Ocean circulation II

Reading: GPC Ch 7

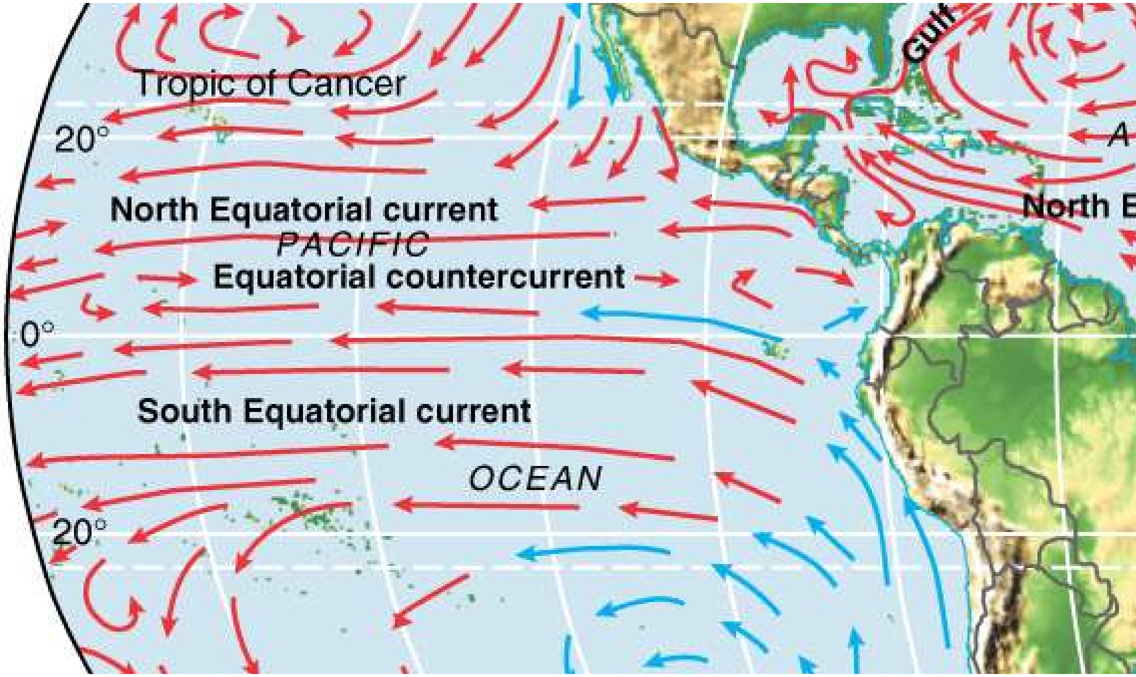
Wind driven circulations, continued:

- Equatorial currents, Antarctic circumpolar current
- Ekman currents
- How to set up a subtropical gyre circulation
- Coastal and equatorial upwelling
- How to set up a Walker circulation

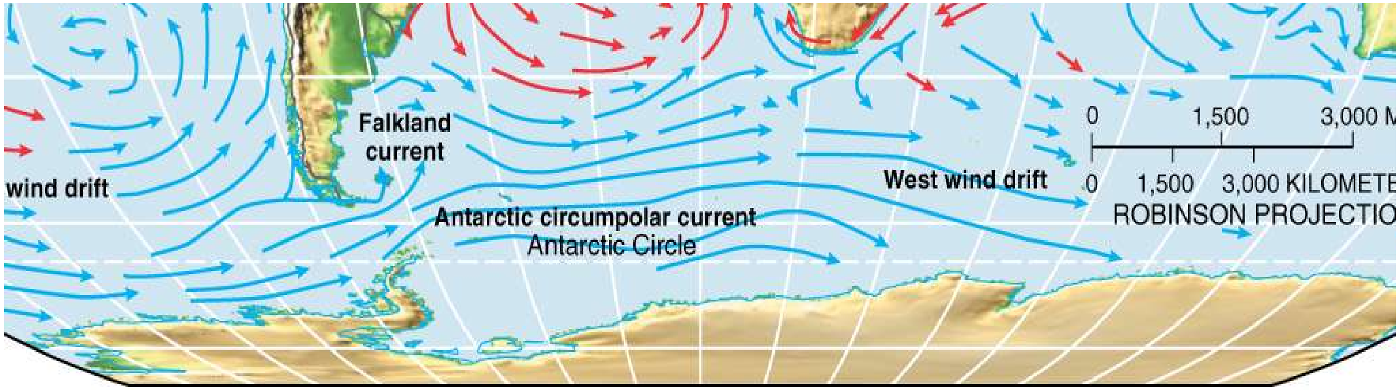
Another example of a wind-driven ocean circulation - **equatorial current system**

Example**: Pacific Ocean**

Equatorial currents consist of currents going east-to-west (e.g. north equatorial current, south equatorial current) and countercurrents (e.g. north equatorial countercurrent). The structure is determined by the cross-equatorial atmospheric surface flow.



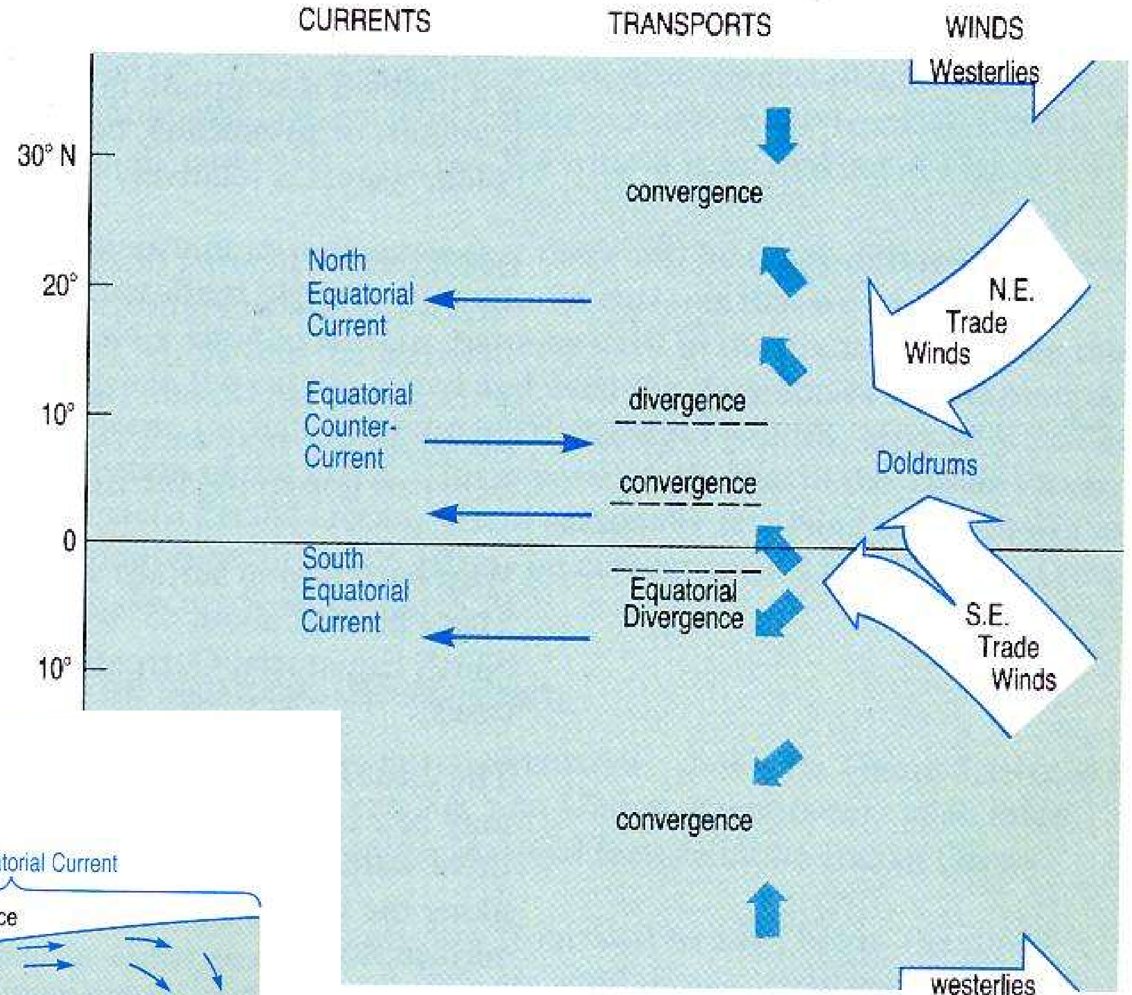
Another example: **Antarctic circumpolar current**

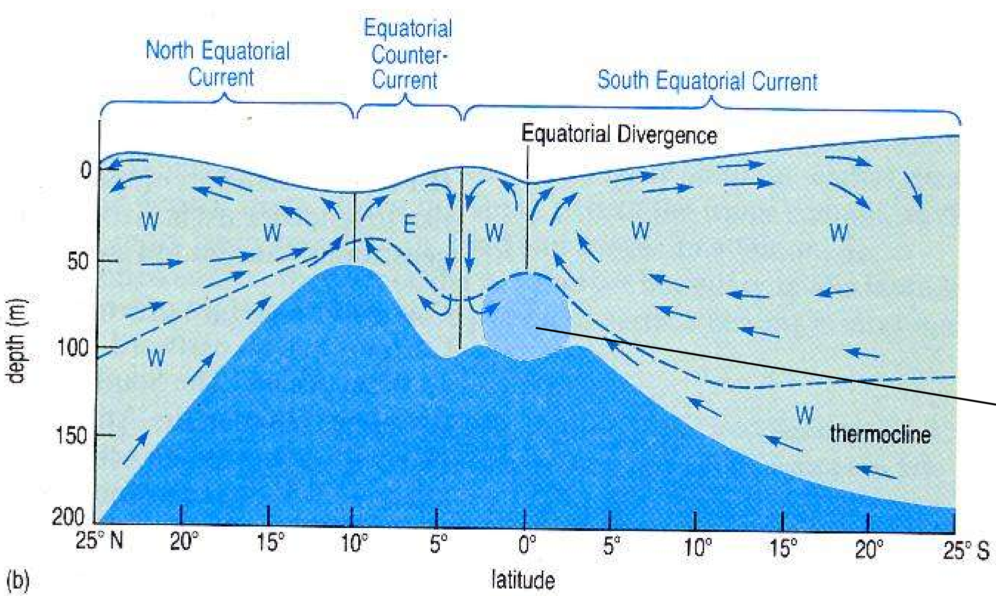


Circumnavigates the globe at the high latitudes. Unlike the subtropical gyre circulation, it is a ***deep*** current - extends up to 4000m deep. Much slower than the Gulf stream - typical velocity ~0.1m/s (as opposed to ~1m/s). But since it is deep, it carries a lot of water with it.

Wind-driven ocean circulations (continued)

Equatorial current and counter-currents





Equatorial undercurrent

Antarctic circumpolar current (ACC) *(continued)*

•Associated with two ***fronts*** - the Antarctic front, and the Subantarctic front - characterized by temperature and salinity contrasts. These form density gradients that are associated with two jets, located in each of the fronts. The ACC is generally in geostrophic balance.

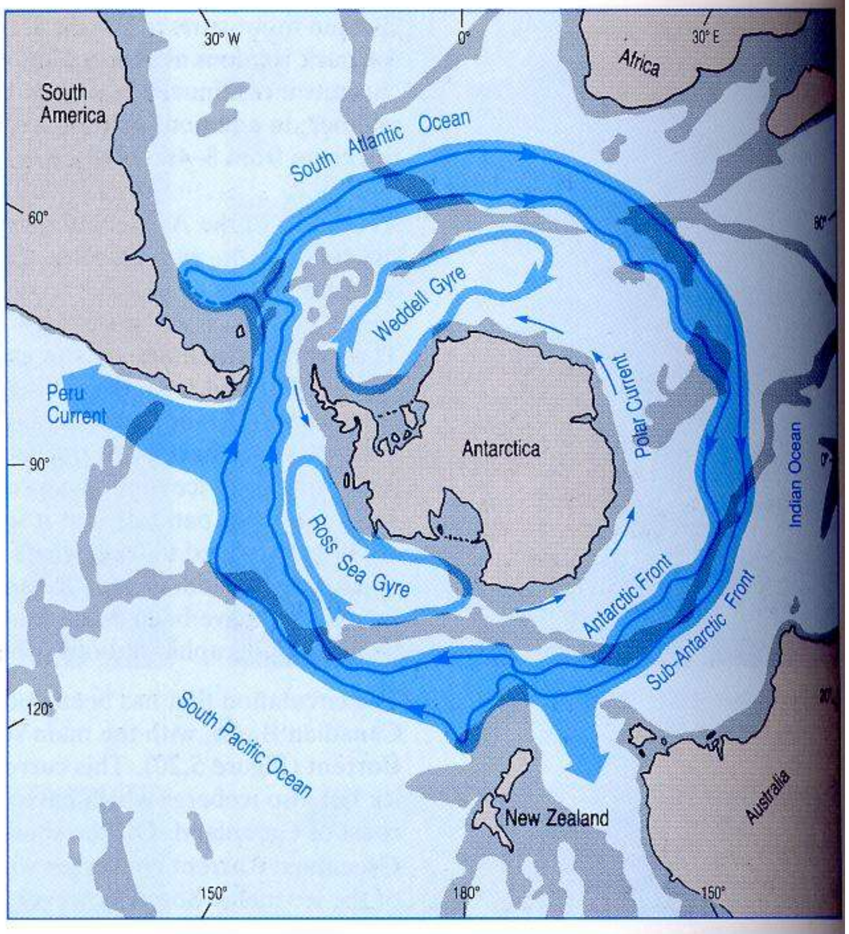


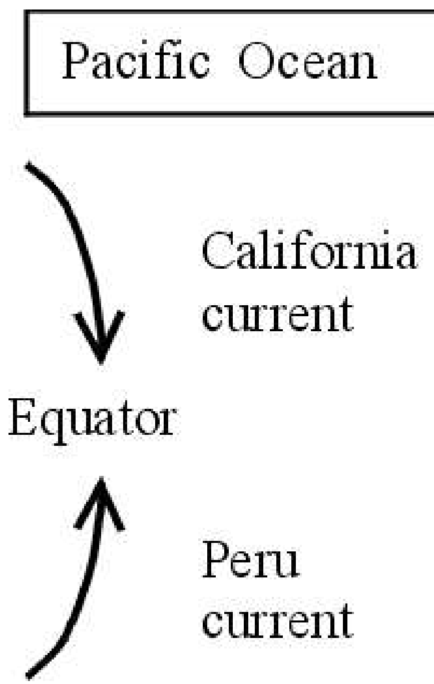
Figure 5.22 Schematic map showing the circulation in the Southern Ocean. The path of the Antarctic

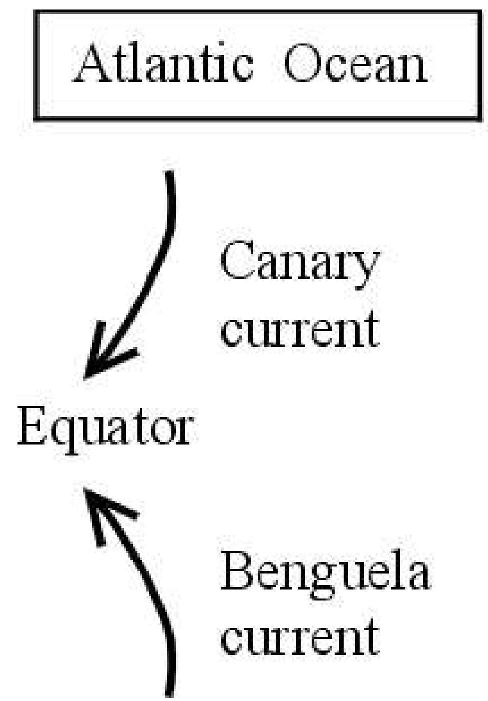
Eastern boundary currents

They occur in tropical and subtropical latitudes at the eastern margins of the oceans, flowing along the coast toward the equator and then turning westward toward the center of the basin.

They are best developed in summer in the NH and about year-round in the SH.

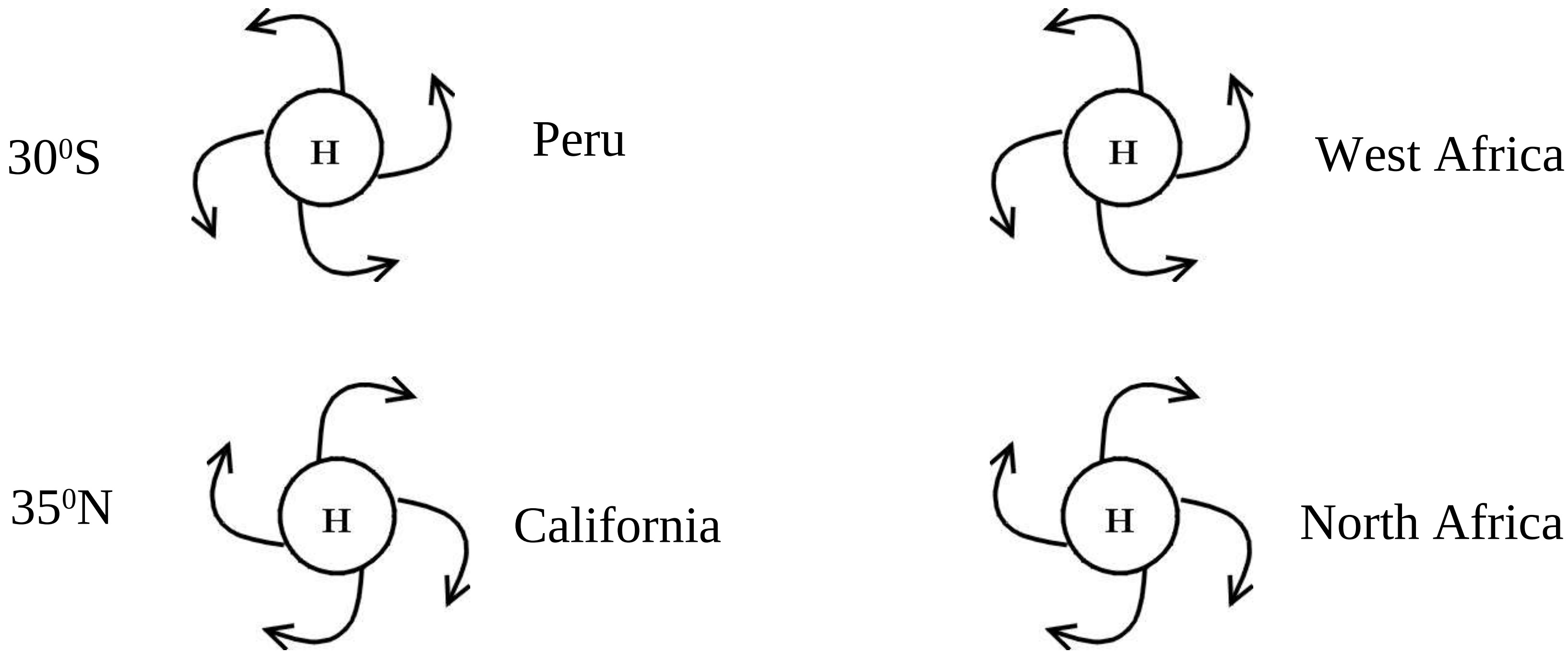
They are associated with cold SST $\rightarrow$ the SST in the subtropics west of the continents is much colder than the zonal average at each latitude.



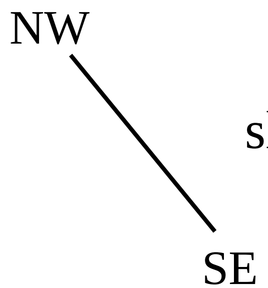


The low SST near the coast is produced by upwelling of cold subsurface waters, which is driven by alongshore or offshore winds at low levels, associated with surface H centers in the atmosphere above the eastern subtropical ocean basins.

Example: July (features best developed in summer)



It is believed that the geometry of the coastlines in the two oceans, and in particular the



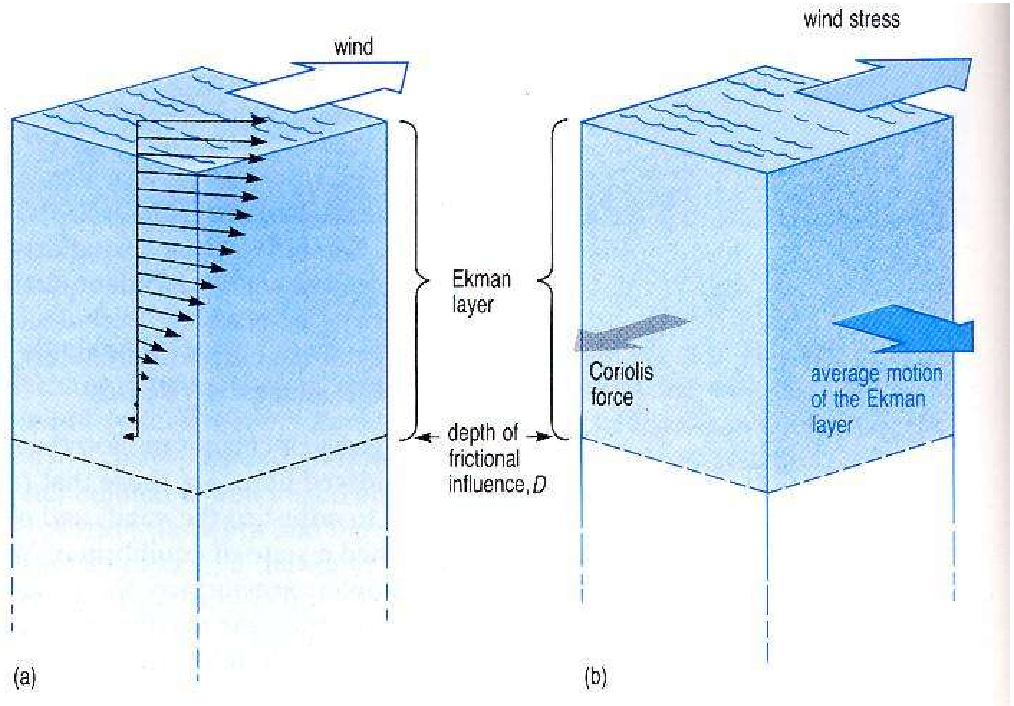
slopes of South America and Africa,

causes the eastrrn boundar currents in the SH to be better developed and to extend to the equator and then westward along the equator.

The cooler tha average SST in these regions are often associated with atmospheric subsidence and persistent stratiform cloud cover.

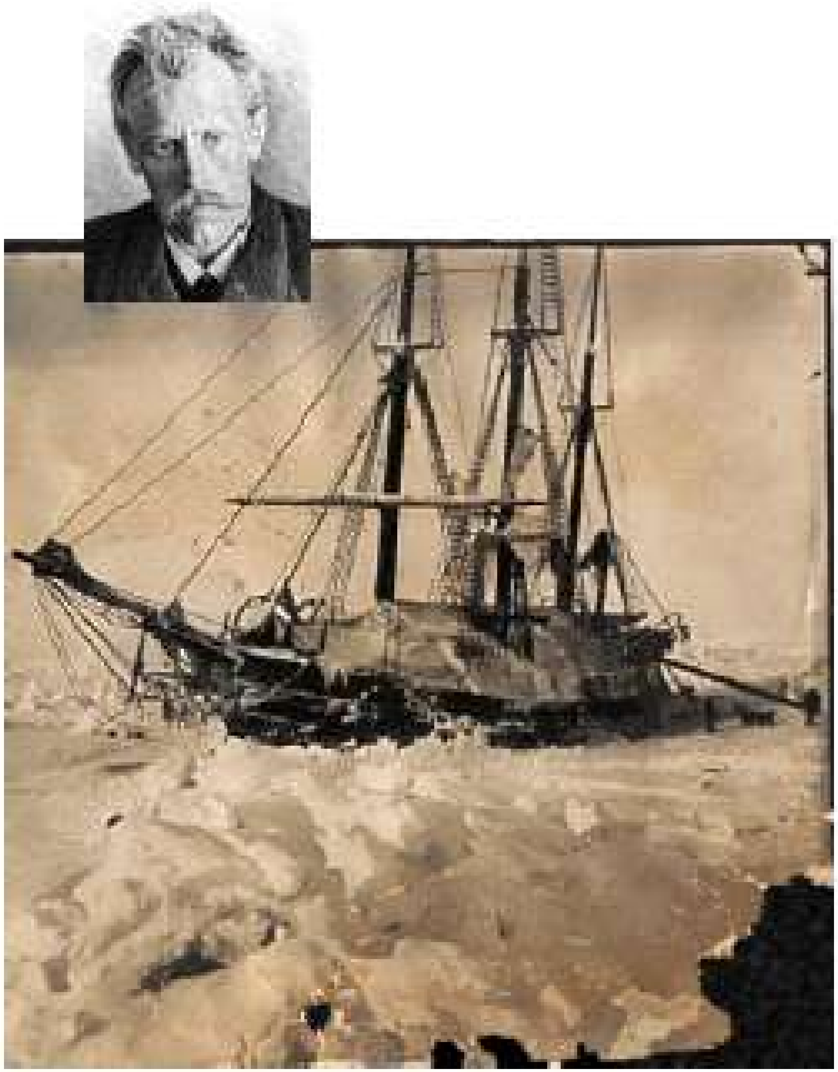
How do winds drive the ocean circulation?

Ekman currents: come through surface wind on the mixed-layer ocean; the stress is transmitted into the mixed layer through turbulent motions, and is balanced by Coriolis effects. The ocean velocity is at 45 degrees to the right of the wind at the surface, and 'spirals' with depth (see figure). The ***mean motion averaged over the mixed layer is perpendicular*** (right in the NH, left in the SH) ***of the wind direction***.



Ekman spiral: magnitude decreasing exponentially with depth.

Wind stress: the stress of the wind on the water surface. Units are N/m^2. Typically denoted as τ_x and τ_y for the zonal and meridional components.



"The Ekman spiral is one of the oldest results in dynamical oceanography. It was first proposed (conceptually) by the great Norwegian explorer Fridtjof Nansen. As part of a polar expedition in the late 1890s, Nansen froze his ship *Fram* into the ice north of Spitzbergen Island and allowed it to drift for more than two years. During the expedition he noticed that the drift of the boat was generally to the right of the wind. Nansen proposed that this motion was the result of the Coriolis force, which causes objects to veer to the right in the northern hemisphere and to the left in the southern hemisphere. He supposed further that as the ice pushed on the water immediately below it, that water would move still further to the right of the wind, though a little more slowly. Extended down through the water column, the result would be a spiral structure. "

(from Anand Gnandesikan's website:http://www.gfdl.gov/~a1g/)