FACULTY OF GEOGRAPHY
Lomonosov Moscow State University

Online Young Scientist School (YSS) MEGAPOLIS 2021

UNIVERSITY OF HELSINKI

Multi Scales and Processes Integrated Modelling, Observations and Assessments for Environmental Applications

L21. Meteorological and hydrological measurements

Pt. 2. Hydrological measurements

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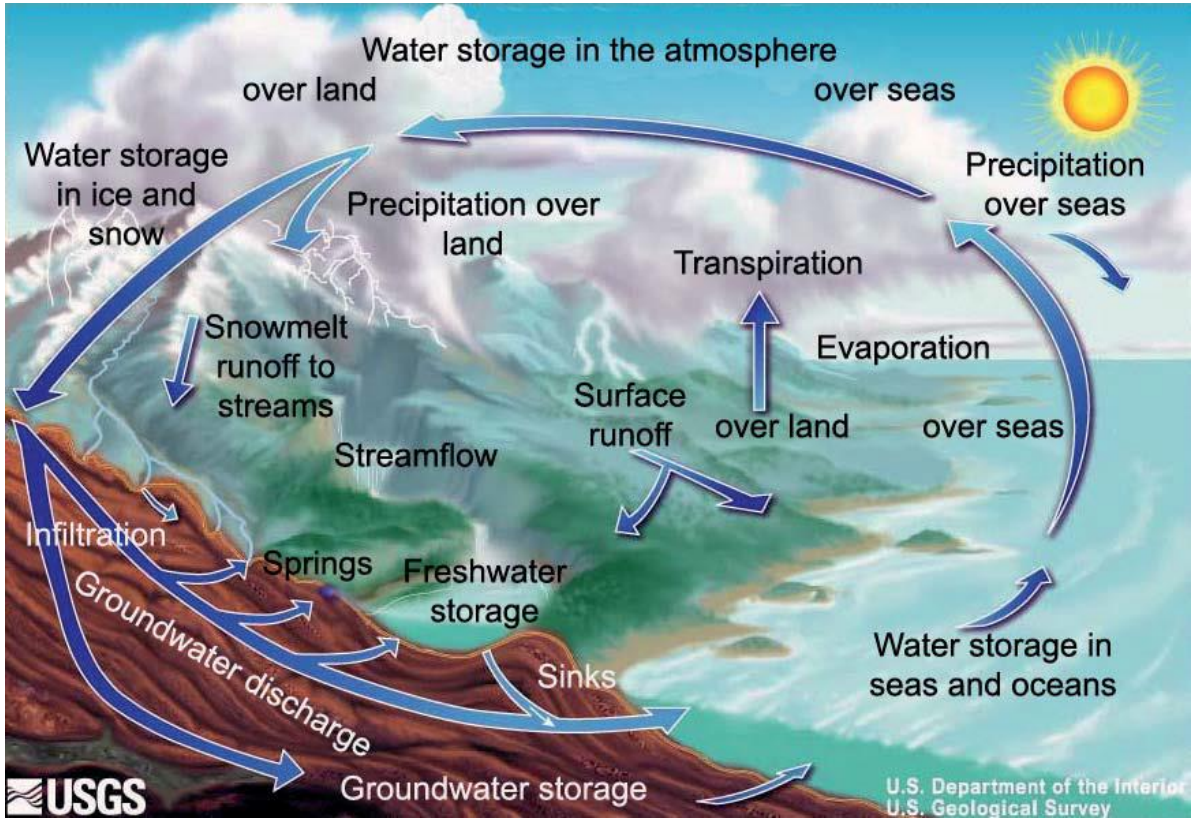
Department of Land Hydrology
Faculty of Geography
LMSU, researcher

November 19, Moscow, Russia

Hydrology

Hydrology is the study of water. In terms of measurements, hydrology refers to the physical movement of water, including changes in water level, flow, and other dynamic processes



https://public.wmo.int/en/our-mandate/water

Hydrology and meteorology have symbiotic relationship

Water stress

Water-related hazards

Water quality

The impact of climate change through water

Why hydrological measurements?

Purposes and requirements

Planning - Construction

Design - How high…? Where do we need…?)

Management (When to start…?)

Research – processes, interaction, changes

Planning – time series (large time scale)

Design - time series (small time scale)

Management – real time data, forecast

Research – high quality data

Hydrosphere measurements:

Groundwater, Infiltration and Retention

Sediment Transport and Deposition

Streamflow

Waves, Tides and Currents

https://ocw.tudelft.nl/
https://www.fondriest.com/

Developing Data

Data (raw)	Data analysis	Data implementation
• Data Collection • Data Storage and Retrieval • Dissemination of data	• Correlation theory • Assessment of errors and uncertainties • Statistical analysis – trends etc.	• Water Resources Assessment • Hydrological Predictions and Forecasting • Management and Warning

Gauging network principles

1. Spatial distribution and density

   (to reflect different natural conditions)

2. Representative measurements on the stations

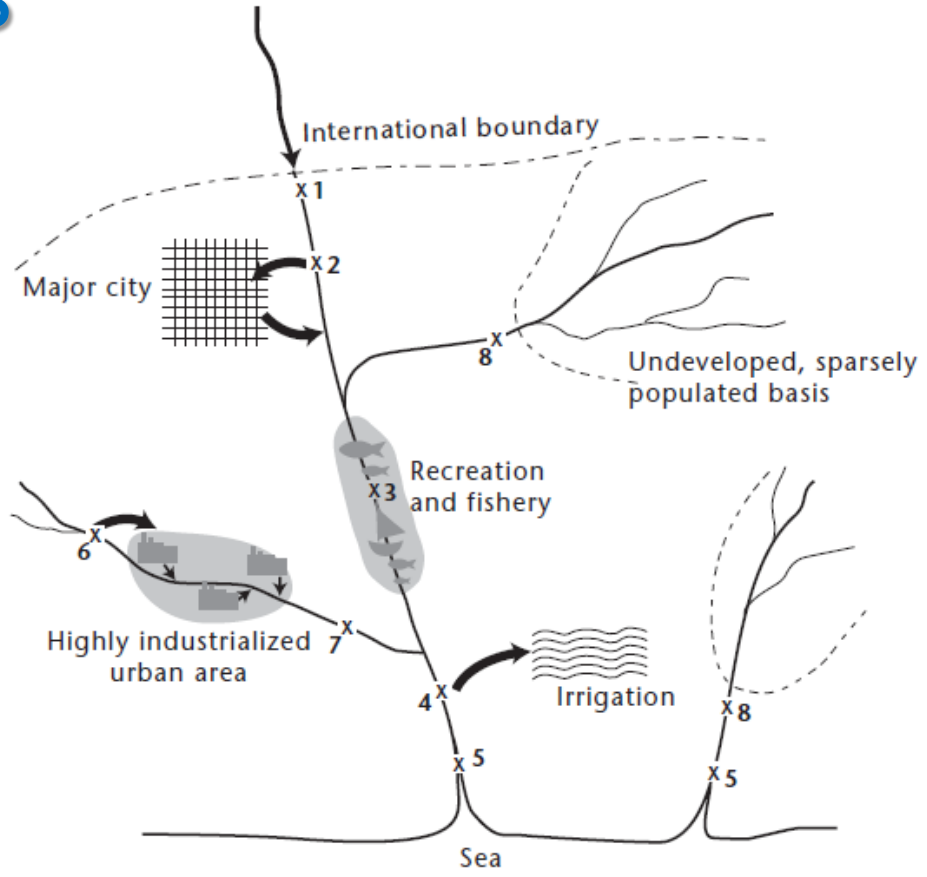
   (to describe distinctive water characteristics)

3. Accuracy

   (adequate to scientific and economic needs)

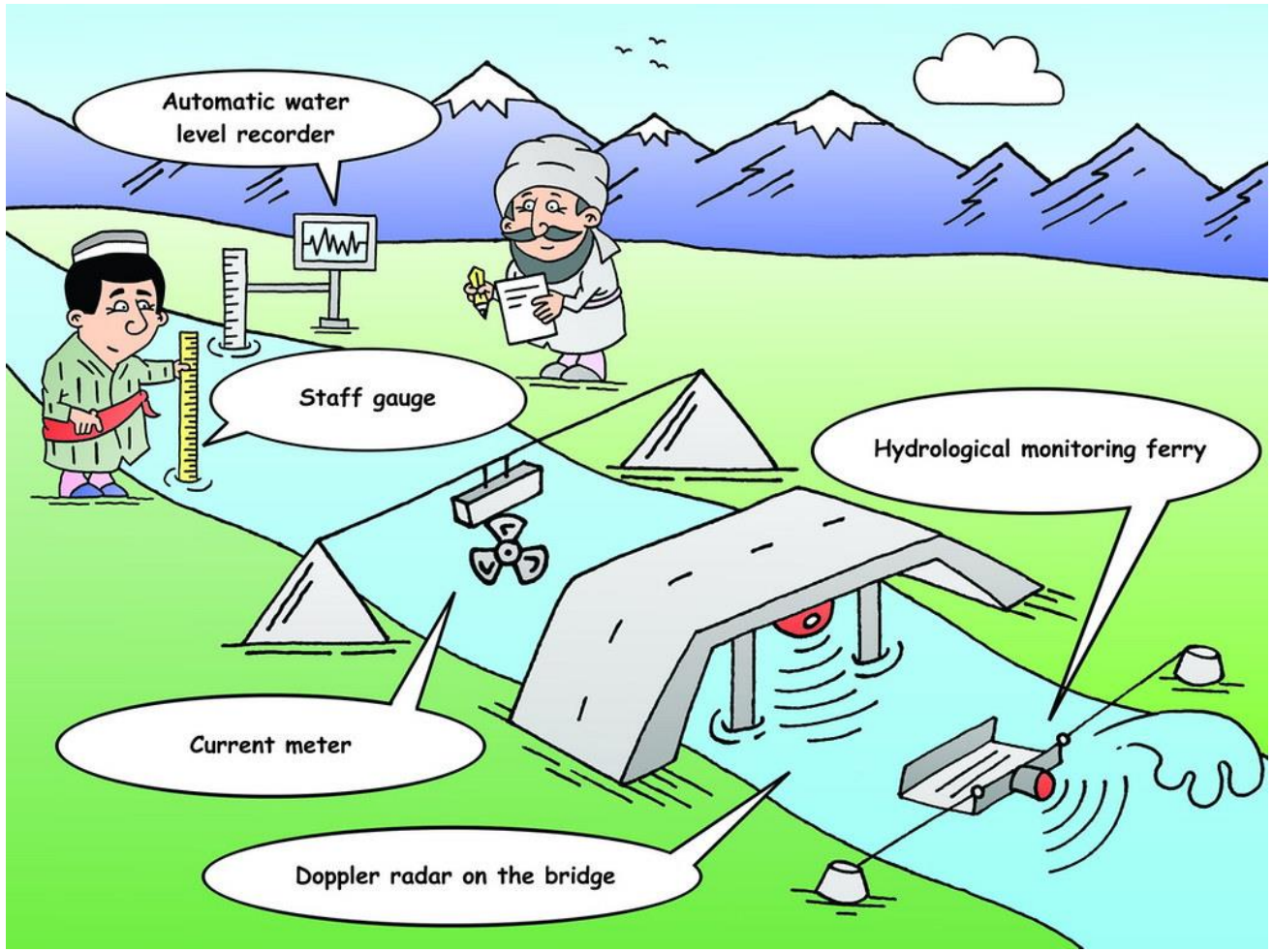
4. Water use plan

5. Limited funding



1	Immediately downstream of an international boundary	5	Freshwater tidal limit of major river
2	Diversion for public supply of large town	6	Diversion for large industrial supply
3	Important fishing, recreation and amenity zone	7	Downstream of industrial effluent discharges and important tributary influencing main river
4	Diversion for large-scale agricultural irrigation	8	Baseline station, water in natural state

Streamflow gauging



Water bodies monitoring:

Water level (stage)

Water discharge and velocity

Temperature

Sediment transport

Ice regime

Water quality

Hydro morphological monitoring

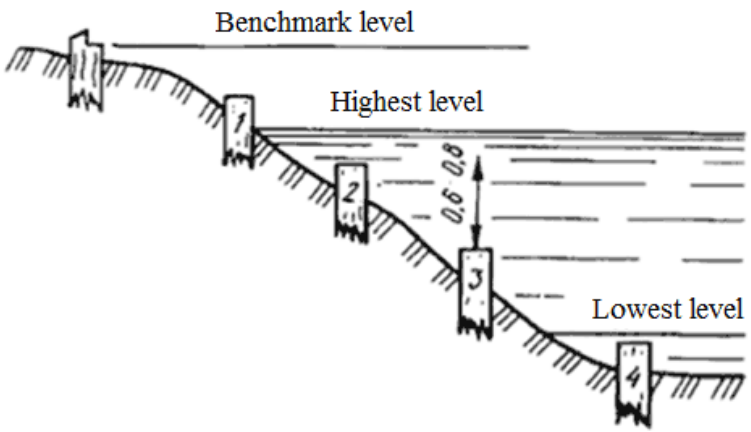
Hydrological situation

Water level gauge types

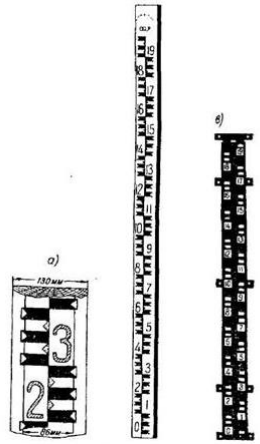
Water level, also known as **gauge height** or **stage**, is the elevation of the free surface of the water body relative to a specified vertical datum

Piled gauge

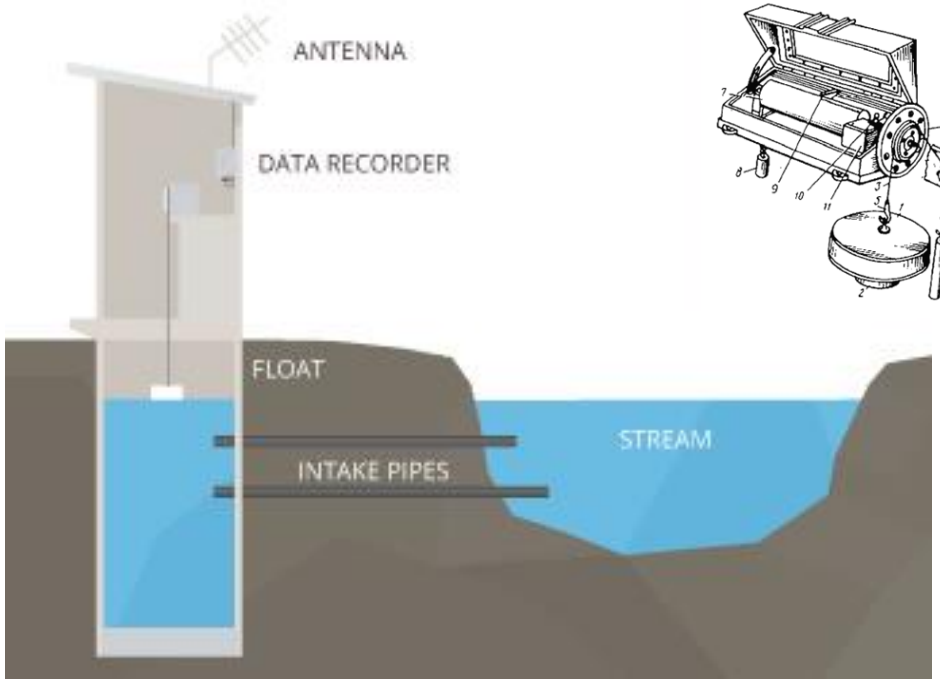
long steep slopes, high level fluctuations



Rack based (Staff gauge) – embankments, low level fluctuations



Water-level gauges with recorders (limnographs)



Water measurement tower with float and wheel register “Valday” limnograph

Automatic water level gage types

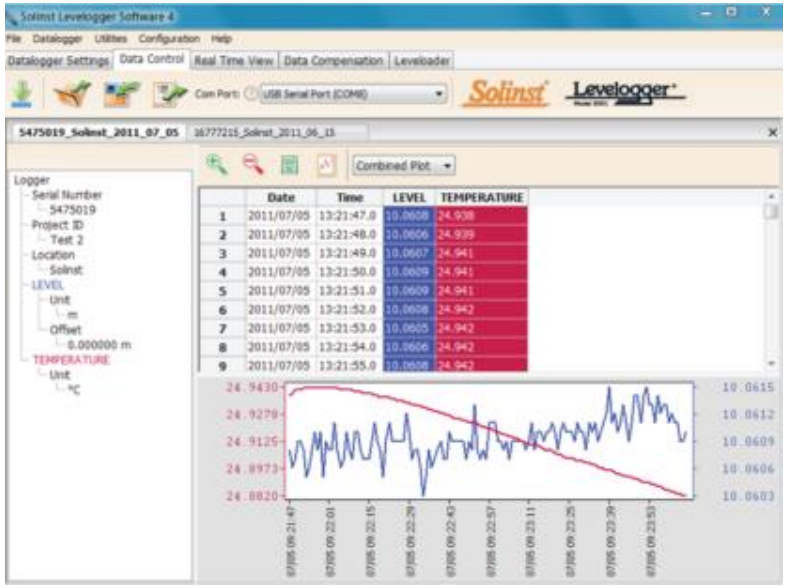
Measuring principles

- Optic
- Pressure
- Radiolocation

Automatic water level gauges

- Autonomous (internal storage)
- Wired with barometric correction
- GSM or WiFi => Cloud storage

EMERCIT equipment
(flood protection)



Raw data: total pressure (water+atm.
and temperature (Solinst interface)

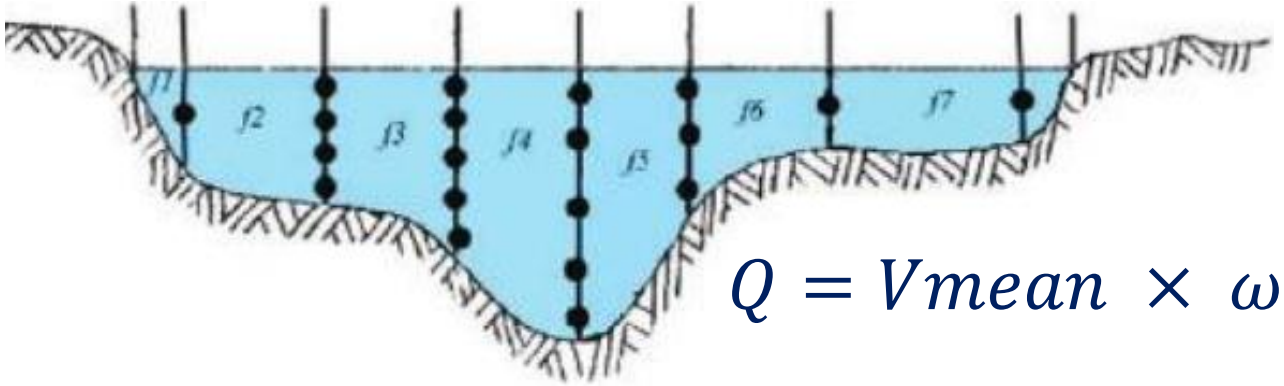
Problems: Theft, Vandalism

Measurement of discharge with current meters

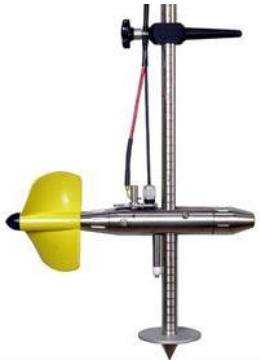
Equipment measuring water velocity in the only point

Russian current meter ISP-1M

Soviet c.m. GR-21



$$Q = Vmean \times \omega$$



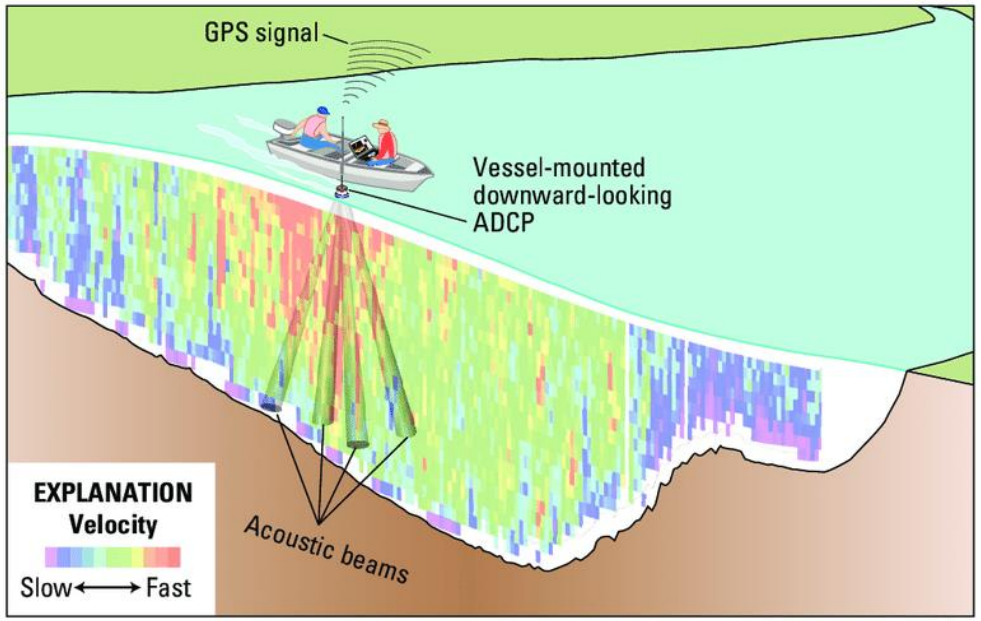
Ott, Seba and Valeport propeller current meters

Discharge measuring with the boat, winch6 depth counter and weight. Oka river, Russia

Ott Acoustic and electromagnetic current meters with real-time discharge calculation

Measurement of discharge with ADCP

ADCP - Acoustic Doppler Current Profiler
RD Instruments (Teledyne) USA

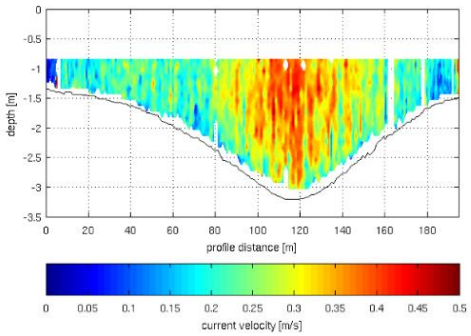


Scheme by Mueller D. S. et al. Measuring discharge with acoustic Doppler current profilers from a moving boat. – Reston, Virginia (EUA) : US Department of the Interior, US Geological Survey, 2009

Flow characteristics and distribution:

- Velocity magnitude and direction
- Backscatter intensity
- Discharge
- 3 scales – transect, ensemble, cell

Etc.



ADCP with the float

Volga river, Russia

Measurements in winter

Difficulties

Solid precipitation (accumulation)

Snow cover

Ice covered water surface

Elements of ice regime

Ice cover ratio

Thickness of ice

Features of ice destruction

Dates of ice formation, shifting and break-up

etc.

ADCP in the hole,
Onega estuary, Northern Russia

Snow surveys

Snow depth

Snow water equivalent

Purpose

Spring flood forecast

Water balance assessment

Pollution analysis etc.

Measurement data – the basis for modeling

HYDROLOGIC MODELING

Required:

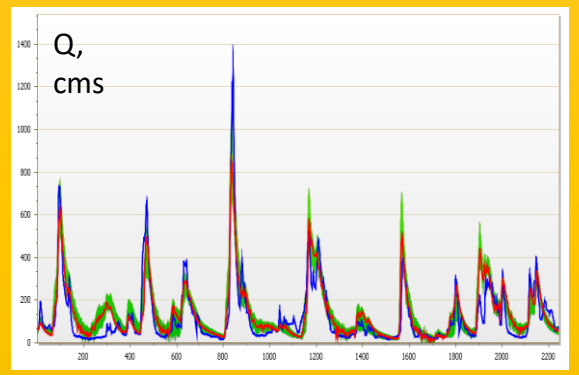
River discharge time series

Meteorological data

Watershed data (dem, lulc)

Example: Western Dvina basin, SWAT model

DOI: 10.3389/feart.2019.00241

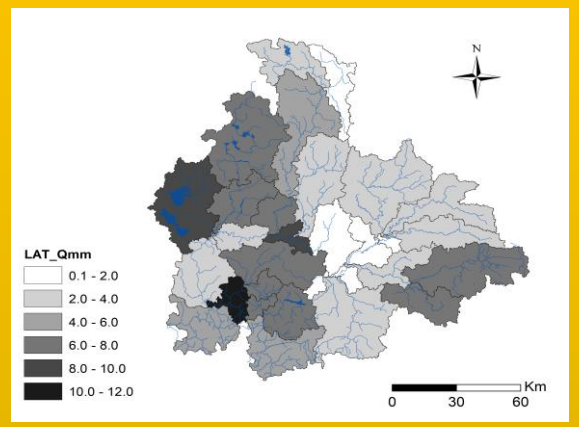


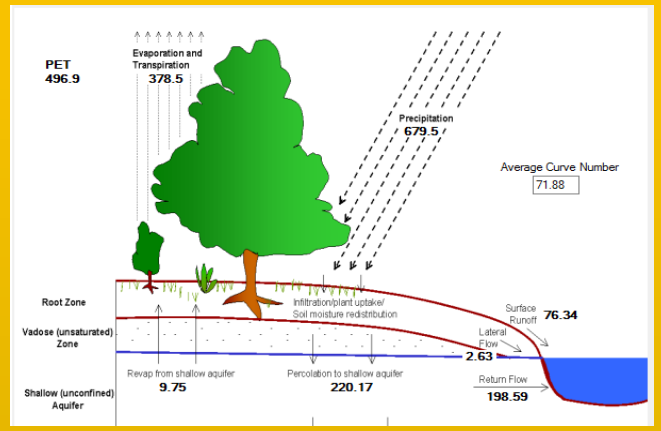
Results:

Simulated time series

Water balance elements

Hydrological consequences of climate change





HYDRAULIC MODELING

Required:

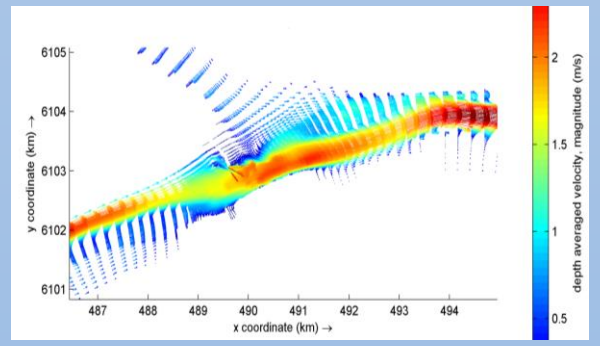
Discharge and level data

Morphometric data

Meteorological data (optional)

Example: Oka river, DELFT3D, Volga river (erosion) MIKE 21

DOI: 10.1051/e3sconf/202016301012

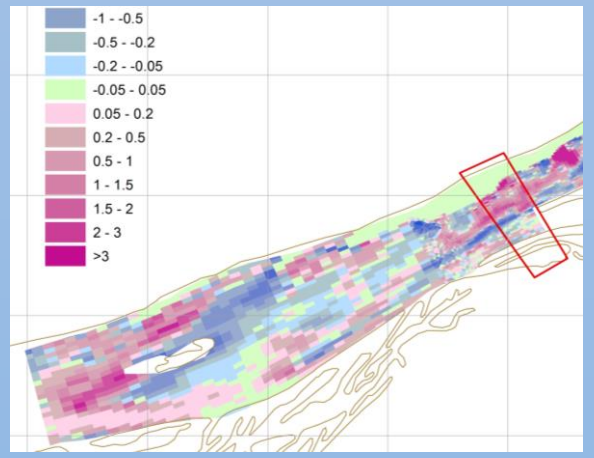


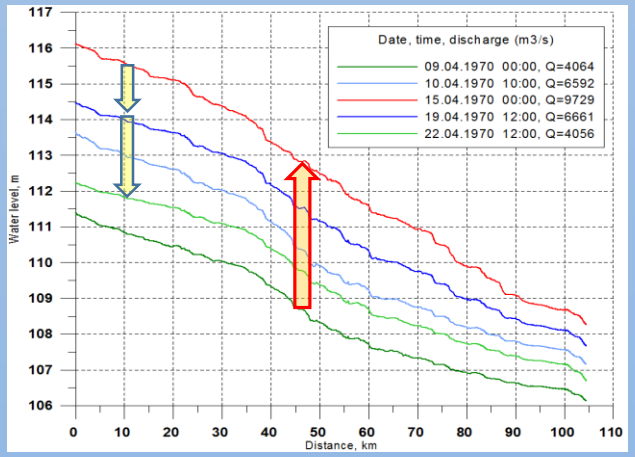
Results:

Water level velocity and discharge distribution

Flood wave simulation

Erosion scenarios etc.





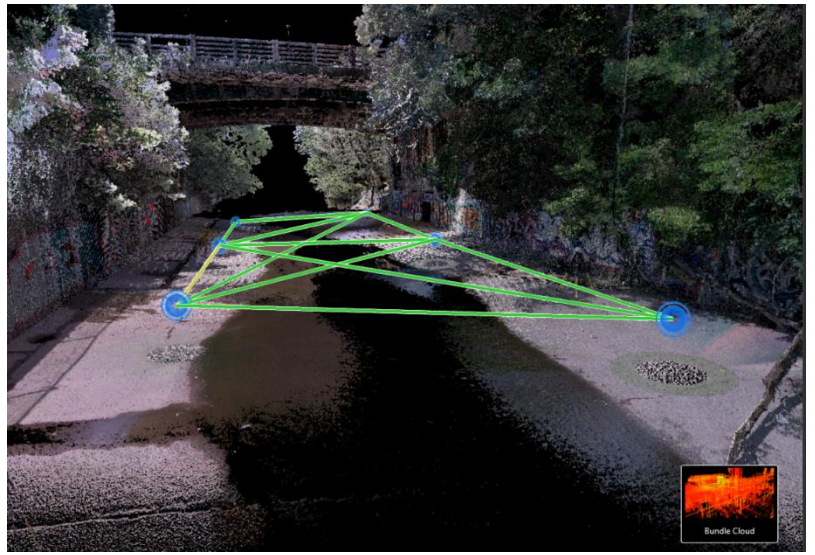
Innovative measuring methods

Large-Scale Particle Image Velocimetry (LSPIV)
is an emerging technique to obtain measurements of surface velocity in streams and rivers. Advantages:

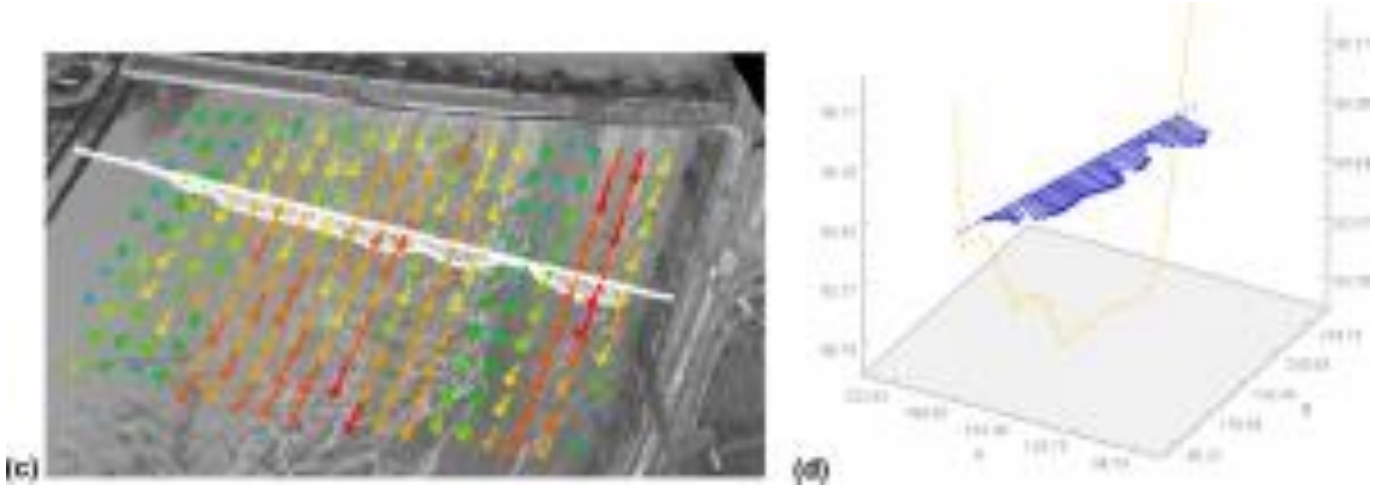
- non-intrusive measurement technique
- instant and average two-dimensional velocity fields
- advantageous in the case of dangerous flows
- is successfully applied for gauging campaigns
- crowd-sourced video analysis

A camera system to measure water level and surface velocity

The application for smartphone



Lidar scan and rectifying to construct a 3-dimensional stream channel



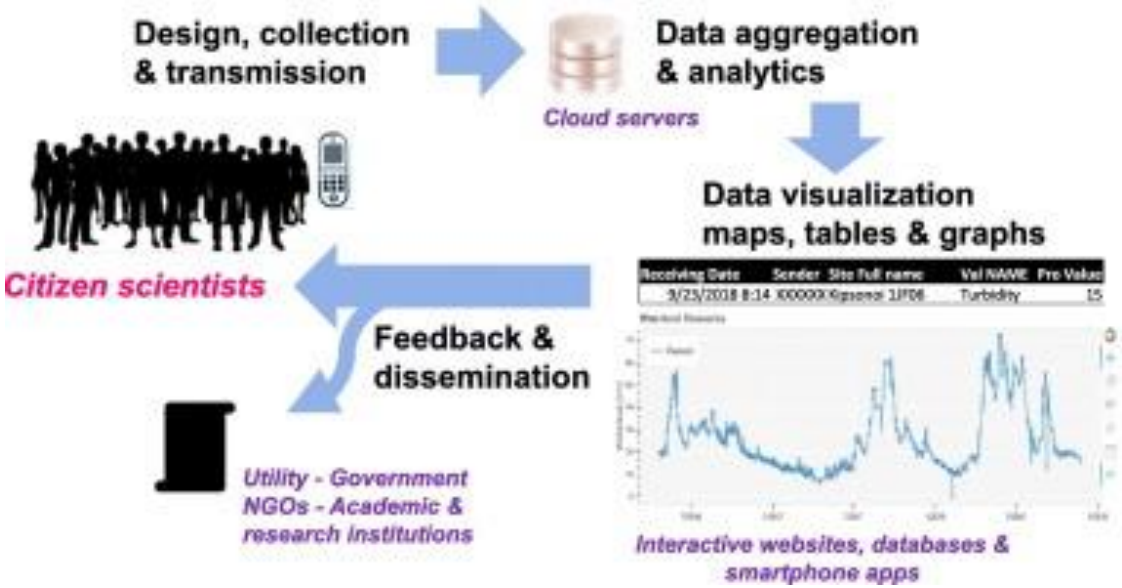
https://riverhydraulics.inrae.fr/en/tools/measurement-software/fudaa-lspiv-2/

https://www.usgs.gov/media/images/photo-a-camera-system-will-be-tested-measure-water-level

Innovative measuring methods

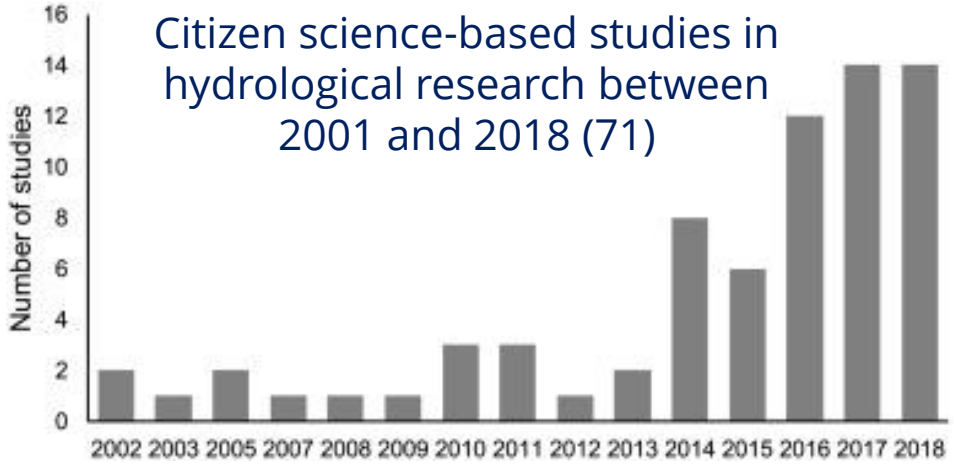
Citizen science – the alternative method for data collection

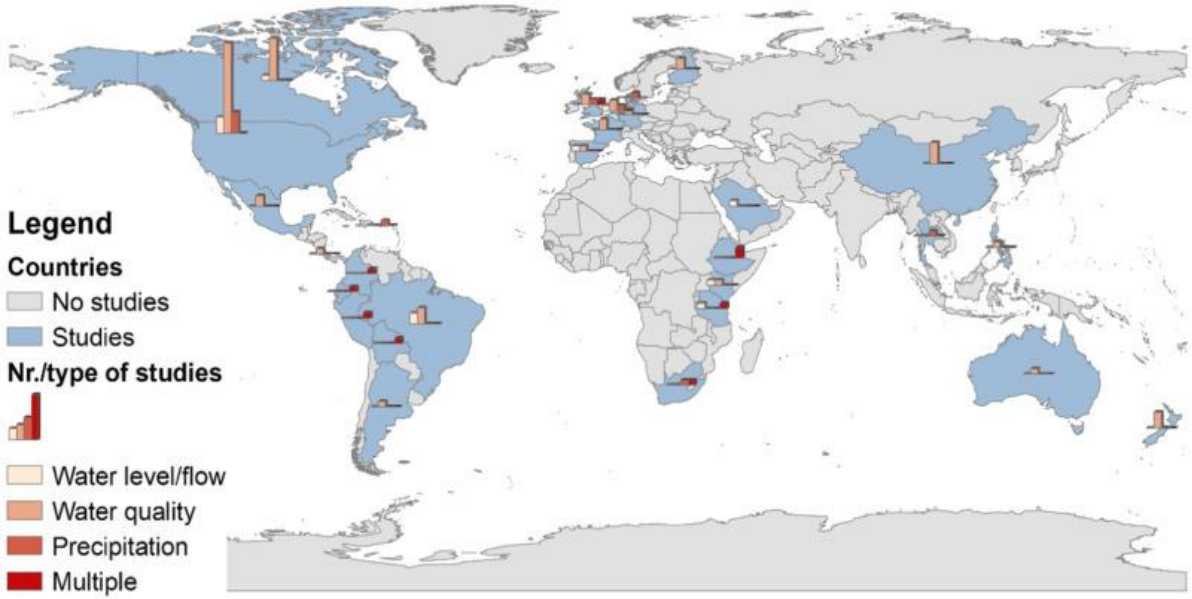
Crowdsourced data collection - water levels, water quality and/or precipitation as examples in hydrology. Most of the programs are found in North America and Europe



https://doi.org/10.1016/j.scitotenv.2019.07.337

Citizen science-based studies in hydrological research between 2001 and 2018 (71)





https://www.tandfonline.com/doi/full/10.1080/02626667.2020.1849707

Thank you for your attention

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https://crowdwater.ch/en/start/