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The Planet Earth podcast - 'Carbon capture and storage, floods, CryoSat-2'.

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I'm Richard Hollingham, welcome to the Planet Earth Podcast and I can't believe we've never done this before. This time we're in a pub. There's a good excuse, which I'll come to in a moment. Also we'll be reporting on the latest from the European space mission that's investigating the Earth's ice cover and the joy of science in a cold, rainy flooded meadow.

Swooshing of water....

Researcher: We did have one lady come and ask us - quite concerned one evening, at about six o'clock as it was getting dark - were we all right? And we had to wonder whether we were, but the things we do in the name of science I suppose.

RH: So, the pub. It's the curiously named Ye Olde Trip to Jerusalem in the centre of Nottingham. It lays claim to being the oldest inn in England. The pub is built into a sandstone cliff and inside it feels more like being in a cave than a pub. A cave with beer, and I'm here to meet Mike Stephenson, the director of the National Centre for Carbon Capture and Storage. Mike, why have we come to the pub?

MS: Well, I thought I'd just show you what an extraordinary place this is. Basically we're in a cave as you said. A cave of sandstone and it's a great place to show you how we can use these rocks to actually absorb carbon dioxide. We can take carbon dioxide out of the atmosphere and push it or force it into these rocks. And we think it could probably stay there for a very, very long time.

RH: Now I had this idea in my mind of carbon capture and storage, that it was using reservoirs underground. I don't know, vacant spaces in the rock like tanks that you could inject the carbon dioxide into, but that's not the case?

MS: No, no. It's not like that at all. There are very few open spaces if you go down deep into the rocks. The pressure's too big to get open space. But what these rocks illustrate quite well is that there are a lot of very small spaces between the particles that make up the rock. So for example, if I just show you very quickly, a demonstration, if you put a little bit of beer on the sandstone which is the wall of the pub, what you see is it's all wet and shiny at first, and then what you slowly begin to see is the beer soaking into the rock.

RH: It's disappearing very, very quickly and now it's almost dry. I suppose it's like a beach when you step on it and get the water there and it goes dry very quickly.

MS: What you've really got here is the sandstone itself made of particles. More-or-less spherical particles, and they're all packed together. But they're not packed together perfectly because there are spaces in between, and when I'm pouring the beer in there what's really happening is that the water in the beer is leaking into, or soaking into, these spaces in between the particles. You can't see them, but there is a huge amount of space inside this sandstone. And that's what we propose to do: fill it up with carbon dioxide.

RH: How would you do that? It's very easy to drip beer onto a little bit of wall but it's quite different to inject carbon dioxide.

MS: Well, if you do it right you should be able to push it into this rock quite effectively. This has been done for a long, long time; for example in the United States they've been injecting carbon dioxide into rocks for 30 or 40 years, actually for enhanced oil recovery. That means squeezing the last bit of oil out of an old oil reservoir. So we know how to do this. It's not, to use a cliché, rocket science. It's something that we know how to do. And we think we could probably store quite a lot of CO_2 in this particular rock. This is another reason why this pub is interesting because this is bunter sandstone, and this bunter sandstone underlies a lot of the North Sea, and the Irish Sea, and these are places where we might put the CO_2. So you're actually looking at the rock that would be our storage space underneath the North Sea.

RH: Now, you dribbled the beer on a couple of minutes ago, it's almost disappeared but some of it's come out again. How do you ensure that your carbon dioxide stays there, how do you know it's going to be there, it's got to be there for thousands of years, tens of thousands of years?

MS: Well the main thing is to have the right kind of structure that will keep the CO_2 in place. CO_2 is a buoyant fluid when it gets injected at that depth and it will tend to rise up above the water that's also in the rock, because most rocks at a certain depth have a lot of water in them. So it will tend to float up and the key really is to making sure the rocks above the reservoir, or above the sandstone, are completely impermeable. It's a bit like a damp course in a house - in a wall, the damp course is what stops the damp getting further up. We're talking about a rock layer, normally a shale, which is a fine-grained black rock that stops the CO_2 going up any further.

RH: So when is this going to happen? Are we on the cusp of this technology being available, so we start injecting carbon dioxide into these areas?

MS: The key thing is [there are] three types of technology. There is capture, which is really a chemical engineering activity; the transport, which is putting it through pipes; and the storage or injection into rocks. All those three things are known about and we've been able to do them for a long, long time separately.

RH: And just to clarify, there's the capture from say a power station or something like that?

MS: Yes. Generally we capture from power stations, but there's no reason why you couldn't capture from a cement works or an ammonia factory, all of them produce a lot of CO_2.

RH: OK, so you've got all those in place but ...

MS: ...the problem is the size of the activity, the sheer scale at which we have to do this is daunting. And also putting it together into a system that works where one thing feeds another, not too fast, not too slow: that's a big challenge.

RH: Couldn't it just be used as an excuse to carry on producing the amount of carbon dioxide we are?

MS: You could see it like that. I remember talking to somebody from a green organisation who said, 'Well carbon capture storage is a bit like liposuction on a fat person. Really you're not solving the problem, you're just kind of letting that person continue in the way they've always done.' And there is an argument that says we should spend more money on renewables or on trying to save energy use or what have you. But I think, for me, one of the complexities of this is other parts of the world, where there is a lot of coal, and there are a lot of coal power stations. And really those parts of the world are going to burn their coal and they are already building a lot of power stations, so I think carbon capture and storage has its place internationally and in Britain, and it's one of the things we can use to attack this problem of too much CO_2 in the atmosphere.

RH: Mike Stephenson from the National Centre for Carbon Capture and Storage, thanks very much for joining me for the Planet Earth Podcast, and I'm certain this is a subject we'll be coming back to. We'll put some pictures of the pub here on the Planet Earth Online Facebook page: type 'Planet Earth Online' into any search engine to find that and the Planet Earth Online website with the latest news from the natural world.

Sadly very little of this job involves sitting in the pub drinking beer. Take our next research story, for example, as we head to field on the outskirts of Oxford. Here hydrogeologist Kate Griffiths from the British Geological Survey is investigating the effect flood plains have on water pollution.

KG: We're standing on Port Meadow, which lies just outside the city of Oxford. It's a beautiful water meadow area. There are some horses and cows grazing in the distance. Over there we can see the River Thames, which flows from the north down to the south. In the far distance you can see the dreaming spires of Oxford and you can also see some of the new developments taking place on the edge of the city of Oxford.

RH: One thing you forget to mention was that we are standing practically in a lake, because the water in the meadow blends into the river. In fact I can't see where the meadow stops and the river itself starts.

KG: Yes that's right. Being February it's probably the wettest time of the year for this meadow so we've got some surface water flooding; so we've got [this area] where the river's overbanked and this channel that runs alongside us is creating this surface water feature which is here for quite a large part of the year. We've also got very high groundwater levels at this time of the year so where the water levels from the ground are rising up [to] the surface we've got this huge area of wet, and that's where we're trying to work at the moment.

RH: Let's head across to the experiment itself which is just looks like there's a scientist marooned in the middle of a lake!

Splashing in water...

KG: Yes, we do look a strange site. We did have one lady come and ask us - quite concerned one evening, at about six o'clock as it was getting dark - were we all right? And we had to wonder whether we were, but the things we do in the name of science I suppose.

More splashing ...

RH: It's getting a bit deep here, isn't it?

KG: It is yes, not quite over wellies but we'll go more slowly.

RH: I'd like you to picture the scene. Imagine a vast lake, surrounded by woodland, in the rain. At its centre, a scientist and a wheelbarrow with assorted equipment. What are you doing here?

KG: Well, underneath the lake we have some little wells which we use to sample the groundwater and they're sort of sealed off from the surface. So in order to get our sample we need to first pump out the surface water from around them and then we attach a sort of pipe that enable us to make sure we're only really sampling the groundwater, so we're not getting any interference from the surface water.

RH: Well the scientist standing by that wheelbarrow is Dan Lapworth. How did you even find where your wells were in all this water?

DL: One of the problems is this site has to be concealed, as there are horses that graze this area, so on top of each well we place a piece of metal so we effectively have to find them using a metal detector. Once we've found them we're then able to take a sample as Kate as described, and there's a whole range of different samples we're taking: some to look at the water quality and the water chemistry; some to look at how old the water is, to try and date the water; and some to look at the organic carbon in the water and to get an idea of the different types of organic carbon that's in the water.

RH: And there are multiple sites across this meadow?

DL: There are. There's a transect running from one side near to a landfill, across the meadow towards the river Thames. There's a series of three nests of wells and there are two transects that run across the meadow.

RH: And Kate, you're looking at what happens to the water as it goes across, the effects of the meadow on that water underground?

KG: Yes that's right. Floodplains are very active and dynamic environments so we've got lots of different types of water, we can see some here, groundwater under our feet obviously, and there's a lot of mixing going on in this area. We've got sources of water coming from the river gravels that form the city of Oxford, so urban input coming into the meadow. And then we've got a lot of interaction with the river itself. So as well as the physical mixing of all those waters we've also got a lots of bio-geochemical processes associated with that and we sort of expect those to change spatially and also with time. So seasonally we'll see changes in the chemistry as water levels rise and fall and we also see the influence of factors, as Dan mentions, such as this old domestic landfill which is situated to our left there, and that has its own chemical signature which we can pick up as we monitor.

RH: I notice in the mud that standing still is a mistake because we're likely to lose wellies! Let me move around a little bit. Why do this research? What are you looking for?

KG: The bigger picture really is that these floodplain environments - there's a lot of them across the country - and they're under increasing pressure as our urban areas move out towards floodplains and even onto the floodplains; as you can see over there in the distance the houses are virtually onto the floodplains. So we sort of want to try and understand what role the floodplain can have in trying to reduce pollutants coming from these urban areas and getting towards the surface water over there which is the river Thames. Obviously this is applicable to lots of other situations in the UK. A lot of our big rivers have lots of urban areas on their floodplains - the Thames, the Trent, and the Mersey for example.

RH: Dan, you've got the pump operating here, and it's pulling up some of the water and going into a little beaker. It looks pretty clean to me. Fundamentally is it quite clean water?

DL: It's been moving through the groundwater, the rocks beneath us which are actually sands and gravels, and as it moves through that it's actually being filtered as it moves. So the water you can see is relatively clean compared to the lake water that we're standing in, but it still does have lots of dissolved constituents in it. I wouldn't perhaps drink it though, no! It's got lots of microbes in it as well so it's probably not safe to drink, but it looks very clean.

RH: Now not all the science is being done here. You've got the meter here, it's measuring the ph - the acidity - of the water there, but you're taking samples and taking them back to the lab.

KG: Yes that's right. What Peter's gone to do now is to filter some samples, so they'll go back to our laboratory in Nottingham, at Keyworth, and we also take some samples which go to our labs in Wallingford. And some of those samples [are] of chlorofluorocarbons and sulphur hexafluoride, and those CFCs have been used over the last 80 years and they've been used in different proportions, so by taking a sample and working out what proportion of those CFCs we've got in that sample we can date the water and perhaps look at travel times and pathways through this floodplain meadow.

RH: This is worth it, is it Kate?

KG: Absolutely. We've been sampling here since May last year and we're starting to process the results we've had back from those earlier sampling rounds. But yes, we're beginning to see some very interesting things and we're seeing links between changes in water level and the chemistry and we're hoping that these results are going to be applicable not only here but to wider sites across the country.

RH: Kate Griffiths from the British Geological Survey. And what you didn't hear there were our comical efforts to extract a 4x4 from the flooded field. A process that saw some of us get completely plastered in mud. There's a video and some pictures of the research team on our Facebook page, which are well worth a look.

In the last two podcasts we revisited the GOCE and SMOS satellites for an update on their progress monitoring the Earth's environment. This time we're featuring the third European Space Agency Earth Explorer Mission as we approach the first anniversary of the launch of Cryosat. Its aim is to measure ice cover at the poles and Sue Nelson reports on how the satellite is performing.

Researcher: The satellite itself, the hardware, is all in excellent shape. The hardware and the downlinking to ground is all working perfectly.

SN: Duncan Wingham, Professor of Climate Physics at University College, London and principal scientist for the Cryosat mission. The satellite is using a radar altimeter to map the thickness and shape of the ice to centimetre accuracy. So it's important to know exactly what you are measuring. Seymour Laxon, head of the Centre for Polar Observation and Modelling:

SL: A critical part of the processing is to be able to determine whether you're making a height measurement over water or whether you're making a height measurement over the ice, because it's that difference in height we use to tell us first of all how much ice is sticking up above the water and then we can convert that number into a thickness using a calculation similar to the idea that nine tenths of the ice is beneath the water. So we've already starting looking at how well Cryosat does in distinguishing these two reflections from water and ice and essentially the echoes over water tend to be very mirror-like. The water in the Arctic is very flat, it's very smooth because it's protected from the wind by the ice in between, whereas the water on the ice, which you might think of as new ice, is very smooth, newly formed ice. But generally, first-year and multi-year ice, which is the ice we're trying to measure, the surface is much more rough; it's been deformed, it's got snow on top. So the reflections from that are not mirror-like, they're more diffused, like what you'd get from a bit of paper as compared with what you might get from the mirror. So you can look at the echo shapes from Cryosat and see whether they look like they're coming from a mirror or if they're coming from a more diffused sort of paper-type surface and by doing that you can essentially look at how Cryosat is discriminating between reflections from water and reflections from ice.

SN: In order to verify Cryosat's accuracy, scientists have been comparing its data favourably with the Envisat satellite's radar imagery. And now that the Arctic winter is more forgiving to the researchers on the ground, a team from University College London will visit the Arctic in April to make in-situ measurements on ice sheets and sea ice. Duncan Wingham:

DW: The purpose of these ground measurements is to make local measurements which we can use to verify the satellite measurements and, perhaps slightly more importantly, determine what the error in the satellite measurements are so that when we provide, for example, sea ice thickness for climate modellers, they can have some idea, not just what say, the mass of the ice is doing but also what our error is in those estimates.

SN: And as scientists prepare for the most accurate measurements ever of our planet's ice cover, Cryosat has also managed to give an important first picture of how Arctic Ocean currents are moving, as Seymour Laxon explains.

SL: One of the by-products of measuring sea-ice freeboard using radar altimetry is that, using part of that processing, you have to of course measure the level of the water. And we've known for some time that you could take this data alone, and instead of looking at the thickness of the ice, you could actually look at how the water levels in the arctic are changing. And that's a particular interest because when the water level changes that indicates there are some changes going on in the ocean currents.

What we've done is to take some of the very early data from Cryosat. We've checked that we can identify only those measurements coming from open water so we've just taken that data and generated a map of what we call a dynamic topography in the Arctic - that's how the elevation of the water changes because it's moving. We've been able to generate the first map of that and reassuringly it looks remarkably similar to what ocean models predict. So Cryosat has given us the first picture of how Arctic Ocean currents are moving around, almost up to the North Pole, and the fact that it agrees with the model so well tells us that Cryosat now provides a tool to look at how Arctic currents may change in the future.

RH: Seymour Laxon, head of UCL Centre for Polar Observation and Modelling. And that's the Planet Earth Podcast. All our past podcasts are available on the Planet Earth Online website. I'm Richard Hollingham and I don't know about you, but I could do with another beer. Cheers, thanks for listening.