Finding the Link Between Ocean Density and Circulation Transcription

Now that we have sea surface salinity, I mentioned earlier that the motivation is to get at questions about the fresh water cycle. But there's also another motivation about sea surface salinity, and that comes from its coupling with sea surface temperature. So just as we didn't have sea surface salinity before, we've also never be able to come up with a measure for the sea surface density, because surface density results from both the measure of the salinity and the temperature. That combination then is what gives us the ocean density.

Let me just pull this up. The ocean density is a very interesting feature of the ocean because we have a very rapid change after the surface mixed layer. We have rapid changes and then we principally have deep water. I don't know how many of you are familiar with the story of Count Rumford, but one of the very first understanding or implications for having this density structure came from Count Rumford. Early on in 1751 there were measurements of the deep ocean. It wasn't just Benjamin Franklin taking measurements in a wooden bucket of the surface ocean. There were also being measurements made of the deep ocean in the tropics. Those measurements of the deep ocean showed that no matter how far you went down, the temperatures of the water kept coming up the same. This was very puzzling to many people at the time, but it wasn't until 1800 that Count Rumford figured out that the reason those water temperatures at depths in the tropics were always the same, and were always colder than the air temperatures, was that water must have come from someplace else. So Count Rumford really was one of the first to deduce that changes in density meant changes in ocean circulation.

This is another schematic that shows that the ocean density field is such that we have light waters at the surface, but the deep ocean is filled with waters of a very cold density, and there aren't many changes north to south in that density structure. Once we have the density field, getting it both from the SSP and importantly now from the SSS, that's going to get us information about the ocean circulation. The large scale ocean circulation that we have is really driven by wind forcing which creates the convergence and divergence of the ocean surface waters that we are picking up with the altimeter. But also there are density differences that are created by the differential heating and the differences in sea surface salinity. And those density differences then create what we refer to as density driven circulation.

Many years ago—I think I'll go back to this—not many years ago. For years people have talked about the density driven circulation as an ocean conveyor belt, and there's been this very simple schematic. And the story has gone that the deep waters that are formed in the North Atlantic overturn; they spread to the deep ocean everywhere, then they upwell in the Indian and the Pacific. Then the warm waters are fed back, and we have this global conveyor belt.

Annette mentioned in the introduction that I authored a paper two summers ago called *Deconstructing conveyor belts*. In large part this is a much more complicated image. One of the things in my paper is that we really can't use this schematic, but mainly the point of that paper is that the

overturning is not a simple one-cell system. The overturning is not driven by density changes alone; it's also driven as well by wind changes. Mainly because of all the observations we have now we're starting to get a much greater appreciation for what we call this overturning circulation. Even though it's helpful to think about it as a conveyor belt, that's really an oversimplification. But mainly what I need to tell you tonight is that the density differences as well as the wind forcing act to create these changes, and we're very interested therefore in ocean density, which means we're interested in ocean circulation.