The Oil Drum
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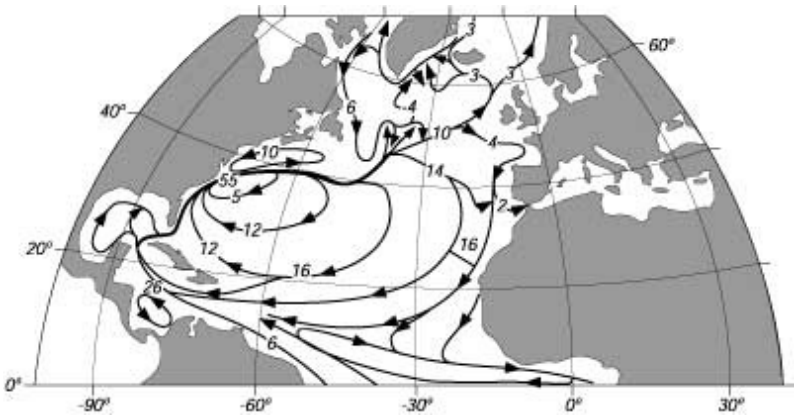
Atlantic Circulation Changes

Posted by Stuart Staniford on November 30, 2005 - 7:37pm
Topic: Environment/Sustainability
Tags: climate change, global warming, hubbert peak, hurricanes, oil prices, peak oil [list all tags]

Nature today reports a new study by Bryden *et al.* suggesting a significant slowdown in the North Atlantic circulation (tip of hat to Westexas). The emphasis in coverage has been on the implications of cooling for Europe. For example, The New Scientist says

> The ocean current that gives western Europe its relatively balmy climate is stuttering, raising fears that it might fail entirely and plunge the continent into a mini ice age. The dramatic finding comes from a study of ocean circulation in the North Atlantic, which found a 30% reduction in the warm currents that carry water north from the Gulf Stream. The slow-down, which has long been predicted as a possible consequence of global warming, will give renewed urgency to intergovernmental talks in Montreal, Canada, this week on a successor to the Kyoto Protocol.

The New Scientist is a UK publication, and this is scary stuff for a country that's running out of natural gas, oil, and coal. But let's just have a quick think about the implications for hurricanes and oil supply.



Sketch of the major surface currents in the North Atlantic. Values are transport in Sverdrups ($10^6 m^3/s$). From Sverdrup, Johnson, and Fleming (1942: fig. 187), via OceanWorld.

For background, we need to have a rough understanding of the circulation of the North Atlantic (the surface currents are shown in the map above). The Gulf Stream carries massive amounts of warm water up very close to the North American coast. As it starts to leave the coast, it splits into three pieces. The most famous piece is the middle one that goes on to warm Europe. Then there's a little piece that splits off and forms a *gyre* near Labrador. Finally, a portion of the surface

current circulates back down towards the tropics again. This last is called the subtropical gyre.

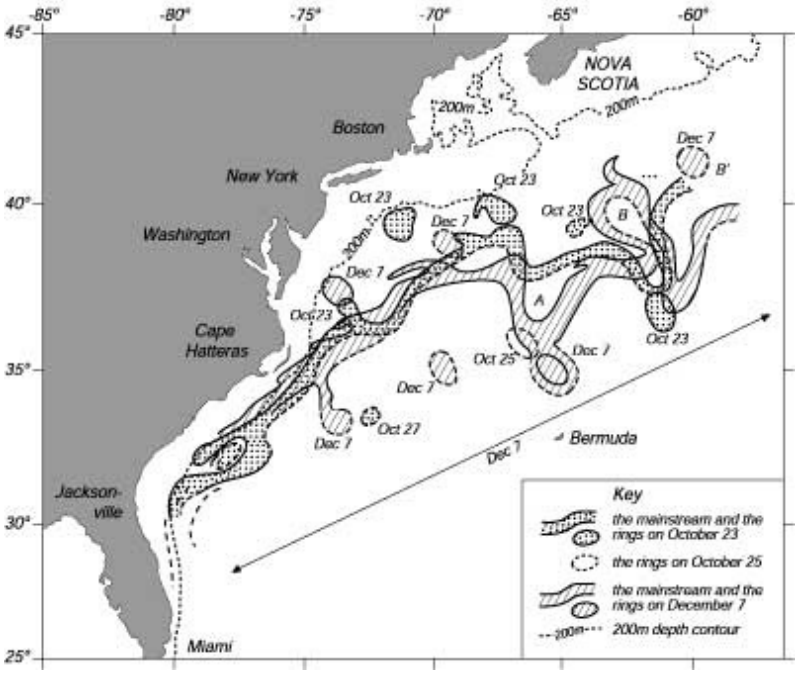
In addition, under the surface, deep cold waters which have sunk in the arctic are moving south and returning the net flow northwards on the surface. The total flow in the North Atlantic has to be roughly balanced because the amount of net transport through the Bering Strait is very small. So the deep cold currents make up the difference between the water the Gulf Stream carries north, and the water the subtropical gyre brings back south. Oceanographers measure the flow of water in currents in units of Sverdrups, with 1 Sverdrup = $10^6 m^3/s$ (one thousandth of a cubic kilometer/second). The flow through the Bering Strait is only 0.8 Sv, while the Gulf Stream through the Florida Straits is 32.2 +- 1.1 Sv.

(As an amusing aside, I note that total global oil production of 30gb/year corresponds to only 0.00016 Sv of fluid flow. So as we will see, we're having a much bigger impact by burning it than we would if we just dumped it into the ocean).

Update [2006-1-25 16:59:21 by Stuart Staniford]: Stig Oye pointed out that I had an arithmetic slip of several orders of magnitude in the "amusing aside", which I've belatedly corrected.

Now the new Bryden *et al.* paper (which I recommend reading if you can: I found it readable with some work and background research after paying my $30 to Nature for it) concerns changes in these flows. In particular, it reports on the latest 2004 survey of flows along the 25 degree latitude line, which has been surveyed before: in 1957, 1981, 1992, and 1998. It's important to understand exactly how the survey line corresponds to the currents.

The Gulf Stream is very tightly concentrated and goes between Florida and the Bahamas:

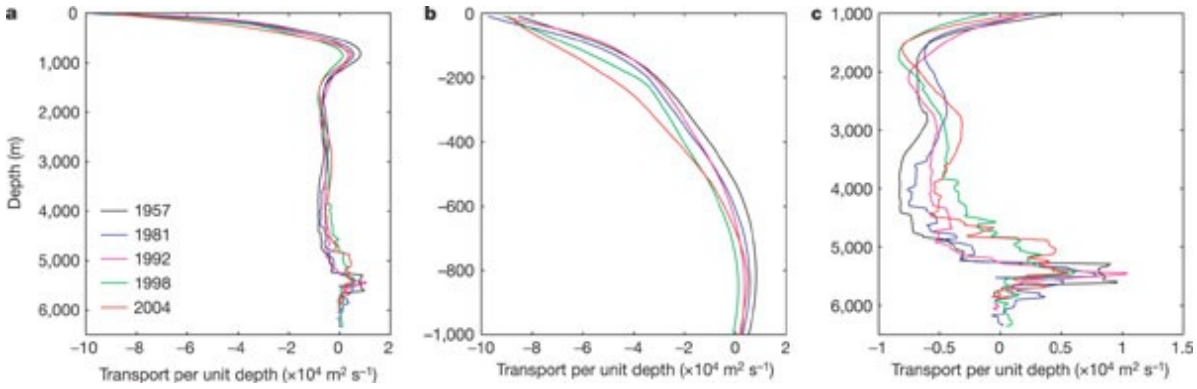


Sketch of the position of the Gulf Stream, warm core, and cold core eddies observed in infrared images of the sea surface collected by the infrared radiometer on NOAA-5 in October and December 1978. From Tolmazin (1985: 91)., via OceanWorld.

It's also believed to have been pretty stable in total water transport since 1980 at the 33.2+-1.1Sv level. Now these surveys take a line across the ocean from the bulge on the coast of Africa

to the Bahamas. So in essence they measure the north/south flows of the Atlantic **excluding** the Gulf Stream. So they see the surface recirculation of the subtropical gyre, and they also see the returning deep cold flows.

And this is where it gets interesting. Exercising my fair use commentary rights, here's the picture from the Nature paper that gets at the point I want to make:

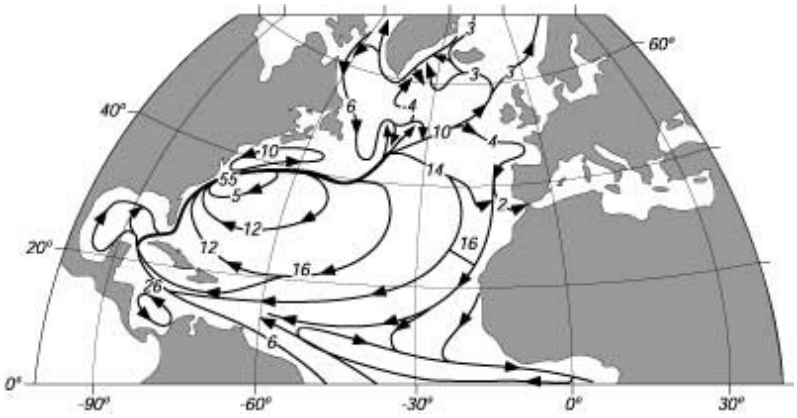


Vertical distribution of water transport across the survey line in Bryden et al.

First look at part a) of the figure to orient yourself to the big picture of what's happening. You can see that at the top, above 1000m or so, the current is negative (ie southwards). That's the surface subtropical gyre - portions of the warm Gulf stream that just turn south and come back into the tropics (bringing their warmth with them). From about 1200m down to 5000m you can see a slower southward transport. That's the deep cold currents carrying water that has sunk in the Arctic back south to continue on the global conveyor.

Now, the main emphasis of the coverage has been on c). This shows a blow-up of the portions of the transport that are the cold return currents. Clearly, these have been reducing - the newer lines are moving steadily to the right. Less and less water is coming down from the Arctic. Climatologists believe this is because more fresh water is coming into the Arctic (from increased river flow and ice sheet melting) and making the water up there less salty and thus less able to sink. Since less water is coming **down** from the Arctic, less water must be going up there in that central piece of the Gulf Stream (as the overall flow is nearly balanced), and so the heat-pump that warms Europe is presumably being affected.

But look at b). That's the returning subtropical gyre (faster currents above 1000m in depth). It's getting stronger and stronger with each passing survey. That's the warm water that didn't go to Europe, and is now coming back into the tropics. Where's it going again?



Sketch of the major surface currents in the North Atlantic. Values are transport in Sverdrups ($10^6 m^3/s$). From Sverdrup, Johnson, and Fleming (1942: fig. 187), via OceanWorld.

Smack into the region where North Atlantic hurricanes form, that's where it's going.

So if this result holds up and these trends continue, I think we can expect to see plenty more of this in the future:

BP's Thunder Horse rig undergoing repairs after hurricane damage. Source: Minerals Management Service.