Ocean Currents - Teacher Background

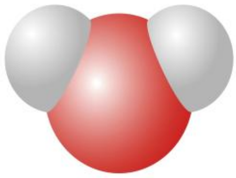
Factors that drive deep ocean currents

Temperature and Salinity
Thermohaline Circulation

Exposed land gains heat from solar radiation and loses its heat by conduction and radiation back into the atmosphere. Although heat driven convection currents in the atmosphere respond quickly to change they play only a small part of the heat transfer systems that regulate the temperature of our atmosphere and climate of our planet.
Four fifths of our planet is covered by sea. Deep ocean currents are very important in transport of heat around the world. They may move more slowly than air currents but they transport more heat and are critical to our understanding of the forces that drive climate change.

The high capacity and density of water relative to air and the great amount of energy (latent heat) required to change state or phase from solid to liquid to gas makes the ocean a powerful stabilising agent for Earth's climate. In particular, oceans transfer significant amounts of heat from lower to higher latitudes.

Superficial ocean currents are the result of wind and sub sea topography. They result in local mixing of surface waters. Their effect is minor and local. The great Global Conveyor Belt lies at greater depths. It is powered by density differences that result from changes in temperature and salinity. Visit
http://oceanservice.noaa.gov/education/pd/oceans_weather_climate/media/ocean_circulation.swf



When a substance cools, the kinetic energy of its molecules decreases permitting them to move closer together. This results in a density decrease. Water is anomalous in this respect. Ice (solid with lower kinetic energy) is less dense than water (liquid with higher kinetic energy). Water molecules are bound together by covalent bonding. Molecule movement decreases until 4^{o}C when another form of bonding comes into play. At 4^{c}C the molecules are sufficiently close together for weak hydrogen bonds to become important arranging the molecules into a hexagonal crystal lattice of ice that takes up more volume than liquid water did. The result is a solid state which is 9% less dense than liquid. Water is the only liquid that behaves in this manner.

Visit https://ed.ted.com/lessons/why-does-ice-float-in-water-george-zaidan-and-charles-morton for a 3.55minute animation and explanation.

When seawater freezes at the poles freshwater ice is formed and the remaining seawater becomes denser and sinks adding to the downward pull.
These currents initiated at the poles move millions of cubic metres in a great current that covers the globe. The events at the North and South Poles are slightly different. In the North Atlantic near the North Pole surface water chilled by Arctic winds sinks to about 2,000 metres. At that depth it overlays an even deeper hypersaline layer and flows south towards the equator and on to the Great Southern Ocean. In the Antarctic similar events occur but the effect is complicated by the occurrence of both sea ice, as in the northern hemisphere and an ice cap formed over land. In the Antarctic Ocean both flows converge to form the circumpolar current which transports water around the globe. Water remains in deep and polar regions longer as it is dense and slow moving (about one to three kilometres a day). As the water warms it rises to the surface and moves northwards to complete the cycle. Carbon isotope dating suggests that water may take hundreds to thousands of

years to complete this cycle. About a third of water in the oceans is actively involved in these circulation patterns.

Climate change and the global conveyor belt

Any increase in global temperatures would affect the density of surface waters resulting in lower salinity. Any increase in precipitation brought on by temperature increase would also decrease salinity. The downward current drive would lessen.

Land ice (ice caps and glaciers) is more stable than sea ice. Monitoring of the Greenland ice cap shows it to be decreasing markedly recently. Both glacial melt and sea ice melt would decrease salinity. Ice acts as an insulator to underlying waters. Reduction in area of thickness would warm polar water decreasing downward current drive.

The albedo effect from ice reflects incoming solar radiation back into space. In the Arctic, sea ice (pack ice) averages three metres thick. In the Southern Ocean it measures only one metre thick. It expands and contracts with the seasons. A decrease in ice cover would cause further atmospheric warming.

Evaporation from the warm seas would increase the amount of water vapour in the atmosphere. Water vapour is a most effective Greenhouse Gas. All of these would produce a marked warming in our water and air temperatures.