Water mass subduction in the isopycnic coordinate

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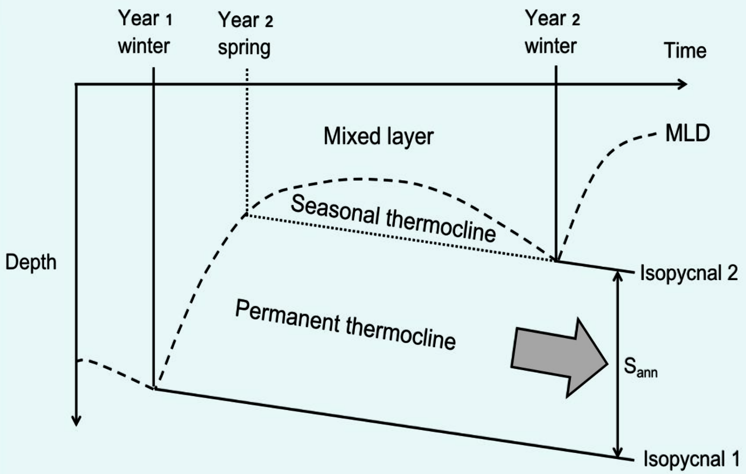
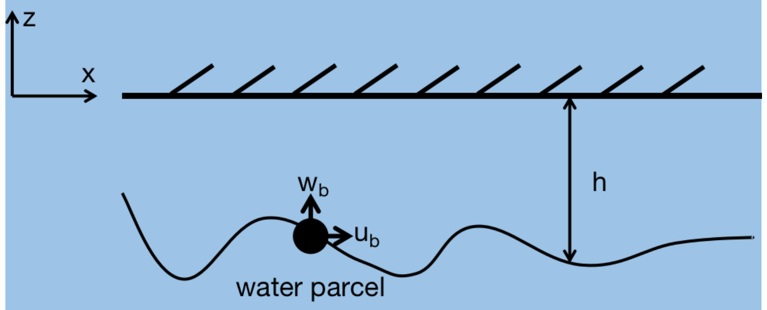
Contents

Classic theories of subduction



Schematic 1 of subduction

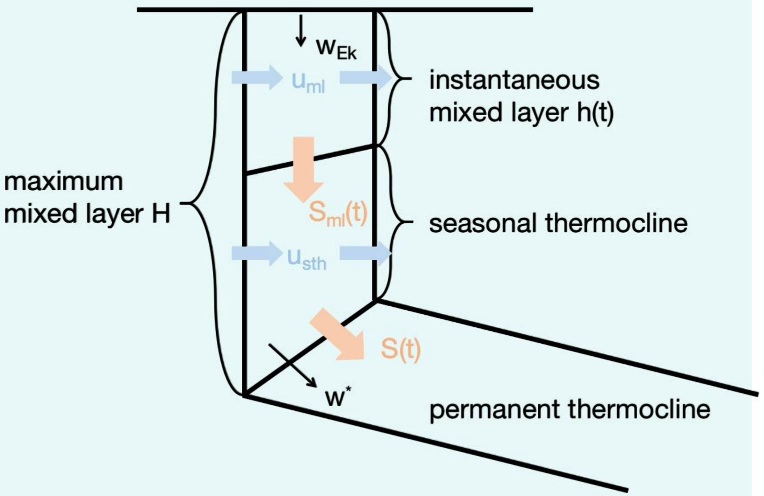
A



$$S = \frac{\partial h}{\partial t} + \boldsymbol{u}_b \cdot \nabla h + w_b$$

Water parcel at the ML base

B



Schematic 2 of subduction

C

Subduction estimated at the migrating isopycnal

$$S = \frac{\partial h}{\partial t} + \boldsymbol{u}_b \cdot \nabla h + w_b \qquad (1)$$

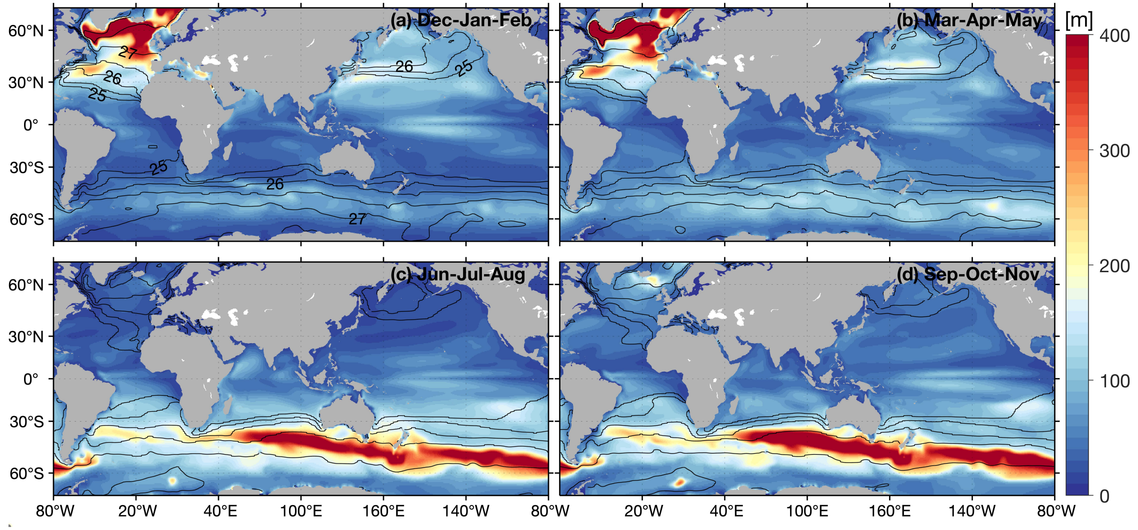
$$\left.\frac{\partial h}{\partial t}\right|_\sigma \Delta t = h(r_0 + \Delta r, t_0 + \Delta t) - h(r_0, t_0) = \left.\frac{\partial h}{\partial t}\right|_r \Delta t + (\boldsymbol{c}\Delta t) \cdot \nabla h \qquad (2)$$

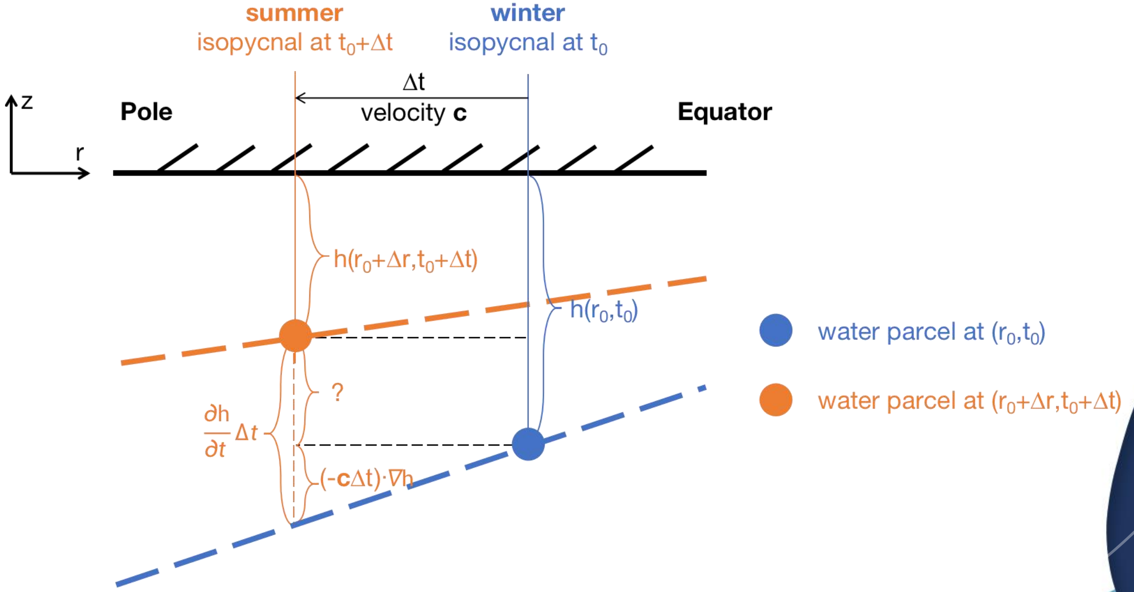
$$S = \left.\frac{\partial h}{\partial t}\right|_\sigma + \left.\boldsymbol{u}_b\right|_\sigma \cdot \nabla h + w_b = \left.\frac{\partial h}{\partial t}\right|_r + \boldsymbol{c} \cdot \nabla h + (\boldsymbol{u}_b - \boldsymbol{c}) \cdot \nabla h + w_b \qquad (3)$$

$$S_t = \left.\frac{\partial h}{\partial t}\right|_\sigma,$$ → temporal term

$$S_h = S_{h1} + S_{h2} = -\boldsymbol{c} \cdot \nabla h + \boldsymbol{u}_b \cdot \nabla h,$$ → lateral induction; → migration of isopycnal

$$S_v = w_b.$$ → vertical velocity





Subduction estimated at the migrating isopycnal

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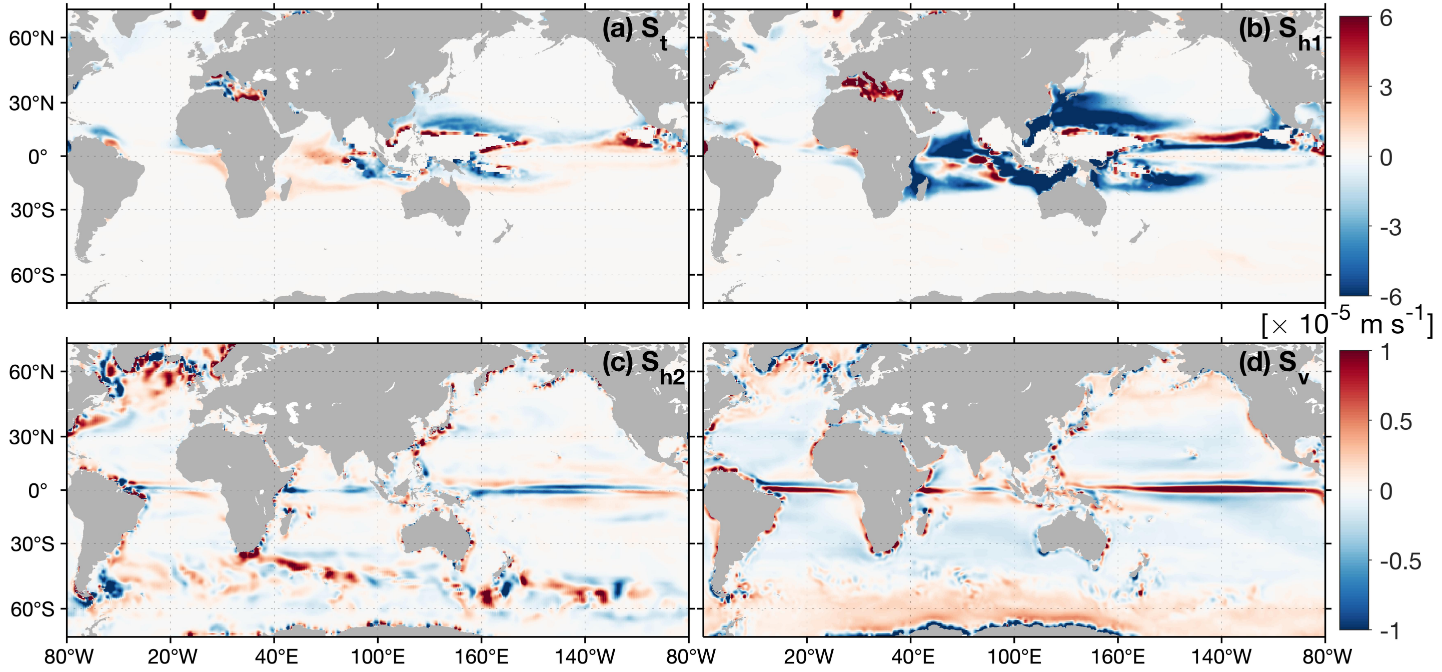


1) Large scale is dominated by the vertical velocity at the ML base, i.e., Ekman pumping.

2) Spatial patterns along the ACC and in the polar North Atlantic are controlled by lateral induction.

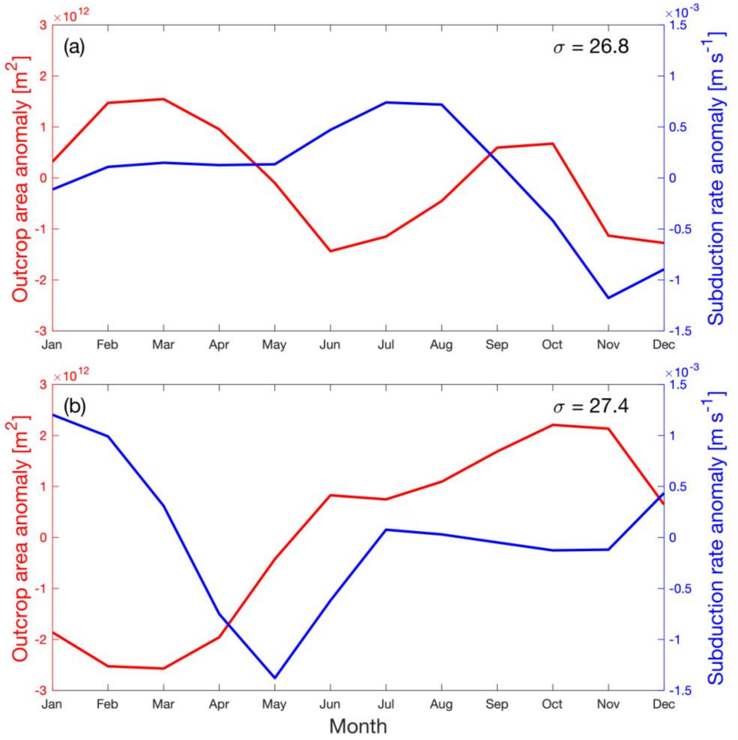
3) Migration of isopycnals matters in the tropical and subtropical regions.

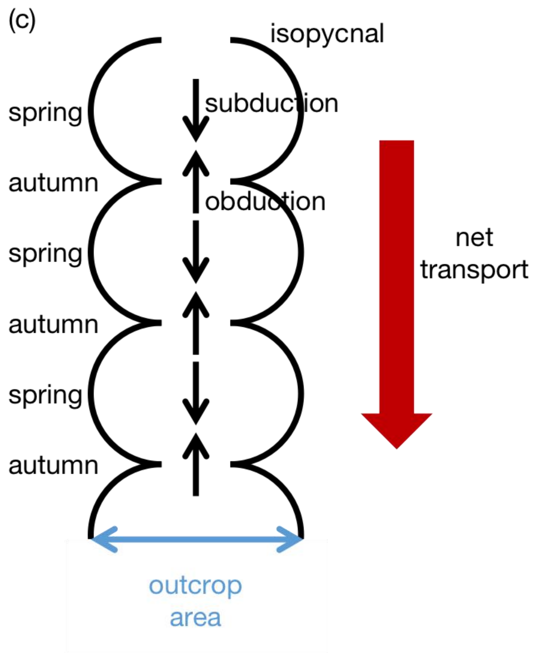
4) The temporal term does not vanish to zero as assumed in the theory of Stommel's demon.

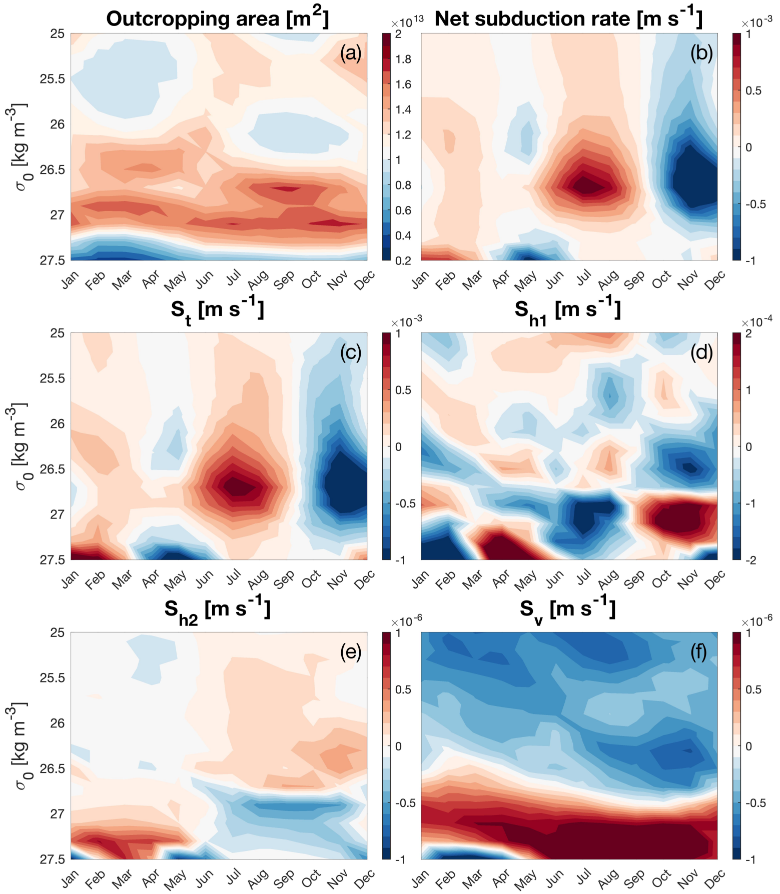
"Eddy" component of subduction

Mean + Eddy: $\bar{u} + u' \longrightarrow \overline{u' \cdot u'}$

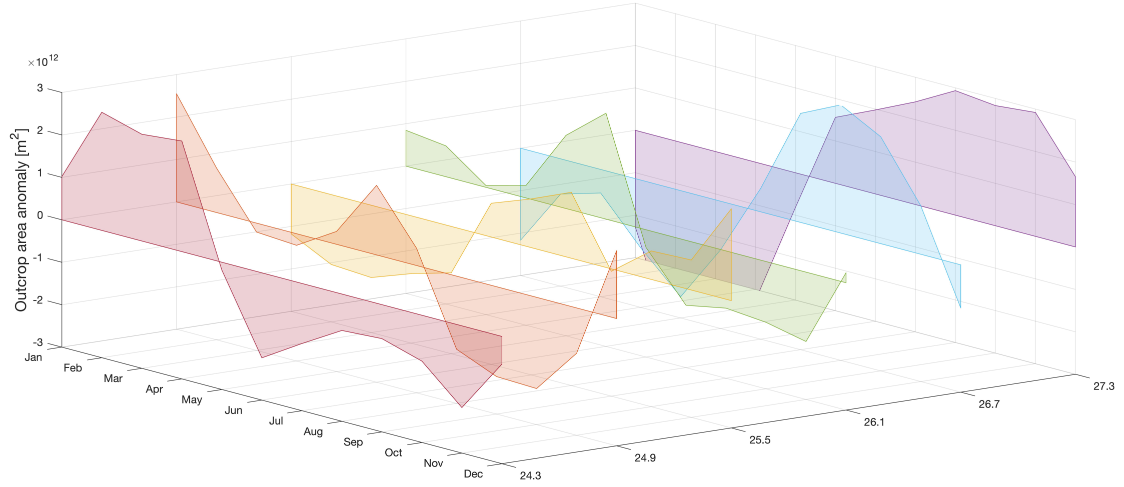
$$\overline{S} = \frac{1}{T}\int_0^T \left(\frac{1}{A}\int_0^A S\,dA\right) dt$$



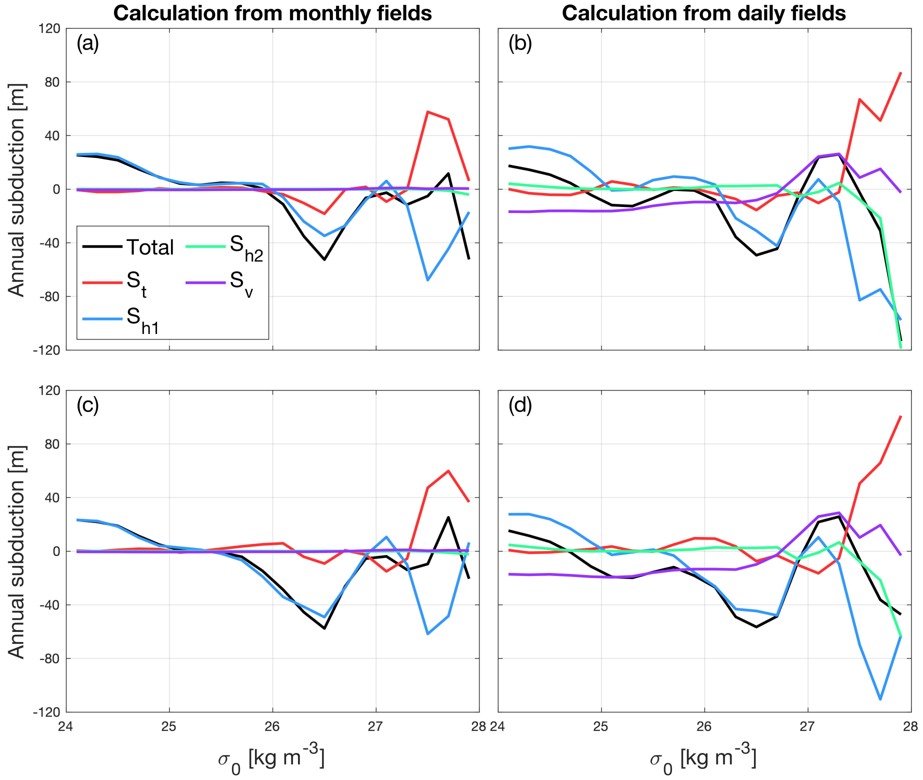




“Eddy” component of subduction



Acronyms	*Full name*	*Density range (ECCO)*	*Density range (Argo)*
NPSTMW	North Pacific Subtropical Mode Water	$25.2 \leq \sigma < 26.4$	$25.1 \leq \sigma < 25.5$
NASTMW	North Atlantic Subtropical Mode Water	$25.2 \leq \sigma < 26.4$	$26.4 \leq \sigma < 26.6$
SHSTMW	Southern Hemisphere Subtropical Mode Water	$25.2 \leq \sigma < 26.4$	$26.3 \leq \sigma < 26.8$
SAMW	Subantarctic Mode Water	$26.4 \leq \sigma < 27.1$	$26.8 \leq \sigma < 27.2$
AAIW	Antarctic Intermediate Water	$27.1 \leq \sigma < 27.6$	$26.8 \leq \sigma < 27.4$



1. The outcropping area is dependent on time and density.
2. Nonlinearity leads to modifications of subduction rates at different isopycnals.

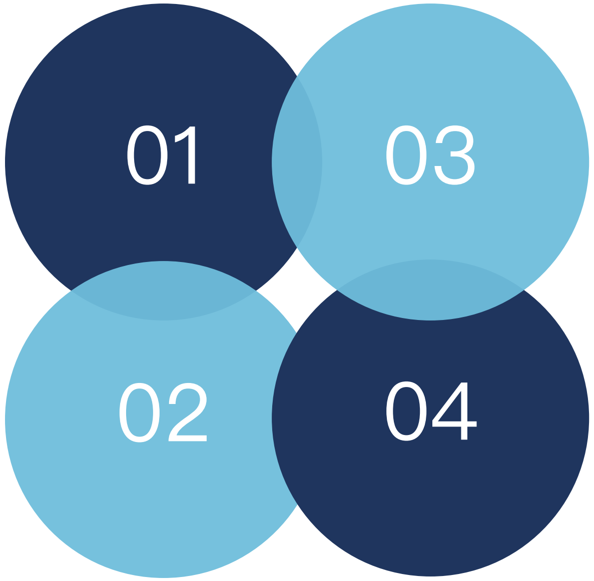
Conclusions and future work

Conclusion 1

It is necessary to switch to the isopycnic coordinate.

Conclusion 2

Subduction rates are greatly modified by the eddy component.



Prospective 1

It is of interest to consider PV fluxes across the ML base.

Prospective 2

Anther interesting calculation will be to connect water mass subduction to transformation at the surface.

Thanks for your attention