Topic 1c - Choosing what data to collect

One of the most important developments of remote sensing over the last 30, 40, 50 years-- and the advent of digital technology has enabled particularly-- is the ability to move beyond the parts of the electromagnetic spectrum that we can see with our eyes. That's obviously a very, very important part of the spectrum, particularly for us, because that's the bit that we see. But it's actually a very, very narrow range of wavelengths that we see.

We see between about 400 and 700 nanometers. So the optical part of the spectrum stretches from about 350 up to about 2,500 nanometers. And we see this little tiny slice through the middle of it. And that little tiny slice, let's say, is very, very important to us, because it's the bit we see.

It's also the bit where, not by coincidence, but about 40% of the sun's total solar energy lies. It's also the bit of the sun's energy that can get through the atmosphere to the surface to enable us to see.

This is an example of an esa Sentinel-2 image over the UK taken in December 2015. If we look over here, these are the dreaming spires of Oxford over here, and the green stretches of the winter countryside in England, surprisingly green, despite the fact that it's winter. And in fact, these turn out many of these fields will be spring or autumn planted crops that either persist through the winter or have recently emerged.

What's interesting is that, again, we look at this image. And we can kind of understand what's going on. We get the idea that green things are plants. Green things are trees. Green things are fields.

Things that are not green, things that are white and grey, tend to be urban things. Things that are brown are probably bare fields. We've got some dark patches over here. This is obviously a water body. It's almost entirely black. There's no reflected radiation coming from this in this part of the spectrum.

We've got some stuff over here. This is an area of woodland. This is Wytham Woods. One of the things that we notice about this is it looks rather blurry and dark. The reason for that is these little white fluffy things over here. So these little white fluffy things are clouds. This is the shadow of these clouds.

This shows us a couple things. Firstly this shows us that this was taken at quite a low sun angle. The sun is obviously down here, shining at quite a low sun angle, casting shadows over here.

This also illustrates one of the real problems that if we are only limited to looking in this narrow part of the spectrum to which our eyes can respond, and which photosynthesis occurs, and which most mammal eyes respond to, it's a very important part of the spectrum. But if we're limited to that bit, one of the things that we're going to struggle with are these things. Clouds. Because we can't see through them.

So that's one of the limitations of optical remote sensing more generally is that clouds get in the way. So we have to think about what to do with those.

What if we were able to look at other parts of the spectrum other than just the purely visible part of the spectrum? What happens if we can look at longer wavelengths? Can we find other useful and interesting things out about the world?

If we can look at other parts of the spectrum, we can capture reflected radiation at longer wavelengths, or sometimes even shorter wavelengths than those of which our eyes are sensitive to. Then the answer is yes. We can find out things about the world that we weren't aware of.

So here is an image, again. This is our Sentinel-2 image of Wytham Woods over here and Oxford. This now is displayed in the colour scheme, which is very far from intuitive. We can look at the spatial patterns and recognise the things that we saw in the real colour image.

So we can see Wytham Woods in the cloud shadow over here. The clouds still show up bright. Here is the city of Oxford. There's some funny blue colours going on here.

Here's our water body, which has very, very low reflectance. It's almost completely black. And that's because when light hits a water surface like this, most of the light passes into the water. And very little of it reflects back to be measured. That's why in the visible part of the spectrum, but also in these different wavelengths, water bodies tend to look very, very dark indeed.

So what is this colour scheme? What is it telling us? We are now looking at a part of the spectrum where our brains are not really able to determine what's going on. Not at least intuitively.

What we're looking at here primarily is a slice through the near-infrared part of the spectrum. So we're moving to wavelengths that are slightly longer than visible. Here, this is looking at around 800 nanometers. So it's not far beyond the visible part of the spectrum. But it's a bit that our eyes are completely insensitive to.

Interestingly, plants are also pretty much insensitive to this part of the spectrum, too. So chlorophyll, which drives photosynthesis and drives life on Earth, provides the basis for life on Earth, photosynthesis responds to the visible part of the spectrum. The photosynthetic pigments of chlorophyll and xanthophyll absorb in the visible part of the spectrum and generate plant material and food and so on.

As we move to longer wavelengths-- just slightly longer wavelengths-- there's less energy from the sun. And chlorophyll and these plant pigments don't absorb that radiation at all. They're not interested in it. They can't use it.

So what happens to that radiation? When that radiation in the slightly longer near-infrared part of the spectrum falls on plants, almost all of it is reflected.

So if we were able to look at slightly longer wavelengths visible in the near infrared part of the spectrum, if we were able to look at plants, plants ought to look pretty bright in that part of the spectrum. And lo and behold, they are.

So where this image is red, that is showing high reflectance from vegetation. The redder and the richer the red it is, the more reflectance is going on from the vegetation. So straight away, just by simply taking a slice through the electromagnetic spectrum at a slightly longer wavelength than we're able to do with our eyes, we are able to highlight areas of vegetation.

The more chlorophyll there is in that vegetation, the healthier it is, the more active it is photosynthetically, the more reflectance there will be in the near infrared. So this is what we're seeing in this image.

The other thing we're seeing is we're seeing the contrast between the near infrared and the visible part of the spectrum. Of vegetation, this photosynthesis process absorbs most of the light in the visible part of the spectrum-- about 90% of the light. And about 50% or 60% of the light in the near infrared is reflected.

So there is this very, very big contrast between what's going on in the near infrared and what's going on in the red. So again, if we are able to look at these two parts of the spectrum, we're able to show very clearly the difference between photosynthetically active vegetation and the areas that are not vegetation. We have areas in between.

So these areas here are probably ploughed fields. These areas here that are kind of pinkish suggest that there's a little bit of vegetation there. Not much.

The denser and darker this red is, the more vegetation there is, and the more chlorophyll there is we're looking at over here. And areas over here, where we're seeing dark colours and blues and whites, that's areas where there is nothing photosynthetically active at all.

This image highlights the sort of thing that we can do if we can look beyond the visible part of the spectrum. As we are able to look further and further at longer wavelengths, and even shorter into the ultraviolet part of the spectrum, we're able to say things about the world that we're just simply not able to say by looking in the visible part. The bits that our eyes respond to.

The advent of digital technology, in particular, silicon detectors and other kinds of more exotic semiconductors, have enabled us to build remote sensing instruments that can look in the visible and in the near infrared, and in the ultraviolet, and in longer wavelengths that tell us a whole different story about the Earth.