Annual Report 2019
January 2019 to December 2019

Margaretha Kamprad Chair
of Environmental Science and Limnology

Physics of Aquatic Systems Laboratory, APHYS at EPFL

1. OBJECTIVES

The aims of the *Physics of Aquatic Systems Laboratory (APHYS)* are to understand the physical processes in natural waters and the responses of aquatic systems to external forcing. The focus is on anthropogenic influences, such as nutrient inputs, hydropower production, heat and cold use from surface waters, climate change and human activities in the catchments. We study the effects on surface waters and their sensitivity to those drivers and outline consequences for water resources management. Besides *in-situ* measurements, we apply hydrodynamic modelling and use remote sensing information.

2. RESEARCH ACTIVITIES

2.1. Use of heat from lakes (FOEN funded)

The governmental goal of reducing fossil fuel consumption will increase the use of lake water for heating and cooling of riparian infrastructures. The aim of this activity is to estimate the potentials for various lakes in Switzerland. After we already performed various expert services for all larger lakes in Switzerland, and held a Peak course in November 2017 at Eawag, we concluded these activities by two reviews of the ecological and technical implications and requirements. The project concluded in September 2018. In 2019, one peer-reviewed and one popular article on the Swiss surface waters heat potential in Switzerland were published.

In a related follow-up project, the expected heating of the rivers and lakes in Switzerland will be systematically evaluated. For lakes, this will include, as an example, the wintertime deep convective mixing. The project runs under the leadership of Hendrik Huwald in collaboration with Martin Schmid and Damien Bouffard (both Eawag) and it is funded by FOEN from 2017 to 2020.

2.2. Autonomous underwater robots of physical-ecological studies (SNF funded)

This Sinergia project "*A Flexible Underwater Distributed Robotic System for High-Resolution Sensing of Aquatic Ecosystems*", under the leadership of Prof Alcherio Martinoli (EPFL) in collaboration with Prof Bas Ibelings (UniGE) is an interdisciplinary project combining AUV robot technology and performing applied research. In a first step (2016-2017) we focused on the explanation of bio-induced mixed layers caused by excessive high concentration of upward swimming sulphur bacteria *Chromatium okenii* in Lake Cadagno. In the second stage of the project, we focused on two subprojects in Lakes Zurich and Geneva, respectively. The first one is about resolving the small-scale heterogeneity of the phytoplankton layer of the filamentous cyanobacteria *Planktothrix Rubescens* in the upper thermocline of Lake Zurich. For the second subproject, we study the mixing generated by the gyres that develop in Lake Geneva during summer and its effect on phytoplankton distribution. Prof Alexander Forrest (UC Davis, USA) spent the summer 2018 as a Visiting Professor with APHYS. This collaboration granted the opportunity to use the UC Davis Slocum glider. Designed to travel long distances in the lake, the Slocum is an idoneous platform to study lateral variability of various water parameters (temperature, algal pigments, etc) and small-scale turbulence in Lake Geneva.

2.3. Lake Ladoga (Limnology Center funded)

The main goal of this project is to study the development of under-ice convection in Lake Ladoga (Russia) and its implications for algae growth under ice. The project is managed by the Limnology Center and includes eight different teams from Switzerland, France, Germany and Russia. However, since the ice-cover on Lake Ladoga was too weak during March 2015, 2016, and 2017 to guarantee safe fieldwork conditions, our observations and experimental work focussed on Lake Onego instead. The study is part of an interdisciplinary research project with the aim to better characterize:

(i)   the radiative energy transfer responsible for the onset of under-ice convection,

    (ii)   the vertical velocities induced by the convective cells and,

    (iii)   the development of phytoplankton under ice.

Our research approach consists in collecting and analysing field data in parallel to comparing with numerical simulations. A conceptual model for the mechanical energy budget in radiatively-heated ice-covered lakes was developed to quantify mixing rates in such systems. The introduced and recently published framework was tested with in-situ observation collected during the field campaigns in Lake Onega. This work provides the fundaments to continue a numerically-based research that aim to understated the under-ice water circulation resulting from radiatively-driven convection. The project was finished in 2018 and the special, issue in *Inland Waters* was published in July 2019.

2.4. Hydrodynamic modelling including data assimilation (CORESIM, ESA funded)

This research project is tight to Damien Bouffard, who is building up an Aquatic Physics group at Eawag. However, the PhD student of the project remained at APHYS to complete his PhD at EPFL.

The aim of this project is to understand spatial variability of biogeophysical processes in lakes. New information provided by remote sensing data coupled to three-dimensional models allows investigating such variability. The approach is to couple all information sources of lake research (remote sensing data, field observations and numerical models) through adapted data assimilation algorithms. The coupling of those three data sources aims at providing a new, reliable, flexible, and global modelling framework for inland waters monitoring across Switzerland, Europe and possibly expanding to other lakes of the world.

The framework is operated in real-time for the four Swiss Lakes Geneva, Biel, Zurich and Greifensee, with short-term forecasting of hydrodynamic and water quality properties, available online, and open to the public. The impacts of such systems are expected at public, governmental and scientific levels. For the latter, this project aims at contributing to advances in aquatic research by (i) identifying and studying mesoscale processes such as up- downwellings, horizontal distribution of ecological properties, and (ii) assessing the variability of lake responses to climate change, such as ice cover.

The online platform can be viewed on www.meteolakes.ch.

2.5. Primary production in lakes under reoligotrophication

This project focuses on short- and long-term developments of primary production (PP) in the large lakes of Switzerland, which are currently recovering from past eutrophication. Phosphorous levels have declined massively in most lakes. However, the various responses of PP in individual lakes are not well understood. In this project, we couple physical, chemical and biological observations in an interdisciplinary framework to resolve the dynamics of PP and its drivers over various spatial and temporal scales. We obtain high-resolution in-situ measurements to assess PP at the diel scale and combine these observations in a modelling approach with data from several governmental long-term monitoring programs. In additions, we use satellite images and 3D-hydrodynamic modelling to assess the variability in primary production at the basin-wide scale. More specifically we:

(i) Employ the diel oxygen and carbon dioxide method to quantify primary production and metabolic balances by using in-situ measurements (data are shared among people within the CARBOGEN project by Marie Perga at UNIL, which aims at quantifying the carbon budget of Lake Geneva).

(ii) Operate an autonomous and high-resolution profiling system ("Thetis") to resolve water optical properties that serve as calibration for remote sensing data for spatial extrapolation (collaboration with Daniel Odermatt at Eawag).

(iii) Quantify the kinetic and potential energy and turbulent mixing and dissipation at different scales of variability to resolve the pathways for energy dissipation and their implications for PP and gas exchange.

(iv) Simulations of nutrients and phytoplankton dynamics using coupled physical-biogeochemical model systems, and statistical and model-based analyses of in-situ data.

The primary study site of this project is the LéXPLORE platform on Lake Geneva, where measurements have started since the installation of the protective circle in October 2018. Further study sites include Lakes Lugano and Constance, for which similar long-term monitoring data exist. These lakes are being studied through collaborative sub-projects with partner Universities (SUPSI, University of Konstanz), and managed by the Limnology Center.

A FOEN (Federal Office) proposal for PP estimates for practitioners, based on the usual routine monitoring data sets, has been submitted in 2019, with the intention to start 1 October 2019.

3. MAJOR ACQUIRED EQUIPMENT

We had the opportunity to complete our field instrumentation with grants from the Kamprad Chair, EPFL and SNF. The acquisitions in 2019 comprised:

3.1. Ten Minilog-II-T Temperature Loggers

Minilog-II-T Loggers are rugged, reliable, submersible temperature loggers with accuracy of 0.1°C and a resolution of 0.01°C.

3.2. KC Portable Winch

The KC Portable Winch (24 V, 750 W), with a maximum load of 50 kg, is ideal for CTD profiling and water sampling (left picture). It is installed on the LéXPLORE platform, but it can easily be install on small boats to sample other lakes.

3.3. Aquadopp HR Current Profiler

This pulse-coherent acoustic Doppler current profiler allows to measure profiles of currents with very high precision and resolution. It is currently installed on the bottom of Lake Geneva (centre picture) to measure bottom boundary currents and boundary turbulence in Lake Geneva for the project "*Primary production under oligotrophication in Lakes*".

3.4. PRO-Oceanus Mini CO₂ Datalogger

These mini probes are designed to measure dissolved CO_2 (right image). The sensor operates through rapid diffusion of gas from the liquid through an oil-resistant, advanced matrix interface to a non-dispersive infrared detector. The signal is compensated for both pressure and temperature. The Mini CO_2 probes will be used in the project "*Primary production under oligotrophication in lakes*".

4. HUMAN RESOURCES

(alphabetic order)

Kevin Bärenzung	Master completed in 2018; worked January 2019 for A&G publication. Scientific assistant during March 2019
Theo Baracchini	PhD student from March 2015 to June 2019
Hannah Chmiel	Post-doc since October 2016 (Primary Production Project)
Lara du Bois	Secretary of APHYS and LIMNC, since February 2019
Bieito Fernández Castro	Post-doc, since February 2019 (Primary Production Project)
Tania Gonin	Secretary of APHYS and LIMNC from November 2013 to February 2019
Ocean Hames	Master student EPFL, assistant during June 2019
Isabel Kiefer	Scientific assistant from October 2018 to February 2019
Shubham Krishna	Post-doc since May 2018 (Primary Production Project)
Sébastien Lavanchy	Technician at APHYS and LIMNC since May 2015
Camille Minaudo	Post-doc since October 2018 (Primary Production Project)
Lucas Serra Moncadas	Civil servant from 01 September to 31 August 2020
Oscar Sepúlveda Steiner	PhD student since April 2016
Cary Troy	Visiting Professor, February-June 2019 from Purdue University, USA
Hugo N. Ulloa	Postdoc since February 2017 (former U de Chile and UC San Diego)
Guillaume Ulrich	Civil servant from 29 April to 13 May 2019
Kraig Winters	Visiting professor, March-June 2019 from SIO, UCSD, USA
Alfred Wüest	Professor, Margaretha Kamprad Chair since 2012 and Director of the Limnology Center since 2013.

Visitors in 2019

- **Leon Boegman,** Queen's University, Kingston, Ontario, Canada
- **Damien Bouffard,** Eawag
- **Philip Chu,** NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan
- **Daniel Odermatt,** Eawag
- **Cary Troy,** Purdue University, Indiana, USA
- **P.N Vinayachandran,** Indian Institute of Science, Bangalore, India.
- **Kraig Winters,** University of California, San Diego, California, USA

5. NETWORKING

5.1. Oxygen depletion in lakes

- Beat Müller, Damien Bouffard, Thomas Steinsberger, Eawag
- Lars Umlauf and Peter Holtermann, Institut für Ostseeforschung, Warnemünde, Germany
- Martin Wessels, Institut für Seenforschung, Langenargen, Germany

5.2. Lake Onega Project Limnology Centre, EPFL

- Natacha Tofield-Pasche, Limnology Centre, EPFL
- Arkady Terzhevik, Nikolay Filatov, Roman Zdorovennov, Nataliia Kalinkina, Natalia Belkina, Dimitry Subetto from Northern Water Problems Institute
- Bertrand Merminod, TOPO, EPFL
- Felix Schill, HYDROMEA SA

- ➢ Martinoli Alcherio, Bahr Alexander, DISAL, EPFL
- ➢ Bas Ibelings, and Daniel Ariztegui, University of Geneva
- ➢ Marie Perga, University of Lausanne, UniL
- ➢ Victor Frossard, Camille Thomas, Emilie Lyautey from University of Savoie
- ➢ Nathalie Dubois, Mischa Haas, Damien Bouffard, Eawag
- ➢ Alexei Kouraev, LEGOS
- ➢ Hilmar Hofmann, University of Konstanz

5.3. Lago Cadagno Project (SNF fund for Prof Tonolla)

- ➢ Mauro Tonolla, Andreas Bruder and Nicola Storelli, University of Applied Sciences and Arts of Southern Switzerland (SUPSI)
- ➢ Anupam Sengupta and Francesco Danza Physics of Living Matter Group, University of Luxemburg, Luxemburg
- ➢ Damien Bouffard, Eawag

5.4. AUV applications in Lakes Zurich and Geneva (Sinergia project)

- ➢ Anwar Quraishi, Alexander Bahr and Alcherio Martinoli, DISAL, EPFL
- ➢ Felix Schill, HYDROMEA SA
- ➢ Alex Forrest and Jasmin McInerney (UC Davis, USA)
- ➢ Bas Ibelings, Ena Suarez Bolanos, Roxane Fillion and Evanthia Mantzouki, U of Geneva
- ➢ Jakob Pernthaler and Thomas Posch, University of Zurich
- ➢ Damien Bouffard, Eawag

5.5. Remote sensing

- ➢ Daniel Odermatt, and Damien Bouffard, Eawag
- ➢ Alexander Damm, Andreas Hueni and Michael Schaepman; RSL University of Zürich
- ➢ Stefan Wunderle, University of Bern
- ➢ Tiit Kutser, Estonia

5.6. Heat use and climate warming of natural waters

- ➢ Officers from Cantons of ZH, LU, TG, SG, NW, BE as well as various engineering companies such as AquaPlus Zug.
- ➢ Hendrik Huwald and Adrien Michel, EPFL
- ➢ Damien Bouffard, Martin Schmid, Love Råman Vinnå, Eawag

5.7. DATALAKES - Heterogeneous data platform for operational modeling and forecasting of Swiss lakes

- ➢ Artur Safin, Jonas Sukys, and Damien Bouffard, Eawag
- ➢ Fotis Georgatos, Swiss Data Science Center.

6. CONCLUSION AND FUTURE DIRECTIONS

Within the next three years, we envisage to pursue the following new projects:

6.1. LéXPLORE research platform on Lake Geneva

The aim of this research platform is to acquire continuous records of physical and biogeochemical properties, as well as phytoplankton and zooplankton. This platform should also promote international collaboration with other research groups interested in this facility. Major equipment was funded by

R'Equip FNS. Since 2017, we were first four partners (UniGE, UniL and Eawag besides EPFL), which committed to finance the platform construction. The platform was mounted off Pully on 19 February 2019 and inaugurated on 24 June 2019. Since mid-2019 we operate the platform with five partners (INRA Thonon-les-Bains joined the consortium in 2019). LéXPLORE is open to any scientists.

6.2. Primary productivity in large lakes

This research project started in August 2018. The goals are to explain the dependency of primary production (PP) on different levels of phosphorus forcing. Beside the reconstruction of primary production over the past decades, this project includes various goals related to new observations technology and new method of PP estimates over short time intervals (days). We plan to cooperate with partners on Lakes Geneva, Lugano-NB, Lugano-SB, Constance and other research institutions such as Eawag.

A FOEN (Federal Office) proposal for PP estimates for practitioners, based on the usual routine monitoring data sets, has been submitted in 2019. FOEN contract was signed on November 28 2019.

7. CONFERENCES IN 2019

Hannah E. Chmiel (1), Camille Minaudo (1), Pascal Perolo (2), Shubham Krishna (1), Hugo N. Ulloa, Marie-Elodie Perga, Alfred Wüest. Spatiotemporal high-resolution data provide new insights on primary production in Lake Geneva (Switzerland). **EGU General Assembly 2019**. Geophysical Research Abstracts, Vol. 21, EGU2019-15679, 2019

Philip Chu, Theo Baracchini, Damien Bouffard, Alfred Wüest, 3D hydrodynamic and bio-physical model with data assimilation – an application for Swiss Lakes, **IAGLR 2019 Conference**, NYC, 2019. Abstract ID Number: A399.

Tomy Doda, Cintia Ramon, Hugo N. Ulloa, Alfred Wüest and Damien Bouffard, October 2019. Density currents induced by differential cooling in a small temperate lake: seasonality in their occurrence and magnitude. **17th Swiss Geoscience Meeting, Fribourg 2019**

Camille Minaudo, Hugo N. Ulloa, Hannah E. Chmiel, Damien Bouffard, Théo Baracchini, Daniel Odermatt, Alfred Wüest, High-resolution scanning of the optical water column properties of a large lake: interplay between biological and physical processes. **EGU General Assembly 2019**, Geophysical Research Abstracts, Vol. 21, EGU2019-15855, 2019

Camille Minaudo, Daniel Odermatt, Damien Bouffard, Théo Baracchini, Alfred Wüest, Sub-daily variability of Inherent Optical Properties in Lake Geneva. **Sentinel 3 Validation Team meeting 2019**, ESA Frascati-Roma.

Artur Safin, Damien Bouffard, Fotis Georgatos, Eric Bouillet, Fernando Perez Cruz, Alfred Wüest, Siddhartha Mishra, and Jonas Sukys. DATALAKES - data platform and stochastic Bayesian forecasting for Swiss lakes using supercomputers. **EGU General Assembly 2019**. Geophysical Research Abstracts, Vol. 21, EGU2019-18467.

Oscar Sepúlveda Steiner, Alexander Forrest, Jasmin McInerney, Theo Baracchini, Sébastien Lavanchy, Damien Bouffard and Alfred Wüest, Lateral variability of mixing in Lake Geneva. **EGU General Assembly 2019**, Vienna, Austria, 2019. Geophysical Research Abstracts, Vol. 21, EGU2019-15064-1, 2019

Hugo N. Ulloa, Kraig B. Winters, Océane Hames, Alfred Wüest, and Damien Bouffard. Circulation and energy distribution in radiatively-heated ice-covered waterbodies: the role of topography. **EGU General Assembly 2019**, Vienna, Austria, 11 Apr 2019, Geophysical Research Abstracts, Vol. 21, EGU2019-9397, 2019

Cintia Ramón, T. Doda, H.N. Ulloa, and D. Bouffard, Density currents induced by night-time cooling: offshore transport of littoral waters. **EGU General Assembly 2019**, Vienna, Austria, 2019.

Fernández-Castro, D. G. Evans, E. Frajka-WIlliams and A.C. Naveira-Garabato. Glider-borne observations of turbulent energy dissipation in an anti-cyclonic mode water eddy. **EGU General Assembly 2019**, Geophysical Research Abstracts, Vol. 21, EGU2019-519, 2019

Shubham Krishna, Onur Kerimoglu, Fabio Lepori, Orlane Anneville, and Alfred Wüest. Coupled 1D physical-biogeochemical model system to simulate primary production in Lake Geneva. **EGU General Assembly 2019**. Geophysical Research Abstracts, Vol. 21, EGU2019-18644, 2019

Alfred Wüest, Tobias Sommer and Martin Schmid, Effects of double diffusion on heat and salt in Lake Kivu, **22nd Workshop on Physical Processes in Natural Waters**, Yichang, China, 9-14 September 2019

Alfred Wüest und P. Rust, Potenzial und Grenzen der Wärmenutzung aus Flüssen und Seen, **Eawag-Info-Tag**, 3 September, Verkehrshaus, Luzern.

Alfred Wüest., Heizen und Kühlen mit Seen und Flüssen, Treffen Contractoren-Mitglieder, **Verband Fernwärme Schweiz (VFS)**, Olten, 4 Sept. 2019

Alfred Wüest, Potentialerläuterung Oberflächengewässer, Informationsanlass: "Energiegewinnung aus dem Bodensee", **Energieagentur St Gallen**, 31. Oktober 2019, Würth Haus Rorschach

Alfred Wüest, Potentialerläuterung Oberflächengewässer, Informationsanlass: "Der Bodensee – Energielieferant der Zukunft", **Amt für Umwelt, Kt Thurgau**, 5. November 2019, Aula, Kantonsschule Romanshorn.

8. PUBLICATIONS IN 2019

8.1. Published peer-reviewed papers in 2019

Published in 2019 but not included in an issue

Chmiel, H.E., Hoffmann, H., Sobek, S., Efremova, T., and N. Pasche. Where does the river end? Drivers of spatiotemporal variability in CO_2 concentration and flux in the inflow area of a large boreal lake. *Limnology and Oceanography* **65**(x). https://doi.org/10.1002/lno.11378.

Dubois, N., L. Råman Vinnå, M. Rabold, M. Hilbe, F.S Anselmetti, A. Wüest, L. Meuriot, A. Jeannet and S. Girardclos (2018). Subaquatic slope instabilities: the aftermath of river correction and artificial dumps in Lake Biel (Switzerland). *Sedimentology* **67**: doi: 10.1111/sed.12669

Published in 2019 and included in an 2019 issue

Abbott, B. W., Bishop, K., Zarnetske, J. P., Minaudo, C**.**, Chapin, F. S., Krause, S., Hannah, D. M., Conner, L., Ellison, D., Godsey, S. E., Plont, S., Marçais, J., Kolbe, T., Huebner, A., Frei, R. J., Hampton, T., Gu, S., Buhman, M., Sara Sayedi, S., Ursache, O., Chapin, M., Henderson, K. D. and Pinay, G.: Human domination of the global water cycle absent from depictions and perceptions, *Nature Geoscience*, **12**(7), 533–540, doi:10.1038/s41561-019-0374-y, 2019b.

Abbott, B. W., Bishop, K., Zarnetske, J. P., Hannah, D. M., Frei, R. J., Minaudo, C., Chapin, F. S., Krause, S., Conner, L., Ellison, D., Godsey, S. E., Plont, S., Marçais, J., Kolbe, T., Huebner, A., Hampton, T., Gu, S., Buhman, M., Sayedi, S. S., Ursache, O., Chapin, M., Henderson, K. D. and Pinay, G. (2019). A water cycle for the Anthropocene, *Hydrological Processes*, **33**(23): 3046-3052. https://doi.org/10.1002/hyp.13544

Berg, J.S., Pjevac, P., Sommer, T., Buckner, C.R.T, Philippi, M., Hach, P. F., Liebeke, M., Holtappels, M., Danza, F., Tonolla, M., Sengupta, A., Schubert, C.J., Milucka, J. and Kuypers, M. M. (2019), Dark aerobic sulfide oxidation by anoxygenic phototrophs in anoxic waters. Environ Microbiol, **21**(5): 1611-1626. doi:10.1111/1462-2920.14543

Bouffard, D. and A. Wüest (2019). Convection in lakes. *Annu. Rev. Fluid Mech.* **51**: 189 – 215. Doi: 10.1146/annurev-fluid-010518-040506.

Bouffard, D. G. Zdorovennova, S. Bogdanov, T. Efremova, S. Lavanchy, N. Palshin, A. Terzhevik, L. Råman Vinnå, S. Volkov, A. Wüest, R. Zdorovennov, and H. N. Ulloa (2019). Under-ice convection dynamics in a boreal lake. *Inland Waters*. **9**(2): 142–161. https://doi.org/10.1080/20442041.2018.1533356.

Dupas, R., C. Minaudo, and B.W. Abbott (2019). Stability of spatial patterns in water chemistry across temperate ecoregions. *Environ. Res. Letters,* **14**(7), 074015. https://doi.org/10.1088/1748-9326/ab24f4.

Efremova, T.A., A.V. Sabylina, P.A. Lozovik, V.I. Slaveykova, M.V. Zobkova, and N. Pasche (2019). Seasonal and spatial variation in hydrochemical parameters of Lake Onego (Russia): insights from

2016 field monitoring. *Inland Waters*. **9**(2): 227–238. https://doi.org/10.1080/20442041.2019.1568097

Fernández-Castro, B., Álvarez, M., Nieto-Cid, M., Zunino, P., Mercier, H., & Alvarez-Salgado, X. A. (2019). Dissolved organic nitrogen production and export by meridional overturning in the eastern subpolar North Atlantic. *Geophysical Research Letters*, *46*(7): 3832-3842. https://doi.org/10.1029/2018GL080284.

Gaudard, A., A. Wüest, M. Schmid (2019). Using lakes and rivers for extraction and disposal of heat: Estimate of regional potentials. *Renewable Energy* **134**: 330–342. doi: 10.1016/j.renene.2018.10.095

Kobler, U.G., A. Wüest, and M. Schmid (2019). Combined effects of pumped-storage operation and climate change on thermal structure and water quality. *Climatic Change* **152**(3-4): 427–443. Doi: 0.1007/s10584-018-2340-x

Krishna, S., M. Pahlow, M. Schartau (2019). Comparison of two carbon-nitrogen regulatory models calibrated with mesocosm data. *Ecological Modelling*, **411**: 108711. https://doi.org/10.1016/j.ecolmodel.2019.05.016

Minaudo, C., R. Dupas, C. Gascuel-Odoux, V. Roubeix, F. Moatar (2019). Seasonal and event-based concentration-discharge relationships to identify catchment controls on nutrient export regimes. *Advances in Water Resources* **131**: 103379.

Müller, B., T. Steinsberger, R. Schwefel, R. Gächter, M. Sturm, and A. Wüest (2019). Oxygen consumption in seasonally stratified lakes decreases only below a marginal phosphorus threshold. *Scientific Reports*, **9**: 18054. https://doi.org/10.1038/s41598-019-54486-3.

Nouchi, V., T. Kutser, A. Wüest, B. Müller, D. Odermatt, T. Baracchini, and D. Bouffard. (2019). Resolving biogeochemical processes in lakes using remote sensing. *Aquatic Sciences* **81**(2): 27, https://doi.org/10.1007/s00027-019-0626-3.

Pasche, N., H. Hofmann, D. Bouffard, C.J. Schubert, P.A. Lozovik, and S. Sobek (2019). Implications of river intrusion and convective mixing on the spatial and temporal variability of under-ice CO_2. *Inland Waters* **9**(2): 162–176, https://doi.org/10.1080/20442041.2019.1568073

Schwefel, R., B. Müller, H. Boisgontier and A. Wüest (2019). Global warming affects nutrient upwelling in deep lakes. *Aquatic Sciences* **81**(3): 50, Doi: 10.1007/s00027-019-0637-0.

Sepúlveda Steiner, O., D. Bouffard and A. Wüest (2020). Convection-diffusion competition within mixed layers of stratified natural waters. *Geophysical Research Letters.* **46**(22): 13,199 – 13,208. https://doi.org/10.1029/2019GL085361.

Sommer, T., M. Schmid, and A. Wüest (2019). The role of double diffusion for the heat and salt balance in Lake Kivu. *Limnology and Oceanography* **64**(2): 650–660, doi: 10.1002/lno.11066

Soomets, T., T. Kutser, A. Wüest, and D. Bouffard (2019). Spatial and temporal changes of primary production in a deep peri-alpine lake. *Inland Waters* **9**(1): 49 – 60, doi: 10.1080/20442041.2018.1530529.

Thomas C., V. Frossard, M.-E. Perga, N. Tofield-Pasche, H. Hofmann, N. Dubois, N. Belkina, M. Zobkova, S. Robert, and E. Lyautey (2019). Lateral variations and vertical structure of the microbial methane cycle in the sediment of Lake Onego (Russia). *Inland Waters* **9**(2): 205–226 https://doi.org/10.1080/20442041.2018.1500227.

Ulloa, H.N., G. Constantinescu, K. Chang, D. Horna-Munoz, O. Sepúlveda-Steiner, D Bouffard, and A. Wüest (2019). Hydrodynamics of a periodically wind-forced small and narrow stratified basin: A large-eddy simulation experiment. *Environmental Fluid Mechanics.* **19**(3): 667 – 698. doi.org/10.1007/s10652-018-9645-1.

Ulloa, H.N., K.B. Winters, A. Wüest, and D. Bouffard (2020). Differential heating drives downslope flows that accelerate mixed-layer warming in ice-covered waters. *Geophysical Research Letters.* **46**(23): 13872-13882. https://doi.org/10.1029/2019GL085258

Winters, K.B., H.N. Ulloa, A. Wüest, and D. Bouffard (2019). Energetics of radiatively heated ice-covered lakes. *Geophysical Research Letters* **46**(15): 8913 – 8925. https://doi.org/10.1029/2019GL084182.

Wüest, A., N. Pasche, B.W. Ibelings, S. Sharma, and N. Filatov (2019). Life under ice in Lake Onego (Russia) – an interdisciplinary winter limnology study. *Inland Waters*. **9**(2): 125-129, doi: 10.1080/20442041.2019.1634450.

8.2. Published non-peer-reviewed papers in 2019

Baracchini, T., K. Bärenzung, D. Bouffard et A. Wüest (2019). Le lac de Zurich en ligne - Prévisions hydrodynamiques 3D en temps-réel sur *meteolakes.ch*. *Aqua & Gas - Fachzeitschrift für Gas, Wasser und Abwasser* **99**(12): 24 - 29.

8.3. Submitted manuscripts to peer-reviewed Journals in 2019

Baracchini, T., P.Y. Chu, J. Šukys, G. Lieberherr, S. Wunderle, A. Wüest, and D. Bouffard, (2019). Data assimilation of in-situ and satellite remote sensing data to 3D hydrodynamic lake models, Special Issue: Modelling lakes in the climate system (GMD/HESS inter-journal SI). *Geoscientific Model Development Discussions.* Doi: 10.5194/gmd-2019-47.

Baracchini, T., Hummel, S., Verlaan, M., Cimatoribus, A., Wüest, A., Bouffard, D., 2019. An automated calibration framework and open source tools for 3D lake hydrodynamic models. Submitted to *Environmental Modelling & Software*.

Baracchini T., A. Wüest, D. Bouffard (2020). Meteolakes: an operational online three-dimensional forecasting platform for lakes. Submitted to *Water Research.*

Fernández-Castro, B., Evans, D.G., Frajka-Williams, E., Vic, C., Naveira-Garabato, A.C. Breaking of internal waves and turbulent dissipation in an anticyclonic mode-water eddy. Submitted to *Journal of Physical Oceanography*.

Man, X., K.A. Bierlein, C. Lei, L.D. Bryant, A. Wüest, and J.C Little (2020). Sediment oxygen kinetics in freshwater lakes and reservoirs. Submitted to *Environmental Science & Technology*.

Steinsberger, T., R. Schwefel, A. Wüest, and B. Müller (2020). Hypolimnetic oxygen depletion in deep lakes: effects of trophic state and organic matter accumulation. *Limnology and Oceanography*. Submitted

Ulloa, H.N., G. Constantinescu, K. Chang, D. Horna-Munoz, O. Hames, and A. Wüest (2020).Horizontal transport under wind-induced resonance in stratified waters. Submitted to *Physical Review Fluids.*

8.4. Reports and expert services in 2019

Schmid, M., C. Gerber, F. Bärenbold, and A. Wüest (2019). Assessment of the effects of different scenarios for methane extraction from Lake Kivu based on numerical modelling. Report commissioned by the Energy Development Corporation Ltd. (EDCL) of the Rwanda Energy Group (REG), Eawag, Kastanienbaum June 2019, Switzerland.

Müller B., A. Gaudard, und A. Wüest (2019). Beurteilung see-interner Massnahmen zur beschleunigten Sanierung des Zugersees. Bericht für AfU Kt. Zug, Eawag Kastanienbaum, Apr. 2019, 25 p.

9. TEACHING

9.1. Courses

> **Limnology**, Master course, spring term 2019, ENV-425, Env. Engineering, EPFL.
> **Design project:** Predicting Oxygen Depletion using Machine Learning, by Joëlle Perreten and Maëlle Romero Grass
> **Minor STAS program:** Physical variability of White, Barents and Kara Sea and observations of Atlantic water input in the Polar region near Scandinavia. Students: Marco Turrini, Gauvain Ramseier, Nicolas Ramseier. Supervisor: Hugo N. Ulloa.

9.2. PhD Student supervised 2019

➢ Ulrike Kobler. Effects of pump storage operation on lakes; exam February 2019

➢ Severin Stähly. Hydropower impact - linking biological and hydromorphological characteristics; exam May 2019

➢ Theo Baracchini. Hydrodynamic modelling and assimilation of remote sensing data; exam May 2019

➢ Sara Venuleo. Continuously-fed density currents over impermeable and porous substrates; exam November 2019

➢ Oscar Sepúlveda Steiner. Resolving horizontal structures in lakes; exam May 2020

➢ Tomy Doda. Convective flows; since February 2018.

9.3. PhD Student exams in 2019

➢ Stähly S (2019) Hydraulic-morphological habitat assessment in rivers considering residual flow, sediment replenishment and artificial flood events. *PhD thesis EPFL no* 9'452. Examiner (Beyer, Schleiss, Molnar, Piegay, Gostner).

➢ Baracchini T (2019). From observations to 3D forecasts: Data assimilation for high resolution lakes monitoring. *PhD thesis EPFL no* 9'475. Examiner (Bouffard, Chu, Verron, Holzner).

➢ Venuleo S (2019). Continuously-fed density currents over impermeable and porous substrates. *PhD thesis EPFL.* Examiner (Bierlaire, Barry, Franca, Adduce, Sequeiros).

➢ Foppiano D. (2019) Hyphenated analytical techniques for studying the speciation and fate of contaminants and nanoparticles in waste treatment and bioenergy processes. *PhD thesis EPFL nr* 9'184. Exam president (Examiners: C. Ludwig, M. Tarik, P.W. Krystek, S. Takahama, J. Wang).

➢ Niayifar A. (2019) Hydrological and hydraulic solutions for the sustainability of habitat life in human altered streams. Exam president (Examiners: T. Battin, P. Perona, P. Burlando, G. Characklis, K. Edmaier).

➢ Pereira Barbosa SANTOS A.C. (2019). On flow duration curve modelling in Alpine catchments. *PhD thesis EPFL.* Examiner (Examiners: Nussbaumer, Rinaldo, Schäfli, Schirmer).

➢ Sung Eun Lim (2019). Reactions of nitrogen-containing compounds with ozone: kinetics and mechanisms. *PhD thesis EPFL nr* 7095. Exam president (Examiners: Urs vonGunten, Christa McArdell, Tamar Kohn, Ternes, Yunho Lee).

9.4. Master students in 2019

➢ Kevin Bärenzung (January 2019). 3D hydrodynamic modeling of Lake Zürich. Master thesis. École Polytechnique Fédérale de Lausanne, EPFL (*Supervisor:* Theo Baracchini).

➢ Mathieu Laura (April 2019). Using a towed undulating platform to measure ocean velocities and to estimate turbulent dissipation rate. Master thesis. École Polytechnique Fédérale de Lausanne, EPFL (*Supervisor:* Wilken-Jon von Appen). Physical Oceanography, Alfred Wegner Institute, Germany.

➢ Emile Barbie (September 2019 to February 2020). Long–term changes in phytoplankton functional groups in Lake Geneva.

10. CURRENT EXPERT AND CONSULTING ACTIVITIES

➢ Member of the Eawag Directorate (since 2014)
➢ Member of Doctoral Program in Civil and Environmental Engineering (since 2014)
➢ Member of Advisory Board to the Swiss Competence Centre for Energy Research

- ➢ Member of Advisory Board to Forschungsstelle Nachhaltige Energie- und Wasserversorgung, University of Basel
- ➢ ContourGlobal, Methane extraction in Lake Kivu, external advisor
- ➢ Co-editor of Aquatic Sciences
- ➢ Member of the Scientific/Technical Board for Lake Restoration on the Swiss Plateau, ASSAN
- ➢ Member of Group of Expert for IGKB (Lake Constance International Commission (Sachverständiger).

11. PROPOSALS

New

- ➢ FOEN, Swiss Federal Office for Environment, Bern, Project: "*Primärproduktion in Seen unter Oligotrophierung: Verfahren zur Erhebung des Produktionsstatus basierend auf Routineuntersuchungen und öffentlich zugänglichen Daten" (Trophie Status)* ". Dossier No: 17978. Total amount: 372,000 CHF.

Recent on-going funding

- ➢ **Primary production under oligotrophication in lakes**. Alfred Wüest (responsible). SNF grant 200021_179123, 1. August 2018 to 31 July 2021. Internal EPFL number 514 254. Total amount: 547'560 CHF.
- ➢ **Heterogeneous data platform for operational modeling and forecasting of Swiss lakes (DATALAKES)**, Sykus and Bouffard (Eawag), Wüest (EPFL) and Siddhartha Mishra, ETH Zurich. Swiss Data Science Center
- ➢ NCCS Hydro-CH2018 – Research Project: **Evolution of stream and lake water temperatures under climate change.** Hendrik Huwald and Alfred Wüest (EPFL) and Damien Bouffard and Martin Schmid (Eawag), FOEN, Swiss Federal Office for Environment.
- ➢ **Kivu Monitoring project,** Hydrodynamic modelling of Lake Kivu (EDMC/LKMP, Rwanda); PI: Deltares, NL, Damien Bouffard (EPFL, now Eawag), started in 2016.

Recently finished

- ➢ **Life under the ice in Lake Ladoga**; 109 kF; contribution from the Limnology Center (external sponsoring by FEEL Foundation); total 1,300 kF; dossier number: 9660, Internal project : 531,254 (01.12.2014 au 30.11.2017). Ended November 2017. Special issue published in 2019.
- ➢ **CORESIM**, **CO**upling **RE**mote **S**ensing, **I**n situ and **M**odelling data for inland waters, Bouffard D. (EPFL), Odermatt D (Odermatt and Brockmann GmbH), Anneville O (UMR CARRTEL) and A. Wüest (EPFL), ESA, 2016 - 2018. Final report will be issued in 2019.
- ➢ **A Flexible Underwater Distributed Robotic System for High-Resolution Sensing of Aquatic Ecosystems,** Alcherio Martinoli (responsible), Alfred Wüest, Bastiaan Ibelings (Uni Geneva), CRSII2_160726, *SINERGIA*, SNF, 386'304 kF (Total amount = 1,675 kF). Ends July 2019.