

Ocean: Heat budget and transport

ATM2106

The heat budget for a column of ocean

$$\frac{\partial H}{\partial t} = -Q_{net} - \left(\frac{\partial H_x}{\partial x} + \frac{\partial H_y}{\partial y} \right)$$

$$H = \rho_{ref} c_w \int_{bottom}^{top} T dz$$

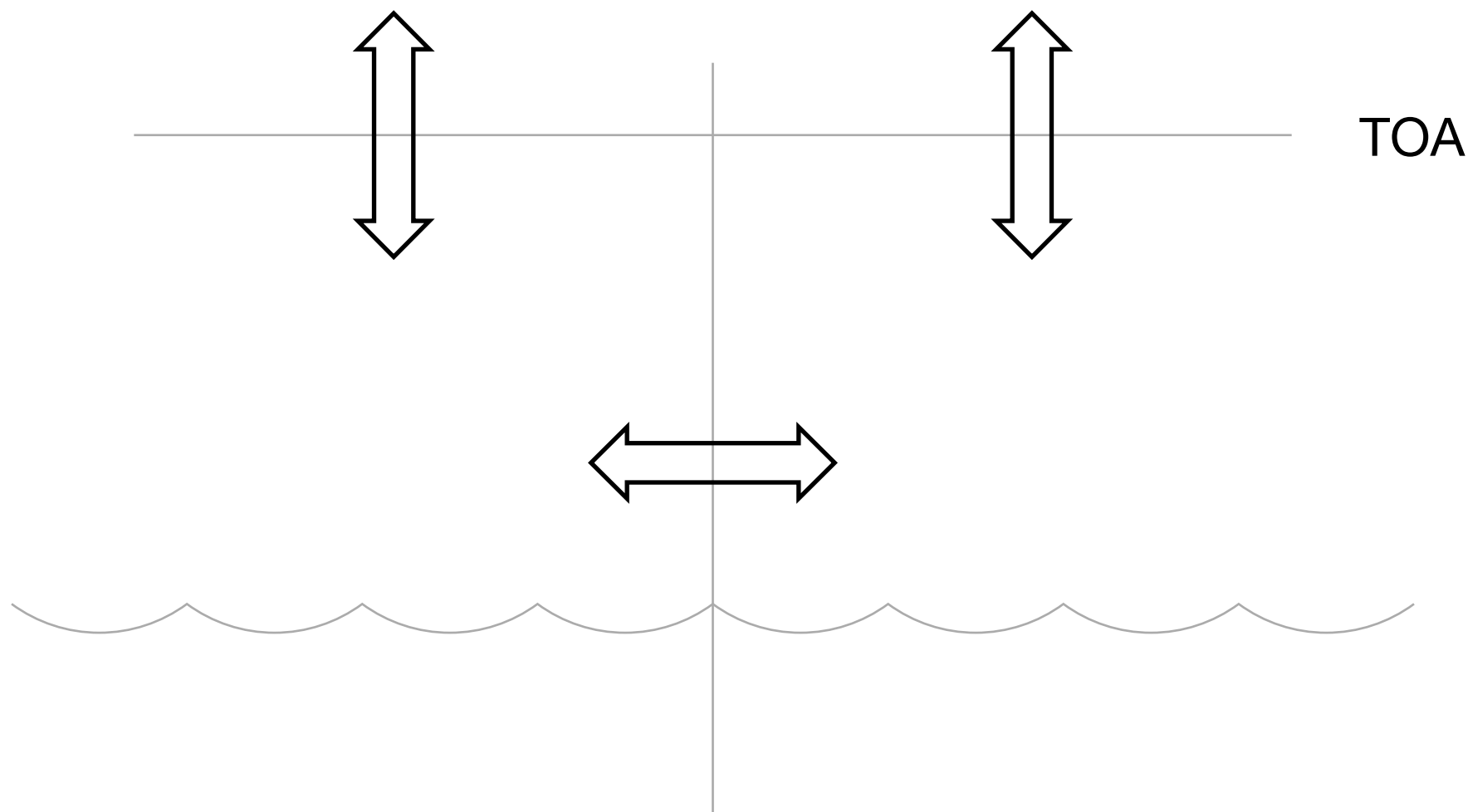
$$H_x = \rho_{ref} c_w \int_{bottom}^{top} u T dz$$

$$H_y = \rho_{ref} c_w \int_{bottom}^{top} v T dz$$

Changes in heat stored in a column of the ocean
= surface heat flux + horizontal heat flux by ocean currents

How to measure ocean heat transport?

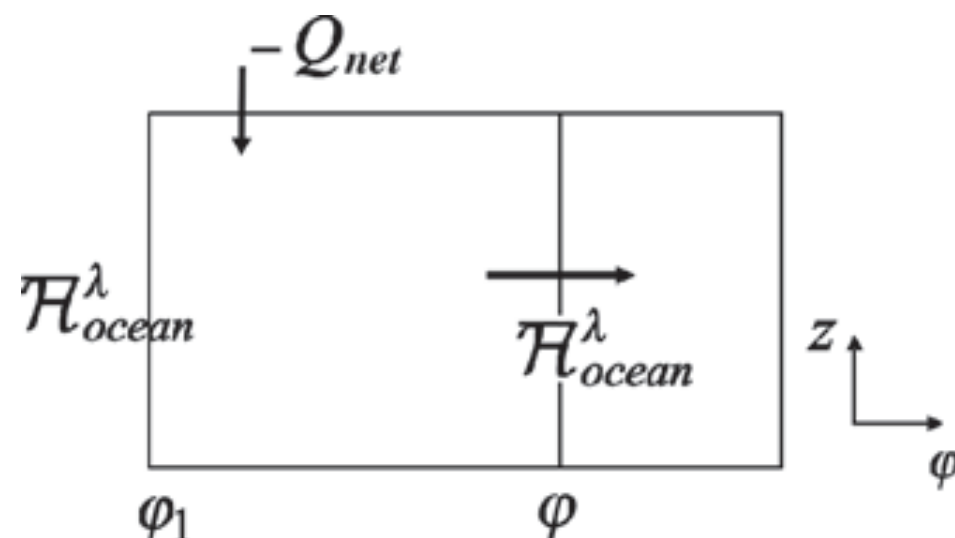
- By subtracting atmospheric heat transport from the total heat transport measured at the top of the atmosphere.



How to measure ocean heat transport?

- By subtracting atmospheric heat transport from the total heat transport measured at the top of the atmosphere.
- By finding the heat transport that balances the surface heat flux under the assumption of steady state.

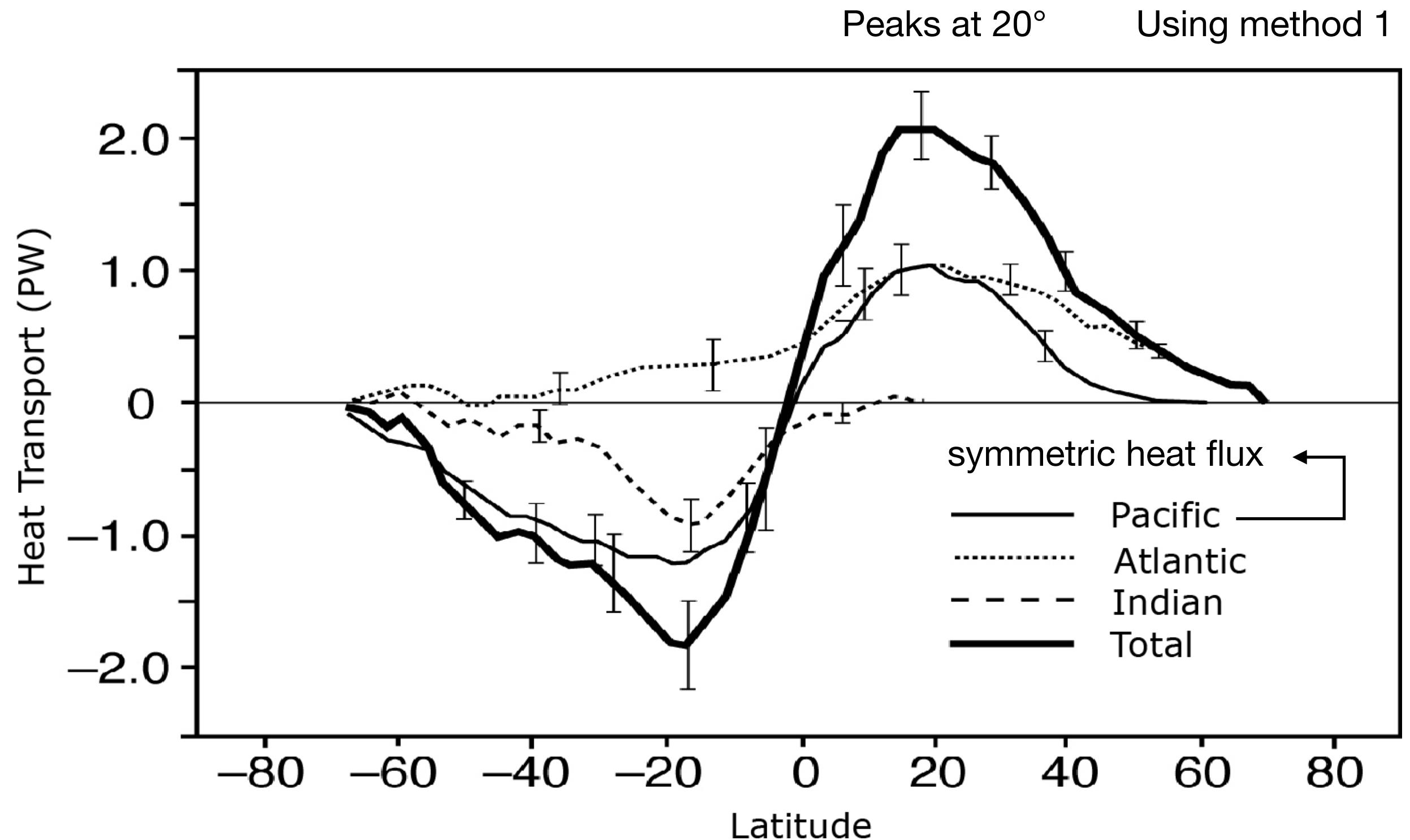
$$H_{ocean}^{\lambda}(\phi) - H_{ocean}^{\lambda}(\phi_1) = -a^2 \cos \phi \int_{\phi_1}^{\phi} \int_{\lambda_{west}}^{\lambda_{east}} Q_{net} d\lambda d\phi$$



How to measure ocean heat transport?

- By subtracting atmospheric heat transport from the total heat transport measured at the top of the atmosphere.
- By finding the heat transport that balances the surface heat flux under the assumption of steady state.
- By directly measuring the heat transport at a few locations.

Northward heat transport in the world ocean

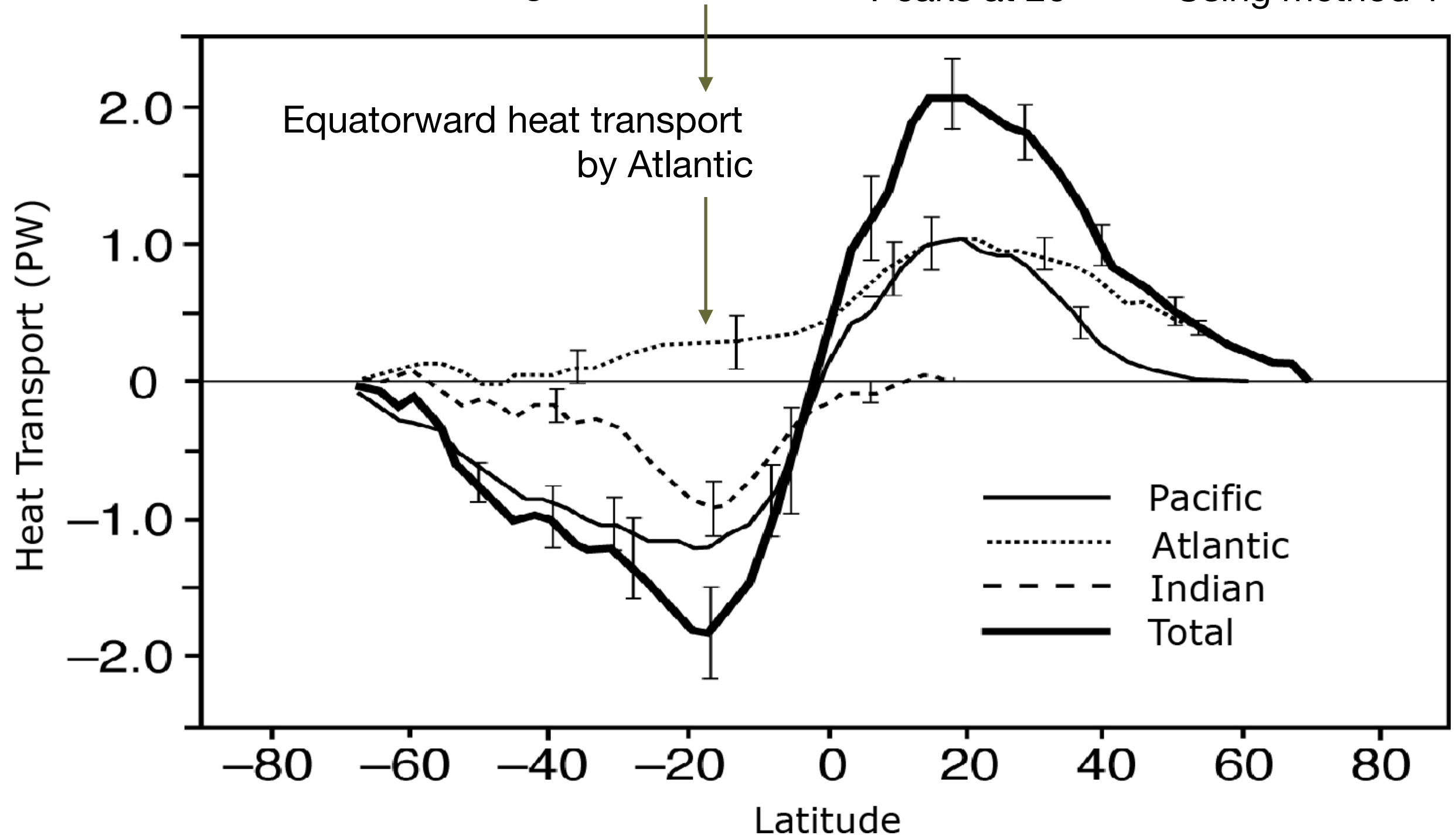


Northward heat transport in the world ocean

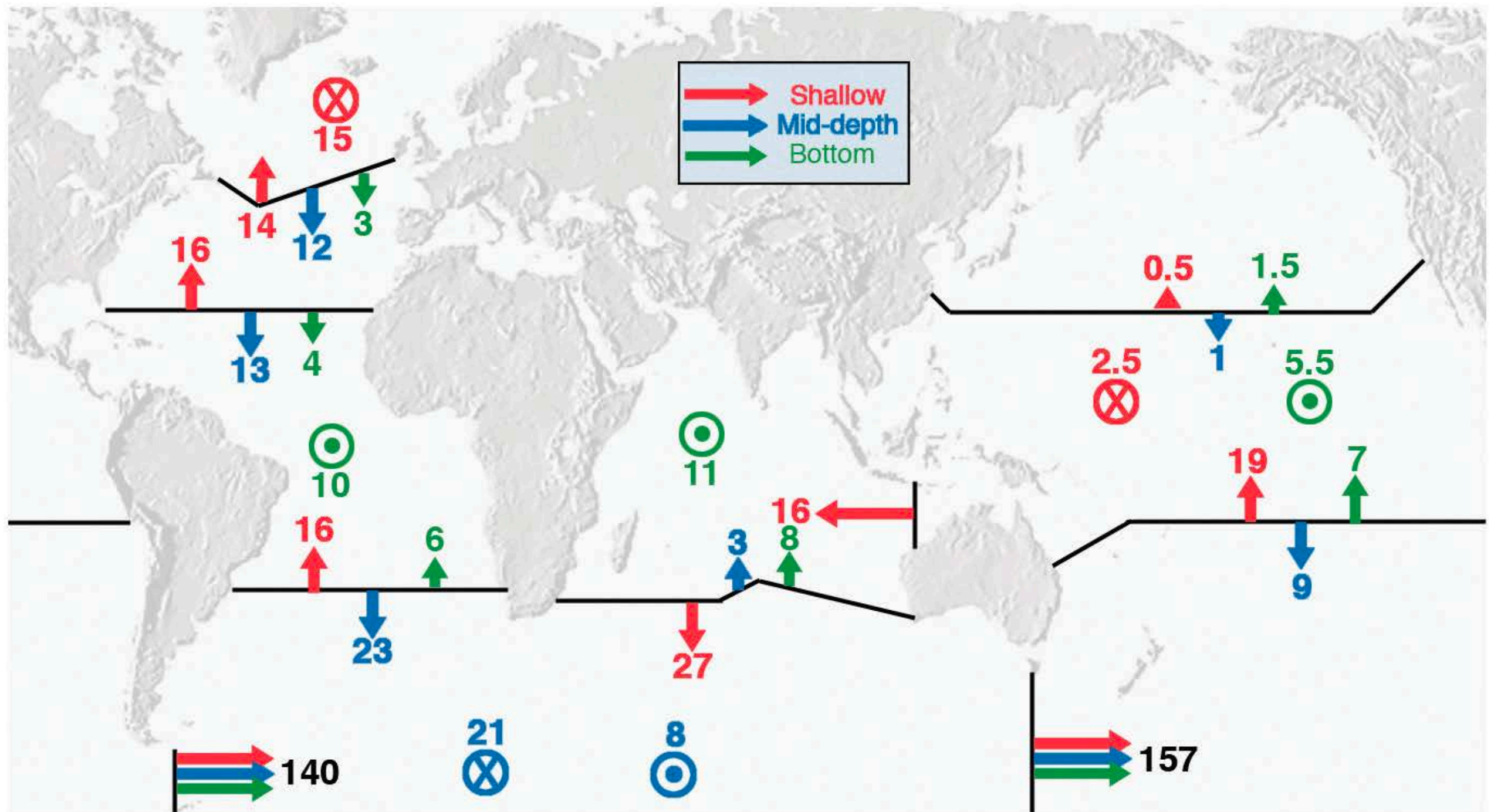
Atlantic Meridional Overturning Circulation

Peaks at 20°

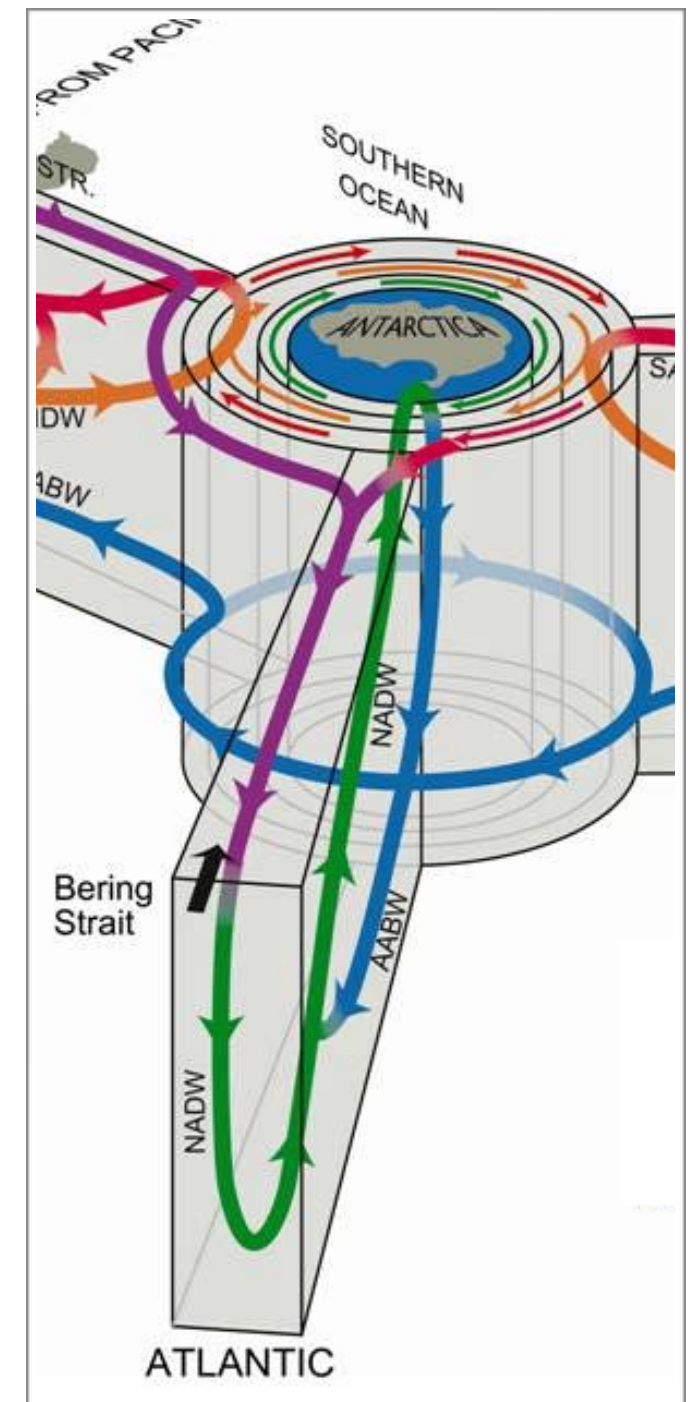
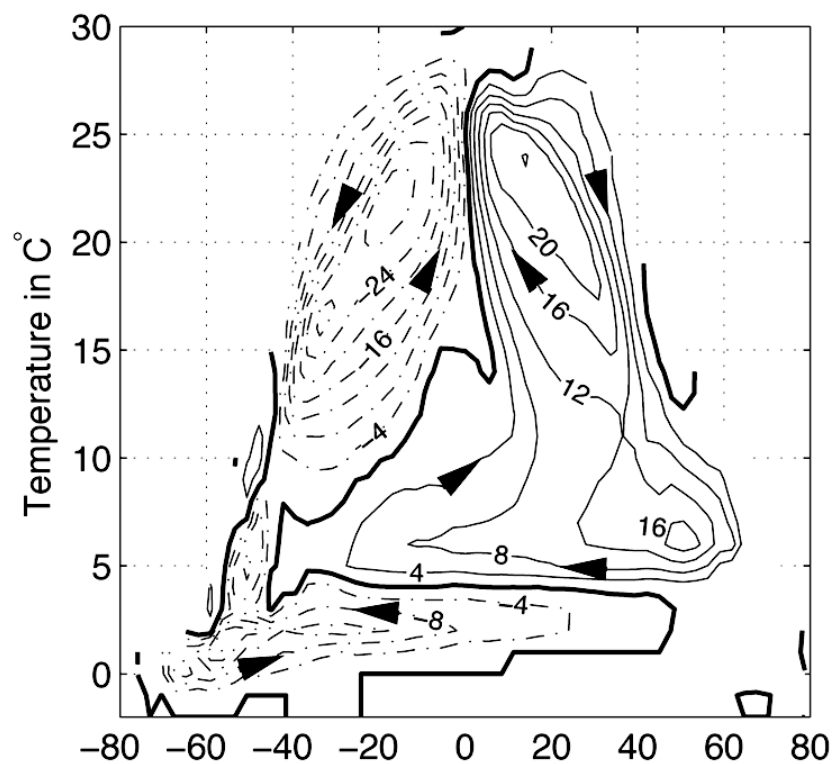
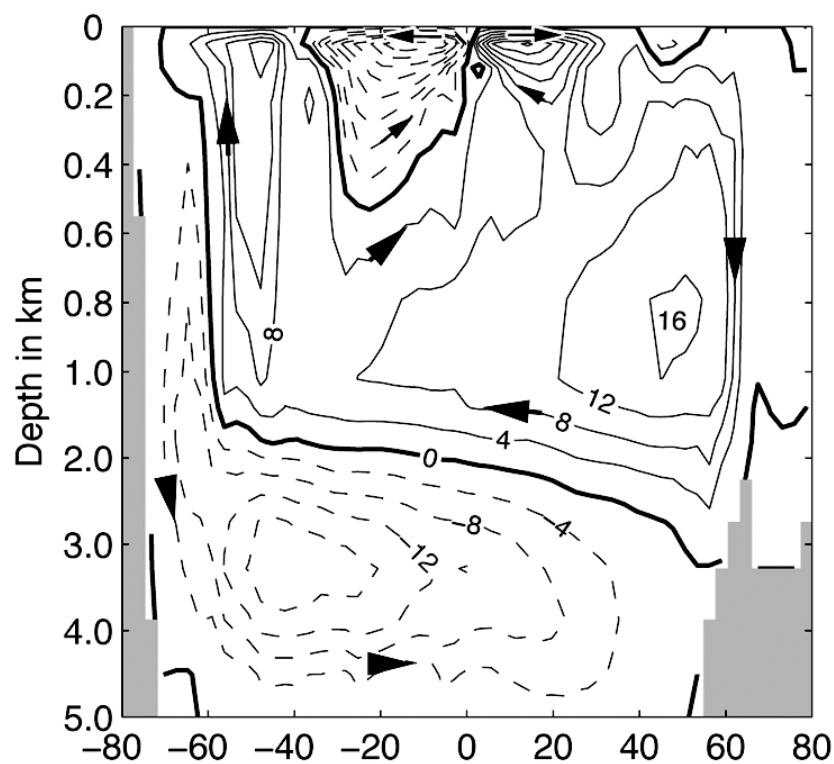
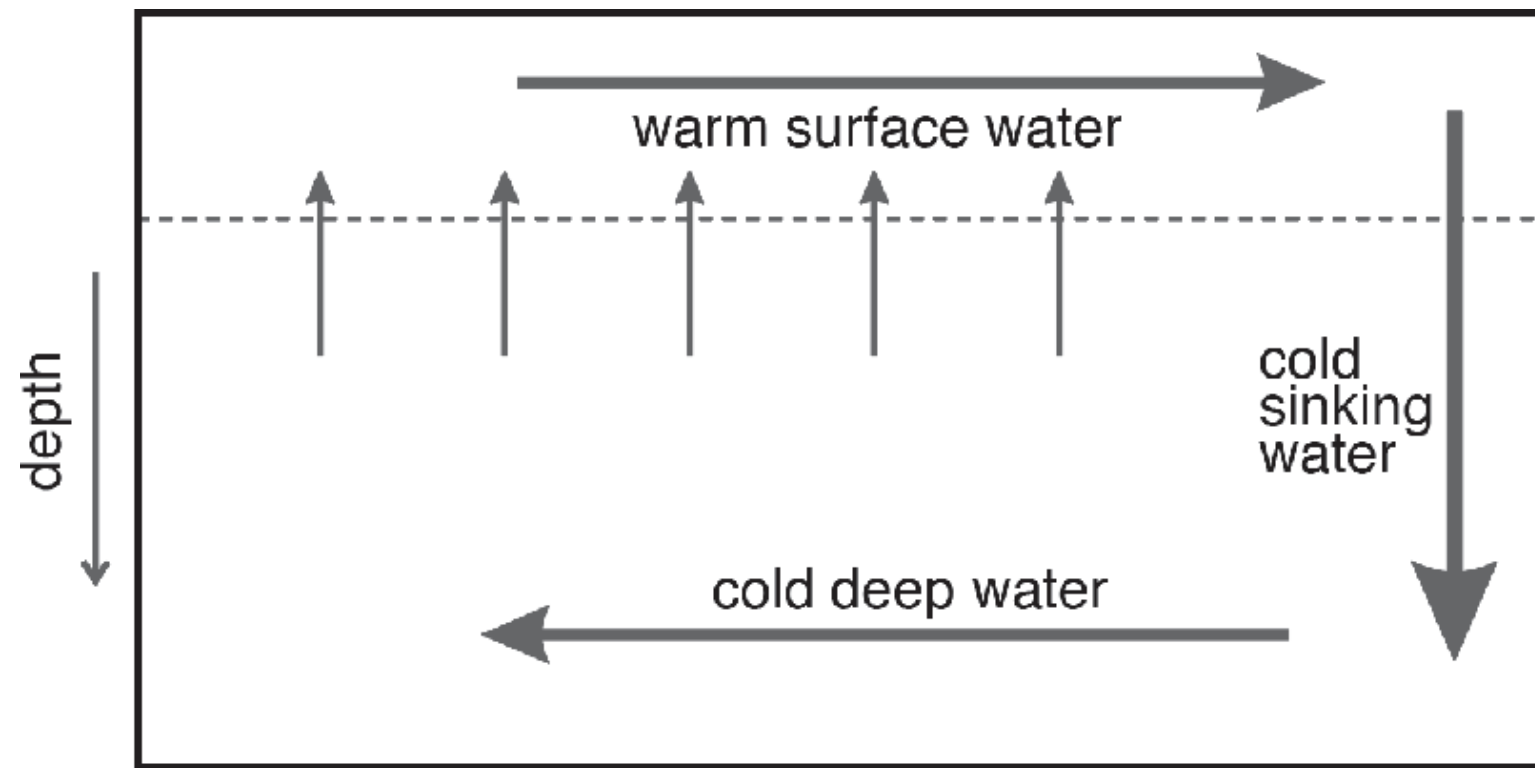
Using method 1



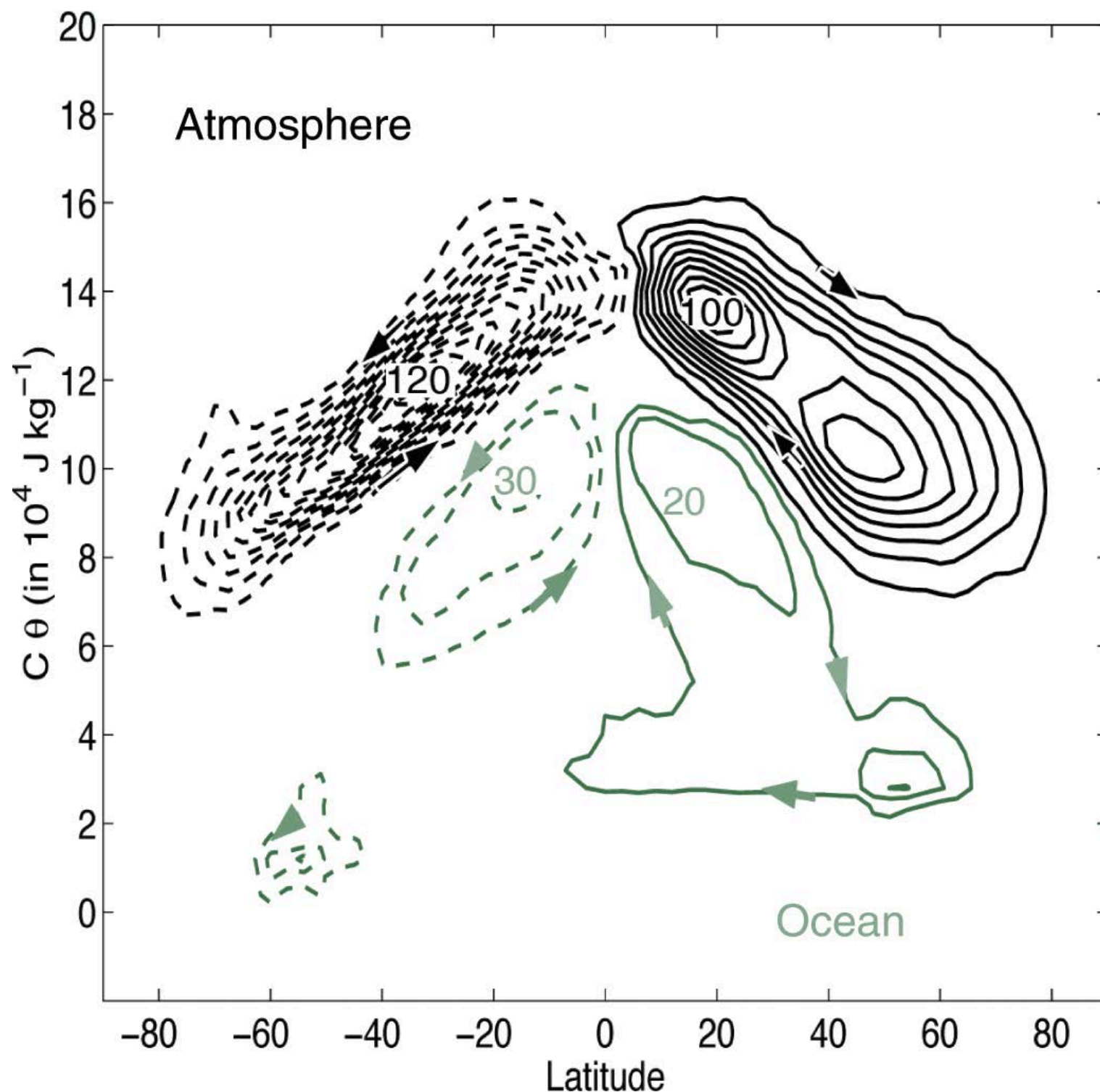
The estimate of global ocean circulation pattern



The ocean's meridional circulation

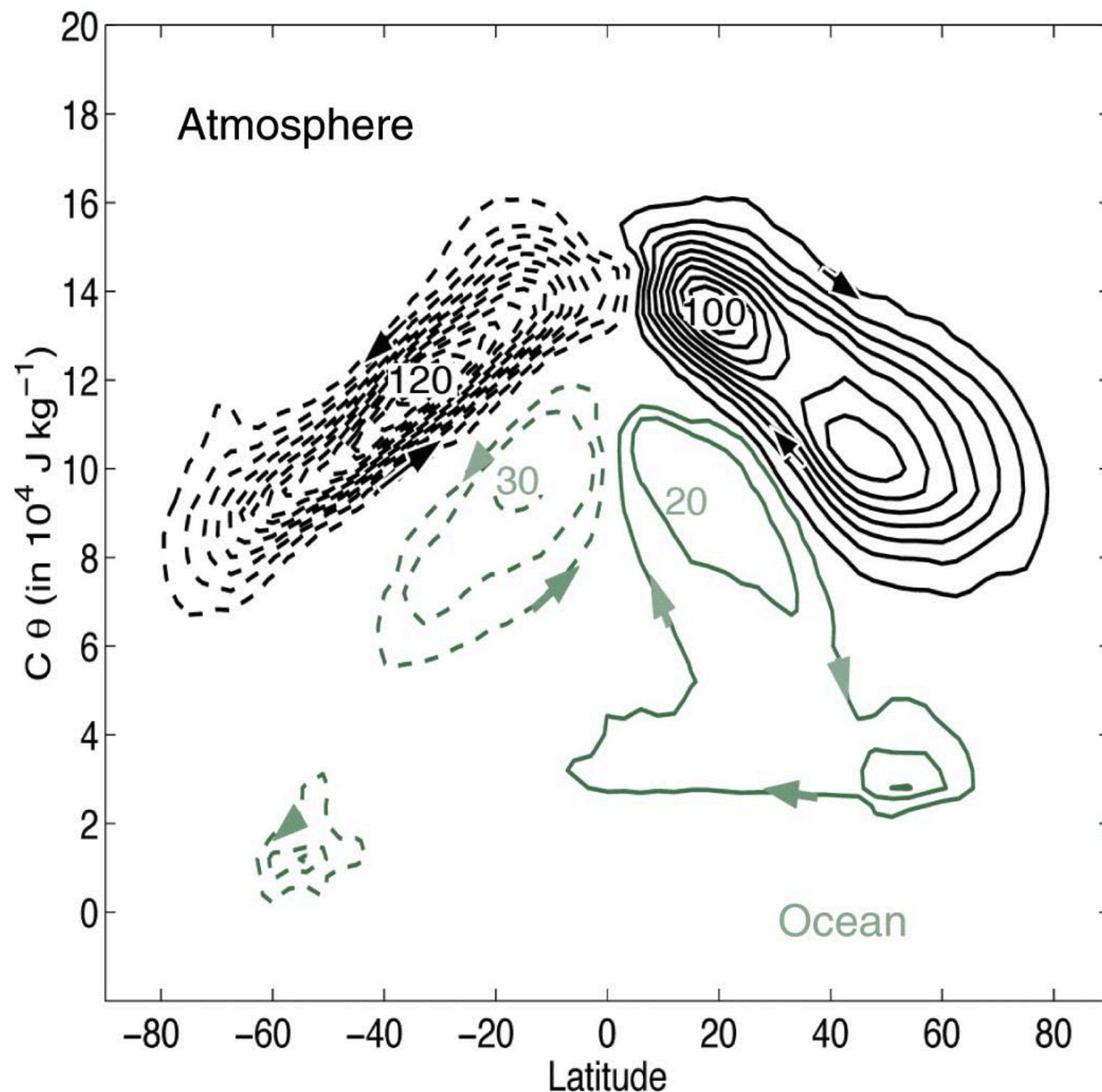


Annual mean mass streamfunction



- One big cell for the atmospheric overturning circulation
 - Mean + eddy
 - Mean: tropics
 - Eddies: middle- to high latitudes

Annual mean mass streamfunction



- Atmospheric overturning circulation is much stronger than the one of the ocean.
 - Similar “thickness” of the overturning circulation
- higher heat capacity of the ocean v.s. greater temperature differences in the atmosphere

Freshwater transport

- Freshwater transport can be estimated by the methods similar to the heat transport.
- Equatorward freshwater transport = poleward salt transport → important in preconditioning the surface waters of the Atlantic to convection

