Proposal for 1st Collaborative European Freshwater Science Project for Young Researchers ("FreshProject")

Assessing CO_2 Fluxes from **Euro**pean **Run**ning Waters

– EuroRun –

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Keywords: carbon dioxide flux, greenhouse gas, drifting flux chamber, streams, rivers

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Abstract

Most inland waters are known to emit large amounts of carbon dioxide (CO_2) to the atmosphere. Recent CO_2 flux estimates suggest that running waters are major CO_2 emitters, accounting for approximately 70% of the total flux from inland waters. However, the magnitude and mechanisms of these fluxes are still not adequately quantified or understood, contributing to a high uncertainty in upscaling approaches. As regional CO_2 fluxes are important for our understanding of the global carbon cycle and greenhouse gas balances, we aim to assess seasonal and annual CO_2 fluxes from European running waters at multiple locations with a team of early career scientists from all over Europe. The focus of the proposed project EuroRun is laid on estimating CO_2 fluxes from European running waters and thus represents the first coordinated European-wide study to examine fluvial CO_2 fluxes. The extended team allows comparing seasonal and diurnal fluvial CO_2 fluxes but also differences between Northern and Southern Europe.

The measurements will be conducted with drifting flux chambers equipped with mini-loggers to continuously measure CO_2 in the chamber headspace. This is a straight forward and inexpensive method for direct measurements of CO_2 fluxes which can be easily replicated in space and time. In the frame of the project, the participants will meet for a workshop where they build the flux chamber, learn how to measure as well as analyze the data correctly. Following this, participants will conduct the measurements in their home country in different running waters within coordinated periods and at day and night. Thereby, a unique dataset will be generated that will allow us to make estimations on CO_2 fluxes from European running waters.

The proposed project EuroRun is original and innovative in terms of the topic as well as the methodological approach. EuroRun aims towards a better estimation and understanding of riverine CO_2 fluxes and their underlying mechanisms, as well as improving current regional and global carbon budgets. A successful execution of the proposed project is given through (i) a joint workshop for the construction of the standardized flux chamber for the participants, (ii) the knowledge and network of the proposing investigators, and (iii) the simple yet robust application of the CO_2 flux measurements. The joint workshop also gives the opportunity to personally meet and strengthen collaborations among early careers limnologists. EuroRun feeds from the establishment of a strong collaborative environment and the development of synergies between early career European researchers. EuroRun can only be conducted with the united power of early career European researchers, thus gathering together all the ingredients to be a successful 1st Collaborative European Freshwater Science project for Young Researchers.

1. State of the art

In the last decade, the contribution of inland water bodies to the global carbon cycle has come into focus of climate change research (Cole et al., 2007, Tranvik et al., 2009, Aufdenkampe et al., 2011). A recent estimate suggests that up to 3 Pg C yr^{-1} is emitted as CO_2 from global inland waters, which is on similar levels as the global soil carbon sink (Raymond et al., 2013). Thus, the understanding of inland water carbon emissions and related mechanisms are of high relevance and can contribute to improving future predictions and models on the global carbon cycle. However, the data needed for accurate regional and global flux estimates are spatially and temporally sparse which highlights the requirement for high quality direct CO_2 flux measurements in inland waters.

Considering all inland waters, up to 70% of the global CO_2 flux is assigned to running waters (Raymond et al., 2013), identifying these systems as ”hotspots” of greenhouse gas emissions. Recent assessments of global CO_2 fluxes from running waters are considerably higher than previously calculated, with an increase from 750-1200 Tg C yr^{-1} (Cole et al., 2007, Battin et al., 2009) to 2100-3280 Tg C yr^{-1} (Aufdenkampe et al., 2011, Raymond et al., 2013). However, the magnitude is likely to change again caused by higher precision of large scale estimates combined with continuous improvements of methods and higher number of field measurements. First attempts were done to determine large-scale CO_2 fluxes, for example, for Africa (Borges et al., 2015) and the conterminous United States (Butman and Raymond, 2011, Butman et al., 2016). However, none of these studies were able to measure CO_2 fluxes directly across a whole continent with the same method and at similar timespans.

The processes that drive CO_2 fluxes in running waters are complex and include several physical and biological factors. The diffusive gas exchange at the air-water interface depends on the gas transfer coefficient and the air-water concentration gradient (Raymond and Cole, 2001). The gas exchange coefficient is mainly controlled by turbulence in the water (MacIntyre et al., 2010), which is in turn driven by stream velocity, depth and bottom roughness (Marion et al., 2014). Moreover, metabolic processes such as gross primary production and ecosystem respiration influence CO_2 partial pressure (pCO_2) in the water, acting on a diurnal scale (Guasch et al., 1998, Lynch et al., 2010). Peter et al. (2014) also underline that temperature is a major driver of pCO_2 dynamics, suggesting that diurnal variations and temperature are important drivers of pCO_2 and CO_2 fluxes.

The use of floating flux chambers has become the most reliable and cost-efficient technique for directly monitoring in-situ CO_2 fluxes at the air-water interface (Bastviken et al., 2015). It is this method that will be adopted in EuroRun. The chamber, including a sensor continuously monitoring pCO_2 in the headspace will be placed on the surface of the water for a certain amount of time (Fig. 1a) and CO_2 fluxes will be calculated from the slope of a linear regression (Fig. 1b), representing the quantity of CO_2 emitted or absorbed. Additionally, the chamber can be anchored along the running water and the measurements are run until the headspace pCO_2 has equilibrated with the pCO_2 in the surface water (stationary phase; Fig. 1b) to obtain values for pCO_2 in the water. Recently, a novel guidance on how to apply flux chambers in running waters was published (Lorke et al., 2015), recommending freely drifting flux chambers on the water surface to reduce artificial intrusion of turbulence by the chamber itself. With these new and cost-efficient techniques at hand, it is now possible to improve current CO_2 emission datasets from running waters and investigate its mechanisms.

The overall objective of the proposed project is the assessment of CO_2 fluxes from European running waters. In order to get a spatially and temporally resolved dataset, a group of early career scientists from across Europe will measure both day and nighttime CO_2 fluxes every three months for a one year period. The dataset will allow us to estimate CO_2 emissions from running waters, the "hotspots" of inland waters in terms of greenhouse gas emissions, for the European continent. Furthermore, the dataset will contain CO_2 fluxes on different temporal scales (diurnal and seasonal) and across a broad spatial gradient that will allow us to test the following hypotheses:

1. Ranges of diurnal CO_2 fluxes, especially in summer, are higher in Southern Europe than in Northern Europe due to higher temperatures in combination with longer nights in Southern Europe.
2. Annual CO_2 fluxes from running waters in Southern Europe are higher than in Northern Europe due to higher mean temperatures in Southern Europe in combination with longer ice coverage of running waters in Northern Europe.

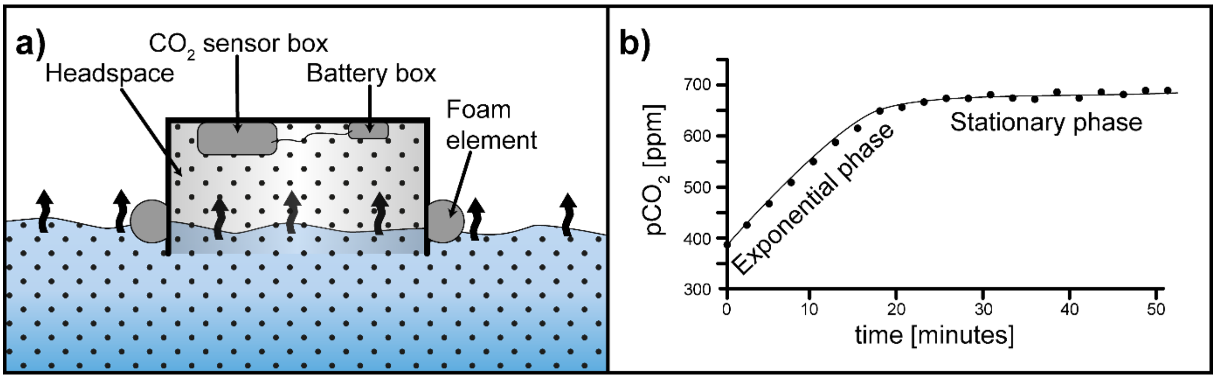

Figure 1. Illustrations of the floating gas chamber technique with (a) a schematic illustration of the setup of the floating chamber on the water and (b) an example of a linear regression from data generated by the sensor to calculate the CO_2 flux (in both illustrations: water is supersaturated with CO_2 and CO_2 is emitted).

2. Methods and development of the project

A standardized and integrative assessment of CO_2 fluxes from running waters across Europe will lead towards an extensive compilation of CO_2 flux data thus representing a unique project which has not been conducted before. The project will be led by Dr. Katrin Attermeyer (member of the German Society of Limnology) and Pascal Bodmer (member of the Swiss Society of Hydrology and Limnology) (= PIs) who are currently supported by a team of scientists in order to cover five out of seven different European Freshwater Societies donating money for this project. There is Núria Catalán (member of the Iberian Association for Limnology), Francesca Pilotto (soon member of the Italian Association of Oceanography and Limnology) and Peter Gilbert (member of the Freshwater Biological Association of the United Kingdom). We are currently in contact with other scientists representing the other two Freshwater Societies (Austria and France) to complete the team. Both PIs are experienced researchers in the field of carbon fluxes and greenhouse gas emissions from inland waters (see CVs and included publication lists in Annex). Dr. Katrin Attermeyer recently published a study about greenhouse gas emissions from a tropical lake and Pascal Bodmer coauthored a technical note on the advantages of the drifting flux chamber technique and applied the method in several streams during his PhD thesis. Furthermore, both PIs were integrated into larger projects during their doctoral and postdoctoral studies and thus familiar with structuring and organizing large scale projects on carbon cycling.

Additionally, the team of scientists (PIs plus the five other team members) will be complemented by early career European limnologists who will be invited to participate in the project by an open call. The participants should be a group of at least two early career scientists (EuroRunner team) working at the same place and thereby supporting each other and assure the safety standards. The number of sampling locations will only be limited by the timespan specified (about two weeks) for each sampling campaign. The EuroRunner team can thus chose several locations for their measurements. The formation of teams for the different locations ensures the continuation of the measurements even if one person has to withdraw from the project. The number of EuroRunners working in each team is not limited, and the teams will be constituted following geographic criteria. One representative of each EuroRunner team will join the workshop, but all the EuroRunners are invited to contribute to the different phases of the project development. The requirements for being part of EuroRun are as follows:

- The EuroRunner team should have access to a running water where drifting is possible and basic knowledge about the stream exists (e.g. catchment size, stream order, surrounding land use)
- The EuroRunner team is available to measure CO_2 fluxes four times between September 2016 and June 2017
- The EuroRunner team should have access to additional measurement equipment (pH, conductivity, temperature, discharge and wind)
- The EuroRunner team should be in their early career stage (max. 4 years after their PhD) and highly motivated because they need to go out sampling also during the night

The number of EuroRunner teams is currently limited to 20 because of financial restrictions. If our project will be granted, the director of the Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB Berlin) agreed to support our research with an additional amount of 5000€ which we plan to use for the funding of an additional number of ten EuroRunner teams. If more people are interested than the funding allows, early career scientists can build additional EuroRunner teams when they bring their own money for the equipment and workshop participation.

2.1 Methods

The major method to assess CO_2 fluxes is the drifting flux chamber technique which will be applied during this project. CO_2 fluxes are measured at the air-water interface with a drifting chamber equipped with a CO_2 sensor (minimum measuring frequency: 30s; Bastviken et al., 2015). The drifting chamber consists of an inverted plastic bucket with attached foam elements to ensure flotation (Fig. 1a). The position of the edge of the drifting chamber is adjusted to two centimeters below the water level in order to separate the chamber from ambient air, while creating a minimum of artificial turbulence (Gålfalk et al., 2013). The chamber will be covered with aluminum foil to prevent heating inside the chamber in case of an exposure to sunlight. In order to make the chamber visible during night time, every chamber will be equipped with an illuminant (for example glow sticks working with chemiluminescence). The chamber will be allowed to freely drift on the water surface with the water current (as described in Lorke et al., 2015) retrieving at least 10 data points (i.e. 5 min drifting time). The measurements have to be repeated five times at daylight and five times at nighttime, in order to get representative CO_2 flux data. During the measurements, any disturbance should be avoided that could create additional turbulence and consequently increase fluxes of CO_2. Fluxes will be calculated from the slopes of the measured pCO_2 in the headspace of the chambers, which are assumed to be linear throughout the measurements (Fig. 1b; McGinnis et al., 2015). After each measurement, the floating chamber will be anchored and pCO_2 will be recorded until equilibrium is reached in order to measure the pCO_2 of the water (as described in Bastviken et al., 2015). Briefly, those pCO_2 measurements are based on the principle that after a floating chamber headspace has equilibrated with the water, the measured pCO_2 in the chamber headspace represents the surface water pCO_2.The pCO_2 in the water can be used, for example, to interpret ecosystem carbon metabolism. Moreover, if the flux, as well as pCO_2 in the water and atmosphere is known, it is possible to calculate the gas exchange coefficient, providing additional information to understand CO_2 flux patterns among running waters on spatial and temporal scales.

Additionally, discharge and other environmental parameters such as water temperature, pH, conductivity as well as air temperature, solar radiation/light and wind need to be measured at the day of the CO_2 flux measurements. This requires general equipment in limnological research facilities that needs to be supplied by the participants and/or retrieved from a weather station close to the studied section of the running water. The construction of the floating chamber, the handling and the analysis of the data will be taught to the participants during a workshop. The direct contact with the participants and the teaching of the correct measurements ensures a reliable and comparable dataset of CO_2 fluxes and other environmental parameters.

The selection of the running waters needs to be restricted and the choice of potential study sites will be mainly based on three criteria. First, we will focus on the stream orders one to five ("Strahler stream order"; Horton, 1945, Strahler, 1957), because it was shown that small stream order running waters emit most CO_2 to the atmosphere (Butman and Raymond, 2011, Hotchkiss et al., 2015) and they are manageable for the EuroRunner teams without extensive logistics (e.g. large boat). Second, running waters will be selected in order to be comparable in terms of land use in the catchment. Third, we will select the running waters representatively distributed across Europe, in order to cover a wide range climatic conditions.

2.2 Development of the project

The project is divided into three steps that will be executed consecutively during the project: (1) the induction, (2) the measurements and (3) the data analysis/communication/publication of results:

During the induction, the participants will be selected and the workshop will be prepared and conducted. The workshop will terminate the induction phase in autumn 2016. During the workshop, the participants will build their own flux chamber under the supervision of the two PIs. Additionally, several measurements will be performed with all participants at the workshop and the data will be analyzed together. A detailed protocol with all working steps as well as the performance and analysis of the measurements will be taught during the workshop and handed over to each participant in a written form. This protocol also includes a general form with all parameters to be collected during each measurement campaign. The workshop can be held at low costs for each participant at the Erken Laboratory of Uppsala University which hosts field courses in limnology and ecology on a regular basis. At the end of the workshop, the participants will be able to build gas chambers with the sensors described in Bastviken et al. (2015) as well as measure and analyze the data according to a common protocol. Both PIs have the experience in gas chamber construction and measurements as indicated by their publications (see CVs in Annex). Furthermore, Prof. David Bastviken, a well-known expert of biogeochemistry of inland waters and greenhouse gas emissions supports the PIs with his technical and scientific knowledge.

The core part of the project is the coordinated measurement of CO_2 emissions from running waters across Europe. These measurements will be conducted every three months for a whole year to cover every season and thus different climatic conditions. The regions that do not allow for winter measurements have to record the duration of the ice coverage of their streams and the fluxes will be set to zero.

The data analysis will mainly be carried out by the participants. They are going to learn the handling and calculations for the data analysis during the workshop according to a template ensuring a comparable and correct data analysis. After every measurement campaign, the participants have to report their results and the PIs will conduct a first comparison and interpretation of the data. Thereby, possible flaws or problems of the method can be evaluated and corrected before the next campaign. After the last measurement campaign, the data will be assembled and analyzed according to the aim and hypotheses (see above). Whenever possible, the major scientific advancements will be communicated via popular-science forums (Twitter and Facebook), the blog of the EFFS homepage and press releases by the Universities and Institutes where the people involved are active. The acquisition of comprehensive communication of scientific results and knowledge through contributions in several contests (articles for a popular scientific journals and a movie for a scientific video competition, see CVs) already showed the great interest of the PIs to make their own research comprehensible to the broader public. These experiences will help to communicate the results of this project to scientists from other disciplines and the public. The results from the project will be published in at least one peer-reviewed paper and presented at international scientific conferences. More precisely, preliminary results will be presented at the SEFS 10 conference in Olomouc (Czech Republic) and the whole project will then be completed at the end of 2017 (see Timetable).

2.3 Timetable

	2016										2017											
	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1. Induction																						
Writing of invitation for participants																						
Selection of participants																						
Preparation of workshop																						
Workshop																						
2. Measurements																						
3. Analysis & Publication																						
Data analysis																						
Final report																						
Publication																						
SEFS 10 Conference																						

2.4 Budget (the additional money from IGB Berlin is put in parentheses)

Application	Details	Amount of money (in Euro)
Preparation	Travel expenses for meeting/workshop: PIs	500
Workshop	Travel expenses for workshop: participants	2000 (+2400)
	Accommodation expenses (Erken Laboratory)	800 (+600)
Consumables	Equipment for 20 flux chambers (+10 extra)	4000 (+2000)
Output	Conference expenses for SEFS 10	700

3. Impact of the project

The focus of the project EuroRun is laid on basic research to understand and estimate CO_2 fluxes from European running waters. Thereby, it substantially contributes to our knowledge on the role of running waters in the global carbon cycle, a highly relevant topic in ongoing climate impact research. The proposed project thus represents the first European-wide study to examine riverine CO_2 fluxes. It furthermore provides multiple scientific and also social impacts for the participating early career scientists. In the framework of EuroRun, we aim at improving estimates of CO_2 fluxes from European stream networks, improving the understanding of the underlying mechanisms influencing those fluxes as well as establishing a network of early career European limnologists.

The goals of the proposed project will be achieved by involving a large number of early career scientists from all over Europe and by applying cutting-edge research methods. Recent methodological developments now enable improved estimates of CO_2 fluxes via drifting flux chambers in running waters (Lorke et al., 2015). One strength of EuroRun is that it represents the first coordinated and nearly simultaneous assessment of CO_2 fluxes from running waters across whole Europe with the same method. The flux measurements will be performed almost simultaneously during the same period and at similar time points during 24 hours which significantly lowers measurement uncertainties. The high number of participants that can be supported with the money from the project and an external funding from IGB Berlin allows for a high number of CO_2 flux measurements that will lead to a valuable and unique CO_2 flux dataset. This dataset can then be used to test different hypotheses ranging from diurnal to seasonal time scales on a North – South gradient across Europe and thus will enhance the understanding of underlying mechanisms of CO_2 fluxes in running waters.

The execution of the proposed project needs the integration of a large number of scientists from all over Europe which can be achieved with the help of a successfully operating European Federation of Freshwater Sciences and an established network of European Fresh and Young Researchers (EFYR). The workshop aims at gathering all participants for the construction of an identical flux chamber and instruction on proper measurements and data handling, ensuring a high data quality. All participants will thus be relatively independent from their research facility because the main instrument will be constructed during the workshop in this project. As a consequence, there are almost no limitations for the participants, and early career scientists from all disciplines in limnology can participate and become a EuroRunner. The experience of both PIs in studies about flux measurements with floating chambers including publications (see CVs in Annexes) provides the optimal basis for a successful scientific output in the form of a publication. Finally, the close collaboration with Prof. David Bastviken from Linköping University for technical and scientific support regarding the sensor/chamber construction and greenhouse gas emissions guarantees a prosperous realization of EuroRun.

Beside the scientific impact, the project provides the opportunity to connect early career researchers from all over Europe. Several benefits for the participants and PIs will be gained during the execution of this project: (1) a high scientific knowledge transfer between all participants; (2) intensified networking during the common workshop and the following measurements with great opportunities for potential interactions among early career researchers of different scientific disciplines and genders; and (3) achievement/increase of independence of early career scientists. EuroRun can thus contribute to strengthen a network among early career limnologists that was already started and built by EFYR and related initiatives and build or strengthen new friendships and collaborations in order to push freshwater sciences forward.

4. References

AUFDENKAMPE, A. K., MAYORGA, E., RAYMOND, P. A., MELACK, J. M., DONEY, S. C., ALIN, S. R., AALTO, R. E. & YOO, K. 2011. Riverine coupling of biogeochemical cycles between land, oceans, and atmosphere. *Frontiers in Ecology and the Environment,* 9**,** 53-60.

BASTVIKEN, D., SUNDGREN, I., NATCHIMUTHU, S., REYIER, H. & GÅLFALK, M. 2015. Technical Note: Cost-efficient approaches to measure carbon dioxide (CO_2) fluxes and concentrations in terrestrial and aquatic environments using mini loggers. *Biogeosciences,* 12**,** 3849-3859.

BATTIN, T. J., LUYSSAERT, S., KAPLAN, L. A., AUFDENKAMPE, A. K., RICHTER, A. & TRANVIK, L. J. 2009. The boundless carbon cycle. *Nature Geoscience,* 2**,** 598-600.

BORGES, A. V., DARCHAMBEAU, F., TEODORU, C. R., MARWICK, T. R., TAMOOH, F., GEERAERT, N., OMENGO, F. O., GUÉRIN, F., LAMBERT, T. & MORANA, C. 2015. Globally significant greenhouse gas emissions from African inland waters. *Nature Geoscience,* 8**,** 637-642.

BUTMAN, D. & RAYMOND, P. A. 2011. Significant efflux of carbon dioxide from streams and rivers in the United States. *Nature Geoscience,* 4**,** 839-842.

BUTMAN, D., STACKPOOLE, S., STETS, E., MCDONALD, C. P., CLOW, D. W. & STRIEGL, R. G. 2016. Aquatic carbon cycling in the conterminous United States and implications for terrestrial carbon accounting. *Proceedings of the National Academy of Sciences***,** 113**,** 58-63.

COLE, J. J., PRAIRIE, Y. T., CARACO, N. F., MCDOWELL, W. H., TRANVIK, L. J., STRIEGL, R. G., DUARTE, C. M., KORTELAINEN, P., DOWNING, J. A. & MIDDELBURG, J. J. 2007. Plumbing the global carbon cycle: integrating inland waters into the terrestrial carbon budget. *Ecosystems,* 10**,** 172-185.

GÅLFALK, M., BASTVIKEN, D., FREDRIKSSON, S. & ARNEBORG, L. 2013. Determination of the piston velocity for water-air interfaces using flux chambers, acoustic Doppler velocimetry, and IR imaging of the water surface. *Journal of Geophysical Research: Biogeosciences,* 118**,** 770-782.

GUASCH, H., ARMENGOL, J., MARTí, E. & SABATER, S. 1998. Diurnal variation in dissolved oxygen and carbon dioxide in two low-order streams. *Water Research,* 32**,** 1067-1074.

HORTON, R. E. 1945. Erosional development of streams and their drainage basins; hydrophysical approach to quantitative morphology. *Bulletin of the Geological Society of America,* 56**,** 275-370.

HOTCHKISS, E. R., HALL JR, R. O., SPONSELLER, R. A., BUTMAN, D., KLAMINDER, J., LAUDON, H., ROSVALL, M. & KARLSSON, J. 2015. Sources of and processes controlling CO_2 emissions change with the size of streams and rivers. *Nature Geoscience,* 8**,** 696-699.

LORKE, A., BODMER, P., NOSS, C., ALSHBOUL, Z., KOSCHORRECK, M., SOMLAI, C., BASTVIKEN, D., FLURY, S., MCGINNIS, D. & MAECK, A. 2015. Technical Note: drifting vs. anchored flux chambers for measuring greenhouse gas emissions from running waters. *Biogeosciences,* 12**,** 7013-7024.

LYNCH, J. K., BEATTY, C. M., SEIDEL, M. P., JUNGST, L. J. & DEGRANDPRE, M. D. 2010. Controls of riverine CO_2 over an annual cycle determined using direct, high temporal resolution pCO_2 measurements. *Journal of Geophysical Research: Biogeosciences,* 115**,** G03016.

MACINTYRE, S., JONSSON, A., JANSSON, M., ABERG, J., TURNEY, D. E. & MILLER, S. D. 2010. Buoyancy flux, turbulence, and the gas transfer coefficient in a stratified lake. *Geophysical Research Letters,* 37**,** L24604.

MARION, A., NIKORA, V., PUIJALON, S., BOUMA, T., KOLL, K., BALLIO, F., TAIT, S., ZARAMELLA, M., SUKHODOLOV, A. & O'HARE, M. 2014. Aquatic interfaces: a hydrodynamic and ecological perspective. *Journal of Hydraulic Research,* 52**,** 744-758.

MCGINNIS, D. F., KIRILLIN, G., TANG, K. W., FLURY, S., BODMER, P., ENGELHARDT, C., CASPER, P. & GROSSART, H. P. 2015. Enhancing surface methane fluxes from an oligotrophic lake: exploring the microbubble hypothesis. *Environmental Science & Technology,* 49**,** 873-880.

PETER, H., SINGER, G. A., PREILER, C., CHIFFLARD, P., STENICZKA, G. & BATTIN, T. J. 2014. Scales and drivers of temporal pCO_2 dynamics in an Alpine stream. *Journal of Geophysical Research: Biogeosciences,* 119**,** 1078-1091.

RAYMOND, P. A. & COLE, J. J. 2001. Gas exchange in rivers and estuaries: Choosing a gas transfer velocity. *Estuaries and Coasts,* 24**,** 312-317.

RAYMOND, P. A., HARTMANN, J., LAUERWALD, R., SOBEK, S., MCDONALD, C., HOOVER, M., BUTMAN, D., STRIEGL, R., MAYORGA, E. & HUMBORG, C. 2013. Global carbon dioxide emissions from inland waters. *Nature,* 503**,** 355-359.

STRAHLER, A. N. 1957. Quantitative analysis of watershed geomorphology. *Transactions American Geophysical Union*, 38, 913-920.

TRANVIK, L. J., DOWNING, J. A., COTNER, J. B., LOISELLE, S. A., STRIEGL, et al. 2009. Lakes and reservoirs as regulators of carbon cycling and climate. *Limnology and Oceanography,* 54**,** 2298-2314.

5. Annex

5.1 Curriculum vitae: Katrin Attermeyer

❖ Personal Dates

Address	Kastanjegatan 7, 75434 Uppsala
Date of birth:	22.02.1985
Nationality:	German

❖ Education and Scientific Experiences

10/2015 – present	**Uppsala University, Dept. of Ecology & Genetics, Limnology** Postdoc in the group of Prof. Dr. Lars Tranvik (DFG research fellowship)
10/2013 – 09/2015	**Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany** Postdoc in the group of Dr. Katrin Premke (LandScales project)
02/2015 – 03/2015	**Indian Institute of Technology, Madras, India** Field trip to Chennai, India to study C mineralisation in tropical freshwater lakes
03/2014 – 04/2014	**Indian Institute of Technology, Madras, India** Field trip to Chennai, India to study C turnover in and greenhouse gas emissions from a tropical freshwater lake
01/2010 – 09/2013	**Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Neuglobsow, Germany** Doctoral thesis in Aquatic Microbiology supervised by Prof. Dr. Hans-Peter Grossart “Effects of allochthonous organic carbon on bacterial metabolism and subsequent consequences for food webs and carbon cycling in small and shallow lakes” (Terralac project)
10/2004 – 12/2009	**University of Rostock, Rostock, Germany** Diploma thesis in Applied Ecology supervised by PD Dr. Rhena Schumann and PD Dr. Matthias Labrenz “Identification and characterization of Gram-positive aquatic bacterial isolates”

❖ Institutional Responsibilities and Teaching Experiences

04/2011 – 03/2013	PhD representative at Leibniz-Institute of Freshwater Ecology and Inland Fisheries
2010 - 2013	Lab courses: Introduction of graduate students of the University of Osnabrück, University of Dresden and Potsdam University to microbiological and molecular biological techniques
2011 – present	Supervision of diploma/bachelor/master and doctoral students

❖ Scientific achievements and Grants

10/2015	Grant from the German Research Foundation (DFG) for a 2-year research fellowship at Uppsala University

08/2014	Participation in the contest "Fast Forward Science 2014" with a scientific webvideo on You Tube
05/2014	Grant from the Association for the Sciences of Limnology and Oceanography (ASLO) for the participation in the Joint Aquatic Sciences Meeting in Portland, USA
09/2013	Young Research Award (Schwoerbel-Benndorf Nachwuchspreis) by the German Limnological Society (DGL) and Oral Presentation at DGL Meeting, Potsdam, Germany
02/2013	Grant from the German Academic Exchange Service (DAAD) for the participation at the Aquatic Sciences Meeting of the Association for the Sciences of Limnology and Oceanography (ASLO) in New Orleans, USA
05/2012	Participation in the contest "Comprehensive Science" with a written article for a popular science journal "Spektrum der Wissenschaft" (among the best 10 articles)
02/2012	Participation in winter school „Meeting the challenges of sustainability in a socio-economically dynamic region of South-East India" in Chennai, India
02/2012	Grant from the German Academic Exchange Service (DAAD) for the participation in a winter school in Chennai, India

❖ Key Skills and Competencies

Reviewing	Aquatic Sciences, Ecological Engineering, Ecology, Freshwater Biology, Journal of Limnology, Microbial Ecology
Key skills	Biogeochemistry, Carbon cycling, Greenhouse gas emissions, Aquatic microbial ecology
Methodological skills	CO_2/CH_4 measurement and analyses (gas chromatography and LosGatos ultraportable GHG analyser), stable isotope measurements and analyses (CCIA, LosGatos), molecular techniques (PCR, DGGE, next generation sequencing), optode systems (PreSens), chemical analysis of DOC, epifluorescence microscopy, bacterial protein production (^{14}C leucine incorporation)
Languages	English (fluent), French (basic)
Software	SPSS, R, Adobe Illustrator and Photoshop, Origin

❖ Memberships

National	German Limnological Society (DGL)
International	Association for the Sciences of Limnology and Oceanography (ASLO)

❖ Peer-reviewed Publications

1. **Attermeyer, K.**, S. Flury, R. Jayakumar, P. Fiener, K. Steger, V. Arya, F. Wilken, R. van Geldern, K. Premke (2015) Invasive floating macrophytes reduce greenhouse gas emissions from a small tropical lake. Scientific Reports (in press).
2. Lischke, B., G. Weithoff, S. A. Wickham, **K. Attermeyer**, H.-P. Grossart, K. Scharnweber, S. Hilt, U. Gaedke (2016) Large biomass of small feeders: ciliates may dominate herbivory in eutrophic lakes. Journal of Plankton Research (in press).
3. Mehner, T., **K. Attermeyer**, M. Brauns, S. Brothers, J. Diekmann, U. Gaedke, H.-P. Grossart, J. Köhler, B. Lischke, N. Meyer, K. Scharnweber, J. Syväranta, M. J. Vanni, S. Hilt (2016) Weak

response of animal allochthony and production to enhanced supply of terrestrial leaf litter in nutrient-rich lakes. Ecosystems (in press).
4. **Attermeyer, K.**, J. Tittel, M. Allgaier, K. Frindte, C. Wurzbacher, S. Hilt, N. Kamjunke, H.-P. Grossart (2015) Effects of light and autochthonous carbon additions on microbial turnover of allochthonous organic carbon and community composition. Microbial Ecology. 69: 361-371.
5. Brothers, S., J. Köhler, **K. Attermeyer**, H.-P. Grossart, T. Mehner, N. Meyer, K. Scharnweber, S. Hilt (2014) A feedback loop links brownification and anoxia in a temperate, shallow lake. Limnology and Oceanography 59(4): 1388–1398.
6. **Attermeyer, K.**, T. Hornick, Z. E. Kayler, A. Bahr, E. Zwirnmann, H.-P. Grossart, K. Premke (2014) Enhanced bacterial decomposition with increasing addition of autochthonous to allochthonous carbon without any effect on bacterial community composition. Biogeosciences. 11: 1479-1489.
7. Brothers, S. M., S. Hilt, **K. Attermeyer**, H.-P. Grossart, S. Kosten, T. Mehner, N. Meyer, K. Scharnweber, J. Köhler (2013) A regime shift from macrophyte to phytoplankton dominance enhances carbon burial in a shallow, eutrophic lake. Ecosphere 4 (11): art137.
8. **Attermeyer, K.**, K. Premke, T. Hornick, S. Hilt, H.-P. Grossart (2013) Ecosystem-level studies of terrestrial carbon reveal contrasting bacterial metabolism in different aquatic habitats. Ecology 94(12): 2754-2766.
9. Frindte, K., W. Eckert, **K. Attermeyer**, H.-P. Grossart (2013) Internal wave-induced redox shifts affect biogeochemistry and microbial activity in sediments: a simulation experiment. Biogeochemistry 113(1-3): 423-434.

5.2 Curriculum vitae: Pascal Bodmer

❖ Personal Dates

Address	Fürstenwalder Damm 480, 12587 Berlin, Germany
Date of birth:	20.07.1986
Nationality:	Swiss

❖ Education and Scientific Experiences

06/2016 – 06/2017	**University of Koblenz – Landau, Institute of Environmental Sciences, Landau, Germany** Postdoc in the group of Prof. Dr. Andreas Lorke
02/2015 – 03/2015	**Indian Institute of Technology, Madras, India** Field trip to Chennai, India to study C mineralisation in tropical freshwater lakes
10/2012 – present	**Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Germany** PhD student within the Erasmus Mundus Joint Doctorate Programme “Science for the Management of Rivers and their Tidal Systems” (SMART) Primary University: Freie Universität Berlin, Germany Secondary University: University of Trento, Italy Supervisors: Dr. Katrin Premke (IGB Berlin, Germany), Prof. Alberto Bellin (University of Trento, Italy), PD Dr. Martin Pusch (IGB Berlin, Germany) Doctoral thesis in Aquatic Biogeochemistry

	"Linking carbon dynamics in stream ecosystems to dissolved organic matter quality"
10/2006 – 06/2011	**University of Basel, Basel, Switzerland** Bachelor & Master, Major: Environmental Geosciences; Module: Biogeography; Master thesis supervised by Dr. S. von Fumetti (University of Basel, Switzerland), PD Dr. C.T. Robinson and Dr. M. Doering (Eawag, Switzerland) "Habitat heterogeneity, respiration and microbial dynamics: The Alpine floodplain of the Urbach"

❖ Institutional Responsibilities and Teaching Experiences

01/2016	Assistant of the practical part of the lecture "Winter limnology – Aquatic Biogeochemistry and Microbiology", Master course at the Freie Universität Berlin
11/2013 – 11/2014	PhD representative within the Erasmus Mundus Joint Doctorate Programme "Science for the Management of Rivers and their Tidal Systems" (SMART)
03/2013 – 11/2015	PhD representative at Leibniz-Institute of Freshwater Ecology and Inland Fisheries
2013 – present	Supervision of interns
01/2009 – 08/2011	Tutorial assistant in the Department of Biogeography, University of Basel, Switzerland (teaching field methods for ecological river assessment to undergraduate students)

❖ Grants

2014	German Academic Exchange Service (DAAD); Subsidies for conference travels abroad
2012	GU International Postgraduate Research Scholarship & Griffith University Postgraduate Research Scholarship for four years at the Griffith University, Australia (declined)
2011	- Swiss Geography Association, travel grant - Swiss Society for Hydrology and Limnology, travel grant
2010	Swiss Geography Association, travel grant

❖ Key Skills and Competencies

Reviewing	Biogeosciences
Key skills	Aquatic biogeochemistry, CO_2/CH_4 emissions, aquatic metabolism, carbon cycling in aquatic ecosystems, stream ecosystems, carbon/DOM quality
Methodological skills	GHG flux measurements (CO_2 and CH_4) and data handling of floating chamber (with Ultraportable Greenhouse gas Analyzer, Los Gatos Research, Inc., USA); measurement and data handling of dissolved CO_2 and CH_4 with sensors (HydroC™; KM CONTROS, Germany); MiniDOT oxygen sensors (PME, USA); Microx oxygen sensor (PreSens); extraction and data handling of phospholipid fatty acids (PLFA); experience in carbon stable isotope data (CO_2 and PLFA, sediment, DOC); handling absorbance and fluorescence data and

	experience in calculating quality indices; experience in whole lake/stream metabolism calculations
Languages	Swiss German (native), German (fluent), English (fluent), French (fair), Spanish (beginner)
Software & programming	SPSS, R, Adobe Illustrator, Origin, Fortran 95

❖ **Memberships**

National	Swiss Society for Hydrology and Limnology (SGHL)
International	Association for the Sciences of Limnology and Oceanography (ASLO)

❖ **Peer-reviewed Publications**

1. Lorke, A., **P. Bodmer**, C. Noss, Z. Alshboul, M. Koschorreck, C. Somlai, D. Bastviken, S. Flury, D. F. McGinnis, A. Maeck, D. Müller, and K. Premke (2015) Technical note: drifting versus anchored flux chambers for measuring greenhouse gas emissions from running waters. Biogeosciences, 12: 7013–7024, DOI 10.5194/bg-12-7013-2015.
2. **Bodmer, P.**, R. Freimann, S. von Fumetti, C. T. Robinson, and M. Doering (2015) Spatio-temporal Relationships between Habitat Types and Microbial Function of an Upland Floodplain. Aquatic Sciences, DOI 10.1007/s00027-015-0420-9.
3. McGinnis, D. F., G. Kirillin, K. W. Tang, S. Flury, **P. Bodmer**, C. Engelhardt, P. Casper, and H.-P. Grossart (2015) Enhancing Surface Methane Fluxes from an Oligotrophic Lake: Exploring the Microbubble Hypothesis. Environmental Science and Technology 49(2): 873-880.

5.3 Support letters

2016-01-26

UPPSALA
UNIVERSITET

Lars Tranvik

Professor

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To Whom It May Concern:

Herewith, I express my full approval for the research proposal of Dr. Katrin Attermeyer to the "FreshProject" call. I also confirm that she will be hosted at Uppsala University during the proposed project.

Sincerely,

Lars Tranvik
Chair of the Deaprtment of Ecology and Genetics
Postdoc advisor of Katrin Attermeyer

Leibniz-Institut für
Gewässerökologie
und Binnenfischerei

IGB · Müggelseedamm 310 · 12587 Berlin · Germany

To whom it may concern

Berlin, 27.01.2016

Prof. Dr. Klement
Tockner
Direktor

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12587 Berlin
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tockner@igb-berlin.de

Herewith, I express my full approval for the research proposal of Pascal Bodmer to the "FreshProject" call. In case of a successful selection of the proposed project "Assessing CO_2 Fluxes from European Running Waters", the Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB Berlin) will contribute additional 5.000 Euro from own resources to support the project.

Best regards

Prof. Dr. Klement Tockner
Director