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From: SA Agulhas Radio Room <sa.agulhas@andrapido.com>
Date: Mon, Feb 15, 2010 at 8:17 AM
Subject: Scholes cabin 5: The thermocline
To: stirlingj.scholes@gmail.com

To: Subject:
15 February 2010 0030 UTM -65.3468, 0.0019

Dear Stirling

Why does the ocean have layers? Since it is a fluid, we would expect it to be mixed up by the currents and the action of the waves. But just about everywhere that we take a measurement, we find quite distinct horizontal layers. We detect them by sending down a probe which measures temperature and salinity at different depths. Then we plot the measured values on the horizontal axis (the X-axis) against the depth downwards on the vertical axis (the Y-axis). The line does not go straight down - which would mean that the temperature is the same at all depths - nor does it have an even slope, which would mean that the water gets gradually saltier and colder with depth. It has distinct steps, and sometimes even quite complicated wiggles.

The simplest case - a warm water layer on top of colder water - is fairly simple to explain. The oceans get most of their heat from the sun, and the sun shines on the upper layers. This, and contact with the overlying atmosphere causes them to warm up. Since warm water is less dense than cold water (down to about 4 degrees, below which the water expands again, and of course ice is much less dense than liquid water), the warmer water floats to the top, and becomes warmer still - a little positive feedback loop which keeps the separation stable and sharp. The depth at which we measure that sudden cooling is called the thermocline. It is like an invisible barrier in the ocean - the water above it stays quite separate from the water below.

It gets a bit more complicated when we consider salinity as well. Salt dissolved in water also makes it more dense. So in principle, it can work either in the same direction as the temperature-controlled density, or in the opposite direction, leading to all sorts of wiggles. For example, when ice forms at the beginning of winter, the salts are excluded, as a dense, cold brine, which sinks to the bottom. This is how Antarctic Deep Water forms. It can be found at the bottom of the ocean all around the world. On the other hand, when the ice melts, cold, fresh water is released. It forms a tongue between the saltier but warmer surface waters, and the saltier but colder water below.

Now think of that warm, tropical surface water, lying on top of the Antarctic water. As it travels across the ocean, water is evaporating to form the clouds that bring us rain on land. So it gets saltier and saltier. If it is also getting closer and closer to the poles (for instance, if it is in the Gulf Stream, which carries warm water from the Caribbean over to Europe) it starts to cool down. At some point it is denser than the cold but fresh water coming from the polar icecaps, and the freshwater running off the land. It sinks, and pulls the water behind it along like a duvet when you roll over in bed. This is called the 'Thermohaline circulation' (THC) and is the motor that drives the big ocean currents, both on the surface and at depth. The location of the warm and cold currents, in turn, strongly controls the climate on land.

You can now understand why the strength and location of the THC depends on a balance of heat and salt. If we warm up the world, there will still be a THC, but it might take a different route. In fact, it has flip-flopped in the not-so-distant past: as the world warmed up following the last ice age, the THC switched position several times. It could do so again - but we don't really know where the threshold is. The scary bit is that it can change quite quickly, and get stuck in its new position. That is one of those 'tipping points' people talk about. Better to stay well away from them, if you can.

I had a frustrating day yesterday, fixing things and breaking things.

Hugs, Dad.