Eddy effects on South Atlantic Ventilation Pathways using Lagrangian backtracking

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How do eddy effects alter source regions of South Atlantic AAIW?

→ Lagrangian backtracking from AAIW to surface to determine source region, pathway and transit time

→ **Eddy resolving velocities** vs **Seasonal mean flow**

Objective – AAIW Formation

- Source regions influence inventory and age of AAIW [1]
- Coarse vs high resolution ocean models: strong influence of eddy effects on AAIW formation [2]
- Lagrangian backtracking provides insight into discrete pathways from water mass to source region

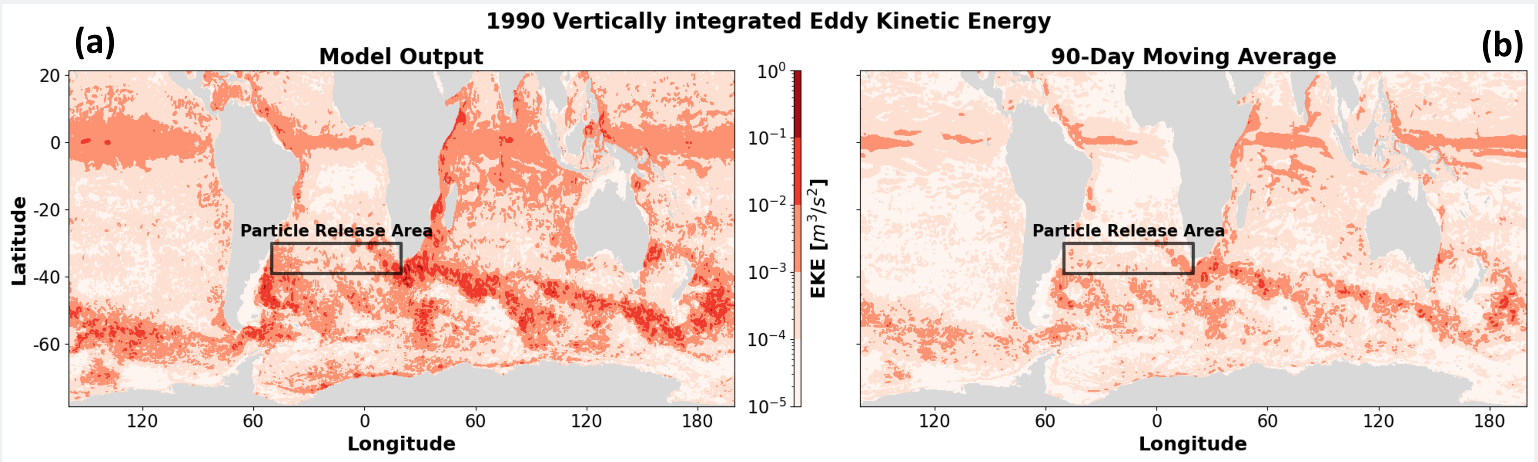

Figure 1: $EKE = \frac{1}{2n}\sum^n \vec{u}'^2$ $u' = u - \overline{u_{year}}$. **(a)** Eddy permitting model output, $u = \overline{u_{1d}}$. **(b)** Seasonal mean flow: , $u = \overline{u_{90d}}$. Black box indicates particle release area.

Setup

Configuration (Fig. 1):

- Eddy permitting: 1-Day mean (standard output)
- Seasonal mean flow: 90-Day rolling mean of standard output

Advection:

- Parcels: discrete advective particle tracking
- AAIW definition: 30°-40°S, 60°W-20°E, σ = 26.8-27.4 kg/m³, >10^5 particles
- Surface criterion: $z_{particle}$<10m
- Velocities: 1/10° ocean model (Parallel Ocean Program) Time: 1990, 120 cycles

Using Lagrangian backtracking, we demonstrate how mesoscale eddy effects connect the ACC with South Atlantic AAIW and accelerate water mass formation by altering ventilation pathways.

Source Regions – Eddy effects let ACC surface waters reach South Atlantic AAIW

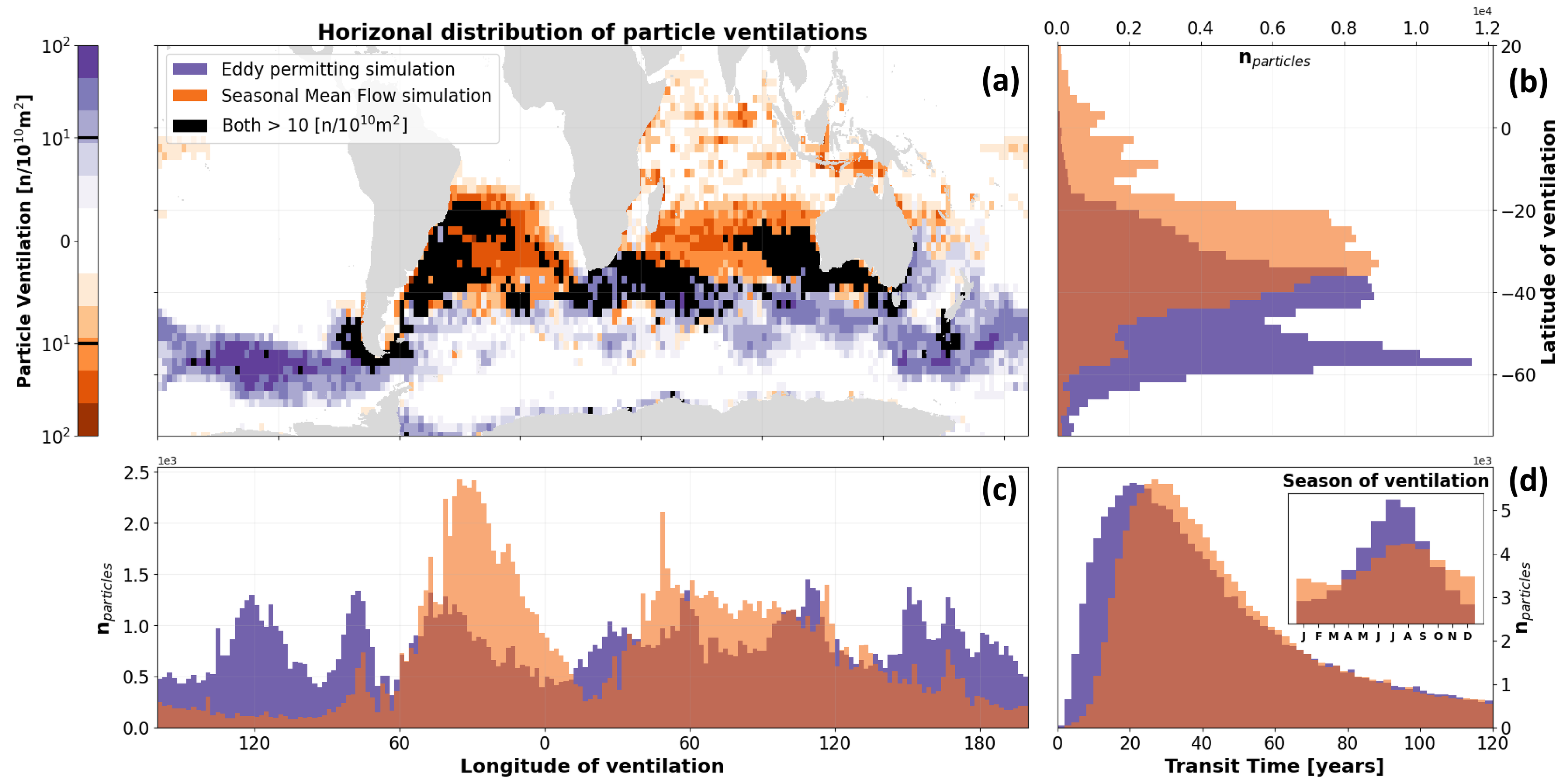

Figure 2: South Atlantic AAIW source regions (here: last surface contact) of eddy permitting (purple) and seasonal mean flow (orange) simulation. **(a)** Horizontal distribution (2x2°) of ventilations, black patches indicate strong ventilation in both simulations. **(b)** Latitudinal (2°) and **(c)** longitudinal (2°) distribution. **(d)** Transit times ($\Delta t = 2a$) and seasonality of ventilations.

Pathways - Seasonal mean overestimates Atlantic and Indian Ocean's contribution to South Atlantic AAIW

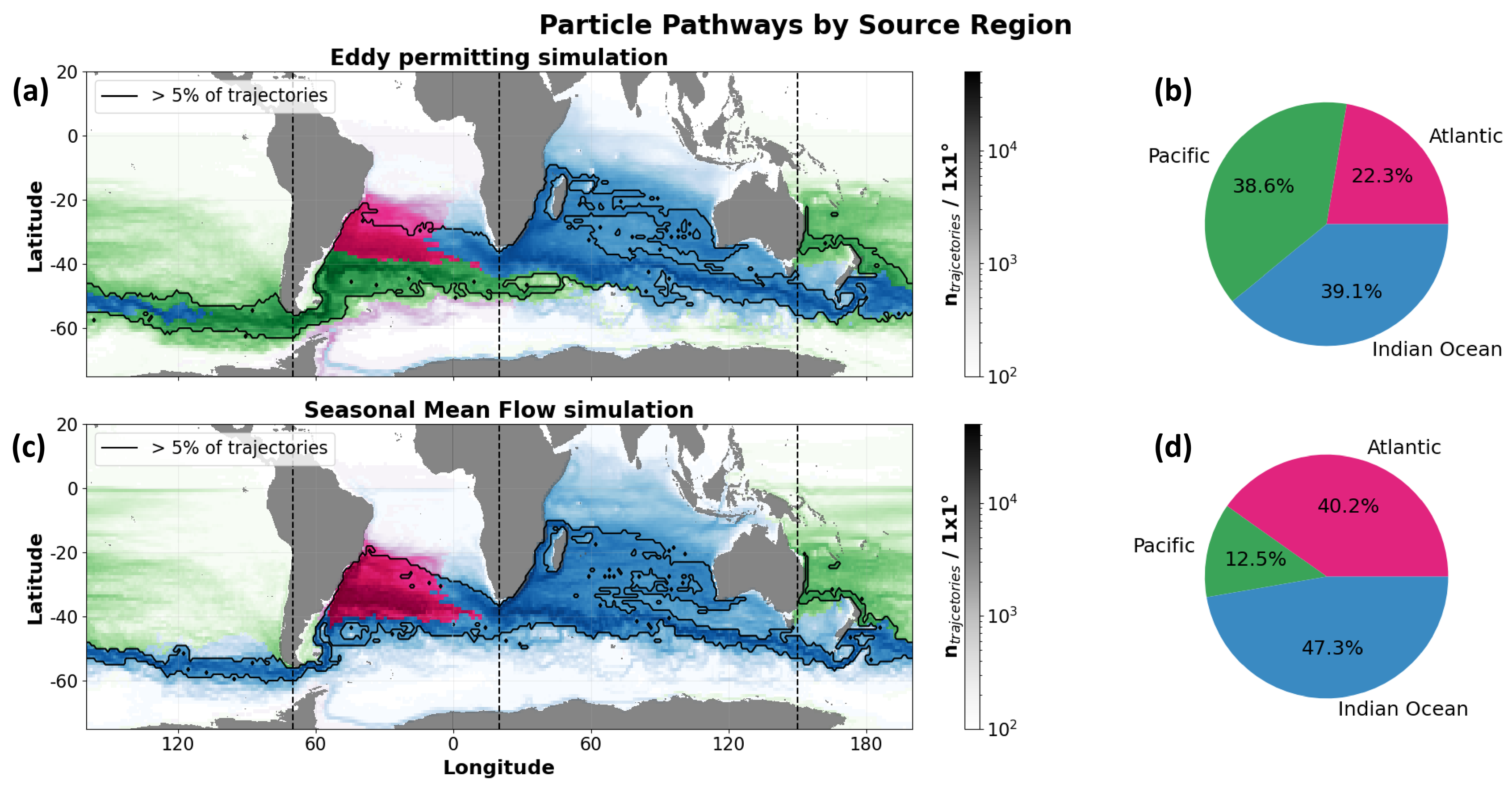

Figure 3: Pathways and distributions by source region for **(a-b)** eddy permitting and **(c-d)** seasonal mean flow simulation. **(a,c)** Trajectories per 1x1° dyed in dominating source region. Source region defined by ventilation inside the ocean basin (dashed line). Black contour shows main pathways (>5% of trajectories).
(b,c) Share of ventilations by source region (compare Fig. 2c).

Key Results

- Without eddy effects, AAIW originates from Atlantic and Indian Ocean's mid-latitudes
- Eddy effects facilitate a meridional "escape" of ACC surface waters into AAIW
- Pacific water masses get favored by eddy effects and rejuvenate AAIW
- Mesoscale eddies rejuvenate South Atlantic AAIW by ~4 years by favoring the cold-water route and blocking water masses from the Indian Ocean.

Transit times – Eddy effects rejuvenate South Atlantic AAIW with young Pacific water masses

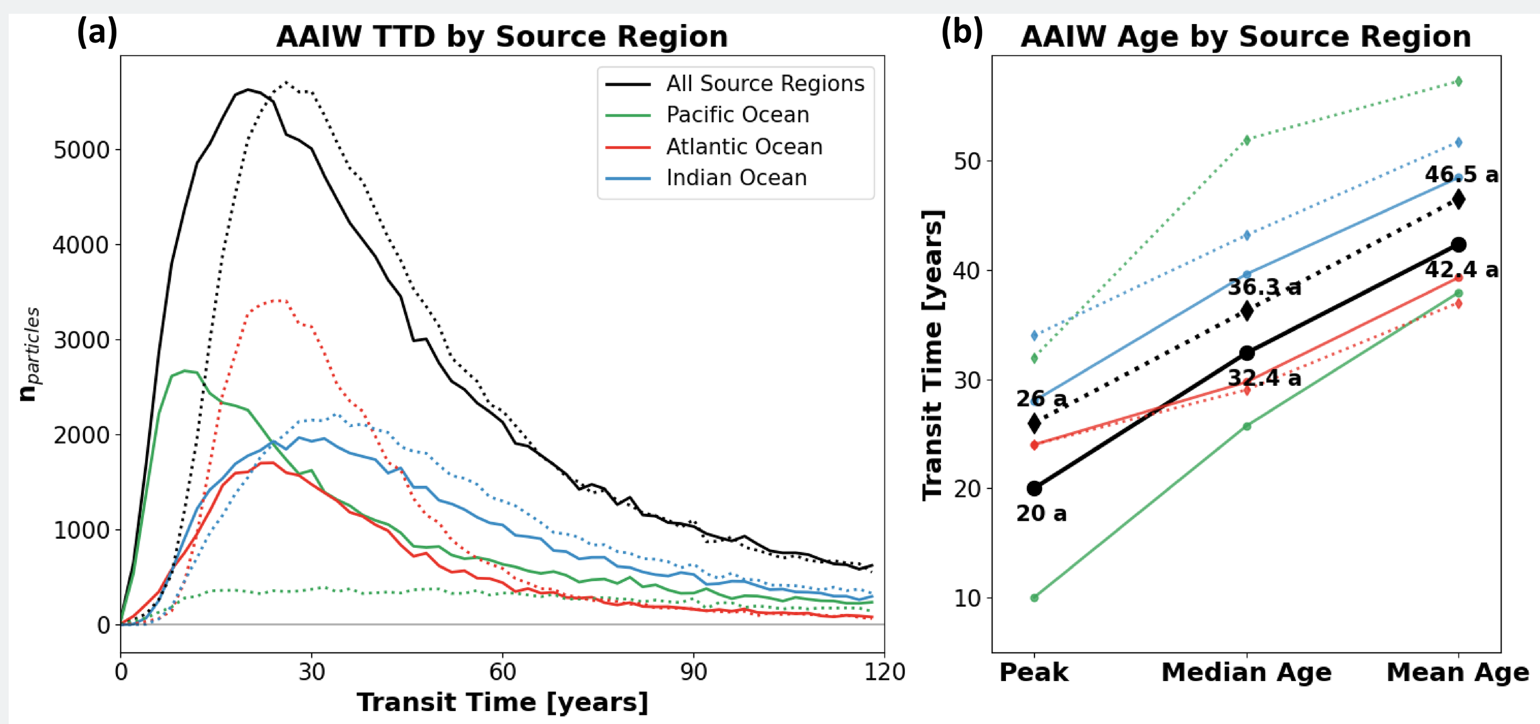

Figure 4: **(a)** Transit time distribution of particles in eddy permitting (solid) and seasonal mean flow (dotted) simulation ($\Delta t = 2a$). Source regions (ocean basins) show different distributions. **(b)** chart of water mass ages derived from (a). Time of ventilation maximum (peak), median, and average shown for each source region in both simulations.

References:

[1] Chouksey, M., Griesel, A., Eden, C. and Steinfeldt, R., **2022**. Transit Time Distributions and ventilation pathways using CFCs and Lagrangian backtracking in the South Atlantic of an eddying ocean model. *Journal of Physical Oceanography, 52(7)*, pp.1531-1548.

[2] Kamenkovich, I., Garraffo, Z., Pennel, R. and Fine, R.A., **2017**. Importance of mesoscale eddies and mean circulation in ventilation of the S outhern O cean. *Journal of Geophysical Research: Oceans, 122*(4), pp.2724-2741.