In situ pelagic dataset from continuous monitoring: A mesocosm experiment in Lake Geneva (MESOLAC)

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Viet Tran-Khac[1], Philippe Quetin[1], Isabelle Domaizon[1], Stéphan Jacquet[1], Laurent Espinat[1], Clémentine Gallot[1,2], Serena Rasconi[1]

[1] Université Savoie Mont Blanc, INRAE, CARRTEL, 74200 Thonon les Bains, France
[2]Current address: University Rennes 1, UMR ECOBIO, 35042 Rennes, France

Corresponding author: Serena Rasconi (serena.rasconi@inrae.fr)

Abstract

This dataset corresponds to a data series produced from automated data loggers during the MESOLAC experimental project. Nine pelagic mesocosms (about 3000 L, 3m depth) were deployed in July 2019 in Lake Geneva near the shore of Thonon les Bains (France), simulating predicted climate scenarios (i.e. intense weather events) by applying a combination of forcing. The design consisted of three treatments each replicated three times: a control treatment (named C – no treatment applied) and two different treatments simulating different intensities of weather events. The high intensity treatment (named H) aimed to reproduce short and intense weather events such as violent storms. It consisted of a short-term stress applied during the first week, with high pulse of dissolved organic carbon (5x increased concentration, i.e. total DOC ~ 6 mgL^{-1}), transmitted light reduced to 15% and water column manual mixing. The medium intensity treatment (named M) simulated less intense and more prolonged exposures such as during flood events. It was maintained during the 4 weeks of the experiment and consisted of 1.5x increased concentration of dissolved organic carbon (i.e. total DOC ~ 2 mgL^{-1}), 70% transmitted light and water column manual mixing. Automated data loggers were placed for the entire period of the experiment in the mesocosms and in the lake for comparison with natural conditions. Temperature, conductivity, dissolved oxygen and CO_2 were monitored every 15 minutes at different depths (0.15, 0.25, 1 and 2m).

This data set aims to contribute our understanding of the effect of environmental forcing on lake ecosystem processes (such as production, respiration and CO_2 exchange) under simulated intense weather events and the ability of the planktonic community to recover after perturbation. To a broader extent, the presented data can be used for a wide variety of applications, including monitoring of lake community functioning during a period of high productivity on a large peri-alpine lake and being included in further meta-analysis aiming at generalising the effect of climate change on large lakes.

Keywords

Automated data loggers; Experimental ecology; Climate change; Ecosystem functioning; Large peri-alpine lakes

Specifications Table

Subject	Environmental Science - Ecology
Specific subject area	Continuous environmental monitoring dataset produced from automated data loggers placed during an *in situ* mesocosm experiment in Lake Geneva.
Type of data	Table
How data were acquired	Data were continuously acquired (every 5 to 15 minutes) from automated data loggers. Measured parameters and used data loggers include: Temperature: Hobo Water pro onset, Tinytag sensors, Therm107 - Campbell Scientific, MiniDOT- PME Conductivity: CS547A-L - Campbell Scientific Dissolved oxygen: MiniDOT - PME CO_2: GMP221 -Vaisala Hobo Water pro onset, Tinytag Wpro and MiniDOT are autonomous sensors and were ready for deployment. Temperature, conductivity (Therm107 and CS547A-L - Campbell Scientific) and CO_2 (GMP221 -Vaisala) sensors are analog and needed to be connected to dataloggers. Dataloggers Campbell CR10x were used in C1 and M1 treatment and CR1000 for H1 treatment. Temperature sensors were calibrated in an environmental chamber. For Hobo and Tinytag sensors, the factory calibration data were used because manufacturing company does not allow modifying the software. For Campbell and MiniDOT, calibration data were updated via the software. Conductivity sensors were calibrated using a potassium chloride standard solution of 300 µS/cm. The calibration included temperature compensation. Oxygen sensors were calibrated at 100% saturation in air and 0% in anoxic water taking into account the barometric pressure.

	CO_2 sensors were calibrated in the air and in a closed chamber. The intercalibration was done with certified reference CO_2 sensor (AMT).
Data format	Raw
Parameters for data collection	Data loggers were placed in the mesocosms and in the lake at different depths (air, 0.15, 0.25, 1 and 2m). Data were continuously acquired from 5 minutes to 15 minutes and downloaded once a week and at the end of the experiment.
Description of data collection	Data were collected in July 2019 during an *in situ* mesocosm experiment simulating extreme weather events in Lake Geneva, FR. The experiment included three treatments: a control (no treatment) and two treatments simulating medium and high intensity extreme weather events. The high intensity treatment aimed at reproducing violent storms and consisted of applying an intense stress for 5 days (5x increased DOC concentration, 15% transmitted light and water column manual mixing daily for 15 mins. The medium intensity treatment simulated flood events, it was maintained for 4 weeks and consisted of 1.5x increased DOC concentration, 70% transmitted light and water column manual mixing daily for 5 mins.
Data source location	Institution: UMR INRAE CARRTEL City/Town/Region: Thonon les Bains Country: France The mesocosms were placed in a rectangle with coordinates: 46°22’09.64” N 6°27’09.89” E 46°22’11.39” N 6°27’08.73” E 46°22’ 12.58” N 6°27’ 13.74” E 46°22’ 11.19” N 6°27’ 14.80” E

Data accessibility	The dataset described in this data paper is accessible as open file in the INRAE Dataverse repository as single excel file [1]. Repository name: Dataverse INRAE Data identification number: doi: https://doi.org/10.15454/T3VCB0 Direct URL to data: https://data.inra.fr/dataset.xhtml?persistentId=doi:10.15454/T3VCB0
Related research article	None

Value of the Data

- This data set improve our understanding of the effect of environmental forcing on lake ecosystem processes (such as production, respiration and CO_2 exchange) under simulated intense weather events and the ability of the planktonic community to recover after perturbation.
- This open and raw dataset will benefit the scientific community as can be used for a wide variety of applications including further meta-analysis aiming at generalising the effect of climate change on large lakes
- The presented data can moreover potentially be helpful and make an impact on society as they include the monitoring of lake processes functioning during a period of high productivity on a large peri-alpine lake.

Data Description

Data are stored as single excel file containing two sheets. The first sheet contains the dataset with the data presented in rows for each time point (CET date and summer time). The measured parameters are listed in columns, including information on the used device (data logger brand) and the unit of the measure (flagged by “#”). Unique ID for each column includes the mesocosm treatment and replicate, the measured parameter and the depth as listed below (Table 1).

Table 1: Definition of ID variables in the data set, including treatment, replicate, parameter, unit of measurement and depth of the data logger.

ID	Treatment	Replicate	Parameter	Unit	Depth (m)
C1_Temp_0.25	C	1	Temperature	°C	0.25
C1_Temp_1	C	1	Temperature	°C	1
C1_Temp_1	C	1	Temperature	°C	1
C1_Temp_2	C	1	Temperature	°C	2
C1_Temp_Air	C	1	Temperature	°C	Air
C1_Ox-Conc_1	C	1	Oxygen concentration	mgL^{-1}	1
C1_Ox-Sat_1	C	1	Oxygen saturation	%	1
C1_CO2_1	C	1	CO2 concentration	ppm	1
C1_Cond_1	C	1	Conductivity	μScm^{-1}	1
C2_Temp_0.15	C	2	Temperature	°C	0.15
C2_Temp_1	C	2	Temperature	°C	1
C2_Temp_2	C	2	Temperature	°C	2
C2_Ox-Conc_1	C	2	Oxygen concentration	mgL^{-1}	1
C2_Ox-Sat_1	C	2	Oxygen saturation	%	1
C3_Temp_0.15	C	3	Temperature	°C	0.15
C3_Temp_1	C	3	Temperature	°C	1
C3_Ox-Conc_1	C	3	Oxygen concentration	mgL^{-1}	1
C3_Ox-Sat_1	C	3	Oxygen saturation	%	1
H1_Temp_0.25	H	1	Temperature	°C	0.25
H1_Temp_1	H	1	Temperature	°C	1
H1_Temp_1	H	1	Temperature	°C	1
H1_Temp_2	H	1	Temperature	°C	2
H1_Temp_Air	H	1	Temperature	°C	Air
H1_Ox-Conc_1	H	1	Oxygen concentration	mgL^{-1}	1
H1_Ox-Sat_1	H	1	Oxygen saturation	%	1
H1_CO2_1	H	1	CO2 concentration	ppm	1
H1_Cond_1	H	1	Conductivity	μScm^{-1}	1
H2_Temp_0.15	H	2	Temperature	°C	0.15
H2_Temp_1	H	2	Temperature	°C	1
H2_Temp_2	H	2	Temperature	°C	2
H2_Ox-Conc_1	H	2	Oxygen concentration	mgL^{-1}	1
H2_Ox-Sat_1	H	2	Oxygen saturation	%	1
H3_Temp_0.15	H	3	Temperature	°C	0.15
H3_Temp_1	H	3	Temperature	°C	1
H3_Ox-Conc_1	H	3	Oxygen concentration	mgL^{-1}	1
H3_Ox-Sat_1	H	3	Oxygen saturation	%	1

M1_Temp_0.25	M	1	Temperature	°C	0.25
M1_Temp_1	M	1	Temperature	°C	1
M1_Temp_1	M	1	Temperature	°C	1
M1_Temp_2	M	1	Temperature	°C	2
M1_Temp_Air	M	1	Temperature	°C	Air
M1_Ox-Conc_1	M	1	Oxygen concentration	mgL^{-1}	1
M1_Ox-Sat_1	M	1	Oxygen saturation	%	1
M1_CO2_1	M	1	CO2 concentration	Ppm	1
M1_Cond_1	M	1	Conductivity	µScm^{-1}	1
M2_Temp_0.15	M	2	Temperature	°C	0.15
M2_Temp_2	M	2	Temperature	°C	1
M3_Temp_0.15	M	3	Temperature	°C	0.15
M3_Temp_1	M	3	Temperature	°C	1
M3_Ox-Conc_1	M	3	Oxygen concentration	mgL^{-1}	1
M3_Ox-Sat_1	M	3	Oxygen saturation	%	1
Lake_Temp_0.15	Lake		Temperature	°C	0.15
Lake_Temp_1	Lake		Temperature	°C	1
Lake_Temp_1	Lake		Temperature	°C	1
Lake_Temp_2	Lake		Temperature	°C	2
Lake_Temp_2.5	Lake		Temperature	°C	2.5
Lake_Ox-Conc_1	Lake		Oxygen concentration	mgL^{-1}	1
Lake_Ox-Sat_1	Lake		Oxygen saturation	%	1

Missing value code: NA

In the second sheet is provided a summary table (same as Table 2) of all the measures, depths and data loggers

Table 2: Schematic overview of the used data loggers, measured parameters, depth and mesocosm replicate where they were placed.

Logger	Parameter	Depth (m)	C1	C2	C3	H1	H2	H3	M1	M2	M3	Lake
Hobo	Temperature	0.15		■			■			■		■
Tinytag	Temperature	0.15			■			■			■	
Campbell	Temperature	0.25	■			■			■			
MiniDot	Temperature	1	■	■	■	■	■	■	■		■	■
Campbell	Temperature	1	■			■			■			■
Tinytag	Temperature	2	■	■		■	■		■	■		■
Hobo	Temperature	2.5										■

Tinytag	Temperature	Air
MiniDot	Oxygen-conc	1
MiniDot	Oxygen-sat	1
Campbell	CO2-ppm	1
Campbell	Conductivity	1

Experimental Design, Materials and Methods

Experimental design: The mesocosm experiment was performed during a period of high production in Lake Geneva to simulate predicted climate scenarios in a deep peri-alpine lake. The experimental design consisted of nine pelagic mesocosms (about 3000 L, 3m depth) placed near the shore of Thonon les Bains, France (Fig.1).

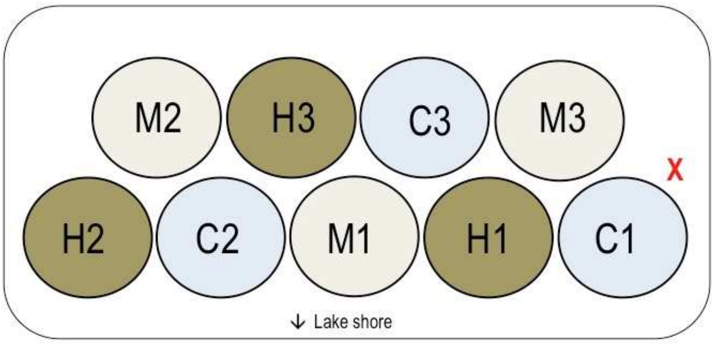

Fig.1 Experimental design and position of the 9 *in situ* floating mesocosm. The red cross indicates the position of the data loggers placed in the lake for comparison with the natural conditions.

The experiment lasted 4 weeks in July 2019 and included three treatments each replicated three times: a control treatment (no treatment applied – named C) and two different treatments simulating medium and high intensity extreme weather events. The high intensity treatment (named H) aimed at reproducing short and intense weather events such as violent storms. It consisted of a short-term intense stress applied for 5 days during the first week (from July 4 to 8), with high pulses of dissolved organic carbon (5x increased concentration, i.e. total DOC ~ 6 mgL^{-1}), transmitted light reduced to 15% and water column manual mixing daily for 15 minutes. The medium intensity treatment (named M) simulated less intense and more prolonged exposures such as flood events. It was maintained for 4 weeks and consisted of 1.5x increased concentration of dissolved organic carbon (i.e. total DOC ~ 2 mgL^{-1}), 70% transmitted light and water column manual mixing daily for 5 minutes.
The objective of the experiment was to disentangle ecosystems responses to local and global disturbances by assessing the effects of extreme climate events on natural plankton communities' diversity and dynamics. The broad aim is to achieve a better understanding of processes (e.g. production, respiration, resource use efficiency, sedimentation…) that govern the functioning and recovery of aquatic food webs when submitted to environmental stress.
Design characteristics: The mesocosms consisted of reinforced polyethylene bags (produced by Insinööritoimisto Haikonen Oy, Finland), supported at every meter of depth by plastic frames to avoid collapse of the structure due to the lake currents and supported by a double system of buoys at the

surface to allow floating. Each bag was filled with water the same day within a few hours and the mesocosms were left to acclimate for three days before the start of the experiment.

The experimental design included three treatments each replicated three times:

Control – no variation applied, total DOC concentration ~ 1.5 mgL^{-1} and covered with a 95% transmitted light filter.

Medium intensity and continuous exposure treatment (M) – stressors were applied for 4 weeks and consisted of light reduction (~70% transmitted light), DOC concentration increased 1.5 times (i.e. total DOC concentration ~ 2 mgL^{-1}) and regular mixing applied manually daily for 5 minutes.

High intensity and short-term exposure treatment (H) – stressors were applied for only a short period (5 days) and more intensively. Transmitted light was reduced to ~15%, DOC concentration increased 5 times (i.e. total DOC concentration ~ 6 mgL^{-1}) and daily mixing for 15 minutes. After this period, the treatments were exposed to control conditions (covered with a 95% transmitted light filter, no further DOC increase and no mixing).

Instrumentation: Loggers used for measuring temperature were: Hobo Water pro onset, Tinytag sensors, Therm107 - Campbell Scientific, MiniDOT; for conductivity: CS547A-L - Campbell Scientific Dissolved oxygen: MiniDOT and for CO_2: GMP221 –Vaisala.

Hobo Water pro onset, Tinytag Wpro and MiniDOT are autonomous sensors and were ready for deployment. Temperature, conductivity (Therm107 and CS547A-L - Campbell Scientific) and CO2 (GMP221 -Vaisala) sensors are analog and needed to be connected to dataloggers. Dataloggers Campbell CR10x were used in C1 and M1 treatment and CR1000 for H1 treatment.

Data forms or acquisition methods: Data were continuously acquired from 5 to 15 minutes and raw data were downloaded once a week and at the end of the experiment and sequentially named with date and time. Data are provided in the form of csv or txt files.

Data entry verification procedures: Digital data were recorded and exported using specific software developed by manufacturing companies.

Quality assurance/quality control procedures: Temperature sensors were calibrated before deployment in an environmental chamber. For Hobo and Tinytag sensors, the factory calibration data were used because manufacturing company does not allow modifying the software. For Campbell and Minidot, calibration data were updated via software.

Conductivity sensors were calibrated using a potassium chloride standard solution of 300 µScm^{-1}. The calibration included temperature compensation.

Oxygen sensors were calibrated at 100% saturation in air and 0% in anoxic water taking into account the barometric pressure.

CO_2 sensors were calibrated in the air and in a closed chamber. The intercalibration was done with certified reference CO_2 sensor (AMT).

Verification at the end of experiment: All the sensors were calibrated at the end of experiment in order to determine potential sensors deviations.

Data anomalies: All the devices Campbell on C1, M1 and H1 treatment needed to be activated during the deployment. Others devices such as Tinytag, HOBO and MiniDOT were pre-activated before the deployment. During the first day of experiment, the first device Campbell (temperature and CO2) was deployed and activated in H1 treatment on July 4th at 12:00 (CET summer time). The logistic deployment of other devices was finished during the first day of the experiment except for the Campbell M1 treatment due to a technical issue. The measurements of temperature, conductivity and CO_2 in M1 treatment started July 5th at 16:00 (CET summer time).
CO2 data are missing for the C treatment from July 7th at 17:45 to July 9th at 20:15 because of a technical outage of the device provoked by a storm.
Conductivity parameters for the M1 treatment are lower compared to the C1 and H1 treatments, we think this is due to instability of conductivity cell and should be discarded.
Temperature data measured by HOBO, Tinytag and MiniDOT during the first day from 12:00 to 19:45 seems to be too high and close to air temperature, which is probably due to the fact that measurements were triggered before deployment. Non-systematic anomalies are removed using different methods of identification and treatment of outliers during the quality assurance and quality control procedures. Quality assurance was entirely performed on R in order to keep data transparency and maintain reproducibility. Calibrations and deviation data were applied to the final dataset.

Computer programs and data-processing algorithms: For data formatting, homogenization and first check inspection we used the software Open Refine and R. Data outliers were mostly identified using median filter and matrix profile analysis [2]. We used the packages “dplyr”, “reshape”, “tdyr”, “prospectr”, “tsmp” and “ggplot2” within R.

Acknowledgments

We thank the INRAE CARRTEL personnel that helped during the experiment: Laura Crépin, Jade Ezzedine, Jean-Christophe Hustache, Jean-Philippe Jenny, Vincent Lacaud, Pascal Perney, Valentin Vasselon, Marine Vautier and Mathilde Chevallay.
Sources of funding: OLA (Alpine Lakes Observatory - https://www6.inrae.fr/soere-ola_eng/) [3] and AnaEE France (Analysis and Experimentation on Ecosystems - https://www.anaee.com) provided funding for the purchase of the experimental structures (mesocosm enclosures adapted for experimental purposes and all the facilities for the pelagic incubation) and supported CG.
INRAE and the UMR CARRTEL supported the purchase of the data loggers and all the personnel working on the project
Permit history: A legal authorization of territory occupation for a period of 3 months (from June to August 2019) was obtained from local competent authorities (Direction Départementale des Territoires) for the installation of the ecological anchor system, buoys and mesocosms and followed by the complete removal of the structure.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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