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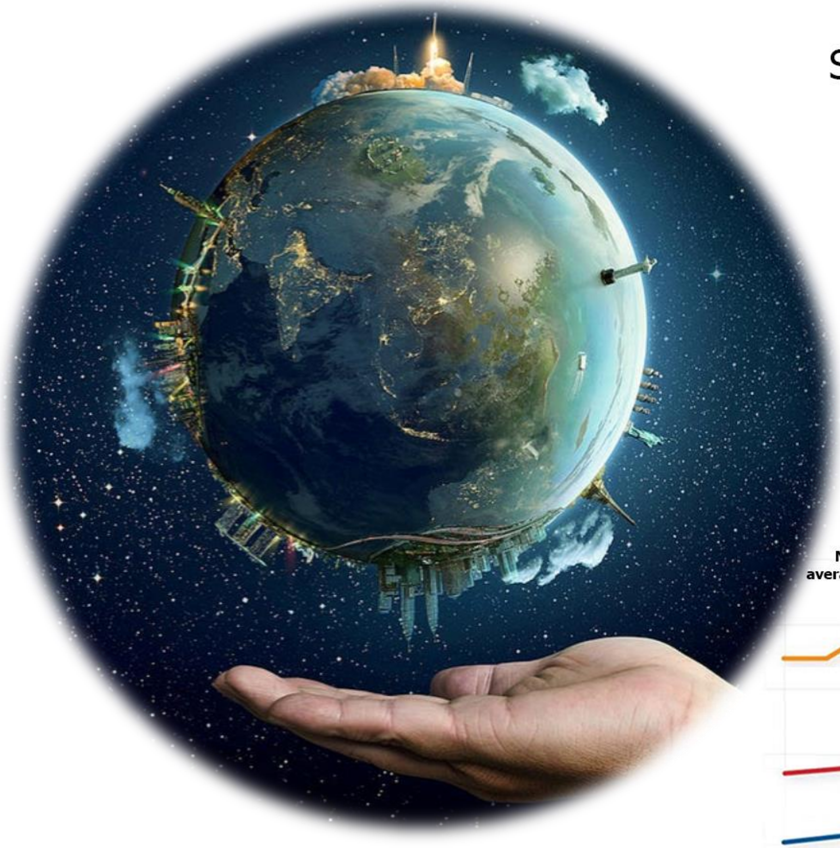
Digitalization and Sustainability Aspects of Environmental Monitoring

3rd ACM Europe Digital Humanism Summer School - 3rd September 2024

Katrin Attermeyer & Atakan Aral

Introduction



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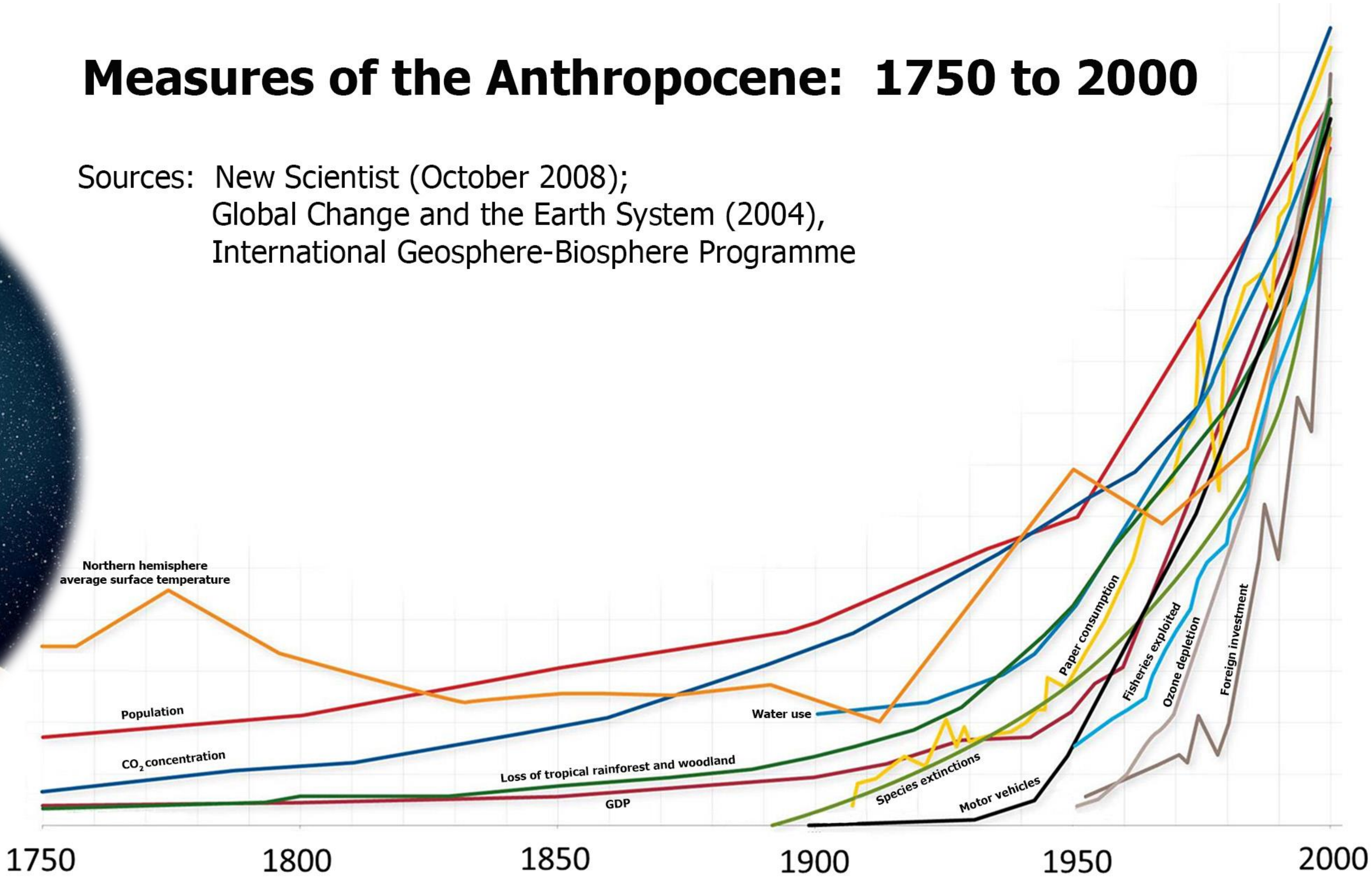


Introduction

One Health

recognizes that the health of people is closely connected to the health of animals and our shared environment

calling for "the collaborative efforts of multiple disciplines working locally, nationally, and globally, to attain optimal health for people, animals and our environment"

https://www.aihsp.or.id/storage/articles/dr-qadeer-one-health-pPM11.jpg

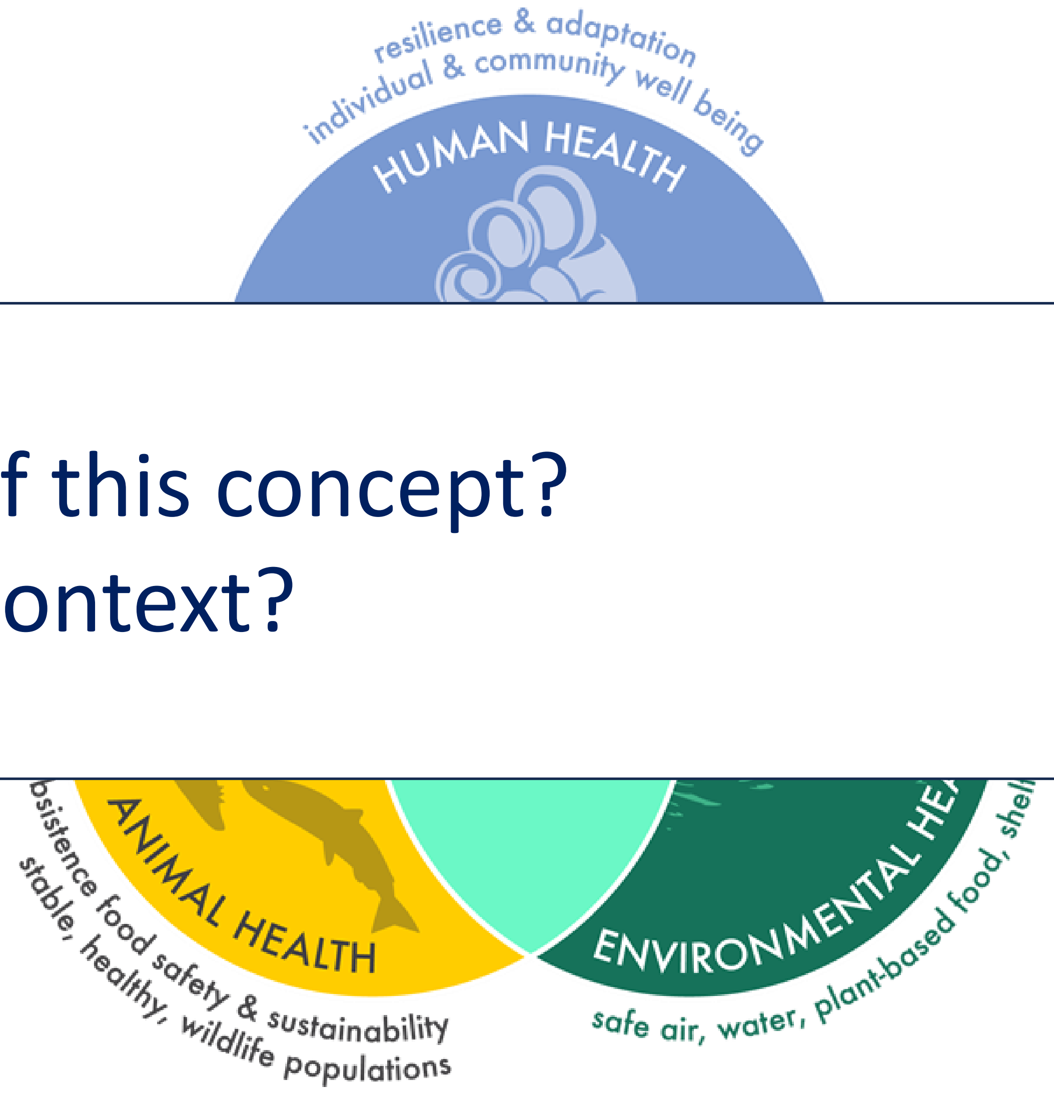
Introduction

One Health

recognizes that the health of
people is closely connected to

Who has heard of this concept?
In which context?

health for people, animals
and our environment"



https://www.aihsp.or.id/storage/articles/dr-qadeer-one-health-pPM11.jpg

Definition of environmental monitoring

"Systematic sampling of air, water, soil, and biota to observe and study the environment, as well as to derive knowledge from this process" (Artiola et al. 2004)

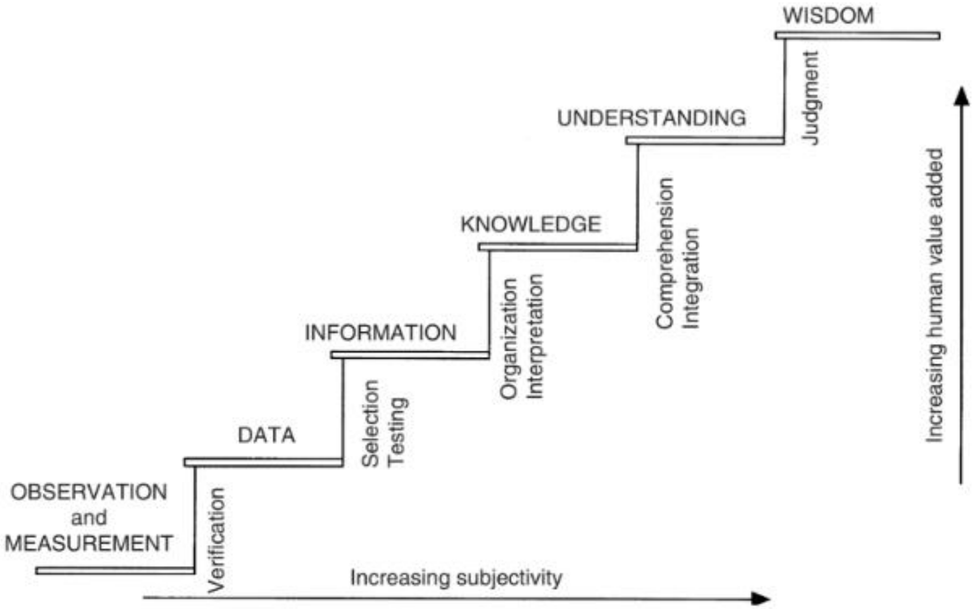


FIGURE 1.1 The staircase of knowing. Science-based observations and measurements improve our understanding of the environment and lead to wise decision-making. (From Roots, E.F. (1997) Inclusion of different knowledge systems in research. In: Terra Borealis. Traditional and Western Scientific Environmental Knowledge. Workshop Proceedings, Northwest River, Labrador 10 & 11 Sept. 1997. No. 1. Manseau M. (ed), Institute for Environmental Monitoring and Research, P.O. Box 1859, Station B Happy Valley–Goose Bay Labrador, Newfoundland, AOP E10. Terra Borealis 1:42–49, 1998.)

Definition of environmental monitoring

"Systematic sampling of air, water, soil, and biota to observe and study the environment, as well as to derive knowledge from this process" (Artiola et al. 2004)

BOX 1.1 *Knowledge-Based Regulation and Benefits of Environmental Monitoring*

Protection of public water supplies: Including surface and groundwater monitoring; sources of water pollution; waste and wastewater treatment and their disposal and discharge into the environment

Hazardous, nonhazardous and radioactive waste management: Including disposal, reuse, and possible impacts to human health and the environment

Urban air quality: Sources of pollution, transportation, and industrial effects on human health

Natural resources protection and management: Land and soil degradation; forests and wood harvesting; water supplies, including lakes, rivers, and oceans; recreation; food supply

Weather forecasting: Anticipating weather, long- and short-term climatic changes, and weather-related catastrophes, including floods, droughts, hurricanes, and tornadoes

Economic development and land planning: Resources allocation; resource exploitation

Population growth: Density patterns, related to economic development and natural resources

Delineation: Mapping of natural resources; soil classification; wetland delineation; critical habitats; water resources; boundary changes

Endangered species and biodiversity: Enumeration of species; extinction, discovery, protection

Global climate changes: Strategies to control pollution emissions and weather- and health-related gaseous emissions

Overview of Environmental Monitoring on the ground

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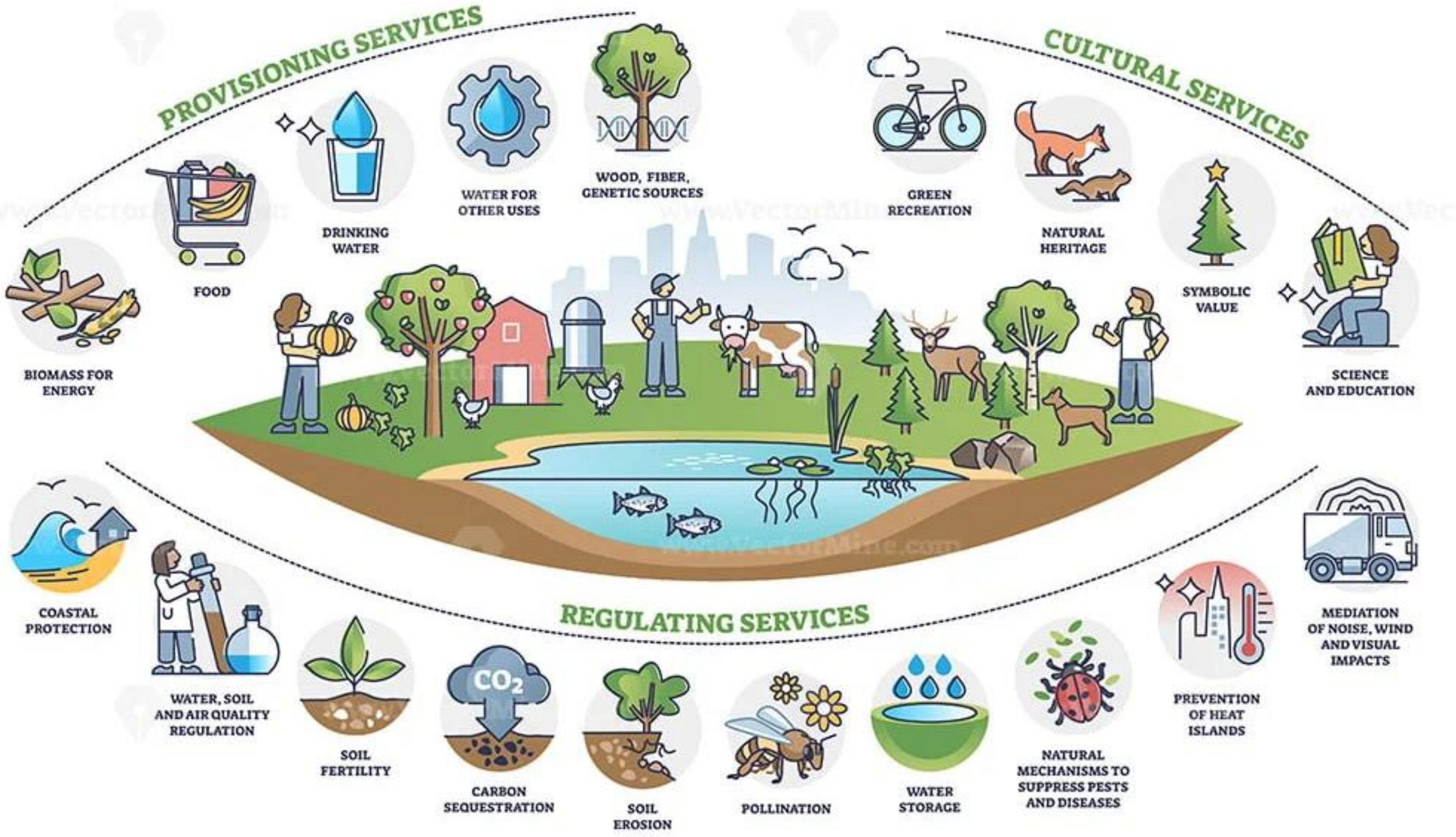
Katrin Attermeyer (katrin.attermeyer@wcl.ac.at)

Why environmental monitoring?

Ecosystem services

- the benefits people get from ecosystems (Millennium Ecosystem Assessment (MEA) report)
- contributions of ecosystem structure and function, along with a combination of other inputs, to human well-being.



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Why environmental monitoring?

Environmental threats

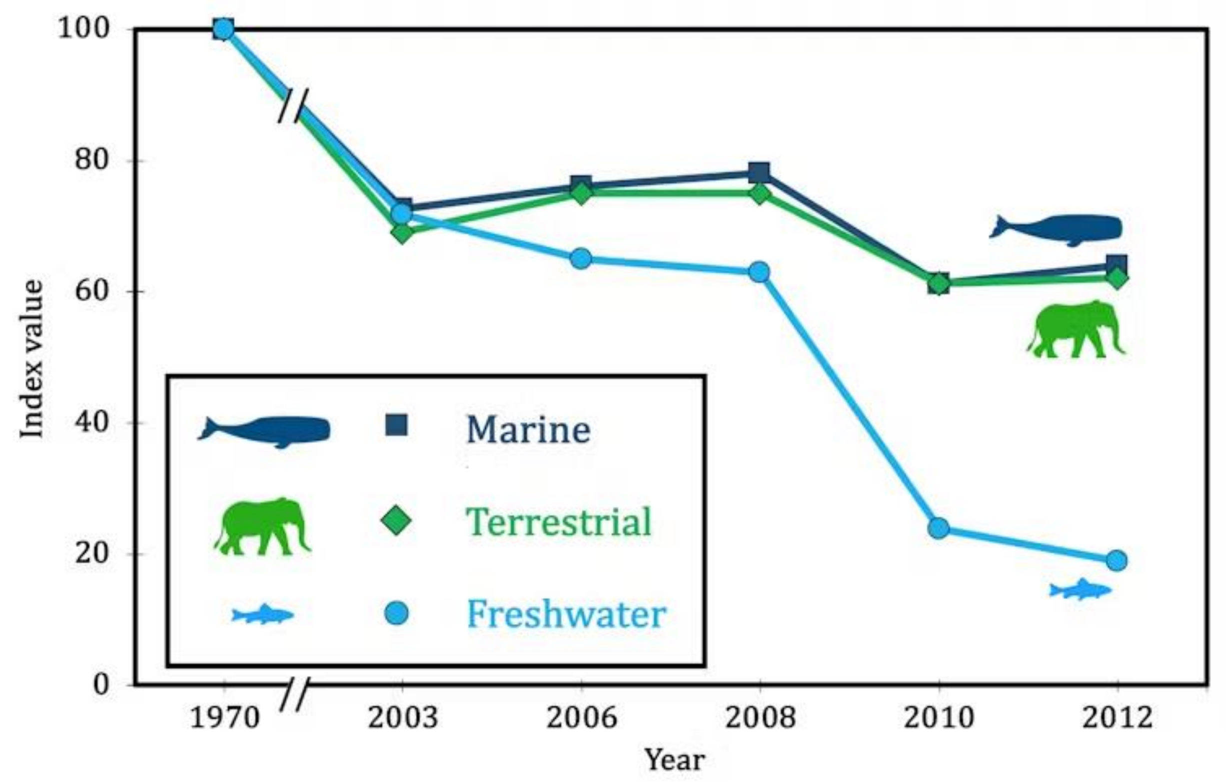
Air Pollution
- Global climate change
- Stratospheric ozone depletion
- Urban air pollution
- Acid deposition
- Outdoor and indoor pollutants
- Noise

Waste Production
- Solid waste
- Hazardous waste

Biodiversity depletion
- Habitat destruction and degradation
- Extinction

Food supply problems
- Overgrazing/-fishing
- Farmland/Wetland loss and degradation
- Coastal pollution
- Soil erosion/salinization /waterlogging
- Water shortages
- Loss of biodiversity
- Groundwater depletion
- Poor nutrition

Water Pollution
- Sediment
- Nutrient overload
- Toxic chemicals
- Infectious agents
- Oxygen depletion
- Pesticides
- Oil spills
- Excess heat



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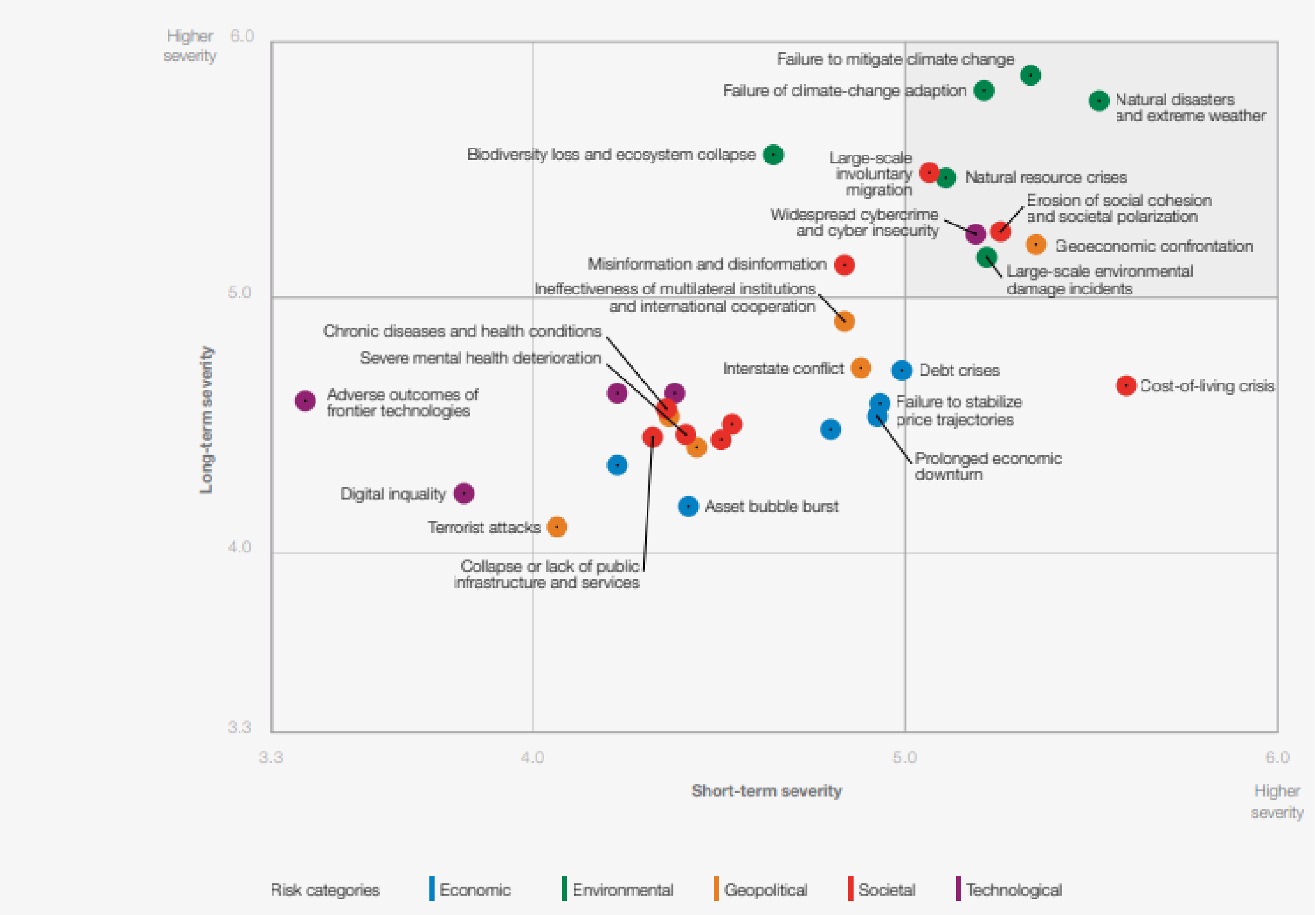
Why environmental monitoring?

Environmental threats

FIGURE 2.2 **Relative severity of risks over a 2 and 10-year period**



Source

World Economic Forum Global Risks Perception Survey 2022-2023.

Note

Severity was assessed on a 1-7 Likert scale [1 – Low severity, 7 – High severity].

Objectives of environmental monitoring

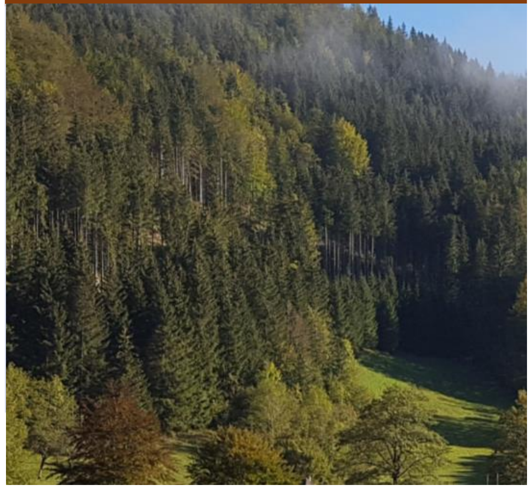
Monitoring is conducted:

- To establish environmental “baselines, trends, and cumulative effects” (Mitchell 2002)
- To contribute to environmental modeling processes
- To educate the public about environmental conditions
- To inform policy and decision-making
- To ensure compliance with environmental regulations
- To assess the effects of anthropogenic and climatic influences
- To conduct an inventory of natural resources (Mitchell 2002)

Environmental monitoring types

Air

Soil



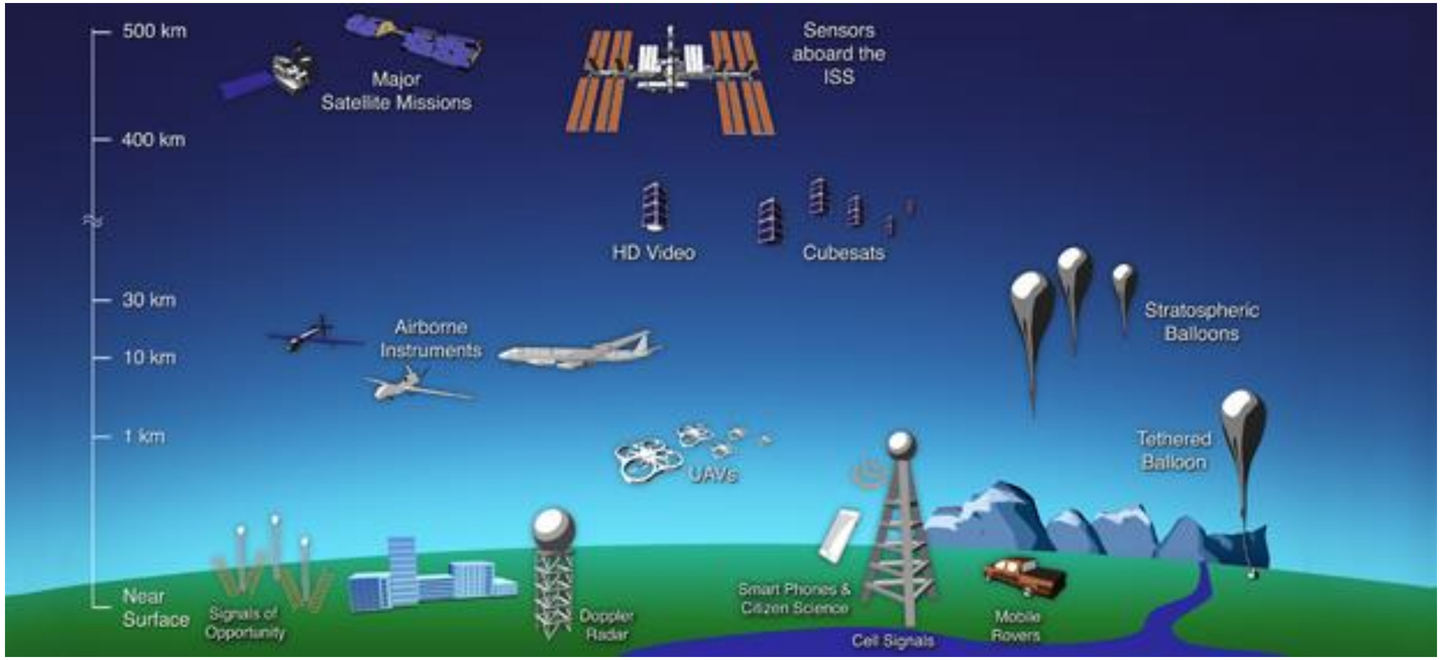
Water

Environmental monitoring types

Remote sensing

Environmental monitoring types

Remote sensing



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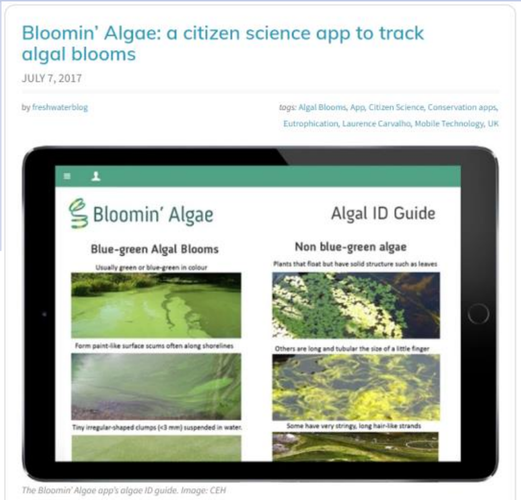
Environmental monitoring types

Remote sensing

Citizen science



On the ground

Focus on freshwater monitoring on the ground

Water

&

On the ground

Why freshwater?

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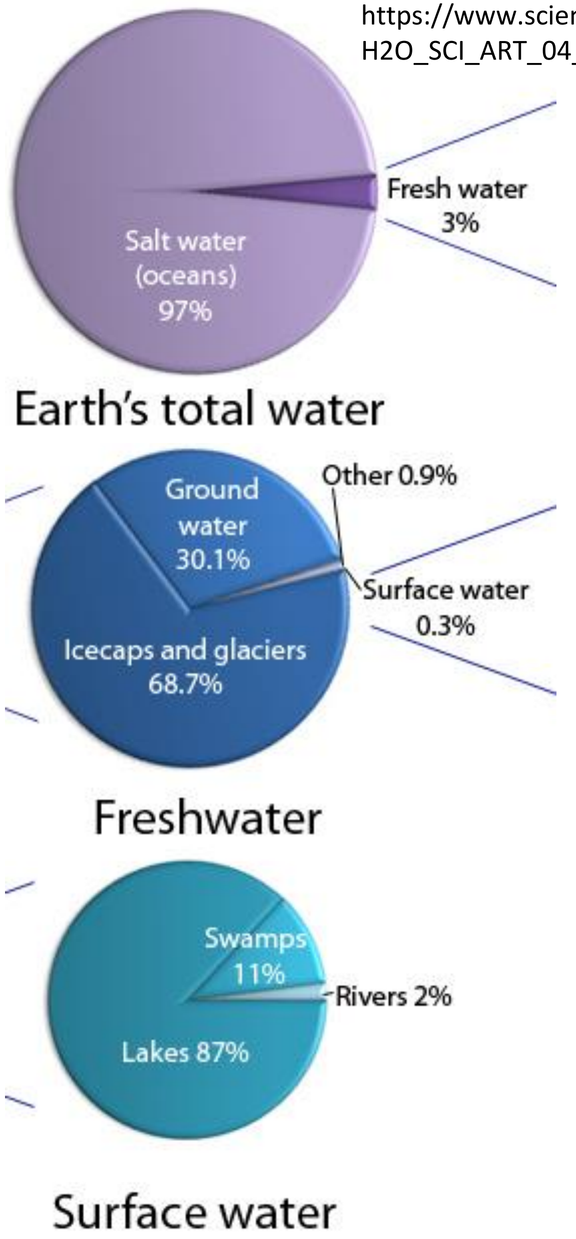
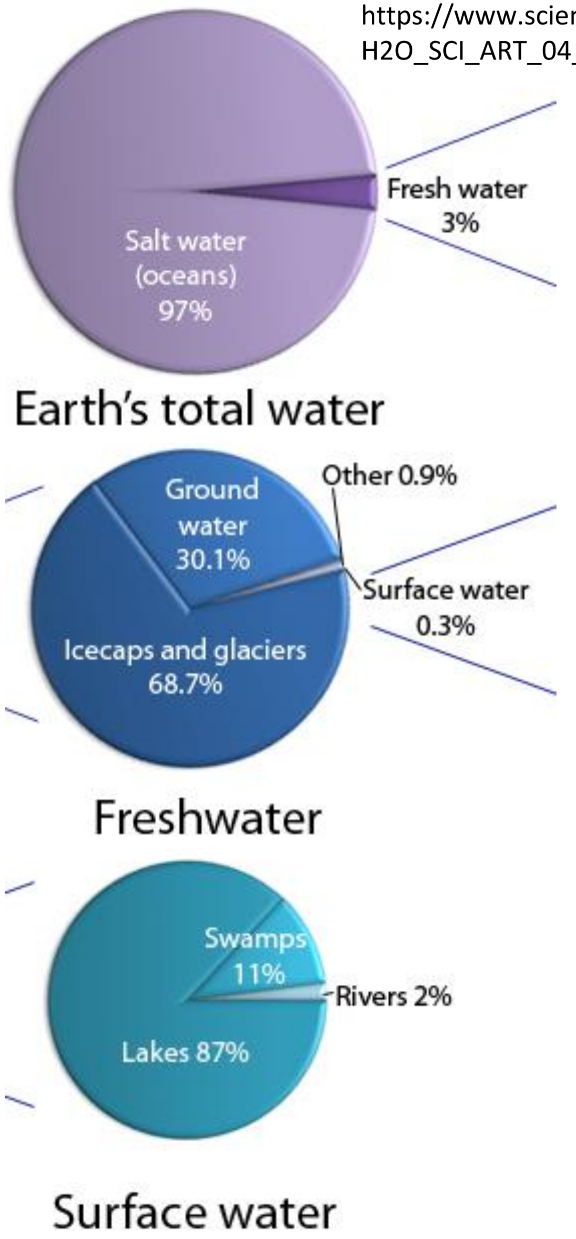


Why freshwater?



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https://vectormine.b-cdn.net/wp-content/uploads/ecosystem_services_outline_diagram_2-1.jpg

Why freshwater?

It has been said that "that which cannot be monitored, cannot be (effectively) managed": and it is our contention that effective monitoring of global freshwaters is a prerequisite for sustainable development, healthy societies, and a healthy environment.

Chapman and Sullivan (2022)

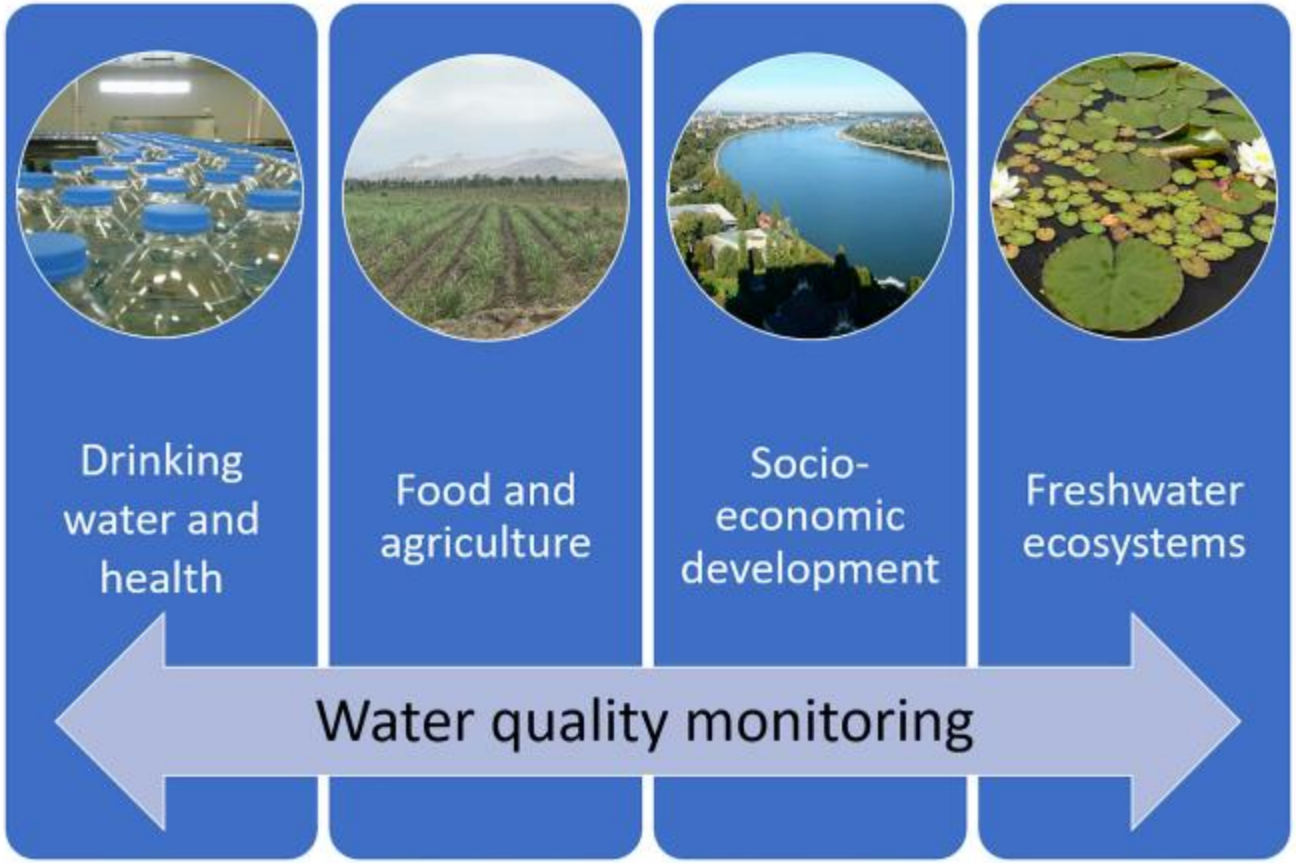


Figure 1. Water quality monitoring is an essential activity for society and the freshwater ecosystem
Ambient water quality directly or indirectly influences much of human society, for example, in the provision of drinking water, the production of food, and in the requirements for a stable, equitable, and healthy society. It also influences the overall quality and health of our environment, biodiversity, and biogeochemical processes

Freshwater and quality

Water quality:

- Physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water
- General descriptor of water properties in terms of physical, chemical, and/or biological characteristics

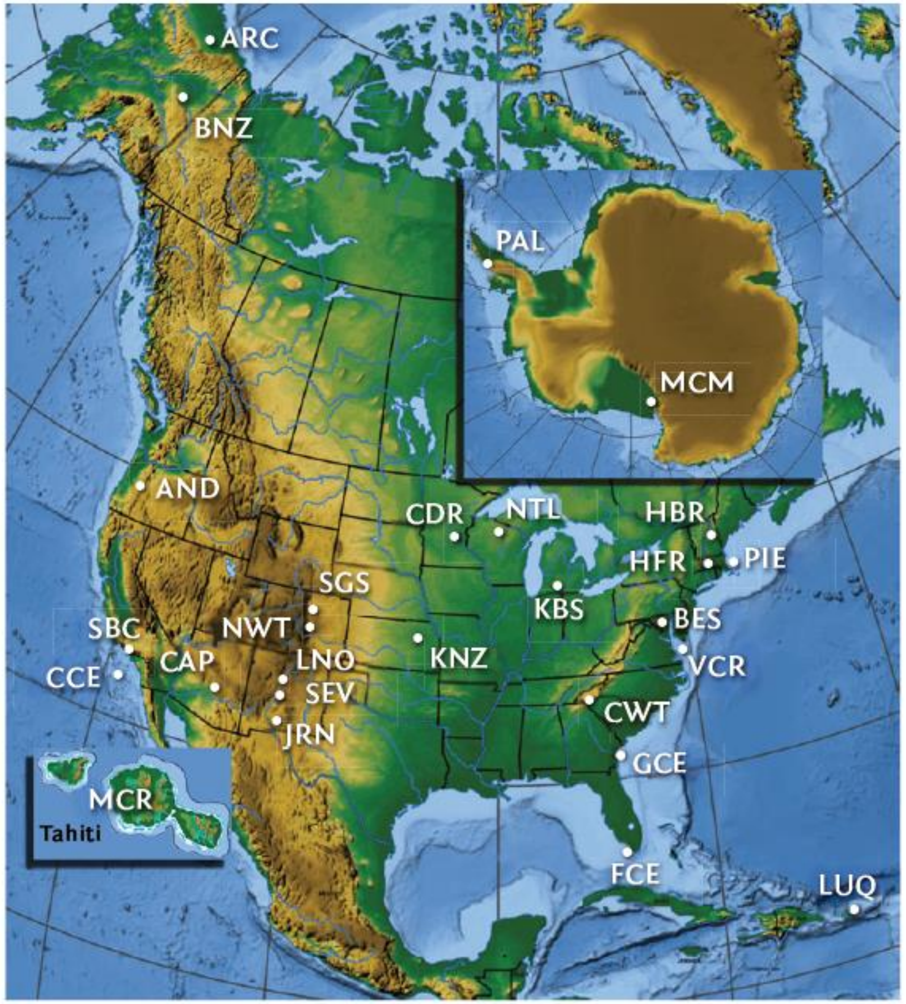
- <u>Physical:</u> solids, color, temperature, turbidity, conductivity, density, odor and taste, etc.
- <u>Chemical:</u> oxygen, pH, alkalinity, acidity, total organic carbon, phenols, pesticides, hardness, chloride, etc.
- <u>Biological:</u> Biological oxygen demand (BOD), microorganisms, etc.

Regional and global networks

Join forces to tackle environmental threats via monitoring together

- In 1980, US National Science Foundation initiated and first coined the term “Long-Term Ecological Research” (LTER)
- 28 US-LTER sites
- Ecosystems: desert, alpine, forests, coastal, grassland, urban, agricultural, Antarctic
- Same core processes are being studied at all sites
- Projects include integrative, cross-site, network-wide research to address questions at broad temporal and spatial scales

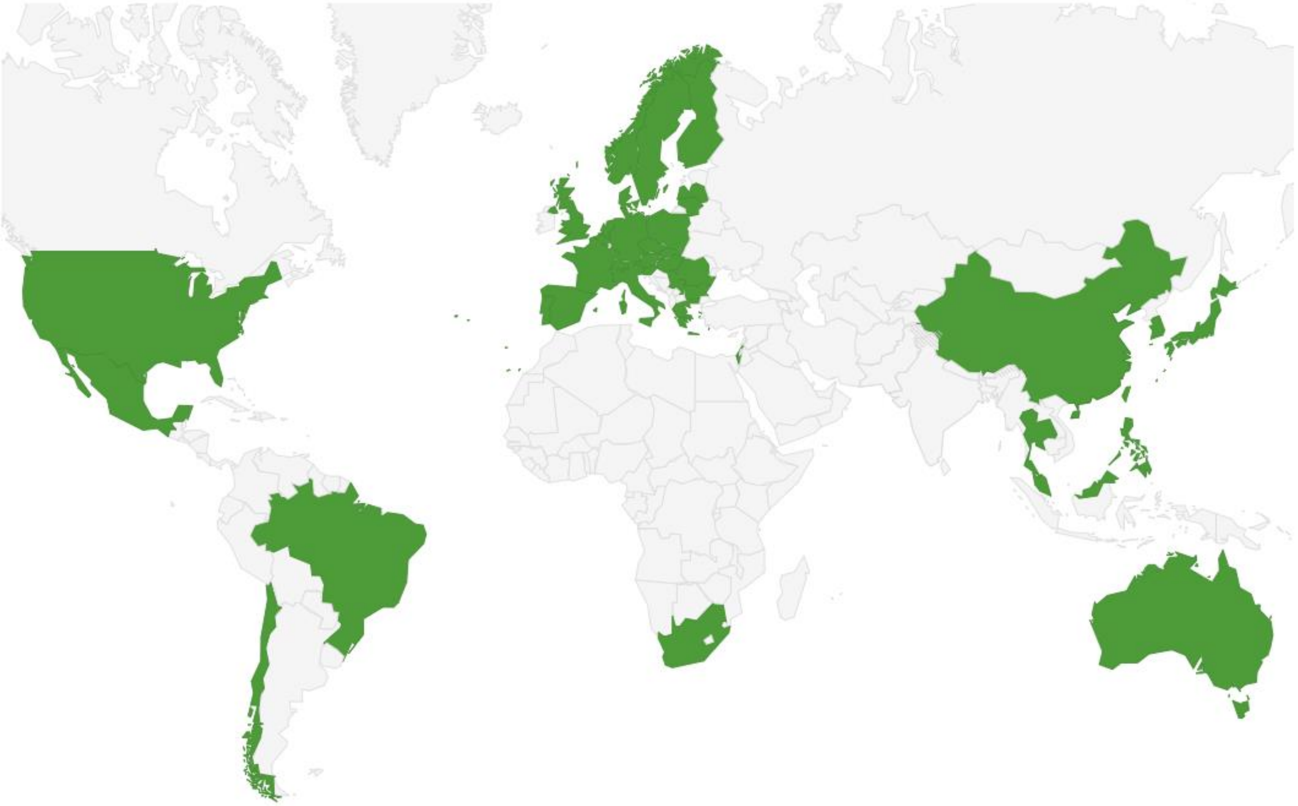
Figure 1. Map of the 26 US LTER Sites



Regional and global networks

ILTER: 39 member networks which together operate more than 750 sites

Australia
Austria
Belgium
Brazil
Bulgaria
Chile
China
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Israel
Italy
Japan
South Korea
Latvia
Lithuania
Malaysia
Mexico
Netherlands
Norway
Philippines
Poland
Portugal
Romania
Serbia
Slovakia
Slovenia
South Africa
Spain
Sweden
Switzerland
Taiwan
Thailand
United Kingdom
USA



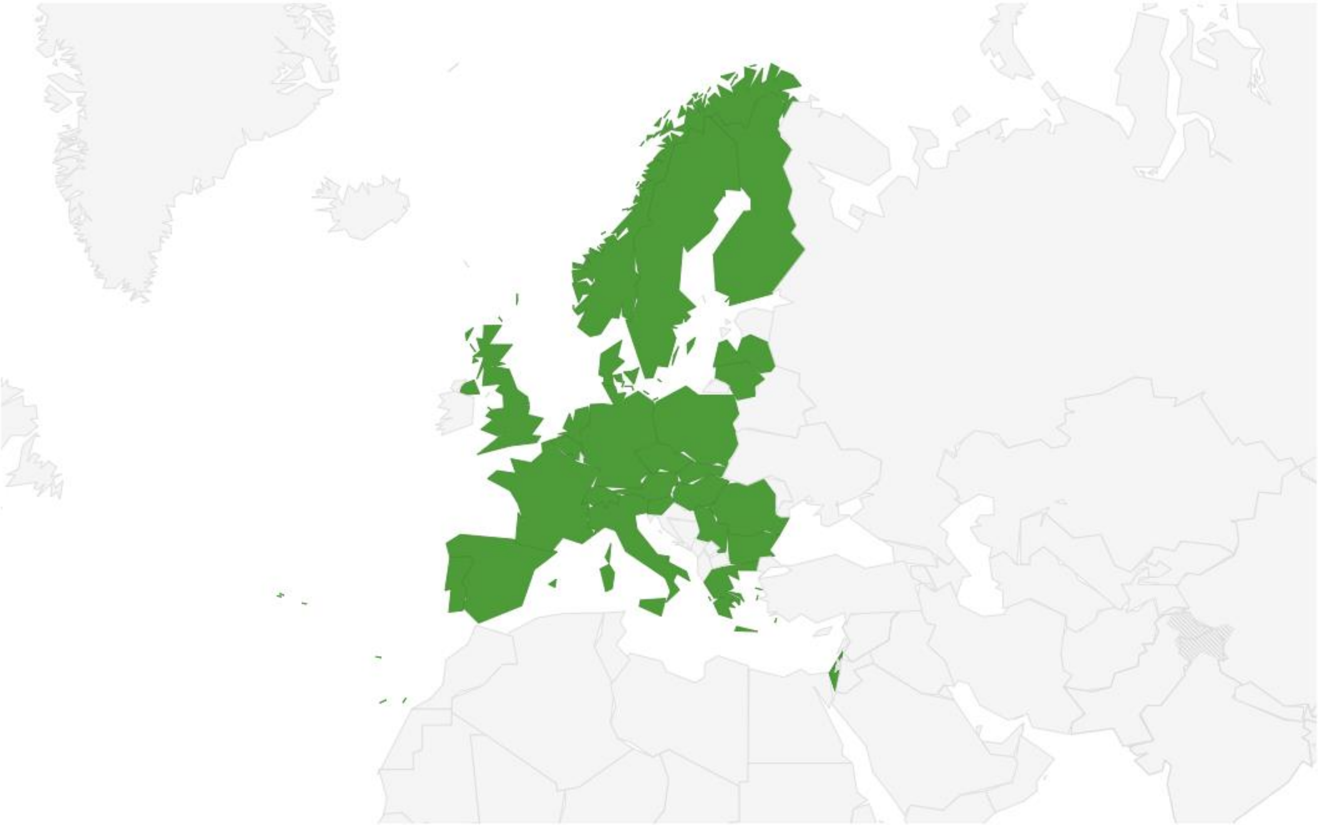
- During 1990s, NSF supported LTER scientists to reach out to colleagues around the world to catalyze development of LTER Networks in other countries
- In 1993, US National Science Foundation initiated ILTER

Regional and global networks

LTER-Europe: 26 member states

- launched in 2003 as the umbrella network for Long-Term Ecosystem Research (LTER) in Europe
- LTER-Europe was heavily involved in developing the concept of Long-Term Socio-Ecological Research (LTSER)
- within LTER-Europe, the eLTER Research Infrastructure (eLTER RI) is being developed in the framework of ESFRI (European Strategy Forum on Research Infrastructures) focusing, among many matters, on harmonized parameters and methods

Austria	Finland	Israel	Norway	Slovakia	United Kingdom
Belgium	France	Italy	Poland	Slovenia	
Bulgaria	Germany	Latvia	Portugal	Spain	
Czech Republic	Greece	Lithuania	Romania	Sweden	
Denmark	Hungary	Netherlands	Serbia	Switzerland	



Regional and global networks

LTER-Austria involves 38 LTER Sites and LTSER Platforms

- Austria is involved in the global LTER network (ILTER) since 2001
- In 2002, the Austrian Society for Long-Term Ecological Research was founded
- In accordance with LTER-Europe standards, Austrian Sites were selected and LTSER Platforms were/are developed.

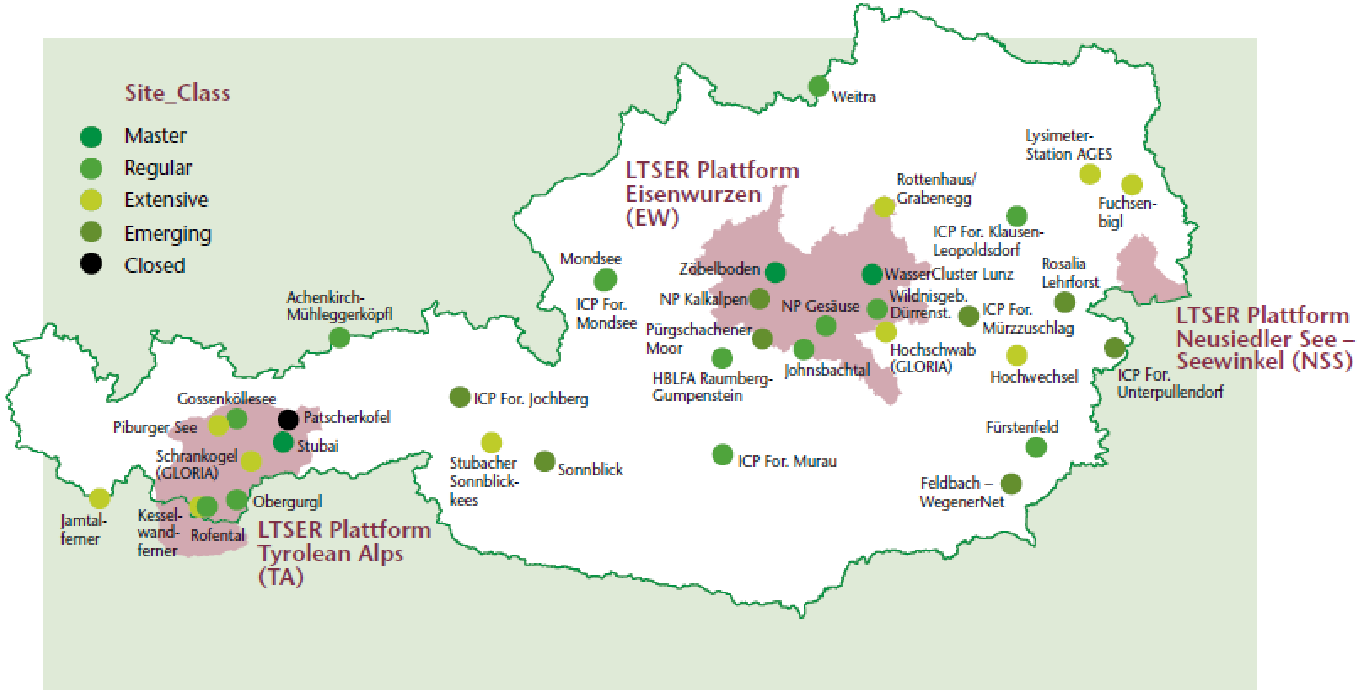


Fig. 6: Map showing the Austrian LTER Sites and LTSER Platforms

Regional and global networks

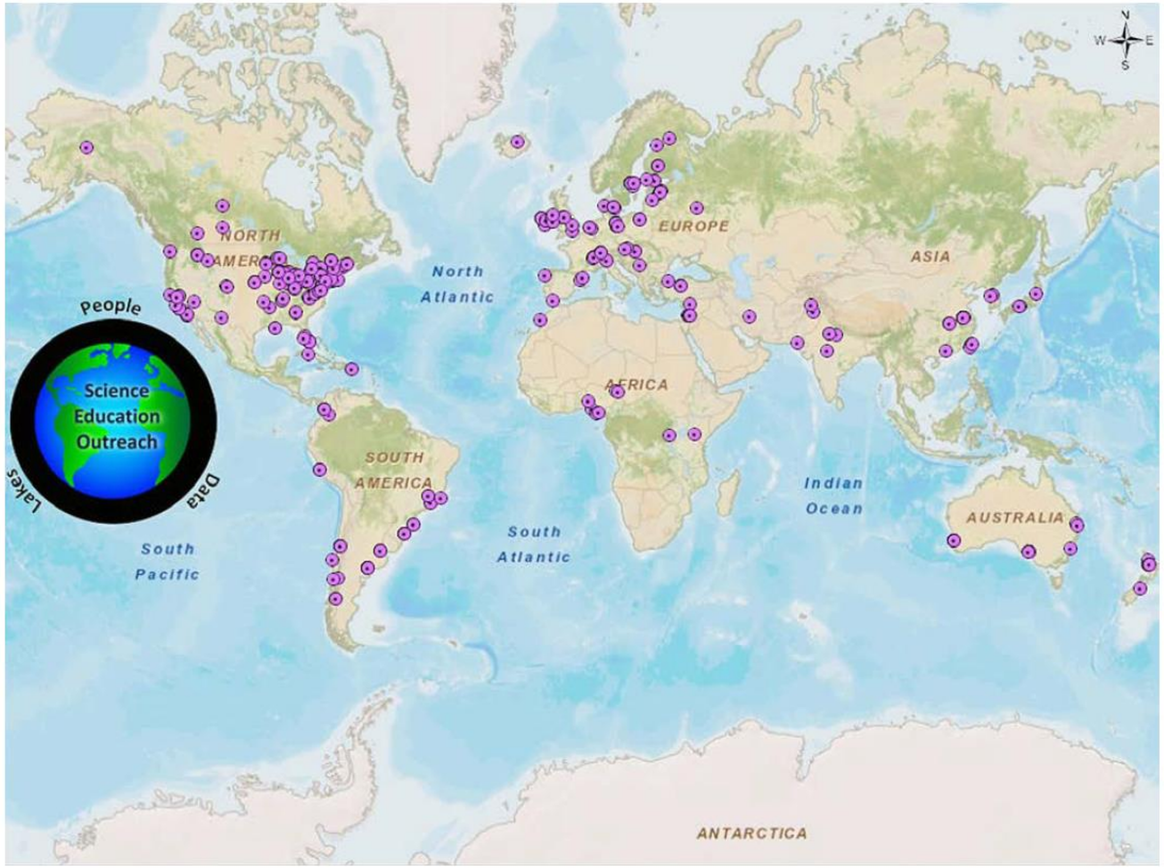
GLEON = Global Lake Observatory Network

A grassroots, global network to examine lake function using sensor data? Why not? That was the perspective of Drs. Tim Kratz (limnologist), David Hamilton (limnologist), Peter Arzberger (mathematician), and Fang-Pang Lin (computer scientist) in 2004 when they hatched the idea of the Global Lake Ecological Observatory Network.

Regional and global networks

GLEON = Global Lake Observatory Network

- Worldwide network of instrumented buoys on lakes, placing critical lake information at the fingertips of researchers, managers, and the general public
- Network of lake observatories with research sites on more than 100 lakes across six continents
- Research environment that fosters collaboration across disciplines and political borders
- International community of scientists, educators, policy makers, and citizens invested in the future of freshwaters



Regional and global networks

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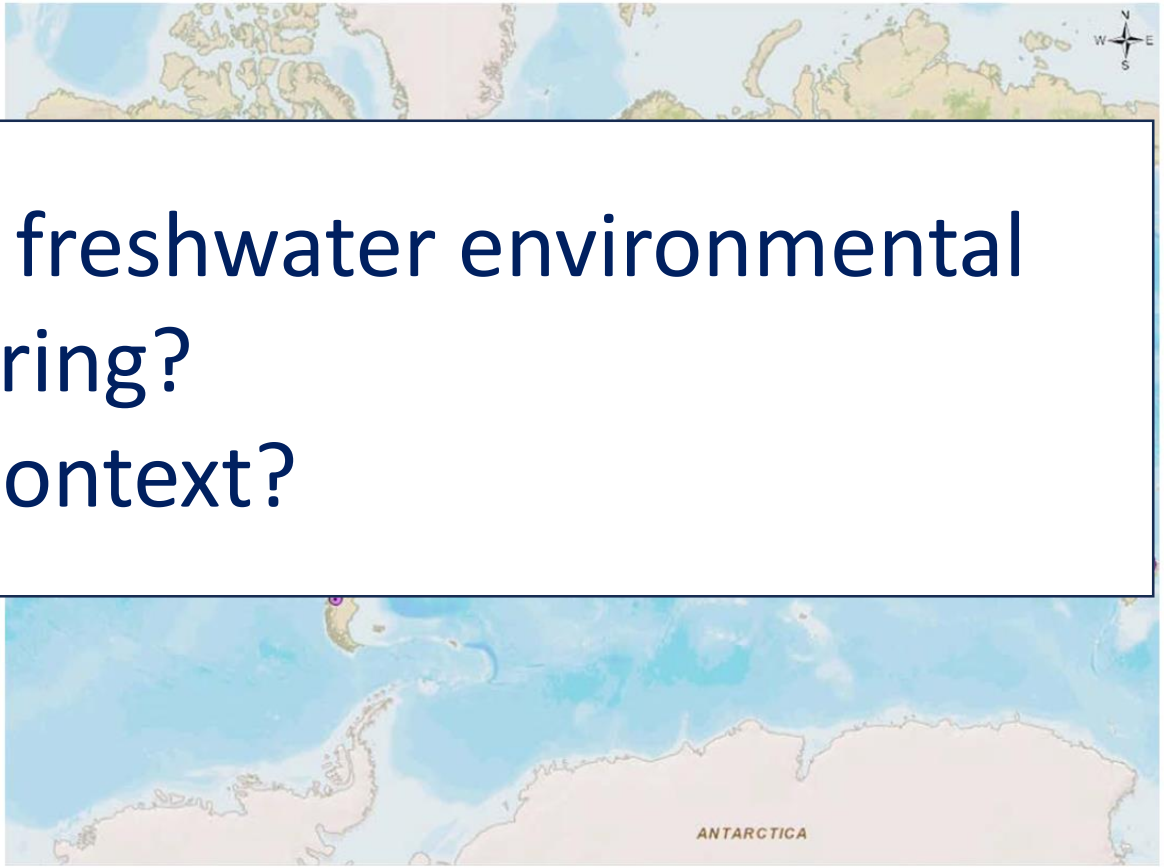


Have you been in touch with freshwater environmental monitoring?
In which context?

Example from WasserCluster Lunz (WCL)

WCL: Member of LTER-Austria and GLEON

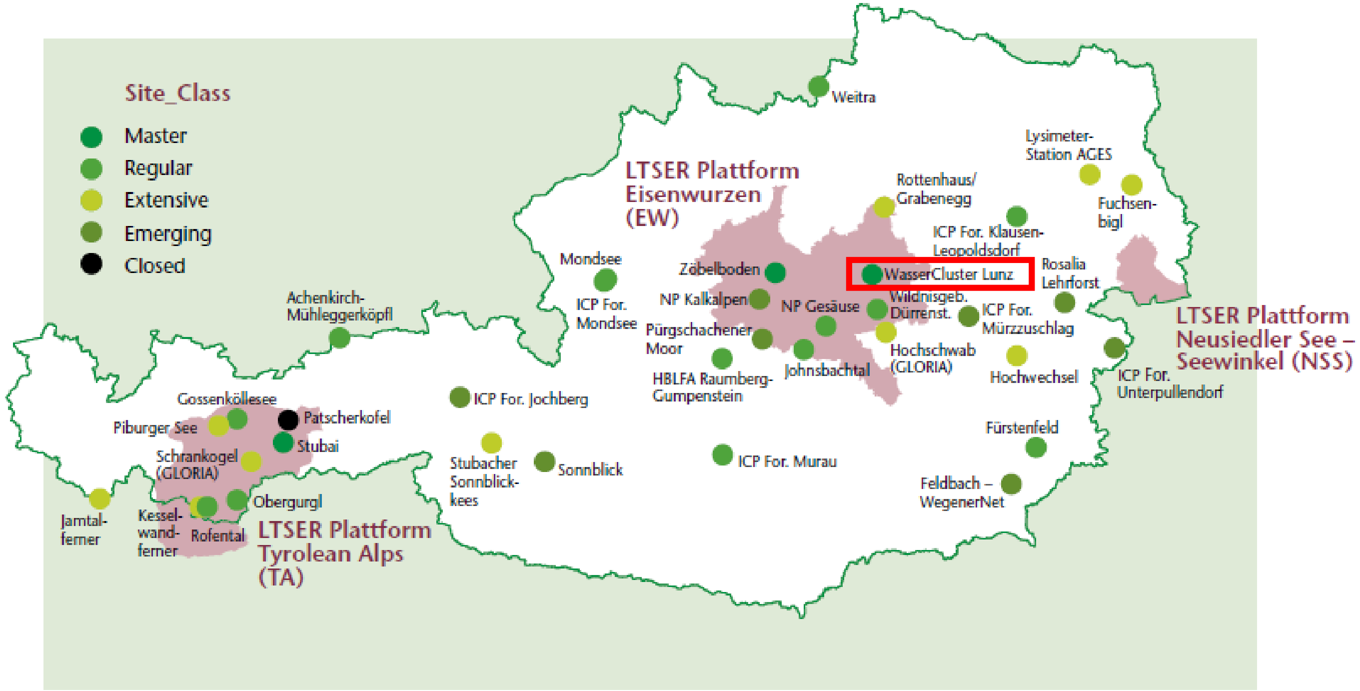
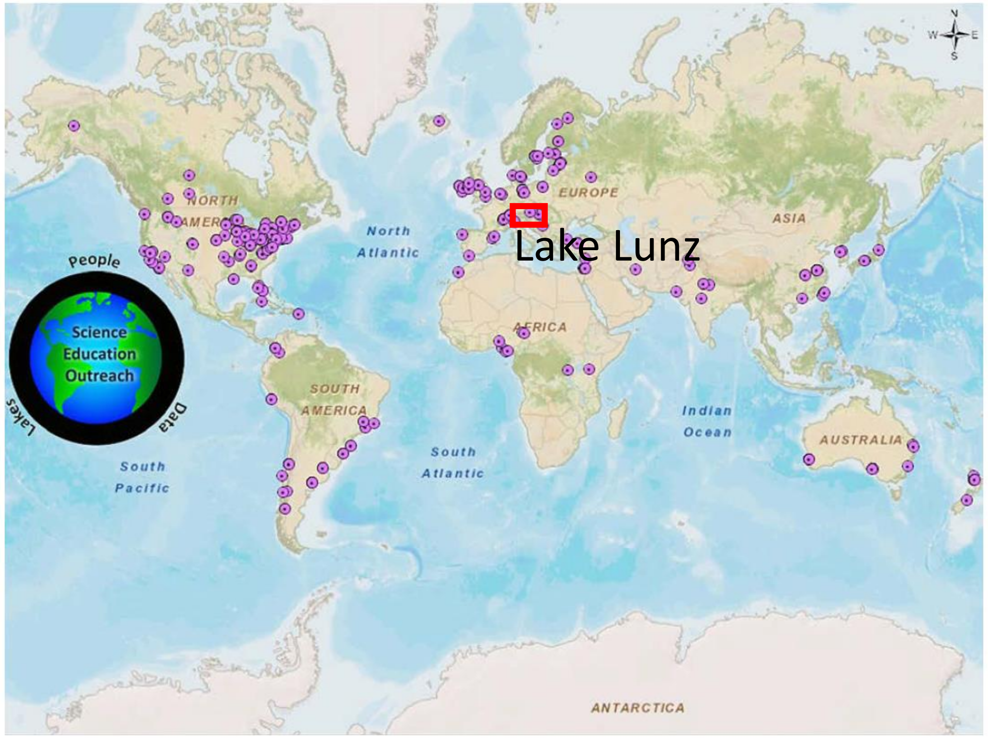
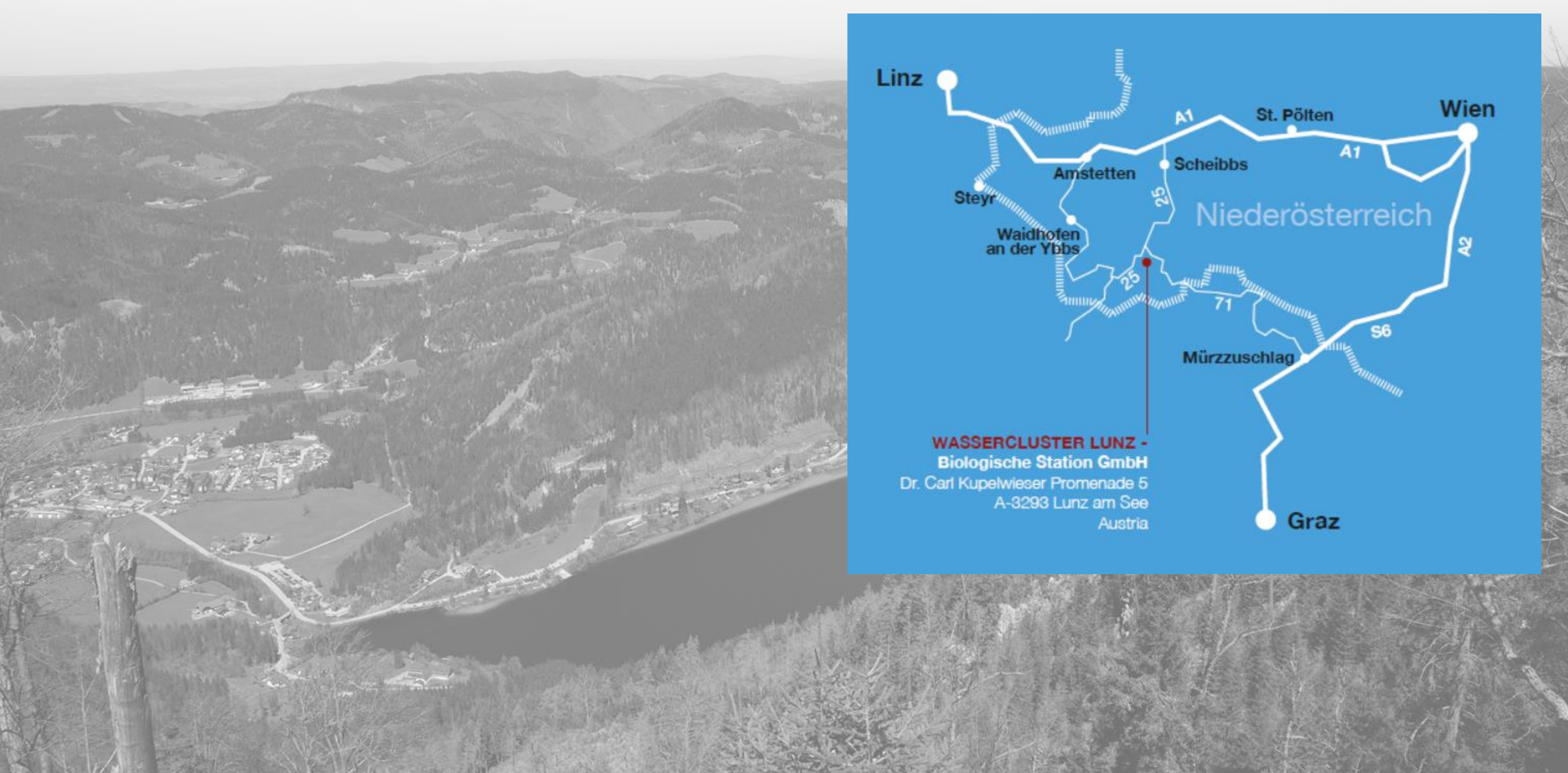


Fig. 6: Map showing the Austrian LTER Sites and LTSER Platforms



Lunz am See and WasserCluster Lunz (WCL)



History of WCL

3rd oldest limnological research station

Biological Station founded

1905

1908

Dr. Franz Ruttner

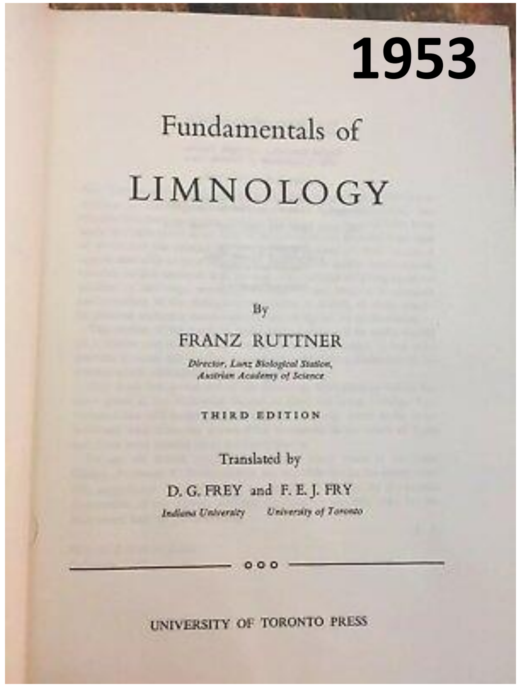
History of WCL

Biological Station founded

1905

1908

Dr. Franz Ruttner



History of WCL

Biological Station founded
1905

1908
Dr. Franz Ruttner

1957
Prof. Ingo Findenegg

Prof. Heinz Löffler
1967

1972
Prof. Agnes Ruttner-Kolisko

Dr. Gernot Bretschko
1977

History of WCL

1905
Biological Station founded

1908
Dr. Franz Ruttner

1957
Prof. Ingo Findenegg

1967
Prof. Heinz Löffler

1972
Prof. Agnes Ruttner-Kolisko

1977
Dr. Gernot Bretschko

2003
Biological Station closed

2007
wasser cluster lunz

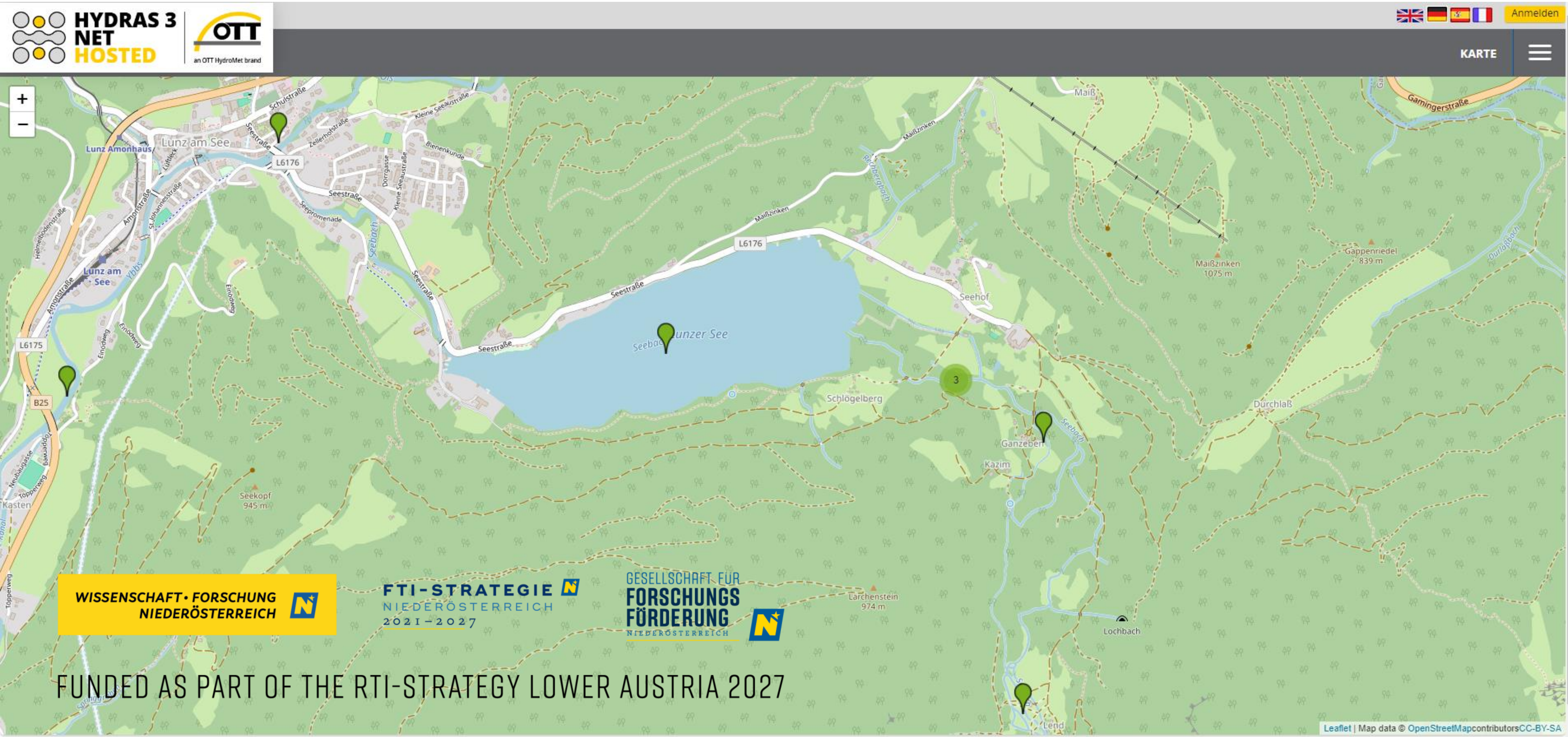
WCL today

Today`s monitoring at WCL

Objectives: tradition & process-based understanding on catchment-scale to assess effects of anthropogenic and climatic influences

Automatic stations and manual samplings

Map of automatic monitoring stations



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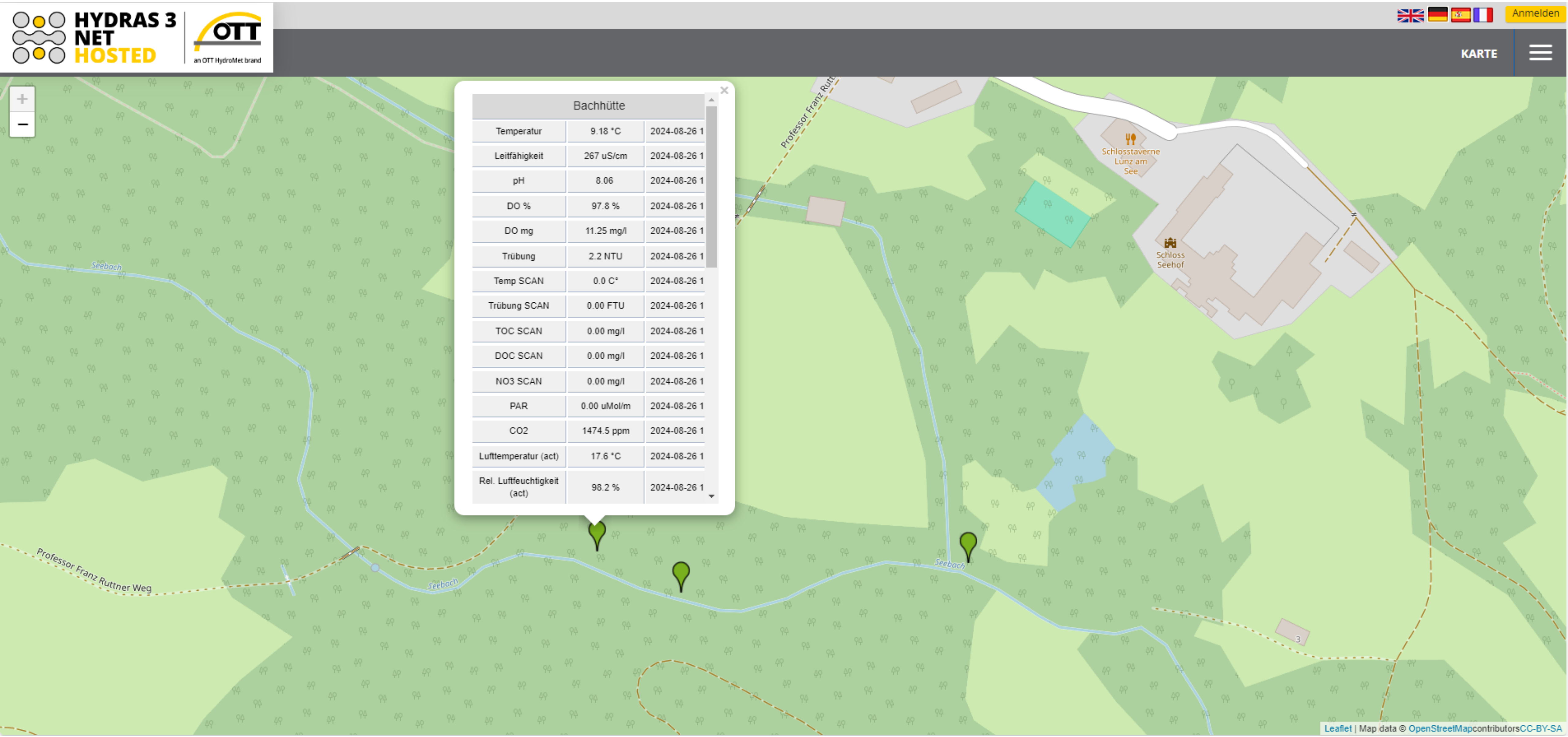
FTI-STRATEGIE NIEDERÖSTERREICH 2021–2027

GESELLSCHAFT FÜR FORSCHUNGSFÖRDERUNG NIEDERÖSTERREICH

FUNDED AS PART OF THE RTI-STRATEGY LOWER AUSTRIA 2027

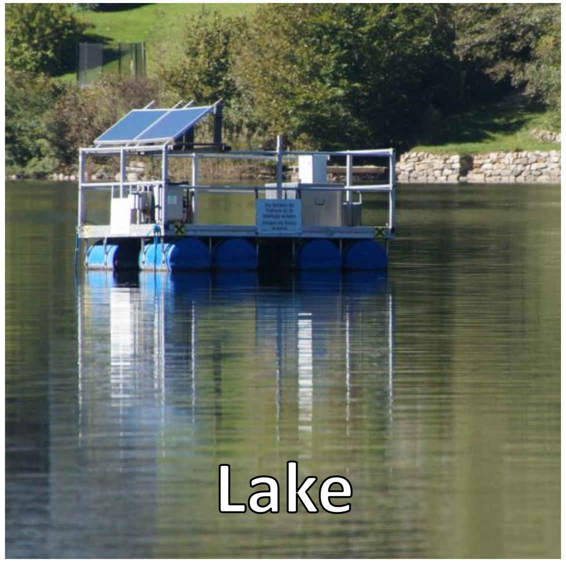
Map of automatic monitoring stations



Automatic monitoring stations

Continuous measurements (every 10 min) at the outlet of the lake

- S:can Spectrolyzer for total organic carbon, dissolved organic carbon, and nitrate



Profiles at the deepest point of the lake 3 times a day from April/May to November

- Multiprobe HL7 (Ott Hydromet) with sensors for temperature, turbidity, oxygen, electrical conductivity, pH, and chlorophyll a
- S:can Spectrolyzer for total organic carbon, dissolved organic carbon, and nitrate

Continuous measurements (every 10 min) in Oberer Seebach at the inlet of the lake

- Multiprobe EXO3s (ecoTech GmbH) with temperature, turbidity, oxygen, electrical conductivity, and pH
- S:can Spectrolyzer for total organic carbon, dissolved organic carbon, and nitrate
- Mini CO_2 sensor (Pro-Oceanus)
- Weather station with PAR, wind, and temperature sensor
- Upstream two water level sensors

Continuous measurements (every 1 h) at two spots in the catchment of Lake Lunz

- Multiprobe EXO3s (ecoTech GmbH) with temperature, turbidity, oxygen, electrical conductivity, and pH
- S:can Spectrolyzer for total organic carbon, dissolved organic carbon, and nitrate
- Water level sensor

Manual monitoring – outlet of lake

- Total organic carbon
- Dissolved organic carbon
- Nitrate

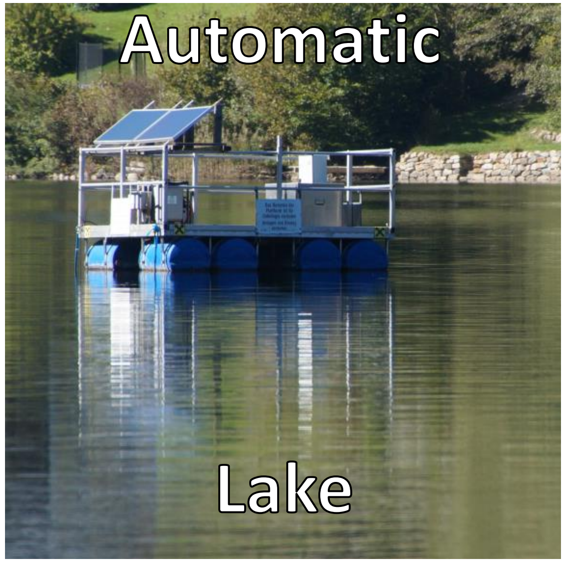
<u>Manual sampling once per month</u>

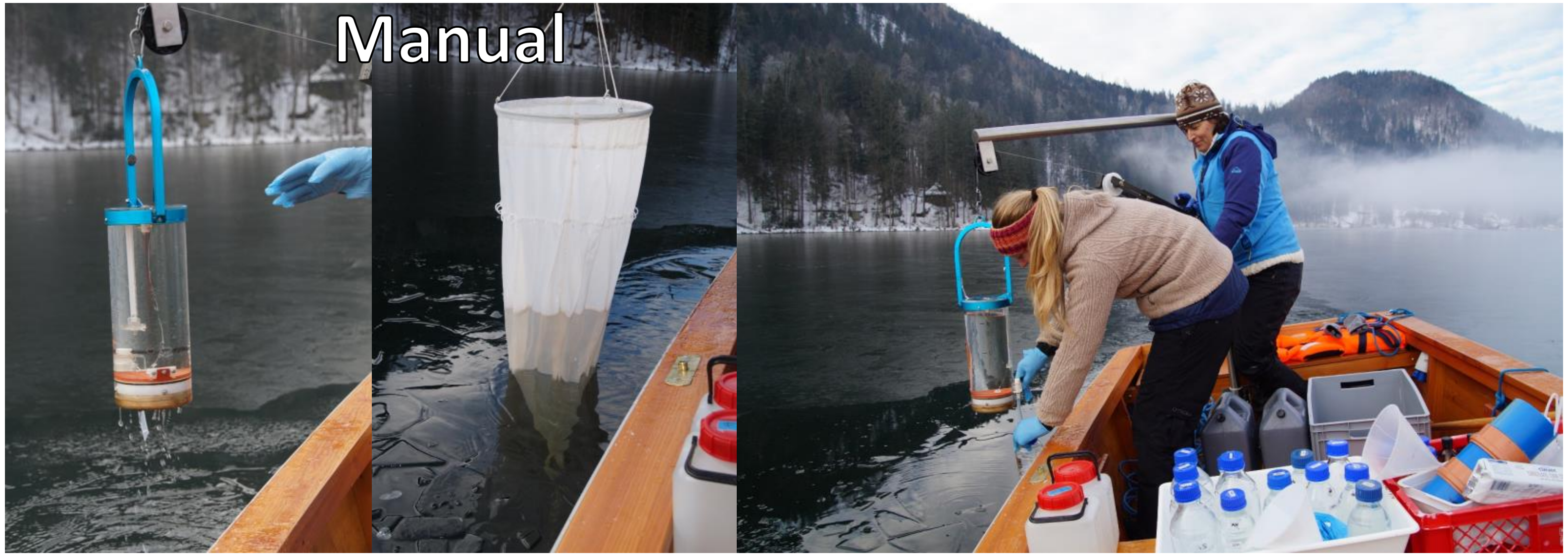
- Total phosphorus and soluble reactive phosphorus
- Nitrate, nitrite and ammonium

<u>Manual sampling every Monday</u>

- Dissolved organic carbon (Shimadzu)
- Dissolved organic matter (absorbance and fluorescence)

Manual monitoring – lake





- Temperature
- Oxygen (DO)
- Electrical conductivity
- pH
- Chlorophyll a
- Total organic carbon
- Dissolved organic carbon
- Nitrate

<u>Manual sampling once per month</u>

- Total phosphorus and soluble reactive phosphorus
- Nitrate, nitrite and ammonium
- Dissolved organic carbon (Shimadzu)
- Dissolved organic matter (absorbance and fluorescence)
- Organisms: Phytoplankton (& Pigments) & Zooplankton & Microbial community (molecular analyses)

Manual monitoring – inlet

- Temperature & Turbidity
- Oxygen (DO) & pH
- Electrical conductivity
- Total organic carbon
- Dissolved organic carbon
- Nitrate
- Carbon dioxide (CO_2)
- Photosynthetic Active Radiation
- Wind & Air temp

<u>Manual sampling once per month</u>

- Total phosphorus and soluble reactive phosphorus
- Nitrate, nitrite and ammonium

<u>Manual sampling every Monday</u>

- Dissolved organic carbon (Shimadzu)
- Dissolved organic matter (absorbance and fluorescence)

Manual monitoring – groundwater

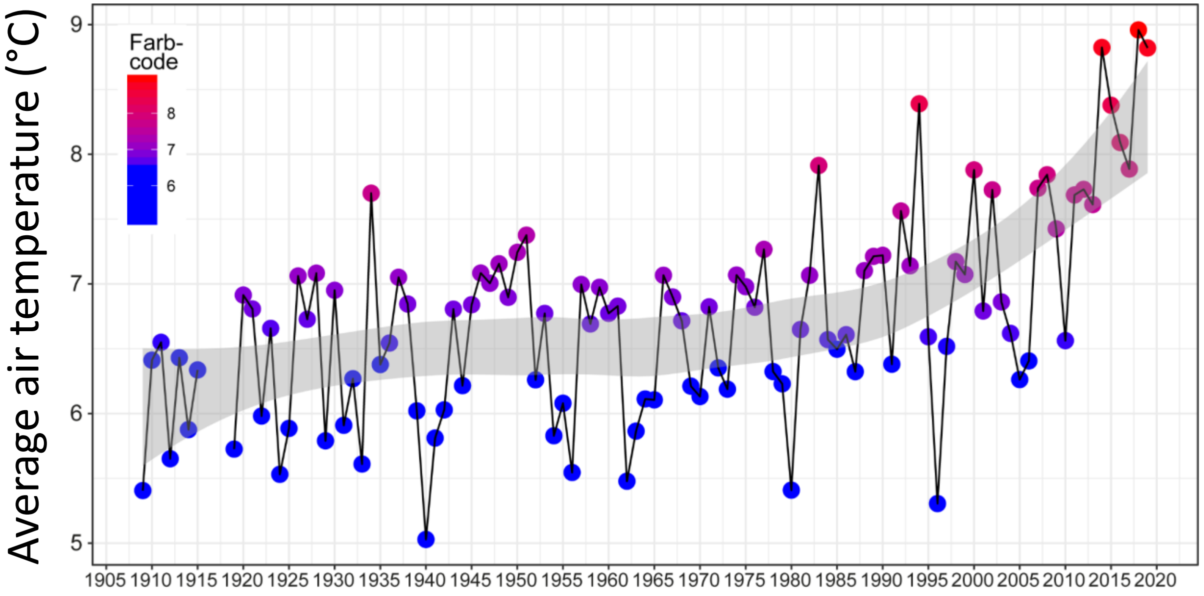
- Temperature
- Turbidity
- Oxygen (DO)
- Electrical conductivity
- pH
- Total organic carbon
- Dissolved organic carbon
- Nitrate
- Water level

<u>Manual sampling</u>

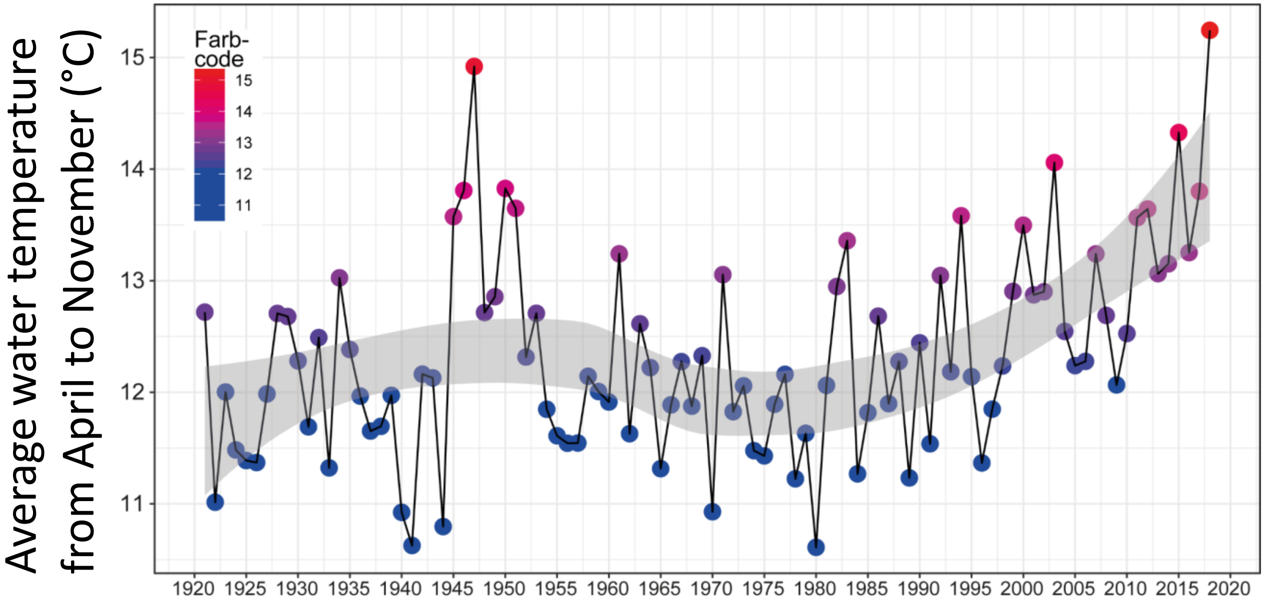
- Total organic carbon
- Dissolved organic carbon
- Nitrate
- Dissolved organic matter (absorbance and fluorescence)
- Organisms: Macrozoobenthos & Microbial community (molecular analyses)

Monitoring data - examples

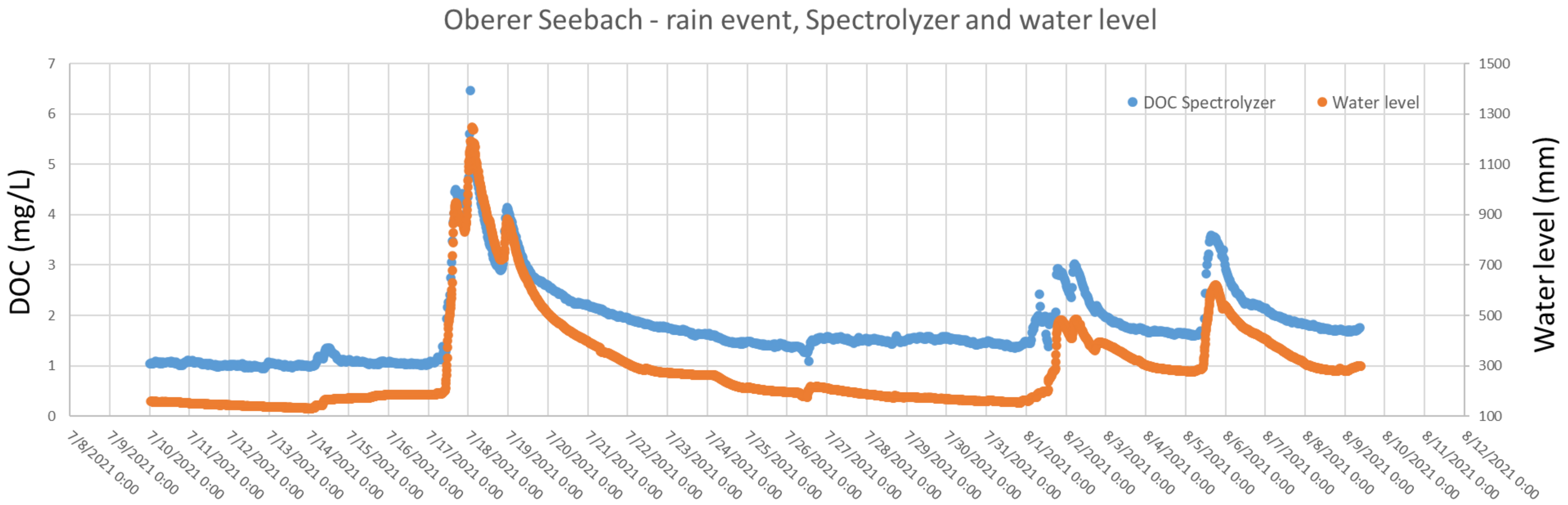
Air



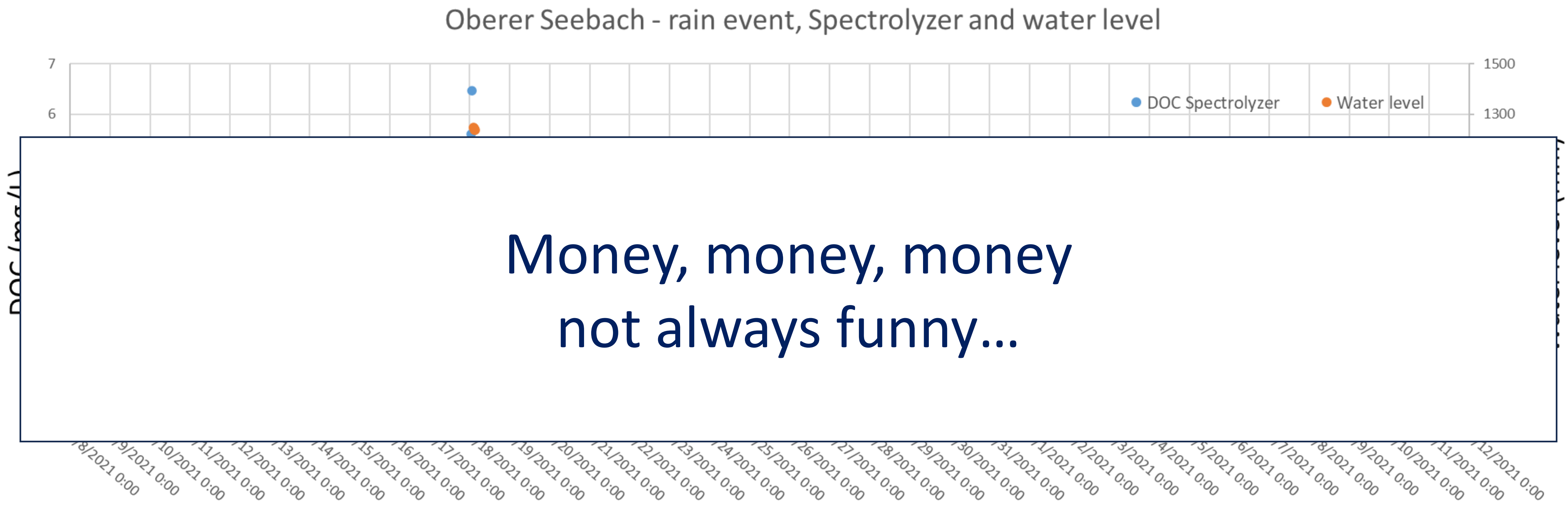
Water



Monitoring data - examples



Monitoring data - examples



Money, money, money
not always funny…

Environmental monitoring and big data – what to do?

A revolution in environmental decision-making: The emergence of Big Data has fundamentally overturned decision-making processes. Thanks to sophisticated analysis of the wide range of data collected, and to the predictive models now available, businesses- such as farmers or manufacturers- or local authorities can make informed decisions to improve their environmental impact and profitability.

FIGURE 1. An overview of the framework from recording data to data storage, analysis, and modeling, and finally, communication of the results to relevant authorities.

Montillet et al. 2024

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