

## 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

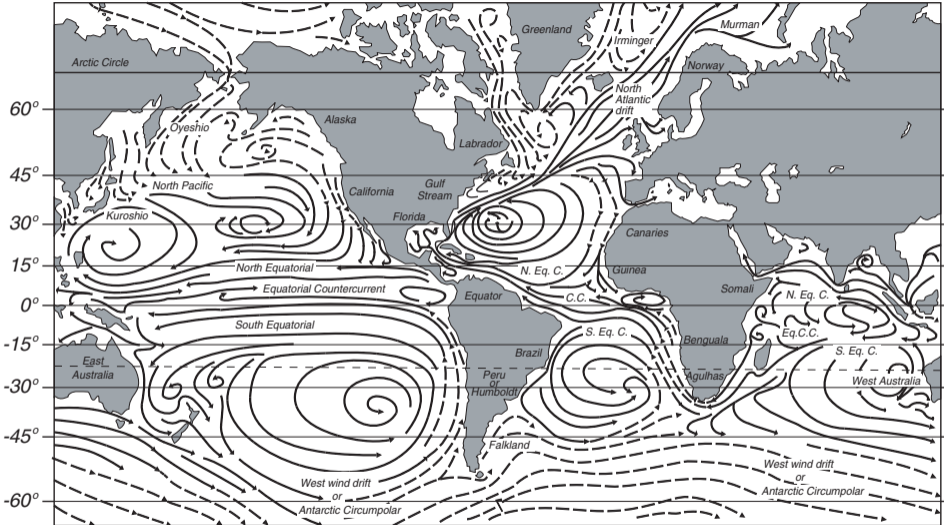
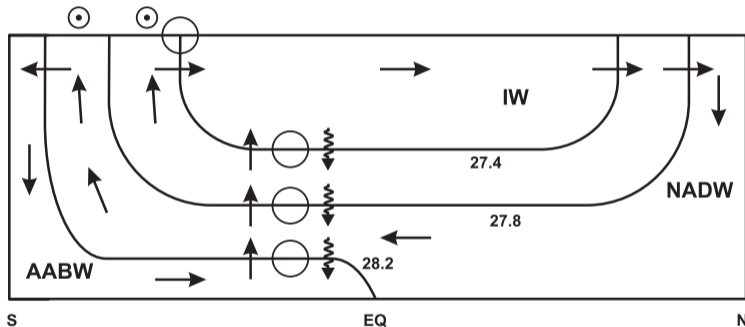


Figure: Stewart 2008

# Meridional overturning circulation

- ▶ Definition: meridional-vertical circulation (“meridional overturning circulation” or “thermohaline circulation”)
- ▶ Function:
  - meridional heat transport
  - vertical heat storage (also CO<sub>2</sub> 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



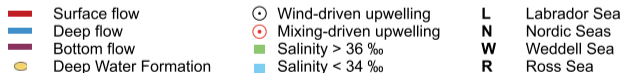
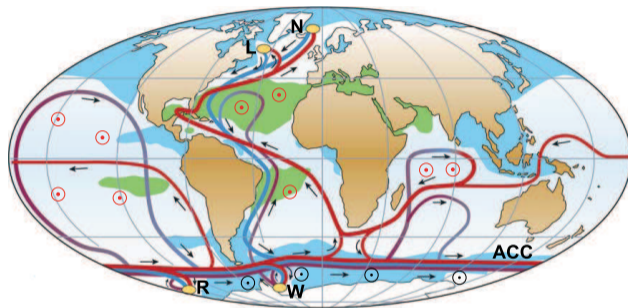
# The global conveyor belt

## Meridional overturning circulation

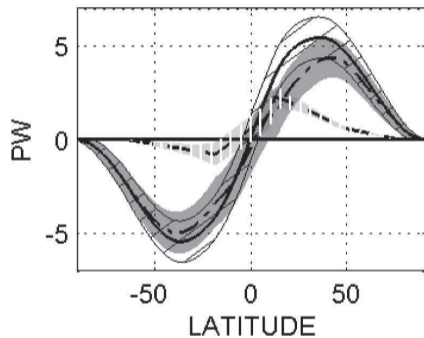
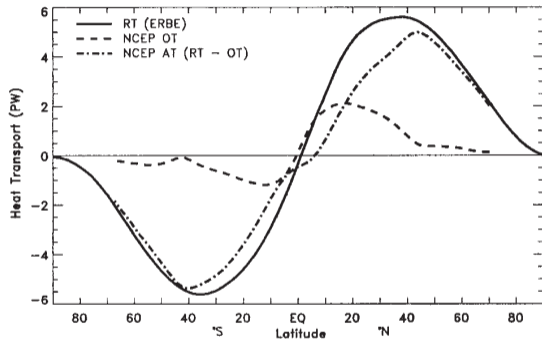
- ▶ Upwelling processes that transport volume from depth to near the ocean surface
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## Deepwater formation

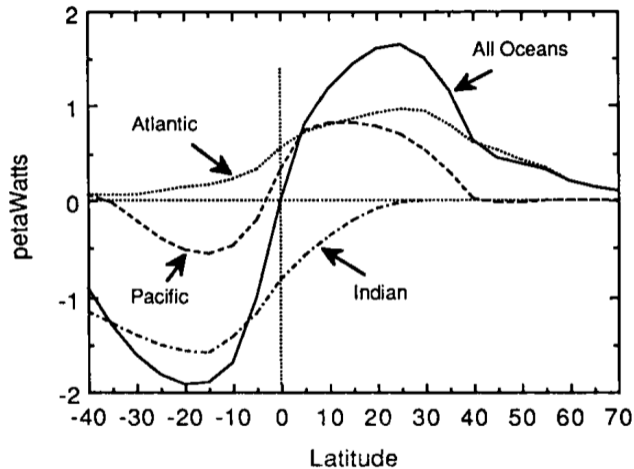
- ▶ Density dictates vertical motion
- ▶ Temperature of all oceans is approximately  $-2^{\circ}\text{C}$  at the poleward boundary (ice formation)
- ▶ Whether water is dense enough to sink is decided mainly by salinity
- ▶ Sufficient salinity is reached in the north Atlantic and under the Antarctic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



## Partitioning between atmospheric and oceanic transport

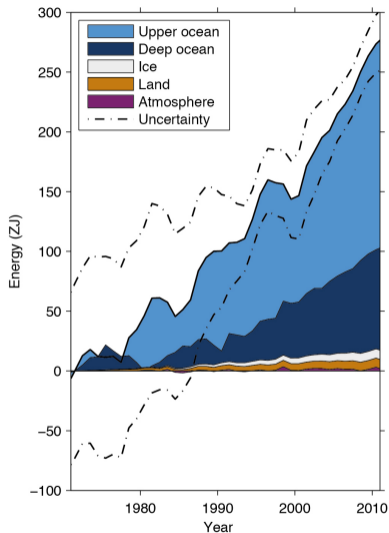


## Partitioning of meridional transport between oceans



Note the anomalous equatorward transport in the South Atlantic Ocean

# 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  $0.4 \text{ W m}^{-2}$  (global average), or  $0.55 \text{ W m}^{-2}$  (ocean average)