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TITLE: Is Ocean Heat Storage Presently Knowable?

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ABSTRACT BODY: Ocean heat storage plays a key role in predictions of global warming. The oceans' great thermal inertia moderates any radiative energy imbalance.

A number of authors have suggested that most ocean heat storage takes place in the upper 700 meters. With the deployment of the Argo system in 2003 and the subsequent failure to detect the expected ocean warming investigators started to look deeper, down to 2000 meters.

A mostly ignored problem with using ocean heat below the tropical/ temperate thermocline to measure current energy imbalances is that, as revealed by tracer studies, below thermocline water is old water that has not been in good thermal communication with the atmosphere for hundreds of years. The thermocline can be thought of as a collision between the mixed layer and very old and cold water that is rising from the abyss in an elevator-like fashion, at a rate that is uncertain but perhaps a few meters per year. The elevator is driven by dense water that, in the polar regions sinks into the abyss. A slow downward flow of heat from vertical mixing, driven by currents and tides, warms the bottom water, thus making room for new, denser, bottom water.

It is helpful, as a thinking aid, to divide the Earth into the surface realm, consisting of the atmosphere and upper layer of the oceans and a second realm consisting of the deep ocean. The deep ocean may as well be in outer space since it is thermally isolated from the Earth's climate except for a very slow and presumed constant seepage of heat. Between the two realms are transition regions, the polar sinking regions and the thermocline upwelling regions. Cold water sinking warms the surface because we have removed water colder than the Earth's average temperature of 15 C from the surface realm. Upwelling cools the surface because we add water colder than the average temperature to the surface realm. The sinking and upwelling flows are equal but variable. If we draw a line at 2000 meters we can hope that the upwelling mainly consists of water riding the "elevator" driven by polar sinking, 2000 meters being mostly below vertical circulations such as coastal upwelling. A complication is that both deep upwelling and downwelling is thought to take place in Antarctica. We may be able to quantify the heat flow through 2000 meters as the combined effect of upward mass transfer of cold water less a smaller, and fairly constant, downward flow of heat due to mixing. If the deep ocean is in a steady state there are 3 components to the heat flow: sinking water near 0 degrees, rising water at 2000 meters near 2 degrees, and the (nearly constant) slow downward, mixing-driven heat flow. If this works (i.e.is not fatally oversimplified), then variation of heat flow into or out of the deep ocean is mainly due the 2 degree difference, between sinking water, and rising water at 2000 meters, times the heat capacity of the rising or sinking mass of water. If the sinking circulation is 30 Sv the heat flow proportional to the circulation amounts to about 1/2 watt over the Earth's surface.

If the ocean is warming in the region of 700-2000 meters the proximate cause may be a slackening of the overturning circulation accompanied by a downward drift of the thermocline, not warming of the

atmosphere.

I will try to work through this puzzle with the hope of adding clarity.

KEYWORDS: [3015] MARINE GEOLOGY AND GEOPHYSICS / Heat flow, [0312] ATMOSPHERIC COMPOSITION AND STRUCTURE / Air/sea constituent fluxes, [1626] GLOBAL CHANGE / Global climate models, [4283] OCEANOGRAPHY: GENERAL / Water masses.

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Additional Details

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