DDAHS 2026 summer school Wednesday morning keynote & virtual fieldtrip 2-20260715_090525-Meeting Recording

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52m 39s

Gianni Vesuviano started transcription

Gianni Vesuviano 0:05

Okay, the recording has just started now. All right. Good morning, everybody. To start this session today on a Wednesday morning, we're going to take another virtual field trip. And this time it will be to the Thames. And then following that, it'll be a video, 12 minutes long. Following that,
Mike, who you'll see in the video, will be around to answer questions.
So, I'm going to start sharing my screen.
With the video on it, and sharing the sound.
quite work for you, don't worry, we'll put a link to the video in the chat for you to watch in your own time. And hopefully this time we will not take any detours into air conditioning adverts. So video starts now.
Hello and welcome to the River Thames here in Oxfordshire. My name's Mike Bowes. I lead the River Water Quality and Ecology Group here at the UK Centre for Ecology & Hydrology at Wallingford. I study the River Thames and its catchment.
The reason we're interested in the River Thames, it's an internationally renowned river. It's the longest river wholly in England. The catchment houses 1/5 of the UK's population, including its capital, and it provides most of the drinking water in London and the southeast of England. So it also has really high amenity value.
It's widely used by fishermen, by walkers, by boat users for wild swimming as well.
The River Thames is facing a wide range of environmental problems. It suffers from floods. It also suffers from droughts. So during 2022 there was a major drought and the river was barely flowing at all.
So this has big impacts on the ecology of the river and the mobilisation of pollutants as well. Other problems are invasive species. So London is a major port and this is a route for creatures like zebra mussels to invade our local environment. There is a major problem with sewage spills. This is

all over the press at the moment with storm overflows happening and sewage treatment work spills and breakdowns. Perhaps nutrients are the major problem with this river and many rivers across the south of England. When we're talking about nutrients we're talking about nitrogen, phosphorus and carbon.
They're absolutely required for a functioning aquatic ecosystem. All organisms require these elements to produce DNA, bones, teeth. Over the centuries due to increasing urbanisation, due to our connection of our wastewater to the river through sewage systems.
and through the intensification of agriculture and the use of fertilizer, we have seen a huge increase in nutrient pollution in this river. The problem is that when these nutrients become too high in concentration in a river, this can result in excessive algal growth. The algae can smother out the plants that are living.
under the water and they get shaded out and they die. This loses habitat for the insects, ultimately can result in fish kills due to low oxygen concentrations in the water. This is why we started the UK Centre for Ecology & Hydrology's Thames Initiative Monitoring Platform.
It essentially focuses on the nutrients, how they're changing across the catchment and what impact they're having on river ecology, in particular algae and bacteria.
Every Monday we go out and we sample up to 23 sites acrossthe entire Thames catchment using a bucket on a rope.
That bulk sample is then filtered using simple syringe and filter units.
It's important to filter the samples immediately, as this really improves.
The quality of the nutrient data that it produces.
We also measure some parameters immediately, water temperature, we measure pH, ORP, oxidative reductive potential, and dissolved oxygen.
We then store the samples in a cool box in the dark, 4 degrees, and we transport it back to our laboratories as quickly as we can.
So after we've taken the samples, we analyse the pollutants that are least stable first to maximise the quality of the data, ideally within 24 hours. So our main instrument that we use is this AA500, which is an air-segmented continuous flow instrument that uses colourimetry to determine
concentrations of soluble reactive phosphorus, silica and ammonia. We put our samples from the field into these tubes. It splits it into three and passes it through this series of tubes and coils. It mixes with a whole range of
reagents which react with the nutrient of interest and it forms a blue colour and then

we measure how blue the sample goes with these spectrophotometers. We also carry out algae analysis, measuring chlorophyll so this gives us an idea of the biomass of algae that's present in the river. We do this by filtering
the water sample and then we soak the filter paper that contains the algae in acetone and then we can measure how green the resulting solution is and this tells us how much chlorophyll is present. This gives us a proxy for how much algal biomass is in the river. We also use iron chromatography to measure a wide range of anions such as chlorides and sulphates.
and nitrate and nitrite as well. I'm Isabelle Fournier. I'm A freshwater biogeochemist at the UK Centre for Ecology & Hydrology.
Algae are an important component of freshwater ecosystems, mainly because they produce oxygen, but they also are a food source for higher trophic levels, such as zooplankton or fish. And they are also involved in the cycling of nutrients.
nutrients and greenhouse gases. But as important as they are, if they're growing too much, which we call algal blooms, they can cause massive problems. So one problem that will be common to all algal blooms will be happening at the end of it, so when the algae will die. So when algae will die, they will be decomposed by bacteria.
And decomposition is a process that consumes oxygen. So the more biomass there was to start with, the less oxygen there will be in the water at the end. So in extreme scenarios, that could lead to fish kills. Other problems that arise from algal blooms will depend more on the species that is blooming.
So an algal bloom is normally composed of about one or two main species. So for example, there's a group called dinoflagellates, which would produce bad taste and bad odor. There are some green algae that produce the gel-like substance that can block filters at the water treatment plants. And the most known of them all are cyanobacteria.
bacteria or blue-green algae that sometimes can produce toxins. So in our lab, what we want to do is we want to understand which algae are blooming under which conditions. And to do that, we realise the water chemistry that we've been talking about earlier with the identification of algae. To ID algae, we use mainly 3 methods. So DNA, which people normally know, microscopy, which speaks for itself, as well as another method, which is less time consuming and doesn't need expertise, which is flow cytometry. So a flow cytometer, like the one I'm standing beside of, is a machine that will align every particle in a sample
In a tiny tube, and a fluid will force those particles in front of a laser.

So in case of algae, this laser will trigger their photosynthetic pigments. So those are the molecules that the algae are using to capture the light to do photosynthesis. So different groups of algae will have different pigments in different ratios. So the information from the flow cytometer will allow us to discriminate between these groups.

...from all of these multiple sites across the Thames catchment. So what do we actually use the data for? Well, we can use it to identify how water quality has been changing over the recent decades. And despite what we read in the newspapers on almost daily basis, the phosphate concentration

has actually improved dramatically. So back in 1998, the concentration used to be up to about 2,000 micrograms per litre of phosphorus. Now it's down to 200 or 300 micrograms per litre. So there's been an 80 or 90% reduction in most of our sites. So a huge increase in water quality. And that's had an impact on algae as well. So we're getting less algal blooms as well.

The reason we've seen this huge decrease in phosphorus is almost certainly due to improved sewage treatment works rather than improvements or reductions in agricultural pollution. And the reason we know this is because changes are very sudden and they coincide with major sewage works being improved

in the late 1990s. That's the good news, but we also know from the patterns of phosphate concentration with flow that most of the tributaries of the River Thames and the River Thames itself are still mainly polluted by sewage sources rather than agricultural diffuse sources.

So we've seen big improvements in sewage treatment, but there's still a long way for us to go to get to where we want to get to in terms of river water quality and ecology. So the data that we produce is really valuable and it is routinely used to show the impacts of mitigation by

the water companies and through changes in land use on water quality and ecology. It's also used to evaluate the impact of major infrastructure projects such as new reservoir building, flood relief channel building. It's routinely used by DEFRA, the EA, universities, water companies and it is a particularly valuable source of data for modelling.

I am Ponnambalam Rameshwaran and I am an environment scientist. In my work, I spend a lot of my time doing hydrological and water quality modelling. Water quality observations are essential to understand whether our models work, for example, whether we have correctly modelled pollutant runoff from land and the chemical

interaction in the rivers.
Water quality is particularly challenging to model as there aren't many routine measurements of how much pollution is entering our rivers from soil and point sources. Instead, we usually estimate pollution input to rivers from our understanding of upstream land cover, for example, whether
there are farm, wastewater treatment works, or peat moor draining into the rivers further up in the catchment. River water quality measurement provide one of the very few ways we have understanding what type of pollutant have entered our rivers as they have account of pollutant source upstream of the sampling location.
For example, water quality monitoring in India recently alerted us to the fact that in many Indian rivers, most of the dissolved nitrogen is in the form of what we are not expecting. Following some additional research, we are able to develop an Indian water quality model that accounts for more forms of nitrogen
Which help us to make more accurate estimate of the total flux of nitrogen passing into the ocean and estuaries around India.
So this kind of data is absolutely vital if we want to truly understand the impacts of future climate change and increasing population densities in this area. Data is freely available on our website if you're interested to use it.

All right, so as we learned yesterday, the Thames is the favourite river of at least one of the participants in this summer school. But I hope that all of you enjoyed your virtual field trip to the Thames, learning about the Thames initiative and also the South Asian Nitrogen Hub. If you have any questions for Mike, please either raise your hand in the Teams chat or type your question into the chat. We got our first hand raised from Sam.
Sam, go ahead.

ST **Sam Tulloch (PGR)** 13:46
Morning, Mike, I have a question for you. I'm sorry if this is a bit of a curve ball, but you talked about separate mussels and I'm curious about what kind of monitoring programmes
in the UK. Like I know there are a huge issue over in like North America and particularly the Great Lakes, but I'm curious what kind of monitoring you've got for them.

Mike Bowes 14:07
This is a very easy one to answer. We have no monitoring whatsoever on zebra mussels. But what we're finding is that we've been doing a lot of research looking at the impacts of

Sam Tulloch (PGR) 14:12
Ohh, dear.

Mike Bowes 14:26
water temperature and flow and nutrients on the causes of algal blooms. And we've now got a model where we can predict really accurately when certain types of algae are going to start growing and when they're going to start collapsing. And it's really dependent on
water temperature. So we thought we'd absolutely cracked it. We thought, yeah, it's all about water temperature and flow. So we did some experiments to prove this. And what we found was in the lab, the algae didn't respond to temperature at all. So we now know that
the patterns that we see in the river.
Are not due to temperature, but they're something that correlates with temperature, and one of the biggest things we can think of is potentially...
grazing rates are affected by temperature. So when we get to a particular high temperature, we see all the algae, certain types of algae suddenly disappearing. And we think it's because at that temperature, the grazers suddenly kick in and eat that kind of algae. And the biggest culprits are probably the zebra mussels, which which have infested the River Thames. But yeah, we don't have a monitoring programme at all. We're kind of reliant on hearsay and the odd bit of monitoring by the EA, I guess. But yeah, it's our next experiment. We want to see the effect of temperature on grazing rates of the zebra mussels. So we might start doing some experiments in big fish tanks with zebra mussels in there. It's our next plan for the next few years.

Sam Tulloch (PGR) 16:16
Thank you, that sounds exciting.

Gianni Vesuviano 16:18
Okay, there are two questions. Martha got her hand up first, so Martha.

Mike Bowes 16:23
Martha.

Gianni Vesuviano 16:29
Please do.

Martha McKee 16:29
Yeah, morning. Thank you for that video, Mike. That was very interesting. I was just wondering, you were talking about, you know, the data that you guys collect with your monitoring systems helps evaluate how well the mitigations of water companies are doing. I know UKWIR does quite a lot of work with various water companies

Martha McKee 16:49
all over England and I was just wondering how receptive they are to these, to this data and this monitoring and that, you know, like is it more of them ticking a box or do they take it quite seriously and engage with you guys a lot?

Mike Bowes 16:55
We do do a lot of work with the water company or for the water companies. But yeah, UKCEH is in a unique position in that we, despite us being employed by the water companies, we have to be completely evidence led and completely independent. So we quite often don't give them the answer that they want, um, so

Martha McKee 17:22
Yeah, I can imagine.

Mike Bowes 17:26
I think a lot of the messaging that I come up with in that, and I said it in the video, is that there has been massive improvements and it is definitely because of the water company investments that they made in the late 1990s and the 2000s. And that's great news, but they still need to do more. So we're really, I think, in a

Martha McKee 17:37
Mhm.

Mike Bowes 17:49
the sort of a balanced position with them. And you know what, I think they're really receptive. So a good example of that is we've done some work with Northumbrian Water and they were telling us where they were planning to do the latest improvements to sewage treatment works.
And they're almost inevitably at the really big sewage treatment works, but most of those are at the bottom end of the river. And I'd suggest some. Have you ever considered doing some of the smaller treatment works in the headwaters? Because if you improve the quality of the effluent there, you'll actually improve.

Mike Bowes 18:27
the whole length of the river. And they went, oh, yeah, that's a good idea. And then about two years later, they contacted me and said, we're going to do what you said, that throwaway comment in a meeting, we're going to do what you said. And we're about to install really high quality improvements at three really small

Mike Bowes 18:46
village sewage works and they asked us to do the monitoring. So yeah, I think generally they're really receptive. I think they're very sensitive to the amount of bashing they're getting in the media and which kind of helps. Yeah, I think that kind of helps. I think if they weren't getting that pressure, they wouldn't be bothered. But

Martha McKee 18:48
Yeah. Yeah, that was something I was curious about. Yeah.

Mike Bowes 19:08
desperate to to improve their image, and in which case that the best way for them to do that is to do do the best for the environment, and I do believe they are trying.
Yeah.

Martha McKee 19:11

That's good. That's reassuring to hear. Thank you. Good to hear it from the kind of scientist perspective versus just the kind of media and the water quality, not the water quality, the water company's perspective. So no, it's good to hear that they're receptive to you guys. Thank you for answering my question.

Gianni Vesuviano 19:19
Yeah.
Okay.

Mike Bowes 19:20
Yeah it is, isn't it?
Mm.
Yeah.

Gianni Vesuviano 19:36
Yeah, thank you, Martha. Robyn?

JR **Jones, Robyn (MECP)** 19:41
Morning. My question is very similar. I'm interested in, so are the sewage works mostly like direct discharges into the river or are they subsurface? And I'm just wondering if you can kind of speak to if you've noticed anything specifically on if dischargers in the UK have like any monitoring requirements themselves.

Mike Bowes 20:02
Okay, I think virtually all of the sewage treatment works discharge directly into a water course. So that, yeah, the treated effluent usually goes into a small ditch or small river and then goes into the River Thames. There's a few
examples of where it is discharged directly into the Thames. But yeah, they all go into the river. They don't go into the subsurface, which is possibly a good thing because we're in a big chalk aquifer, which is very permeable and we'd end up really polluting the ground water, which a lot of people, a lot of areas use for drinking water.
The second part of your question, I can't remember. Can you remind me? Sorry, I should have read it down.

JR **Jones, Robyn (MECP)** 20:50

That's okay. Three questions in one. I was just wondering if there's any monitoring requirements for the dischargers.

Mike Bowes 20:53
Okay.

Mike Bowes 20:56
Oh yeah.
Yeah, um...
Previously, there hasn't been. So the Environment Agency would sample rivers about once a month. Now it's about four times a year. And quite often they're downstream of larger sewage works. And occasionally the Environment Agency will come and test the quality of the effluent as well in sewage treatment works and then we'll do that, like they will turn up unannounced and take the samples. But things are really moving forward now and because of all the bad publicity about sewage spills and things,

Mike Bowes 21:39
The water companies are being forced by legislation to install water quality monitoring probes upstream and downstream of all of their wastewater treatment works, which is a huge undertaking. There's a lot of sewage treatment works in the UK.
And it's, yeah, it's costing them a fortune. So that is that is going ahead. I'm not sure when they have to have everything installed and reporting the data, but all of that data will be in the public domain. They have to make it available to anybody. So it's going to be very transparent whether their sewage works are operating correctly or not.

JR **Jones, Robyn (MECP)** 22:23
Thank you.

Gianni Vesuviano 22:24
Okay. We have one question in the chat from Mayuran, who asks, would converting the combined sewage system in the UK to separate sewage systems help improve the water quality in rivers? And to follow up that, if budget is not a concern.

Mike Bowes 22:38

Yeah.

It definitely would. So the problem we've got at the moment is we've inherited A Victorian sewage system. So when it rains, the normal effluent is also mixed with all the rainwater that is flowing down drains in

in the road or in car parks. So we get this sudden increase in volume of water that's all hurtling towards the sewage treatment works. And the way sewage treatment works work is that they have a set volume, so they have all sorts of sort of huge tanks and things and

Mike Bowes 23:21

and that is a set volume. So as the volume of water increases, as the input increases, it means that they have to flow through the different treatment stages faster or else the sewage treatment works will stop flooding. And if you pass the water,

too quickly through the treatment processes, it doesn't really work. So what happens is they get to a capacity where they can treat, you know, they'll treat the water that's coming in, but once they get to that capacity, any excess has to be diverted straight into the river. So

This is the stuff that we hear about in the news on almost a weekly basis where there is this, well, what the press would say is raw sewage is being diverted into rivers. Actually what happens is it's raw sewage that is diluted massively with

rainwater that's flowing down our road drains. So it's not quite as bad as it sounds. And then it also discharges into a river, which is in flood. So again, that effluent and the pollutants are massively diluted. Yeah, so if you could split

the road drains from the sewage system, that would be brilliant because it means that all the sewage or the volume of sewage would remain relatively constant and the sewage treatment works would be able to treat it. The only problem is, in order to do that, you would need to dig up every road in

the country and that is a colossal expense and not just for the water companies, but just the sheer mayhem that it would cause is colossal. So, but I don't know why they're not doing this for new developments. I mean, maybe that is the way

the way forward. This is a bit out of my area now, but surely for new housing developments, they should be trying to separate out the rainwater from the sewage water. So yeah, good question.

Gianni Vesuviano 25:31
Yeah, if I can just chip in on that, they are supposed to be completely separated for new developments.

Mike Bowes 25:41
Are they? Oh, great. Thank goodness for that. So, we're moving in the right direction, but yeah, it might take, it might take 100 years before we get there. Yeah.

Gianni Vesuviano 25:42
Yeah.

Mike Bowes 25:56
So Gianni, do you know what happens to that water that goes down the drain? Is it sort of stored and used as for flushing toilets and things or is it going to ground water or?

Gianni Vesuviano 25:57
So the sustainable drainage systems that they're supposed to have on all the new developments, they're supposed to collect rainfall, you know, and other water like that and pass it through an on-site treatment system. So that could be something like a pond or I guess a basin.

Mike Bowes 26:18
Mm.

Gianni Vesuviano 26:27
Like sometimes you see the play areas in the new developments where they get flooded when it rains and that's on purpose. It's holding the water back to keep it out of the sewer systems and infiltrating it into the ground slowly. Or you often quite see, you quite often see big ponds as well and they do a similar thing.

Mike Bowes 26:27
Mm.

Gianni Vesuviano 26:48

Where they slow down the water, hold it on site.

Mike Bowes 26:53

Yeah, so we're moving in the right direction, which is good news.

Gianni Vesuviano 26:57

Is very good news.

So, yeah, thank you for that. That's been a very good discussion. I've enjoyed it. I hope everyone has. And we're now going to move on to our next keynote speech, and that will be delivered by Setareh from the British Geological Survey.

And that will be called from data to model, advancing BGWM with a data-driven approach. So, you can start whenever you're ready.

Setareh Nagheli - BGS 27:25

Yeah, thank you. I should share my screen first.

Can you see my slides?

Mike Bowes 27:47

Yeah.

Gianni Vesuviano 27:47

I can see them, yeah.

Setareh Nagheli - BGS 27:50

I think Andrew Hughes wanted to add some things at first. I don't know if he's in there or not.

Yeah. Good morning everyone. My name is and I'm very excited to present our work on the improvement of the BGWM, which is the national-scale Groundwater Flow Model of the Great Britain. First and foremost, this is the

results of the hard efforts of the BGWM team led by Marco Bianchi, including Johanna Scheidegger, Andrew Hughes and many others.

And I'm very proud to be a part of this team. As you can see, this slide, I selected the from data to the models as a title. Why did I select this title? The main message I

would like to talk about this today
It is improvement in the new version of the BGWM comes not from the changing the governing the equation. It is from improving the data sets and also improving the calibration data set and collecting more
observational data set. And finally, we changed the calibration approach to improve the model.
Let me begin by explaining about the BGWM role in the Hydro-JULES project. Sorry, as many of you know, one of the key goals of the Hydro-JULES project is understanding the subsurface process and its interaction with the surface layer.
as the groundwater is the main component of the hydrological cycle and also it is the main source of the fresh water in the UK. The BGS decided to develop the first national scale ground water in the Hydro-JULES project.
Based on the complexity, this model, the BGWM1, is located between the very complex regional model that provided by EA, and so it is located, is slightly more complex compared to the bucket model that is usually use for the hydrological model.
So the BGWM1 developed and published in 2024 in Hydrological Sciences Journal.
The starting point that this model, it was the geological framework. The model could represent whole of the Great Britain in by using the 15 hydrogeological units in four layers. The depth of model it was 400 metres below the surface. And this model could cover all of the main aquifer in the Great Britain mainland. Unfortunately, in this model, we couldn't consider the finer heterogeneity and transitions in between each aquifer in each unit.
This is the limitation of the, one of the limitation of this model. And another input we need for model, it was the abstraction. That time, unfortunately, we couldn't find very good abstraction data set.
We, you know, found only one magnitude for abstraction rate for each borehole in the mainland. And we had to use this data that time. And we used this data for BGWM1. And also we
extracted the river flow network and stage of them from the very accurate data and implemented in a support package in the model. We considered the coastline as a general head boundary. In this type of boundary, you can define the
inflow and outflow to aquifer based on the differences between the groundwater level in the aquifer and the head at the boundary. And the final parameter we added to the model, it was the recharge. The recharge extracted

Uh...

The recharge extracted from a distributed is distributed as you draw more dead and tell inside.

Harsh 32:57

Hello!

Sorry to disturb you, ma'am. Your slide is not visible. Can you please re-share your screen?

Setareh Nagheli - BGS 33:06

Ohh, sorry, sorry, I'm sorry.

Stop sharing.

Is it okay now?

Can you see it?

Harsh 33:28

No, ma'am, it's not.

Setareh Nagheli - BGS 33:34

I think someone can see it.

Is it okay now?

Martha McKee 33:55

It's okay for me, I can see it.

Setareh Nagheli - BGS 33:58

Okay, yeah.

Because I can see in the Teams, but yeah.

Yelesen, Sebastian 34:06

I can see it too.

Gianni Vesuviano 34:06

We've been having this discussion in the meeting chat and a lot of people can see it, but a few people can't.

Gianni Vesuviano 34:16

So, it's not a problem that's affecting everyone.

I'd like to reassure everybody who can't see it that this session is being recorded and we will distribute it to all the participants soon after.

SB Setareh Nagheli - BGS 34:32

Yeah, thank you. Yeah, that's great.

AB Andrew Hughes - BGS 34:34

Yeah, sorry, sorry. I just, yeah, I can see the slides. I'm sure hopefully you can.

SB Setareh Nagheli - BGS 34:41

Thank you.

Yeah, yeah, I reached the recharge. Yeah, the recharge model. Yeah, it's it is the distributed model. The resolution is a 2 kilometre by 2 kilometre. This model developed.

by Mansour et al in 2018 and they are using the rainfall, PET, land cover, land use and other parameters such as soil moisture and root zone and other things to calculate the

potential recharge. And we use the monthly potential recharge for the BGWM.

Finally, we implemented all of the input data in MODFLOW 6 on a structured 3D quadric grid that we had the refinement around the rivers and boreholes to reach the minimum resolution 1 kilometre by 1 kilometre. Regarding the time, this is the, this, I should say this was a full transient ground water flow water that covered the period from 1970 to 2018 with a monthly resolution.

In the sun point, we ran the model with the daily resolution for calculating groundwater flood and some things, but the published one, it was the monthly resolution.

Every model, this model has the limitation. One of them that I mentioned, we didn't consider the finite heterogeneity in the each unit of the hydrogeological unit. And so I mentioned the abstraction data was limited.

And other things I should say, we use the only national groundwater level archive data for calibration of the ground water level. And

We understood these limitations there is in the model and we decided to improve

the model in Hydro-JULES Next and develop the BGLWM2. The first point for improvement, it was
adding the EA boreholes and also for England and SEPA boreholes for Scotland to the NGLA boreholes and improve the calibration data set for ground water level.
With adding and integrating all of the data together, the number of boreholes reached to the
1000, that is five times more than the previous version that we used.
In the right map, you can see the NGLA boreholes, National Groundwater Level Archive boreholes as a yellow dots and the DEFRA and SEPA boreholes as green dots.
So we use the National River Flow Archive for the calibration of the base flow. This, it was the same as the BGWM1. We didn't change it. The next improvement, and it was the key improvement, it was the abstraction data.
We use the time-variant actual abstraction data that provided by EA and the SEPA.
The EA data covers the period from 1999 to 2014, and the SEPA one
is from 2009 to 2023. As I mentioned, we covered the period from 1970 to 2018.
Therefore, there is the mismatch in between data and so there is the missing data in the model as well.
we try to use the actual abstraction data that the period that we have the data, and for the rest of them, we calculate the long-term monthly average and use the long-term monthly average. For the
Just in case, and for let you know, I added the reference up there and that the data we downloaded from the these portal for, yeah, it is good to downloading the data from the website and from the portal SEPA portal and see that.
Another improvement, it was the redesigning the grid. In the BGWM1, the grid was the quadtree and you cannot represent the boundary perfectly in the quadtree grid.
And also the rivers and boreholes are not located at the center of the cell.
I said it was important for us for calculating groundwater flow.
So we decided to redesign the grid based on the Voronoi grid, which is irregular shape, and we refined the grid around the rivers and boreholes to reach the one kilometre resolution.
There are 200, around 200,000 cells in each layer. This is 20% more cells in upper layer compared to the first version.
And.
As I mentioned in the first slide, we changed the calibration approach as well. In the

first version, we used the classic PEST for automatic calibration, and in the second version, we decided to use the ENSI approach, which is ensemble space inversion. cooperation approach. If I want to compare them together in the simple way, yeah, I should mention that the difference is very complex, and I want to just explain in the simple words in that classic
when in each iteration, when you want to calibrate the parameters, the model and the automatic calibration engine, change one parameter slightly, run the model, change another parameter, run the model, and change the N parameters.
and run the model N times for each iteration. But in the PEST ENSI, the engine create the more 1000 model parallel, change parameters, and run all of them parallel together, get the results.
This is, so this model is completely and this approach is completely faster compared to the classic pest.
So, we could define more parameters for calibration, and we decided to apply a refiner heterogeneity in the model, the BGWM.
In the PEST ENSI approach, as the model is completely fast, you can calibrate in the regional model, you can calibrate cell by cell. But we are doing the national scale model. This is if you want to calibrate cell by cell, it takes ages.
And we decided to define the pilot points to calibrate and then do creating between each pilot points to calculate and find the calibrate parameter between them. The strategy for defining the pilot point, it was for considering four pilot points around each observation boreholes with 1.5 kilometre distance, and also we considered additional points at the river catchment centroid.
And for filling the gaps, we consider regular 15 kilometre grids across the main model.
And then we define the bulk, define the bulk parameter for horizontal hydraulic conductivity, vertical hydraulic conductivity, specific and the storage for 15 hydrogeological units, and also
we define multiplier for each pilot point to do the multiple one value to the bulk value to get the new horizontal hydraulic conductivity and other parameters.
And so, we calibrate river-bed conductance for the far reach as well.
Another issue we faced it, it was the time.
Because if we wanted to calibrate the model with a full transient state, in each iteration, it takes 12 hours running. And as you know, for calibration, you need more than 1000 iterations.

And if we wanted to use the full transient, it takes ages. We decided to use the long-term monthly average for calibration, and we designed 14 stress periods. The first one, we used the long-term average data, input data,
for steady state. We considered the long-term December average data for transition between the steady state and transient zone, and we didn't use the output of this December. And then we ran 12 search periods.
from January to December to calibrate the model.
The 1st result of the calibration that we got, it was very good and there was a very good improvement in there. RMSE at the BGWM1, it was 19 metres for ground water level.
But in the first calibration of the BGWM2, it was 10 meter. And also the RMSE for the river discharge, the base one, it was 4.38 cubic metre per second.
in the BGWM1 and in the BGWM2, we reach to the 3.18 cubic metre per second.
We did continue the calibration by changing the weights of the boreholes, changing the weights of the base load gauging station and other things to reach to the best one, this is this one, and RMSE reached to the 6.24 metres and RMSE for
and for the base below reach to 1.48. And you can see in the left diagram that all our parameters follow the 45-degree line.
This is another output of the model. You can see they are located between minus 5 to 5 in the most of them and for national scale. I can say this model is very good.
This is the, in the right side, you can see the horizontal hydraulic conductivity for first layer, second layer, specifically for first layer and second layer. This is the output of the calibration and
We wanted to compare one of the specific location with one of the original model that developed by EA, and...
This is the transmissivity map of the original model that I that we compare with the our model. The pattern looks promising and we understood our model could develop the finer heterogeneity in each hydrogeological unit.
I select the sample of the head hydrograph of the model and compare with the BGWM1 output. And you can see the purple line, it is BGWM2 and the blue line is BGWM1.
You can see the.
BGWM2 is quite better than the BGWM1.
But yeah, still we have the bad result as well. You can see this one. It's completely bad. I should present this one. It's not completely good in every borehole. We got

the bad result as well.
But in the summary, the BGWM2 represents a significant advancement in the national scale ground water modelling driven by the higher quality input data, enhancing the observational data set, and we changed the calibration approach.
This model is a very good digital representation of the groundwater resources, and also this model can support the water resources management policy and climate resilience, and we can use it as a foundation for future enhancements, especially for Climate scenario.
Thank you for your attention, and I would like to take a question.

Gianni Vesuviano 50:29
Thank you for that presentation, Setareh. It's been, yeah, very interesting to learn about major advances that have been made to ground water modelling and all the implications that has. If anybody has any questions they'd like to ask, please raise your hand or type into the chat.

SB **Setareh Nagheli - BGS** 50:32
Thanks.
Thank you.

Gianni Vesuviano 51:07
Well, it uh...
Looks like you're getting away with no questions. If you could maybe just put your last slide back on so that if people do want to find out more information, they've got the QR code there for them to scan.

SB **Setareh Nagheli - BGS** 51:11
Yeah, and I say again, sorry.

Gianni Vesuviano 51:32
Yeah.
That QR code will go to more information about this. It's not to ask questions, is it?

SB **Setareh Nagheli - BGS** 51:40
Yeah.

Gianni Vesuviano 51:41
Okay, right.

Setareh Nagheli - BGS 51:43
Yeah, this is the website, sorry.

Gianni Vesuviano 51:49
Okay, well, great. Thank you to both of you for these, the brilliant start to Wednesday morning that we've had.

Setareh Nagheli - BGS 51:54
Thanks.
Thank you.

Gianni Vesuviano 52:01
And to the participants, remember to be back by 10.30, so that's in 33 minutes time. And remember that we're using a different Teams link for the next session. And that will be Workshop 3, exploring hydrological data.
So, I look forward to seeing you all there.

Andrew Hughes - BGS 52:25
Thanks very much, the speakers, and hope you enjoy the rest of...

Setareh Nagheli - BGS 52:26
Thank you.

Andrew Hughes - BGS 52:30
Summer school.

Setareh Nagheli - BGS 52:32
Thank you so much. Thank you. Bye.

Gianni Vesuviano 52:32
Thank you.

Andrew Hughes - BGS 52:34
Cheers, bye bye.

Gianni Vesuviano 52:36
Bye.

Gianni Vesuviano stopped transcription