# Summer school keynote - using drones and phones to collect river flow data-20250714_093348-Meeting Recording

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**Samantha Rees** started transcription

**Samantha Rees** 0:05

Thank you, nick.

**Nick Everard** 0:07

OK. Well, good morning, everybody. So yeah, as Sammy said, I'm Nick Everard. I'm as it says here on the slide, the senior hydroelectric scientist here at UK central ecology and hydrology and this talk is about measuring river discharge. So what we mean by that?

It's volumes of water moving through river systems, so you know, if you I I believe you will have a pretty good understanding of hydrology. So hopefully you understand that rivers are kind of where the water ends up, it falls from the sky, it runs through the soil and comes out of the ground and you know it ends up in the river. So understanding river discharge.

Is a really key variable for understanding in hydrology. And so this one, this presentation is going to look at a number of tools and techniques we can use for that, including some of the more cutting edge and exciting ones like drones and satellites and stuff. And there is even a place for Rice Krispies breakfast cereal as we'll see towards the end of the.

Of the presentation. So sorry, apologies, I've got the wrong day on here. I was on holiday last week and we extended our holiday until I got back late last night, at which point I realised oh, I'm giving a presentation first thing in the morning. So so this is hastily compiled from lots of other slideshows, but I think it'll make sense. So. So anyway, who am I and why am I here?

So yeah, I I started as a boy hydrometrist measuring rivers at the age of about 5, presumably because I've now spent 3.7 decades. I think it is measuring rivers with a variety, so during our period we've used a variety of different tools, but there's been

this real acceleration in recent years.
In terms of new methods, new techniques, and also as we'll see in a minute why we need these things, you know it's getting more difficult and it's ever more important to make sensible measures of river discharge. So back in February, when I was giving a similar presentation, I thought, let's see what AI knows about this.
So I asked ChatGPT to generate an image of someone measuring stream flow with a current metre, and it's sort of got elements of it right? But it's kind of clearly misunderstood. Certain bits of it. This giant backpack that looks very technical. I don't know what that's all about, but but fundamentally this isn't that far off. Traditionally we use.
Using what we call a current metre, which is basically like propeller but in reverse, so it turned by the flow of the water. The mover of the water makes this thing rotate and then you count the rotations with some sort of little gadget and then you calculate discharge based upon the velocity of the water and the cross-sectional area. But this is a velocity measure.

JL **Jay Lindle** 2:18
Yeah.
What?

NE **Nick Everard** 2:35
The reason they've got it wrong is the whole of the impeller is usually in the water, because otherwise it's going to be influenced by wind and things so so ChatGPT needs to go back to the textbooks I think and improve its understanding of measuring river discharge. But anyway, why is it important? I mean it's really important for, you know, water is arguably our planets most important resource, you know with.

JL **Jay Lindle** 2:48
Yeah.

NE **Nick Everard** 2:55
Without it, we would all pretty soon cease to be here. Agriculture would cease, industry would cease, the economy would seize up. It. Nothing much would happen. So water as a results. But flooding is perhaps the one that captures the attention

most often. You know flooding most.
Blood events we see is an excess of water in the river, so it's a river discharge greater than the channel can can contain and it causes all manner of destruction and financial cost and tragically, loss of human life as well and.
Things like effluent and wastewater. If you want to put anything into a river, you need to know how much water is there to to dilute it and carry it away. Agriculture and industry need water, obviously, for their activities, energy production, whether it's hydropower or cooling, a nuclear power station, it's needed environmental flows, you know, all of this stuff we've talked about is.
People stuff. But you know, I think I read the other day. We're one of eight million species on this planet, but we kind of treat it like we're the only species sometimes. So we need to leave water for the environment as well for animals and creatures and plants. Navigation. I've done a lot of work on the River Thames. Lots of boats use the River Thames.
So they need enough water. And yeah, I think I was presenting this at Oxford University. So I was talking about rowing because we were going to do some field work down by the rowing down by the rowing buildings. So. So, yeah, you know, all that kind of stuff. It's important for loads of reasons I could have said, have been a bit more succinct.
I talked about quite a bit about how, you know, we're looking at new methods, so these are some of the traditional methods. These are some of the methods I used for many years. This isn't actually Auk river. I've never known UK river to to freeze up quite like this. This is a picture from the US, from the United States Geological Survey, but he's waiting.
Cross the river with a little current metre in under the ice is this little thing rotating from the flow of the water. But you can imagine this is going to be pretty cold and pretty miserable and pretty difficult and pretty dangerous. So if we can develop new methods that mean we don't have to do that anymore.
This one we used to do this, so this is like a winch system. It's mounted on this big sort of metal frame. It's got wheels on the bottom. You can't quite see. But, and this is a 25 kilogramme lump of lead which was used to hold the propeller thingy, the thing just above it.
Still in the water, so we winch this thing down into the river and and it would sit there, held steady by this big lump of lead. And we would count exactly the same as with the the top left. We would count the number of revolutions of this little

propeller, but then we have to move it to another place and another place and another place. So we would do a whole series of measurements. You can see this guy.

**396 611 257 854 0** 5:39
11.

**Nick Everard** 5:40
Top left. He's doing a measurement at this location, but he will have done about 15 before. He's got to that point and he'll do another 15 before he gets to the far side. So it's a slow process and you you leave this thing in the water for about a minute at each location. So it'll take you something like an hour, maybe an hour and a half, to do a single measurement.
This is me as a boy hydrometrist mucking about on a boat on the River Thames and a few details to notice. We've got a cable stretched all the way across the river. This thin little grey line you can see here. There's a steel cable which we've stretched all the way across the river and then winched really tight so we could tie the boat to it. So the.
So it's got a mount board, but it's not turned on. We've got the boat just tied to this cable and then we've got a 7 metre long aluminium pole and imagine 7 metres go find somewhere that's two metres long or three metres long and then more than double it and then try and sort of hold it and wave it around. And then imagine sticking it into flowing water. So what we've got here though?
The reason we've got such a long pole is the water's sort of four or five metres deep, but we've got five of these impeller metres. These current metres mounted on this pole, the bottom ones under the water. But we had five. What that means is we can get readings at a whole range of depths because as you'll see.
Water doesn't flow at a uniform velocity in a river. It's faster tends to be faster at the top than it is at the bottom, tends to be faster in the middle than it is at the edges, but that doesn't always hold true. So so by using five of these things we could get 5 readings at once and make it a bit quicker.
But it was very hazardous. So what do we do? More recently, the current kind of established state-of-the-art is acoustic sensors called acoustic Doppler current profilers. And we've developed a remote control boat. I kind of led the development of this in my previous job before moving to CEH.

But at Wallingford in Oxfordshire, we developed and built this little boat that deploys an acoustic sensor and you just stay on the bank and drive this thing across the river and it measures the depth, measures the speed and reports discharge when it gets to the far side. So it's pretty neat. So we still do that, that's widely practised.
In the UK and and around the world, and if my slide will advance, we can see what we get from that. So Adcp stands for acoustic Doppler current profiler and we'll talk about a Doppler thing very briefly in a minute. But it uses pulses of sound to measure the depth and the speed of the water.
And it does it as the boat carries this thing across the river. So we just basically drive it from one side to the other and it's producing this data as it goes. So this is like half the river measured and the other half is going to look pretty similar, but sort of almost reflected. So as we've come from the bank, the colours tell us what's going on.
It's getting deeper. We can see it gets deeper because we've got more data extending further down the screen and it's getting faster. So purple equals very slow flowing water. Red equals relatively fast flowing water and blue and green colours somewhere in between. So it's a really nice solution. It's using these pulses of sound. Constantly doing that as it moves across the river and it's pretty neat. It takes about 3 minutes to do a a single crossing and a single measurement because it's so quick.
We tend to do four of these things we'll do across and back across and back and then we've got a cross validation, you know, do we see four consistent results?
Or are there any outliers? So how does this thing work so it uses acoustics so the the instrument if you can see it looks like this. It has these acoustic transducers since pulses of sound out into the water column and it uses those pulses down to measure water depth.
Water speed and what we're calling boat speed. So it's measuring how deep is the water, how fast is it flowing. But it also needs to how fast needs to know how fast it is moving across the river. So the detail of why that's the case, you don't need to worry about at the moment but. But just know that that's what it does. And again you know this is a full.
Cross section of a river from one bank to the other bank and as you see again slower water at the banks. The purple colours faster water in the middle and faster water towards the top and that's that's the normal distribution, but doesn't always hold true.
So how does this thing work? So for getting velocity it's putting the sound into the

water, but it's listening to echoes coming back from the water, but it doesn't come back from the water itself. The Echo comes back from particles and things in the water. So this picture here shows you this is a little stream in.
Lost to share? I think I got my I just got a GoPro. So I was very excited about could I imagine look at things under the water and you can see there's all these little bits of suspended sediment, maybe little bits of aeration, little tiny little bubbles of air. But this is the stuff that the velocity signal comes back from because it gets a Doppler shift.
Because of the movement of these pascals, so a Doppler shift is something that we experience in in, in everyday life. If we live in a town or a city and maybe more, more infrequently in the coach side. But basically the most obvious example of this that we experience is a police siren. So you know what a police siren goes past you. You can tell even if your eyes shut.
You hear that change in the sound? It goes Nina, Nina, and then it goes, Nina. And you know it's a lower sound. Lower frequency sound as it goes away from you. And that's because as the as the source of the sound in this case, the police siren is moving towards you. The sound waves effectively sort of compress up a little bit. And then as it passes, you moves away the sound waves.
Stretch out a little bit and so you get this lower frequency, so going back to my little picture here, particles moving towards this sensor are going to create a higher frequency in the echoed signal and moving away it's going to get a lower frequency. So it's using that same principle as the police siren to figure out the movement of these particles in the.
Water. Pretty clever, really nice, gives us great data. Here's an example. Again, that's similar sort of pattern. Yet again, this is a flood measurement on the River Severn. You can see it's a flood because this is the river and this is farmland ordinarily, but it's gone all over. So it's about, you know, the river has gone from being about 80 metres wide to being about a mile wide, which shows.
One of our one of our challenges, but yeah, we got this really nice set of data and this is important to note now because we're going to start to move on to methods of measuring rivers that are just looking at velocity, speed of the surface okay. So we're only everything about the surface from now on and that's important because.
The ADCP is important. Rather in this context because it collects so much data. Each one of these little boxes of colour is a representation of velocity, and if you think about it, you know you're seeing it spread across the screen like that. But if you were

to turn that thing through 90° and look at it sideways, you'd see something like this, a velocity profile.
So this is representing those colours as dots on on an X axis of velocity. So basically what you can see is from zero the water speed gets faster as it comes up from the bottom, gets faster and faster. In this case the highest velocity is.
About mid depth and then it gets slower to slightly slower towards the surface. Did I see a question then? Do we want to take questions as we're going? Is there a question in the chat?

**Samantha Rees** 12:56
We can or at the end which which works. This question says.

**Nick Everard** 12:58
Yeah. What's what's, what's the question? I don't see the chat at the moment.

**Samantha Rees** 13:02
ADC PS require particles in the water to function, meaning the water needs to be turbid. But what if the water is too clear or too pure?

**Nick Everard** 13:11
OK, now that's a good time to take that question. It's a very good question and that's very rare, but it is a very good point. If there aren't the pascals in the water, the ACP won't work. Different frequencies of ADCPS can work better if there's less.
Particles in the water, but for context, I've had one occasion in all you know, I've spent 25 years using ADCPS in UK rivers and only once was there not enough suspended sediment to get a reading. And actually what we did, it was a small river we just got in and.
Stirred some sediment up off the bottom just upstream of the sensor and that that solved the problem. But whoever posted the question it's a very good question.
Without enough suspended sediment, they don't work in small rivers. You can try and stir stuff off the bottom, but in larger rivers, yeah, you you probably have to find another solution, but ATP's work so effectively in so many rivers that they have.
Actively become the sort of default river discharge tool over the last sort of 10 or 15 years. Even when you read science papers, if someones reporting the performance of some other method, they'll tend to just refer to compared to an ADCP measurement

because it's it's become the kind of benchmark.
Did I just see another one? Or sorry, I can't quite see the chat. I don't want to reconfigure my windows to.

**Samantha Rees** 14:27
No, that's OK. Sorry. Christina asked. How do you know which depth the data is coming from?

NE **Nick Everard** 14:34
Okay. Well, I mean it kind of presents it like this. So it's not so much. How do I know? I know because it's being shown to me very, very clearly like this by the software when it's presenting it. But how the ADCP does it is these pulses have sounded. I have a graphic that show. Yeah. So here we go.
So it sends these posters out there in a sort of beam, and the beams are kind of inclined. But don't worry about that. But sound passes through air or water or any other medium at a known speed in water. Gosh, I can't remember what the speed is. Something like a.
What is it about 1000 metres a second or something? I can't remember. But anyway, let's say it is so. It measures water temperature so it knows because more speed in water measure varies with temperature. But it knows that you know for it. Basically it does something they call.
Range gating so it knows that after a certain period of time, the sound that echoes back will have come from a certain depth because that's how long it takes to travel down there and travel back again. So you know, by the time it's got down to here, you know it's going to be sort of half the depth, but it's going to know. So it's just going okay sound that comes back, it transmits, it waits.
Takes a while says sound the first sound that comes back again is going to be from relatively close to the top, and then you know the last sound that comes back is going to be from quite close to the bottom. And so that's how it does it. But then we don't have to worry about that. It does all that for us and just places it at the right place.
In that vertical profile. So we probably ought to move on if there's more questions than ATP, maybe we'll take them at the end because now we're going to talk about what happens when you ATP isn't going to work and this is an example. This is photoshopped. We didn't actually put our boat into this flood.

But this is a flood in the UK River. I think it's one of the rivers in Scotland, maybe the river D and you wouldn't want to be on this bridge. You wouldn't want to be anywhere near this river. If you put your ADP into this river, you would just lose it. You'd kiss goodbye to it and have to buy another one so you'll get washed away or damaged. So what can we do? And just to provide more context?
On this and monitoring networks around the world are these big floods are larger and more destructive than monitoring networks can typically cope with. So this is an example from the UK in 2015. This was our first big sort of wake up call about floods getting worse in the UK, a flood called Storm Desmond.
Hit primarily the north of the country, but here we can see what's left of the flow measurement station, which was located just here. So the river normally is is this bit from these trees at the top of the picture to these few trees here. That's the full extent of the river. But during the flood it's gone all over these fields.
Completely destroyed the measurement station and so I I think of how accurate the measurement of a station that's trying to calculate discharge through just this section doesn't have any idea what's going on in this section because there are no sensors to detect in this section because this is normally a dry field.
How accurately is it going to make this measurement? Even if it wasn't destroyed by the flood, and in this case it was completely destroyed, so we have a an acute need to to improve our ability to measure. In these cases. Climate change, of course, is making everything worse. This is a selection of pictures of floods that happened in in just in two months.
In 2024, this was a big one. I think it was Storm Boris that hit Europe. This was Hurricane Helene in the US. This was one in Nepal. I think it was, and this was the Valencia flood. To add more context, I put these slides together just after these events.
But just look at a few fixed features in these couple of before and after pictures just to understand what we're dealing with here. So look at these lines on the road. Look at these posts here.
That's what it looked like afterwards, that before afterwards and we need to try to measure that the destructive power of that, the volume of water, incredible. The next one. The only feature I could find that remains is I don't know if this is a little sleeping pod or what it is.
So we need to try and measure those. Clearly you cannot put sensors into the water. You can't have fixed stations. They're all going to get washed away. A couple more

pictures from ARC and Elaine, you know, you cannot put people out there. You can't. You could. The biggest truck in America is going to be washed away by these floods. So how on Earth do we measure these things? And we really need to measure these things I put here. These are not just hydrological events. These are geological events. This is Hurricane Helene again. You know, the river used to be over here somewhere during the peak of this event, it's gone all over the landscape, carving new channels, just changing the landscape.

Escape dramatically, so huge, huge impacts and quantifying this on a you bring it back to the UK and quantifying it.

UKCHQH, the National River Flow Archive as as you're probably aware, that holds data for about 950 river flow measurement stations. And what I've done here is I've graphed the ratio between the highest reported discharge for the river Flow gauging station and the highest that's been.

Been checked or validated so to sort of get your minds around this. We have permanently installed river flow gauging stations. There's about 1700 in the UK. So these stations are monitoring all the time. We take a subset of those 950 or so going to the NRFA. They're monitoring all the time. But to check their performance.

People need to go out there and deploy a current metre, deploy an ADCP to make sure they're performing correctly and rewinding to that picture where the river's all over the field. The peak floods are the most important measurements, because if the river's no longer in the channel.

How on earth do you know how much water there is? So the answer is you have to go out there and try and take a manual measurement. So what this is is how big is the peak reported discharge versus how big is the peak validated measured discharge and for half of all the stations?

The highest reported discharge is twice as big as what we've been able to manually go out and check. So if we think, say, a gauging station on the River Thames near Oxford, the peak discharge reported for that station will be somewhere like 100 or 150 cubic metres a second. That's the unit we use.

The biggest we will have measured will be more like 50, so we're we're we're extrapolating into the unknown. But as we come along here by the time we get down to here for about 100 and 3000 and 40 gauging stations, it's four times as big. If we think it was 200. We've never measured more than 50. So the uncertainty is going to be really big.

I can see that Sam's got her hand up. So what? Sorry. What's your what's your?

**Samantha Rees** 21:22
Sorry, we had a question. Do you want me to interrupt you with questions or how would is that the best way? Yeah. OK, cool.

**Nick Everard** 21:26
Yeah, I mean, we do still have quite a few more slides to go. So yeah, it's sort of try and race through if we can, but what's the question?

**Samantha Rees** 21:30
OK, sure. We'll we'll hold monitoring network. Is there a thumb rule for assigning monitoring stations in unengaged watersheds?

**Nick Everard** 21:40
Oh, who asked that question? You want to ask it unmute and ask it because I'm not quite sure what the question.
Who is that? Do you want to unmute and clarify?

**Samantha Rees** 21:48
Yeah. Sorry. Yeah. Who? Who else? Sorry. It's just a set of numbers for me. Go ahead. Thank you.

**Nick Everard** 21:54
Oh, OK. Yeah, can you? Sorry, I don't quite understand the question. Do you want to? Speak the question so I can hear it.

**396 611 257 854 0** 22:04
Yes. Am I audible?

**Nick Everard** 22:08
Yes, yes. Can hear you, yeah.

**396 611 257 854 0** 22:10
Yeah. When you talk about the damaged network, regarding the metrological stations.

I just want to know that if we have a grid to watershed. So for initiating such kinds of monitoring the network, is there any kind of rule to start as initial?
I said Watership label.

NE **Nick Everard** 22:37
What to to trigger measurements to be made you mean?

**396 611 257 854 0** 22:41
Number of stations.
Our watershed.

NE **Nick Everard** 22:47
Oh, helmet.

**396 611 257 854 0** 22:47
That means the network, how many number of. Yeah, measuring the station is enough for a given order sheet.

NE **Nick Everard** 22:51
Yeah, OK. Yeah. So, I mean typically on a on auk scale like you know on the River Thames for example, we have something like 7 or 8 river monitoring stations on the Thames and the Thames is about what is it 200, two, 150.
Miles long, but with, you know, within the the bigger warshed of the Thames, you know to, you know, the basin to include all the tributaries, then it's going to be more like 102 hundred. So I mean on a on a given it all depends on the scale of your catchment and how many you know if it's.
An area if it's an urban area, you need to be monitoring it more carefully. If there's population there. So, but I mean, typically most tributaries on the Thames will have what between 1:00 and 3:00 river flow gauging stations. So. But I mean the number of gauging stations on a given or shed size.
Will vary enormously around the world because you know many countries in the world. We're lucky in this country. We have a very mature, pretty dense network. Many countries in the world don't, so you know, typically you'll want to have between 1:00 and 3:00 measurement stations on on a on a reasonable sized tributary. So take the char well.

Which which joins the River Thames in Oxford. There's about 3 gauging stations on that, but for completely ungaged catchments, knowing the discharge is very difficult and you know getting out there and making observations.
With the type of tools we're going to talk about, it is really important to try to start to build up a picture of what's there, because you know installing fixed monitoring stages is quite expensive. You have to get landowner permissions and all sorts of things. So so I think.
The days of fixed monitoring stations, perhaps. I think we're going to see fewer fixed monitoring stations and more need to get out and make observations when events happen. I think that perhaps there'll be a bit of a shift, but I hope that kind of at least partly answers your question. But we've probably made a crack on because we got a lot of other stuff.

**396 611 257 854 0** 24:56
Yeah, I think it's fine.

NE **Nick Everard** 24:58
To come up. But thanks. Thanks for the question. So anyway so so how so looking at this you know just to illustrate this graphically as I always like to.
This is a simulation of, well, this is a roof flow gauging station in Scotland. It's on the river Tweed. This is the river Tweed. Again, the measuring section is this little bit here. We visited shortly after a flood had come through. And these are our cars. We parked them here. They would have been completely submerged by the flood was the first thing we noticed.
We could see a very clear line of rack marks. We could see debris marks at the peak of the flood across the field. So what we could see was this was the full extent of the flood. This is the measured section. This is what we would be able to measure with those lovely acoustic interests that we just talked about, IE not very much. So how do we measure all of this stuff?
And the clue is here buzzing about in the sky would probably be able to do a good job of measuring this with a drone, so we're going to now look at the tools that we could use when we can't use these established ones. So yeah, so we're going to start looking at this thing video velocimetry. So this is the main.
The main theme really of this Princess, there's been background so far, so video velocimetry with a drone works like this. We hover the drone above the river and we

point the camera straight down at the water surface so we get what we call a Nadia view and we shoot a 22nd video and we end up with something that.
Looks like this.
And the principle here is basically it's. It's really, really simple. You can see the flow of the water, right. You can see that it flows pretty fast close to this bank, pretty fast, close to this bank and a bit slower in the middle. So using software we can and and using and scaling the imagery.
Once we can scale the imagery so we know how big a pixel is in in real world scale, we can simply track the movement of these visible features down the river and we can produce this map of water velocity using those. The movement of these visible features, which in this case is these kind of foam and bubble patterns.
Being generated by this little riffle upstream, but it's important to note, remember, we talked about the velocity profile. This is not giving us a velocity profile. This is just giving us the surface velocity. Only the surface velocity that we get from this. But if you think about those flood events.
The drone is unaffected, doesn't matter how fast the water's going. Doesn't matter how destructive it becomes. The drone can hover above it untouched as long as the weather's good enough. Because of course, if you're in a hurricane, you can't fly your drone during the hurricane. But.
Thinking of Hurricane Aline, the peak of the floods in Hurricane Aline happened way after the rain and the strong winds. The sun was shining. Couple of guys did get drones up over at the peak of the flood, so yeah, it it can be difficult to fly a drone during a storm, but soon afterwards it's often very, very possible.
Possible to do so? So how does this thing work? So I think this is another video. It is. So the method we're using is a method called space-time imaging velocimetry. There's a number of different methods of working out. Most commonly, people talk about particle tracking velocimetry. This is a slightly different approach. So the way this works is.
Imagine I I only drew four of these lines just to illustrate, but in reality you'd have these little lines drawn all the way across the screen so that the user using the software draws these what we call tracking lines across down the stream in the direction of the flow of the water.
And the way the software works is it's just detecting changes in position of these little brightness features along these lines, so it's checking brightness along each of these lines over time. Heads the little stopwatch, and this here's an ADP doing a

measurement. This is a great site for doing this because we've got.
Really nicely distributed patterns of foam. So you see all the foam on surface. We could track these really, really well, but not all rivers have all of these foam features, so that's worth knowing. And that's why there's a pint of beer at the side of the screen here, because the rule of thumb and I like these simple kind of rules.
The more your river looks like it's full of beer, the better these methods work because this looks to be like a sort of a medium brown coloured sort of ale, and it generates these lovely water surface features. The Thames, by comparison, doesn't have so many of these features. But anyway, importantly, we need these visible features and we track their position.
Changes along these lines throughout a 22nd video. Then what we end up with is something that looks like this. So for each frame of the video.
One of those these are those lines. Sorry, I've sort of rotated them through 90° for the sake of this, but for each of the lines you just saw, we can see a brightness feature, right? This is one of those bits of foam. You see it here, but then in the next frame it's here. And in the next frame it's here. So it's displaced slightly to the right. So each of those features.
Here's where it is at frame at time, one time, 2 time 3. So it's moving along the line, right? So if you stick all those lines together, you stack them on top of one another. You end up with this. So because we're seeing displacement frame by frame by frame, we end up with a horizontal well, sorry with an inclined.
Diagonal line and the angle of that line is what gives us velocity and we see multiple traces because through the 22nd video multiple pieces of foam or whatever else appear into the frame and drift along the line. So we end up with this whole series of streaks.
And the way the software works is just finding the average direction or the average inclination of those diagonal lines, and then it draws these lines and says this is what I think it is. One of the things I love about this software, if you disagree because it does sometimes get it wrong, you can just go in and correct them. And I like that because.
So the human brain, you know, in this age of AI and everything else, I think we neglect the power of the human brain to actually get stuff done and to perceive things better even than computers can still, even now anyway. So that's how it works. It draws these diagonal lines.
So traces are really important and that's what we mean the visible features on the

surface. This was a really striking example. Again from Scotland, the best rivers look as though they're made of Guinness. Taking this sort of beer analogy a bit further, this one looks to me like a river of Guinness. But look, we've got these really clear white features on the very dark.
Water. That's. That's what I mean by that. Guinness is very always has this very white foam on the top down in Devon, we tend to get this sort of brown water, but it also still has the white foam features, the middle of the country. It's not quite so good. It still works, but we don't have quite such good beery water. So here again, this is just the.
Perfect example. We've got white tracers all the way across. Very dark water. We got really good results from a from a video 22nd video captured with the cheapest DJI drone. You can buy a DJI mini. Nothing fancy, just a flying camera and superb results. So here's the important question that hopefully is is running around all your. All your minds is knowing the surface velocity enough to calculate discharge, and of course the answer is no. And now hopefully you'll recognise this plot from when we saw earlier. This is where we're going to use ADCP data.
To enable us to use these non contact tools. So we will go to the site where we can deploy the ADCP on the boat. We'll get this lovely set of data, we'll analyse it and figure out the velocity profile so that we start to understand the relationship.
Between the surface velocity and the mean channel velocity. So because we're now only looking at the top, it's really important that we understand how that surface relates to everything else, because if we don't, we've got big errors baked into our measurement right from the start. And the other thing we need of course is the cross section.
The drones, the optical drones cannot measure the River cross section, so we need to get that from the ADCP to the ADCP now becomes a really important enabling tool. It lets us go and use the non contact methods so quickly. We're just going to scamper through a few other methods of of doing this so.
Before drones were around, and even now the drones are around. If you want to get a continuous record, you can just stick a camera on a wall. So this I don't know why that moved on. That was me. Newcastle University did this one for the Environment Agency. It's a CCTV camera connected to a I think to a Raspberry Pi or something to do the processing and.
And capture the data and it's just going to collect a video every. I think every 5 minutes and then it's going to process. The reason this is more challenging because

it's not got that vertical view. So you've got an oblique view which gives you distortion of the imagery which can be processed for, but it becomes a bit more challenging.
I think we had phones mentioned in the title of this thing and so this is this is what I processed a few years ago, which was oh.
We've got auto advance set in the slides I think, but this was a flood in Australia and this House drifted down the river and I thought, hey, can we determine how fast that house is drifting down the river? So the video had to be stabilised. That's why you see these dynamically changing.
Boundaries around the imagery, but sure enough from this literally 2 1/2 second video. Oops, I was able to get all these velocity vectors so we can see that that house rather alarmingly is moving down the river at about 6 1/2 metres a second.
Which is very, very fast. It's a lot faster than those UK rivers are the methods doing this wildlife cameras. So this is a wildlife camera or a trail camera. We've mounted it 2 1/2 thousand metres up a upper mountain in Austria. It's capturing videos four times a day and we've processed those videos to get.
Velocity so we can see changes in water depth from the video and we can see velocity from the video. So it becomes a super low cost, not a river gauging station but a means of observing variations in discharge, shall we say. It's not super accurate but it gives you a pretty good picture of what's going on and it's dirt cheap cost about 150.
3 lbs.
And to my surprise, it lasted the winter. We had it out there all winter and it was still alive when we visited it early this year. Can we do any of this stuff from space or is that a leap too far? So we became aware about, I don't know.
Seven or eight years ago now, the there are just kind of drones in space. A company called Planet Labs has a constellation of satellites. That is, the sky sat constellation and they can shoot video from 450 kilometres up in space. So our question was, our challenge was, can we use that video?
Just like we do with the drone to work out surface velocity. So in other words, if it works with drones, why not satellites? So how come any of this is kind of possible? I mean, this is from the presentation, but just to illustrate, a lot of people were with Sentinel two data. It's great, it's free. It's openly available. It looks great when you zoom out.
Now when you zoom in, this is the Eiffel Tower from Sentinel to imagery. But my

point is modern, usually commercial constellations have just orders of magnitude better resolution. So Airbus has this constellation called play at Neo. It does 15 centimetre pixels.
OK, they get 30 centimetres native and then they do some AI to make it super resolvable. But you can see individual people. You can almost tell what make and model of cars are on the roads. And by contrast the Sentinel data I would.
Challenge anybody to tell me what that was? So commercial high res data has huge potential for hydrology, I think so we demonstrated that potential with the Planet Lab Sky SAT data and our FLUVISAT project. So this stands for fluvial measurements using video obtained by satellite were sponsored by European.
Space agency, we applied exactly the same methods we use as with the drones to videos that were captured from space. So this is a still from a video from space and you can see the features that we were tracking. You see these features, these roughness features on the water surface.
We tracked their movement and we've got not not just one reading but 21 readings of velocity across the river. So it it worked really, really well and yeah, just to illustrate, these are the patterns that we were tracking on the industry river in Pakistan and elsewhere with that was just one example.
And but and for validation we went to validate this using cross sections obtained with ADCPS velocity profiles obtained with ADCPS and drone videos. For direct comparison. We weren't able to get out to Pakistan to to validate the industry. We didn't have enough money to do that. But where we were able to.
To validate the vast majority of our results were within 5%, which is kind of crazy good when you think about trying to measure from space. The paper is just in review at the moment. So hopefully it will be published soon and you better read it. But yeah, it worked really well. So yeah, just to show you some results from the from the Indus.
This was during flooding in 2022. The huge floods that that had a huge impact on Pakistan in that year. In the one video we were able to measure in three different locations because we could see very clearly the structure and the movement of the features up here and here and here. So we can kind of self validate, we can we're validating.
Each one of these vectors, because we compare it to the independently derived 1 next to it. So if we see a logical distribution of velocity that reflects the flow as it would be in reality, that's a good check. But if we can do 3 readings within the frame

of one video and we get similar results.
That's another good self validation check, so we would love to have had the budget to go out there and make some observations in, in, in real time, but we didn't. And the other thing was we were able to task the satellite. We had no idea this flood was coming no more than anyone else. But once we knew it was there, we contacted Planet Labs and said.
Get me a video. Get me one tomorrow. Get me one. Three days later. Get me one three days later. And they did. So you know they did that way quicker than we could have put together a field measurement team. This isn't an advertisement for Planet Labs and their capabilities. It's just pointing out how the commercial sector can really advance things.
Satellites again are amazing. They're awesome. I'm not putting them down in any way, but revisit times are in the measured in days, sometimes weeks, with 21 satellites in the constellation, we could get up to 12 revisits a day so we could get 12. Observations of the same place every day. If we had the budget, if we had the means to pay for them, and these are 4 observations of the River Tweed in Scotland, obtained on the same day. So to prove that, you know it's not just marketing Buster, they were able to get 4 great observations.
In the space of 24 hours, which is a huge advance for for temporal resolution clouds, this is optical satellite imagery. It doesn't work if there are clouds. This one we were able to get results just, but even this little fluffy cloud is ruining the signal. But if here it has the satellite move the.
This cloud also kind of moves because of the change in the viewing angle. So clouds are a real problem. So it's not the answer to all our problems. So given that we want to keep advancing things and given that we found that limitation, how can we overcome that limitation? Well, there are also very high resolution constellations of synthetic aperture radar satellites.
So synthetic capture radar or SAR is an active satellite sensing system. It sends a radio signal and then receives it again and it's processing that received signal to usually to look at landforms, but also to look at things like navigation, like figuring how many ships are in port.
Seeing when armies are amassing all that kind of stuff because it can see through clouds. But here what we're interested in, we're not interested in any of that stuff. We're interested in the fact I can see the waves breaking on the beach. So if I can see waves breaking on the beach, maybe I could work out current in rivers.

At the moment we don't know we we need a we need a project funded to enable us to find out. But yeah, credit to Isai the Finnish satellite company who collected this data for us. They do very high res SAR stuff getting towards the end because there's so much stuff that was exciting going on right now thermal.
The thermal signal we bought a drone with a thermal camera. I was blown away by this thing. So here we're trying to do Val symmetry on this chalk stream in southern England. There are no traces. It doesn't look like beer. It looks like gin. If we want to use a kind of alcohol analogy.
But there's nothing to track. So we got two readings here out of. We tried to get. What did we get? We got 15 here. We tried to get another 15 here. We got two readings, but neither of them was very good. But we're using the thermal signal. We've got almost a full set that one wasn't quite right and that one wasn't quite right, but we got 13 out of 15 really good readings. How does this work? The water in a river has variation in temperature. It's not uniform in its temperature. So on a sunny day.
The sun will warm the surface and then turbulence in the river. Moves that water around, so it's it ends up all jumbled up, so you get subtle variations in temperature. And of course those subtle variations in temperature are all moving down the river with the flow. And in this case.
Just to add complexity to this somewhat, this wasn't a sunny day. What this is is a chalk stream which has a lot of inflow from groundwater, and this was in a really cold day in January. On that cold day in January, the water temperature in the river was at 4°, but the groundwater entering the river was about 10°. So we're.
Seeing a mixture of water that's already in the river and variation in temperature coming from groundwater entering the system so we can see that we can track it and we can do velocimetry. We can also use it to figure out where is the groundwater entering the river.
Which up to now has been pretty difficult.
That's a small river. This is the Thames. This is a sunny day on the Thames and you can see even with this is the cheapest thermal camera that you can buy on a drone on this sunny day on the Thames. It worked really, really well. If you look at the peak velocities here, 1.6.
1.60, point 5. There's small variations, but it works really really well. So we're really excited about potential thermal. All of these methods now just to sort of recap and bring it bring this thing towards a close, we need this cross section, we need this

velocity profile. So we need systems that make that stuff available.
So this just to kind of illustrate how that might work. The Environment Agency has mapped the bathymetry of the River Thames all the way up to Oxford. So they've driven a boat with a multi beam sonar. This thing captures multiple readings of depth all the time in all directions beneath it. So they've just driven this thing off the middle of the river and it's.
Trapping the depth beneath itself and all the way to the banks. And then they put this data online. It's open data, so I took that data and just put it into QGIS, made a surface out of it, dropped into the Google image and here we've got bathymetry of the whole reach of the river. So what does this mean?
This means I could go and take my measurement with my drone pretty much anywhere. I'd I'd still want that velocity profile if I could get it, but I've got the really crucial thing of the River Cross section because it's already there online, so this isn't the case for many rivers globally.
But my point here is if we can start to get cross sections or mapped pathymetry for rivers around the world, we can start to use these non contact techniques in way more places and adding to this what if the flood happens and the rivers gone all over the all over the land surface?
The Environment Agency has also published LIDAR data for the entirety of of England, so we can map. We can stitch together the bathymetry data, the the water depth, and the water, and the and the land surface data. And then even if the river is flooded and gone all over the land surface, we've got a cross section by stitching together the Lidar.
And the bathymetry and you can see here there's complete coverage for England and actually it's complete coverage for Wales and most of the major rivers in Scotland have been mapped with Lydar as well, not the bathymetry. The land surface with Lidar.
So now onto the outlook and then we finish and we can take a few more questions if we've got them. So this one really is focusing on the sort of satellite thing, because I think it's the most exciting and the one that's got the greatest global potential perhaps. But I think the potential for wholly remotely sensed river discharge monitoring is close.
In other words, you know people not having to go there put themselves in danger. I think there's huge potential for data sparse areas. So you know, much of Africa has very poor monitoring networks, as do parts of South America and elsewhere. We got

great results on some Arctic rivers which are barely monitored as well.
And going to be increasingly important for understanding climate change impact, of course, and a very low latency, very rapid repeat observations are now possible. So thinking of the satellite thing, if you think how many there are now multiple companies with constellations of satellites.
And so the opportunities without any place on the Earth's surface, you know, we could observe any place about 30 times a day if we were able to to bring together the high resolution optical and and radar operators. It's kind of almost just a question of of finding a way. Technically it's all possible.
And there were you had a pile of Rice Krispies on my introductory slide. And so here's why we had two Rice Krispies again on a river that didn't look like beer. Didn't look like gin. And I didn't have my thermal camera. There was nothing to track. So we got some Rice Krispies. We chopped them into the river and.
We've got great results, so I think you'll see me throwing the Rice Krispies from so that stage left here every so often. Handful Rice Krispies lands on the river surface and we were able to track them. They made great tracers like artificial foam.
Other breakfast cereals are available. You know, we didn't buy Kellogg's. Actually, we bought Tesco because they were cheaper. But yeah, they provided the tracer. So you know, you can provide your own tracer when it doesn't exist.
And that's the end view. And in summary, this kind of thing, what you can do with the satellite, you can probably do with the drone and vice versa. So we we see a really good synergy between drones and satellites and you know, taking my institute chapter, we've a load a lot of drone pilots and some really good drones.
So we're keen to see how we can build new science and new solutions that link high resolution satellite stuff to what we can do with drones. And there I will finish and thank you for your apparent attention, unless you've got AI generated sort of semi interested looking heads.
You haven't fallen asleep, at least so are there questions?

**Samantha Rees** 48:39
Thank you, nick. That was brilliant, Christina.

KG **Kristina Grolmusova** 48:45
Hello can you?

**Samantha Rees** 48:47

Oh, we can't hear you very well. Sorry.

**Kristina Grolmusova** 48:51

Can you hear me?

**Nick Everard** 48:53

Keep talking, Christina. See if we're going to.

**Kristina Grolmusova** 48:56

Can you hear me now?

**Samantha Rees** 48:58

Yeah.

**Nick Everard** 48:58

Yes. Yeah, I think if you. Yeah. Yeah.

**Kristina Grolmusova** 48:59

OK.

So my question is.

If you tried, let's say putting the acoustic sensors on drones, why would that not work? Or has anyone tried doing that or?

**Nick Everard** 49:17

That's a great question and and it's something we I would love to do actually. So I mean the acoustic centre has to be in contact with the water, right? So you you can't just fly above the water, it's got to go into the water. So to deploy an acoustic centre with the drone.

You'd have to have a cable beneath the drone, and you'd dangle the thing in the water, so you'd need very good drone control software, you know, to make sure your drone maintained a safe height above the water and didn't collide into, you know, crash into things. But that's available. There's companies who are already doing that stuff.

There's already a drone flown single beam depth sounder, so you know much simpler than an ACP, but they dunk it in the water. It did use the pulse sound to measure depth, so it's entirely possible the only thing that's stopping it at the moment is we haven't found a project to support us to do it, but you know.
A few years ago, the answer would have been the sensors are too big and complex, so there's there's there's one sensor on the market that would work for this. It's it's made by a company called Suntec, but it's only weighs 500 grammes. So not long ago, ADCP has weighed about 8910 kilos.

KG **Kristina Grolmusova** 50:22
Mm-hmm.

NE **Nick Everard** 50:26
And they were, you know, effectively too big and too heavy to fly with the drone. But yeah, you could do that. I think it were very difficult to.
To do a complete transect of the river, as we do with the boat, I have the thing in motion would be difficult, but the ATCP's also have the ability to do point by point measurements, so you put it in the water for 10 seconds and get a reading, move it, put it in the water for 10 seconds.
That should be possible. So yeah, a brilliant question. The answer is, yeah, we we just need someone to fund us to go and try and figure this out and look, because it it'd be fun and it'd be big advance for hydrology. And aside from being fun, the big application, the big benefit to from that would be.
When the flood happens, it goes all over the floodplain. If you remember my pictures of, you know, here's where the gate station one here's. Here's the flow all over the floodplain. The optical method might work using a drone on the floodplain, but in reality, the flow in the floodplain is usually much, much slower than the flow in the river.
And it usually contains much less kind of visible features like the the foam and stuff. So we think the drone should work well over the floodplain. But we also know that in some cases it probably won't because the water will be pretty slow flowing.
And it, you know, it's important to know if it's, you might say, well, if it's not flowing, why do you care about it? Well, because you need to know whether it's like or not and then quantify the velocity. So dunking an ADCP into a flood, I think would be a disaster. Your drone would get washed away. But if you could dunk it into the water,

that's not in the in the channel. But it's in the floodplain.
I think it would work really really well. So yeah, great question. We'd love to try it out.

KG **Kristina Grolmusova** 52:11
Can I just ask for in terms of why do you have to put it in water like could you not just keep it and because obviously the sound would travel through the air and then eventually to the water and then back?

NE **Nick Everard** 52:19
OK.
I think because the interface with water surface would just.
Would attenuate almost all of the sound, so there wouldn't be enough acoustic energy then to penetrate the woods. So what can what you can use is, I said with optical drones you can't get the River cross section, and that's true. But with radar you can so you can fly a ground penetrating.

KG **Kristina Grolmusova** 52:38
OK.

NE **Nick Everard** 52:53
Radar. So there are now ground penetrating radars. So the idea of ground penetrating radar is, as the name suggests, you use it for archaeological things and for geology, geological surveys or whatever else. It's a radar that can that can push enough energy into the land that you can see what's beneath the surface.
There's now drone flyable ground penetrating radar that from about a metre above the water surface can penetrate the water and detect a signal coming back off the bed. So I think the answer is acoustics aren't powerful enough to do it.
But some radar technologies are powerful enough to give us the bed. What no one's yet developed, but should theoretically be possible, is something that can actually also get a sort of Doppler shift in the radar signal. You know, from the from the water column as well. So in theory, you could have a sort of drone flying.
Non contact ADCP that's using radar rather than acoustics. That would be really cool. Let's make one.

**Kristina Grolmusova** 53:54

Interesting. Thank you.

**Samantha Rees** 53:57

Thank you. Great question, Jay.

**Jay Lindle** 54:02

Hi everyone. I just wanted to ask a question around the STIV and when you're calculating the velocity. So when you're sort of showing the theory behind it, you're kind of using straight lines. But what if there's some kind of like horizontal movement where in between the two distance points there's?

Being measured between and, how do you kind of optimise that for different rivers? Because I imagine that kind of like the conditions might be quite different and based on the width etcetera. So how does how do you decide what's the best way to calculate the speed?

**Nick Everard** 54:37

Yeah. So, so I guess. So what? So what we do, I mean to try and answer your question, if I'm understanding correctly. So we tend to do 21 of these lines across the river. So I mean the first thing to know I suppose is.

I think part of what you're asking is like water. Maybe we can see it in this video. These little features on the surface represent the flow of water, right? They're the surface, but they represent flow, so water doesn't always go straight downstream. Sometimes it's kind of skew. It's going across the river a little bit, and these are these are pretty much going straight downstream, but you see they don't follow these lines precisely, they sort of wander a little bit here and there.

So the only thing velocity that contributes to discharge is the component velocity is going down the river right? So if if some particle is sort of drifting across the river, its speed its its velocity, its absolute velocity might be, say, a metre a second. But if it's going across the river.

The contribution to discharge is only going to be, say, .9 of a metre a second. It's only actually gone. It might have gone from here if you can see my cursor to here, you know, and that might be a metre. But from here to here downriver, it's only .9 of a metre, so it kind of works like that.

So yeah, first thing, the component of velocity that contributes to discharge is what we call the X component. Is this the direct downriver contribution? Think about, you know, if water was some reason or other weird reason with jetting from from this bank to that bank doesn't matter how fast it's going. It's not moving down the river. So it's not contributing to discharge. So you know.
Every increment of angle from from that sort of straight across to to straight downriver. You know it will have a different contribution to this child to come to, to deal with the fact that velocity varies across the river. You know that downriver component varies across the river. We just do a distribution of these things across the river and we've.
Down just through kind of iteration and and just from observations about 21 readings is good for giving us a good distribution of velocity. You can see how these typically you'll see just as in the ASP data where we represented this with colour. You see how we've got effectively purple here the slow velocity.
And we've got effectively the red here, we've got the fast velocity, so the velocity tends to get faster towards the middle, slower towards the bank. And we found if we do more than 21, it increases processing time. We do have to manually check these at the moment because it does sometimes get it wrong.
So 21 gives us a really good picture. There are standards, there's British standards and international standards on how many, what they call verticals you should do. So remember the poor bloke stood in the river getting cold and wet. This guy here.
So there are standards that dictate how many of these points across the review you should measure. So you know we we could and arguably should apply those standards to what we do here, but I prefer to go with my knowledge and and understanding and at the moment you know there will come a point where standards will be developed for these methods.
That that will come. But at the moment it hasn't come so at the moment I find 21 of these is the sweet spot between too much too big a data file, too long to process and representing the reality of the river is that is that does that kind of answer your question?

JL **Jay Lindle** 58:05

Yes, it was. It was more just the like. You like you said, if there is some kind of horizontal drift, like can it account for that? Especially if that drift is different on different points of like different parts of the rift across across the cross across the.

**NE** **Nick Everard** 58:19

Yeah, well, it it. It does do that by having all those different, you know, by having these points across the river, we've got that. But then if the velocity isn't going straight down the river, the component that is going straight down the river is what is represented by these lines.

Because we drew them straight down the river. So because these are straight down the river, you know, even if my particle is sort of going slightly across the screen, it's it's it'll only be detected. It's motion only be detected for a short period. So we'll end up with.

So where we see a big long streak, this is a particle that tracked along those lines for quite a long period of time. This these little tiny streaks probably just sort of drifted across just. And so we're only moving through that line for a short period of time.

That's, I mean, that's such a it's a great question because I've never had to answer it because no one's asked it before. But yeah, features that just drift across the line and then disappear are going to appear as a short streak and something that drifts along the line is going to appear as a long streak. But you notice whether it's long or short, the angle of the of the.

The resultant little squiggly line is about the same, so it's because it's it's only detecting the motion along those lines. It's ignoring everything either side. It's just looking what's happening down this line. So it's sort of self regulates and self.

**JL** **Jay Lindle** 59:33

You.

**NE** **Nick Everard** 59:46

Kind of self eliminates that that Cross River thing by just taking the period at which you know that one it was in the line always come back in again further down. But you know that drift across the river is not being quantified. What all is quantified is the motion down the line. And in that case on several occasions.

It sort of drifts in and then drifts back again.

**JL** **Jay Lindle** 1:00:08

Yeah. Yeah, because my thought was depending on the distance of the two points that you're measuring. Then if there is a, you know, the the impact of the drift on the

kind of like noise component of how of the velocity is going to be.
It's going to be smaller if you've got a big gap, whereas you know if you've got a lot of drift in the in between two points that I've also together it's going to have a bigger impact on your on your vocity measurement.

NE **Nick Everard** 1:00:34
Yeah, it's a.

JL **Jay Lindle** 1:00:36
But yeah that.

NE **Nick Everard** 1:00:37
One of these things, the other thing says all of these methods are imperfect. I was a joint author on a hydrology paper a couple of years ago that started off by saying something like observational hydrology is by its nature and inexact science, and at the time I was like what you aren't you saying that our science isn't very good, but but it's absolutely true, you know?

JL **Jay Lindle** 1:00:55
Yeah.

NE **Nick Everard** 1:00:56
Everything we do, you can't absolutely quantify the volume of water going flowing through a river. The only way to do that would be if you could divert into a giant swimming pool, you know, and measure the increase in depth over time. You know, every everything else effectively is an estimate of discharge. And so, you know, talking coming back to 80 speeds.
ADC PS are recognised as being, generally speaking, the the most reliable reference, so you sort of compare everything else you say. We got this, the HP gave us that it's because it's measuring most everything ADC PS I didn't have time to talk about it, but they measure.
The vertical component velocity. They measure the you know they measure a skew flow. They measure everything, but they calculate discharge. You know they'll throw away. They'll measure that vertical velocity. They'll measure that Cross River velocity, but they'll throw that away when they calculate discharge and just use the

component of that vector. That's the downriver component.
That's one of the reasons why there's they are awesome instruments. You know, they they just meet their limit in in, in floods, right. We probably have one more question. I think we've we've got here and then we probably better finish.

**Jay Lindle** 1:02:00
Thank you.

**Samantha Rees** 1:02:01
One more question, yeah.

**Subhajit Ghosh** 1:02:04
Yeah, actually I want to know how popular these methods are in UK or anywhere you are working in the operational forecasting on now casting portfolio is any national agencies are using these methods for the daily operations something like.

**Nick Everard** 1:02:20
Yeah. Again, a really good question.
Not as much as I think they they could be. And I think so. I think. Well, there's a there's one or two agencies in Australia. So the, the, the satellite project, I go get credit was the idea of a guy named Mark Randall who works in the Queensland Government.
Doing river measurements now he is one of the world's leaders on using cameras for river discharge measurement and he's got lots of cameras installed and they are now very much a part of their operational monitoring in Australia. He also has done lots and lots of work on the drone based method. He's been involved in refining.
This software, so the software comes from a group in Japan, but Mark has done an awful lot to refine, so there's a lot going on there. Marks Group in Queensland doing a lot.
Canada and the US are trying to kind of make it operational. So both environment and climate change Canada and the US Geological Survey in in the United States are trying to to do that. So they've got quite a lot of deployed cameras. They've not done as much with drones.
I think partly because the US government doesn't like DJI because they're Chinese, but DJI make all the drones that most everyone uses, so it hasn't gone as far as it as

it could have and should have, and that one of the reasons I take the opportunities to do these kind of presentations is.
In the hydrology community, not enough people go into making measurements, so there's lots and lots of people go into modelling and that's great. But even if you want to use build build models, you need some measurements to to inform the design of your model and to validate your model.
Very few people, and I think I and I keep asking why this is the case and and all the people I talk to are basically modellers and they say I don't know really, but I I do wonder whether this is the problem that measurements until very recently, if there was a section of a of a of a of a university course.
Talking about observational hydrology, they would show somebody doing this and everybody probably thinks well, I don't want to do that. That looks miserable and this looks pretty miserable. This looks it's a bit more fun, but it's dangerous and it's not great. But, you know, drones and satellites.
So really you know to answer your question, it's not being used as widely as it could be. Part of the reason is inertia and lack of imagination in in the measurement authorities, part of the reason is the the slowness in developing standards has quite reasonably some.
You know, if your job is to provide flood warnings and flood risk assessments, you're actually going to want a standard that says we applied this standard, so we know it's reliable. Bloody bloody blood. So they're not fully developed. But part of the problem is not enough. Smart people are coming into measurements.
You know, to drive these things and then drive the standards and prove that they meet the standards and everything else because that will really accelerate things, I think.
Gosh, there's another question. This has to be the very last question.

**Samantha Rees** 1:05:28
Sorry, is there is there a hand up that I can't see? Oh.

**Nick Everard** 1:05:32
There was a shake shaken Shogun.

**Shagun Garg** 1:05:36
Hello. Hi. Hi, nick. Thanks for the talk. Was amazing. I just wanted to ask now with the

sort mission up the Surface water version, topography mission up, you can get the the depths of the water. So with this combined with your?
So sort of like surface water velocity. Do you think it's going to be the next big revolution in hydrology?

NE **Nick Everard** 1:06:01
Yeah, another great question. I would I would love it to be, but I think the statement that you can get depth from swap isn't quite true. So the swap mission. So for those who don't know it, the swap mission is the surface water, an ocean topography mission. It's a $1 billion satellite launched by NASA.
Co developed with Kness, the French agency, and I think the UK Space Agency has something to do with it, so it's a wide swath radar system. So it goes around a lot all the time and it's looking at the surface and it's designed to look at water and so it's mapping the surface height of water and across our I think it's.
120 kilometre wide swath at a pretty high resolution. So what it gives you is a very good and accurate picture of water surface height and it gives you kind of a map, not just a point reading it gives you water, surface slope doing very well at giving water surface slope.
But it can't penetrate the water, so it can't give death. So one way in which it kind of gives death is imagine you have a river. I don't know if I've got an example in my slides, but if you have a river where?
Like I don't know. Take take this one here. Now it's been massively over, widened by the flood, but, but now the actual flowing body of water is probably only half a metre deep, or maybe a metre deep. The bulk of the channel is exposed, so the swap mission would be able to map this channel.
So the SWAT mission can effectively map unwetted parts of river channels. So imagine, you know, imagine you've got a river, so like marks rivers in Australia, his rivers in Queensland are bone dry for most of the year and they're they might be 300 metres wide and 15 metres deep. And they're bone dry. Swat could could probably.
Provide some pretty useful information on those, but once they're full of water or all it can give you is the water surface height. But conceptually yes, if we could, if there was a satellite mission that could give us the water depth.
Or even do what we just discussed and start routinely.
And kind of systematically mapping the dry sections of of rivers to build up this. You know this, this section that will fill up with water and flood then. Yeah. Then we

suddenly we have much more valuable results from squat itself.
Because the surface slope stuff is very valuable and can be used to calculate discharge. But then yeah, all these velocity methods suddenly become really valuable tools. So you know we ours was a proof of concept, but you've just outlined the steps that need to be taken.
Over the next few years, to make it really operationally useful. So yeah, come and work with me and solve all this stuff. It would be. It's a challenge that needs to be addressed.

SG **Shagun Garg** 1:08:55
Thank you very much. Thanks.

NE **Nick Everard** 1:09:00
Right. Should I I better stop sharing now, and we probably better wrap up.

**Samantha Rees** 1:09:00
Thank you though. Thank you. Yeah, that was a brilliant question. So thank you everyone for engaging so fabulously and thank you, Nick, what a fabulous keynote speaker in our first one for the summer school this year. So, so, yeah.

NE **Nick Everard** 1:09:13
Ah.

**Samantha Rees** 1:09:16
I'll let everyone go and have your break now and I'll see you at 11 at the next one. Thank you, nick. Again. Thank you everyone. Have a lovely rest of you. Have a lovely break.

NE **Nick Everard** 1:09:23
All right, thanks. Nice to meet you everybody. Thanks for your questions.

HL **Hywel Lloyd** 1:09:25
Thank you. Thanks very much.

JL **Jay Lindle** 1:09:26
Thanks, nick. Thank you, nick. Bye bye.

NE **Nick Everard** 1:09:28
But.

D **Dayan Renán Saynes Puma** 1:09:29
You.

◉ **Samantha Rees** stopped transcription