The role of lee waves for dissipation of transient eddies in the Southern Ocean

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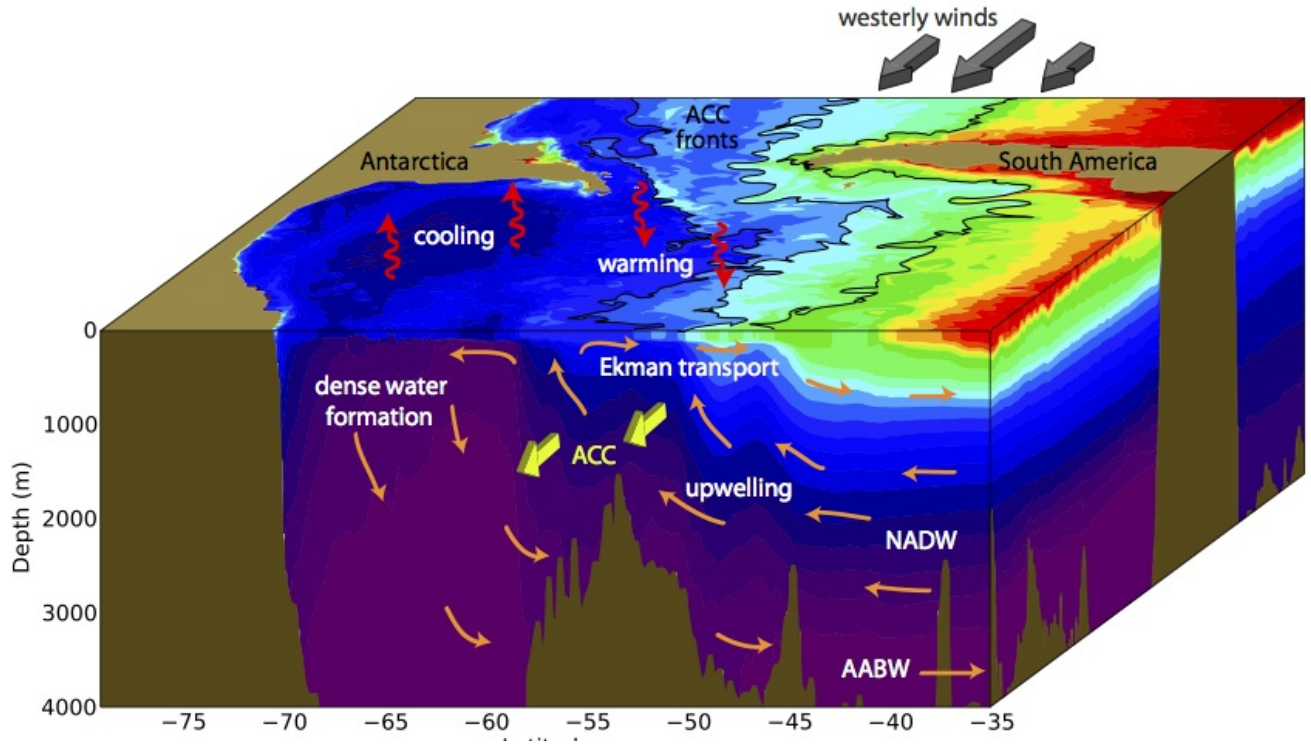
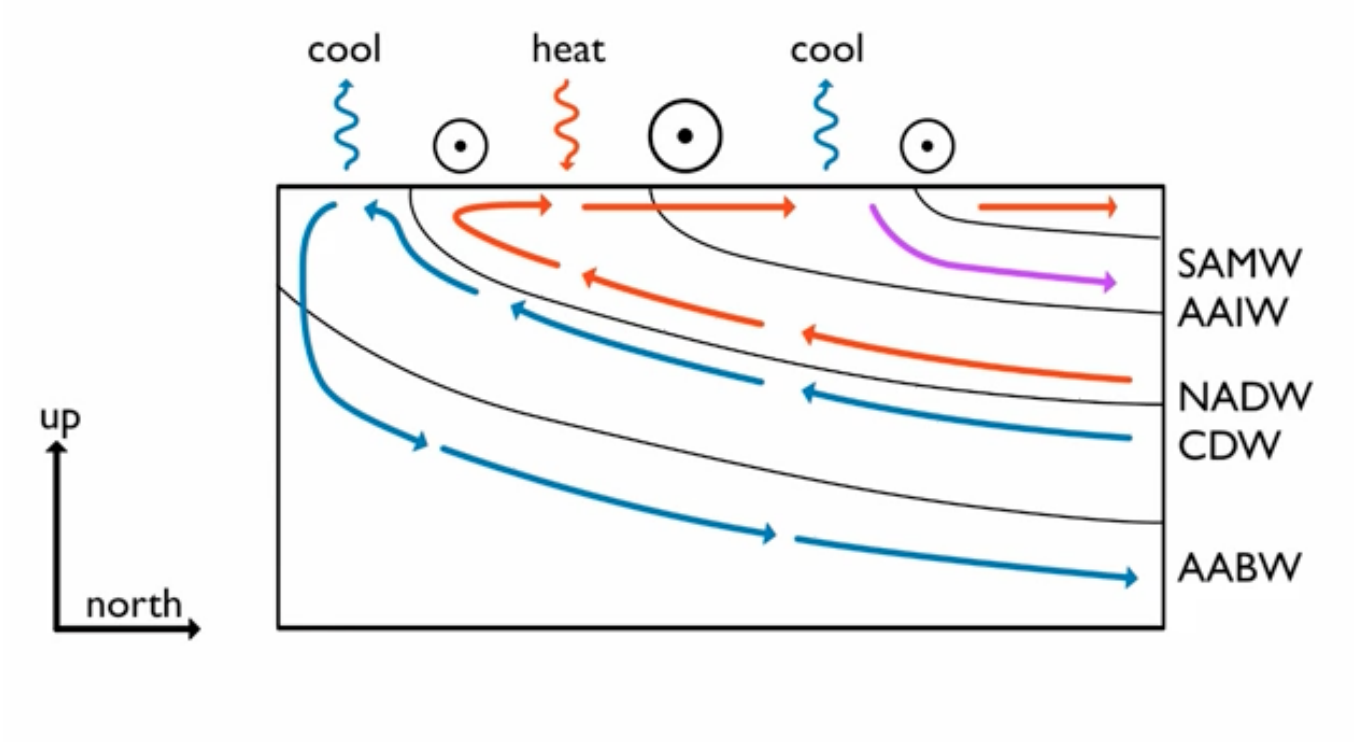
Southern Ocean circulation



- Antarctic Circumpolar Current (ACC)
- Meridional Overturning Circulation (MOC)

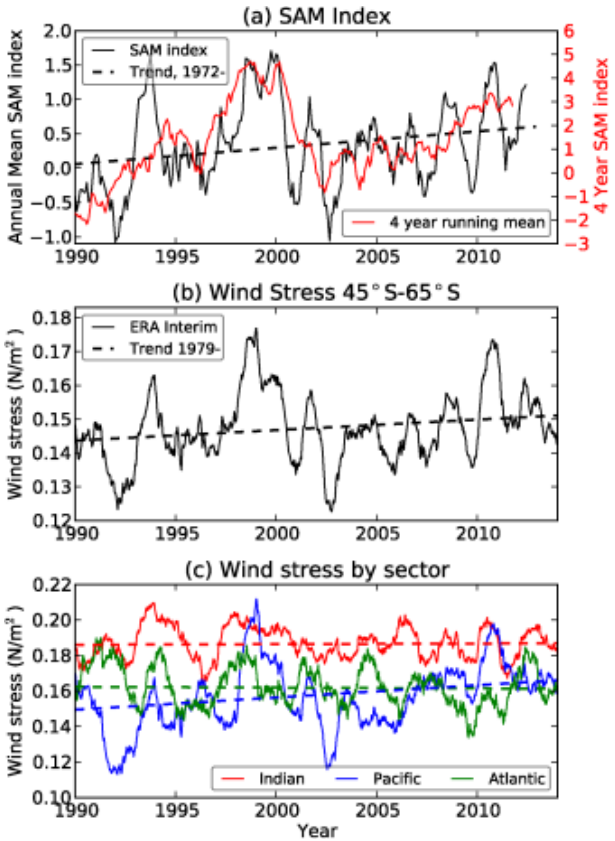
Transient eddies

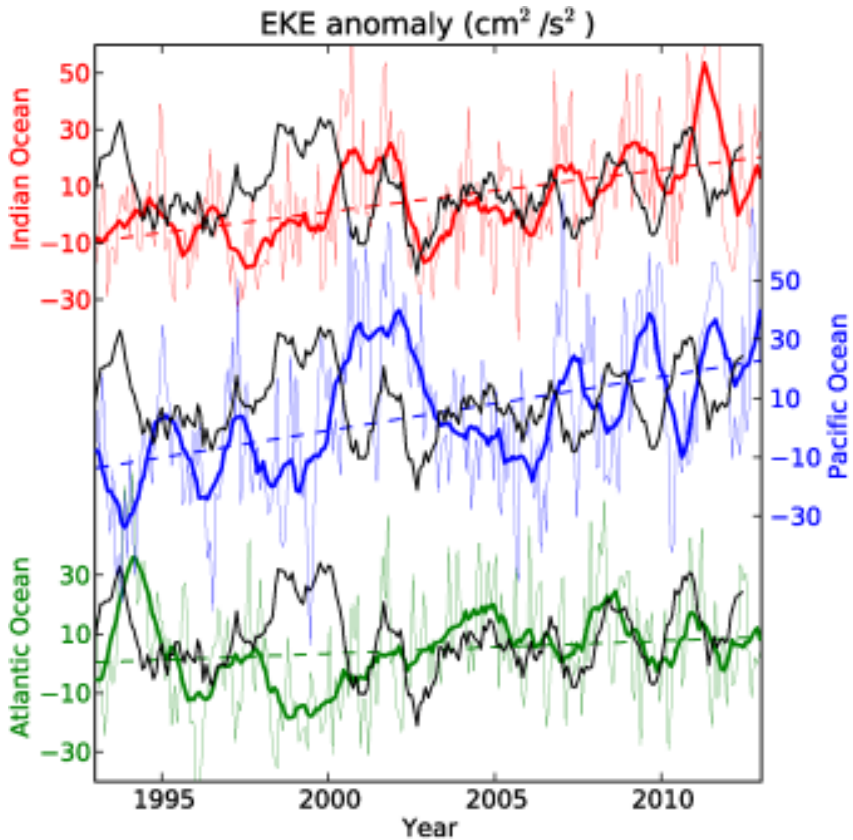


Courtesy by Ryan Abernathey

- ACC $\leftarrow$ Slope of isopycnals $\leftarrow$ Eddy generation
- MOC $\leftarrow$ Water mass transformation $\leftarrow$ Eddy fluxes

Sensitivity to wind stress

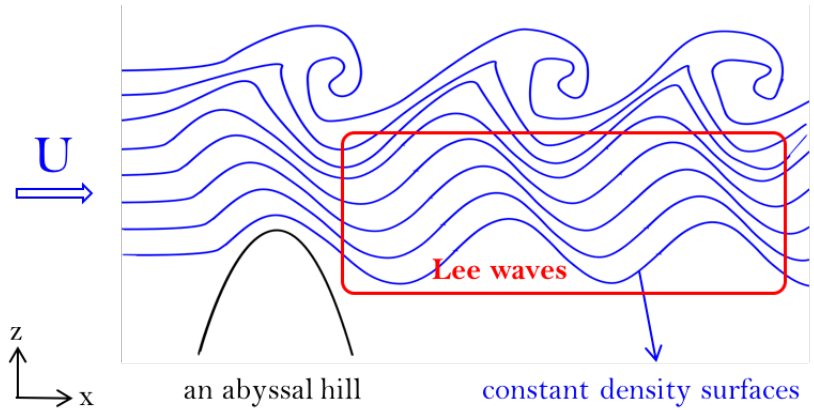




Hogg et al. (2015)

Energy dissipation

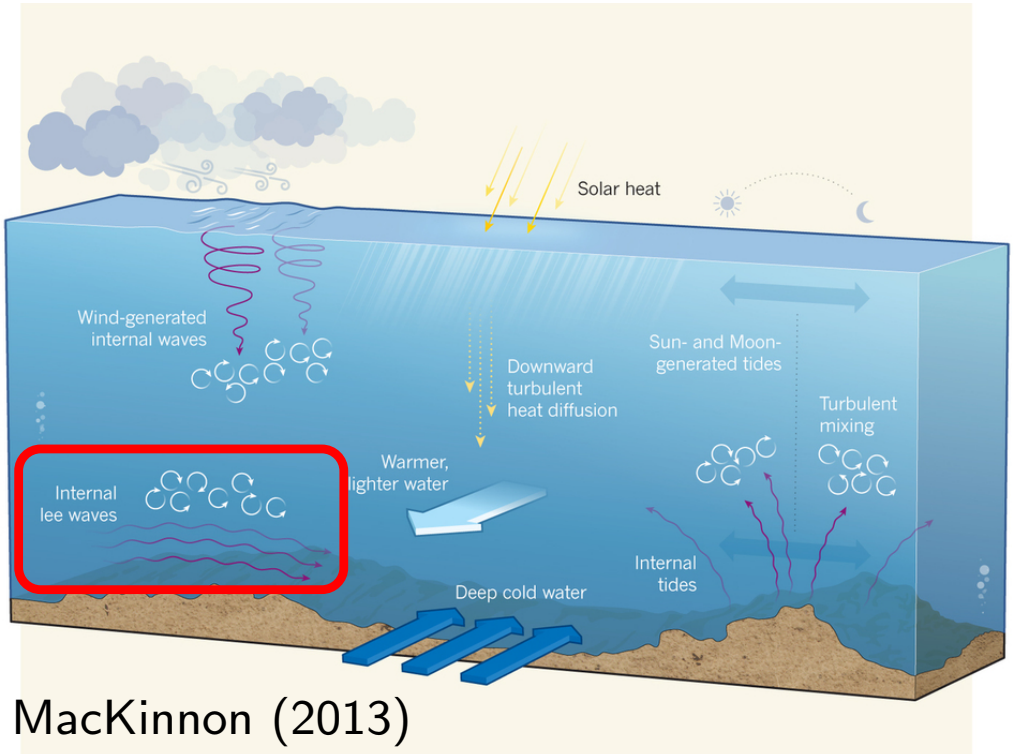
Transient eddies $\rightarrow$ Lee waves $\rightarrow$ Turbulent mixing



MOC $\leftarrow$ Water mass transformation $\leftarrow$ Enhanced mixing

- Transient eddies $\rightarrow$ Lee waves
- ... (e.g., Mean flow) $\rightarrow$ **Lee waves**
- **Transient eddies** $\rightarrow$ ... (e.g., turbulences in TBBL)

Lee waves



MacKinnon (2013)

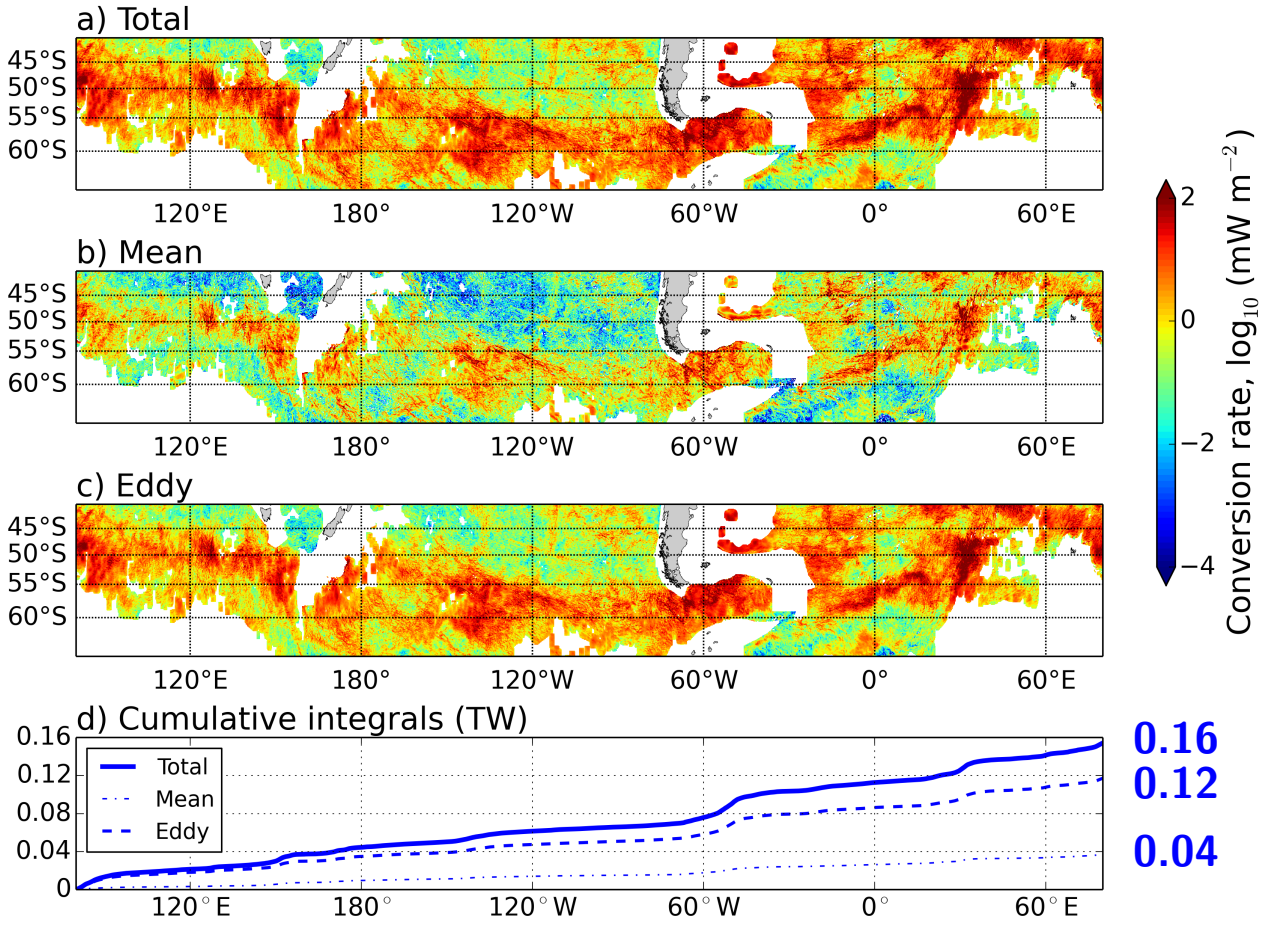
- Geostrophic flow, subinertial frequency
- Rough small-scale topography, O(100m-10km)
- Weak stratification (e.g., Bell 1975)

Data

- Near-bottom velocity and stratification
  - MOM5-SIS (Sea Ice Simulator) (Stewart et al. 2017)
  - Eddy-resolving ($1/10^{\circ}$)
  - 50 vertical levels

- Small-scale topography
  - Goff 2010
  - Goff and Arbic 2010
  - Nikurashin and Ferrari 2011

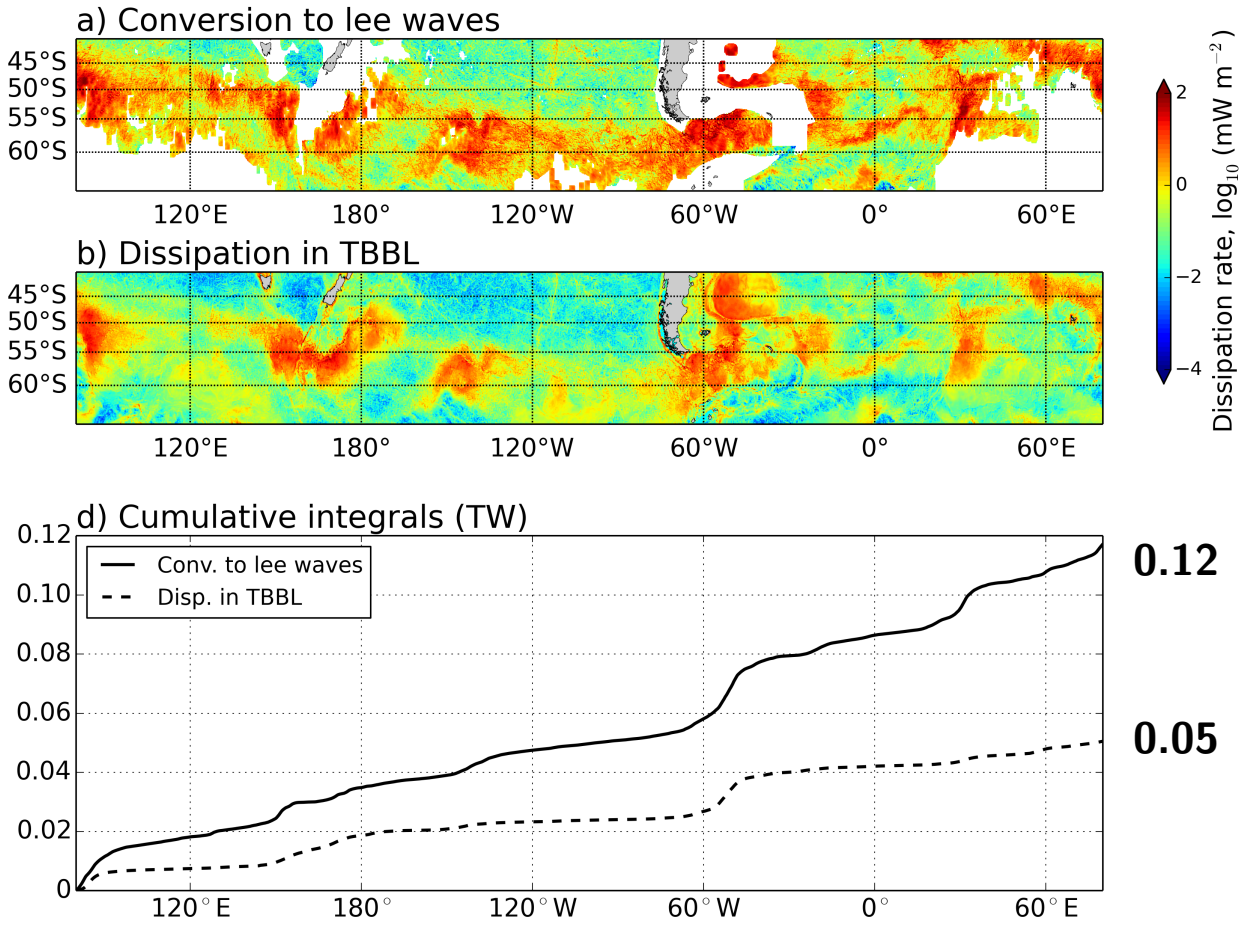
Energy conversion to lee waves



- Mean flow (0.04 TW)
- Eddy flow (0.12 TW)

$\Big\} \rightarrow$ Lee waves

Energy dissipation of eddies



Transient eddies $\rightarrow$ { Conversion to lee waves (0.12 TW); Dissipation in TBBL (0.05 TW)

Comparisons

Table 1: Southern Ocean-integrated dissipation rates, unit: TW

	Total	Eddy	Mean	Topography
Conversion into lee waves	0.16	0.12 (75%)	0.04 (25%)	G2010
	0.10	0.07 (76%)	0.03 (24%)	GA2010
	0.09	0.06 (69%)	0.03 (31%)	NF2011
Dissipation in TBBL	0.07	0.05 (75%)	0.02 (25%)	—

- **Energy conversion into lee waves:**
  - Mean flow ($\leq$ 31%)
  - Eddy flow ($\geq$ 69%)

  $\}\rightarrow$ Lee waves

- **Energy dissipation of transient eddies:**

  Transient eddies $\rightarrow$ { Conversion to lee waves; Dissipation in TBBL

Conclusions

Transient eddies $\rightarrow$ Lee waves $\rightarrow$ Turbulent mixing

The energy conversion from eddies to lee waves is significant and should be represented in eddy-resolving ocean models as a dissipation mechanism for transient eddies.

Work in progress

Idealised periodic channel configuration, MOM6

- Sensitivity to wind stress
- Parameterised lee waves $\rightarrow$ mixing
- Parameterised eddies $\rightarrow$ lee waves

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