UNIVERSITÄT LEIPZIG

Climate Dynamics (Summer Semester 2017)
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Today's Lecture (Lecture 8): Meridional overturning circulation of the oceans

Reference

Hartmann, *Global Physical Climatology* (1994), Ch. 2, 3, 6
Peixoto and Oort, Ch. 4, 6, 7, 14, 15
Kuhlbrodt et al. (2007), linked from course webpage

2.5 – Meridional overturning circulation of the oceans

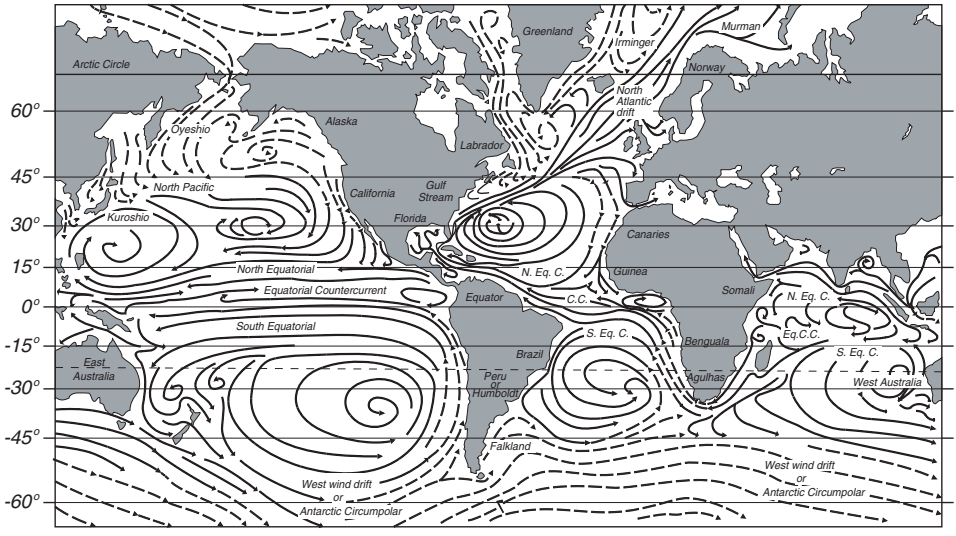


Figure: Stewart 2008

Meridional overturning circulation

- Definition: meridional–vertical circulation ("meridional overturning circulation" or "thermohaline circulation")
- Function:

  meridional heat transport

  vertical heat storage (also CO_2 storage)

- Structure:
  - Upwelling processes that transport volume from depth to near the ocean surface
  - Surface currents that transport relatively light water toward high latitudes
  - Deepwater formation regions where waters become denser and sink
  - Deep currents closing the loop
- Timescales: millennial

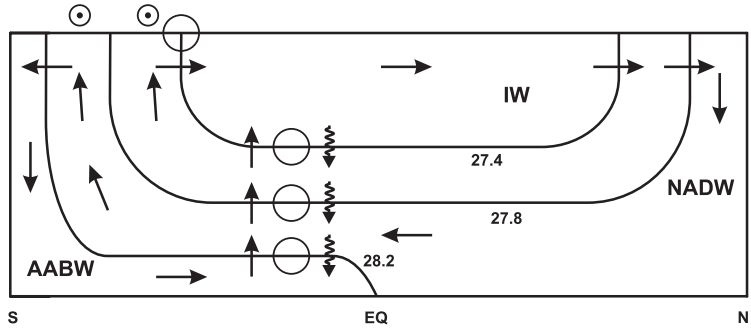


Figure: Kuhlbrodt et al., 2007

The global conveyor belt

Meridional overturning circulation

- Upwelling processes that transport volume from depth to near the ocean surface
- Surface currents that transport relatively light water toward high latitudes
- Deepwater formation regions where waters become denser and sink
- Deep currents closing the loop

Deepwater formation

- Density dictates vertical motion
- Temperature of all oceans is approximately $-2°C$ at the poleward boundary (ice formation)
- Whether water is dense enough to sink is decided mainly by salinity
- Sufficient salinity is reached in the north Atlantic and under the Antarctic ice sheets (due to brine production during freezing)

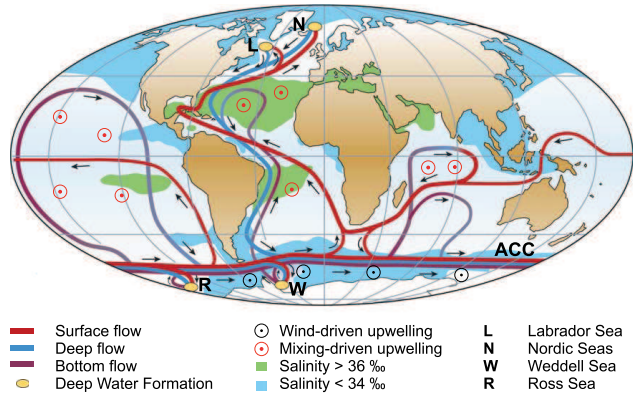
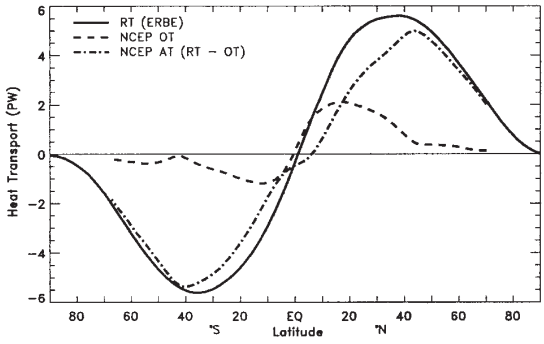
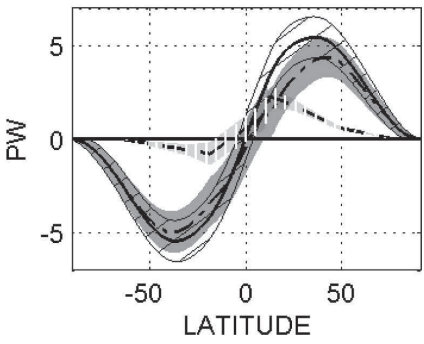


Figure: Kuhlbrodt et al., 2007

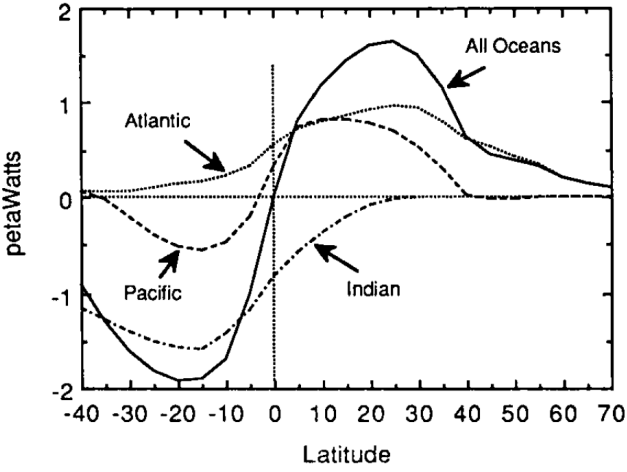
Partitioning between atmospheric and oceanic transport





Figures: Trenberth and Caron (2001), Wunsch (2005)

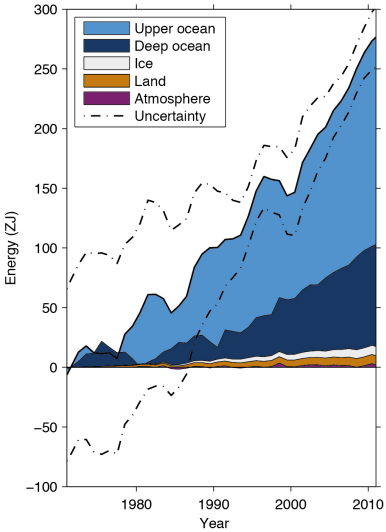
Partitioning of meridional transport between oceans



Note the anomalous equatorward transport in the South Atlantic Ocean

Figure: Hartmann (1994)

Oceanic heat uptake



- Ocean warming dominates the global energy uptake
- Warming of the ocean accounts for about 93% of the energy uptake between 1971 and 2010
- Warming of the upper (0 to 700 m) ocean accounts for about 64% of the total
- Energy uptake is equivalent to 0.4 W m^{-2} (global average), or 0.55 W m^{-2} (ocean average)

Figure: IPCC AR5