Lectures XXIX
The Abyssal Ocean Circulation
Lecture XXIX Outline

1. Heat, freshwater, and buoyancy fluxes at the ocean surface
2. Sites of deep convection
3. The observed deep/abyssal circulation

Sunday, November 21, 2010
The deep/abyssal ocean circulation

Meridional salinity section across the Atlantic Ocean
The general ocean circulation

- Shallow circulation: driven by surface wind
- Abyssal circulation: associated with thermohaline fluxes
Abyssal/deep circulation

Meridional salinity section across the Atlantic Ocean

Sunday, November 21, 2010
Abyssal/deep circulation

Meridional salinity section across the Pacific Ocean
Abyssal/deep circulation - Atlantic

Oxygen is close to saturation at surface and decays as waters sink and age (due to respiration)
Abyssal/deep circulation - Pacific

No formation of new waters in North Pacific

=> deep convection occurs in North Atlantic + Southern Ocean

Age increases
Surface heat fluxes


Figure 11.2: Upper: Zonal averages of heat transfer to the ocean by insolation $Q_{SW}$ and loss by long-wave radiation $Q_{LW}$, sensible heat flux $Q_s$, and latent heat flux $Q_l$, calculated by DaSilva, Young, and Levitus (1995) using the COADS data set. Lower: Net heat flux through the sea surface calculated from the data above (solid line) and net heat flux constrained to give heat and fresh water transports by the ocean that match independent calculations of these transports. The area under the lower curves ought to be zero, but it is 16 W m$^{-2}$ for the unconstrained case (solid line) and -3 W m$^{-2}$ for the constrained case (dotted line).

(From Stewart (2005).)
Figure 11.5: Latent heat is taken from the ocean to evaporate water that is subsequently released into the atmosphere when the vapor condenses to form rain.

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Surface haline fluxes

http://paoc.mit.edu/labweb/images/evap_precip.htm

Figure 11.7: The zonally-averaged buoyancy forcing (thick black line) and the thermal (dotted line) and haline (thin line) components that make it up, Eq. 11-4 in units of m\(^2\) s\(^{-3}\). Courtesy of Arnaud Czaja (Imperial College). Note that a heat flux of 50 W m\(^{-2}\) is (roughly) equal to a buoyancy flux of 2 \(\times 10^{-8}\) m\(^2\) s\(^{-3}\).

(Data from Kalnay et al. (1996).)
Surface buoyancy fluxes

- Buoyancy flux is out of the ocean at midlatitudes
- Why is convection to the ocean bottom confined too high latitudes (regions denoted with stars)?

**Figure 4. Annual air-sea density fluxes, contour interval $2 \times 10^6 \text{ kg m}^{-2} \text{s}^{-1}$**
Ocean temperature surfaces