ANNUAL REPORT 2024

LIMNOLOGY CENTER

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1. Objectives

The Limnology Center at EPFL aims to advance research on lake ecosystems, with a particular focus on Lake Geneva. It supports interdisciplinary studies, operates the LéXPLORE platform as a hub for aquatic science and innovative technology development, and fosters collaboration among scientists and society.

2. Promote interdisciplinary collaborations

Networking

The Limnology Center team oversees the collection of settling matter using sediment traps, which are currently deployed from LéXPLORE for multiple projects in collaboration with various institutions:

- Eawag-EPFL, Ecotox Center: Determine the effects of suspended matter on ostracods (LéXPOSTRAC) 2023-2024.
- Eawag, Sedimentology Group: Establish radiocarbon inventories of dissolved and particulate carbon phases (RICH) 2022-2024.
- Eawag, Sedimentology Group: Characterize the fluxes of nutrients, organic and inorganic carbon, as well as minerals (SEDTRAP) 2019-present.
- EPFL, Center for Imaging: Analyze the images of particles taken by a holographic camera (Lake Snow) 2023-present.
- EPFL-ENAC, Central Environmental Laboratory: Assess the deposition and accumulation of microplastics in lake sediments (Microsed) 2019-present.
- UNIL, Past, Present and Future of Alpine Lakes: Quantify the sedimentation of fecal pellets and zooplankton (GEN-Z) 2024-present.

In partnership with EAWAG - Remote Sensing Group, UNIL-ColLaboratoire and Association pour la Sauvegarde du Léman, the LIMNC team leads a major citizen science project, Lémanscope, aimed at bridging science and society while raising awareness of Lake Geneva's ecological state (Lémanscope) 2023-present.

In addition, the LIMNC team collaborated closely with the following partners, who had an active project (acronym in parenthesis) on LéXPLORE.

Projects which started in 2024:

- EPFL-ENAC, SENSE: Test and improve the SubOcean probe (SubOcean++); Design and build a probe for continuous monitoring of dissolved CO2 in seawater (SENSE-pCO2) 2024-present.
- UNIGE, Microbial Ecology Group: Investigate dynamics of phytoplankton (ALGA) 2024-present.
- UNIGE, School of pharmaceutical sciences, Department of Microbiology and Molecular Medicine: Identify antimicrobial and anti-virulence compounds from fungal microorganisms (MycoMediX) 2024-present.
- UNIL, Past, Present and Future of Alpine Lakes: Quantify zooplankton link in lakes: Lake Geneva as a sandbox (GEN-Z) 2024-present.
- UNIL, Institute of Earth Surface Dynamics (IDYST): Understand the Interflow of the Rhône River in Lake Geneva (RIDLE) 2024-present.
- Pepperdine University, Seaver College's Natural Science Division: Quantify Lake Geneva biological metabolism and validate a novel pCO2 sensor system (SIPCO2) 2024.

Earlier projects still running in 2024:

- Eawag, Microbial Ecology Group: Study bacterial resistance to antibiotics (ARTFUL) 2023-present.
- UNIGE, The climate and non-linearity group: Determine the effects of wind on waves (Wind2Waves) 2023-present.
- UNIGE, Microbial Ecology Group: Investigate biofilm on microplastics (Plastiphere) 2023-present, and parasites on diatoms (Asterionella) 2023-present.
- EPFL-ENAC, Central Environmental Laboratory: Quantify Quagga mussels within the EPFL water cooling system (QuagPlore) 2023-present.
- UMR CARRTEL: Investigate carbon dioxide and methane through different methods (CarboLéX) 2023-present.

- Eawag, Remote Sensing Group: Quantify primary production (Lake3P) 2022-present.
- EPFL-SB, Laboratory of Astrophysics: Use a lake telescope to detect cosmic ray particles from the Milky Way Galaxy (LACTEL) 2022-present.

- UNIL, Forensic Science: Quantify the contamination of pollutants (Aqua-Gabs) 2021-present.
- UNIL, GAIA lab: Characterize the precipitation in Lausanne area (RainGauge) 2021-present.
- UNIGE, The Bakker Group: Measure arsenic with innovative in situ probes (SyBam) 2021-2024.
- Eawag - UNIL, Aquatic Physics Group: Measuring turbulence at high frequency (LéWalk) and measure skin to bulk temperature (Skin2Bulk) 2020-present.
- EPFL-ENAC, Environmental Microbiology Laboratory: Test an innovative device to measure DNA in the field (GenoRobotics) 2020-2024.

Workshop

The Limnology Center successfully hosted the 4th LéXPLORE workshop on 5th September 2024, bringing together 44 scientists from 10 institutions to promote networking and collaboration. The event featured presentations on four major research projects, 15 pitches, and an engaging poster session. Florian Breider from EPFL delivered the keynote address, sharing valuable insights into tracking microplastics in Lake Geneva's water column and sediments.

3. LéXPLORE Management

Business plan

On 26th February 2024, Damien Bouffard was nominated as the president of the LéXPLORE Steering Committee.

The committee finalized a vision document in June 2024 outlining the platform's strategic direction beyond 2026. This document was prepared to further emphasize LéXPLORE's critical role in enabling high-frequency measurements of Lake Geneva's, physical, chemical and biological processes. Since its launch in January 2019, LéXPLORE has become a pivotal research hub for Swiss lake studies, hosting 197 researchers, producing 25 publications, and supporting 11 SNSF projects. The platform has facilitated interdisciplinary collaborations, advanced limnology, and contributed to international standards through the online data portal, DATALAKES. It has also enhanced education and strengthened partnerships with lake management entities, such as CIPEL.

In parallel, in July 2024, the Operational Director submitted a document to the Canton of Vaud requesting an extension of the current concession until December 2036. Following a public consultation, the LIMNC, ENAC and EPFL legal department have dealt with three oppositions.

The Operational Director, continued the initial discussions with the EPFL Controlling Department, to analyse the costs and usage of the platform. Together they have defined the operational and unit costs for LéXPLORE, so that it can be recognized as an eligible platform by the SNSF. The tariffication has been discussed and reviewed within the Steering Committee. The final version together with the new financial management will be validated early 2025.

Safety perimeter

The Limnology Center efficiently managed LéXPLORE daily operations, addressing key technical challenges. The broken buoy cables (B1 and B9) were repaired by April 2024, and six buoys (B2, B3, B4, B5, B6, B7, and B8) were inspected in January 2024. These inspections confirmed the stability of Dyneema ropes, enabling heavy equipment installations for LACTEL and CARBOLEX projects.

The technical team commissioned the ENAC workshop to build extensions for the navigation lamps, aiming to minimize the number of broken lamps during strong current events. Additionally, new lamps have been purchased.

Improve the quality of the core dataset

The LIMNC technicians maintained their focus on improving data quality through regular cleanings and calibrations. The main efforts are summarized below:

- Two multiparameter probes (Sea and Sun & Idronaut) allowed for seamless rotation during calibrations.
- A new Turner Designs C-Fluor submersible sensor has been acquired, and both Idronaut probes are now equipped with these sensors to measure chlorophyll levels in the water column.
- The second meteorological station was installed in May 2024, allowing the original station to be sent for factory calibration without disrupting data collection.
- The preparation and testing of the new inductive temperature chain has begun, aiming for deployment and integration into the core dataset and DATALAKES by early 2025.
- Updated maintenance protocols now include biannual cross-calibrations involving all sondes and sensors, ensuring robust and reliable operations. This also allows for two

cross-comparisons per year between the various CTDs (Sea and Sun and Idronaut) and Thetis.

- Jérémy Keller refined the temperature chain data by removing outliers and enhancing its quality. He also converted the detailed metadata into a user-friendly format, that will be publicly accessible on the DATALAKES website. These metadata from the core dataset are used to highlight significant events directly on the website.

In conclusion, all instruments in the core dataset have been calibrated this year, leading to improved data quality.

4. Major equipment acquired

The following equipment were purchased for the LéXLORE platform through the common fund, shared between all the partners:

- Idronaut: one Turner Design C-Fluor Chlorophyll sensor and three 120m long coaxial communication cables.
- Weather station: New CS301 pyranometer purchased for the second weather station in anticipation of the May swap. The other sensors were just calibrated.
- Lamps extension lamps and buoys for the perimeter.

5. Human resources

Tom Battin	Director ad Interim
Natacha Tofield-Pasche	Operational Director
Guillaume Cunillera	Chief Technical Officer
Jérémy Keller	Technician Specialist
Laurence Glass-Haller	Administrative assistant and scientist managing the project Lémanscope, started working on 15th January 2024

6. Communication and outreach

The LIMNC team have organised the logistics and participated in 19 visits of LéXPLORE for different groups, including 6 public visits for ~180 persons.

During the reported period, the following various communication, events, and outreach activities—primarily related to the Lémanscope project—took place. Additional communication efforts related to the LéXPLORE platform can be found on its website (www.LéXPLORE.ch).

On TV

11.03.2024 : RTS – Couleurs locales

07.03.2024 : France 2 – Réchauffement climatique : le lac Léman menacé par des températures élevées

14.01.2024: RTS – La météo glaciale actuelle favorise le brassage des eaux du lac Léman

On Radio

16.08.2024 : RTS – Les scientifiques innovent pour comprendre le réchauffement des lacs suisses – rts.ch – Sciences-Tech

15.08.2024 : RTS – Quelles conséquences après les températures records des lacs? Interview de Natacha Tofield-Pasche – rts.ch – Portail Audio

03.03.2024 : RFI – Réchauffement climatique: le lac Léman se réchauffe 4 à 5 fois plus vite que les océans

In the newspapers

03.06.2024: UNIGE Jump-to-science, Agir plutôt que s'angoisser : projet citoyen Lémanscope

10.05.2024: Eawag, Cherche 500 bénévoles pour mesurer la clarté des eaux du Léman

10.05.2024: EPFL news, Cherche 500 bénévoles pour mesurer la clarté des eaux du Léman, published in Myscience, Arcinfo, RadioLac and Sciena

10.05.2024: Le Matin, L'EPFL cherche 500 bénévoles pour scruter le Léman

10.05.2024: Tribunal de Genève, L'EPFL veut évaluer la santé du Léman

10.05.2024: 24heures, L'EPFL veut évaluer la santé du Léman

10.05.2024: Le Temps, La santé du Léman au cœur d'un projet participatif

10.05.2024: la Liberté, Un œil sur la santé du lac Léman

10.05.2024: Le Dauphiné libéré, Et si vous deveniez « co-chercheurs » pour sonder le Léman

10.05.2024: Le courrier, Un projet pour évaluer la santé du Léman

09.05.2024: RTS l'Info, L'EPFL lance un projet participatif pour évaluer la santé du Léman

08.03.2024: Euronews, Lake Geneva is warming at an alarming rate and its delicate ecosystem is under threat

21.02.2024: 24heures , «Le Léman va mieux que dans les années 80 mais…»

The LIMNC also regularly updated the websites www.lexplore.ch and for the Limnology Center.

7. Research activities within LIMNC

Lémanscope

The SNF AGORA project Lémanscope, a major citizen science project in collaboration with EAWAG, UNIL and the Association pour la Sauvegarde du Léman (ASL), was launched at EPFL on the 30th of April 2024, attracting 130 participants. Its main objective is to connect science with society and raise awareness about Lake Geneva's ecological state. Participants are trained to measure environmental parameters like water colour and transparency using provided equipment. Following this launch, press releases, articles in newspapers like **24heures** and **Le Temps**, and coverage on Swiss Television (**RTS**) further boosted awareness, leading to the enrolment of over 600 citizens with access to boats or other embarkations on Lake Geneva. Since the beginning of the project, more than 2400 measures were taken by citizens. The entire lake is covered, particularly in areas close to the shores. Preliminary comparisons between in-situ measurements and remote sensing products are consistent with previous comparisons, indicating a good quality of the data collected by citizens. This project also fosters public-scientist dialogue through workshops, webinars on specific themes and LéXPLORE public visits. A webinar, in regards to the mixing of Lake Geneva, attracted more than 100 participants on 25th November 2024.

SEDTRAP

The LIMNC team investigates the suspended particles in Lake Geneva. For this, they have continued to deploy the four sediment traps near LéXPLORE, in collaboration with the Central Environmental Laboratory, the Ecotox Center and UNIL. The SEDTRAP project is a collaboration with Nathalie Dubois and David Janssen from Eawag.

LAKESNOW

Within the Lake Snow project, the goal is to investigate suspended particles and the effect of the Rhône River interflow on their flocculation. Three students have acquired images with the

LISST-Holo2: Louise Noël du Payrat for a semester work, Armelle Bouhali for her Master Thesis, and Itsaso Lopez during a summer internship. In addition, we have collaborated with EPFL Center for Imaging during a machine-learning project to better identify and segment the observed particles.

Lake3P

In the field of remote sensing, the LIMNC team has collaborated with Daniel Odermatt in the SNF project Lake3P. Guillaume Cunillera ensures the operations of the Thetis profiler, and Natacha Tofield-Pasche participates actively in the meetings.

Pockmarks

We investigated one active pockmark in Lake Geneva for potential geothermal use. It was a collaboration with the « Division Géologie, Sols, Déchets et Eaux Souterraines » (DGE GEOD). Further investigations are scheduled in 2025.

Conferences

- Natacha Tofield-Pasche, Nathalie Dubois, David Janssen, Guillaume Cunillera: **Temporal and vertical variations of the settling particles fluxes in Lake Geneva**. Presentation. 37th SIL International Congress on Limnology, 7-9.05.2024, Iguassu, Brazil.
- Swiss Geoscience Meeting, 8-9.11.2024, Basel:
    - Natacha Tofield-Pasche: co-chair Limnology and Oceanography session
    - Laurence Haller, Daniel Odermatt, Adrien Bonny, Alexis Pochelon, Suzanne Mader, Alexandre Camus and Natacha Tofield-Pasche. **Lémanscope: Empowering Citizen Science to Monitor Lake Geneva's Water Quality**. Poster
- Laurence Haller, Daniel Odermatt, Adrien Bonny, Alexis Pochelon, Suzanne Mader, Alexandre Camus and Natacha Tofield-Pasche. **Lémanscope: Empowering Citizen Science to Monitor Lake Geneva's Water Quality**. Presentation. Journée Eau, Spatial et Gouvernance, Cluster Eau Lémanique, 07.11.2024, Evian-Les-Bains.
- Laurence Haller, Daniel Odermatt, Adrien Bonny, Alexis Pochelon, Suzanne Mader, Alexandre Camus and Natacha Tofield-Pasche. **Lémanscope: Empowering Citizen Science to Monitor Lake Geneva's Water Quality**. Presentation. Geneva Forum, session on citizen science, 11.12.2024, Geneva.

Peer-reviewed publications

There are no direct publications for the LIMNC team. However, the LIMNC has allocated 2.8 full-time equivalent positions (85% of its personnel resources) to the management and research coordination of projects from LéXPLORE. In 2024, four peer-reviewed publications resulted from projects conducted at LéXPLORE and are referenced in the LéXPLORE annual report.

Current consulting and expert activities

- Member of the Scientific Committee of CIPEL
- Member of the Committee for the Swiss Society Limnology and Hydrology
- Advisory for the Kivu working group of the African Center for Aquatic Research and Education

Proposals

- **PI for SNSF**: Combining images of lake snow with settling fluxes, to assess flocculation in the Rhone interflow (LakeSnow). The LakeSnow project aims to quantify the fate of particles in a river-lake transition zone beneath LéXPLORE. CHF 542'560, 2025-2028, (submitted).
- **ORD Call**: **F**AIRifying **L**éXPLORE: enhancing open research data pipelines for **A**dvanced La**K**e Scienc**E** (FLAKE). This project aims to enhance the robustness of the LéXPLORE platform data pipeline and to improve the quality control processes of the DataLakes platform. CHF 30'000, 2025 (6 months), (submitted & accepted).
- Accepted letter of intent, submitted on 30th November 2024, for organising the World Lake Conference in Lausanne, in collaboration with Eawag, the Swisstech Convention Center and the Lausanne, Montreux Congress. A detailed proposal will be submitted at the end of January 2025.

8. Education

Teaching activity

Limnology course, ENV-425 for 14 Master students, spring term 2024, Environmental Engineering, EPFL. 9 students were trained to take measurements on LéXPLORE platform.

Student supervision

- Master thesis, Lake Snow – dynamics of the settling particulate matter in Lake Geneva, Armelle Bouhali, autumn semester 2024
- Emma Favel, Quantifying the metalimnetic oxygen minimum in Lake Geneva, Semester project, autumn semester 2024
- Aolaritei Valentin, De Laurentis Alberto, Le Bras Martin Louis, Plankton Detection and Segmentation in Lake Geneva Using Holographic Imaging with YOLO11 Nano Model. Machine Learning (CS-433) ML4Science, EPFL

Student visits on LéXPLORE

The LIMNC team supported the following visits on LéXPLORE:

- 14.03.2024: 80 bachelor students from UNIL
- 19.03.2024: 18 bachelor students from UNIGE
- 11.04.2024: 80 bachelor students from UNIL
- 24.04.2024: “Décanat” UNIL
- 14.05.2024: 9 master students from EPFL
- 16.05.2024: 11 master students from UNIL
- 17.05.2024: 11 master students from UNIL
- 18.10.2024: bachelor students from UNIL
- 25.10.2024: 28 students from EPFL and UNIL
- 04.12.2024: 14 master students from UNIGE

9. Conclusions and future direction

Despite some changes within the team, 2024 was a productive year for LIMNC. Guillaume Cunillera took on the role of Chief Technical Officer, while Laurence Glass-Haller joined in January as the new administrative assistant and scientist overseeing the Lémanscope project. Successfully launched in 2024, Lémanscope has enrolled over 600 citizens with access to boats or other embarkations on Lake Geneva, resulting in more than 2,400 measurements collected since its inception. Additionally, over four peer-reviewed papers related to LéXPLORE were published.

In 2025, the main objectives are to continue managing the platform's extension process and its strategic direction beyond 2026, while successfully advancing all ongoing research projects, including FLAKE and Lémanscope, and maintaining collaborations with the various institutions involved with LéXPLORE.

LéXPLORE workshop, EPFL, 5th Sept 2024