Topic 2a (part 1) - Weather prediction – overview

This week we're going to look at the details of the ocean surface on quite short time scales, things like the weather, and wind, and waves.

Well, let's talk about weather and weather prediction. Why would someone who's got that job, that task to do, be at all interested in what's happening over the ocean?

A couple of reasons. So either you've got customers or users who are out on the ocean. That's their place of work. So ships, oil rigs, everything like that. Or what's happening over the oceans? They're the storms that are coming to us, particularly in Europe.

And what can you measure over the ocean that is relevant to a weather forecast?

A whole sort of bunch of things. Weather forecasters look at clouds. They'll look at the sea surface temperature. And there's two parameters they can see from satellites. You can look at the winds. And you can look at the waves.

And I can understand a bit if you've got altimeters that you might be able to look at how high the sea surface is. How on earth do you measure the wind, which you can't see here on land, from a satellite?

The wind, as it blows, sets up ripples on the sea surface. And all the satellite is is a thing called a scatterometer. What it does is send energy down towards the Earth's surface. It's a radar.

If there's ripples on the surface, some of that energy will bounce back towards the satellite.

So we've got a diagram of that here. So here's the sea surface.

So you've got the big waves. And on top of the big waves you've got these ripples. And these ripples are set up by the wind blowing across the sea surface.

So there's actually two types of wave here. There's a great big, long wave here. And then there's these little tiny ones on the surface.

Yes. What we're going to do, we're going to send some energy down from the satellite at an angle down towards our waves. And we'll see what happens.

So here we've got an animation. We send some energy down, bounces off. And a lot of it bounces forwards. But some of it bounces back towards the spacecraft.

And the amount of energy that goes back depends on the amount of ripples, which depends on the amount of wind.

So from 800 kilometres away, we're using these tiny little ripples. They're that far apart. We're able to estimate wind speeds over the ocean globally. So we can go where it's too unsafe for a ship to go.

So in the same way when you blow on a cup of tea, and you see the little ripples forming on the surface, the air movement over the top is pushing on those ripples. And it's the air movement you want to measure.

Yep.

And so this is a very complicated way of measuring little ripples down here that are telling you about air movement.

Yes. Exactly.

It's a slightly counter-intuitive thing, the idea that you can measure wind, which you can't see.

Yes.

From a satellite.

Without looking at it.

Without looking at it.

But this is how it works. This is an amazing achievement of satellites to be able to do something like this.

For me, it's one of my favourite instruments. It's a stunning effect that from 800 metres away, and using a wavelength this far apart, using radar energy, that we can actually do this.

And one of the great things is, if you look at charts of ship observations, ships will tell weather forecasters what the weather is where they are. Obviously when there's big storms, the ship should be out of the way. If the weather forecaster has done their job, the ship has gone. And so we're able to get data from dangerous places, from the centres of big storms, from cyclones, and learn much more about cyclones from this sort of thing. It's incredibly useful data.

And what sort of wind speed measurements do you get from it?

So you can get anything from sort of 2 metres a second, up to 40, 50 metres a second in the centre of these storms. So they're incredibly strong winds.

So I recognise these little symbols. These are what weather forecasters use to show the direction and the strength of wind.

Yeah. So what you've got here is a tropical cyclone, tropical cyclone Rammasun, which is just about to strike the Philippines. So this is a storm that has huge human impact, because what happens next, you've got the storm coming. You'll have inundation. You'll have water and wind risk for people living here. So forecasting this properly is really important, then knowing what it's going to do.

And what the forecasters will be looking out for is this sort of storm centre here, how well defined is it.

So these triangles, you're looking at 50 knots of wind. So 25 metres a second. And then you're going up more. So you've got 60 knots of wind.

And the scatterometer tends to measure an average wind. So you'll have gusts which are much, much higher in there. So this is a very serious storm.

And these are places where you wouldn't want to be out here to measure how strong the wind was.

No.

But you can look down with a satellite, and use scatterometry to work out what those winds are. And you can see the pattern, which is the really useful bit.

Yeah.

And so the forecaster will then be able to tell people what's the track of the storm, where is it going to go, and who is most at risk.

In the case of really good forecasting what you're doing is providing a really good warning to people about what's coming so that they can take the right action.

And satellites provide lots of different types of data that could be useful to weather forecasters. Tell me about some of those types.

So you'll see here two types. So you've got the cloud data as well. So the other thing the forecasters will be looking for is the cloud underneath it. You'll be looking at the scatterometer data.

You might have also, for this storm, looked at the sea surface temperatures. Because sea surface temperatures can be the fuel, or the energy, for a storm.

And you might have also used the altimeter data, where you can then work out, is this sea surface temperature just something that's on the surface, or is there a lot of energy there? So that the mixing that happens as the storm travels over, is that going to feed the storm and put more energy in?

Another kind of measurement that we can look at, so this is an example from the North Atlantic Ocean, is the altimeter significant wave heights.

So what the forecast is doing here is looking at the significant wave heights as seen by the altimeter.

What we've got is a map here. So I can see Iceland up here. There's Greenland. Here's the UK. And then we've got these coloured dots going across it all. Tell me what those are.

So the coloured dots are the significant wave height measurements from three different altimeters as they're travelling past. So you've got a reasonable amount of coverage over the ocean.

And what you're seeing where you've got the red and the brighter red estimates, you've got 15 and 20 metre waves.

Which are enormous, gigantic waves.

And these aren't the biggest waves. This is just kind of the biggest third of the waves. The average of the biggest third. So this is what we call the significant wave height.

So you've got some big storm happening here. And with other data you'd actually be able to see that storm.

But what this is telling the forecaster is, how much wave energy is existing. And they can also then make a guess, using the rest of the satellite data, and other data they'll have of that, what wave generation is now going to occur. For two reasons. One, they'll be warning ships in the region. But also, as this storm travels, and in this case towards the coast of Ireland and Scotland, what are the waves that are going to be striking the coast? Because that's going to be a big deal, how much inundation threat is there, if that storm travels across towards the coast.

And there's lots of different types of data. And a weather forecaster wants a single picture. They have a model. They have one model. And they've got all these different types of data. How do they use the mess of different types of data to get a single, coherent picture of what's going on?

So the computer models of the atmosphere that the forecasters have have gotten really good over the last few years. And they've gotten good for several reasons.

One is the way that the computers solve the equations is getting better, and better, and better. But one of the other effects is the quality of the data that's going into the model beforehand.

So the satellite data is a process called data assimilation. All of this data goes in. And we take the very best estimate we can of what's the atmosphere doing, what's the sea surface doing, and what's the ocean doing. Because these elements all interact with each other. And if you want to know what the weather's going to be like in five days time, you need to have quite a good ocean model.

So, for example, with extra tropical storm Sandy, one of the reasons that was so well forecast was because of the data that went into the ocean model. So that was able to feed the storm correctly in the model. And so before the storm had even formed there was an indication that it might hit New York, because of the whole dynamics being so well represented in the models that were available to the forecasters.

And so the weather over the ocean might obviously matter for ships. But what happens in the ocean also matters for weather over land. So even they're two separate sets of users, they both benefit from measuring the sea surface.

Very much so. Very much so.

The storms that come to us in Northern Europe come from across the ocean. So what's happening in the ocean matters very much for what reaches us.

Very much so.

And they can even have a longer journey. Some of our storms, the storms that have at one point been hurricanes, actually start here in West Africa. They start as a wave in the atmosphere, that then turns into a depression, that turns into a storm, that turns into a cyclone.

Some of those storms then turn north. It's what we call extra tropical transition. And they'll then travel up, and they will either turn towards Europe or turn towards the US.

And what's going to happen, of course, is a really important thing for a forecaster. And then they'll travel over towards us in the north of Europe.

So our big storm season is October. Some of our storms will have started out and travelled that entire loop, gathering energy up from the ocean's surface as they've travelled. It's what's going to keep them going until they get up to here. And then they'll gather energy from upper in the atmosphere to really keep them going, and then spin up and become cyclones for us.

And it's not uncommon. If there's a very strong hurricane season in the US, you do hear weather forecasters saying the remnants of a hurricane are going to appear off the North of Scotland, because it's travelled all that way.

Usually about one a year at least we'll get that started out life as a hurricane, and sometimes will actually show the whole life cycle.

It takes quite a few days, travelling across the Atlantic. You see the storm developing, cyclone in the Atlantic, travelling extra tropical transition.

This phrase, extra tropical transition, is because the fuel for the storm changes. So the fuel here is a lot of the energy coming from the sea surface. Once you travel out and you start travelling back towards Europe, you're starting to get the energy from air descending from the top of the atmosphere, from the stratosphere, and really fueling the storm and starting to turn it back into a nice strong cyclone.

So what we're looking at here is sea surface temperature. So around here the ocean waters are getting warmer as you go across the equator here. And this bit here, this is where hurricanes really pick up the power that makes them destructive.

But after they carry on after that, they're travelling over cooler water, but they're still moving, and they can still reach us up here.

And you can see some of the lovely structures that will affect the storms. So things like the Gulf Stream here. So the effects that we have here really do affect our climate, particularly in Europe.

What's striking about this is that this is a map of the ocean. But it's bounded by land. And there are people all the way along these islands here, along this coast here, and then up here that are affected. So the storm is travelling over the ocean, but it bumps up against the lives of a lot of people along the way.

Yeah. And that's the tremendous privilege of living in a satellite age. So if you're a storm, there's been nowhere to hide since 1960. We've been able to see every storm. And we've gotten better at forecasting and warning people.

This is the business we're in is protecting life and livelihood is what we're for.

And it happens days out now. You can see them coming across. If you pay attention to the hurricane watch websites, five days before anything gets there, it's developing here. And you can watch it grow. And you can watch the predictions of where it might go, and see probabilities, which is fantastically useful data.

And that's the next evolution for the modellers is they've now started working much more with probability to really help pin down what exactly is the probability of the storm going here, going here, going here. So you can really start to get the risks really far out.

And knowing the storm is coming, I mean you can't stop the storm hitting you, but being able to prepare is such an important thing. You can lock down your public transport system. You can take anything valuable out of basements. You can move people away from where there might be storm surges. There's a huge amount you can do that reduces the risk to people and our infrastructure if you know far enough in advance there might be a storm.

Yeah. It's an amazing thing to be involved in.