Tim Cline:

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Tim Cline:

Thank you for listening in today, I'm Tim Cline. Joining me for this podcast is Mathis Messager, a graduate student in the School of Aquatic and Fishery Sciences at the University of Washington. He is the lead author on a study that was recently published in Nature Communications titled Estimating The Volume and Age of Water Stored in Global Lakes Using a Geo-statistical Approach. In this study, they used new tools to estimate the number, size, volume, and residence time of lakes globally. He's here to tell us a little more about the research and the importance. Let's first start with a little bit about the research group. So this was a collaborative paper coming out of a group of researchers at McGill, correct?

Mathis Messager:

Mm-hmm (affirmative). Yeah, we were all part of actually the same lab, the Global Hydrolab, we call it at McGill. And so the PI was Bernhard Lehner and all the other authors were actually students in the lab.

Tim Cline:

So the core issue for this paper is that lakes are hard to count?

Mathis Messager:

Yeah, yeah. Very hard to count.

Tim Cline:

And we need to get a better idea of how many there are and how big they are so that we can scale different processes. Can you talk about this a little bit more?

Mathis Messager:

Yeah, I think that we are with remote sensing, we've become pretty good at counting the amount of water that's on Earth. But what's been really hard was actually to count how many lakes we have. Because we have wetlands, we have rivers, we have estuaries. And so it's really hard to differentiate between a lake and any other kind of surface water.

Mathis Messager:

So I think that the big objective of this paper was to produce a lake only database to be able to essentially differentiate the role of lakes from other surface water. And that took essentially a lot of manual corrections for several years. And a lot of its strength, I think of this created database would be potentially to combine them with those large scale, temporarily more fine databases. And kind of combine them to have an idea of what's a lake.

Tim Cline:

what specifically is important about quantifying the number of lakes? You mentioned in the paper a few things like water budgets, up scaling carbon budgets. Can you tell us a little bit more about importance of an accurate count of the number of lakes?

Mathis Messager:

Yeah, for sure. I mean lakes are more and more recognizing them as kind of a ubiquitous element of the landscape. And kind of, for example, they cover 9% of their land, which is quite huge. And so you start to think of everything that goes on on lakes and how the shoreline of lakes is the interface between the landscape and the water system essentially. And so in 2007, it was Cole and Prairie had this paper, it was Plumbing the Carbon Cycle. And I think that that's essentially what we're trying to do is add these lakes in these global models of hydrology and climate change and see how that trend is or results in how we can refine our estimates. And so lakes are really important also in modeling how all kinds of elements go through the landscapes, whether there is natural nutrients or pollutants. And so including them in a hydrological cycle with reverse, allow us to see how all these elements go through the landscape.

Tim Cline:

It seemed to me when I read through the paper that there is an emphasis on small lakes. I think this stems from a common misconception, not necessarily by ecologists anymore, but I still think it's out there, that big lakes are very important compared to small lakes. But we now understand that small lakes per unit area, are more important for most processes. I think there's a line in the paper that states you cannot just multiply the total surface area by a rate and come up with an estimate of your process of interest, because each lake has different rate. So it's very important to really understand this distribution.

Mathis Messager:

Yeah, exactly. I think that even though, I mean large lakes are very unique and they have their own processes. But I think that we need to have an idea of the very specific processes that they place in smaller lakes. And the paper, it's a little difficult because where all smallest lakes are 10 hectors, and some would say that these are not small lakes, you know? But when you see that at a global scale that's the smallest we can go, then that shows how much we need to work on getting more data and more understanding of how the small lakes work on the global scale.

Tim Cline:

Let's talk a little bit about your approach. In the past, this has been done by assuming a distribution, like the Poisson Distribution and then extrapolating from that. But you have some remote sensing data and you are going to try to quantify lakes from that. Can you tell us a little bit more about how you did that?

Mathis Messager:

Yeah. The database that we produced beyond the estimates was essentially trying to stitch together in the most consistent way possible about, I think eight main sources of data. And so most of it, area wise, was actually the satellite mission that was conducted in 2000, that essentially captured the topography of the world. And then they had teams essentially looking at all of these images and tracing manually the shoreline of all these lakes of about 800,000 lakes if I remember well, all the way up to 60 degrees north. And so this was kind of the biggest chunk in this database. And then we added data for Northern Canada, Alaska, Northern Europe, Siberia and all other kinds of places where we could fill in with other databases.

Mathis Messager:

And so a lot of the work actually consisted of making all this consistent and have the same resolution as much as possible to be able to then run their models and something that we think is the most consistent possible, covering all of the land area.

Tim Cline:

The other unique thing about this paper is estimating volume. And this has been a very hard thing to quantify in the past, but you use landscape features around the lakes to then estimate the shape and volume of lakes.

Mathis Messager:

Yeah, the volume. I think the volume and the residence time were really kind of the most exciting parts of this project for me. I focused, most of my work was actually on coming up with these models of volume, or ID at the beginning was to create a more mechanistic idea of volume where it would extend the slope within the leg to reproduce a bathymetry. And sadly, we found that coming back to simpler, kind of average slope within buffers was actually the most parsimonious given the data that's available at this time. I think that in the future, if we wanted to have even better volumes would needs more understanding of how different types of lakes or shapes in relationship to the landscape and where these lakes are. Because we have very little understanding of what type of lakes are where, essentially.

Tim Cline:

So I pulled a few striking numbers out of the paper. You came up with an estimate of 1.4 million lakes globally. These are natural lakes, greater than 10 hectares. Combined they have 2.7 million square kilometers of surface area, which is 1.8% of the land surface area. 7.2 million kilometers of shoreline, which is four times the global ocean coastline. And 182,000 cubic kilometers of volume. This last one is a little more difficult to put in perspective, and of course you measured residence time, which was the other big part of the study. And the median estimate for the residence time was 456 days. Those are just a few fast facts, but what were the big takeaway results that you think came out of this study?

Mathis Messager:

I think that, I was amazed by, in the end, how much these largest lakes contribute to the global volume. And I mean, another fast fact is that 85% of the global volume is in the 10 biggest lakes. It's quite unsettling, but at the same time when you think about processes and you look at shoreline length or area, then you see that actually small lakes matter a lot. And given that we stopped at 10 hectares and that you still have over 60% of the world's shoreline in lakes under 10 square kilometers, then you start really thinking, okay, if we included the smallest lakes into like one hectare or even 0.1 hectare, then really the great majority of the interface between the landscape and the fresh water system through lake shoreline is in small lakes. And that's where I think it matters a lot for all these kind of nutrients and carbon cycling that we're most interested in nowadays.

Tim Cline:

That got me thinking about another question. Were all the lakes permanent? Is there any way to deal with seasonality?

Mathis Messager:

Seasonality is the really tricky thing in this database. One advantage that we have is that a lot of the data comes from topographic maps, were all digitize from topographic maps in many regions. So that generally topographic maps actually are like a longer term completion of knowledge on the geography of a region, and so you tend to have a better idea of what's seasonal versus what's permanent.

Mathis Messager:

I think one good way that we could actually have a better idea of what's seasonal would be to combine the created database that we created with good remote sensing data like, I don't know if you've seen, but in December of last year, the European Union Agency, with pixels published I think it was 30 yearly worldwide of extents. Essentially they had estimated for each pixel, 30 meter by 30 meters pixel on Earth off the seasonality of water in that location. And so I think that really interesting analysis could be combining these kind of estimates with ours and saying what percentage of the world that's seasonal, and also how much water we might have lost in the past 30 years in terms of volume.

Tim Cline:

Did the results of this study improve on our understanding of the number of lakes? I know the volume and the residence time estimates were novel, but did this improve on the distributional assumptions we've made in the past?

Mathis Messager:

So the Pareto Distribution is always very tricky and I think it's still at the center of a large controversy in the field. Whether lakes follow kind of parallel. It wasn't really our goal to prove this in the end. I think we used as distribution because it seemed to fit our data and we tested that. And it was a convenient way to make estimates of how many smaller lakes there it might be.

Mathis Messager:

Some people focus much more in depth on trying to prove or disprove the existence of a power law distribution. In our case it was mostly like, okay, it seems like it's fitting one, so what does that tell us about lakes in terms of volume? Another thing that was surprising is that previous estimates were pretty good and I think that resides in the fact that most water is in big lakes and we've known that the size of big lakes for a long time. But I mean the beauty of it now is that we actually have distributed over the landscape and over water shares and we can now actually implement these estimates of volume in models and see how that plays out in the global hydrology because this entire database is actually included in a river network with combines essentially, or lake database and we've linked it to a river database. And so now we can just run cycles, which is the most interesting part of it.

Tim Cline:

Is there anything else you want to add about this work?

Mathis Messager:

Personally for me it was mostly a really great learning experience, and I was very lucky to be doing this as an undergrad. And that's what essentially brought me to be here now, at the University of Washington and really enjoying doing science. And I think that was actually just possible because of there were systems in place to allow me to do this kind of research through funding and mentorship. So I think that personally, that's the most, it was very an exciting part of it.

Tim Cline:

Yeah, I think it was a good opportunity for a young scientist and you've certainly made the most of it. Thank you for joining us.

Mathis Messager:

Thank you.

Tim Cline:

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