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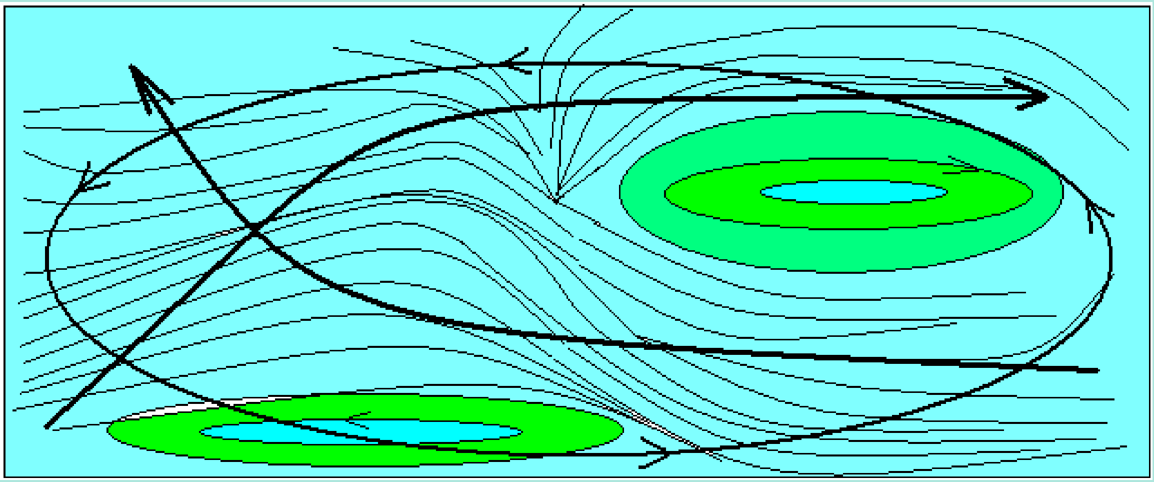
Climate and churning of the ocean

Ocean currents form a complex traffic pattern of masses of water moving from one end of the earth to another, says S.Ananthanrayanan.



The scale of these flows is incredible. The Gulf Stream, for instance, moves 30 million tonnes water every second, compared to just 1 million tonnes by all the world's rivers put together.

The currents also affect the earth's climate system and biochemical cycling - as significantly as the atmosphere and the distribution of the ice masses at the poles. There are mechanisms that make cold and dense water sink in the north and then for warm, nutrient rich water to rise to the surface, which make for vegetation and fish population. But the rising water does not match the quantity that sinks and how the accounts balance has been a matter of interest. ***Nature***, this week reports evidence of 'short circuits' in the traditional models of mixing of ocean currents, which may refine our understanding..

Regulate temperature

Ocean currents, like winds, are convection currents, of cool, dense water sinking and warm water flowing in to take its place. And like the cooling sea breeze that brings relief to sun baked landmasses at evenfall, ocean currents maintain steady temperatures in places blessed with extensive coastlines. The Labrador coast of Canada and the southwestern tip of Britain, for instance, are at the same latitude. But Labrador is frozen all year through, while Cornwall has palms and rarely sees frost, thanks to warm ocean currents.

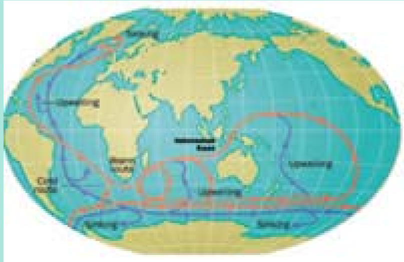
Thermohaline circulation

Temperature and salinity change the density of water, the colder and saltier, the heavier. Ocean currents get moving when heavier water sinks and lighter water flows in to take its place. The flows caused by these two effects, in turn caused by temperature and salinity, are called ‘thermohaline’ circulation. Places where cold, salty water predominates are called ‘**sinks**’ and those with warmer and fresher water are called ‘**upwellings**’.

The Earth's largest ocean sinks are in the North Atlantic: the Labrador and Greenland seas. Now, when water cools below 4°C, its starts getting less dense, and remains afloat. For this reason, when arctic winds cool the surface of the North Atlantic, sea ice forms on the surface and it deposits salt, to increase the salinity of the remaining water. The very dense water, which is the result, plummets into the depths.

As polar water sinks, warmer water is drawn in from the south, creating a current from south to north. This is the Gulf Stream, which contributes around 20% of the winter warmth in Northern Europe.

While warm, surface waters flow in, the cold, dense water deep down flows along the Atlantic bed to the south. It flows down to Antarctica, where it joins the 'Southern Ocean Raceway’ a group of currents that circumnavigates the South Pole, common to the Atlantic, Pacific and Indian oceans



And the ‘Upwellings’?

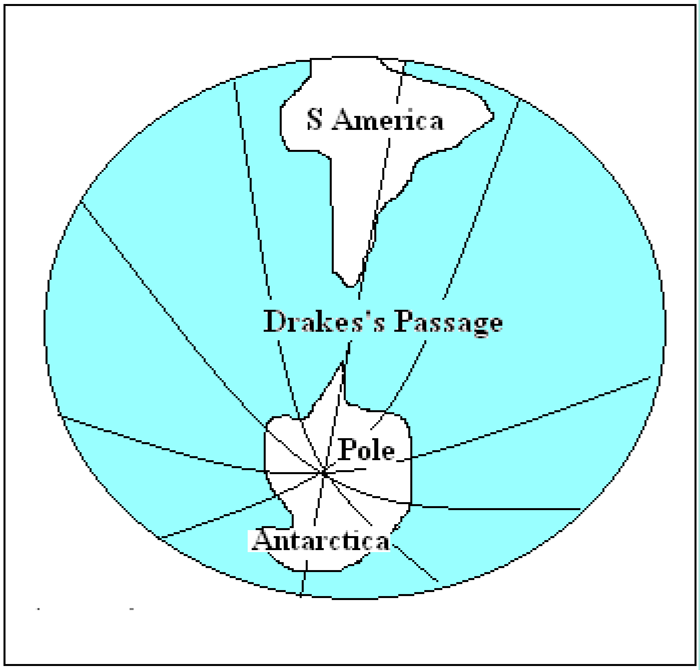
The vast sinking of dense water around the poles is not matched by comparable ‘upwellings’ of warmer water. Which is not unusual, as why should cold water get warm to ‘well up’? Streams of water at different temperatures and salinity can retain their identity when they pass each other. Mixing takes special effort and consumes energy. So if waters mix, a question is, “where does the energy come from?”

The moon is at work

Recent studies have shown that the answer lies in the tidal energy from the moon. It is found that about a third of the energy that the moon supplies goes to create tidal flows in the deep ocean. Like the surging of surface tides at coastlines, these deep-sea tides result in turbulence and mixing. Dense water is thus not locked to the seabed but returns to circulate!

While this explanation is acceptable at a general level, actual modeling has not shown the same results as found in practice. The principles of hydrodynamics dictate what flows can take place between surfaces of equal density, or ***isopycnals***, and these suggest a lower rate or mixing in the deep sea.

Alberto C. Naveira Garabato and colleagues at the University of Southampton, UK have made use of injection of helium from the earth's mantle into the Circumpolar Current near Drake's Passage, as a tracer to follow the stream.



The observations reveal that there is rapid upwelling and intense mixing across isopycnals, at a rate an order of magnitude greater than what the models have predicted. The results suggest that deep water pathways intensify and intertwine as they pass over complex ocean floor topography and effectively short circuit the slower rate of mixing due to circulation alone.