Aquatic research from an altitude of 800 km

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Thanks to Copernicus – the EU Earth Observation Programme initiated in 2014 – environmental researchers now have access to vast amounts of high-quality satellite data. As this is also invaluable for aquatic research, Eawag is currently expanding its capacity in the area of remote sensing.

“That’s probably the most successful proposal I’ve ever made!” says Professor Johny Wüest, his eyes sparkling. In 2013, as a Member of the Directorate, he had suggested that Eawag should recruit a remote sensing specialist. Following an in?depth evaluation and extensive negotiations between Eawag Director Janet Hering and Michael Schaepman (now Vice President for Science at Zurich University), Wüest’s modest proposal turned into something much bigger: Eawag is now developing a joint research cluster with the Department of Geography at Zurich University.

The growing team includes Alexander Damm, who since August 2017 has held a joint assistant professorship in Remote Sensing of Water Systems at Eawag and Zurich University, and Daniel Odermatt, head of the Remote Sensing research group at Eawag since April 2018.

Growing potential of remote sensing for aquatic research

The world’s first civil Earth-observing satellite was Landsat 1, launched by NASA in 1972. As well as cartographic, meteorological and agricultural information, it provided large amounts of hydrological data, particularly for oceanography and coastal studies. Since then, the technical possibilities offered by remote sensing for aquatic research have steadily increased: with the aid of data acquired from space, scientists can now determine, for example, water depth, levels and temperatures, turbidity, precipitation, evaporation, soil moisture, coastlines and river paths, algal distribution and sediment patterns.

The Copernicus programme, initiated in 2014, represents a quantum leap for environmental research, for the first time systematically providing global – and freely accessible – information on a wide variety of atmospheric, terrestrial and marine environmental indicators. Three of a total of six planned Sentinel satellite families have already been launched. They measure electromagnetic radiation from the visible through the infrared to the microwave range of the spectrum. Daniel Odermatt says, “Today, these satellites allow us to make daily observations of phytoplankton, cyanobacteria, inorganic suspended solids and surface water temperature in lakes around the world.”

Inland water monitoring

One important forerunner of Copernicus was the FRESHMON project (High Resolution Freshwater Monitoring, 2010–2013), in which Johny Wüest and Daniel Odermatt of Eawag participated, carrying out studies on Lakes Greifensee and Constance. In Europe, there are more than 500,000 natural lakes larger than one hectare. EU countries are required to monitor the ecological status of surface waters – which, for lack of time and financial resources, would not be feasible using conventional methods. In the FRESHMON project, therefore, various remote sensing techniques for monitoring water quality and water depth were improved, harmonized and integrated with hydrodynamic models.

Remote sensing projects at Eawag

Wüest explains, “For Eawag, as FRESHMON shows, the use of remote sensing data is nothing really new.” He himself also took part in a research project involving Eawag, EPFL and Bern University, which aimed to identify the optimal site for a new lake water intake to provide drinking water supplies for Biel. Here, terrain data from airborne surveys helped to assess lake slope stability around the Aare and Schüss tributaries.

Other Eawag scientists use remote sensing data, for example, for the classification of vegetation in river catchments (e.g. Florian Altermatt), for watershed-scale hydrological modelling (Karim Abbaspour), for the modelling of hydrodynamic processes in Lake Geneva (Damien Bouffard), or for urban flood modelling (Joao Leitão). According to Wüest, the list of researchers already working with remote sensing data is, of course, much longer, but clearly, with the new research cluster, Eawag’s efforts are to be intensified: “Remote sensing methods offer a unique opportunity to obtain comprehensive information and to improve our understanding of the spatial dynamics of environmental systems.” In the past, he adds, research was dependent on models and in situ measurements, but now – thanks to increasingly precise and readily available data provided by satellites or aircraft – scientific methods are rapidly changing.

And what about the question of costs? Fortunately for industry and for science, says Wüest, information from programmes such as Copernicus is made accessible as open data – otherwise, the costs of research would frequently be prohibitive.

Looking ahead

In summer 2018, an experimental platform is to be installed on Lake Geneva in a project known as LéXPLORE, led by the EPFL Limnology Centre. Here, data will be collected automatically on numerous classical parameters including water temperature, salinity, and oxygen, chlorophyll and particle content. In addition, various spectroscopic parameters will be measured with the aid of autonomous underwater vehicles (previously mainly used in seawater, like Tethys from Mbari). The combination of in situ measurements with remote sensing data offers the prospect of new insights in freshwater research and a great potential for the modelling of three-dimensional processes in lakes and coastal waters.

In addition, in the coming years, researchers led by Zurich University are planning to develop a remote sensing system known as ARES (Airborne Research Facility for the Earth System). This will deliver data from the Earth's various spheres, providing information, for example, on surface waters and adjacent vegetation or on snow and ice distribution.

Preparations are also underway for a European Space Agency (ESA) project – the Fluorescence Explorer (FLEX) satellite mission, in the planning of which Alexander Damm is involved. FLEX, which is to be launched in 2022, will for the first time monitor global chlorophyll fluorescence in terrestrial vegetation, with unprecedented spatial and spectral resolution. This is expected to generate new knowledge on photosynthetic activity.

Information on water quality from fluorescence measurements

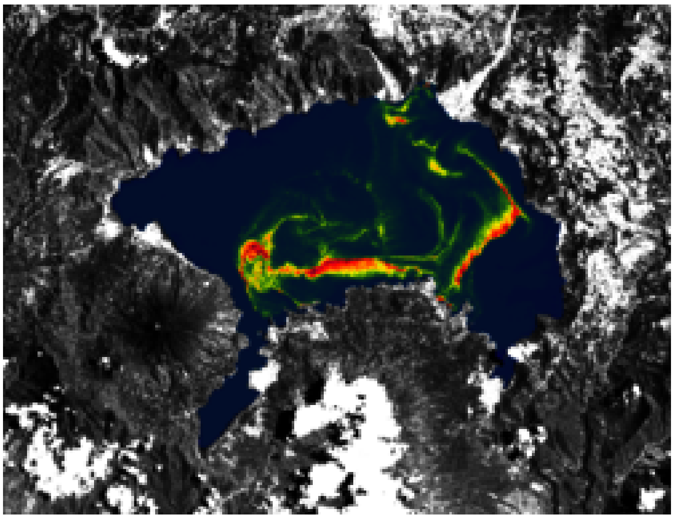
In aquatic remote sensing, the fluorescence signal has long been used to identify phytoplankton and (potentially toxic) cyanobacteria. As Damm explains, the FLEX mission should help to further improve these measurement techniques: information on algal volume, species, photosynthesis and productivity (biomass growth) can be used to assess water pollution or to study (e.g. carbon dioxide) exchange processes between surface waters and the atmosphere. The data can thus be integrated into a global instrument for the monitoring of ecosystems.

Going beyond the shoreline

The collaboration between Eawag and Zurich University has got off to a good start. Alexander Damm's research previously focused on terrestrial ecosystems; he is now investigating how vegetation influences the hydrological cycle. Daniel Odermatt has mainly concentrated on regional and global long-term studies of lakes. Both scientists agree that, as water and land fit together well, their experiences are mutually complementary. The water cycle doesn't simply stop at the shoreline, says Damm: "Aquatic systems are closely linked to the atmosphere and terrestrial ecosystems. If you want to develop solutions for major societal problems such as growing water scarcity, then you need broad, interdisciplinary knowledge on the water cycle and water quality."

Photos

On the surface of various Swiss lakes, the water periodically turns a turquoise colour. This is due to calcite precipitation. The phenomenon has been recognized for some time, but as the changes are short-lived, it has been little studied to date. Using data from the Landsat-8 satellite, scientists from Eawag and EPFL were able to describe the duration, frequency and spatial dimensions of this process in Lake Geneva. These findings, in turn, provide insights into the carbon cycle. In the coming years, as part of the above-mentioned Léxplore project, Eawag will be investigating this phenomenon more closely.
(Photo: Sentinel-2 data provided by ESA, 2017)



Cyanobacterial (Anabaena spiroides) blooms in Lake Atitlán (Guatemala). The cyanobacteria are irregularly distributed across the lake. The data acquired by the Landsat-8 satellite in August 2015 demonstrate the advantages of wide-range imaging over field sampling: they provide a more comprehensive picture, with a lower risk of non-representative measurements. (Photo: D. Odermatt, ESA DUE programme, SPONGE project)

As part of the preparations for the FLEX mission, Eawag PhD student Remika Gupana and Alexander Damm travelled to Italy in June 2018 to collect water samples aboard a research vessel and measure phytoplankton fluorescence using an automated field spectroscopy device. At the same time, the study area was overflown by two Sentinel satellites and by an aircraft with a comparable sensor. One of the aims of this research is to find out to what extent different algal species can be differentiated by remote fluorescence measurements. (Photo: Luca Fiorani, ENEA)

Contributing to the UN 2030 Agenda for Sustainable Development

The Sustainable Development Goals (SDGs) adopted under the United Nations 2030 Agenda came into effect in January 2016. High priority is accorded to clean, accessible water, improved sanitation and the protection of aquatic ecosystems (Goal 6). To help track progress in achieving the SDGs, a global indicator framework was agreed by the UN Statistical Commission in March 2016.

In many areas – e.g. assessment of water quality or measurement of water resources – monitoring poses challenges at the national level. Here, the Eawag/Zurich University remote sensing team wishes to contribute by making available to the federal authorities not only data on water quality, water availability or water use efficiency, but also increasingly comprehensive quantitative information on the capacity of ecosystems (e.g. as CO_2 sinks).

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