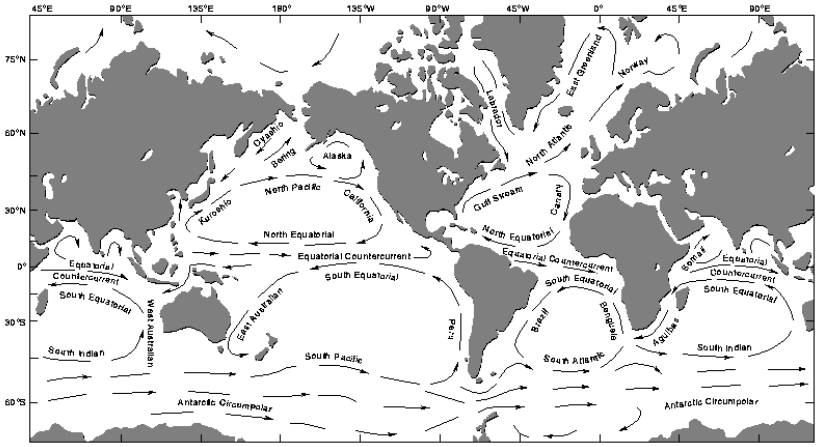
Ocean Circulation

SURFACE CURRENTS

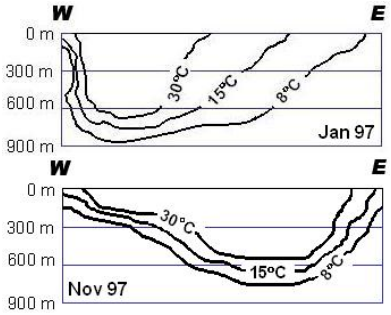
(a) Stable Circulation

The surface circulation is basically thermal, caused by solar heating and driven by the surface wind patterns.



This map is from the URL: http://www.oceansonline.com/ocean_currents.htm

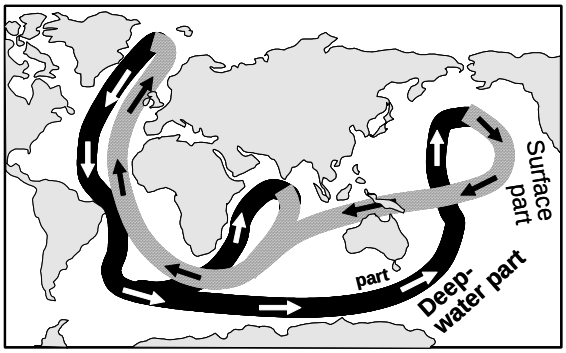
- As equatorial surface air blows to the west, against the spin, it drives the warm tropical waters westward. This produces the warm water equatorial (N and S) currents that flow to the west.
- Obstructed by the land, these warm water currents first move polewards (e.g., Gulf Stream, Kuroshio current), cool down by the time they reach ~45°N and S latitudes, and then turn equator-wards as cold water currents (e.g., California current, Canary current). Currents on the western margins of these oceans tend to be warm and fast moving, therefore, and those on the eastern margins cold and sluggish.
- These constitute the anti-cyclonic current gyres: clock-wise in the northern hemisphere, counterclockwise in the southern hemisphere.
- This also produces (a) temperature and (b) gravity differentials across the E-W profile of tropical/semi-tropical oceans, e.g., warm waters on the western and cold waters on the eastern margins, height differential @4 cm/1000 km; and (c) the up-welling of cold deep waters on the eastern margins of these tropical/semitropical oceans and the down-welling of warm surface waters on the western margins.
- Ordinarily, therefore, land on these eastern margins tends to be cold and dry whereas land on the western margins tends to have warmer and wetter climates. Also, upwelling enhances biological productivity on these eastern margins whereas western margins tend to have poor productivity.
- The 4 cm/1000 km E-W height differential causes the gravitational roll back of warm waters stacked up on the western equatorial shores. This eastward glide of the warm waters creates equatorial countercurrents (e.g., Cromwell Current in equatorial Pacific).
- The two opposing forces of westward push by equatorial wind versus gravitational roll back eastward) balance each other most once every 2-7 years, and produce the recurring El Niño events that make the eastern margins warmer and wetter, and western margins cooler and drier, than before.



Of these E-W profiles of the equatorial Pacific, the top panel shows the normal (or La Niña) situation and the bottom one the arrival of warm waters from western to the eastern margins of the ocean that heralded the 1997-98 El Niño event. Source: http://nsipp.gsfc.nasa.gov/enso/visualizations/

(b) Storm Surges: The local pockets of high atmospheric pressure depress ocean surface, the pockets of low pressure raise it. This low pressure produces the storm surges that are particularly devastating in the (a) low-lying coasts and (b) during the spring (and high) tides.

The Great Ocean Conveyor Belt



DEEPWATER CURRENTS

These currents tend to be slow (~10 km/yr) and density driven. Since water's density depends on temperature, pressure and salinity, this is also called *thermohaline* circulation (note that Antarctic bottom layer is densest of all the deep water masses).

The existence of a global current that influences weather worldwide was first proposed by oceanographer Wallace Broeker in the early 1990s. The conveyor belt works by transporting warm ocean water from the Pacific Ocean through the Indian Ocean and into the Atlantic Ocean. In the north Atlantic, the warm water, which turns very salty due to evaporation during the journey, runs into cold water coming down from the north. The warm water cools quickly, and sinks due to greater density. This creates a sub-surface counter-current which carries the cool water back to the Indian and Pacific oceans.