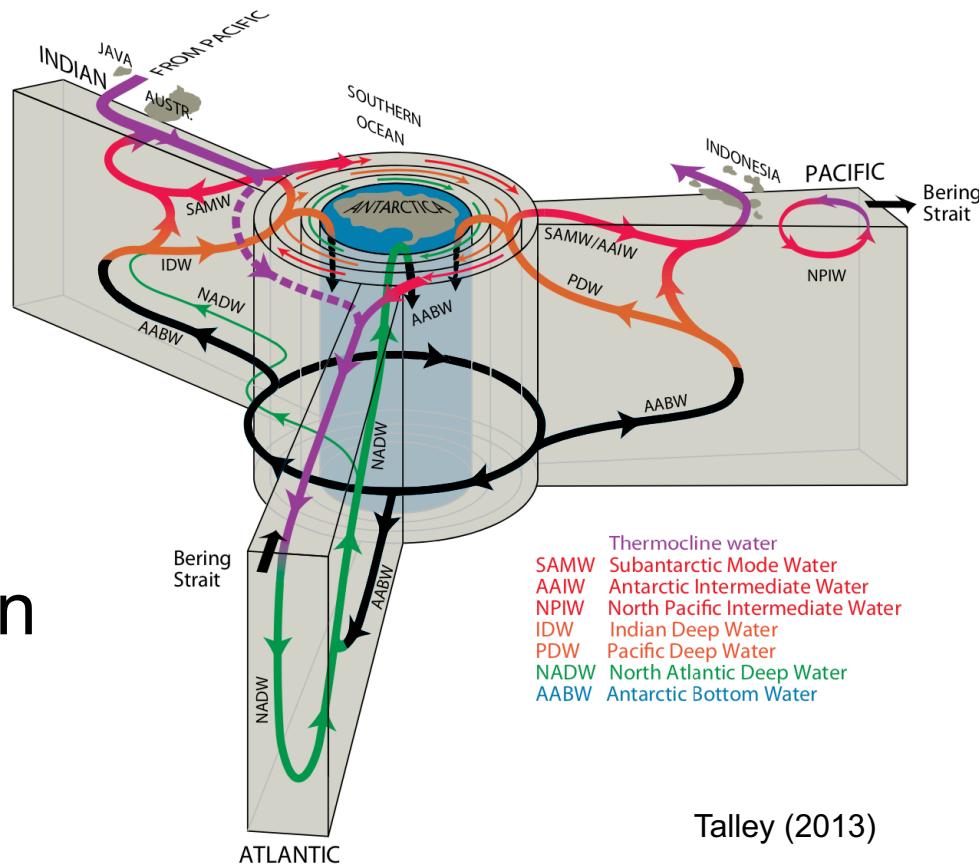


Talley (2013)

# AABW

## (Antarctic Bottom Water)

- Impacts climate
- Variability unknown

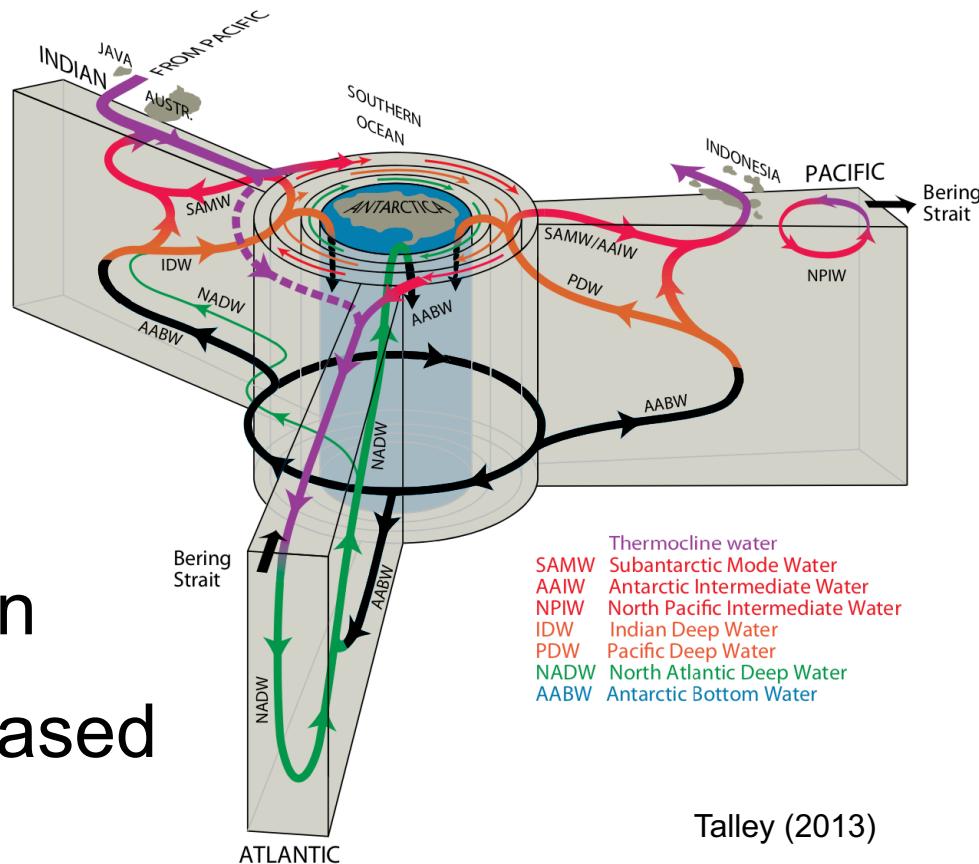


Talley (2013)

# AABW

## (Antarctic Bottom Water)

- Impacts climate
- Variability unknown
- Volume has decreased

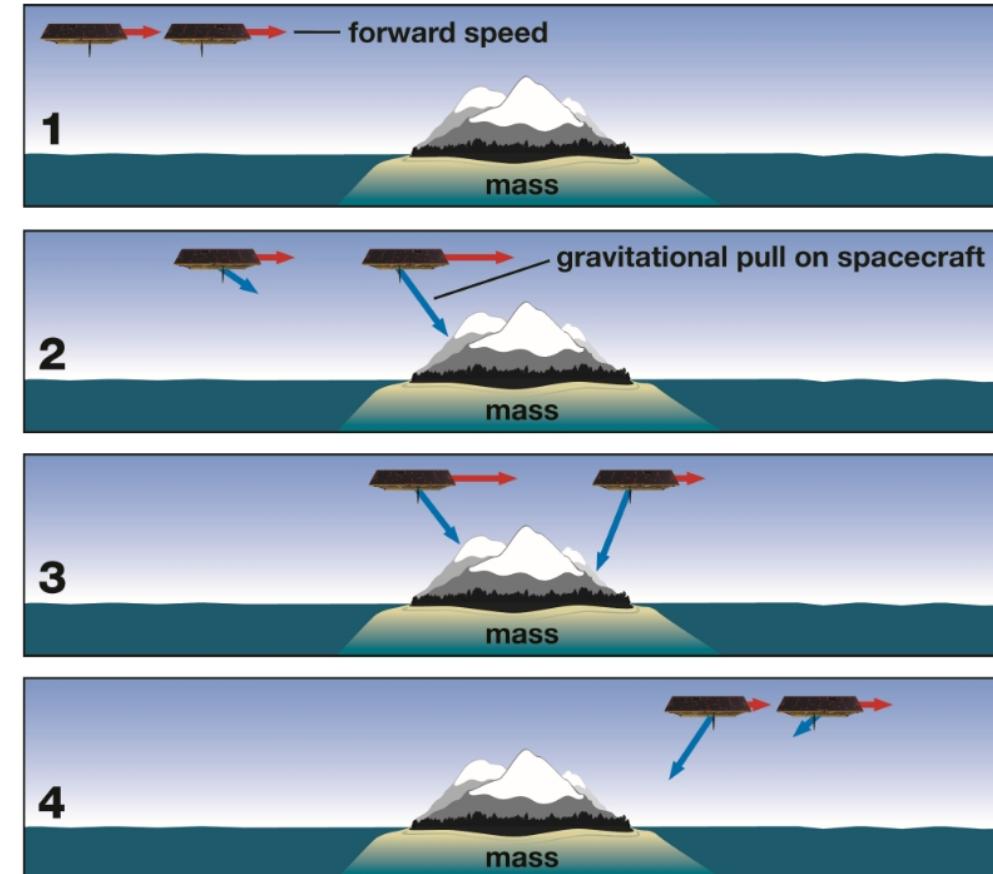


Talley (2013)

# GRACE mission

(Gravity Recovery  
and Climate  
Experiment)

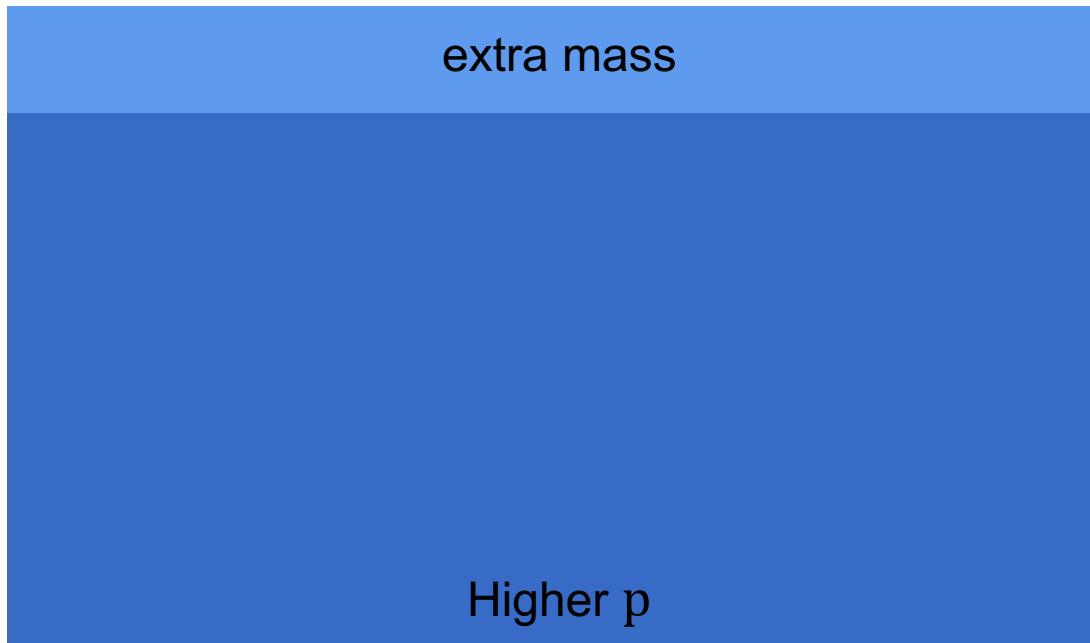
- Measures mass anomalies



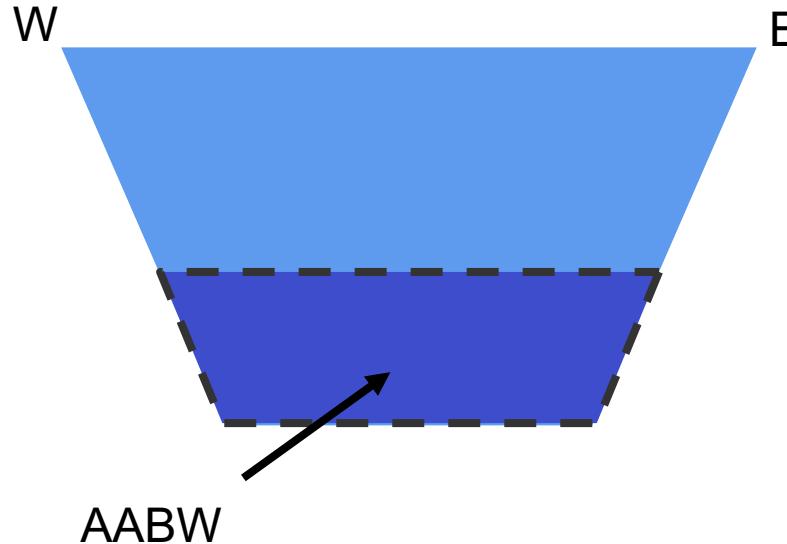
# GRACE mass observations $\approx$ pressure



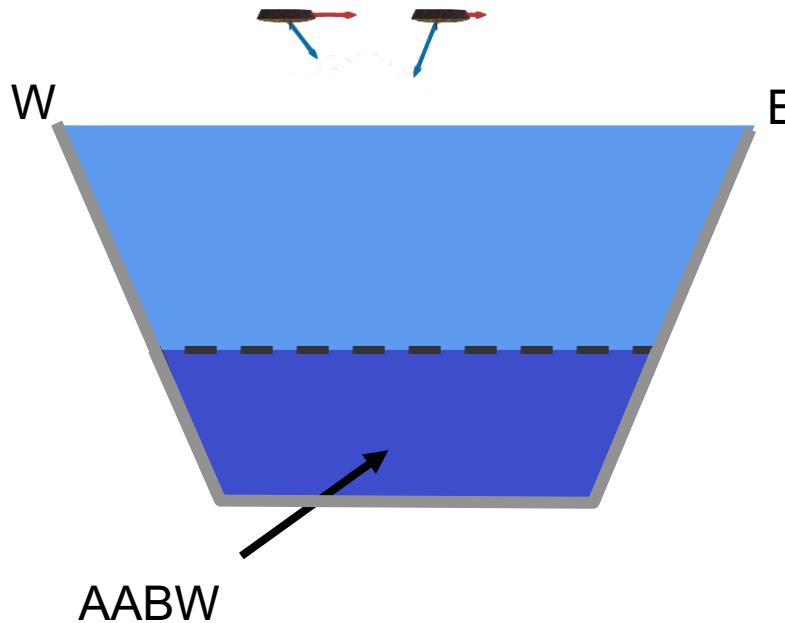
# GRACE mass observations $\approx$ pressure



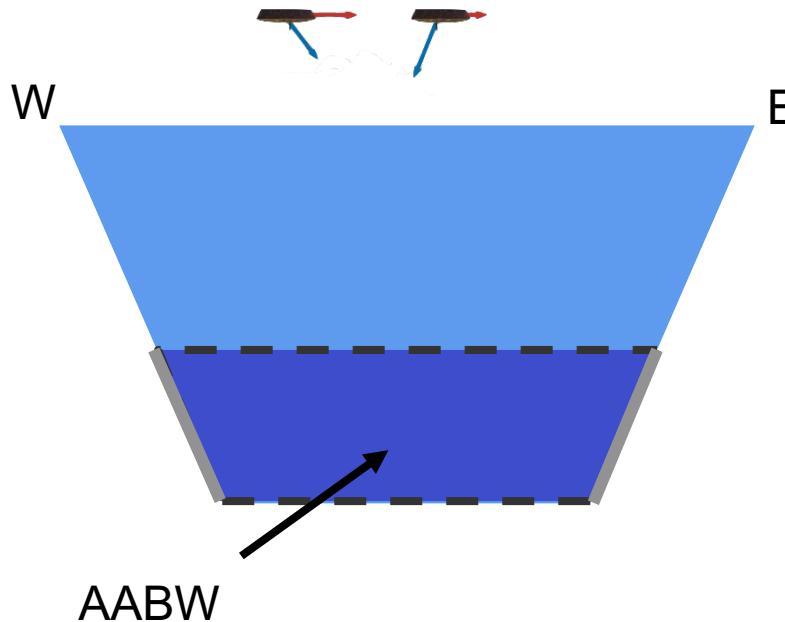
# Why GRACE should be useful



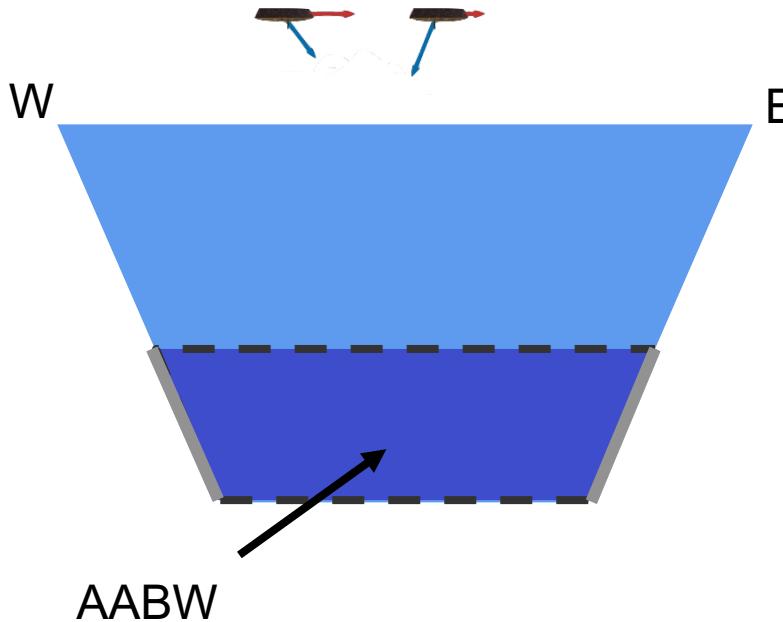
# Why GRACE should be useful



# Why GRACE should be useful



# Why GRACE should be useful



pressure  
change with  
longitude

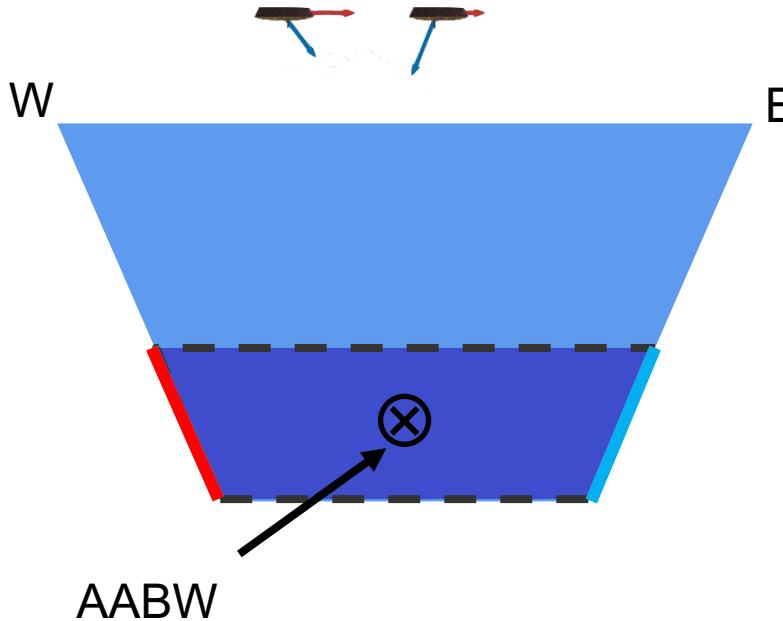
$$\frac{1}{\rho} \frac{\partial p}{\partial x} = f v$$

northward  
velocity

constant

The equation  $\frac{1}{\rho} \frac{\partial p}{\partial x} = f v$  represents the balance between the pressure gradient force and the Coriolis force. The term  $\frac{\partial p}{\partial x}$  is labeled "pressure change with longitude". The term  $f v$  is labeled "northward velocity". The term  $\frac{1}{\rho}$  is labeled "constant". Arrows point from the text labels to their corresponding terms in the equation.

# Why GRACE should be useful



pressure  
change with  
longitude

$$\frac{1}{\rho} \frac{\partial p}{\partial x} = f v$$

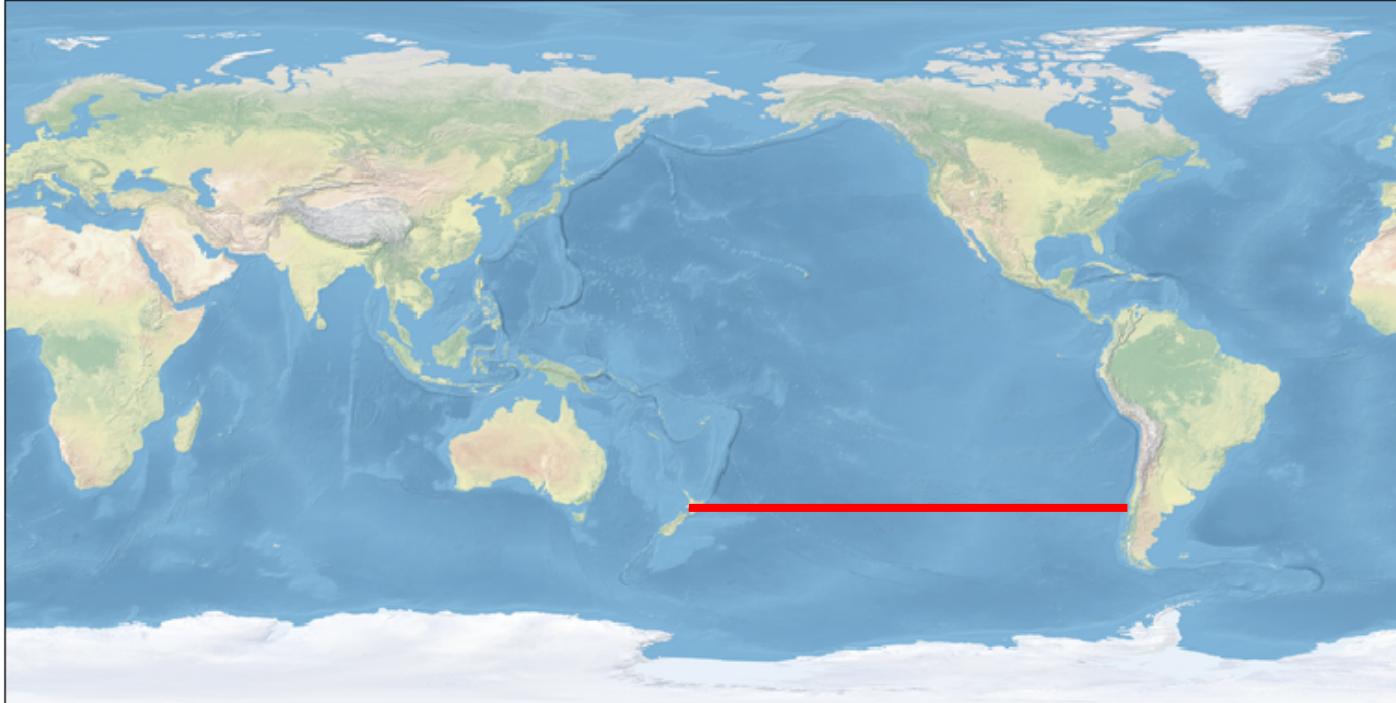
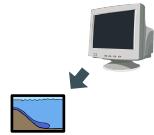
pressure change with longitude

constant

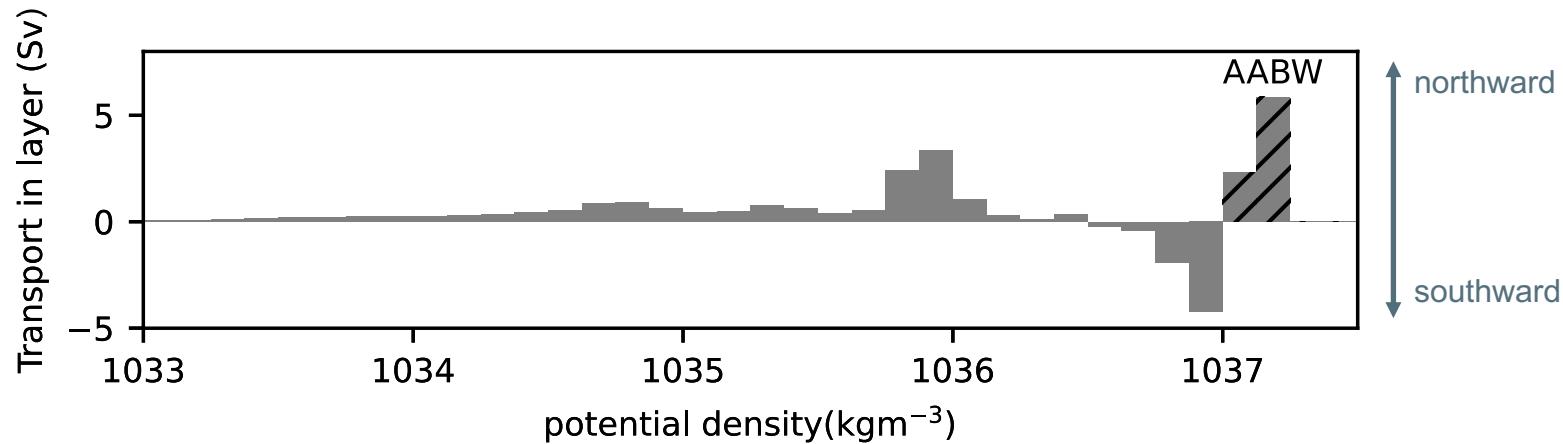
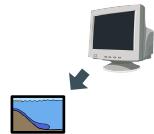
northward velocity

The equation  $\frac{1}{\rho} \frac{\partial p}{\partial x} = f v$  is shown with three annotations: "pressure change with longitude" with a downward arrow above the first term; "constant" with a downward arrow below the second term; and "northward velocity" with an upward arrow next to the  $v$ .

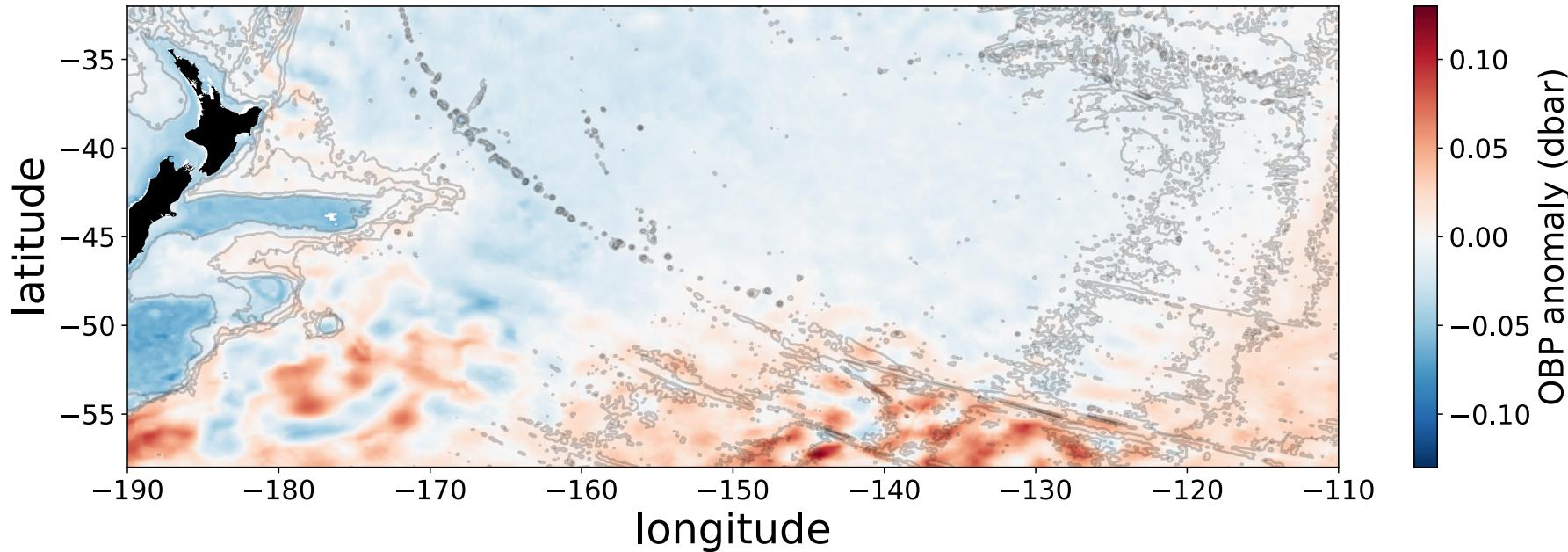
# AABW in ACCESS-OM2-01



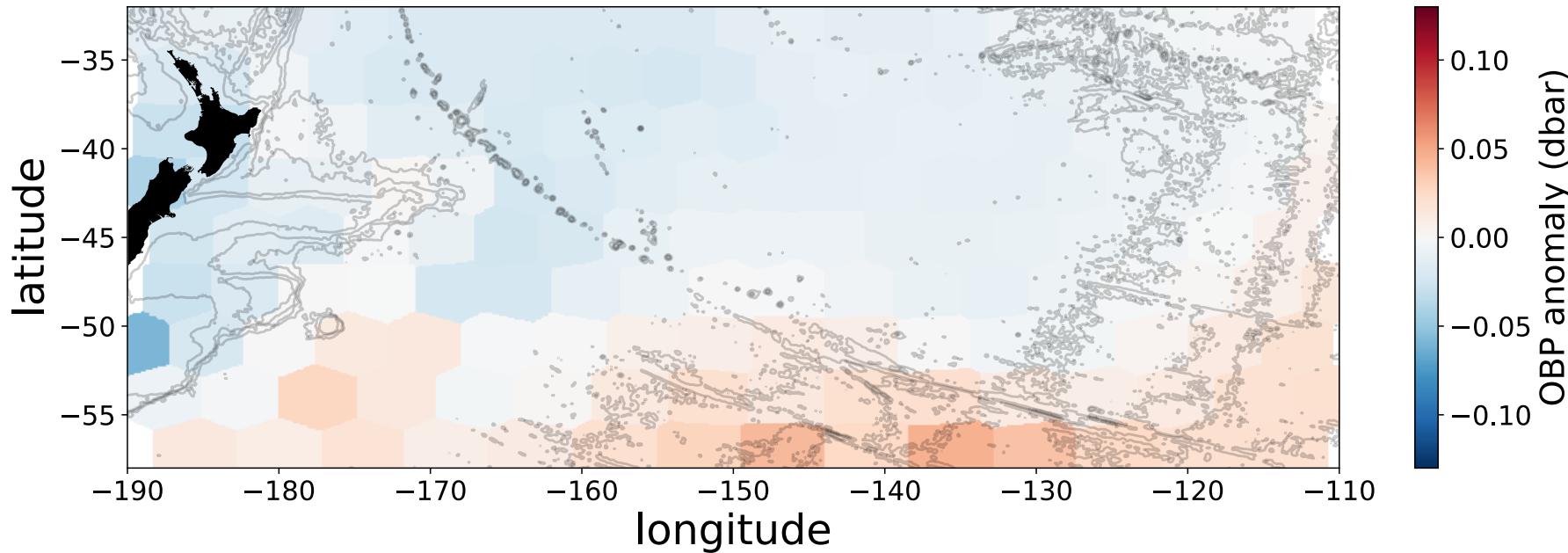
# AABW in ACCESS-OM2-01



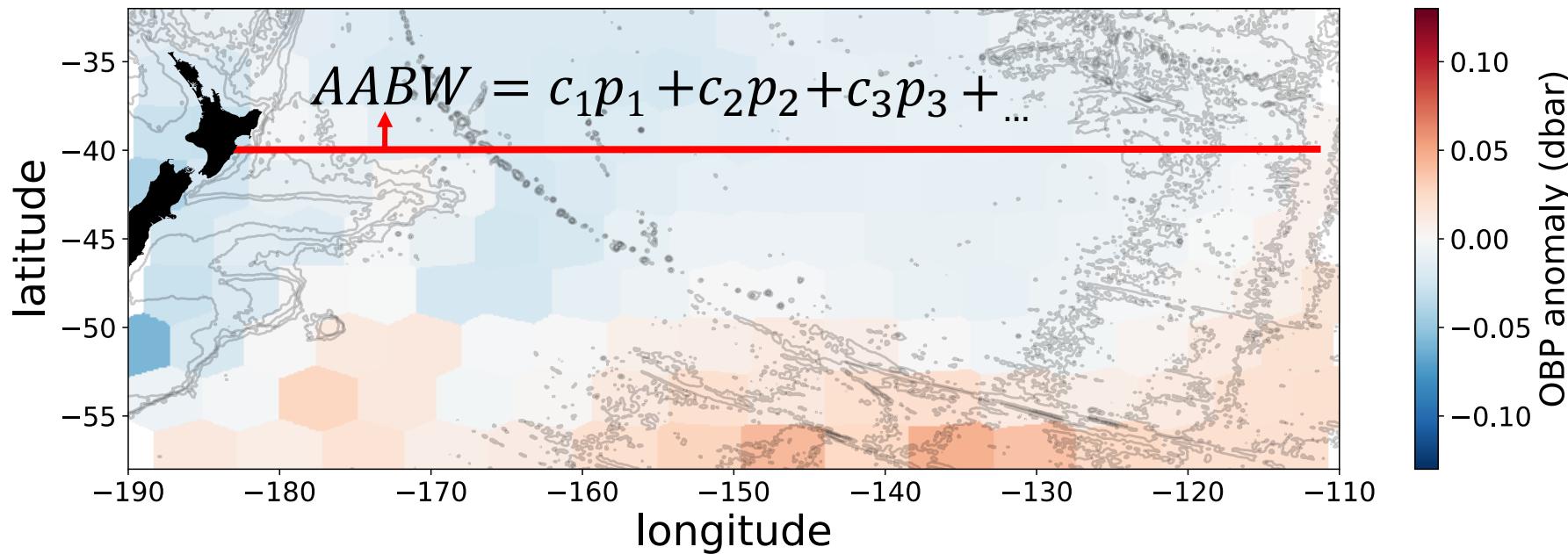
# GRACE in ACCESS-OM2-01



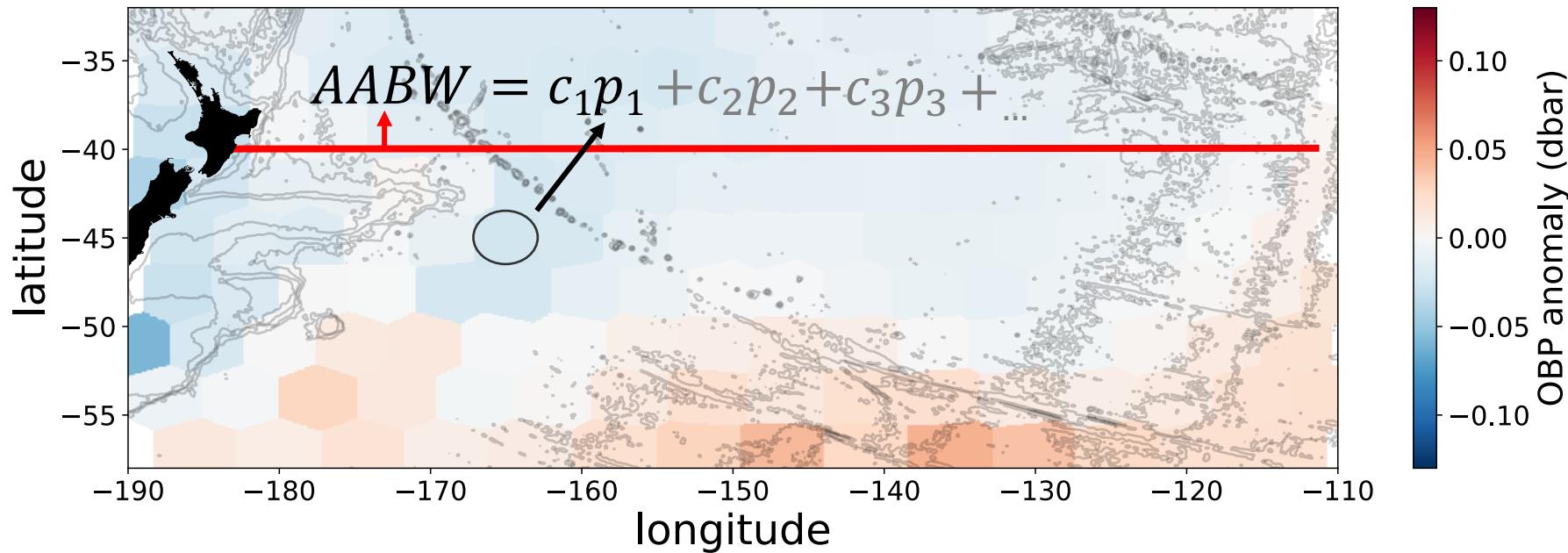
# GRACE in ACCESS-OM2-01



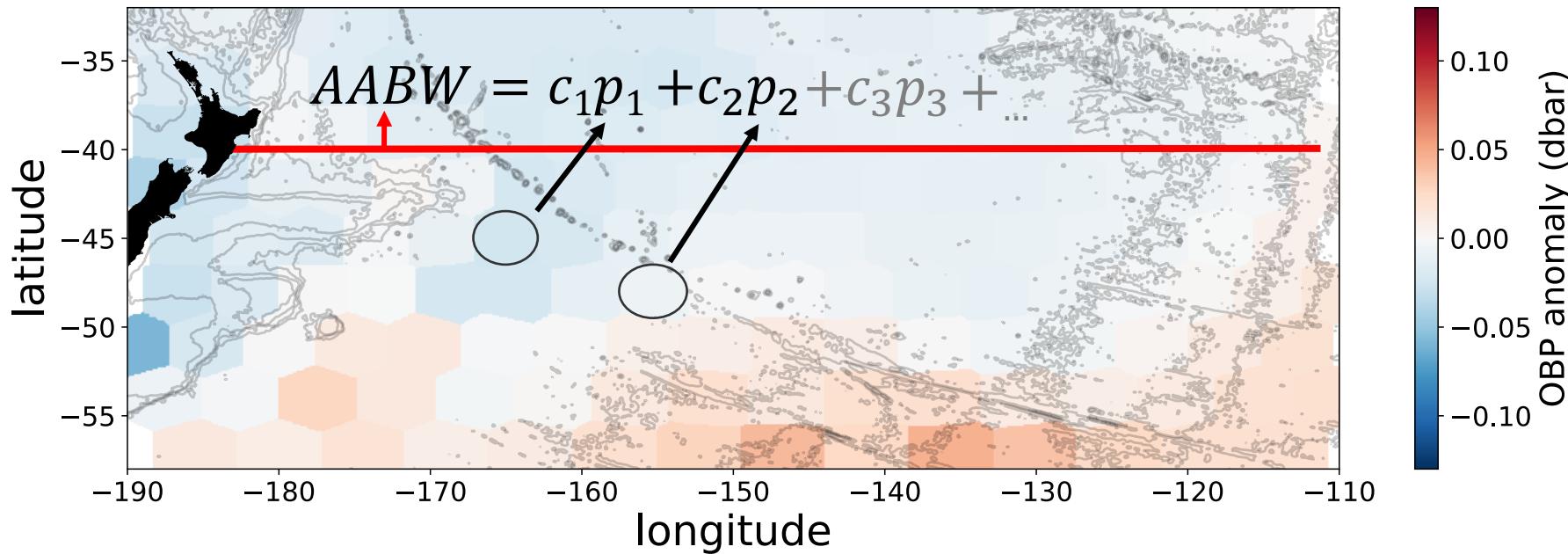
# Link AABW to GRACE



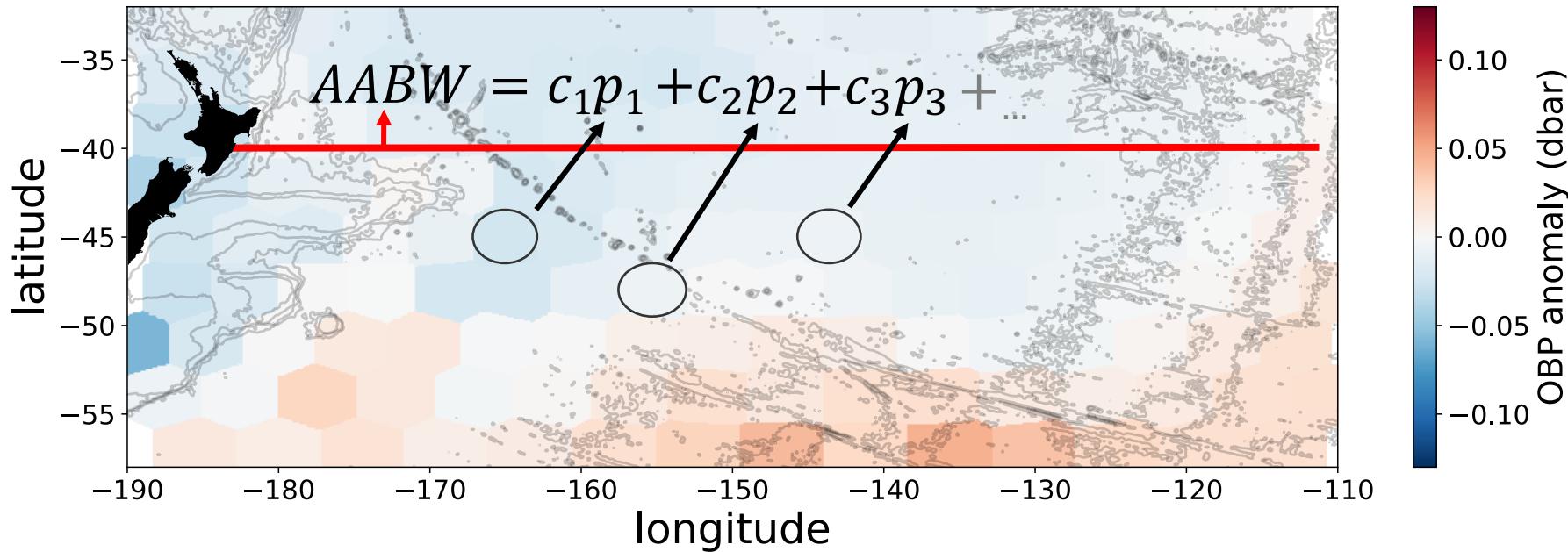
# Link AABW to GRACE



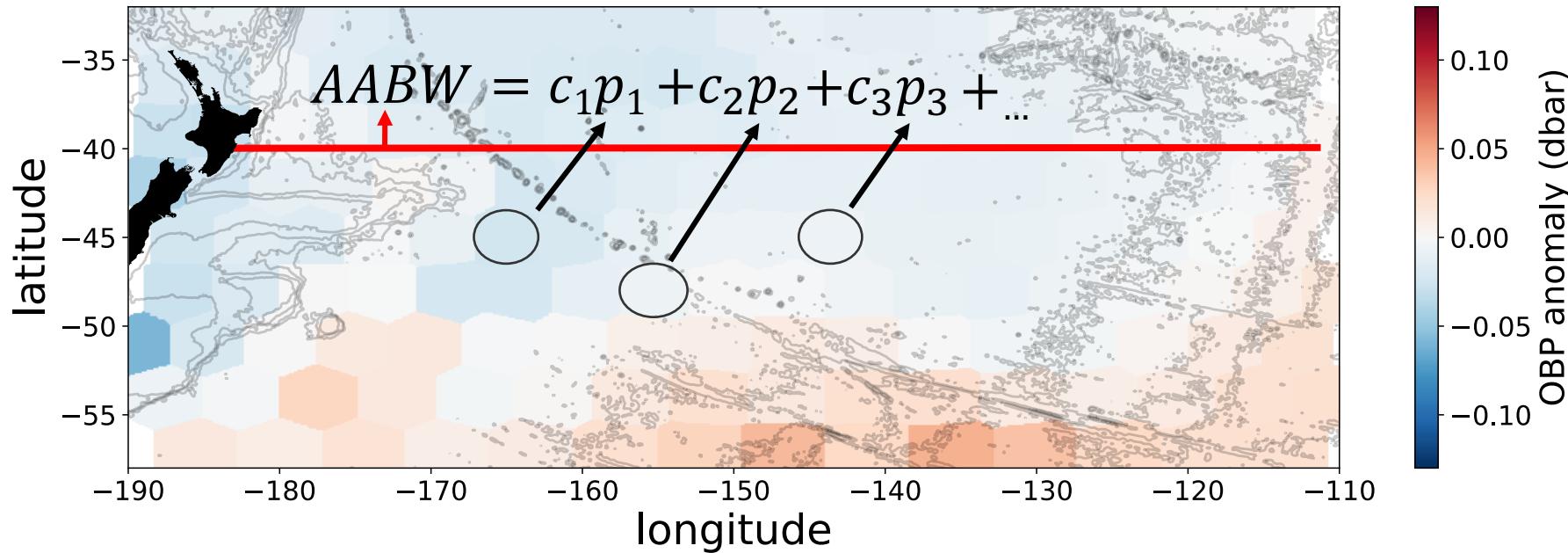
# Link AABW to GRACE



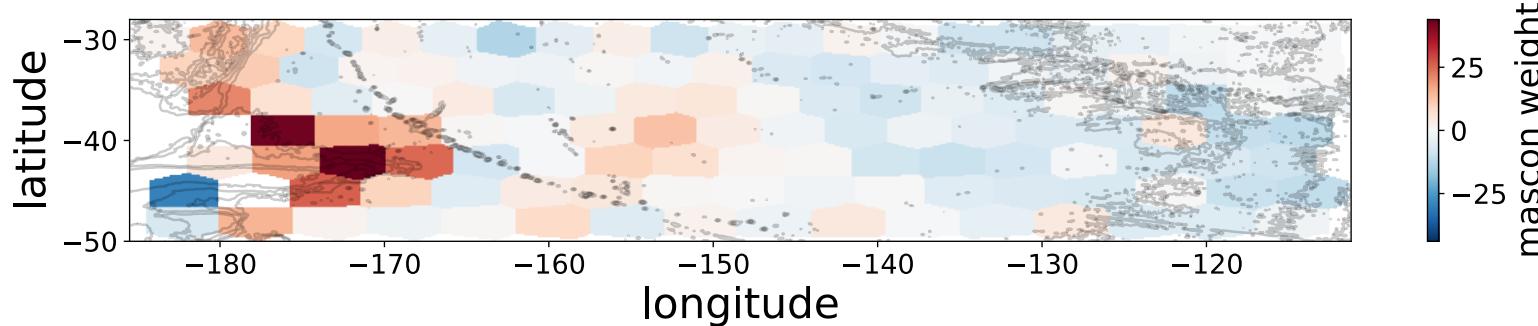
# Link AABW to GRACE



# Link AABW to GRACE

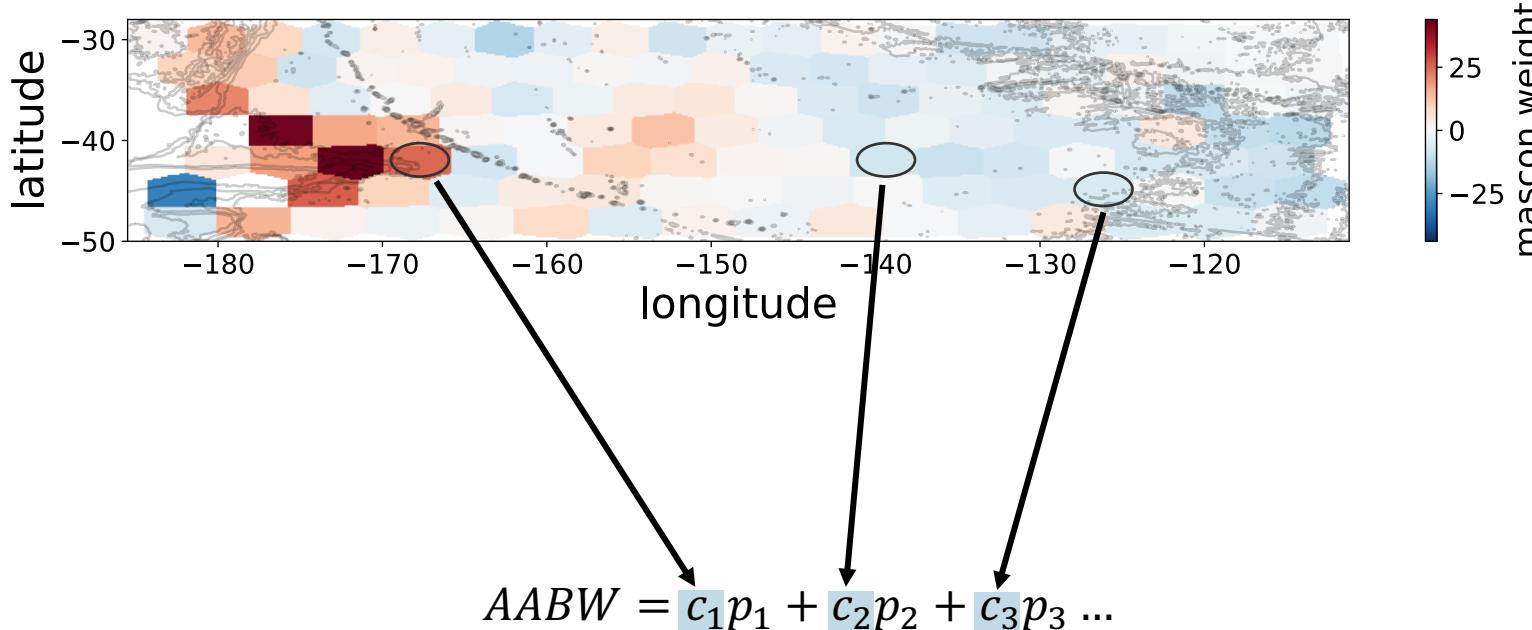


# Linear regression result in model

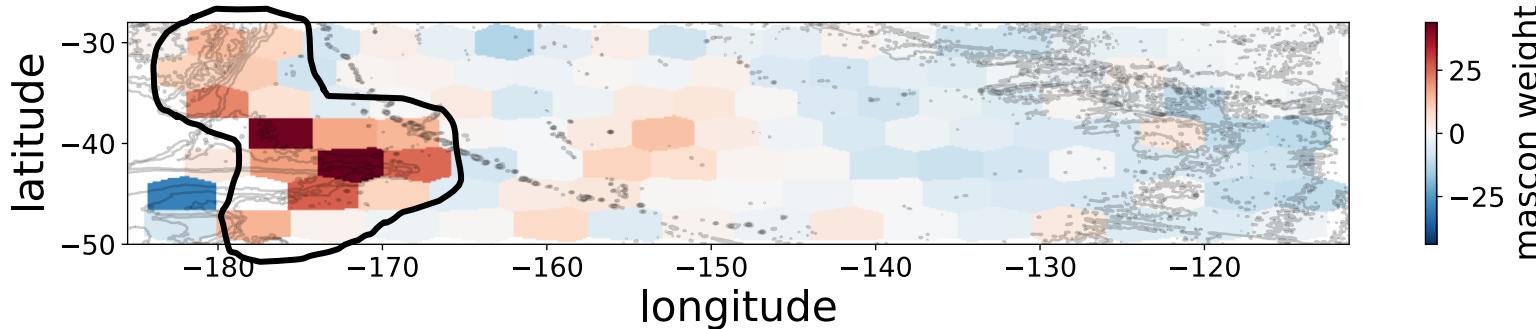


$$AABW = c_1 p_1 + c_2 p_2 + c_3 p_3 \dots$$

# Linear regression result in model

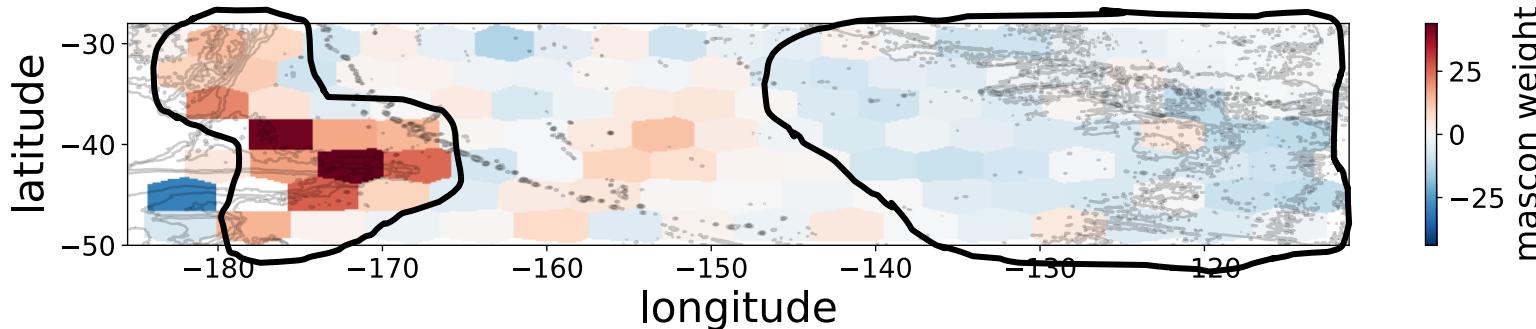


# Linear regression result in model



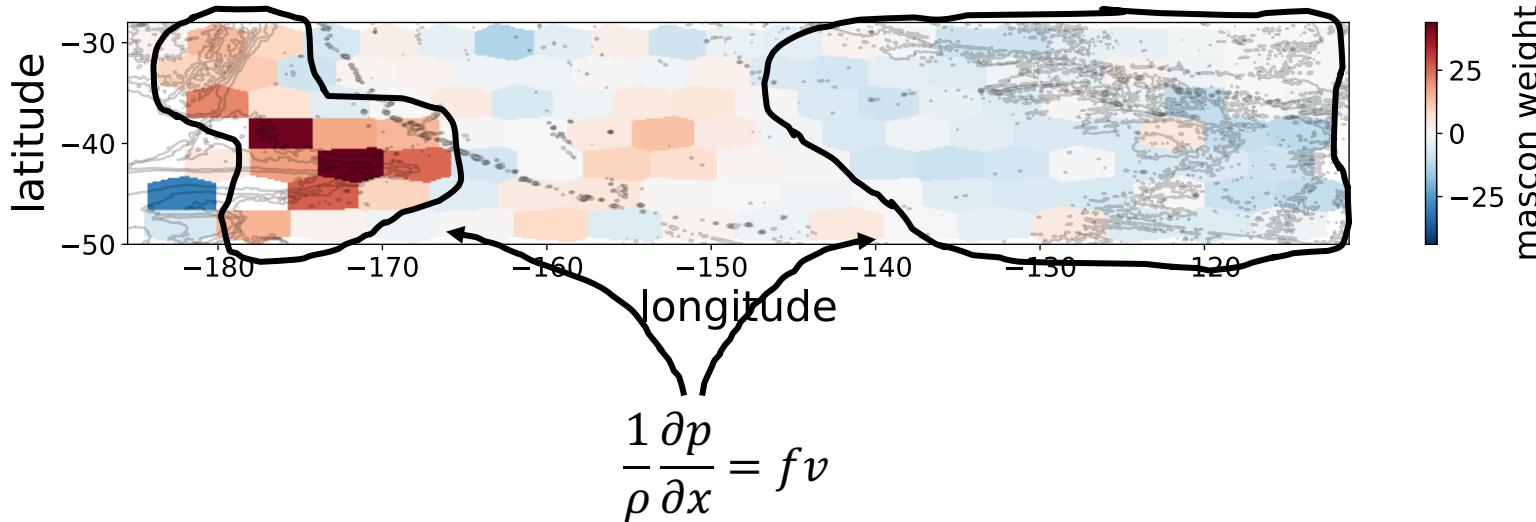
$$AABW = c_1 p_1 + c_2 p_2 + c_3 p_3 \dots$$

# Linear regression result in model



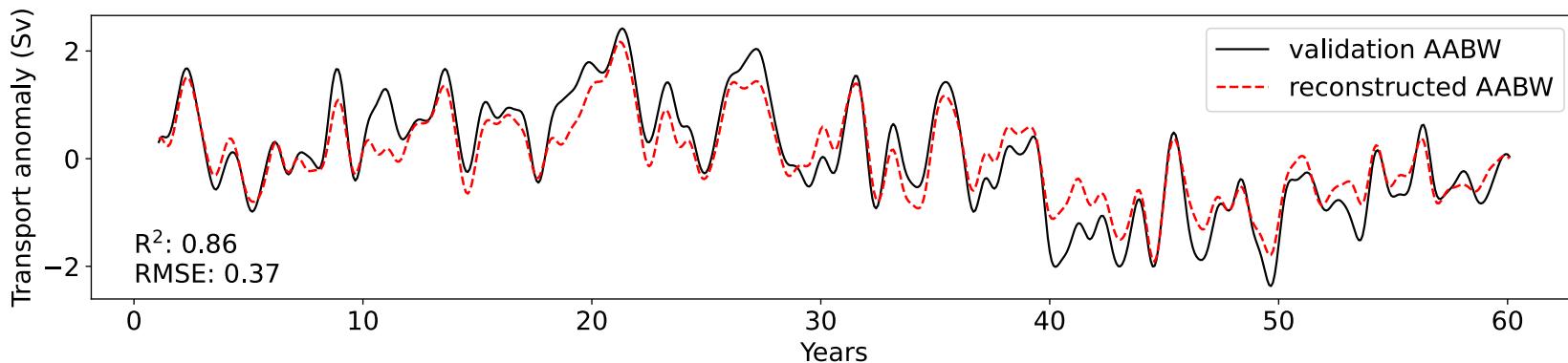
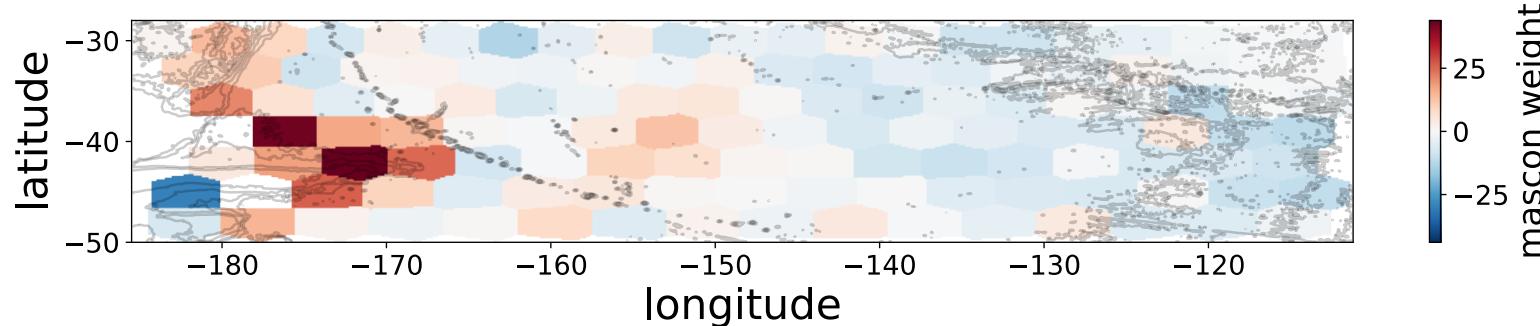
$$AABW = c_1 p_1 + c_2 p_2 + c_3 p_3 \dots$$

# Linear regression result in model

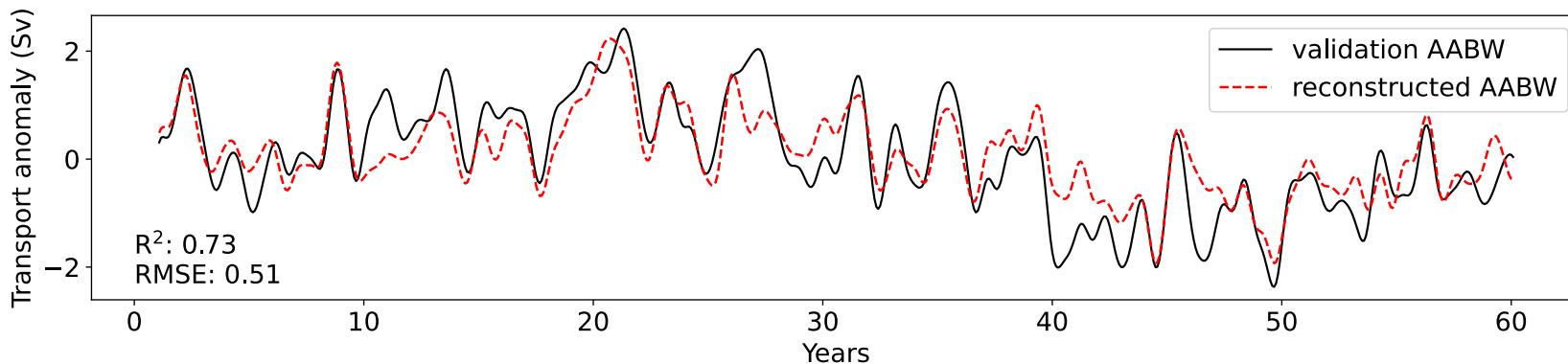
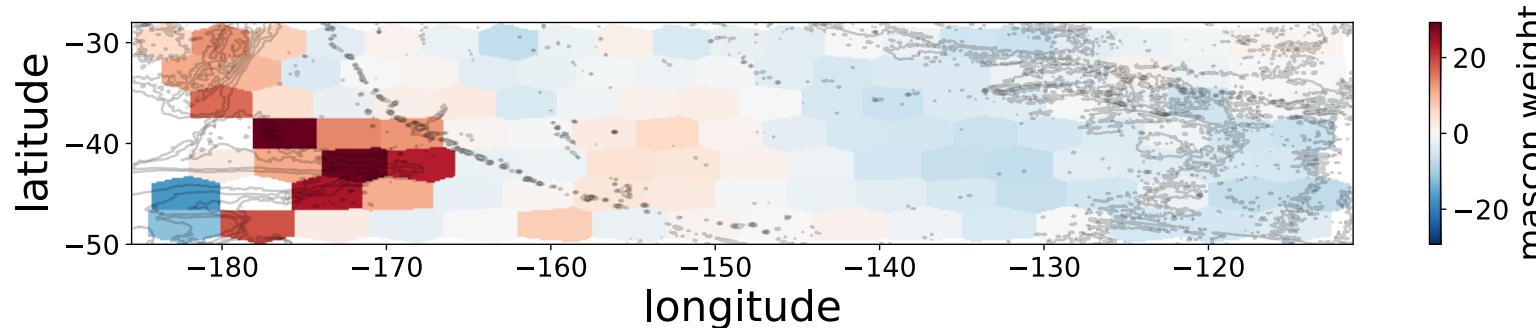


$$AABW = c_1 p_1 + c_2 p_2 + c_3 p_3 \dots$$

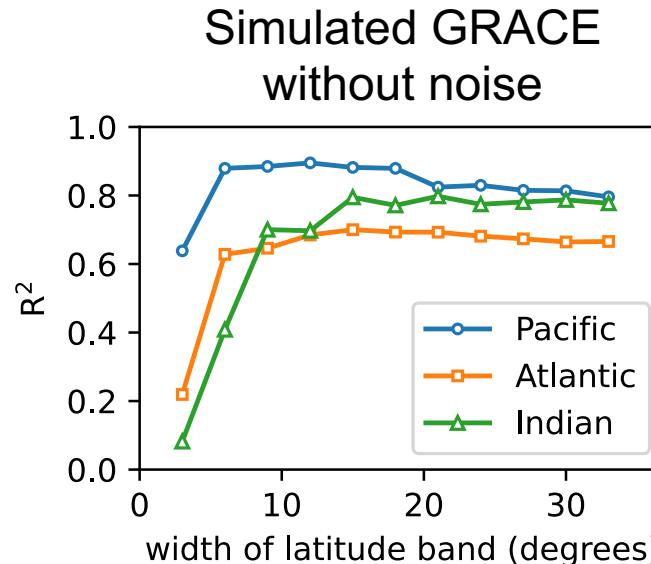
# Linear regression result in model



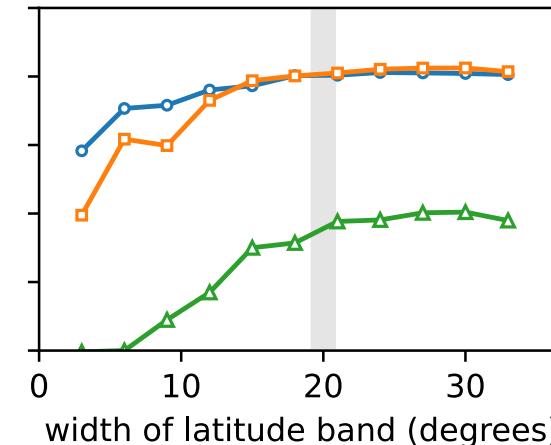
# Linear regression result in model (noisy)



# Optimisation example: latitude

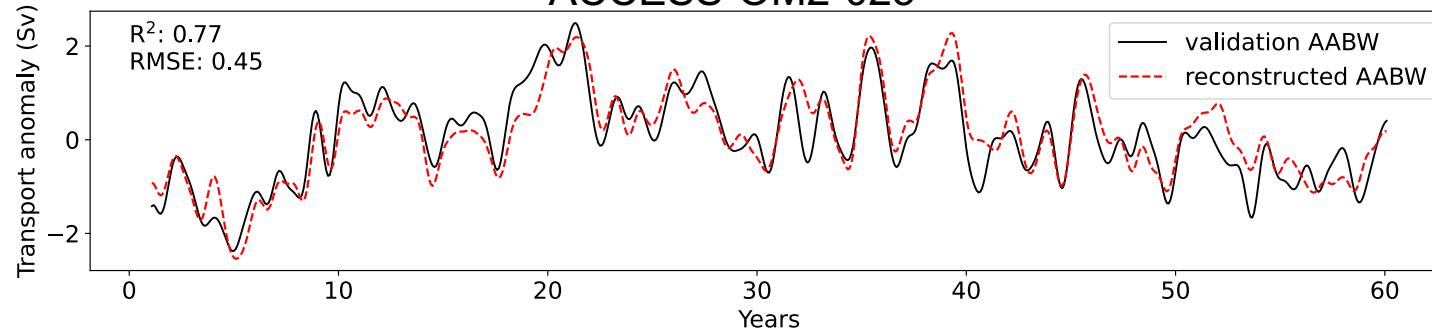


Simulated GRACE  
including noise

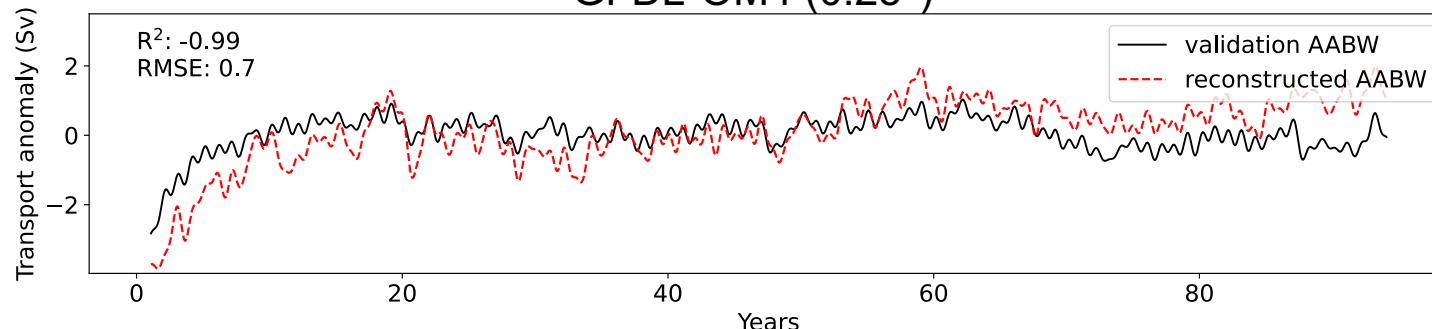


# Test in other models (with noise)

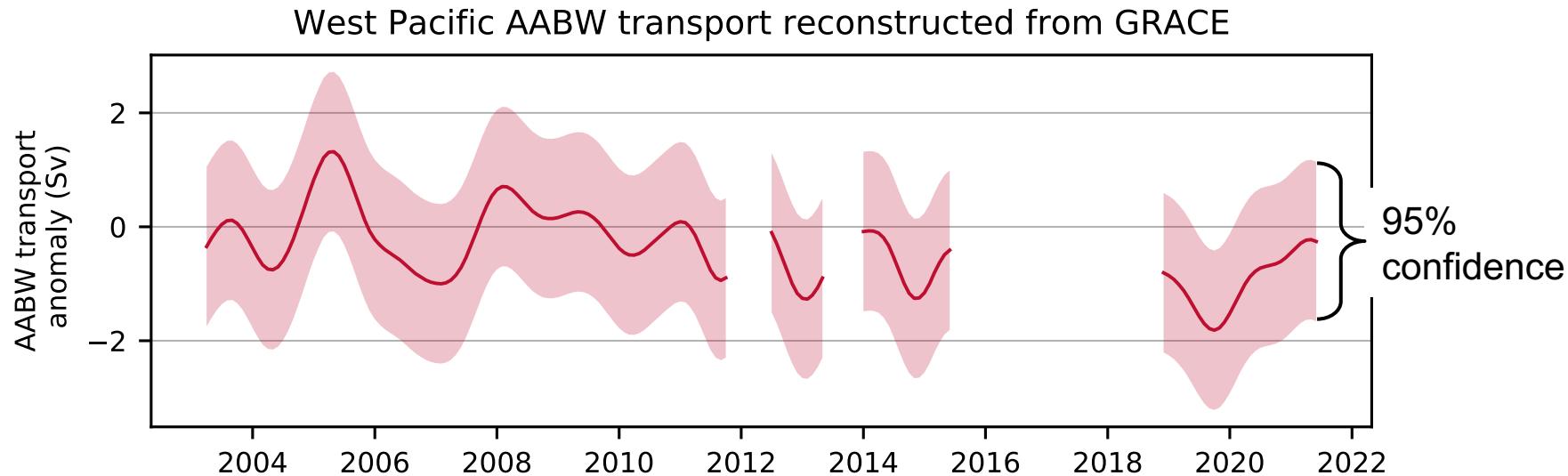
ACCESS-OM2-025



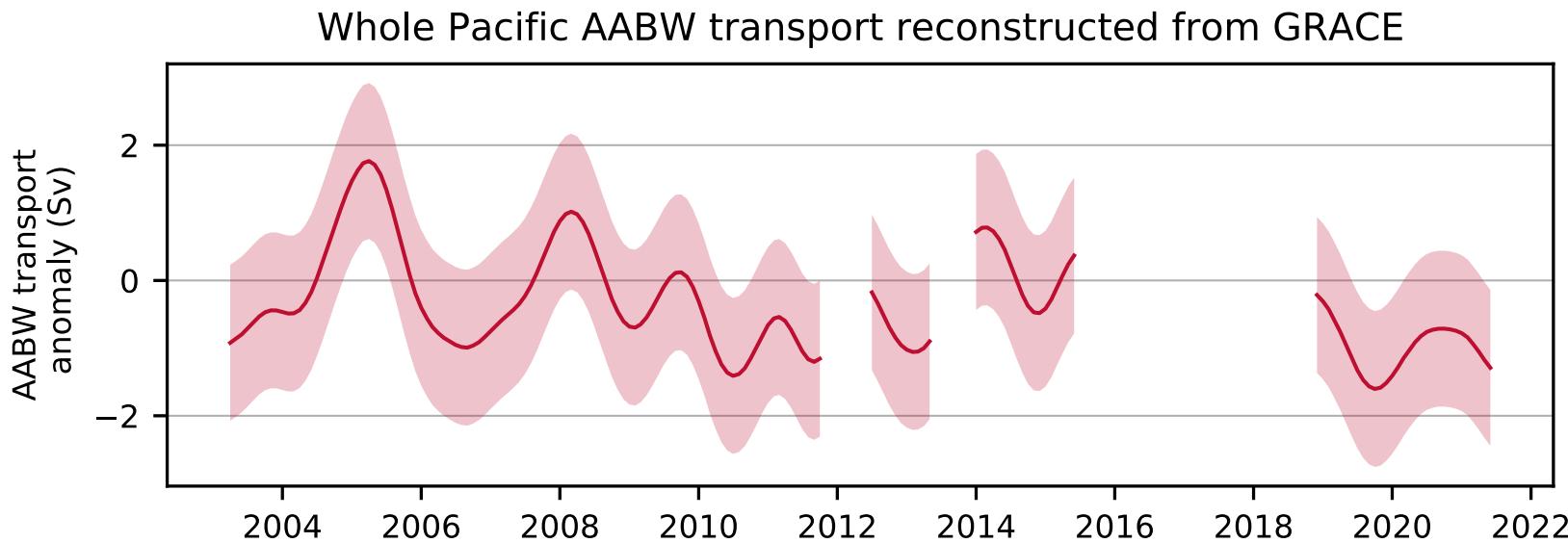
GFDL-OM4 ( $0.25^\circ$ )



# An estimate of AABW transport

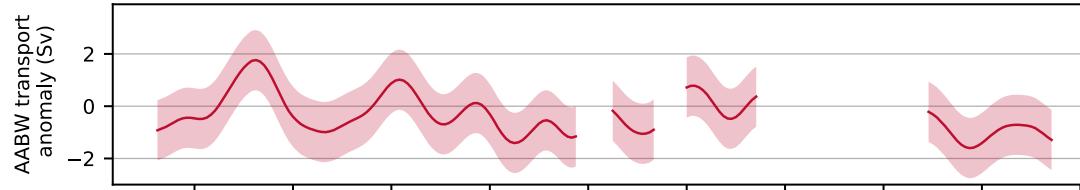


# An estimate of AABW transport

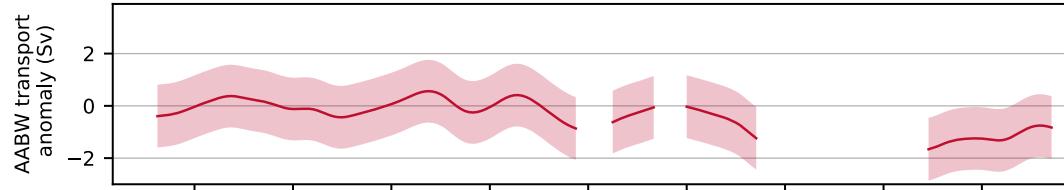


# An estimate of AABW transport

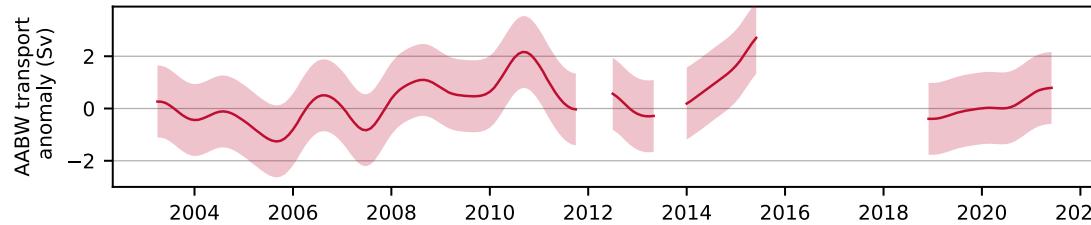
Pacific Ocean



Atlantic Ocean

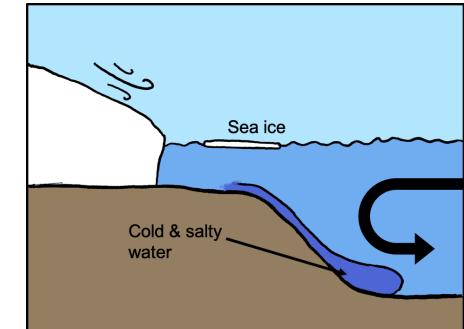


Indian Ocean



# Conclusions

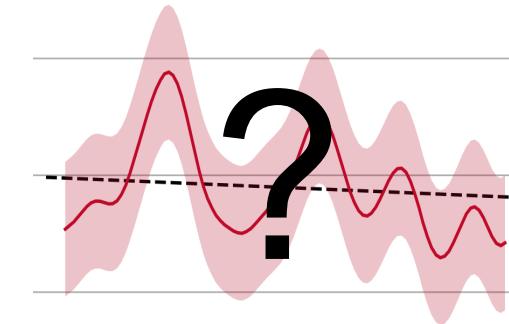
First estimate of AABW transport variability



# Conclusions

First estimate of AABW transport variability

→ No clear response to climate change

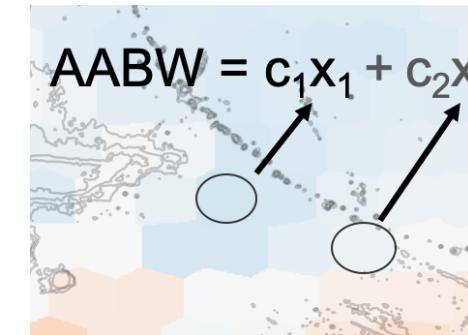


# Conclusions

First estimate of AABW transport variability

→ No clear response to climate change

Modelling satellite data shows how it might be used



# Conclusions

First estimate of AABW transport variability

→ No clear response to climate change

Modelling satellite data shows how  
it might be used

Jemma Jeffree  
[jemma.jeffree@anu.edu.au](mailto:jemma.jeffree@anu.edu.au)

