Annual Report 2021
January 2021 to August 2021

Margaretha Kamprad Chair
of Environmental Science and Limnology

Physics of Aquatic Systems Laboratory, APHYS at EPFL

Working with microstructure devices on the LéXPLORE Platform in the Covid-year 2021

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. Primary production in lakes under oligotrophication

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. 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 addition, we use satellite images and 3D-hydrodynamic modelling to assess the variability in PP at the basin-wide scale. More specifically, we:

(i) Employ the diel oxygen and carbon dioxide method to quantify PP 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 the autonomous and high-resolution profiling system *Thetis* to resolve bio-optical water 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 budget and turbulent mixing at different scales of variability to resolve the pathways to energy dissipation and the implications for PP and gas exchange.

(iv) Simulate nutrients and phytoplankton dynamics using coupled physico-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 (Wüest et al. 2021), where measurements are conducted since its anchoring in Feb 2019. 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 for the Environment) proposal for PP estimates for practitioners, based on the usual routine monitoring data sets, was granted end of 2019. Isabel Kiefer (2020, 2021a, 2021b) worked on knowledge transfer on this project and published two articles in Aqua & Gas and one data analysis guide on the internet.

3. MAJOR ACQUIRED EQUIPMENT

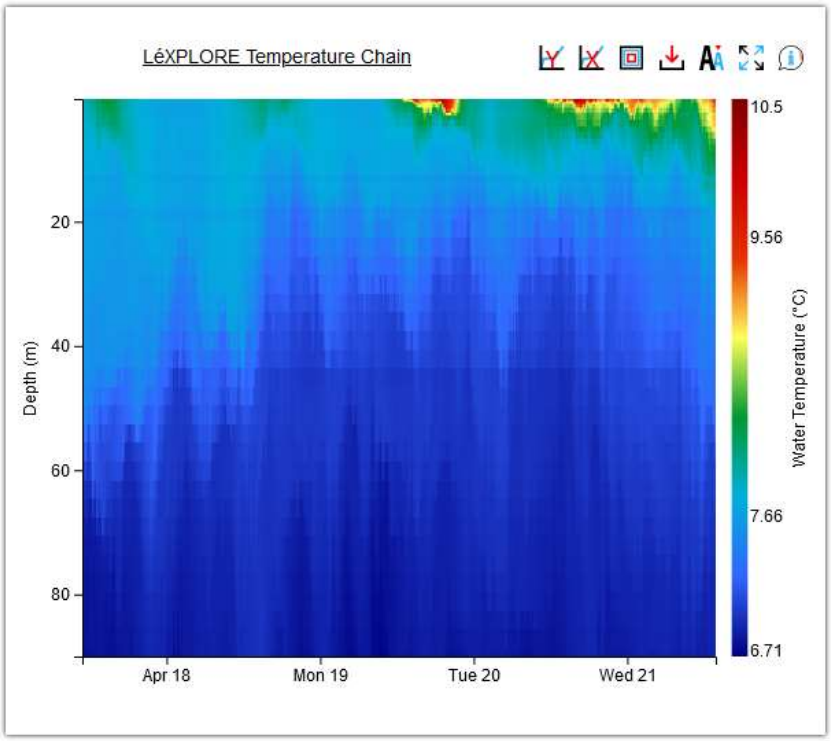
We had the opportunity to complete our field instrumentation with grants from ENAC-EPFL. The acquisitions in 2021 comprised:

3.1. RBR Thermistor String

The thermistor strings configured with 24-thermistor nodes every 3 m is installed on the LéXPLORE platform between 20 m et 90 m depth. The data are collected in real-time and uploaded directly to Datalakes.

3.2. LéWALK, In-house "wave-powered profiler"

LéWalk is an automated profiler propelled by surface waves. A turbulence-measuring device (micro-pod, Rockland) is mounted on it.



4. HUMAN RESOURCES

(alphabetic order)

Hannah Chmiel	Post-doc from October 2016 (Primary Production Project) to Lab-end August 2021
Guillaume Cunillera	Technician at LIMNC since March 2020. Employed for technical work on LéXPLORE Platform
Lucas de Reydet	Master student of University Clermont/Auvergne France was employed as scientific trainee for 5 months. (February-June 2021)
Lara du Bois	Secretary of APHYS and LIMNC, since February 2019
Isabel Kiefer	Scientific assistant since January 2020. Left on January 31, 2021
Shubham Krishna	Post-doc from May 2018 (Primary Production Project) to May 31, 2021
Sébastien Lavanchy	Technician at APHYS and LIMNC since May 2015
Camille Minaudo	Post-doc from October 2018 (Primary Production Project) to July 31, 2021

Sebastiano Piccolroaz	Post-doc from U of Bolzano from April 2020 (Primary Production) to June 30, 2021
Hugo N. Ulloa	Postdoc from February 2017 (former U de Chile and UC San Diego) to Lab-end August 2021
Alfred Wüest	Professor, Margaretha Kamprad Chair since Sep 2012 and Director of the Limnology Center since March 2013.

Visitors in 2021

- No Visiting Prof Program in 2021 due to Covid-19 pandemic
- Romain Tricarico (MSc), Sales & Support EMEA, Rockland Scientific.

4. NETWORKING

4.1. Primary production project

- Miguel Gil Coto, Instituto de Investigacións Mariñas (IIM-CSIC, Vigo, Spain)
- Biel Obrador, University of Barcelona
- Bieito Fernández Castro, University of Southampton (UK)
- Serena Rasconi, UMR CARRTEL, Université Savoie Mont-Blanc
- Massimiliano Cannata, Camillia Capelli, and Fabio Lepori. University of Applied Sciences and Arts of Southern Switzerland (SUPSI)
- Pascal Perolo, Nicolas Escoffier, Marie Perga (UNIL)
- Beat Müller, Thomas Steinsberger (Eawag)

4.2. 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
- George Constantinescu, University of Iowa.

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

- Anwar Quraishi, Alexander Bahr and Prof 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
- Deborah Knapp, Jakob Pernthaler and Thomas Posch, University of Zurich
- Damien Bouffard, Eawag

4.4. 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

4.5. DATALAKES - Heterogeneous data platform for operational modelling and forecasting of Swiss lakes

- Arthur Safin, Jonas Sukys, James Runnalls and Damien Bouffard, Eawag
- Fotis Georgatos, Swiss Data Science Center.

5. CONCLUSION AND FUTURE DIRECTIONS

Currently we are working (and finalizing) the following projects:

5.1. 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. 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 (Wüest et al 2021) is open to any scientists.

5.2. 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 observation technologies and new methods of PP estimates over short time intervals (days). We plan to cooperate with partners and other research institutions such as Eawag on Lakes Geneva, Lugano-NB, Lugano-SB (SUPSI), Constance (IGKB and SFI Langenargen).

A Federal Office for the Environment (FOEN) proposal for PP estimates for practitioners, based on the usual routine monitoring data sets, was granted end of 2019, and started in 2020.

6. CONFERENCES IN 2021

Bouffard D., Runnalls J., Bouillet E., Fernández-Castro, B., Georgatos F., Minaudo C., Ozdemir F., Odermatt D. Datalakes, a data platform for Swiss lakes. **18th Swiss Geoscience Meeting,** Zurich, 6-7 November 2020. Online Meeting.

Chmiel, H. E., Fernandez-Castro, B., Minaudo, C., Krishna, S., Perolo, P., Rasconi, S., Wüest, A., Motion sick: How to estimate ecosystem metabolism in large and energetic lakes. **ASLO Summer meeting, June 2021.**

Fernández Castro Bieito, H. E. Chmiel, C. Minaudo, S. Krishna, P. Perolo, S. Rasconi, A. Wüest. Summer primary and ecosystem production in Lake Geneva diagnosed from high-resolution in situ oxygen measurements. **18th Swiss Geosciences Meeting 2020.** Zurich, 6-7 November 2020. Online Meeting.

Fernández-Castro, B., Bouffard, D., Troy, C., Piccolroaz, S., Lavanchy, S., Chmiel, H.E., Ulloa, H., Sepúlveda-Steiner, O., Wüest, A. Seasonality of the mechanical energy budget in a large lake: Lake Geneva. **18th Swiss Geoscience Meeting**, Zurich, 6-7 November 2020. Online Meeting

Gupana, R. S., Odermatt, D., Rahaghi, A.I., Minaudo, C., Damm, A., Remote sensing of fluorescence in inland waters: improvements from using hyperspectral data. **SPIE Remote Sensing Symposium 2021.**

Hinegk, L. Adami, L., Piccolroaz, S., Amadori, M., Zolezzi, G., Toffolon, M., Tubino, M. Multi-decadal management of Lake Garda water resource. **AIOL Congress**, 30 June – 2 July 2021, Virtual Congress.

Irani Rahaghi A., C. Minaudo, A. Damm, D. Odermatt. Can the bio-optical stratification in a large lake be estimated using temperature profiles and meteorological data? **18th Swiss Geosciences Meeting 2020,** Zurich, 6-7 November 2020. Online Meeting

Irani Rahaghi A., C. Minaudo, A. Damm, D. Odermatt. Optical closure assessment for remote sensing reflectance in Lake Geneva using an automated hyperspctral profiler data. **International Geoscience and Remote Sensing Symposium.** 12-16 July 2021, Brussels, Belgium.

Krishna Shubham, Ulloa H N., Kerimoglu O., C. Minaudo, Anneville O., J.A. Wüest. Model-based data analysis of the effect of winter mixing on primary production in a lake under reoligotrophication. **18th Swiss Geosciences Meeting 2020,** Zurich, 6-7 November 2020. Online Meeting

Minaudo, C, Odermatt, D., Fernandez-Castro, B., Chmiel, H. E., Bouffard, D., Rahaghi, A.I., Lavanchy, S., Wüest, A., Primary production inferred from high-frequency water optical properties in a large lake. **ASLO Summer meeting, June 2021.**

Minaudo C., D. Odermatt, D. Bouffard, A. Irani Rahaghi, S. Lavanchy, J.A. Wüest. Diel patterns in water inherent optical properties of Lake Geneva and their physical and biogeochemical drivers. **18th Swiss Geosciences Meeting 2020,** Zurich, 6-7 November 2020. Online Meeting

Minaudo C., Capelli C., Cannata M., Lepori F. What drives primary production phenology in large mesotrophic lakes? **AIOL Congress**, 30 June – 2 July 2021, Virtual Congress.

Obertegger, U., Andrei, D., Piccolroaz, S., Flaim, G. Dissolved oxygen in a wind-shielded mountain lake is determined by the interplay of ice cover and extreme events. **AIOL Congress**, 30 June – 2 July 2021, Virtual Congress.

Odermatt, D., Rahaghi, A.I., Runnalls, J., Minaudo, C., Primary productivity monitoring in Swiss lakes using Sentinel-3. **SEFS 2021.**

Odermatt Daniel, C. Minaudo, J. Kesselring, J. Runnalls, J.A. Wüest. Satellite Earth observation products for lake research. **18th Swiss Geosciences Meeting 2020,** Zurich, 6-7 November 2020. Online Meeting

Perga M-E., Minaudo C., Ulloa H., Doda T., Chmiel H., Beria H., Perolo P., Escoffier N., Lambert T., Arthaud F., Napoleoni R., Ruegg J., Obrador B., Bouffard D. Oxygen depletion is faster under the ice of clearer alpine lakes. **ASLO Summer meeting, June 2021.**

Piccolroaz, S., Fernández-Castro, B. Chmiel, H.E., Perolo, P., Perga, M.E., and Wüest, A. Lake atmosphere CO_2 fluxes in Lake Geneva disentangling the role of physical and biological processes in affecting diel and seasonal patterns. **18th Swiss Geoscience Meeting**, Zurich, 6-7 November 2020. Online Meeting

Piccolroaz, S., Fernández-Castro, B. Chmiel, H.E., Perolo, P. Wüest A. CO_2 fluxes in a large perialpine lake modulated by near-surface stratification, internal motions and biological processes. **AIOL Congress**, 30 June – 2 July 2021, Virtual Congress.

Safin, A., Šukys, J., Bouffard, D., Runnalls, J., Ramón, C. L., Ozdemir, F., Georgatos, F., Perez Cruz, F., Tagasovska, N., Minaudo, C., A Bayesian Approach to Data Assimilation for a 3D Hydrodynamic Model of Lake Geneva. **SIAM Conference on Computational Science and Engineering, 2021.**

Safin Artur, D. Bouffard , C. Ramon, J. Runnalls, F. Ozdemir, F. Georgatos, N. Tagasovska, C. Minaudo, J. Sukys. A comprehensive Bayesian data assimilation platform for a 3D hydrodynamic model of Lake Geneva. **18th Swiss Geosciences Meeting 2020.**

Swann, G.E.A., V.N. Panizzo, S. Piccolroaz, V. Pashley, M.S.A Horstwood, S. Roberts, E. Vologina, N. Piotrowska, M. Sturm, A. Zhdanov, N. Granin, C. Norman, S. McGowan, A.W. Mackay. Changing nutrient cycling in Lake Baikal determined by enhanced deep ventilation during the last century. **AIOL Congress**, 30 June – 2 July 2021, Virtual Congress.

Wüest A and B Müller. When does productivity decrease as phosphorus levels drop? **AIOL Congress**, 30 June – 2 July 2021, Virtual Congress.

Wüest A. Surface water quality restoration – Successful effort in Switzerland（恢复地表水水质**—瑞士的成功**经验). **Sino Swiss Sustainability Forum** (**中瑞地方可持**续发展论坛). 13. July 2021 Swiss Re Centre for Global Dialogue, Rüschlikon, Switzerland

7. PUBLICATIONS IN 2021

7.1. Published peer-reviewed papers in 2021

Amadori, M., L. Giovannini, M. Toffolon, S. Piccolroaz, D, Zardi, M. Bresciani, C. Giardino, G. Luciani, M. Kliphuis, H. van Haren, H. A. Dijkstra (2021). Multi-scale evaluation of a 3D lake model forced by an atmospheric model against standard monitoring data. *Environmental Modelling & Software*, **139**, 105017, https://doi.org/10.1016/j.envsoft.2021.105017.

Avesani, D., A. Galletti, S. Piccolroaz, A. Bellin and B. Majone (2021). A dual-layer MPI continuous large-scale hydrological model including Human System. *Environmental Modelling & Software*, **139**, 105003, https://doi.org/10.1016/j.envsoft.2021.105003

Biemond B, Amadori M, Toffolon M, Piccolroaz S, van Haren H, Dijkstra HA. (2021). Deep-mixing and deep-cooling events in Lake Garda: Simulation and mechanisms*. J Limnol*. **80**(2): 2010. https://jlimnol.it/index.php/jlimnol/article/view/2010

Calamita, E., S. Piccolroaz, B. Majone, and M. Toffolon (2021) On the role of local depth and latitude on surface warming heterogeneity in the Laurentian Great Lakes, *Inland Waters*. doi: 10.1080/20442041.2021.1873698

El Serafy, G. Y. H., Schaeffer, B. A., Neely, M., Spinosa, A., Odermatt, D., Weathers, K. C., Baracchini, T., Bouffard, D., Carvalho, L., Conmy, R. N., Keukelaere, L. De, Hunter, P. D., Jamet, C., Joehnk, K. D., Johnston, J. M., Knudby, A., Minaudo, C., Pahlevan, N., Reusen, I., Rose, K. C., Schalles, J. and Tzortziou, M. (2021): Integrating Inland and Coastal Water Quality Data for Actionable Knowledge, *Remote Sens.*, **13**(15), 2899, doi:10.3390/rs13152899

Fernández Castro, B., H.E. Chmiel, C. Minaudo, S. Krishna, P. Perolo, S. Rasconi, and A. Wüest (2021). Primary and net ecosystem production in a large lake diagnosed from high-resolution oxygen measurements. *Water Resources Research*, **57**(5): e2020WR029283. https://doi.org/10.1029/2020WR029283

Fernández Castro, B., O. Sepúlveda Steiner, D. Knapp, T. Posch, D. Bouffard, and A. Wüest (2021). Inhibited vertical mixing and seasonal persistence of a thin cyanobacterial layer in a stratified lake. *Aquatic Sciences,* **83**(2): 38. https://doi.org/10.1007/s00027-021-00785-9.

Fernández Castro, B., A. Wüest and A. Lorke (2021). Small-scale turbulence and mixing: energy fluxes in stratified lakes. In: *Encyclopedia of Inland Waters*, Oxford: Elsevier. In press

Fernández Castro, B., Sepúlveda Steiner, O., Knapp, D. *et al.* Correction to: Inhibited vertical mixing and seasonal persistence of a thin cyanobacterial layer in a stratified lake. *Aquatic Sciences,* **83,** 42 (2021). https://doi.org/10.1007/s00027-021-00801-y.

Guillemot, S., Fovet, O., Gascuel-Odoux, C., Gruau, G., Casquin, A., Curie, F., Minaudo, C., Strohmenger, L., and Moatar, F. (2021). Spatio-temporal controls of C–N–P dynamics across headwater catchments of a temperate agricultural region from public data analysis, *Hydrol. Earth Syst. Sci.*, **25**, 2491–2511, https://doi.org/10.5194/hess-25-2491-2021.

Knapp D., B. Fernández-Castro, D. Marty, E. Loher, O. Köster, A. Wüest, and T. Posch (2022). The red harmful plague in times of climate change: Blooms of the cyanobacterium *Planktothrix rubescens* triggered by stratification dynamics and irradiance. *Frontiers in Microbiology - Aquatic Microbiology*. doi: 10.3389/fmicb.2021.705914

Krishna S., H.N. Ulloa, O. Kerimoglu, C. Minaudo, O. Anneville, and A. Wüest (2021). Model-based data analysis of the effect of winter mixing on primary production in a lake under reoligotrophication. *Ecological Modelling.* **440**: 109401

Michel A., Råman Vinnå L., Bouffard D., Epting J., Huwald H., Schaefli B., Schmid M., and Wüest A. (2021). Evolution of stream and lake water temperature under climate change. *Hydro-CH2018 Project.* Commissioned by the Federal Office for the Environment (FOEN), 3003 Bern, Switzerland. 71 pp, doi:10.16904/envidat.207

Minaudo, C., A. Abonyi, M. Leitão, A.M. Lançon, M. Floury, J-P. Descy, and F. Moatar (2021). Long-term impacts of nutrient control, climate change, and invasive clams on phytoplankton and cyanobacteria biomass in a large temperate river. *Science of the Total Environment*, **756**, 144074. https://doi.org/10.1016/j.scitotenv.2020.144074

Müller, B., T. Steinsberger, A. Stöckli, and A. Wüest (2021). Increasing carbon-to-phosphorus ratio (C:P) from seston as a prime indicator for the initiation of lake reoligotrophication. *Environmental Science & Technology*, **55**(9), 6459–6466. https://doi.org/10.1021/acs.est.0c08526

Piccolroaz, S., S. Zhu, M. Ptak, M. Sojka, X. Du (2021). Warming of lowland Polish lakes under future climate change scenarios and consequences for ice cover and mixing dynamics, *Journal of Hydrology: Regional Studies*, **34**, 100780, https://doi.org/10.1016/j.ejrh.2021.100780.

Piccolroaz, S., B. Fernández Castro, M. Toffolon, and H.A. Dijkstra (2021). A multi-site, year-round turbulence microstructure atlas for the deep perialpine Lake Garda, *Scientific Data*, **8**(188), https://doi.org/10.1038/s41597-021-00965-0

Ramón, C. L., Ulloa, H. N., Doda, T., Winters, K. B., and Bouffard, D. (2021). Bathymetry and latitude modify lake warming under ice, *Hydrol. Earth Syst. Sci*., **25**(4): 1813–1825, https://doi.org/10.5194/hess-25-1813-2021.

Sepúlveda Steiner, O., D. Bouffard and A. Wüest (2021). Persistence of bioconvection-induced mixed layers in a stratified lake. *Limnology & Oceanography,* **66**(4): 1531-1547. https://doi.org/10.1002/lno.11702

Steinsberger, T., A. Wüest, and B. Müller (2021). Net ecosystem production of lakes estimated from hypolimnetic organic carbon sinks. *Water Resources Research* **57**(5): e2020WR029473. https://doi.org/10.1029/2020WR029473.

Van Haren, H., S. Piccolroaz, M. Amadori, M. Toffolon, and H.A. Dijkstra (2021). Moored observations of turbulent mixing events in deep Lake Garda, Italy. *Journal of Limnology,* **80**(1): 1983. https://doi.org/10.4081/jlimnol.2020.1983.

Wüest, A., D. Bouffard, J. Guillard, B.W. Ibelings, S. Lavanchy, M-E. Perga, N. Pasche (2021). LéXPLORE – a floating laboratory on Lake Geneva offering unique lake research opportunities. WIREs Water 8, doi:10.1002/wat2.1544.

7.2. Published non-peer-reviewed papers in 2021

Kiefer, I., B. Müller, und A. Wüest (2021). Anleitung zur Analyse von Sauerstoffzehrung und Netto-Ökosystemproduktion in Seen: Arbeitshilfe zur Ermittlung relevanter Grössen der Trophie von Seen. Eawag und EPFL; *https://www.dora.lib4ri.ch/eawag/islandora/object/eawag%3A21995*

Kiefer, I., T. Steinsberger, A. Wüest und B. Müller (2021). Netto- Ökosystemproduktion in Seen - Bestimmung aus Monitoringdaten. *Aqua & Gas - Fachzeitschrift für Gas, Wasser und Abwasser* **101**(4): 22 - 29.

Schmid, M., F. Bärenbold, and A. Wüest (2021). Methane extraction from Lake Kivu - Scientific background, Brochure, Eawag, Kastanienbaum, Switzerland. 15 p

7.3. Submitted manuscripts to peer-reviewed Journals in 2021

Li, C., D. Odermatt, D. Bouffard, A. Wüest, T. Kohn (2022). Coupling remote sensing techniques and particle tracking for trajectory estimation in large water bodies. *Remote Sensing of Environment,* submitted

Doda, T., Cintia L. Ramón, Hugo N. Ulloa, Alfred Wüest, and Damien Bouffard (2022). Seasonality of density currents induced by differential cooling. *Hydrology and Earth System Sciences*. https://doi.org/10.5194/hess-2021-195

Perolo, P., Fernández Castro, B., Escoffier, N., Lambert, T., Bouffard, D., and Perga, M.-E.: (2021). Accounting for surface waves improves gas flux estimation at high wind speed in a large lake, *Earth Syst. Dynam. Discuss*. https://doi.org/10.5194/esd-2021-30.

Minaudo, C., D. Odermatt, D. Bouffard, A. Irani Rahaghi, S. Lavanchy, and A. Wüest (2021). The imprint of primary production in high-frequency profiles of lake optical properties. *Environmental Science & Technology*, Submitted. es-2021-025859

Ulloa, H.N., C.L. Ramón, T., Doda, A. Wüest and D. Bouffard (2021). Development of overturning circulation in sloping waterbodies due to surface cooling. *Journal of Fluid Mechanics* JFM-21-S-0040. Revisions.

Ulloa, H.N. and Letelier, J.A. (2021). Energetics and mixing of thermally driven flows in Hele-Shaw cells. *Journal of Fluid Mechanics* JFM-21-RP-0186. Revisions.

Fernández Castro, B., D. Bouffard, C. Troy, H.N. Ulloa, S. Piccolroaz, O. Sepúlveda Steiner, H.E. Chmiel, L.S. Moncadas, S. Lavanchy, and A. Wüest. Seasonal pathways of mechanical energy in a large lake. *Communications Earth and Environment.* Revisions.

Ramón, C.L., H.N. Ulloa, T. Doda and D. Bouffard (2021). Flushing the lake littoral region: the interaction of differential cooling and mild winds. *Water Resources Research.* Submitted.

Krishna S., H.N. Ulloa, E. Barbe and A. Wüest (2021) Disentangling effects of climate change and reoligotrophication on primary production in a large lake. *Ecological Modelling.* Submitted.

7.4. Reports and expert services in 2021

Schmid, M., F. Bärenbold, and A. Wüest (2021). Methane extraction from Lake Kivu - Scientific background, Brochure, Eawag, Kastanienbaum, Switzerland. 15 p

8. TEACHING

8.1. Courses

- **Limnology**, Master course, spring term 2021, ENV-425, Env. Engineering, EPFL
- **Design project:** none due to Covid-19 pandemic

8.2. PhD Student supervised 2021

- Tomy Doda. Convective flows; since February 2018.

8.3 PhD Student exams in 2021

- Sonya Barzgar (2021), The effect of alkali hydroxides and equilibration time on Al uptake by calcium silicate hydrates (C-S-H). Thèse N° 8870. Exam president (Examiners: Christian Ludwig; Barbara Lothenbach; Dmitrii Kulik; Jorgen Skibsted; Celine Cau-dit-Coumes).
- Rafale S. Reiss (2021). Dynamics of wind-induced coastal upwelling and interbasin exchange in Lake Geneva during winter: Implications for deepwater renewal. Thèse Nº 8110. Examiner (Examiners: F. Porté Agel, D. A. Barry, M. Wells, G. Schladow).

8.4 Master thesis students in 2021

- Emile Barbe (September 2019 to February 2020). "*Long-term changes in phytoplankton function al groups and primary production in Lake Geneva: A Modelling Approach*"
- Walser Manuel (July 2021). Physical drivers of zooplankton diel vertical migration in Lake Léman. Master thesis. École Polytechnique Fédérale de Lausanne, EPFL (*Supervisor:* Camille Minaudo, Hugo Ulloa and Alfred Wüest).

- Hugo Cruz (July 2021). Competition between cooling and shortwave radiation in shaping near-surface convection in pelagic waters of Lake Geneva. Master thesis. École Polytechnique Fédérale de Lausanne, EPFL (*Supervisor:* Hugo Ulloa, Sebastiano Piccolroaz and Alfred Wüest).
- Zhihao Liu (February 2021 to August 2021). *"The Metalimnetic Oxygen Minimum - Disentangling the Drivers for Oxygen Depletion in The Metalimnion of Swiss Perialpine Lakes"* Master thesis in cooperation with the Technical University of Denmark (DTU) (Supervisors at EPFL: Hannah Chmiel, Alfred Wüest, Supervisors at DTU: Borja Valverde-Pérez).”

9. CURRENT EXPERT AND CONSULTING ACTIVITIES

- Member of the Eawag Directorate (since 2014; ended in March 2021)
- Member of Doctoral Program in Civil and Environmental Engineering (since 2014)
- Member of Advisory Board to the Swiss Competence Centre for Energy Research
- 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).

10. PROPOSALS

Submitted

- **SNF Hyperstrata (Hyperspectral retrieval of stratification in aquatic systems)**, Daniel Odermatt (Eawag), Alexander Damm (University of Zürich), Camille Minaudo (EPFL)

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. Ends July 2021
- **FOEN**, Swiss Federal Office for the 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: 387,500 CHF. Active 2019 to September 2021

Recently finished

- 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 the Environment.
- **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