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DFG Deutsche Forschungsgemeinschaft
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Universität Potsdam

Climate Data Collection and Analysis Workshop

February 27, 2024

Today's Schedule

Day 2: Designing, Building, and Analyzing Data from Open-Source Sensors

09:30 – 10:00 Moving towards High-Frequency Data

10:00 – 10:30 Potential of Low-Cost Hardware to Improve Environmental Monitoring

10:30 – 10:45 Tea/Coffee Break

10:45 – 11:15 Designing and Building a Low-Cost River Monitoring Station

11:15 – 12:30 Practical Example – Collecting, Transmitting, and Processing High-Frequency Data

12:30 – 13:30 Lunch Break

13:30 – 14:00 Construction of a Low-Cost Weather Station

14:00 – 14:45 Practical Example – Combining Sensor and Satellite Data for Further Analysis

14:45 – 15:00 Tea/Coffee Break

15:00 – 15:45 Research Outlook and Practical Applications in Nepal

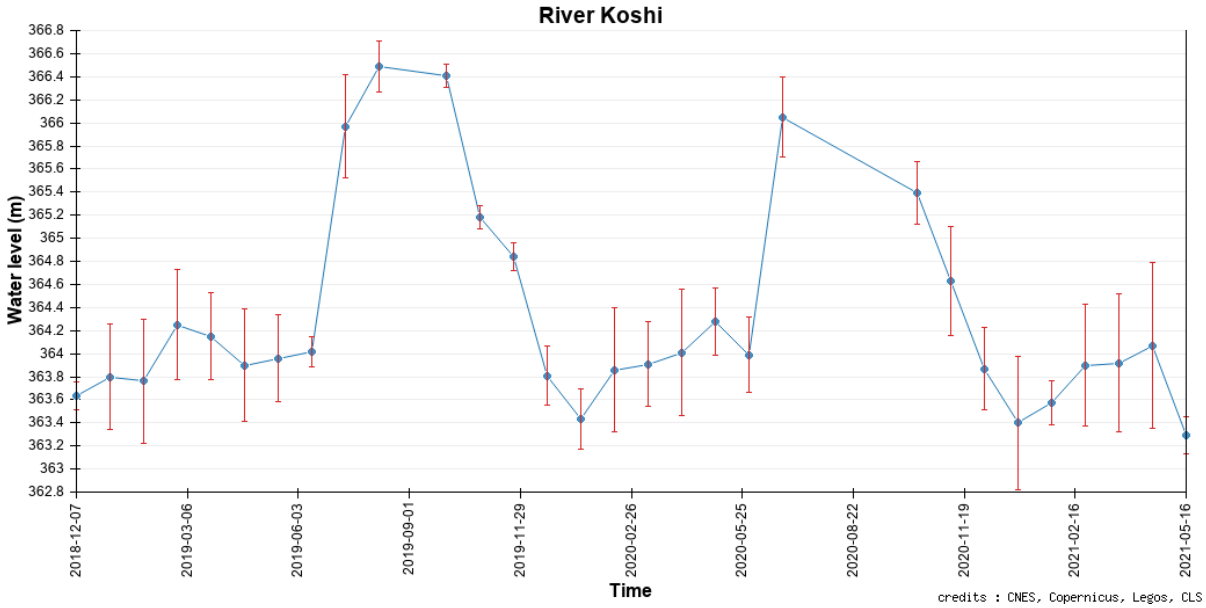
15:45 – 16:00 Wrap Up and Further Resources

Monitoring Alpine Rivers

Alpine rivers are a key source of water, nutrients, and power for a vast number of people

In some cases, it is possible to monitor them from space. However, many rivers are much too narrow to be observed well

The frequency of satellite data is often not sufficient to measure changes in alpine rivers



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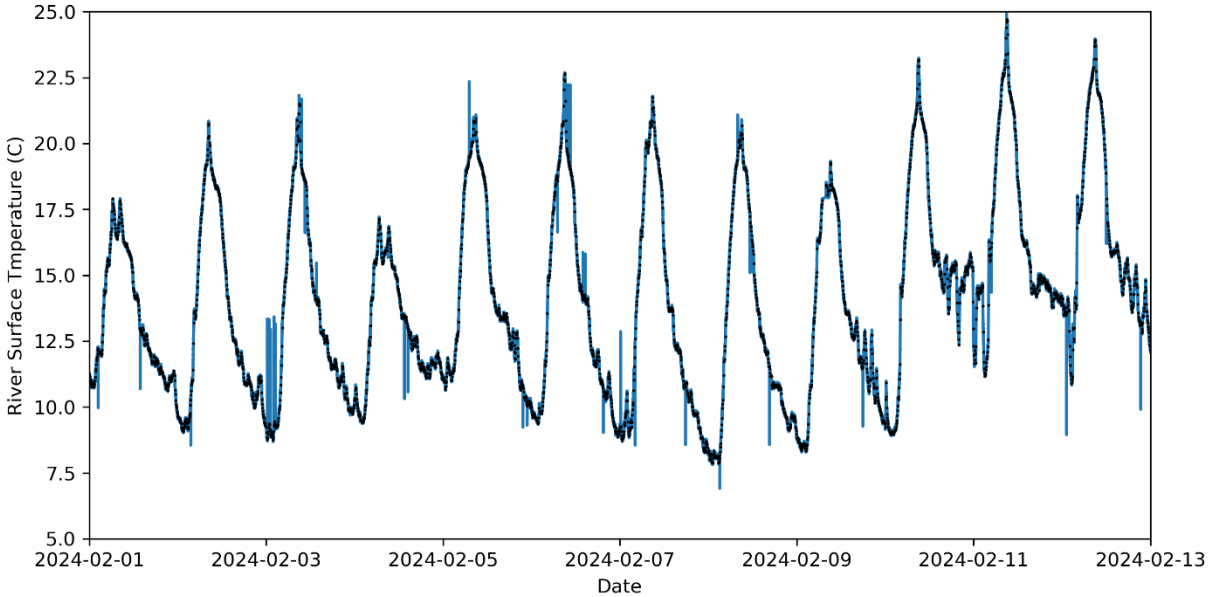

Goal: Monitor Dynamic Rivers

The first iteration of the river monitoring setup aimed to measure:

- 1. River Height
- 2. River Images
- 3. River Temperature

The second iteration has added the additional parameter of sediment flux

A further key aim was to use only open-source and off-the-shelf hardware, so that the sensors could be built by anyone using available components!

River Heights

Arduino-based GNSS (Global Navigation Satellite System, e.g. GPS) can be used to estimate the height of flat surfaces such as water

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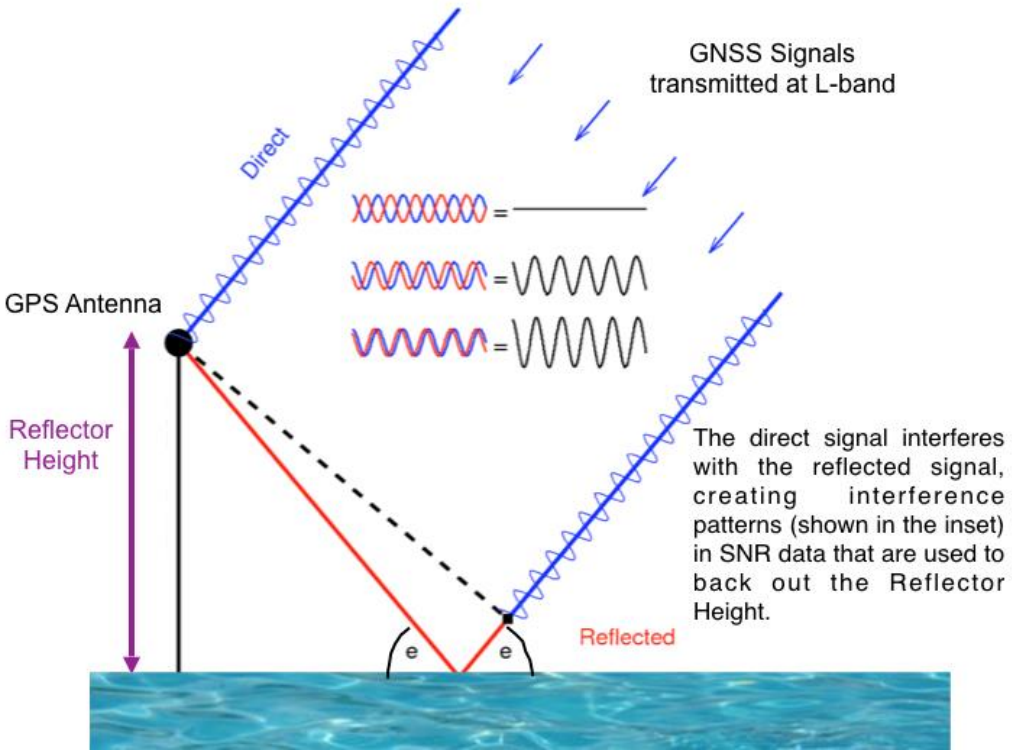
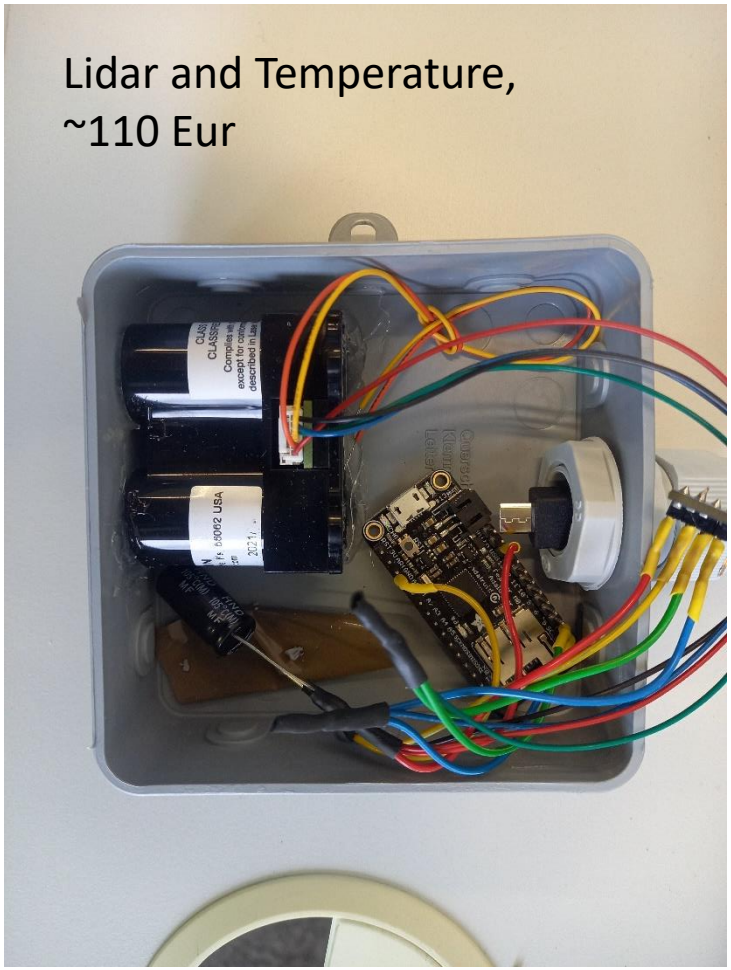


Via: https://gnss-reflections.org/overview

River Heights

An additional sensor based on LIDAR (Light Detection and Ranging) was also used for higher-frequency measurements

This was also based upon the Arduino platform, and also includes ambient air temperature measurements



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This was also based upon the Arduino platform, and also includes ambient air temperature measurements

Lidar, Camera, Temperature ~140 Eur

Image Capture

Any USB camera or webcam would work for this purpose

We use the Raspberry Pi Camera module (~20 Eur)

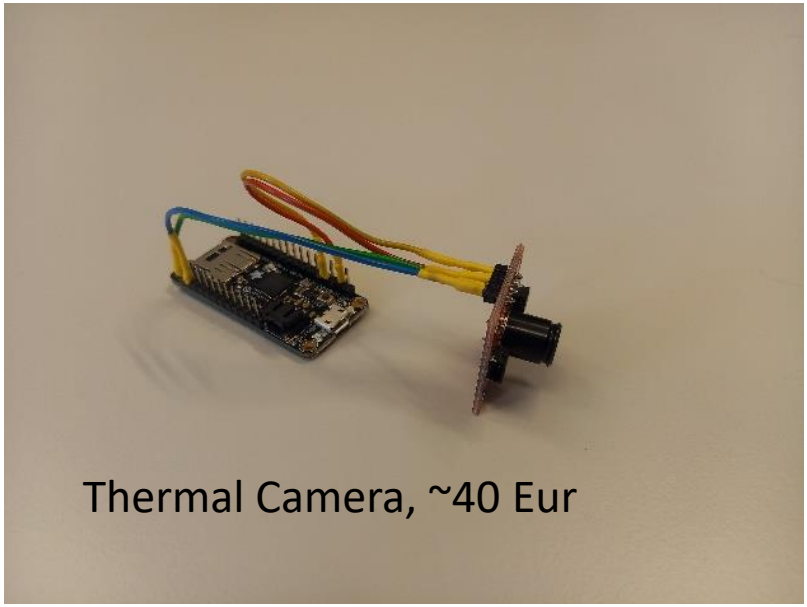
Data is captured at multiple resolutions to trade off between data quality and how much data needs to be transmitted

Via: https://www.raspberrypi.com/products/camera-module-v2/

River Temperature

River temperature is a key parameter which follows nutrient content, dissolved oxygen, and other markers of water quality

It can also be used to track when different water sources mix (e.g., cold snowmelt and warmer rainfall)



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Infrared Laser, ~15 Eur

Via: https://www.melexis.com/en/product/MLX90614/Digital-Plug-Play-Infrared-Thermometer-TO-Can

Sensor Installation

Sensors are installed in weatherproof boxes and mounted facing the river

The exact location depends mostly on what is accessible, and where there is power

Data is transmitted using a SIM Wifi Dongle

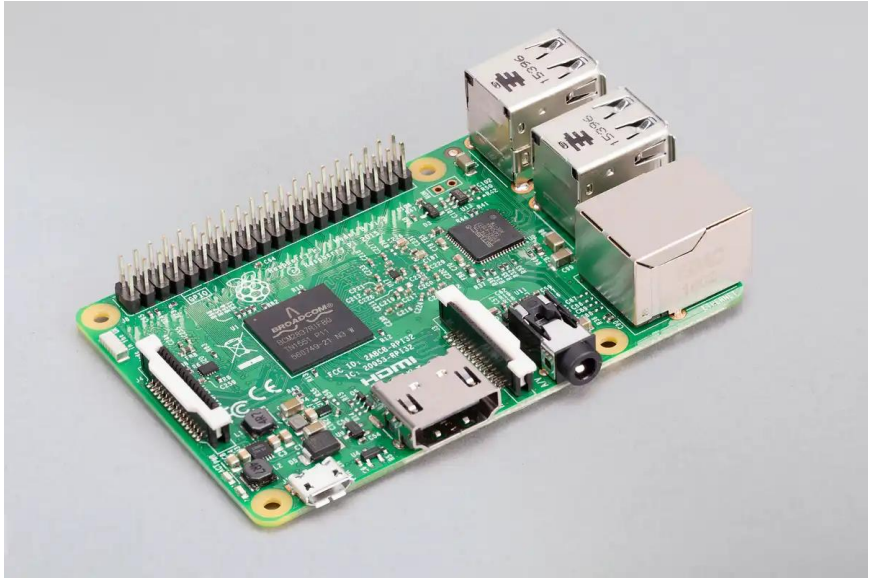
Data Integration

The Raspberry Pi platform is used to gather data from the sensors and transmit it onwards

These are low-cost and low-power computers that can receive data via USB and compress it for transmission

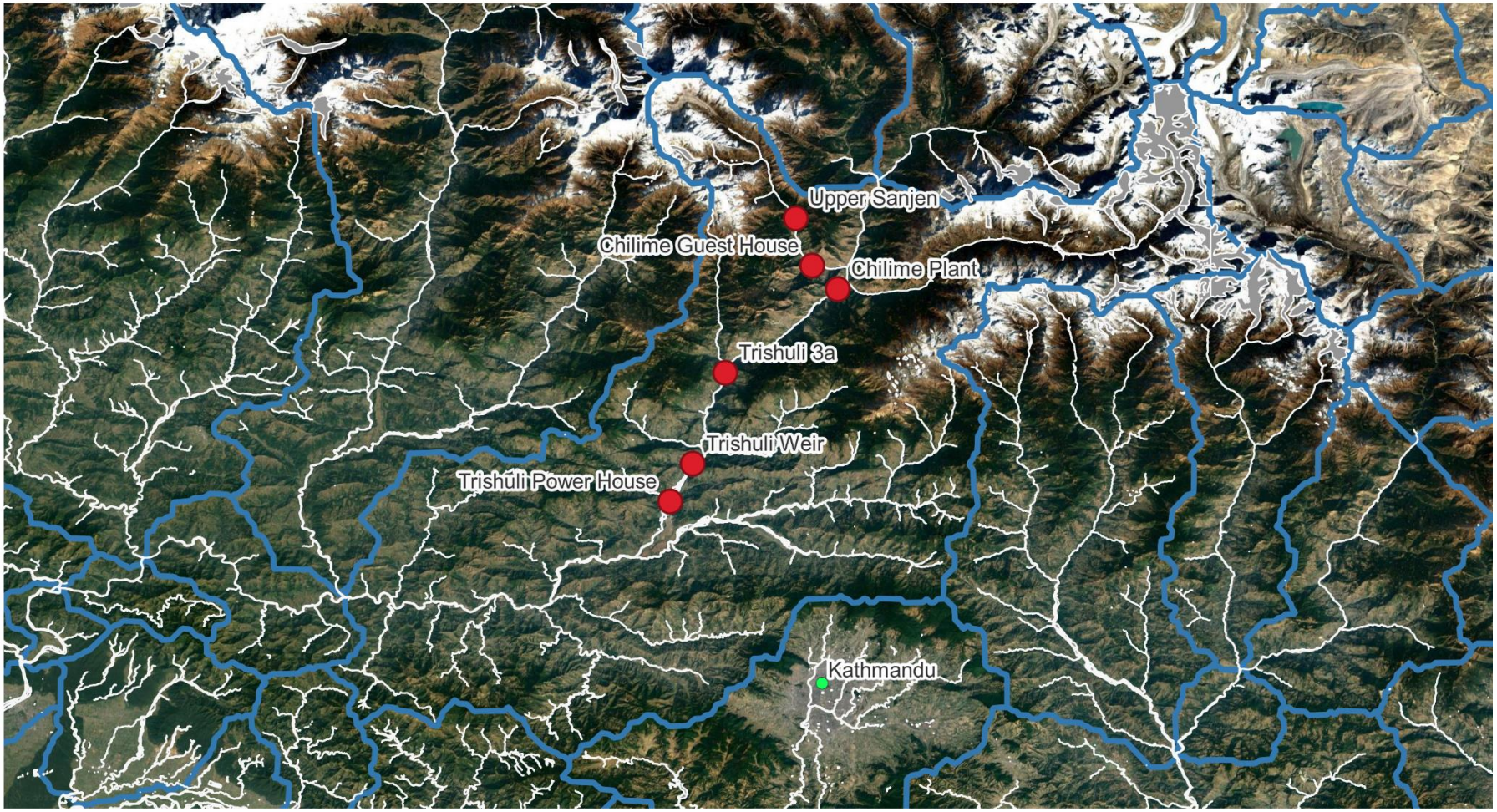
We used the Python programming language to capture all of the data

Linux commands were used to transmit the data

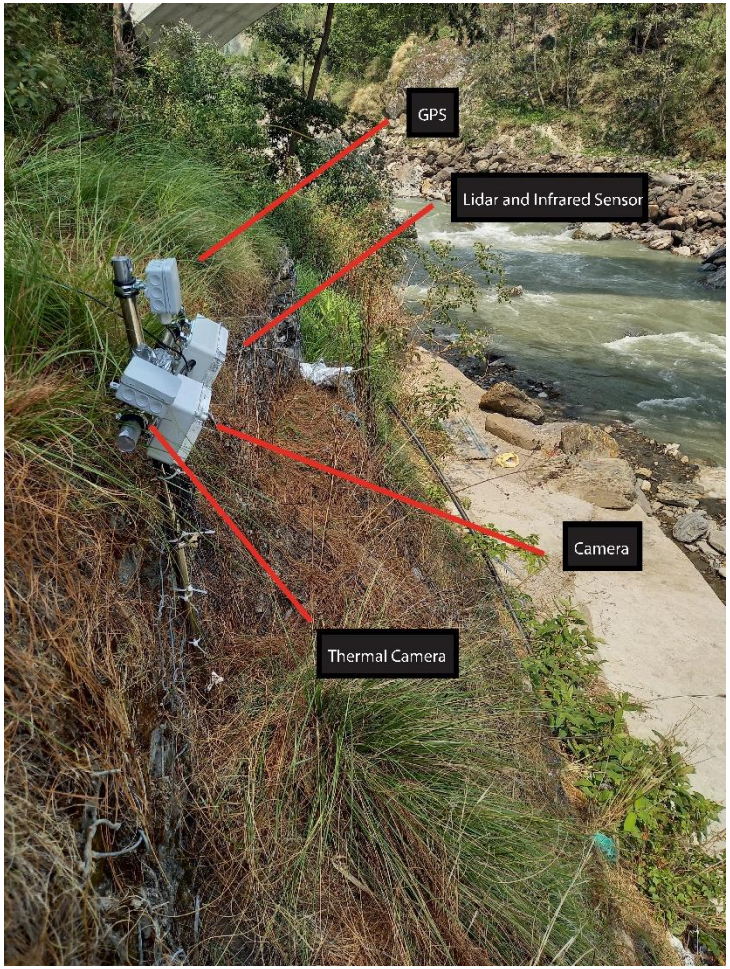


Via: https://www.raspberrypi.com/products/raspberry-pi-3-model-b/

Station Locations – May 2023



Sensor Setup



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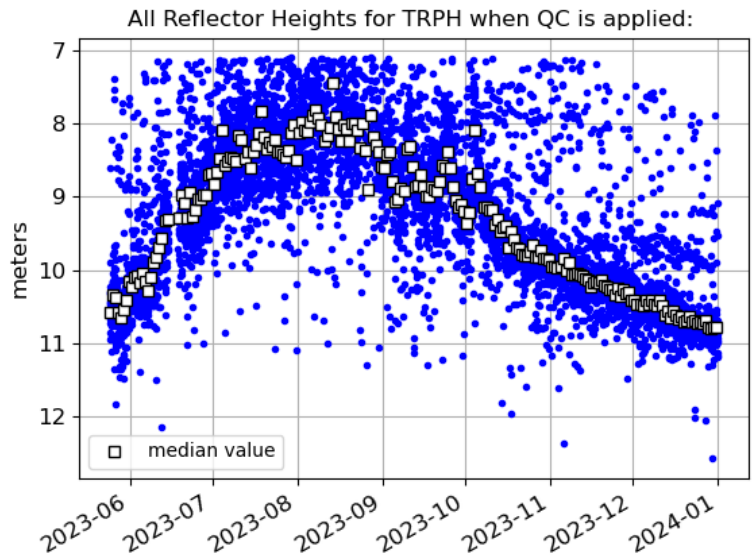
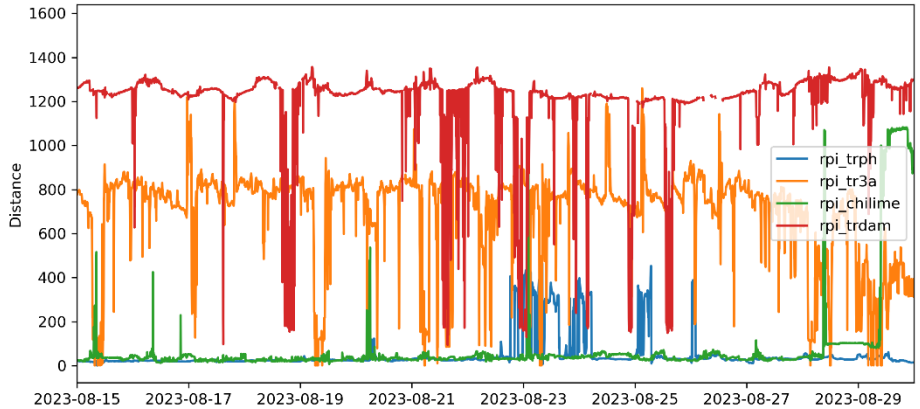
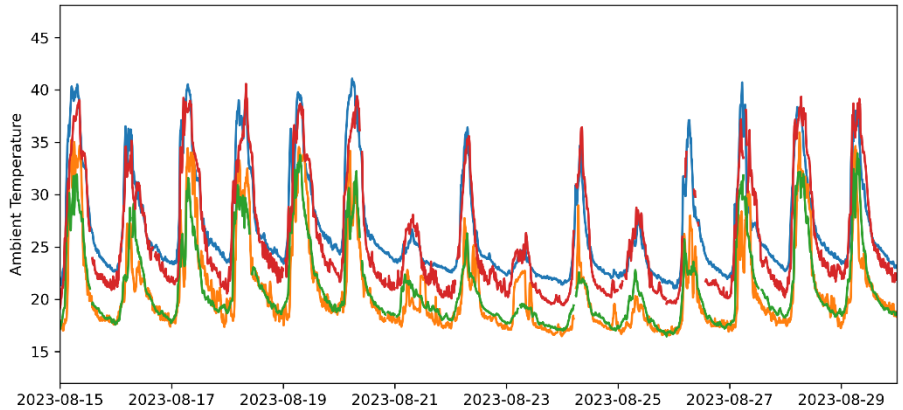






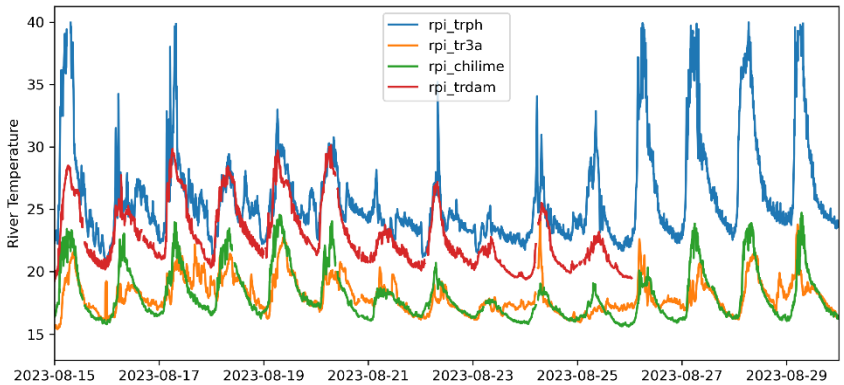
GNSS data is reliable and easy to use in open areas, but does not do well in steep valleys

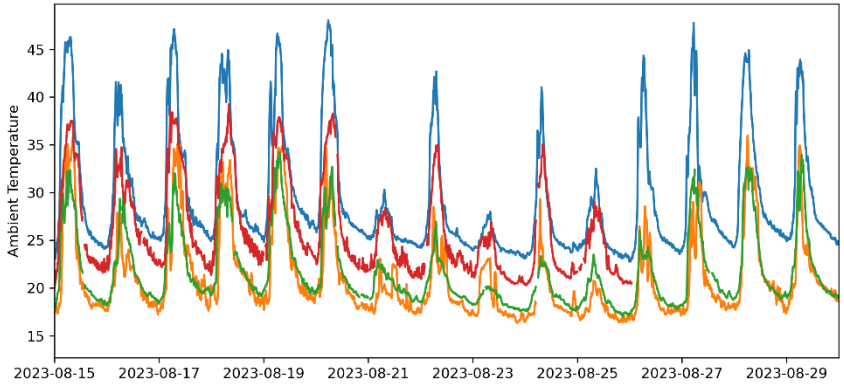
Lidar data works if you have a clear and vertical view of the river

Temperature Data

Each station collect 1-minute temperature data from either an IR single-pixel sensor or a thermal camera (or both!)

This gives us a MUCH more detailed view of fluctuations in river temperature over very short time scales





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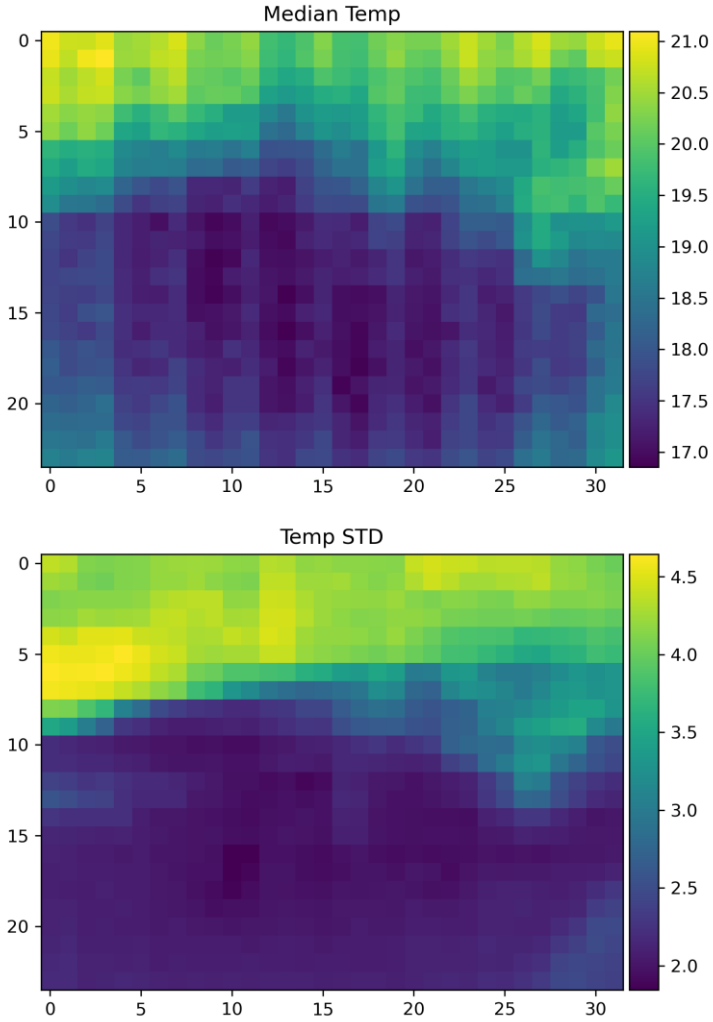
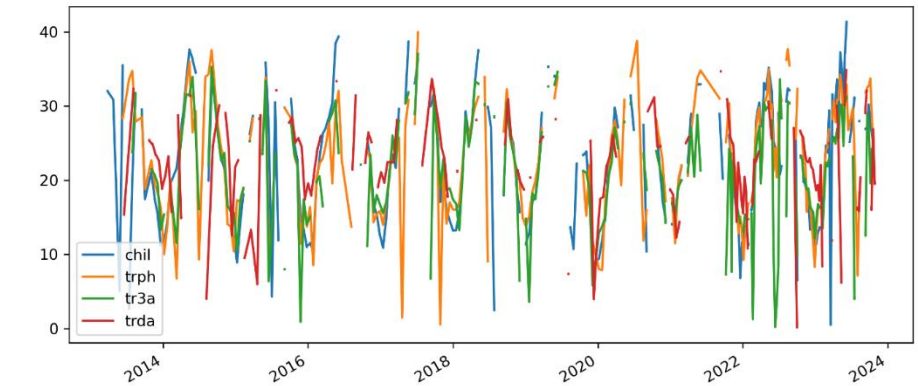
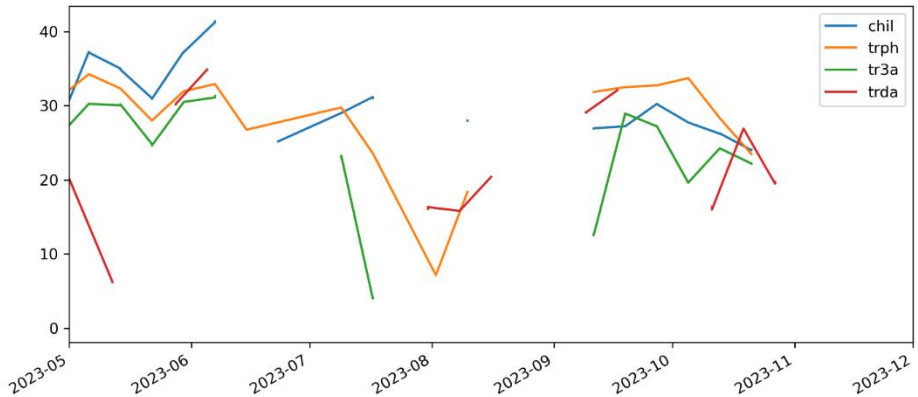


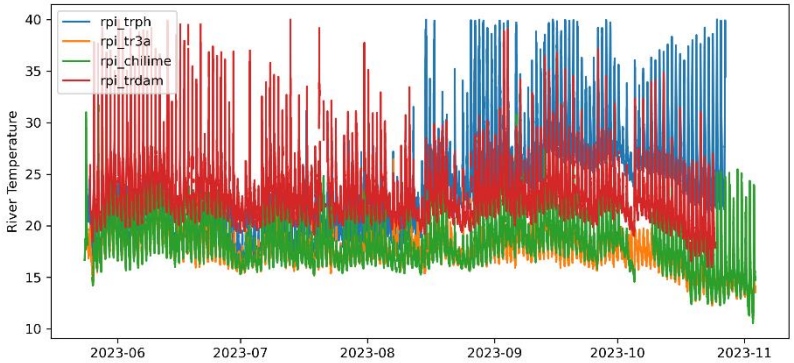
Temperature Data

Landsat, single pixel time series





In-Situ Data



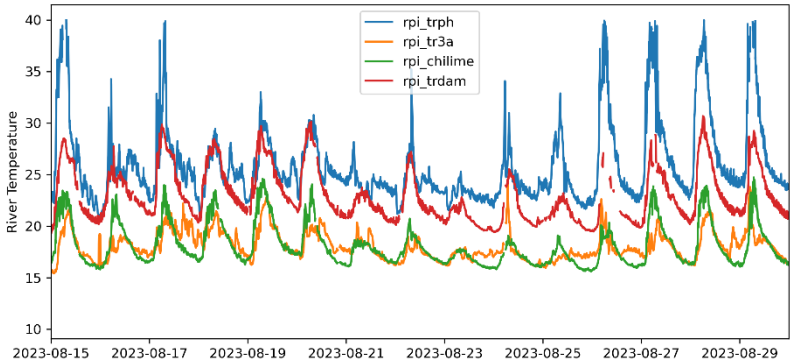


Image Data

Image Data

May 2023

August 2023

Video Data

Image Data

- **Bank-width changes**
- **Water color (sediment flux?)**
- **Pixel tracking – flow velocity**

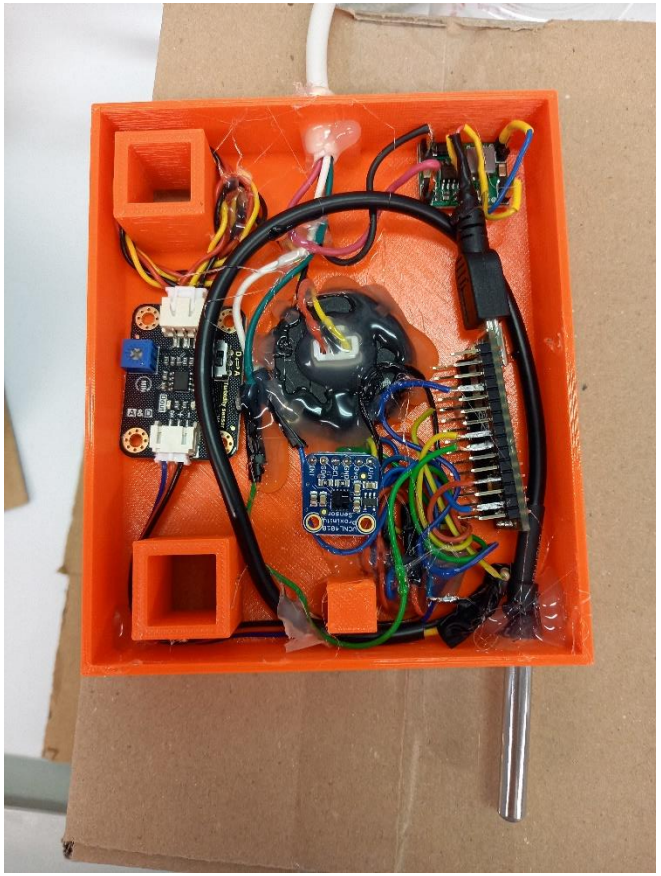
Sediment Flux

Sediment flux is a key geomorphic parameter

It also has strong impacts on hydropower, irrigation, and water quality

It can also be a marker of an upstream landslide

Sediment Flux

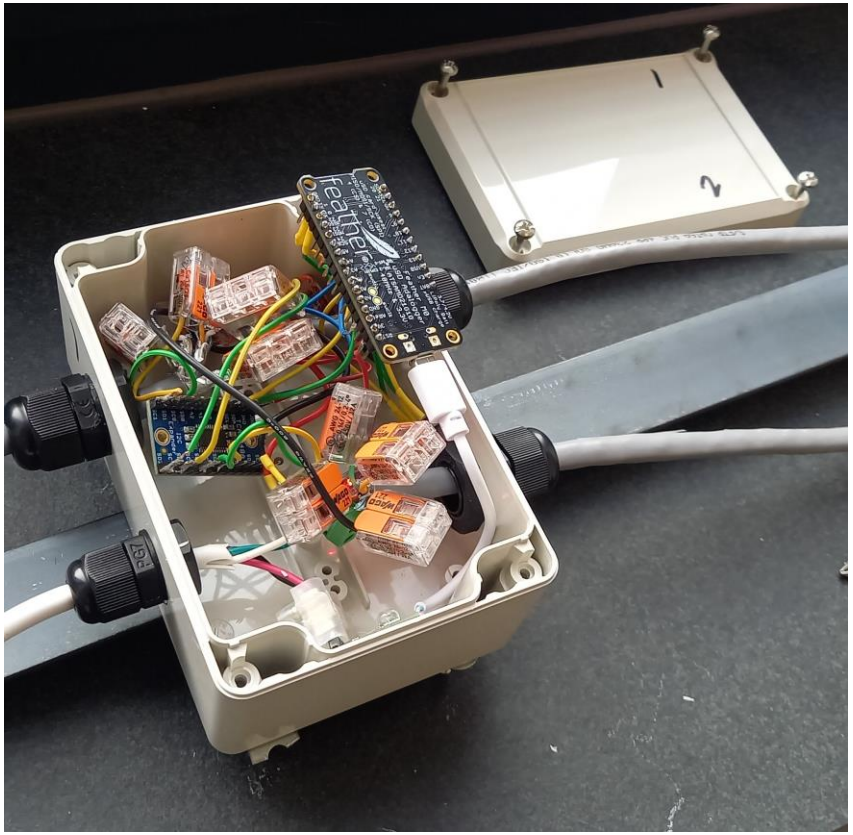


Total cost ~50 Eur

Sediment flux/turbidity can be measured by transmission/reflections at specific wavelengths, especially infrared

We again based our prototype on the Arduino Platform

Sediment Flux



Total cost ~100 Eur

Sediment flux/turbidity can be measured by transmission/reflections at specific wavelengths, especially infrared

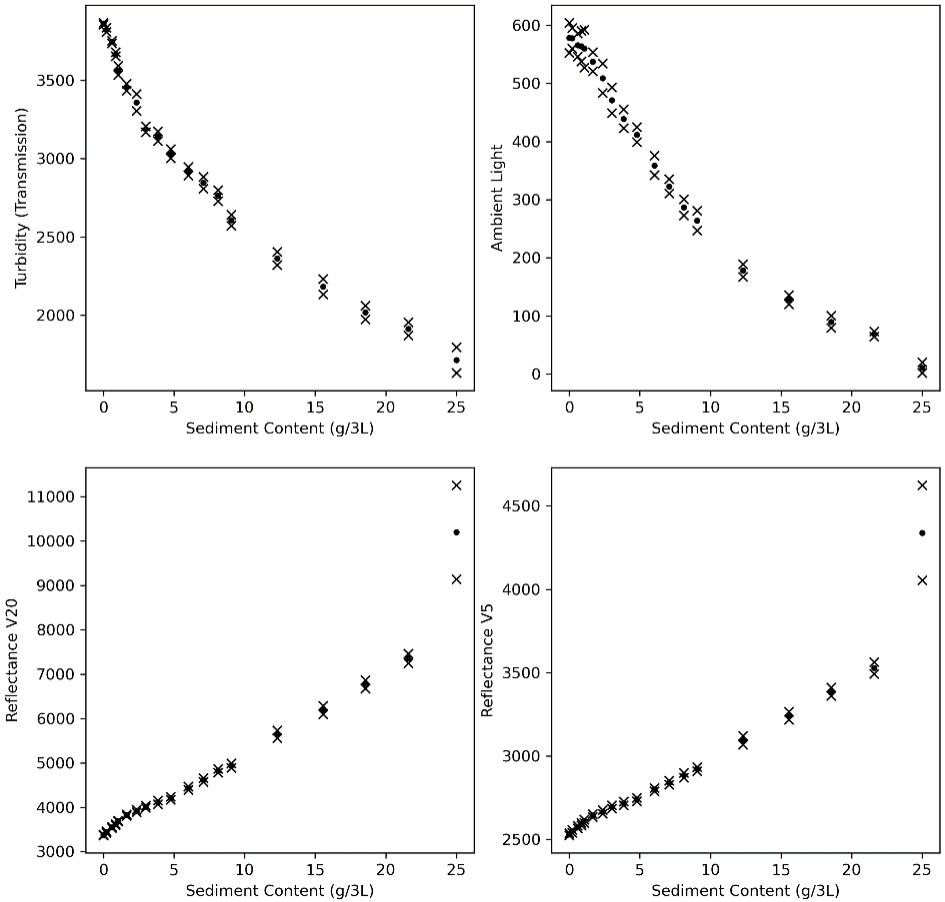
We again based our prototype on the Arduino Platform

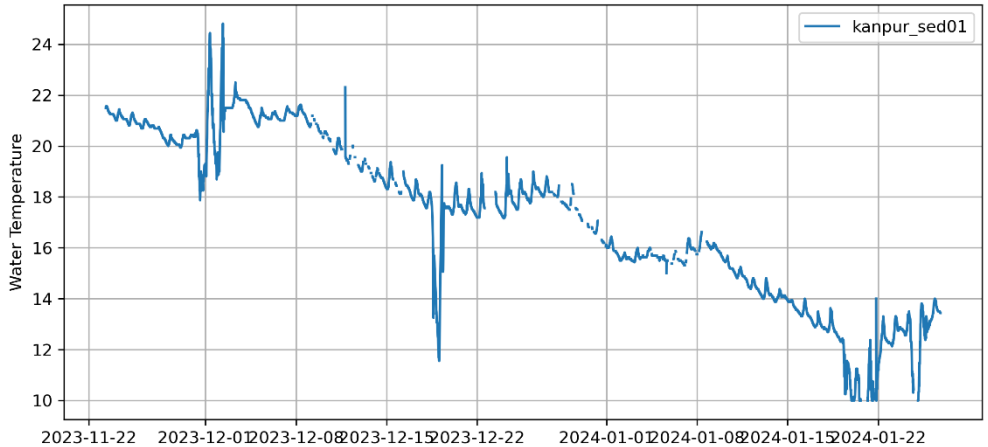
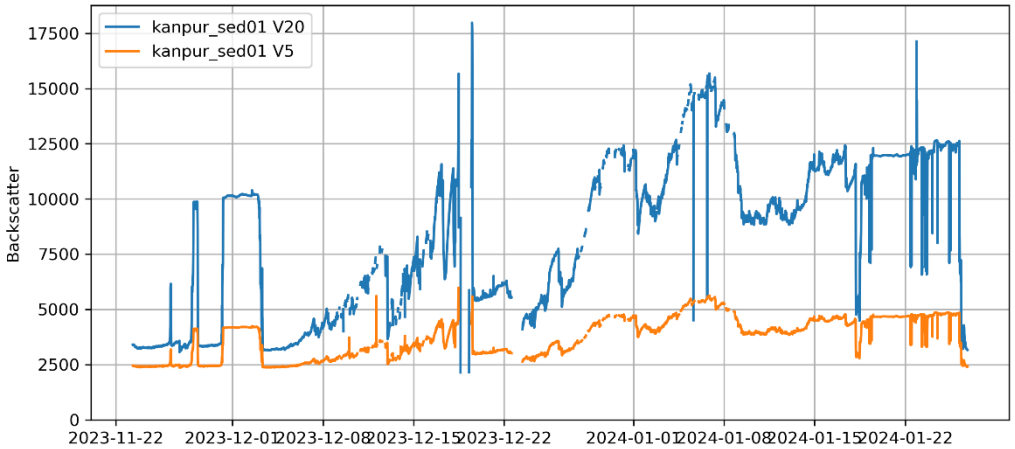
Version 2.0 also measures water depth

Sediment Flux

Received data correlate very strongly with sediment content

Sediment content can be measured with reflected or transmitted IR radiation



Test Location – Ganges Barrage

Sediment Flux – First Results