

Measuring Rivers and Floods with Drones, Phones* and Satellites...!

(*I may have ditched the phones...
We'll see...)

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14/7/2026



Technology-led science!
AKA: Cool gadgets and gizmos to measure things



**3.7 decades
measuring rivers**
**(This is all about measuring river
flow – the most important
hydrological variable...!)**

Measuring river flow – what does **AI** know?

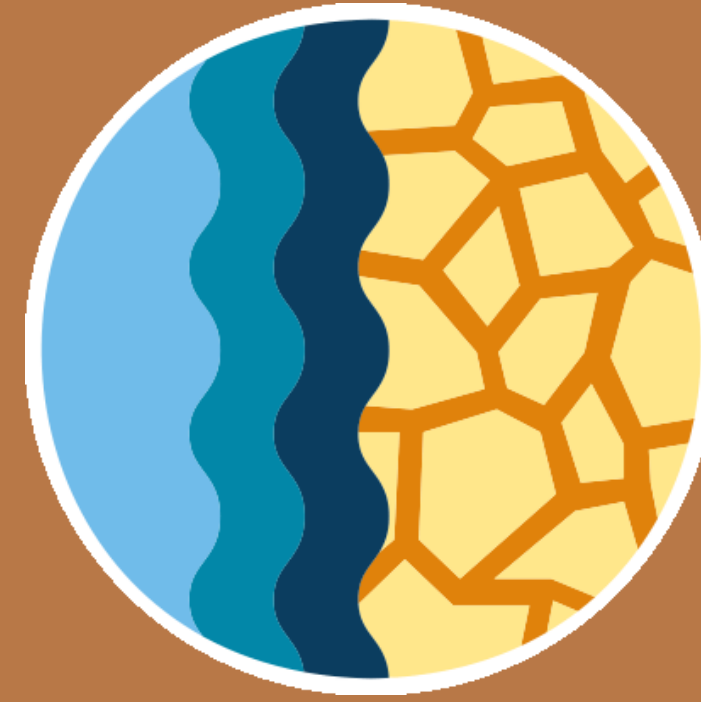
(Not much...!)

Important for:

Water resources
Flooding
Effluent & wastewater
Agriculture
Industry
Energy production
Environmental flows
Navigation
Rowing...!



This stuff is all relevant to



FDRI

FLOODS & DROUGHTS
RESEARCH INFRASTRUCTURE



Floods and Droughts Research Infrastructure (FDRI)

- £38M infrastructure investment
- Delivered by UKCEH and partners
- Enabling the science that will provide resilience from future floods and droughts
- Super-charging new field monitoring and data driven research



Things



we used



to do.



Some we
still do...!



ADCPs and ARCboats!

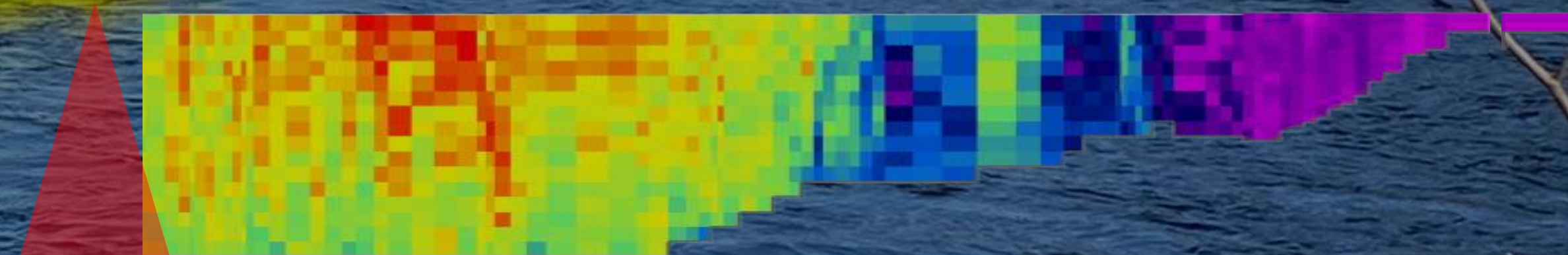
(The current 'operational' state of the art....)

Pulses of sound measure the speed and depth of the water

Other pulses of sound measure boat speed over the bed of the river....

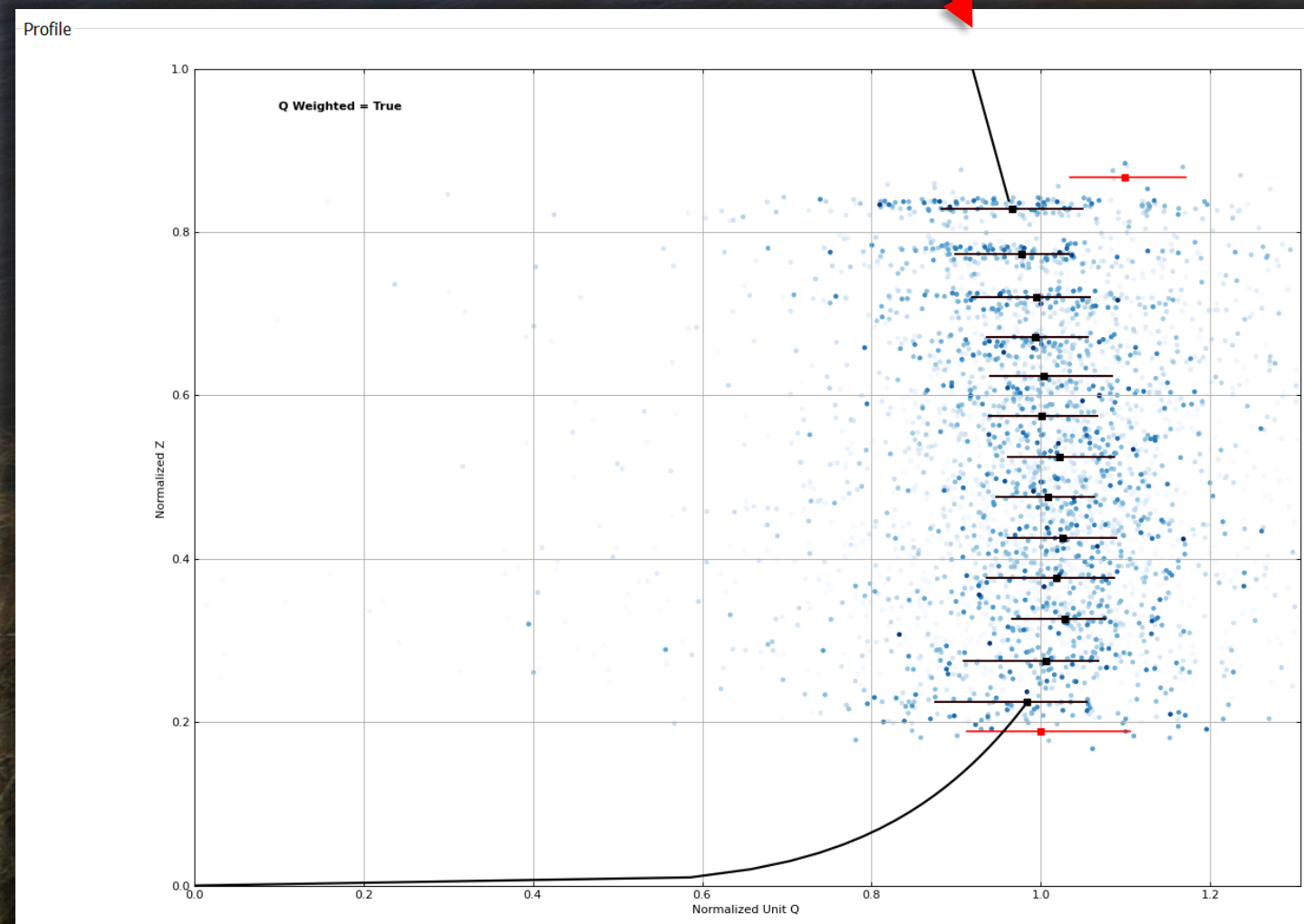
The ARCboat moves the ADCP about (the ADCP's Uber!!)

Data collected in real-time as boat crosses river

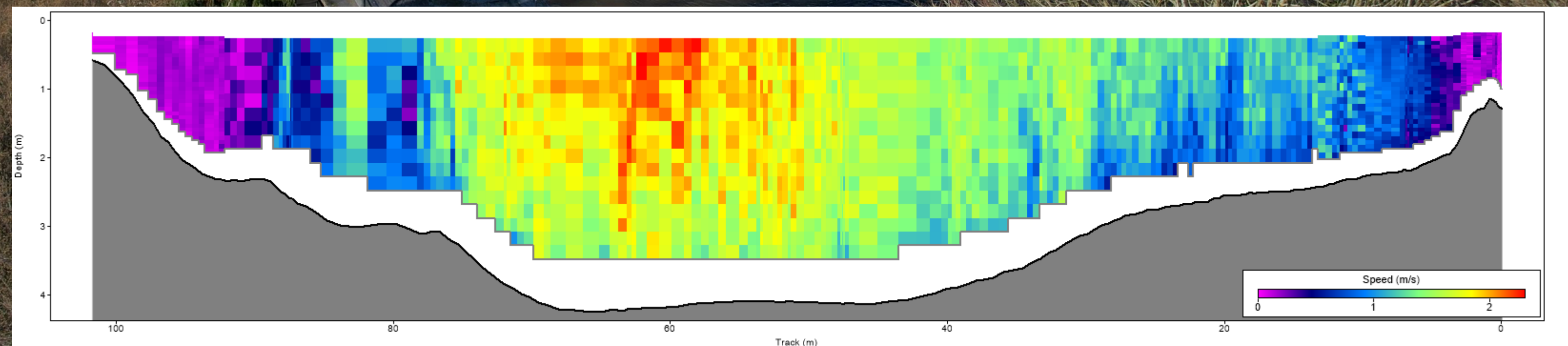


ADCP Data – Enabling new methods....!!

A detailed vertical
velocity (**C**urrent) **P**rofile



A detailed river cross-section –
essential for non-contact
methods (covered later on....!)





But what about.....

Big floods?

Monitoring networks

Many networks globally are **inadequate** and/or **declining**

Can be **destroyed** by floods



The problem:

Climate change will make

everywhere

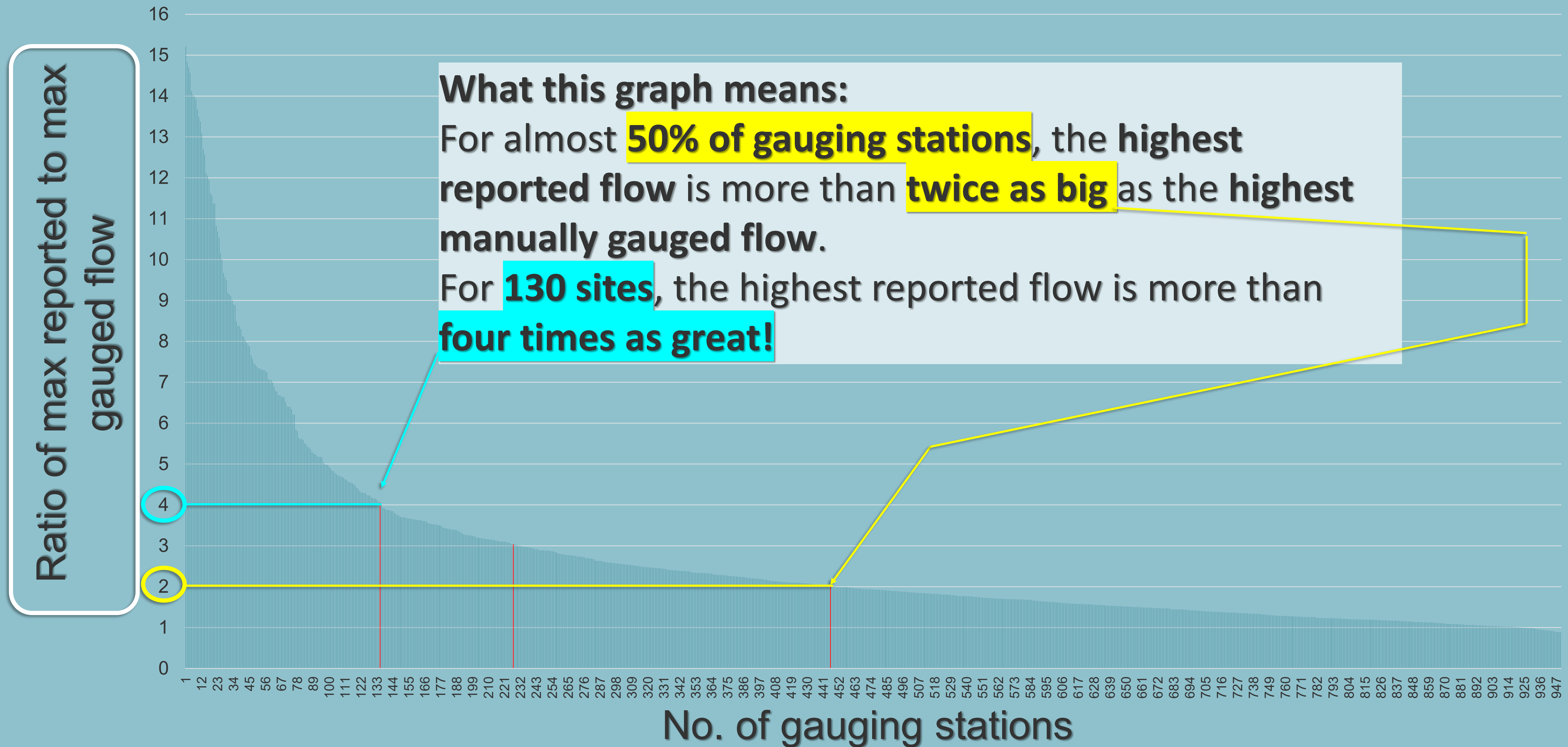


Burns
North Carolina

Greenville
North Carolina

We can't put people or equipment into these situations....

The problem – Measuring big floods is difficult!!!



Here's why.....



Measured section

Flood extent

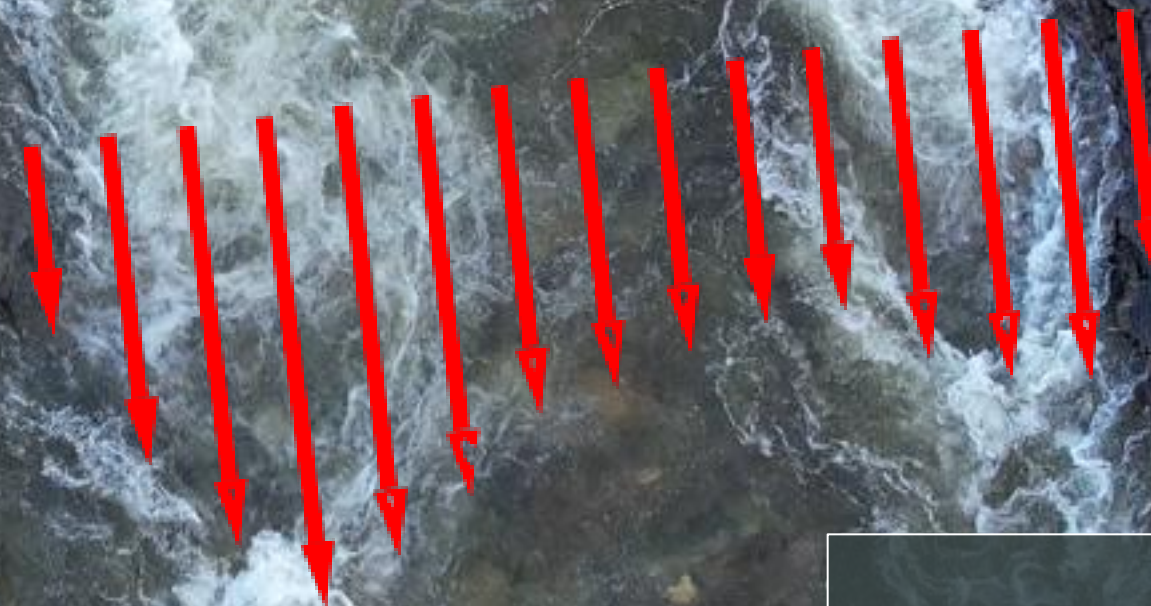
So, what can we do...?

Video velocimetry

(A non-contact* method....)

Short videos (20 sec)

Motion of **visible features** on
water's surface **tracked**
through time



* This **non-contact** thing is
important – it's what enables us
to use drones (and satellites)!!

Space-Time Imaging Velocimetry (STIV)

Timing the **movement** of **visible features**.....

....along user-defined **search lines**...

....parallel to flow direction...

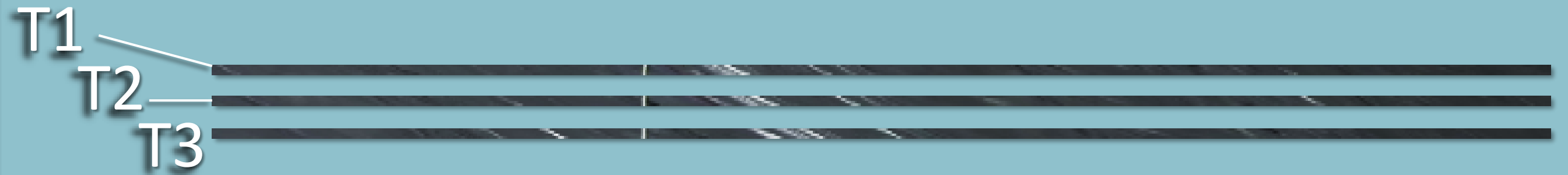


Space-Time Image....

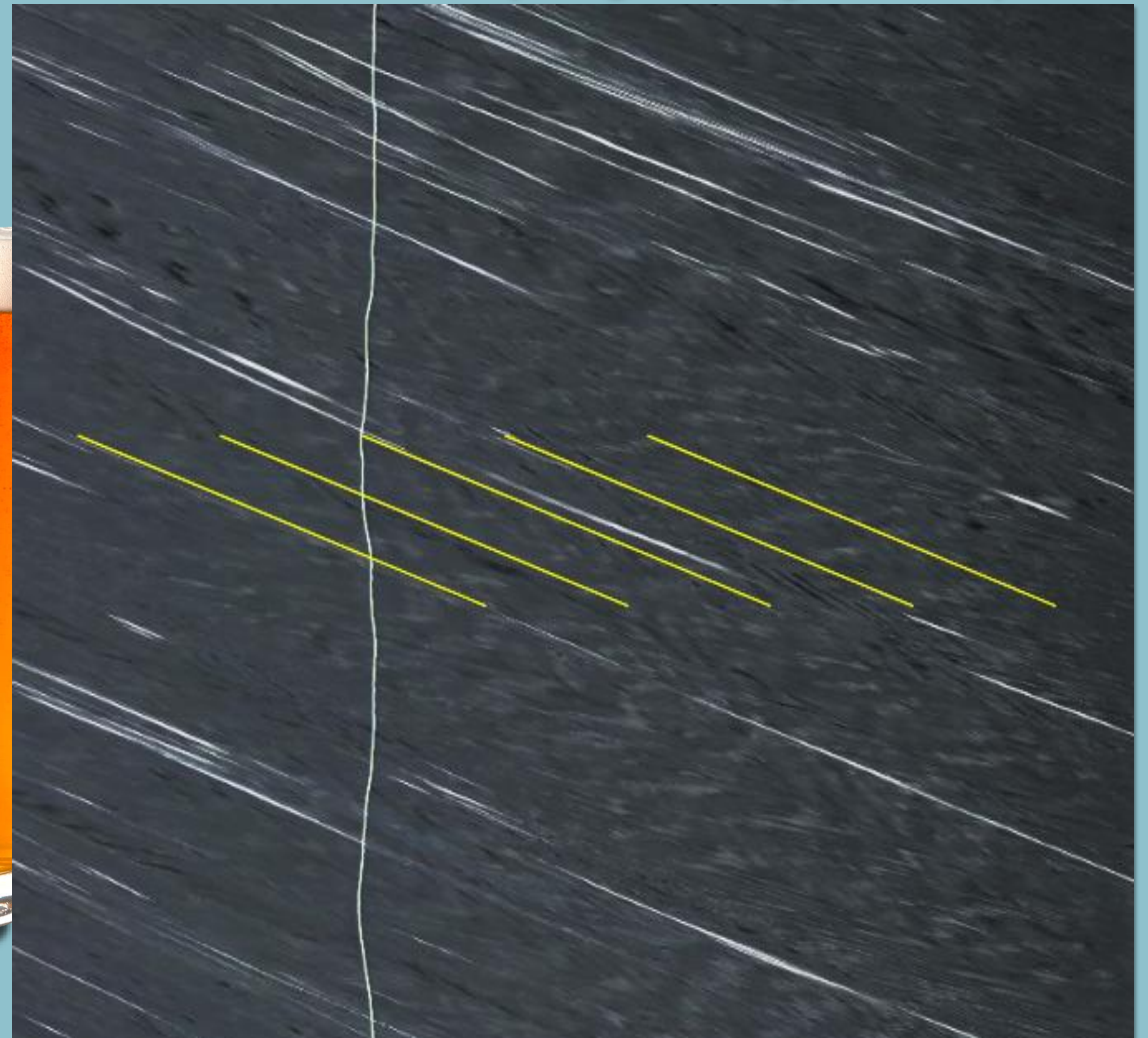
Brightness features appear
displaced along the search-lines

The search-lines are 'stacked' to
form a **composite image**

The **angle** of the resulting **diagonal
lines** gives the water speed!



Stack these lines and you get: diagonal stripes!



Perfect tracers Perfectly distributed!



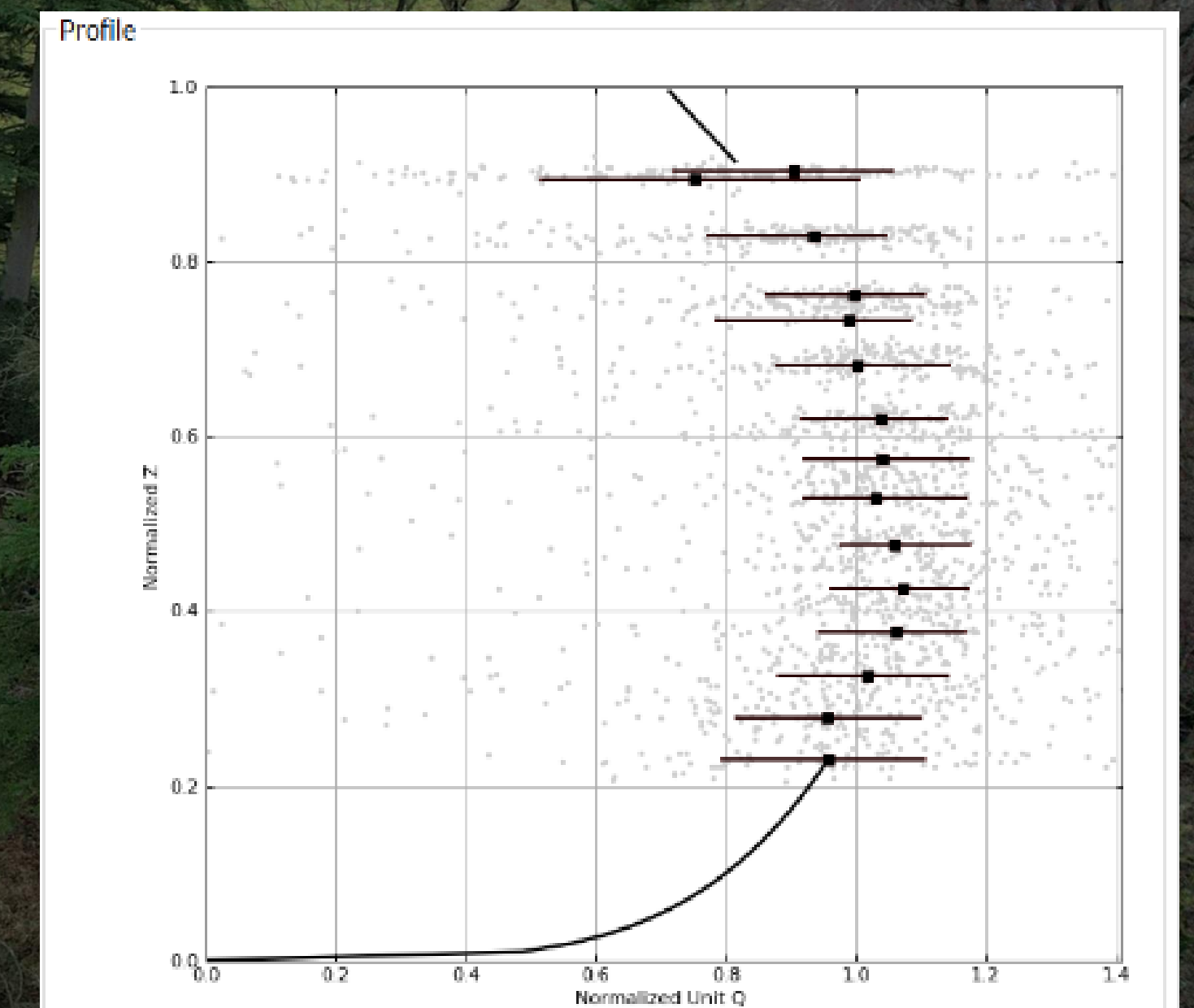
Is knowing the surface velocity enough?

No.

We also need a **cross-section**
and
vertical velocity profile

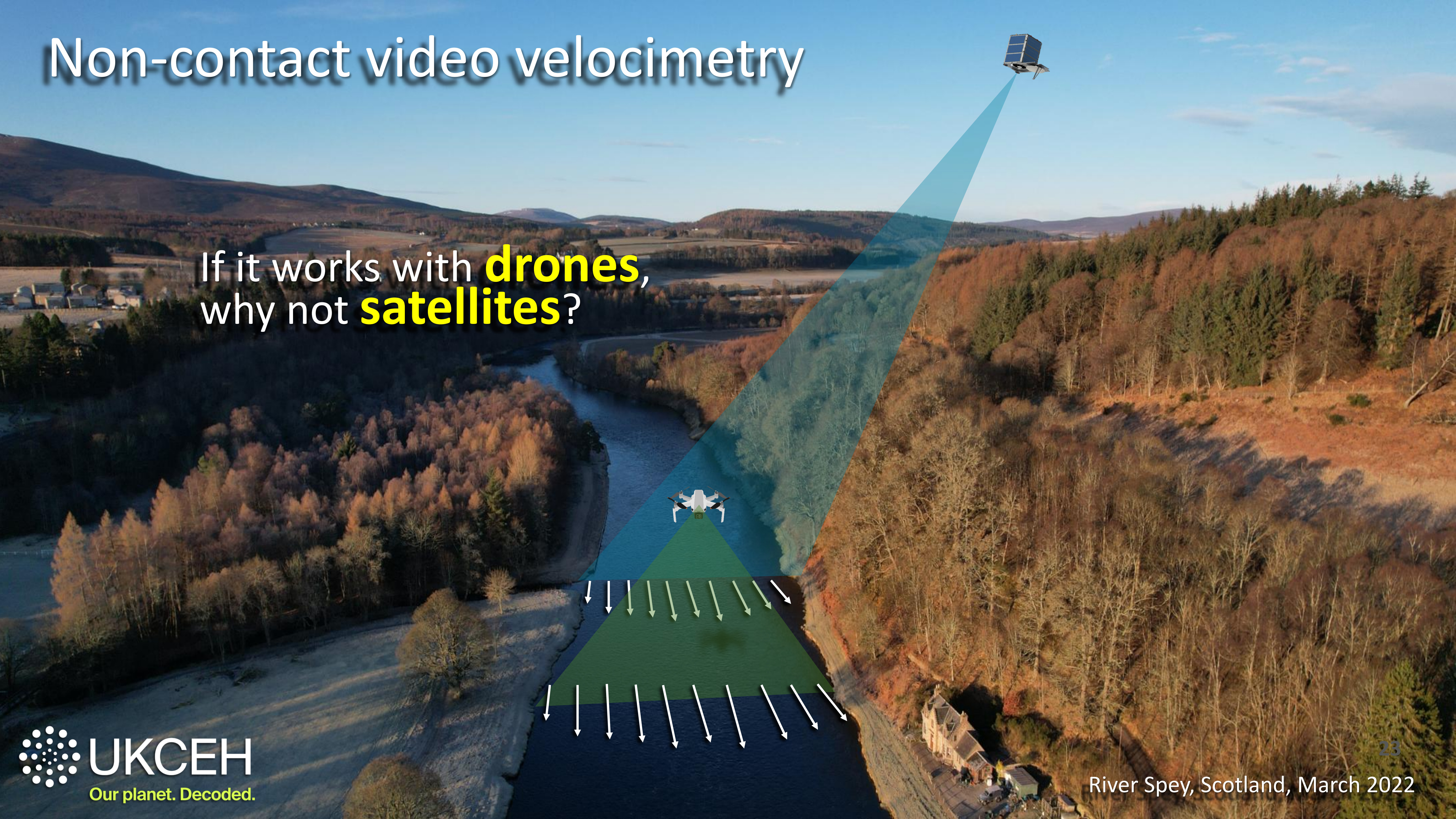
ADCP data provides

- **Cross-section (vital)**
- **Velocity profile (desirable)**



Non-contact video velocimetry

If it works with **drones**,
why not **satellites**?



So, can we

Measure water from space...?



In the beginning

NASA GEOS-3 Mission 1975

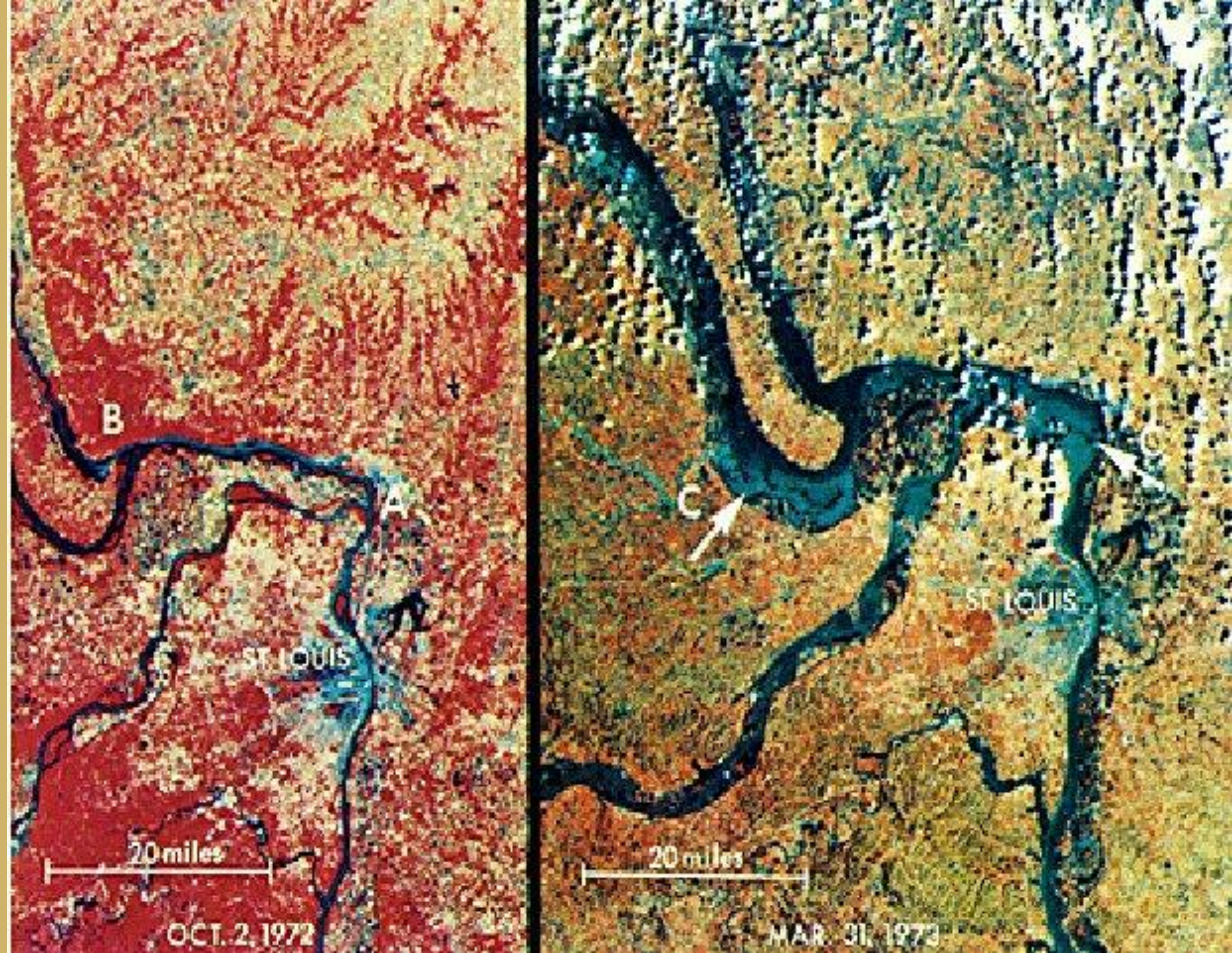


A radar altimeter looking at
sea surface height

River width

Landsat 1 optical images of Mississippi flooding in 1973.

80 metre resolution!

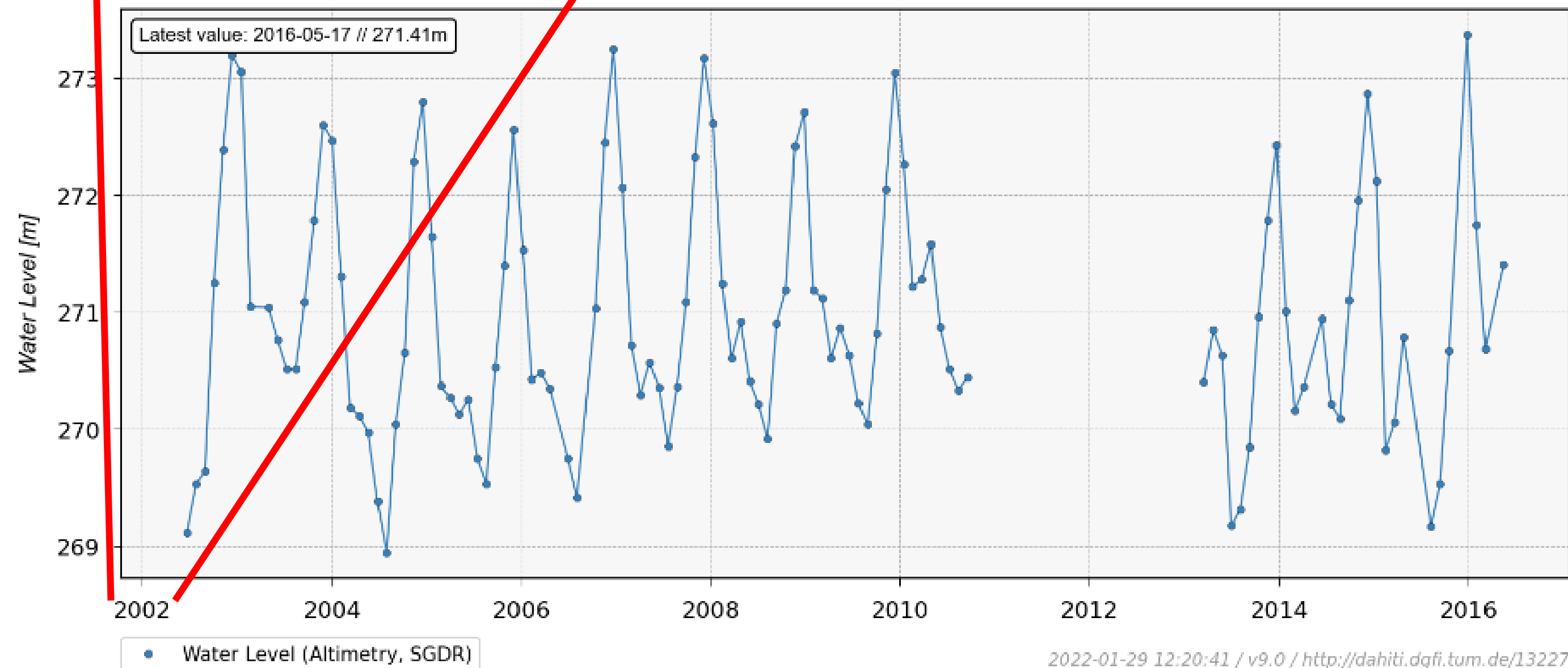


Radar Altimetry

It's been possible for quite a while...

2002

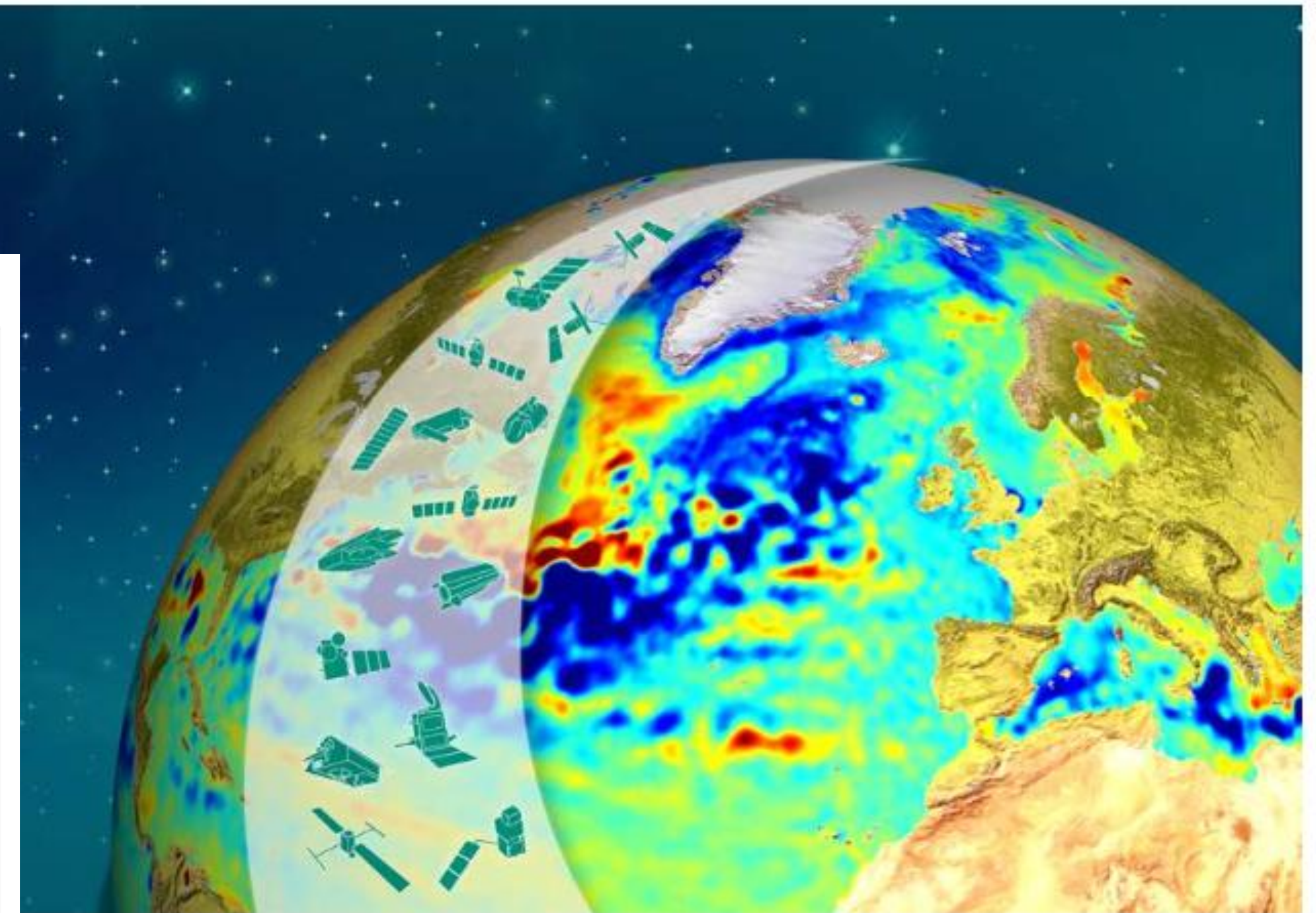
Congo, River (13227)



30 YEARS OF PROGRESS IN RADAR ALTIMETRY" SYMPOSIUM | Montpellier, France 2-7 September 2024

September 2 - September 7

Le Corum – Place Charles de Gaulle | Montpellier, France



<https://altimetry.esa.int/riverlake/info/history.html>

Sentinel 2 'High Resolution' imagery

10 metre pixel size

What is this?
What are we looking at...?

Airbus Pleiades Neo HD15

15-centimetre pixel size

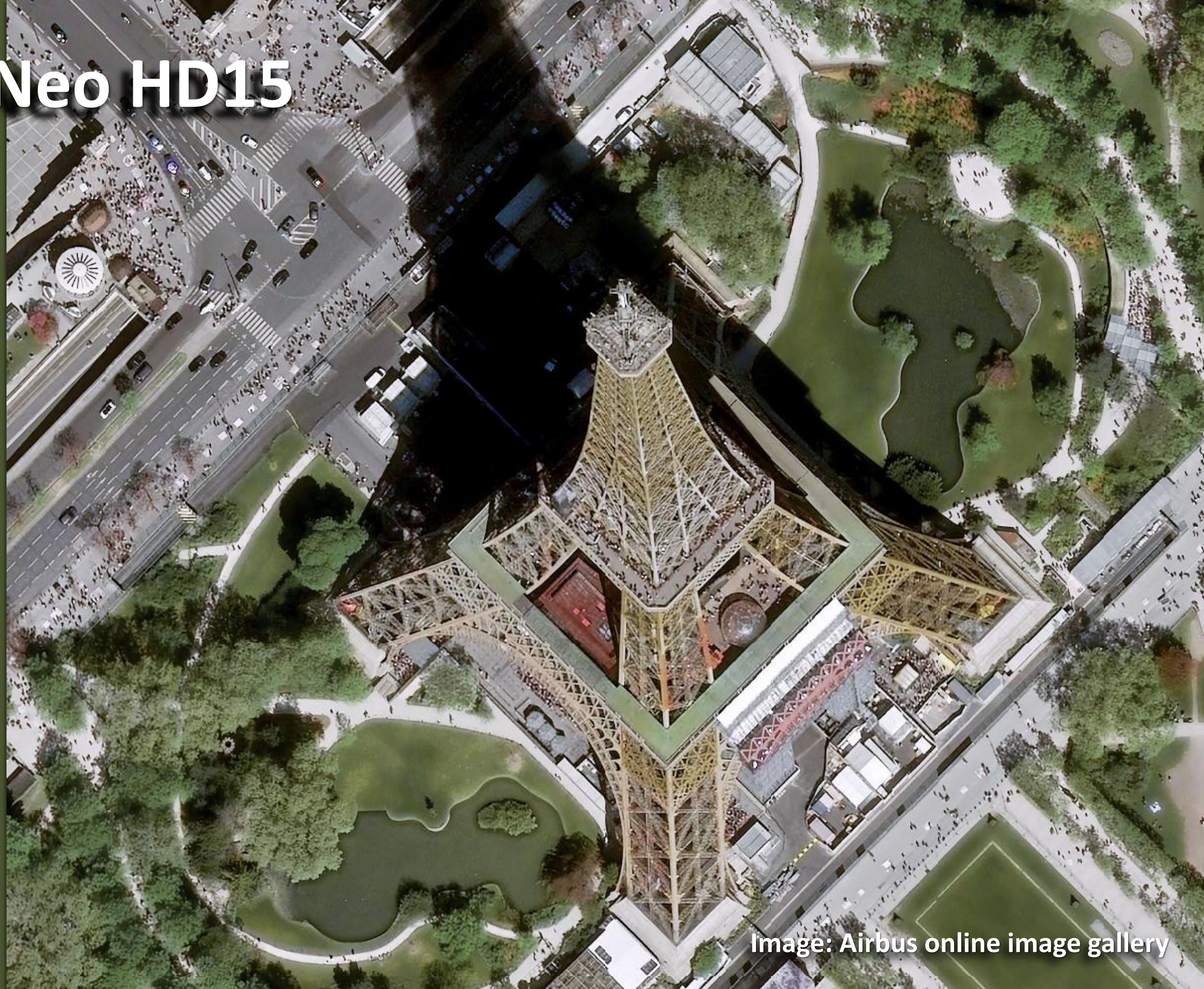


Image: Airbus online image gallery

Sentinel 2 290km swath

Pleiades Neo 14 km swath

(Maximum image size 70km x 110 km)

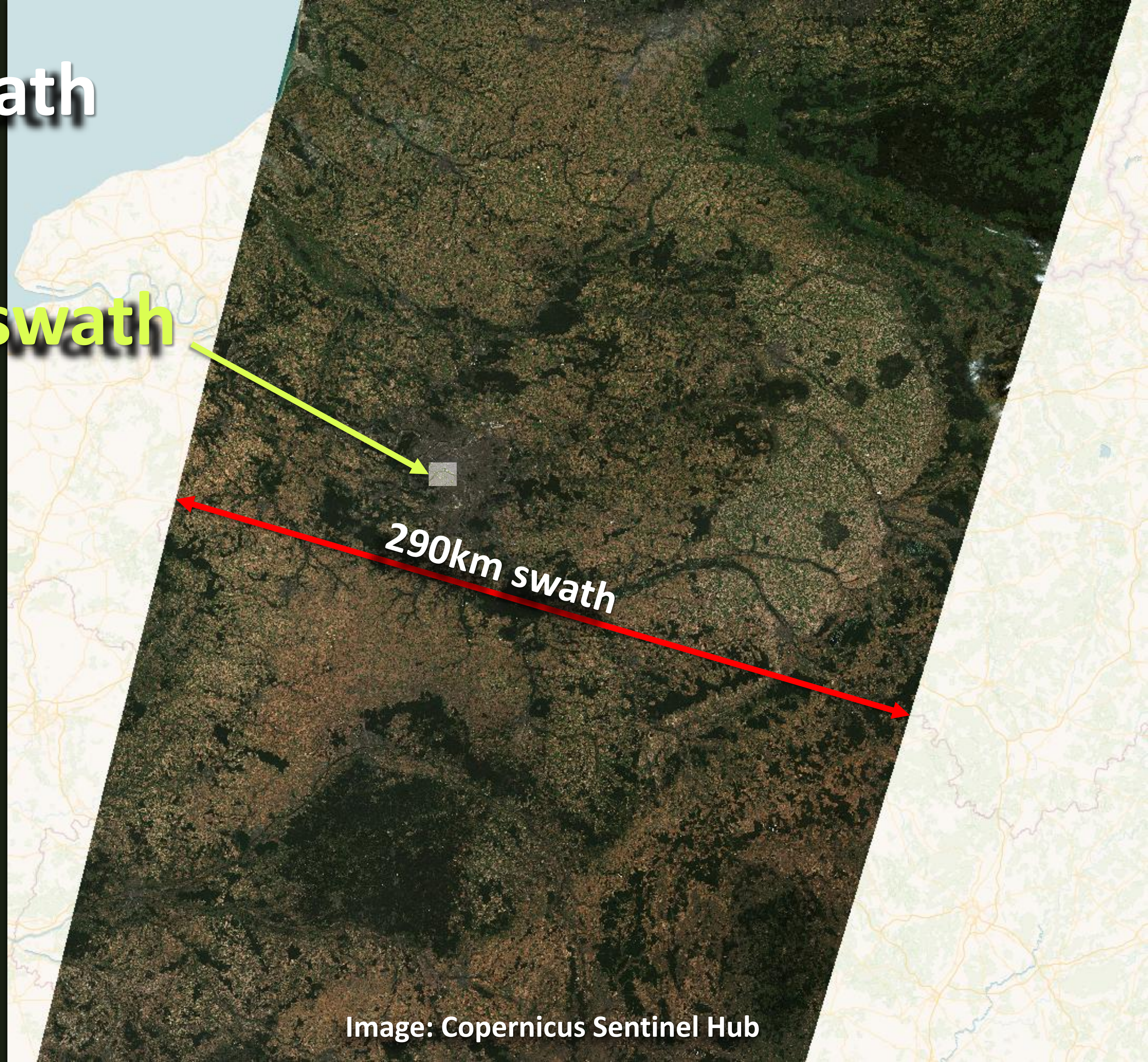
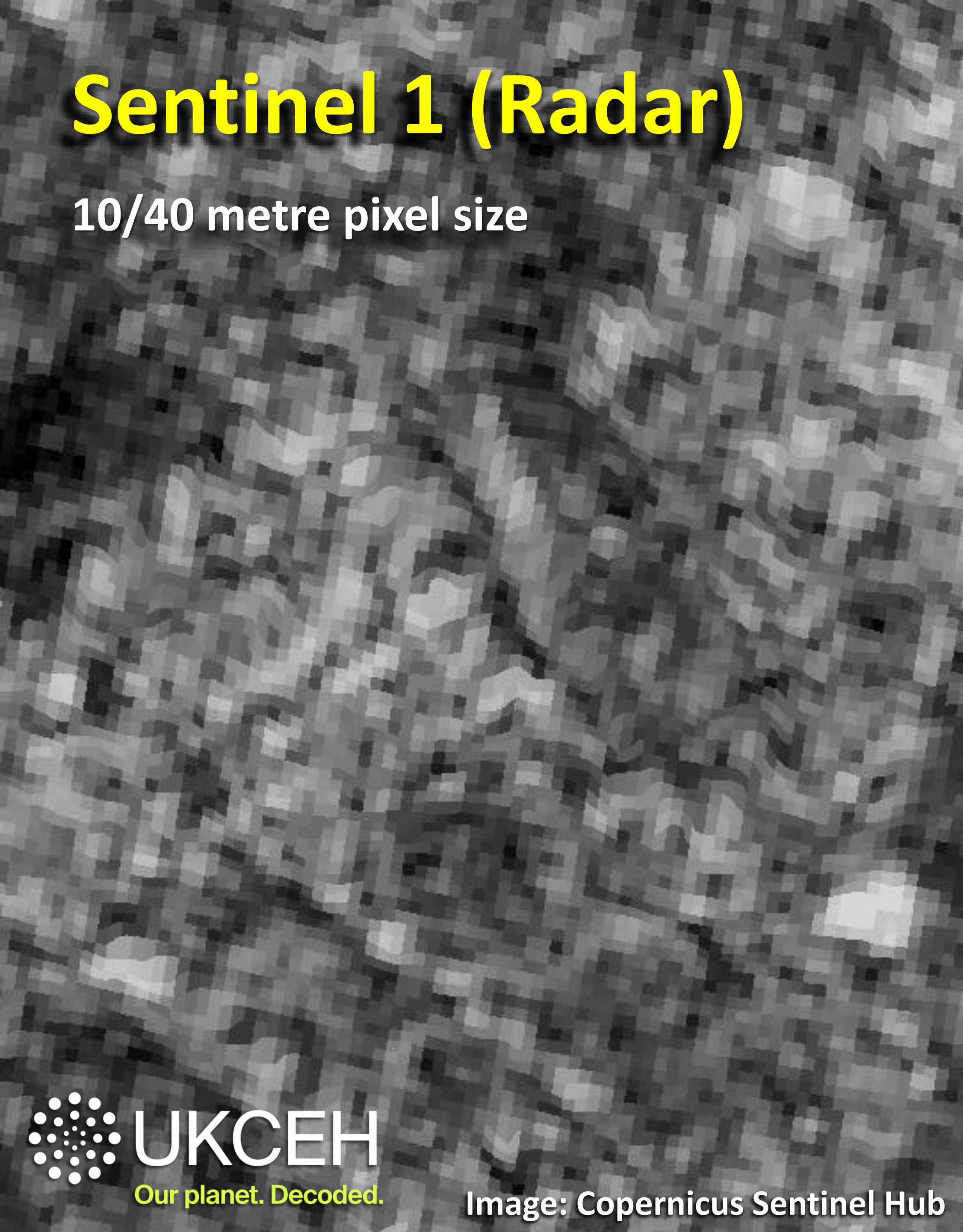


Image: Copernicus Sentinel Hub

Sentinel 1 (Radar)

10/40 metre pixel size



ICEYE Radar

As small as 25cm pixel size

16cm now possible!

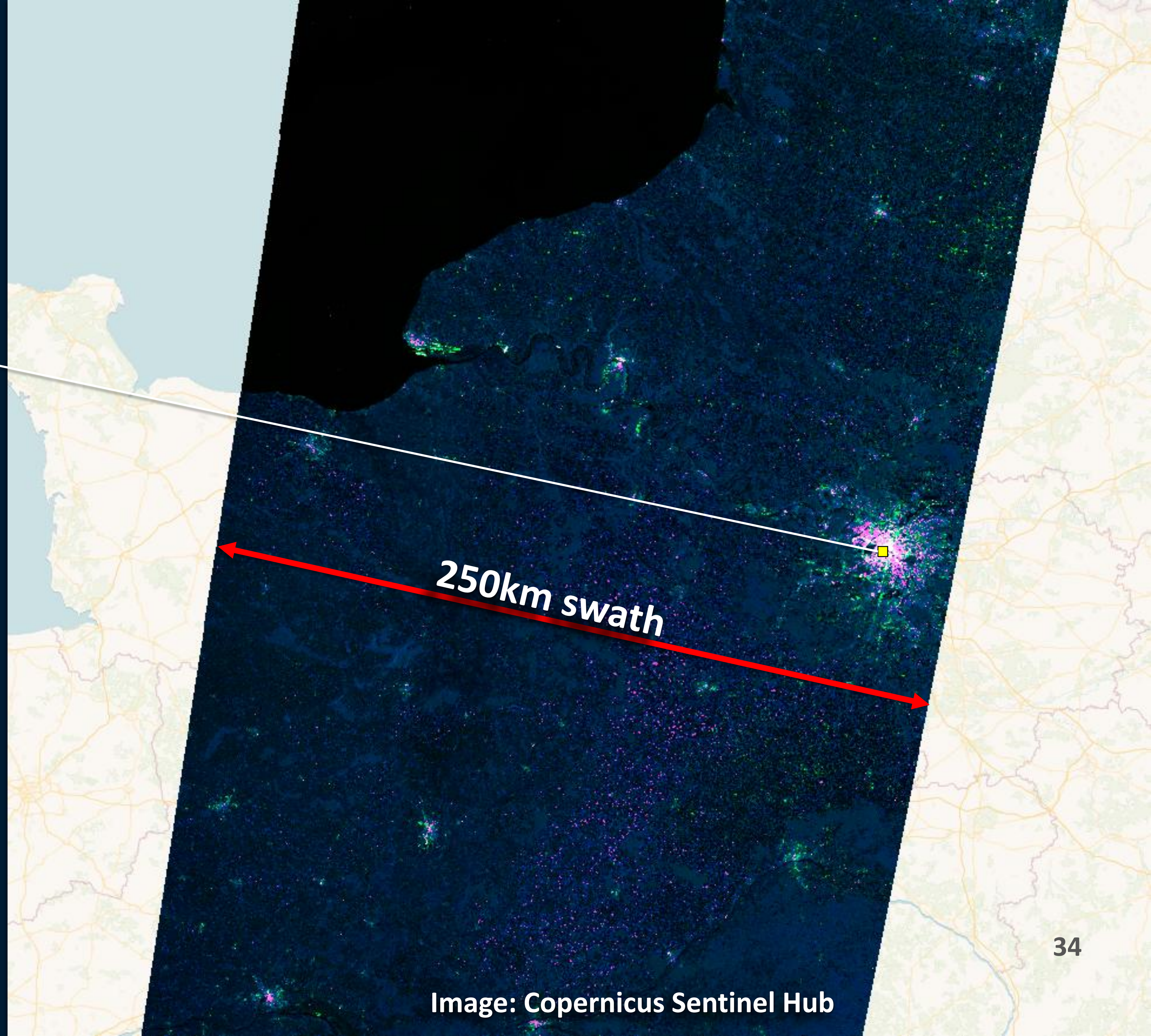


Sentinel 1 swath

250km swath

ICEYE Dwell mode

5km x 5km



250km swath

Revisit times:

Sentinel 1 (2 satellites) – approx. 2-6 days

Sentinel 2 – (2 satellites) approx. 2-5 days

ICEYE, Planet etc

Multiple daily revisits

ICEYE timelapse of
Muldraw Glacier

ICEYE

The Muldraw Glacier USA

16 APRIL

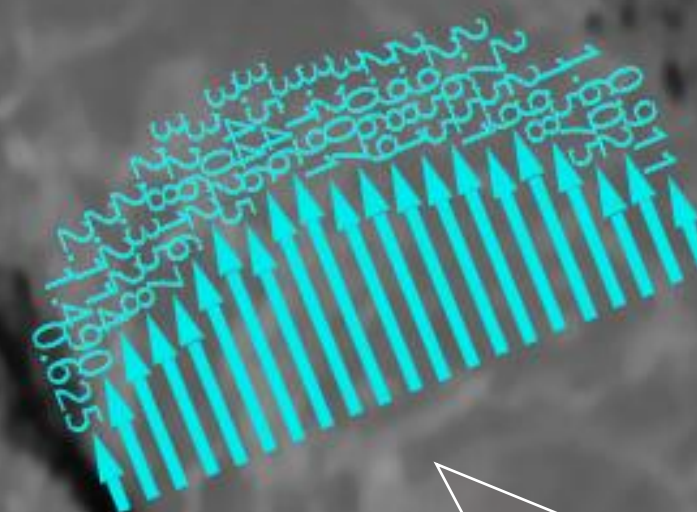
But....

water movers!!!!

The **FluViSat** concept

Fluvial (measurements using)
Video (obtained by)
Satellite

A **direct** measurement*
of water speed



*Actually **21** readings
of water speed!

A frame from
a Planet
SkySat video:



Image: Planet Labs PBC

Indus River, Pakistan
August 2022

Pakistan floods, 2022

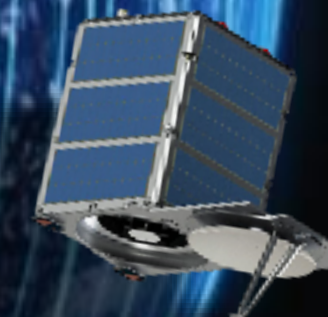
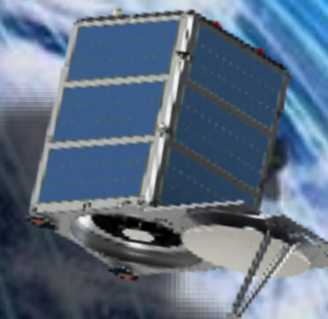
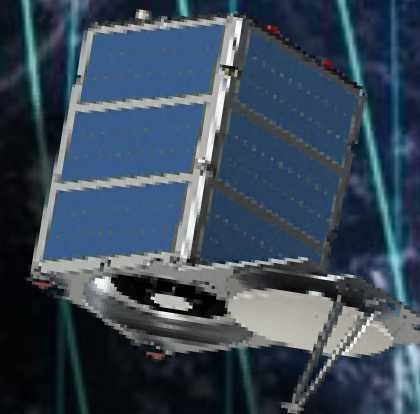
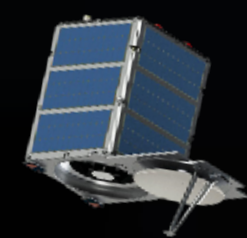
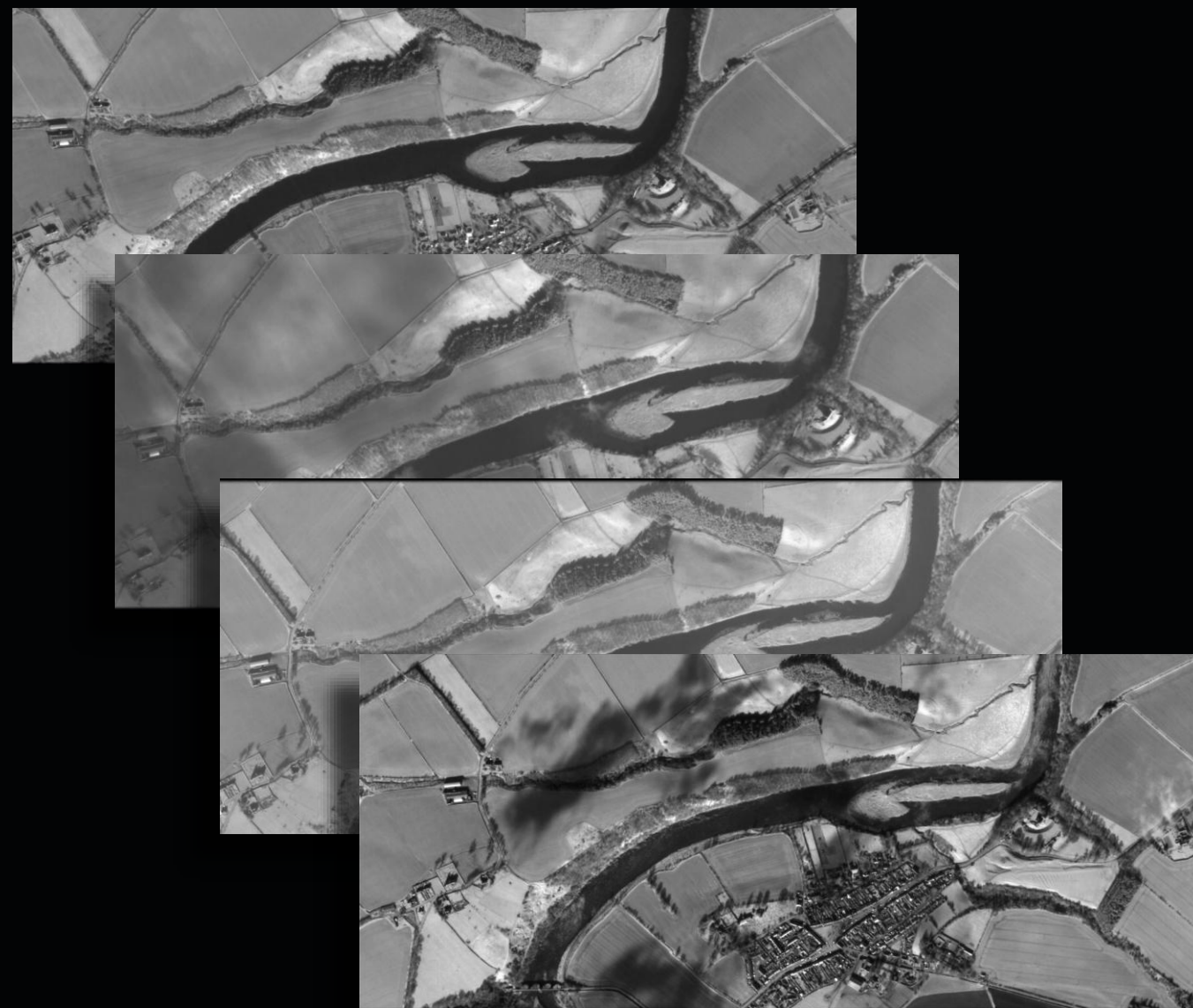
Six videos obtained
in two weeks

Three to four locations could
be processed in each video

Planet SkySat Constellation

21 satellites

Multiple daily revisits



Problems and challenges:

clouds

We can't see through clouds....!

Synthetic Aperture Radar (SAR)

ICEYE SAR video

Can we measure water speed with SAR....??

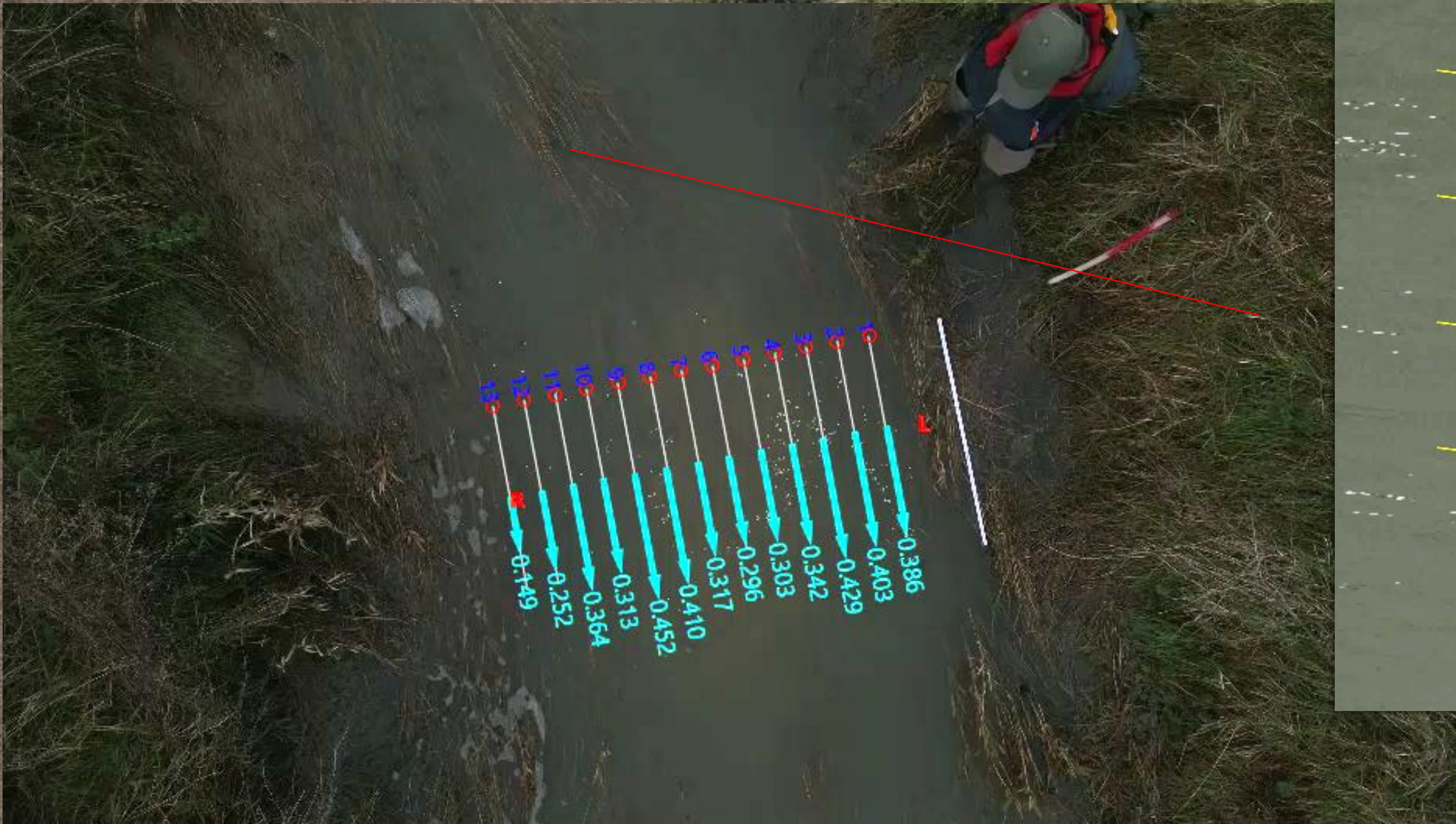
(Yes, I think so....!)

Synthetic Aperture Radar (SAR)



Breakfast cereal velocimetry

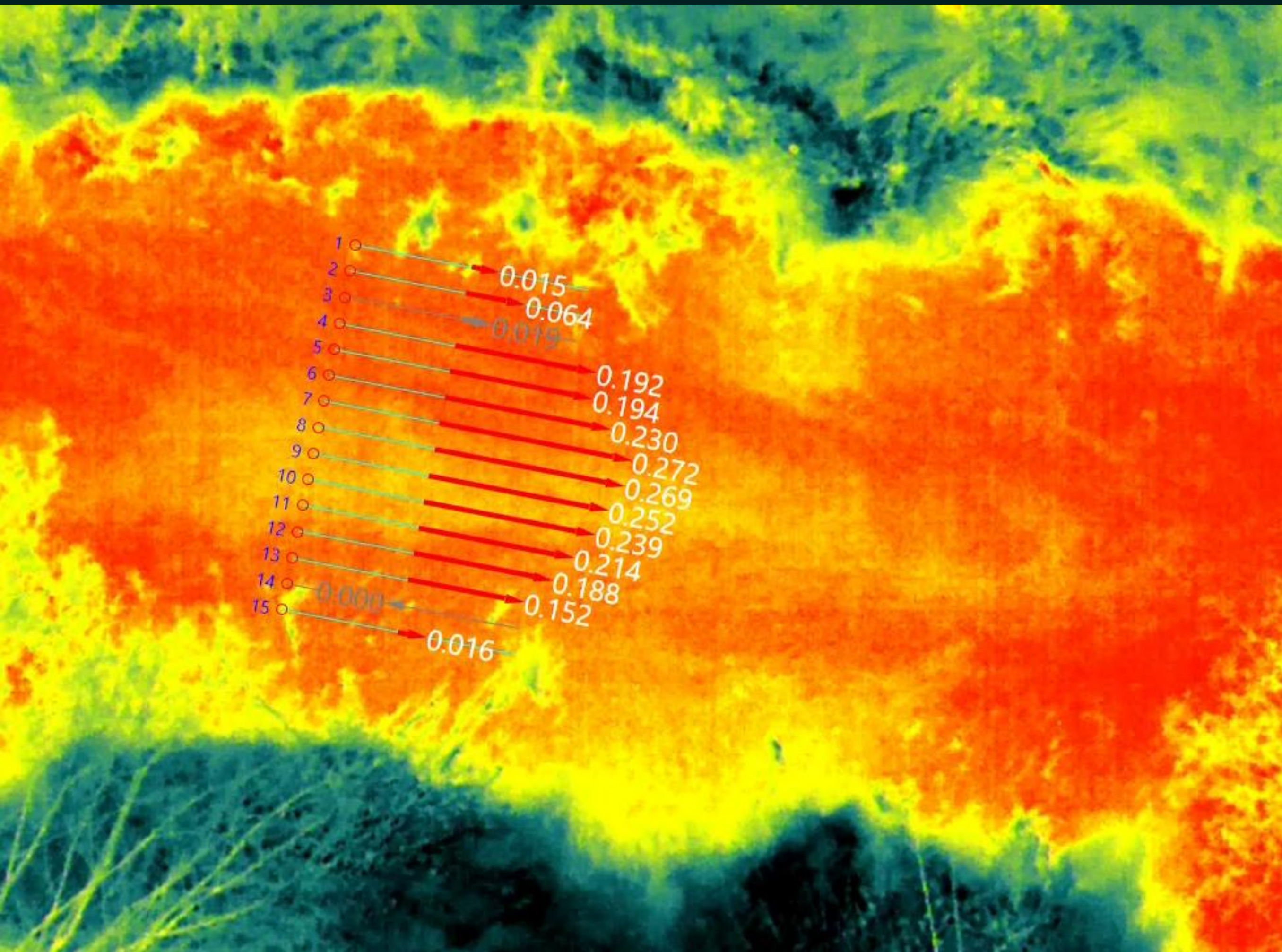
What if the stream has no tracers....?



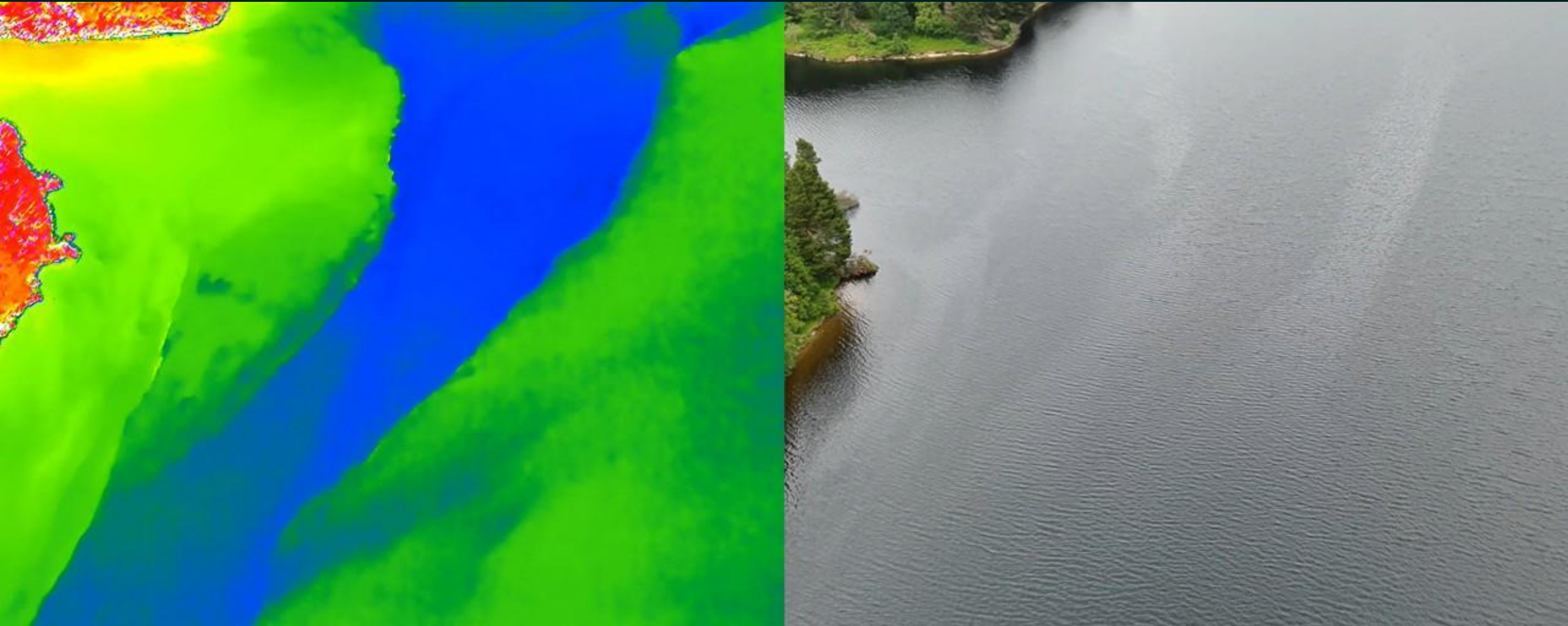
What Nick is most excited
about right now....

Thermaletry

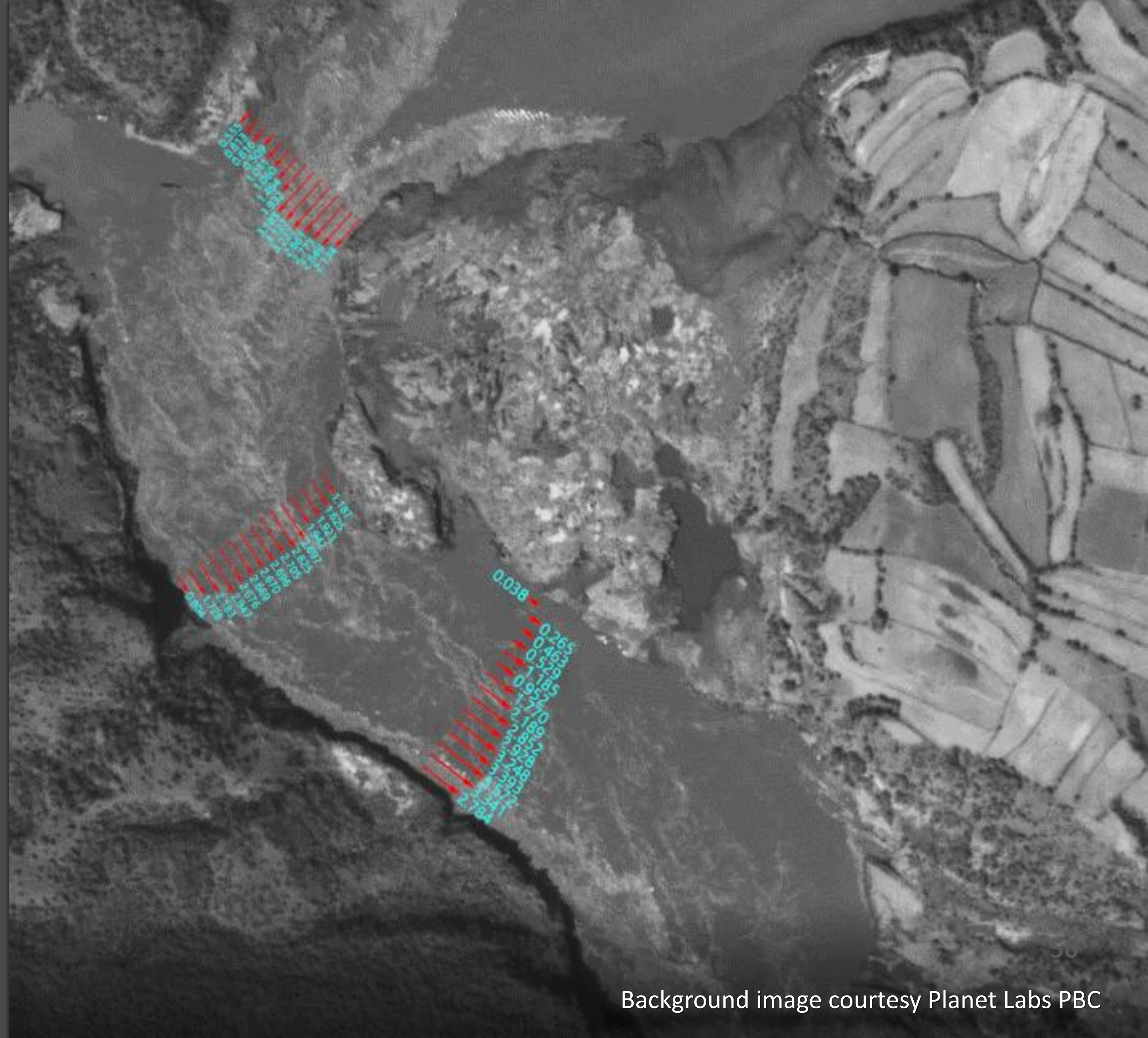
Thermal velocimetry



Reservoir Temperature mapping



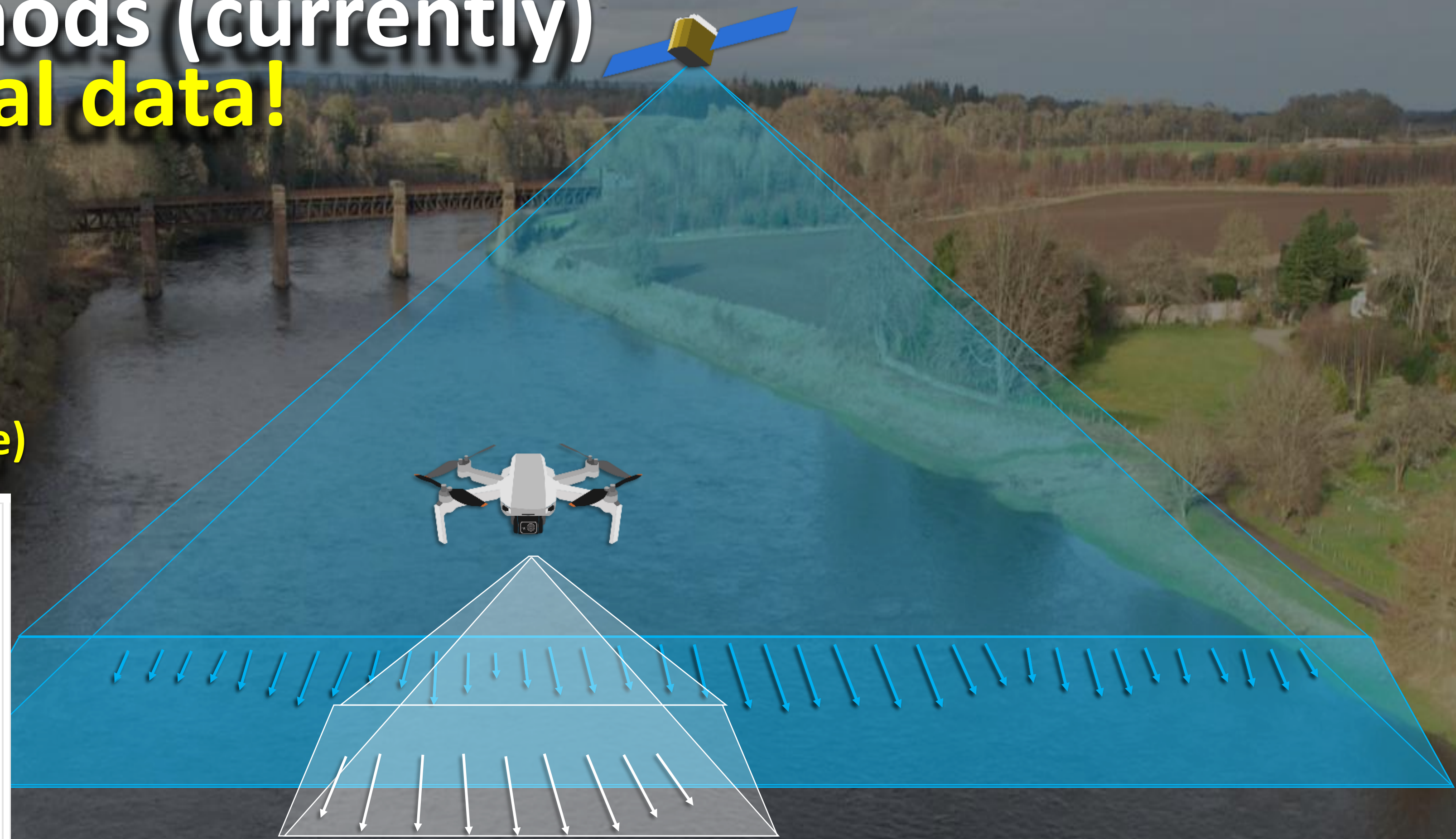
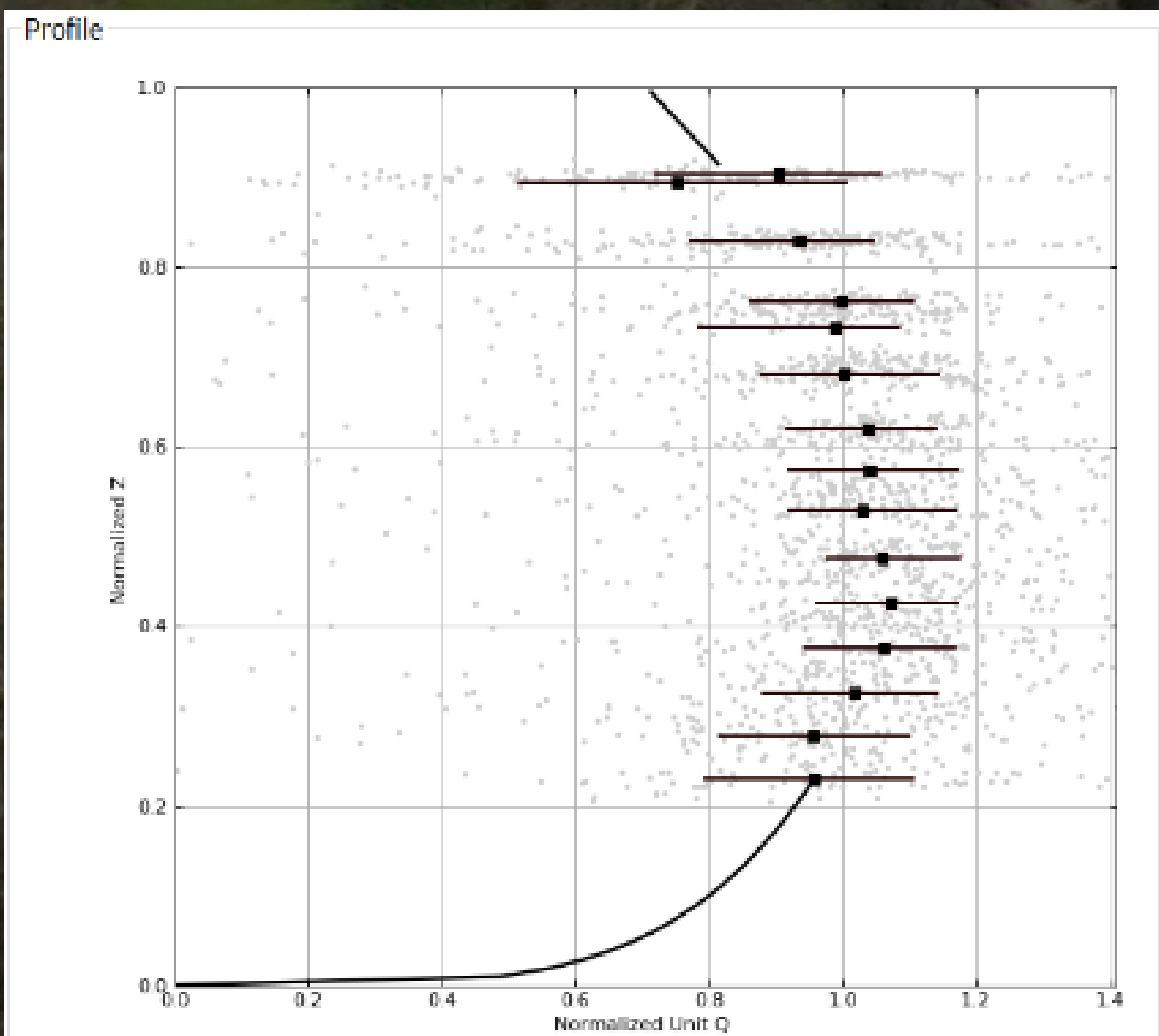
But what's the **flow**?



All these methods (currently) need additional data!

ADCP can provide:

- **Cross-section (vital)**
- **Velocity profile (desirable)**

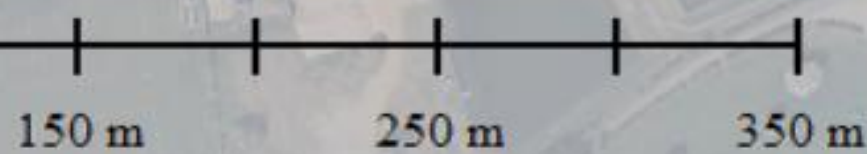


But what if we had

Reach-scale river bathymetry?

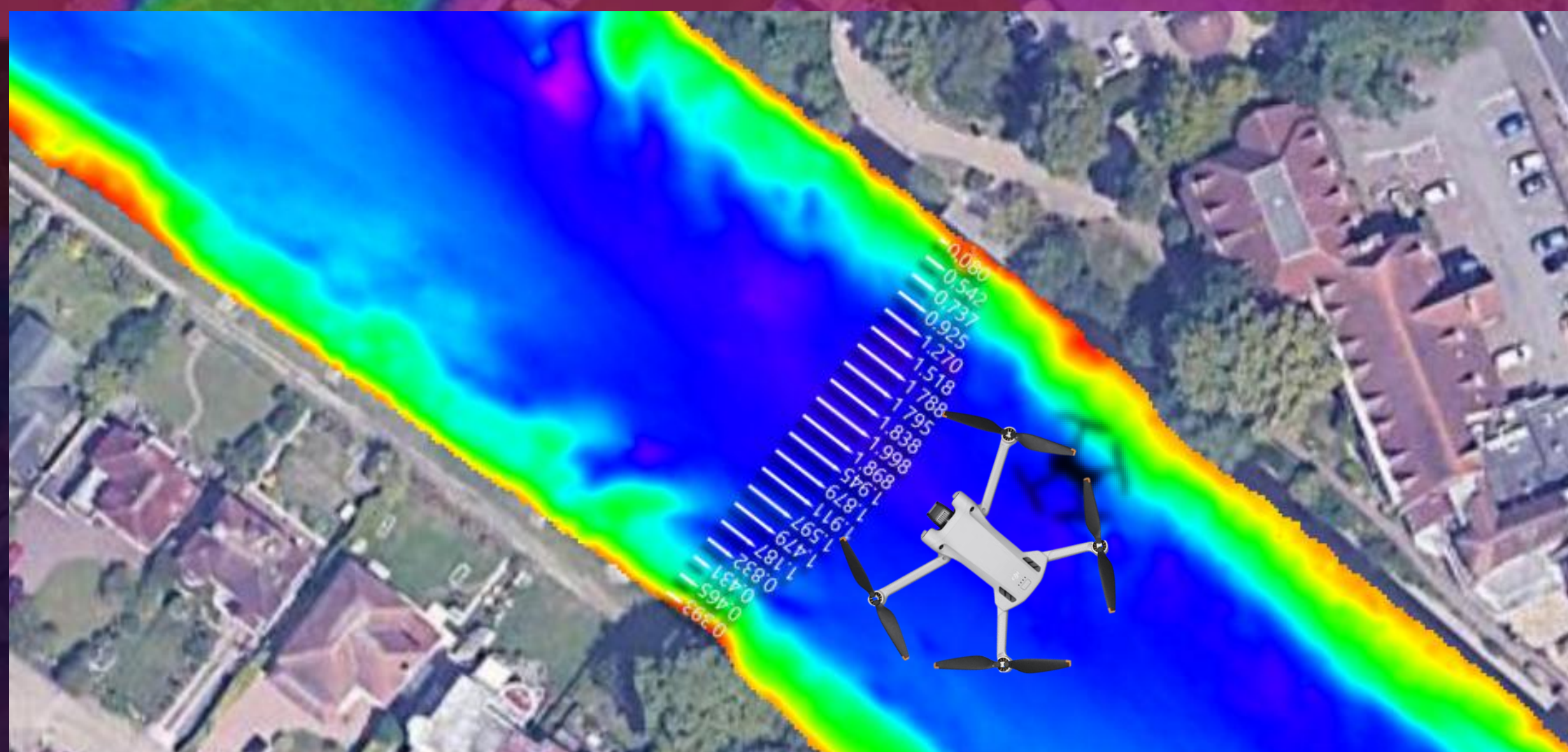
Then we can measure
(almost) **anywhere...!**

Environment Agency **multi-beam bathymetry** and
LiDAR open data



...And what if we also had

LIDAR topography...?



All of England (and Wales!)
Quite a lot of Scotland too!

Environment Agency **multi-beam bathymetry** and **LiDAR** open data

<https://environment.data.gov.uk/survey>

Now we can measure (almost)
anywhere, even when the river
is out of banks!!

Outlook:

Potential for **wholly remotely sensed** river discharge monitoring is close

Huge potential for **data sparse areas** such as Africa, Arctic rivers etc

Very low latency, very **rapid repeat observations** now possible

This is **just the start.**

Questions?



“What you can do with a satellite you can probably do with a drone.”

What you can do with a drone, you can probably do with a satellite.”