Topic 4b – Phytoplankton and Carbon

Victor, we've been learning a lot about climate change during this course. And one of the things that we really think about when we think about climate change is carbon dioxide. Now, the ocean has quite a big role to play in terms of carbon dioxide and its fate in the wider carbon cycle. Can you tell me about that?

The carbon goes into the ocean mainly as a gas goes into the liquid of a fizzy drink. So you could think about it in that way.

Kind of like when I open a can of Coke or something?

Exactly. So the colder the water is, the more gas can come in. The warmer the water is, then the gas goes out. But then there is another part of this cycle, another part of this pumping mechanism, which is biologically driven. And that is driven by the phytoplankton mainly.

Phytoplankton is like micro algae that live in the ocean.

Tiny, little plants.

Tiny, little plants, yeah. And they do photosynthesis. And what do they do? They capture, like a tree. They capture energy from the sun and convert it into organic material. And this organic material then pumps through the chain of other organisms, from phytoplankton, from the plants to the animals, which are the zooplankton, also very tiny, to larger and larger, like the whales and the fish.

Part of that carbon also goes then down through the water column. And by that cycle of giving life to the other organisms in the ecosystem, and the majority of it goes down into the water. But then a part of it goes into the sediment. The main part of it is these organisms that are moving that carbon, taking it from the inorganic in through this organic pool that is circulating, giving life into the ocean. And then part of it-- a very tiny part-- goes sinking down, and ends in the bottom of the ocean. But a lot of it gets into this dissolved form.

If you're able to measure directly the carbon that is in the ocean through ocean colour measurements from a satellite, then you're able to say how good or how bad your models are. And those models you can then use to predict into the future what is going to happen. And currently, one of the very, very, few ways that these global ecosystem models have to be validated against that reality is by comparing with the satellites. And it's an amazing field of research actually.

Validating satellite data with measurements we take actually in the sea seems to be really important. So if we want to know that our chlorophyll estimates from satellite are really good, we check them against ship measurements. Can you do the same thing with estimates of carbon that you might get from ocean colour data as well?

Well, indeed, you have to make sure that any observations that you take from space are properly validated and also used the in situ data for developing and interrogating better algorithms that you construct--

You learn more detail about what you're actually measuring from the in situ methods.

Yes. Through this kind of work, what we have been recently doing is to collect, to gather, large data sets from the ocean for different cruises and different years, different depths.

That's what we can see here.

And this is what we can see here, yes. You see that these data we collect are very sparse and there are very few of them, even though we've been collecting as many as possible. But they're also not evenly distributed around the ocean.

Yeah, I can see lots around the coasts. I guess, because that's easier to get to than, say, the middle of the Atlantic here.

Yes. And you can see also the areas where more effort is needed, like in the Indian Ocean or the Pacific Ocean. These data also link with a satellite, allowing us to have a more especially global picture of what is going on. Just by linking some observations in situ and to the satellite, we're able to extrapolate to the whole of the surface of the ocean.

And then presumably, we can look at long time scales and see how this sort of thing is changing.

Yes, indeed. You can look at then-- If you have images, let's say, every day, you can then put them one after the other. And at different places in the ocean, you can detect changes in the time where the blooms of the phytoplankton occur.

And presumably then, maybe there's more or less carbon being taken up at those times. We can learn about how that cycle works.

Indeed, indeed. And also, because at different times for different blooms, different phytoplankton species appear. So there are species that are very small, different--

Do they absorb carbon differently?

They absorb carbon in the same way as all the other phytoplankton. But just because of their size, they probably don't sink as fast as other, larger phytoplankton. And they have that capability of living in areas where there is not much nutrients. So their importance is greater, even though they fall slower. So it's a special distribution of phytoplankton in the ocean. It also helps us to understand where it is more important or less important on the affect of the biology in the carbon pump.

And all these dynamics are the sort of things we can then compare to the models you mentioned. Yeah? So we see how the different patterns, different behaviours of the phytoplankton, see if they're being represented properly by our models and maybe improve them if they're not.

Yes, indeed. Once you've got a product from satellite that you can rely on because you have done a proper validation with this much data, like these images here, then you can use them to give you additional information that you may not only consider as straight away as it is, like that. You may consider the timing of the blooms. You may consider the phytoplankton species. You may consider the combination of several variables. For instance, the phytoplankton carbon compared with the chlorophyll content in the cells. All these things you can use to validate the properties of the models.

Victor, one of the nice things about satellite image is you get this big, global picture of the world. And we can see lots of different patterns. So I imagine if we can estimate carbon from satellite data, we can also see patterns in that too. Is that true?

Yes, we can see temporal patterns. Here you can see we have put together several images, one per each month, of the global ocean of a particulate organic carbon. So this is the total amount of particulate organic carbon that is in the ocean, including the phytoplankton and what is visible from space.

And this variability that you can see here is related to the seasonal activity.

You can see it moving up and down.

Up and down, up and down with the season practically. The northern hemisphere gets a high concentration of particulate organic carbon related to the spring bloom of the phytoplankton, just like in land you see the spring bloom, and the trees covering with leaves. Right? And this is changing.

You can also see the spatial variability and how some areas in the ocean really don't change very much, like the Pacific Gyre or the South Atlantic Gyre, the North Atlantic Gyre. And these areas are what we call-- or the equivalent of these on land would be the deserts, where there is very little life going on. But still, all of this surface and all this change in activity produces this movement of carbon, this biological pump, which is important to driving overall independently to this chemical pump.