What Can We Learn From Argo Floats? Transcription

What have we learned from something like this, from Argo, and where are we going with this. The next slide shows kind of a gross picture of what the salinity field in the ocean looks like and some things attached to it. The top slide here is just the surface salinity in the world ocean. You can see the color scale there. Where it is red, the ocean is saltier than most places. Where it's blue it is fresher. You can see that the Atlantic tends to be pretty salty compared to the Pacific. The southern hemisphere in the Pacific is saltier than the northern hemisphere. You can see around the Antarctic it's blue. That means it's relatively fresh, and in the Arctic, if we had it on here, you'd see the Arctic was relatively fresh as well mostly because of all the water that gets released when ice melts.

The second plot on here is a plot on the change of salinity. So here my colleagues in Australia, Susan Wijffels and people in her group have taken all of the salinity measurements you can get. The modern Argo measurements are easy to get. This is kind of mining through the data and getting all the good measurements which I mentioned earlier, there aren't that many, going back 50 or 100 years. This is the change in salinity over the last 50 years.

You can see the Atlantic on the top slide is red; the Atlantic on the middle slide is also red, and if you look to the Pacific you'll see that it is already blue, but it also blue in the change. Taken together what these figures show is that where it is the saltiest it is getting even saltier, where it is the freshest it's getting even fresher. This really means that the global water cycle must be accelerating.

Normally when people talk about climate change they think about warming, but the water cycle is an equally important part of climate change as is the CO2 and the distribution. Well here the water cycle really shows a major change in the water cycle here, and it looks like it's accelerating. Things that are salty are getting saltier, and things that are fresh are getting fresher. It's almost like an exponential rate of change here.

We don't understand why this is happening yet, but it is important because if you can think about where it's red here things are getting saltier, that means there has to be more freshwater being removed from the sea surface going into the atmosphere. Well, that means in those places the atmosphere has more water in it, and water vapor is of course an excellent greenhouse gas. We usually think of CO2 or methane as a greenhouse gas, but water vapor itself is a greenhouse gas. To the extent the water cycle is changing, and there's more water vapor in the atmosphere and in those red places, that means there's more greenhouse gases there.

In the bottom picture here is just evaporation minus precipitation. You can see that there is some sort of correspondence between what you see in the top two figures and this one. Where the evaporation is highest is in many cases also where the salinity is highest. Where the precipitation is highest is also where the salinity is lowest, but that correspondence is not perfect because there are other things besides evaporation minus precipitation that can affect surface salinity.

OK. This is an interesting figure put together by my colleagues Dean Roemmich and John Gilson using Argo data again. This is the last 25 years as a function of latitude the change in temperature and salinity. So if you look at the top plot, this is just Argo data from I believe 2008 through 2011 minus whatever temperature was out there in the early 1980s. You can see here that most of the ocean above 2000 m. (this is all the whole world just lumped into a figure by latitude) is either red or yellow. That means the ocean is warmer than it was 20 or 25 years ago. There are a few places near 20 South for example about 400 m. where it's blue; that means it's slightly colder there, but overall most of the ocean is either red or yellow indicating it is warmer—even down to 2000 meters—than it used to be.

The second plot is probably the one we are more interested in because of the change in salinity in the last 20 to 25 years. You can see near the surface in the upper few hundred meters the ocean tends to be saltier for the most part than it was 20 or 25 years ago. But if you look at high latitudes in the southern hemisphere, or you look anywhere between about 400 m. and a 1000 m., you see that the ocean is blue there meaning that part of the ocean is actually fresher than it used to be.

We know that those intermediate waters tend to originate at high latitudes, so this sort of says that there is something going on at high latitudes which is causing the ocean to get less salty, and that something is almost surely the melting of ice. It could be increased precipitation as well, but one culprit is the melting of ice that adds freshwater to the system. Mid-depths here are fresher than they used to be; the upper ocean tends to be saltier than it used to be. I won't say much about it, but those two things together, temperature and salinity of course affect the density which affects the circulation, and in effect what you see are density changes in the third one there.

The next one here is if we took the previous picture and average all that together so we just come up with one set of numbers for the whole world ocean, you would see something like this. This is again from a study by my colleagues Dean Roemmich and John Gilson. You can see if we look at temperature here that near the surface of the ocean the water appears to be about two tenths of a degree warmer than it was 25 years ago.

That doesn't seem like it is very much, but we'll come back to that in a moment. That increase by the time you get to 400 m. or so has gotten back down to zero. There's not much change there, but then below that down to about 2000 you can see there's a small increase in temperature in the deep water averaged globally as well. Salinity, you can see near the sea surface, the change is almost zero. That's because on the previous slide as we saw some of that area near the sea surface is fresher, some is saltier, and it almost balances out.

You don't have to go very deep 'till you see a significant increase in salinity here. There's something like 02, 03; those are numbers that we can measure with some confidence, but then below around 300 meters or so you see the salinity everywhere globally averaged has decreased by quite a lot, again 01, 02, something like that. That's that intrusion of water from high latitude that either came from increased precipitation at high latitude or ice melting.

Now I just want to say something about that .2 at the sea surface. When we all hear about global warming and coral bleaching and things like that, we think about massive increases in ocean

temperature that might be able to do that. Here it says the global average change is about 0.2 degrees, but that doesn't seem like it's very much. Actually it is quite a lot because the heat capacity of water is very high compared to the air. So if you took that .2 degrees and asked, what would be the equivalent change of the lower atmosphere that's equivalent to two tenths of a degree change in water, it would be pretty massive, something like 5 to 10 degrees in the lower atmosphere.

This doesn't look like very much, but the actual amount of heat change there—let's not go by temperature change, but by heat change associated with it—is really massive. There is an observable change in the ocean on a global scale. This is the best representation of that I have seen, and that's why it's included here and salinity as well. Salinity is probably harder to measure as I mentioned earlier, but here we can really demonstrate with some confidence in the last couple of decades there is a measurable change in salinity in the world ocean.