Thermohaline feedbacks and multiple equilibria in the adiabatic regime

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The zonally integrated heat transport

- Total oceanic transport is larger in the NH.
- The atmospheric transport compensates the asymmetry.
- ITCZ shifted to the NH.
The peculiarity of Atlantic heat transport

- The Atlantic HT is northward everywhere.
- Upgradient of the mean temperature in SH.
- Pacific and Indian do not compensate fully.
- Pole-to-pole HT is about 0.8PW.
The quasi-adiabatic Atlantic overturning

- The adiabatic pole-to-pole cell flows along the isopycnals outcropping in the channel and the NH.
- Diapycnal fluxes are mostly confined to the mixed layer.
- Diabatic cells reinforce (weaken) the adiabatic cell in the NH (SH).
- How can we have freshwater fluxes into the ocean at both ends of the overturn?
The idealized Atlantic ocean

- $L_e = 1200$ km
- $L_y = 9600$ km
- $L_x = 2400$ km
- $H = 2400$ m

increase

- Half-sized basin in a notched box
- Hydrostatic MITgcm at 100km grid
- Linear EoS: $b \sim \alpha T - \beta S$
- Parametrized eddies and ML
- $\kappa = 2.5 \times 10^{-6} \text{m}^2\text{s}^{-1}$

Wind-stress and freshwater flux are symmetric around equator in reference case.
Surface temperature is warmer in NH high latitudes.
All forcing depend on latitude only.
Effect of salt: more shared surface isopycnals and stronger ROC

The salt feedback increases the ROC by 47%, by widening the shared surface buoyancy window.
The salt feedback gives a state with a strong pole-to-pole cell, largely adiabatic.
The salt feedback also gives a state with a reversed interhemispheric cell, weaker and more diabatic.
Thermohaline variability: low diffusivity

![Graph showing equatorial freshwater transport vs. equatorial heat transport for left-to-right and right-to-left transport.](image)

<table>
<thead>
<tr>
<th>equatorial freshwater transport [Sv]</th>
<th>equatorial heat transport [TW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.08</td>
<td>-100</td>
</tr>
<tr>
<td>-0.06</td>
<td>-50</td>
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<tr>
<td>-0.04</td>
<td>0</td>
</tr>
<tr>
<td>-0.02</td>
<td>50</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Legend:
- red circle: left-to-right
- blue circle: right-to-left

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Conclusions

- Freshwater flux provides a positive feedback which increases the ROC and decreases the pole-to-pole density difference.

- In the adiabatic regime the meridional heat transport increases with decreasing pole-to-pole density difference.

- The positive feedback allows for a reversed interhemispheric cell, which excludes the ACC region, more diabatic.

- At low diffusivities, large fluctuations are found around each “equilibrium”, which induce transitions between the two states.

Question

- Is the existence of multiple attracting states robust in the eddying regime?
The pattern of the oscillation