

In conversation: Phil Wilson & Hannelore Smith

- HS Thanks for inviting me to Weybourne, so firstly tell me about your research?
- PW My research and the data that your drawings are based on are from Weybourne Atmospheric Observatory, which is out on the Weybourne coast just past The Muckleburgh Collection. There is a 12 metre tower, which takes air in from the atmosphere, and we monitor it for the concentrations of carbon dioxide and oxygen in the air continuously; we take a reading that's averaged every two minutes. Every day, every week, every year we build up different time series of the data and we see how the levels of carbon dioxide and oxygen vary in the atmosphere on different timescales.
- HS And what have you found is happening?
- PW Weybourne has a lot of different kinds of air. Over the course of a year; carbon dioxide and oxygen go up and down throughout the seasons essentially as plants grow and die back. So during the spring and summer when plants are growing leaves and there is lots of sunshine then the plants are photosynthesising; they are taking up carbon dioxide and giving out oxygen. So carbon dioxide reaches its lowest values towards the end of the summer and oxygen reaches its highest values then. In autumn and winter when a lot of plants are dying back there is not as much growth, there is much less photosynthesis and much more respiration. The net effect is of respiration; where the soil, plants themselves and animals are breathing and taking in oxygen and giving out carbon dioxide. So carbon dioxide reaches its maximum in late winter early spring, and oxygen reaches its minimum at this time. So throughout a year you get this curve like a sine wave going up and down
- HS So that is the data that some of my drawings are based on.
- PW Yes, it shows the seasonal cycle in the two species which are anti-correlated. Because of the processes involved when carbon dioxide is going up oxygen is going down. That's why they go in opposite directions.
- HS Are they always equal opposite, or does that change?
- PW They are not quite equal and that is due to different processes which are involved. When we just talk about respiration and photosynthesis then they are equal and opposite pretty much. It's a 1.1 ratio, they are only just unequal. But there are other processes going on as well which occur on different timescales such as out gassing and in gassing from the oceans. This is particularly true for oxygen, because it doesn't do any chemistry in the ocean-it's just a physical property. As the ocean gets warmer things become less soluble in general so in the summer oxygen is out gassing and in the winter in gassing. So that kind of adds to the seasonal cycle because that's in phase with the photosynthesis. Carbon dioxide does go in and out of the oceans as well, but it's a bit more complicated because it reacts with water to form different acids and these buffer the intake of carbon dioxide so it doesn't vary quickly enough to be seen on these timescales.
- HS So how many years has your research been going on?
- PW Oxygen and Carbon Dioxide started being measure in October 2007, so we now have almost a 6 year record.
- HS We are surrounded by a lot of instruments in here- what do they all do?
- PW Weybourne observatory was opened in 1992, and measures a lot of other things. They measure ozone and other volatile species; methane, nitrous oxide and a lot of other gases. Initially there was a lot of other research from the UEA to do with Ozone

depleting gases; CFC's and HFC's and that's why the observatory at Weybourne was originally set up. The Carbon Dioxide research has been a newer thing since my supervisor Andrew Manning started at UEA.

HS And at Weybourne has the research just been about the gases or the weather as well?

PW Yeah, I suppose the weather affects it, the gases are what makes up the atmosphere, the weather and the climate affect the levels of those gases, so the things I have been talking about so far are the really general large scale things that you see everywhere; the background things that you experience all over the world to varying levels. The weather plays a big role in what other signals Weybourne sees. So on much shorter timescales if the wind is blowing from South West of Weybourne then it sees air from London. It sees a lot of polluted air, so high in carbon dioxide levels and carbon monoxide concentrations which you can relate to exhaust fumes and power stations.

HS So those gases travel through the air

PW Yes the weather determines which air Weybourne is seeing at any one time and that is kind of represented in the footprints of the particle dispersion models that you have used in your drawings-that kind of shows where the air has come from-which different regions.

Weybourne was started because it was on the coast; we hoped that we would get background air. Because from Weybourne in an approximately northerly direction there is Ocean all the way to the arctic, we hoped we would see relatively clean unpolluted signals. We do some of the time, but its quite a small percentage of the time, so a lot of the other time Weybourne is seeing air that has passed over mainland Europe and big cities in Germany and France in the last 10 days, Air from the UK and even beyond the UK, it sees air from the Atlantic Ocean on the other side of the UK. So although we hoped to get a clean signal we actually see a lot of complex signals overlaid in the Weybourne data, and that is hopefully going to be a strength in the data because once we can pick out which signals are from where we can get a lot of detail and variety within the data.

PW You have just taken your research data to China for an international conference- how was it received and what is the rest of the world seeing in terms of their research?

HS In that respect, Weybourne is quite a local station, it sees localised signals, because the tower is only 12 metres high and because it sees air from polluted sources a lot of the things we can see in the data are due to local pollution sources, local growth of crops and things in the area and some oceanic signals. We are trying to pick out a clean background signal but that s a work in progress once we can do that then the data from Weybourne can be used in conjunction with data from all of the other stations to go into these global models which help to model what's going on with the climate and from that predict what will happen in the future so we hope that it will go into those models, but at the moment its not clean enough its not in a finalised state to be used. However there was quite a lot of interest in the short term variations that we have seen in some of the local pollution events, there are other people measuring oxygen on an oil platform in the North Sea in Greenland and in Groningen in the Netherlands so we are hoping to work together with them, to characterise the local sources and sinks of the North sea. Also there aren't that many places world wide that are measuring Oxygen, maybe only 10 or 12 laboratories that measure it and maybe 30-40 field sites. For carbon dioxide you are looking at 3-400 sites. It's fairly niche and because of that there is interest around the world in the research we are doing.

PW The data needs to be explored further before it's published properly which is something I will be working on in the next couple of years.

Also although the record goes back to 2007-that is still a relatively short timescale in terms of longer term variations year to year. It's hard to tell what a real difference is and what could be due to the experimental set up that we have at Weybourne.

HS So in the 6 years of data what have you surmised in terms of what might be happening locally?

PW From statistical analysis of the data it looks like carbon dioxide is increasing on average by about 2ppm per year, this is in line with increases observed at other northern hemisphere stations at similar latitudes. So that means that carbon dioxide is at the moment at an annual average of about 394 ppm in the world. It's going up at about 2ppm every year so we are getting close to the 400ppm figure, which was forecast in one of the early IPCC reports (which is the big UN panel that looks into climate change). 400ppm was one of the cut-offs for having the global average temperatures rising above 2 degrees Celsius in the next 100 years. We are getting close to that already and we are not really showing any sign of slowing down our production.

HS Is that happening sooner than was predicted?

PW We are at the higher end of predictions, so whenever they predict these things they predict a range of different scenarios. We are currently on one of the higher rate of emission scenarios so yes we are reaching this figure quickly. I do have some hope that we are more aware of it and that people are trying to slow down. At the conference I was at in China they do seem very keen, in China in particular, to cut their emissions and to try and find alternatives to the coal that they are using. I do feel slightly encouraged that countries are taking their responsibilities more seriously, but it's a slow thing and it's very hard to change an entire infrastructure in a number of countries overnight.

HS And are the main contributor's things like the factories?

PW On large scales, yes its power generation, transport, cement production...

HS What about every day Joe Bloggs, using our cars and things like that –how much is that contributing to the rise?

PW I suppose everything contributes a little bit, when you put things into scale then one person using their car is absolutely tiny, but with all of these things, I think we have all got to be a little bit more aware. It's all very well talking about one person but if we all try and use a little bit less then it can rapidly multiply up throughout the population. I do think it's a good idea to take some personal responsibility for it, it means that we are more aware and able to make slightly better decisions and maybe that will slowly have this drip, drip effect. We might start to use the car a little bit less and choose lower impact fuels, lower carbon impact electricity suppliers and all of this and it will start a bit of a sea change in people's opinions and responses to what's going on. I think that's a relatively easy and low impact thing that everyone can do and should feel good about doing.

HS If the levels keep rising what is the prediction-what will happen?

PW The climate system is incredibly complex, so that is why there is so much debate as to what might happen. All along the way as people have projected climate change and global warming there has been intense debate and argument as to what will happen and why it might be happening. At first people denied that carbon dioxide would cause any warming, it seems to be generally accepted now, and it's a physical property of carbon dioxide and other greenhouse gases in the air trap heat and cause warming. Now the debate seems to be centred on how much warming they will cause and how much our planet has a system that can buffer that change and offset it.

So the predictions seem to be that we are very likely to go over 2 degrees of warming. The average global temperature per year will rise by 2 degrees. Obviously from day to day 2 degrees rise isn't much, but when you take that figure and apply it over the entire system, 2 degrees is likely to cause quite a lot of changes in global circulation both in oceans and the atmosphere. This will potentially change weather patterns, it could lead to different seasonality and weather being experienced in different places.

2 degrees is seen as this cut off where we have some potentially catastrophic effects to do with the loss of the arctic ice in the summer, so the arctic ice sheet will completely disappear in the summers. It increases the sea level; thermal warming causes the ocean to expand a bit so we are likely to see sea levels rise which will obviously affect some islands. It will warm certain parts of the planet, and it will probably cause certain parts of the planet to be colder as well, as the temperature rise doesn't happen evenly over the surface of the planet. The tropics and places around the equator are likely to get very hot and some of the places in higher latitudes are likely to get colder and so this will all cause strange responses and tensions to fairly largely inhabited places and so that puts stresses on the people living there.

HS What about the wildlife?

PW I guess people have a greater control over their own environment than wildlife do, to a certain extent we can create our own environments, responding to changes by increasing the heating or turning on the air conditioning. Whereas some animals have a particular niche that they occupy, so if weather patterns change or if there is a warmer climate in general it may be that they can't cope as well and it puts a pressure on them and we may start to see migration and extinctions. I suppose this relates to things like the Spoonbill which is now migrating to our coastlines when we previously didn't used to see it here, and that's because our summers have got warmer; certainly throughout the 90s and early 2000s we saw a very steep warming; that's levelled off a bit in recent years and we are not seeing warming at quite the same rate. So it's clear the Spoonbills migration patterns are changing in response to the different weather patterns that we are experiencing over here.

HS So good for Birdwatchers!?

PW Yes it changes things for Birdwatchers and I guess with anything it's hard to say what's positive and what's negative. When certain animals move into other animal's habitats and they are better at surviving they might out compete and other animals will decline.

The other things is that in the oceans, when we put more carbon dioxide into the air more is going into the oceans as well and because it undergoes these reactions that I mentioned earlier that causes acidification of the ocean and that softens the shells of certain small organisms and fish. Beyond a certain limit it will become uninhabitable for them and that could lead to the collapse of entire ecosystems. As everything is so interlinked, and particularly in the oceans these very small organisms filter right the way up to larger organisms in the food chain and we are not quite sure what the repercussions will be.

It will certainly change things-how disastrous that it will be, I guess is unknown. It is a case of whether we really want to experiment and find out?

It is just all happening a lot more rapidly than nature tends to happen so that species aren't being given the chance to evolve to meet with the different pressures which are being put on them.

Basically since 1750 and the industrial revolution over the last 250 years, humans have increased the carbon dioxide concentration in the atmosphere by over 40 percent. We have had a massive impact in such a short space of time that we are conducting a massive experiment on the world's wildlife to see how quickly it can adapt to these changes.

- HS So if you know that figure of 40 percent- have carbon dioxide levels been recorded as far back as 1750?
- PW No, so to look backwards in time there is a number of quite clever and ingenious techniques to try and model the atmosphere before we started burning fossil fuels. They include things such as ice cores, where air from different times is trapped in the ice at the poles during the seasons of snowfall and once it freezes and gets to a certain depth and the snow builds up on top it really does seal it off so you can no longer have exchange between the layers. And scientists are able to drill down and the directly extract the air from specific times.
- HS That's amazing!
- PW Very clever, yeah! Scientists also look at tree rings; another affect of carbon dioxide is fertilisation; plants love carbon dioxide- it helps them to grow and that's what's helping to take some of the carbon dioxide out of the atmosphere that we are putting in. This growth can be seen in the rings of a tree-when there is higher levels of carbon dioxide the plants grow more and the rings are further apart. Another way is through looking into sediments; drilling down in the ocean sediment similar to the ice core method.
- HS Wow...I can see a whole new body of work looking at ice cores.
- PW Yeah, this has all come about in response to the realisation that carbon dioxide levels were going up. We only really started directly measuring carbon dioxide in the atmosphere in the 1960s – a guy called Charles Keeling in Hawaii started measuring carbon dioxide and it was only then that we found out that carbon dioxide had this seasonal cycle throughout the year. The pace of research since then has been quite staggering. We recognised the need that in order to model what might happen in the future climate we needed to know what had happened in the past-that's why all these ingenious techniques to measure gases in the past were developed. It's reassuring how innovative and clever human beings can be in response to a challenge put in front of them-that should give us hope for the future. Ultimately I hope it not all doom and gloom, we don't know what will happen; but we should be cautious and make reasonable changes and take responsibility for our own actions.
- HS I heard in the news the other day a group of weather experts met up to discuss the strange behaviour we had been experiencing in our weather recently-do you think that the rising carbon dioxide levels has had a part to play in this?
- PW It's really hard to say and it's quite a contentious subject, because the whole earth system is such a complex thing it's very hard to say directly that one thing is causing another thing. So on a non scientific, on just an intuitive level, to me it does seem likely that if we are changing the atmosphere by 40 percent and increasing temperatures around the globe, it doesn't seem that big a leap to think that weather patterns will change from place to place. At the moment we can't definitively prove that- we are relying on models. Inherently in models they are the best simulations that we can come up with of the planet as a whole but there will always be arguments over how well they simulate the planet-they are just that simulation. It's very hard to prove, but it seems likely that changing the temperature and the way the earth is being warmed will change some of the fundamental circulation patterns.
- HS So I am guessing that gathering all this research hasn't been plain sailing- have there been difficulties?
- PW Unfortunately things are never as easy in real life as they appear on paper! Making the measurements requires a lot of time and attention to detail. The concentration changes we're observing are very small and we have to see these against quite a big background signal so it is technically very challenging. We also have to ensure that

the numbers we're reporting are meaningful and comparable to other laboratories so very careful calibration regimes have to be followed and maintained. Then there are always unexpected problems like analysers breaking down or computer issues that can lead to gaps in the data record too.

HS At the UEA there is a lot of other research going on, do you cross pollinate?

PW The Environmental Sciences Department at the UEA is one of the biggest in the UK and there is an incredible breadth of research going on. There are lunchtime talks several times a week, so you do get see a lot of other peoples work and you have the opportunity to work with people and understand their research. I suppose it is very easy to get caught up in your own little part of what's going on, but from a curiosity point of view it's really valuable to hear about other work. We are lucky at the UEA that there are a lot of clever people carrying out good research and you can always approach them.

HS Have people used your research data for other research projects?

PW Yes some of the Weybourne data has been used in some low level modelling, looking at the expected seasonality of the North Sea areas. That's something that we will hopefully expand on. And as we look more into the data, it will hopefully get used more and more. The data will be uploaded to central databases made freely available and to other modellers for their research. It is still very early and we are still working on the data, but I hope it will be used a lot more.

HS It's very exciting to think that this research is happening on my door step.

PW Yes I guess we don't always realise what's going on around us. Because our data is not really finalised we haven't published it yet, so there isn't the awareness or recognition, which is why its good to collaborate with yourself and have the research highlighted through your work being exhibited at CLEY 13. On a personal level, I like the different synergies between art and science, and I like the fact that our collaboration is opening this up to a whole new audience of people rather than staying within a stuffy academic journal which maybe on 5 or 6 people will read.

HS Yeah I am hoping that my drawings will get people thinking about it, and maybe making some changes...

To find out more about Weybourne Atmospheric Observatory visit:

www.veybourne.uea.ac.uk

To find out more about the research undertaken by Mr Philip Wilson and colleagues at the UEA please contact Mr Wilson through the following link:

www.uea.ac.uk/environmental-sciences/people/People/Contract+Research+Staff/wilsonp