Management of Climatic Extreme Events in Lakes & Reservoirs for the Protection of Ecosystem Services

MANTEL

European Joint Doctorate Innovative Training Network

An introduction

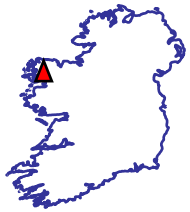
Dr Eleanor Jennings

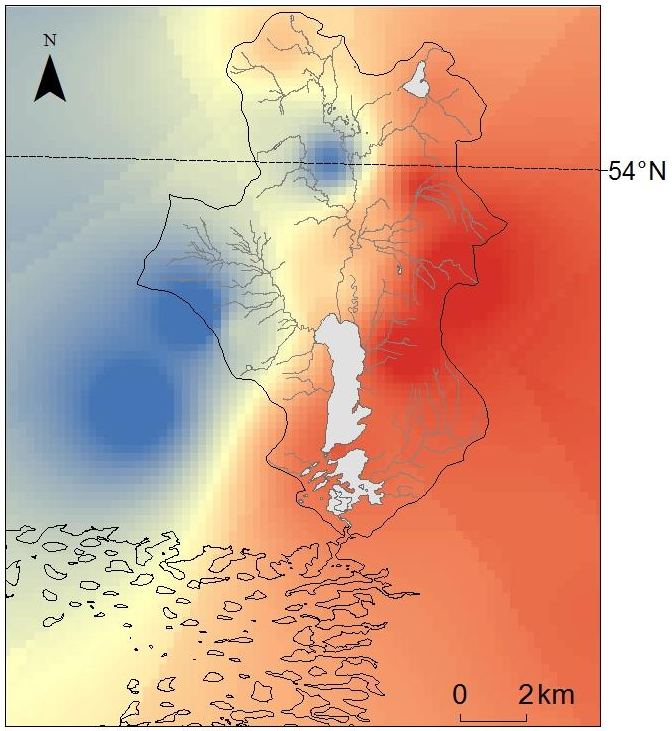
This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 722518.

Current focus on extreme weather events
USA
Asia
Europe

These extreme events – increasing challenge at lake and reservoir level

Burrishoole Catchment, Mayo





Rainfall across catchment

De Eyto et al. 2016 Inland Waters

MANTEL aim:

to **train a cohort of Early Stage Researchers (ESRs)** to investigate the effects of **the most extreme climatic events, and more subtle lower magnitude episodic events**, on lake and reservoir water quality.

2017-2020

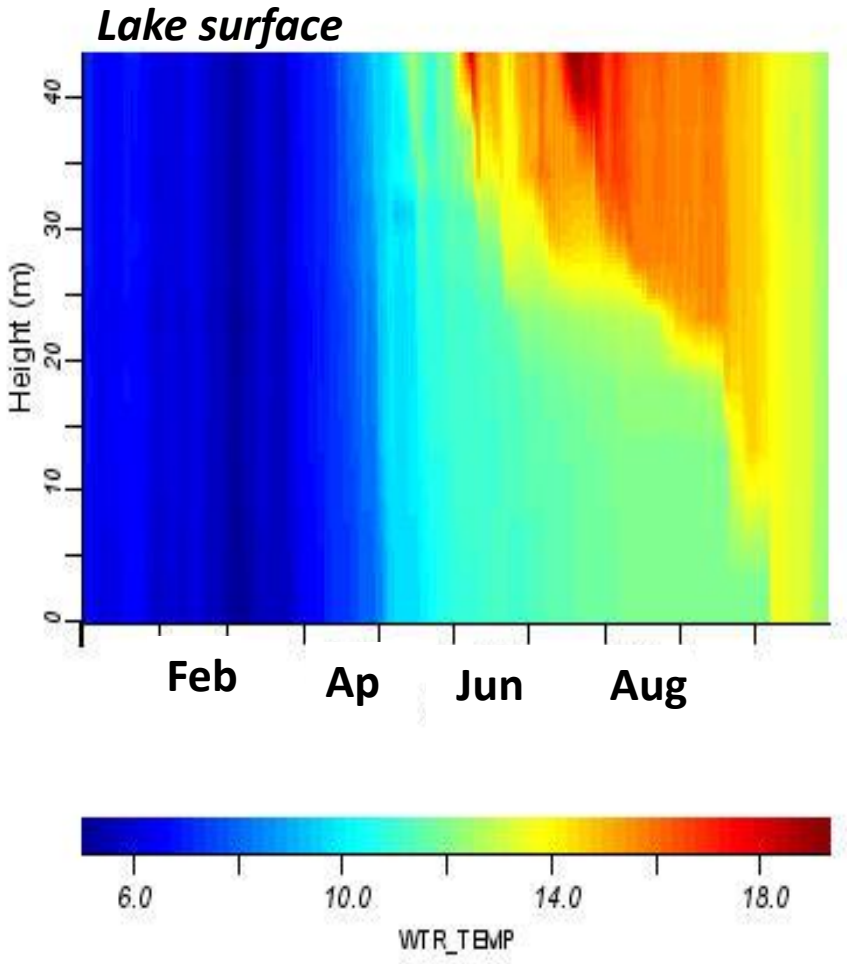
June 2015 **Jan 2016** **May 2016** **Jan 2017 - preparing** **Sep 2017**

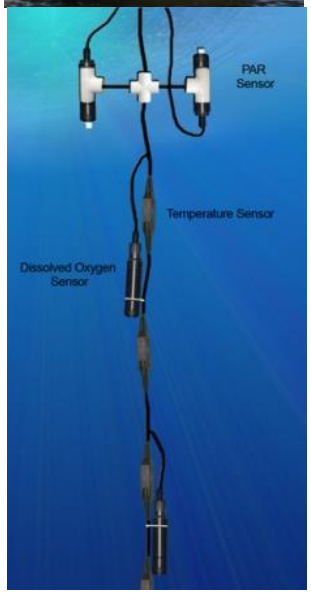
One of major challenges for future scientists

‘Hear this, young men and women everywhere, and proclaim it far and wide. The earth is yours and the fullness thereof. Be kind, but be fierce. **You are needed now more than ever before. Take up the mantel of change. For this is your time**.’

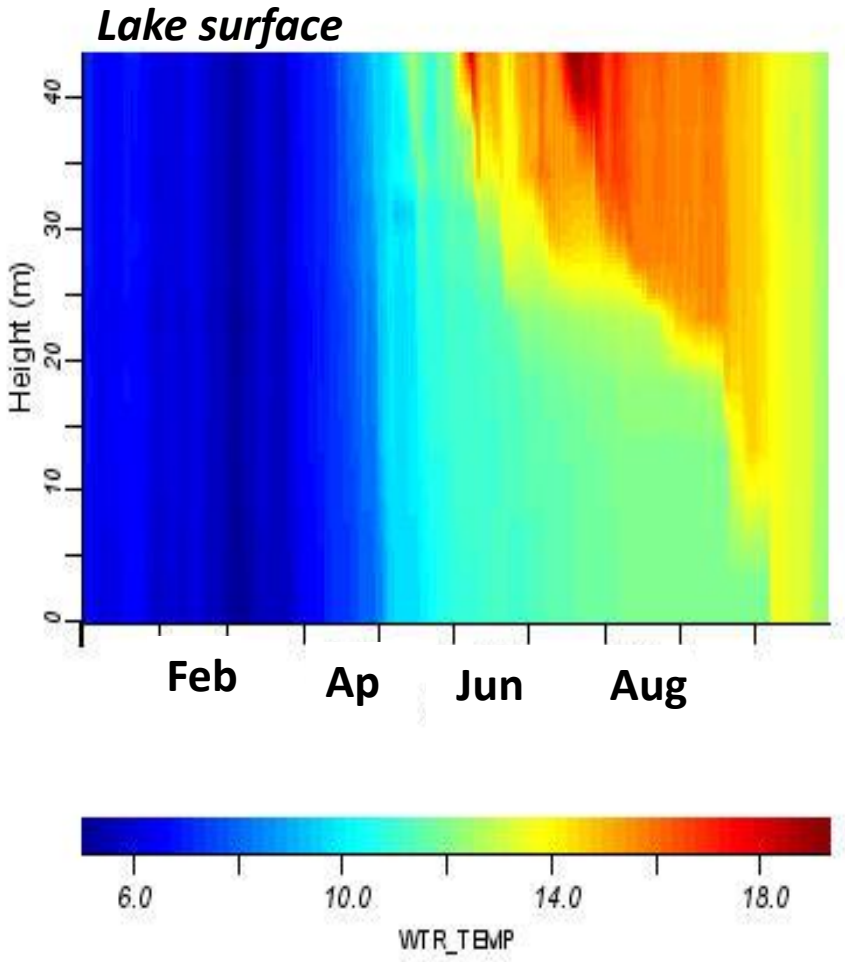
Winston Churchill

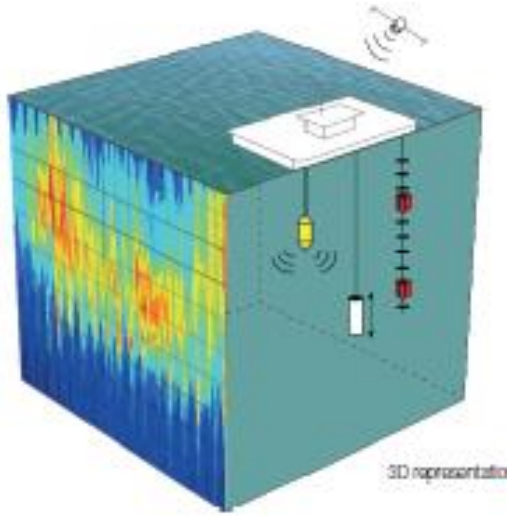
Lake high frequency monitoring systems





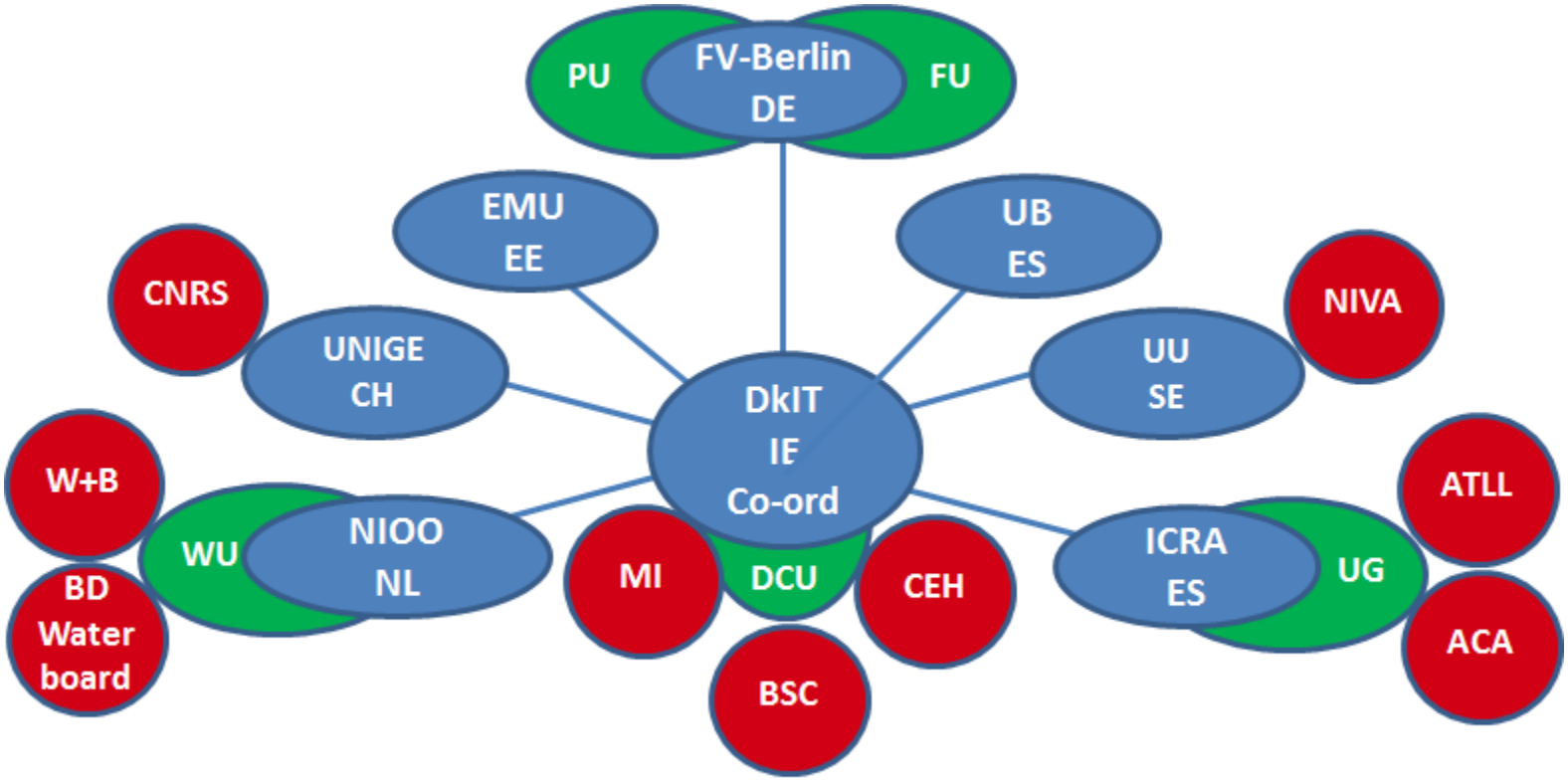
Lake high frequency monitoring systems





L'Explore
Geneva/Leman
100 m^2 floating platform

Who is involved in MANTEL?



8 beneficiaries (blue) 5 degree awarding partners (green) 9 partners (red)

Who is involved in MANTEL?

Beneficiaries (recruit)

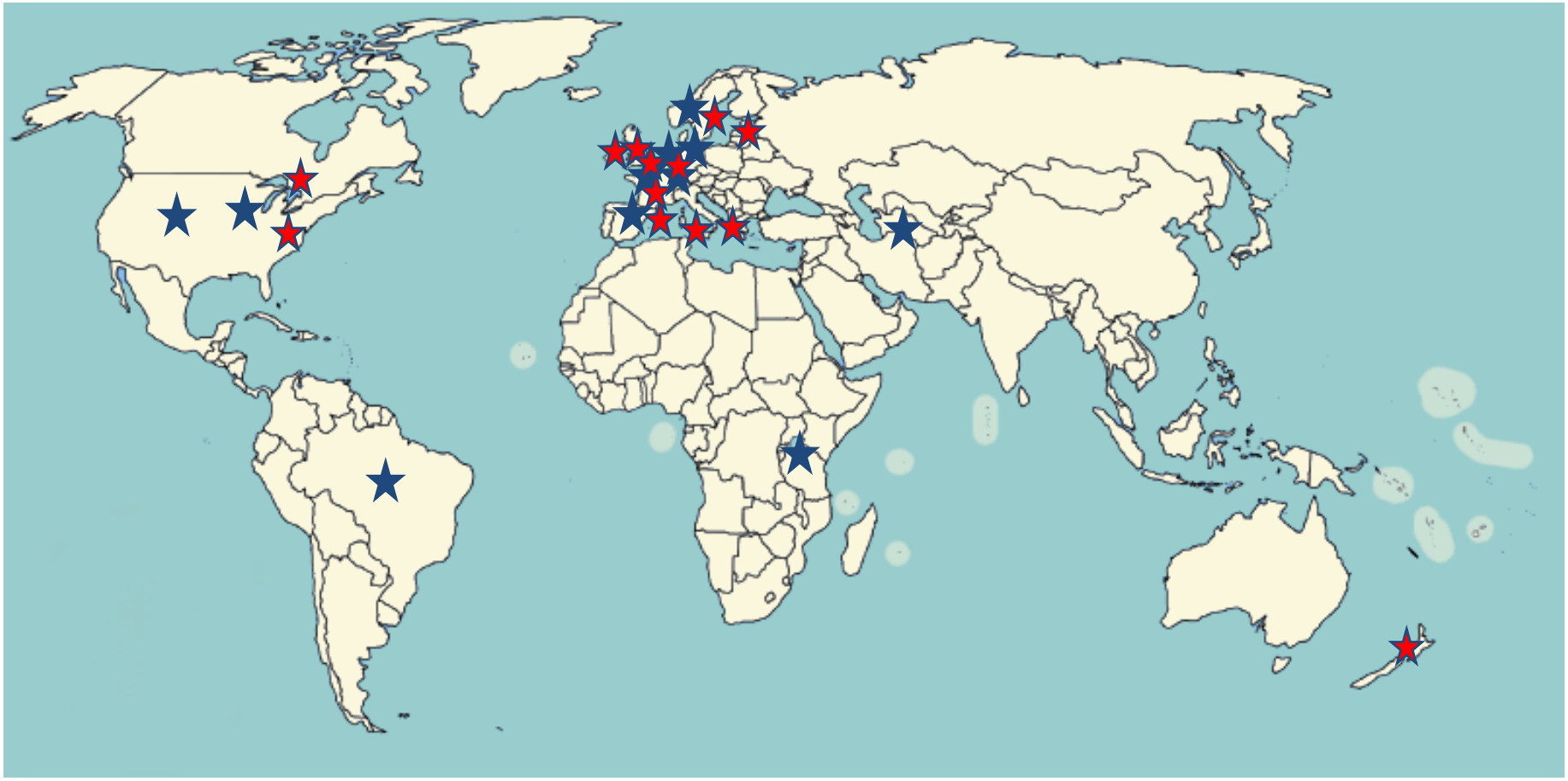
Dundalk Institute of Technology
Catalan Institute for Water Research
Estonian University of Life Sciences
Leibnitz Institute of Freshwater Ecology and Inland Fisheries
Netherlands Institute of Ecology
University of Barcelona
University of Geneva
Uppsala University

Partner organisations (collaborate)

Centre for Ecology and Hydrology
Marine Institute
NIVA
Aigües Ter-Llobregat
Catalan Water Authority
Waterboard BrabantseDelta
Witteveen + Bos
Barcelona Supercomputing Centre
Wageningen
CNRS

International programme

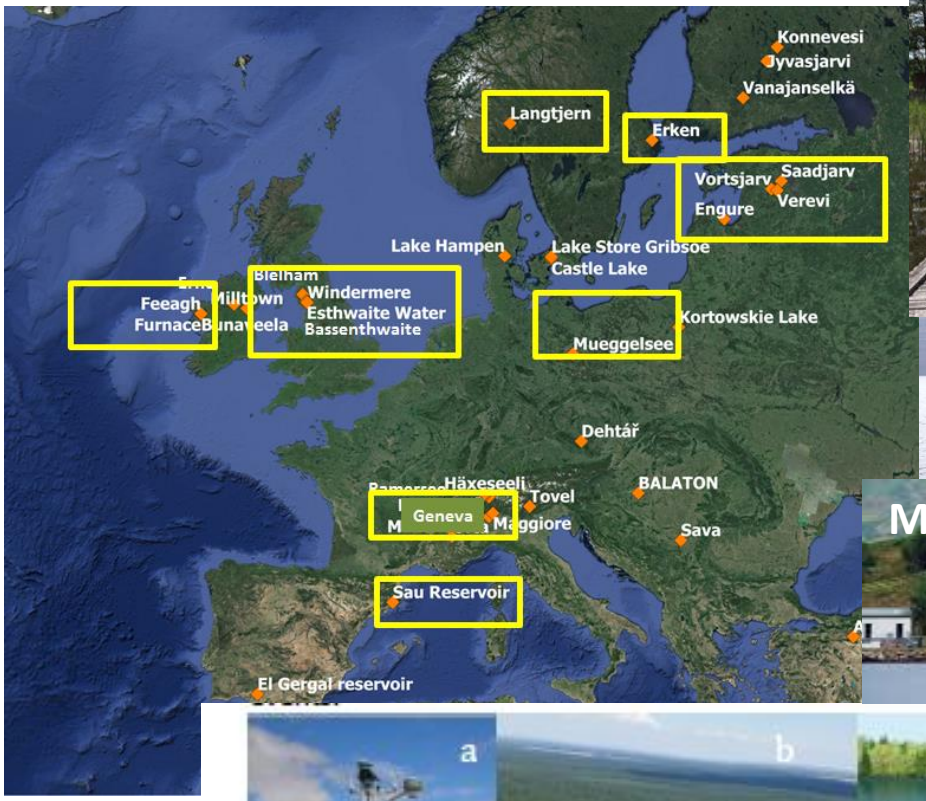
★ Supervisor or partner ★ Early stage researcher



Our logo

12 stars

Facilities in use across MANTEL



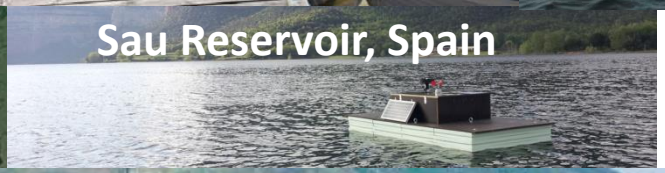


Fig. 1: a. typical lake monitoring buoy (Blelham Tarn, UK); b. LakeLab facility with 24 mesocosms in Lake Stechlin, DE; c. diagram of LakeLab mesocosms; d. Limnotrons in NIOO-KNAW.

MANTEL Work Packages

WP 2
- Data Analysis of historical archives
- Mixing events, metabolism,
- Bacterioplankton, phytoplankton

WP 3
- Modelling climate impacts
- Experimental manipulation using LakeLab

WP 4
- Developing new theory on resilience
- Developing indices
- Future climate impacts on resilience

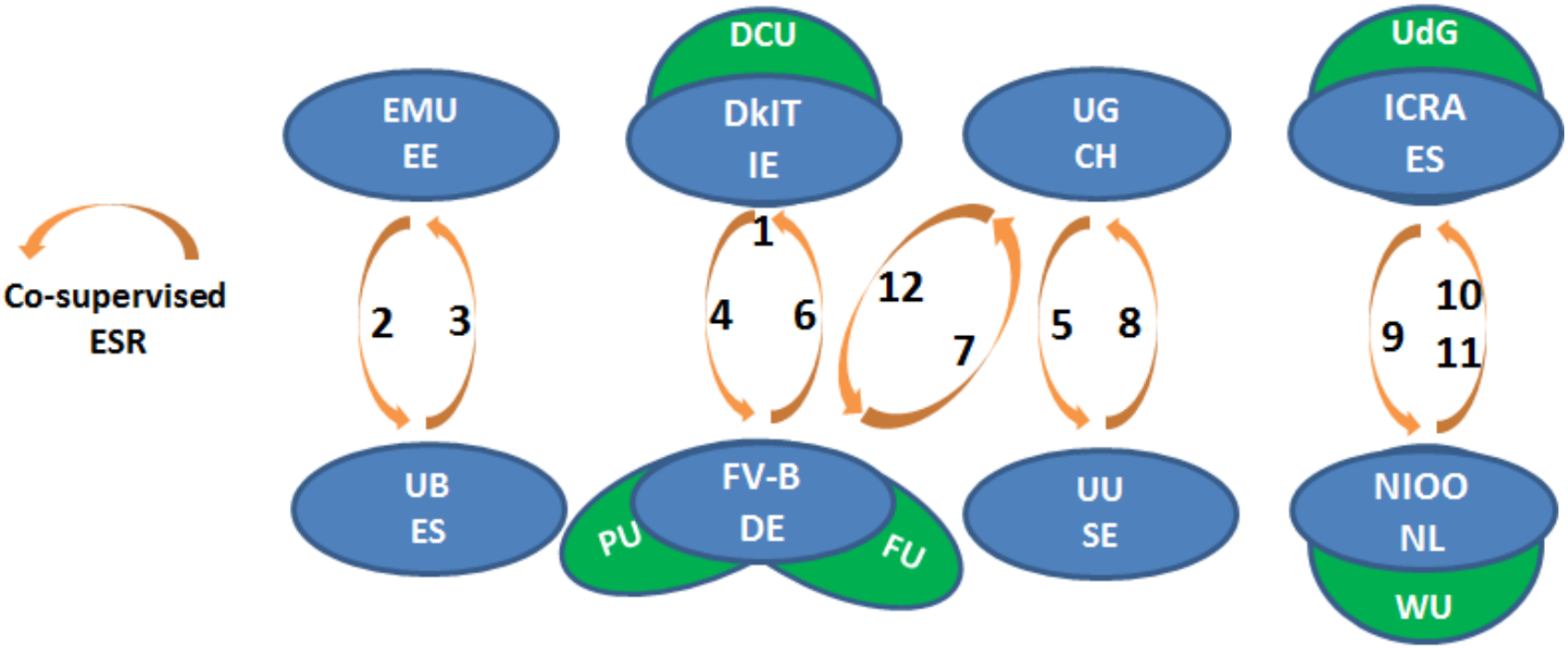
WP 5
- Informing water industry
- Mitigation of phytoplankton and DOC
- Benefit game
- Incorporating resilience theory into management

LakeLab Germany

The Benefit Game

Fig. 4 the Benefit Game

Co-supervision in MANTEL



12 PhD nested within and across these WPs

WP 2 Analysis of HFM data

- ESR 1 Impacts of mixing on lake physics DkIT/CEH
- ESR 2 Episodic events and metabolism UB/EMU
- ESR3 Current and future effects on Phytoplankton EMU/UB
- ESR 4 Episodic events & C-microbial dynamics DkIT/FV-B

WP 3 Future Climate Effects

- ESR 5 Modelling future effects on lake mixing UU/UG
- ESR 6 Exploring future change in microbial dynamics FV-B/DKIT
- ESR 8 Modelling future impacts on resilience UG/UU

WP 4 Assessing ecosystem Resilience

- ESR 7 Assessing lake resilience in data archives IGB/UG
- ESR 9 DOC/DBPs Current and future trends ICRA/NIOO
- ESR 12 Resilience - an exp. approach and informing managers UG/IGB

WP 5 Informing Water Industry

- ESR 10 Mitigation for extreme events NIOO/ICRA
- ESR 11 Ecosystems services – the Benefit Game NIOO/ICRA

ESR secondments

Table 1.4: Secondments for MANTEL ESRs. GREEN = co-supervisor; orange = other secondment.

M ESR	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30	31-32	33-34	35-42
1		CEH			Fv-B	Fv-B	UU	CEH						FV-B	
2					EMU				MI			EMU			
3					UB				CEH			UB			
4				FV-B			UB			FV-B					
5		NIVA		CEH		UG				NIVA	UG			UG	
6				DkIT	MI			DkIT							
7				UG		ETH		UG							
8			UU						UU			ICRA			
9		ATLL		NIOO-KNAW			BSC			NIOO-KNAW					
10	WU		BD	ICRA		WU			BD	ICRA		WU			
11		WB		ICRA			WB			ICRA	WB				
12				FV-B		ETH		NIOO-KNAW							

Will be a 'secondment committee' who will document and oversee changes to the timetable

Aims for this meeting

- To give a general background to high frequency monitoring in lakes, episodic events, ecosystems services and communicating science.
- Explore climatic effects, and get hand-on experience in sensor deployment and dealing with the data.
- Allow supervisory teams and their students to meet and to plan their project work.
- Allow supervisors and students to develop their training and career development plans.

12 PhD nested within and across these WPs

ESR No.	Recruiting		Cosupervisor team (MANTEL team member)
1.	DkIT	*TO BE APPOINTED*	E. Jennings (DkIT); HP Grossart; (I. Jones CEH)
2.	UB	**Hares Khan**	B. Obrador (UB); Alo Laas (EMÜ) (E. de Eyto MI)
3.	EMÜ	**Nasime Janathian**	P. Nõges (EMÜ); B. Obrador (UB); (I. Jones CEH)
4.	DkIT	**Ewan Geffroy**	E. Jennings (DkIT); HP Grossart (IGB); (E. de Eyto MI)
5.	UU	**Ana Zamora**	D. Pierson (UU); M. Beniston (UG); (I Jones CEH)
6.	IGB	**Truls Hansson**	HP Grossart (IGB); E. Jennings (DkIT); (E. de Eyto MI)
7.	IGB	**Michael Thayne**	R. Adrian (IGB); B. Ibelings (UG); (V. Dakos ETH)
8.	UG	**Jorrit Mesman**	M. Beniston (UG); D. Pierson (UU); (R. Couture NIVA)
9.	ICRA	**Elias Munthali**	R. Marce (ICRA); L. deSenorpont Domis (NIOO);
10.	NIOO	**Cleo Stratmann**	L. deSenorpont Domis (NIOO); R. Marce (ICRA) (M. Lürling WU)
11.	NIOO	**Maggie Armstrong**	L.deSenorpont Domis (NIOO); V.Acuña (ICRA) (E. RuijgrokW+B)
12.	UG	**Julio Steltzer**	B. Ibelings (UG); R. Adrian (IGB); (V. Dakos CNRS)
Total	12		

BACKGROUND OF HIGH FREQUENCY MONITORING IN EUROPEAN LAKES

History of lake monitoring

- Until recently monitoring relied on discrete samples, later analysed in the laboratory.
- Typically provided weekly to monthly resolution.

- Now possible to monitor automatically at high frequency using sensors mounted on *in-situ* platforms or buoys.
- Provide web-based access to data.

Monitoring platforms

Typical monitoring station may have:

- Weather station
- Chain of temperature sensors
- Dissolved oxygen
- pH
- Turbidity
- Chlorophyll fluorescence
- All every 2-5 minutes.

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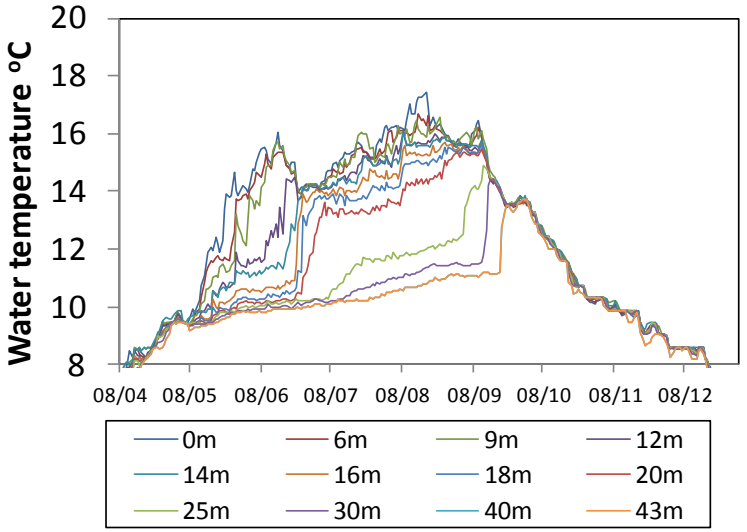


• Provide new insights into processes that drive change.

Early monitoring projects

Early monitoring stations established in EU projects 1996 - 2000

EU framework projects
REFLECT (1998-2000)
CLIME (2003-2005)

Map: Copyright European Commission

GLEON
Global network of lake ecological observatories

Co-chairs Kathie Weathers, Paul Hansen and Bas Ibelings
www.gleon.org

Data available from a range of lake types

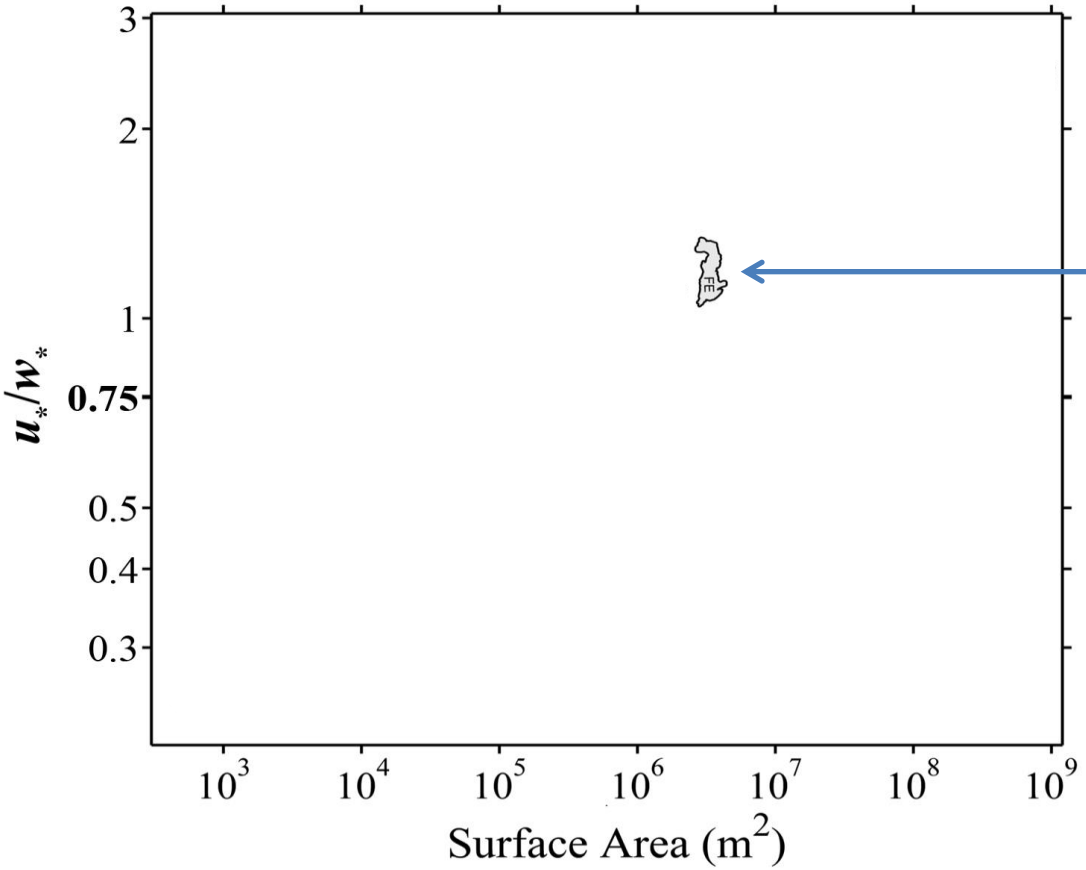
Deep
Shallow

Large
Medium
Small

Eutrophic
Oligotrophic
Coloured

Importance of collaborative science

u/w captures susceptibility to mixing

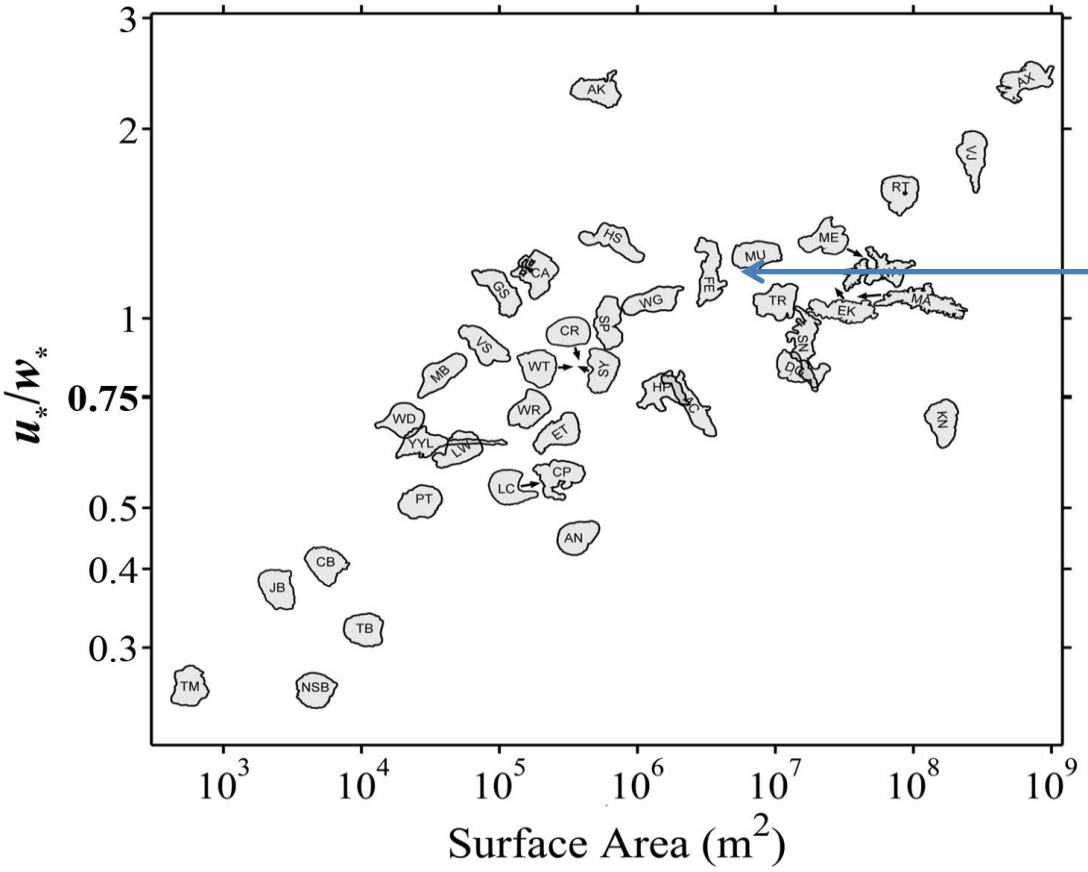


Data for one site provides local insights

Importance of collaborative science

Read et al., 2012

u/w captures susceptibility to mixing



Irish site

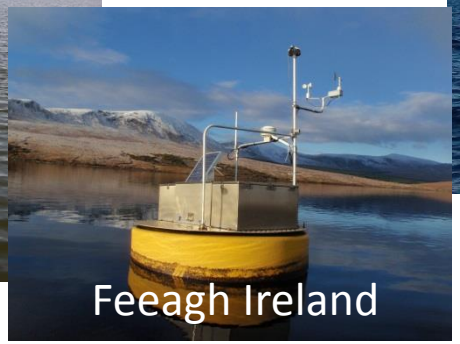
A greater potential lies in collaboration, providing global insights.

NETLAKE COST Action 2012-2016

.....to build a network of sites and individuals to support the development and deployment of sensor-based systems in lakes and reservoirs.

Proposed by European members of GLEON – www.gleon.org


Kortowski Poland


Feeagh Ireland


Erken Sweden

NETLAKE COST Action 2012-2016

The NETLAKE metadatabase – a tool for assessing the scope of automatic monitoring on lakes in Europe and beyond


Lake Eymir Turkey

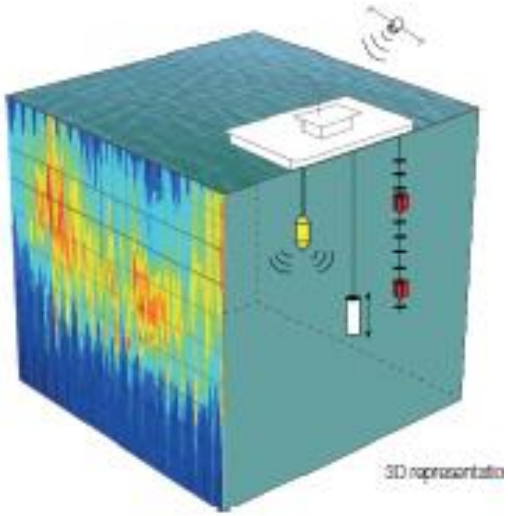
Eleanor Jennings, Elvira de Eyto, Alo Laas, Don Pierson, Andreja Naumoski, Georgina Mirchiva, Andrew Clarke, Mick Healy, Daniel Langerhaun, Katerina Sumberova.

In press: Limnology and Oceanography Bulletin

Automatic stations on lakes – levels of complexity

Simple low cost system
Eymir - Turkey

Profiling system
Erken Sweden



L'Explore
Geneva/Leman
100 m2 floating platform

Environmental Science & Technology

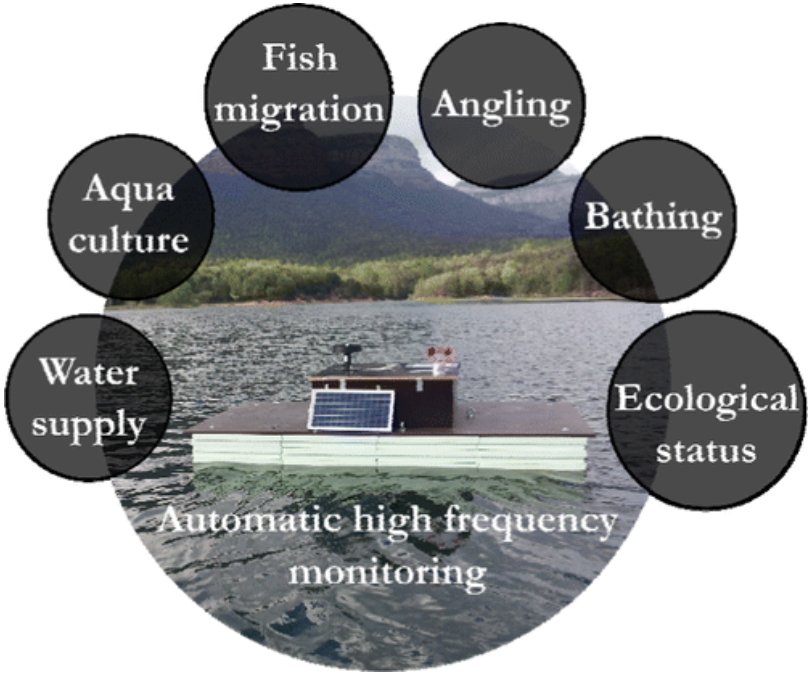
Critical Review

pubs.acs.org/est

Automatic High Frequency Monitoring for Improved Lake and Reservoir Management

Rafael Marcé,[*,†] Glen George,[‡,§] Paola Buscarinu,[⊥] Melania Deidda,[⊥] Julita Dunalska,[#] Elvira de Eyto,[▽] Giovanna Flaim,[○] Hans-Peter Grossart,[◆,¶] Vera Istvanovics,[∥] Mirjana Lenhardt,[@] Enrique Moreno-Ostos,[%] Biel Obrador,[^] Ilia Ostrovsky,[&] Donald C. Pierson,[¢] Jan Potužák,[$] Sandra Poikane,[⊗] Karsten Rinke,[⊕] Sara Rodríguez-Mozaz,[†] Peter A. Staehr,[⌀] Kateřina Šumberová,[$] Guido Waajen,[Φ] Gesa A. Weyhenmeyer,[◊] Kathleen C. Weathers,[◊] Mark Zion,[+] Bas W. Ibelings,[±] and Eleanor Jennings[∞]

Environ. Sci. Technol., **2016**, *50* : 10780–10794




Hellooooo... is there anyone out there?!?

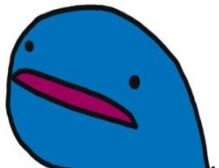
~~Dr~~ Lake equation

$$N = R * f_b * n_s * f_l * f_i * f_c * L$$

- N = the number of **lakes** with which communication might be possible

- R = the average rate of **lake development (eons!)**
- fb = the fraction of those **lakes that have buoys**
- ns = the average number of **buoys that can potentially support scientists**
- fl = the fraction of lakes that actually **support scientists willing to collaborate**
- fi = the fraction of **buoys with 'intelligent life'**
- fc = the fraction of **lakes** that have technology that releases detectable signs of their existence
- L = lifetime of the 'communicative' phase

Apologies to Frank Drake :)



Working Group 1
Data acquisition and management

Deliverables

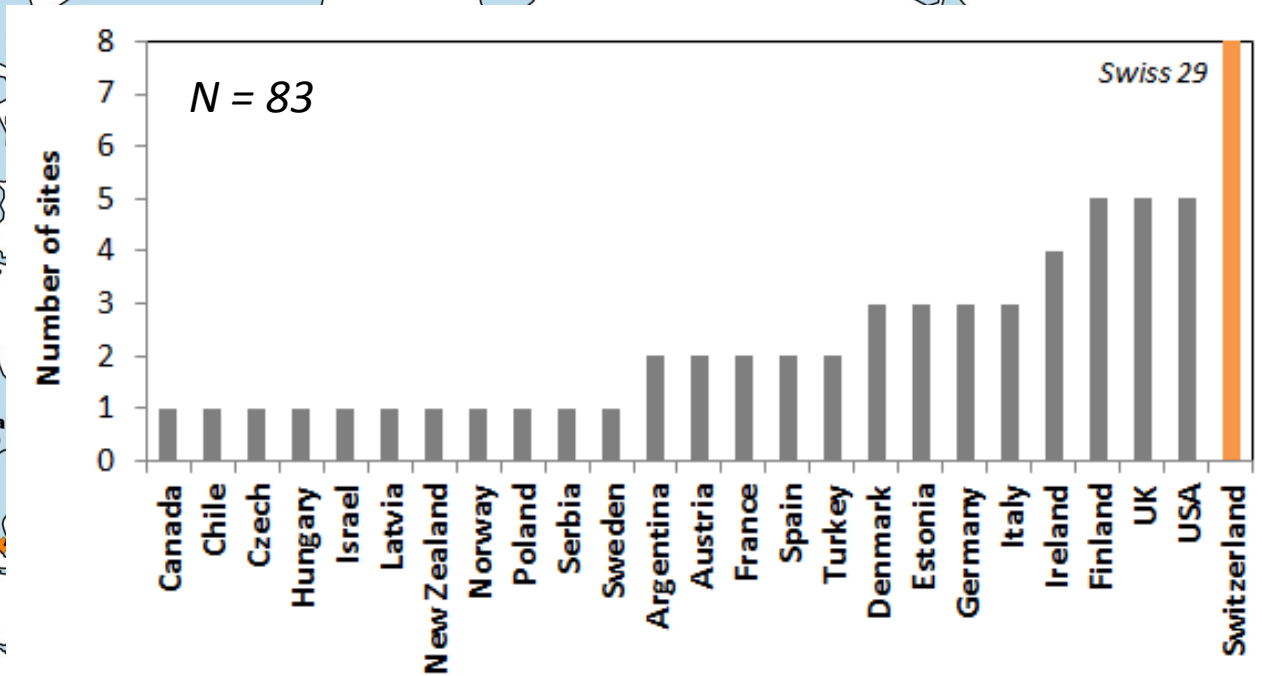
- A meta-database on high resolution lake monitoring sites.
- Standard operating procedures and monitoring protocols.
- Data handling and QA/QC methodologies specific for these large datasets.

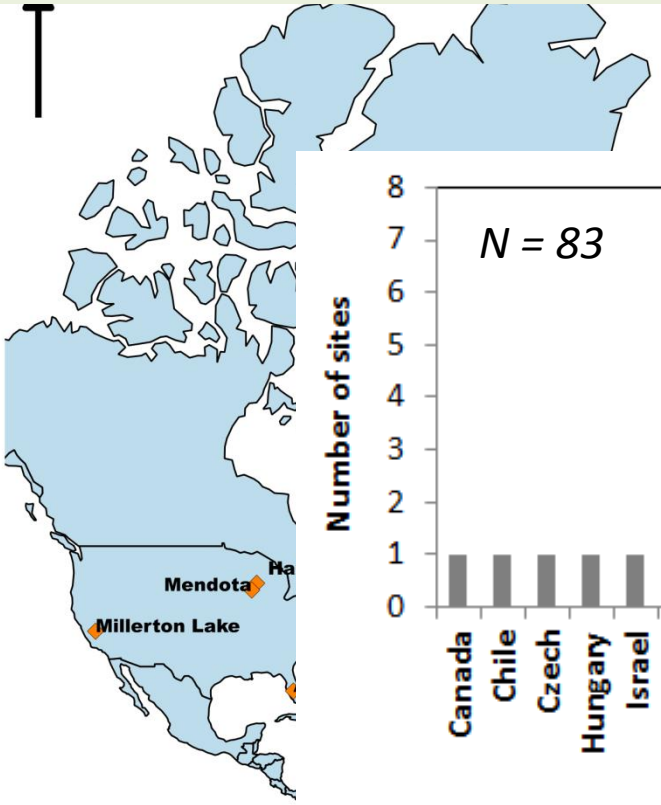
29 oligotrophic; 21 mesotrophic; 20 eutrophic; 9 hypertrophic

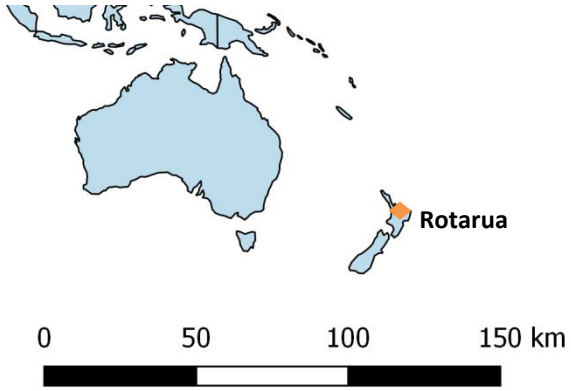
53 with seasonal ice cover

41 altitude greater than 400 m Swiss France Norway, Turkey, Spain, Italy, Austria, Chile

NETLAKE metadatabase sites







460+ dataset descriptions...
140 sensor types

SELECT * FROM "_2_site_details" LIMIT 50 Edit

Modify	site_name	latitude	longitude	country	rbdcode	rbdname	ccm_lake_id	mean_depth	max_depth	surface_area
	Saadjarv	58.5394214	26.6592632	Estonia	*NULL*	East-Estonian	*NULL*	8	25	7.245
	Orta	45.817222	8.406667	Italy	ITB	Po basin	*NULL*	80	143	18.1
	Muzelle	44.95031	6.097607	France	FRD	Rhone and Coastal Mediterranean	*NULL*	11.5	18.8	0.1
	BALATON	46.833333	17.733333	Hungary	HU1000 - Danube	Danube	*NULL*	3.2	12	592
	Vortsjarv	58.28	26.05	Estonia	blank	East-Estonian	96355	2.8	6	270
	Langtjern	60.37	9.73	Norway	NO5102	Vest-Viken (West Bay)	*NULL*	2	12	0.23
	Verevi	58.2316125	26.4057753	Estonia	*NULL*	East-Estonian	*NULL*	3.6	11	0.126
	Furnace	53.916978	-9.571753	Ireland	IEWE	Western	111554	*NULL*	21	1.41
	Anterne	45.990917	6.798283	France	FRD	Rhone and Coastal Mediterranean	*NULL*	6.5	12.7	0.116
	Milltown	54.145149	-6.710555	Ireland	blank	NeaghBann	*NULL*	5.5	12	0.22
	Bunaveela	53.918355	-9.571753	Ireland	IEWE	Western	111554	10	18	0.5
	Bassenthwaite	54.65	-3.22	United Kingdom	*NULL*	*NULL*	*NULL*	5.3	19	5.3
	Esthwaite Water	54.35	-2.98	United Kingdom	*NULL*	*NULL*	*NULL*	6.9	16	0.96
	Dehtář	49.0023	14.1738	Czech	*NULL*	*NULL*	*NULL*	2.6	6	2.38
	Mueggelsee	52.446141	13.650048	Germany	DE5000	Elbe Germany	*NULL*	4.9	8	7.3
	Feeagh	53.94888	-9.575556	Ireland	IEWE	Western	111462	14.5	45	3.92
	Remersee	46.672	8.411	Switzerland	CH10	Rhein	*NULL*	*NULL*	2.1	0.0056
	Hagelseeli	46.756	8.15	Switzerland	CH10	Rhein	*NULL*	*NULL*	*NULL*	0.0064
	Häxeseeli	46.817	8.147	Switzerland	CH10	Rhein	*NULL*	*NULL*	*NULL*	0.0243
	Lower Erne	54.29127	-7.50623	United Kingdom	GBNIIENW	North West	*NULL*	11.9	69	109.5
	Tovel	46.26137	10.94934	Italy	*NULL*	ITA - Eastern Alps	*NULL*	19	39	3825
	Abant	40.36	31.16	Turkey	*NULL*	*NULL*	*NULL*	*NULL*	18	1.25
	Konnevesi	62.64	26.41	Finland	FIVHA2	Kymijoki-Gulf of Finland	*NULL*	10.6	57	189
	Kinneret	32.72	35.56	Israel	*NULL*	*NULL*	*NULL*	24	*NULL*	*NULL*
	Maggiore	45.967621	8.653259	Italy	ITB	Po basin	*NULL*	177	370	212.5
	Sau Reservoir	41.97	2.4	Spain	ES100	Internal Basins of Catalonia	*NULL*	29	65	5.8
	Sava	44.7842	20.3919	Serbia	RO1000	Danube	136190	4.5	12	0.8
	Blelham	54.4	-2.98	United Kingdom	*NULL*	*NULL*	*NULL*	6.8	14.5	0.102
	Windermere	54.36	-2.94	United Kingdom	*NULL*	*NULL*	*NULL*	21.3	64	14.764
	Jyvasjarvi	62.23	25.77	Finland	FIVHA2	Kymijoki-Gulf of Finland	*NULL*	5.8	25	3.1
	Engure	57.281639	23.104591	Latvia	LVVUBA	Venta	*NULL*	0.4	2.1	41.3
	Kortowskie Lake	53.4543	20.2642	Poland	PL7000	Pregolya	*NULL*	5.9	17.2	0.897
	Erken	59.844941	18.588695	Sweden	SE3	North Baltic	*NULL*	*NULL*	*NULL*	*NULL*
	Vanajanselkä	61.14893056	24.27368333	Finland	FIVHA3 - Kokemäenjoki-Archipelago Sea-Bo	Kokemäenjoki	*NULL*	7	24	103

Who's doing what?

- All sites measure water temperature
- 4 use HOBO
- 3 use Minidot

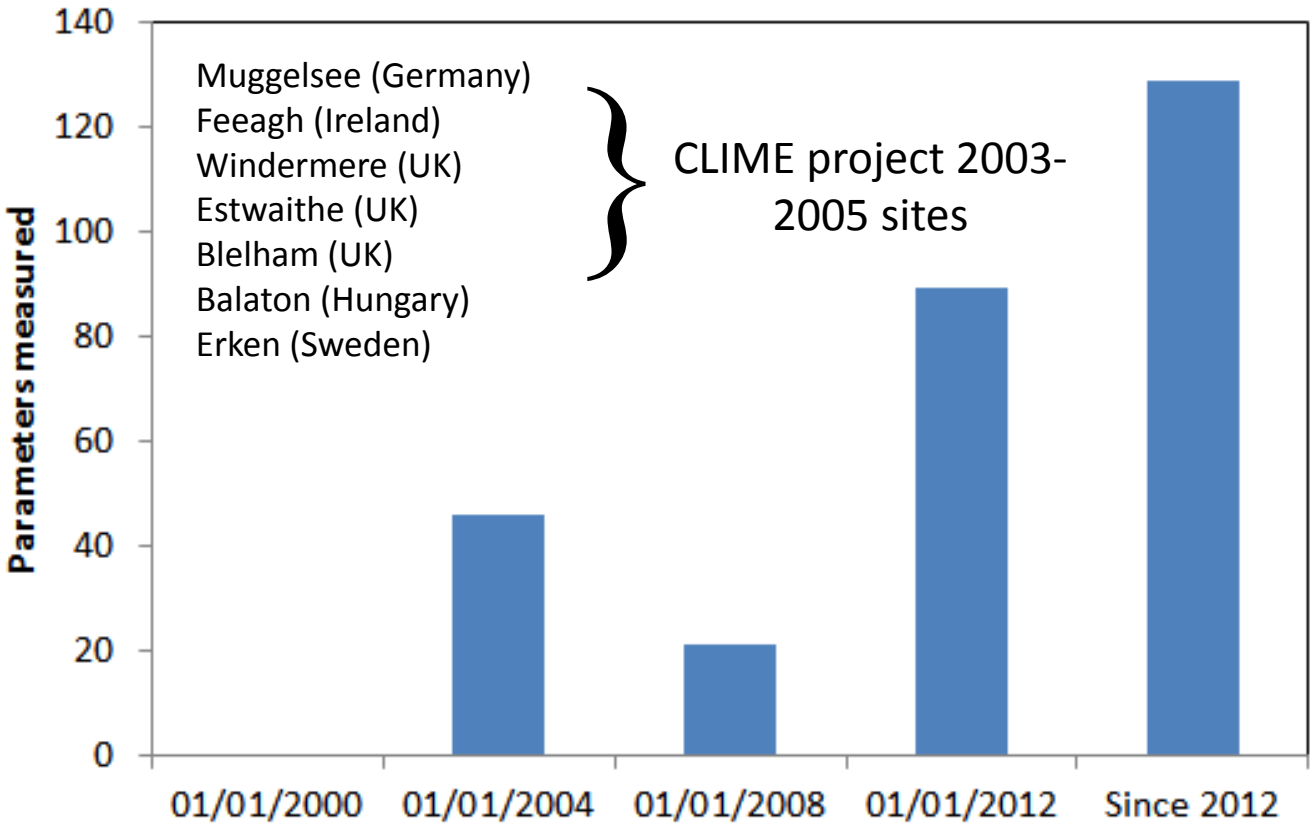
- Dissolved oxygen concentration at 37 sites
- Dissolved carbon dioxide at 5 sites – GLEON DC flux

- 25 stations measure chlorophyll fluorescence
- 5 of those use the Datasonde X5
- 1 delayed fluorescence (Balaton)

- 9 measure phycocyanin fluorescence
- 3 use Datasonde X5; 5 use YSI 6600V2-4

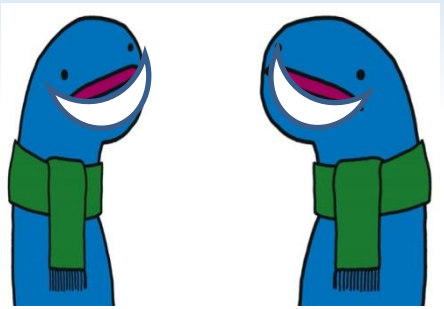
Who's doing what?

7 sites have data for multiple parameters > 10 years



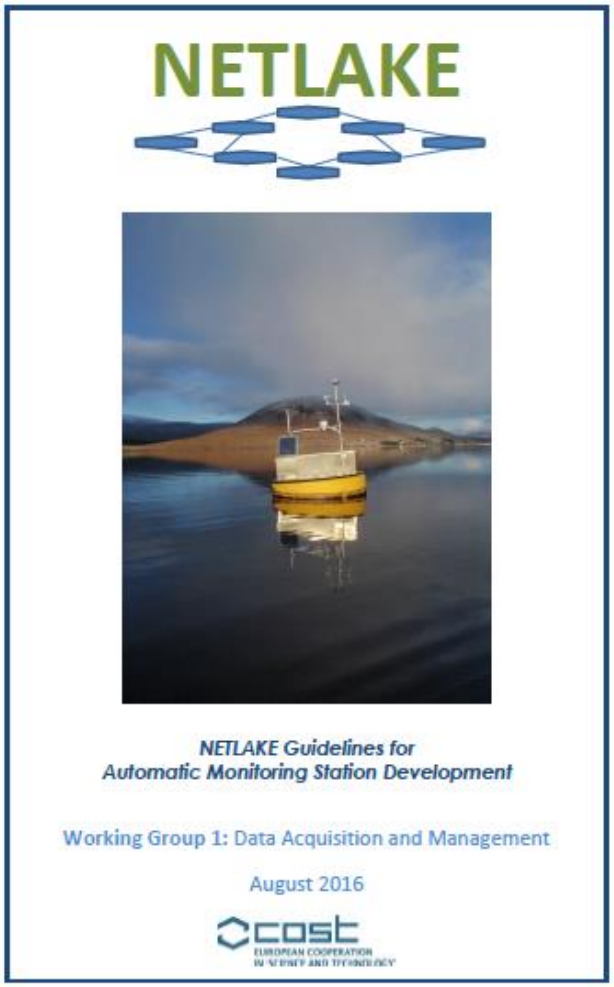
Duration of parameter datasets

Yes there is someone out there!

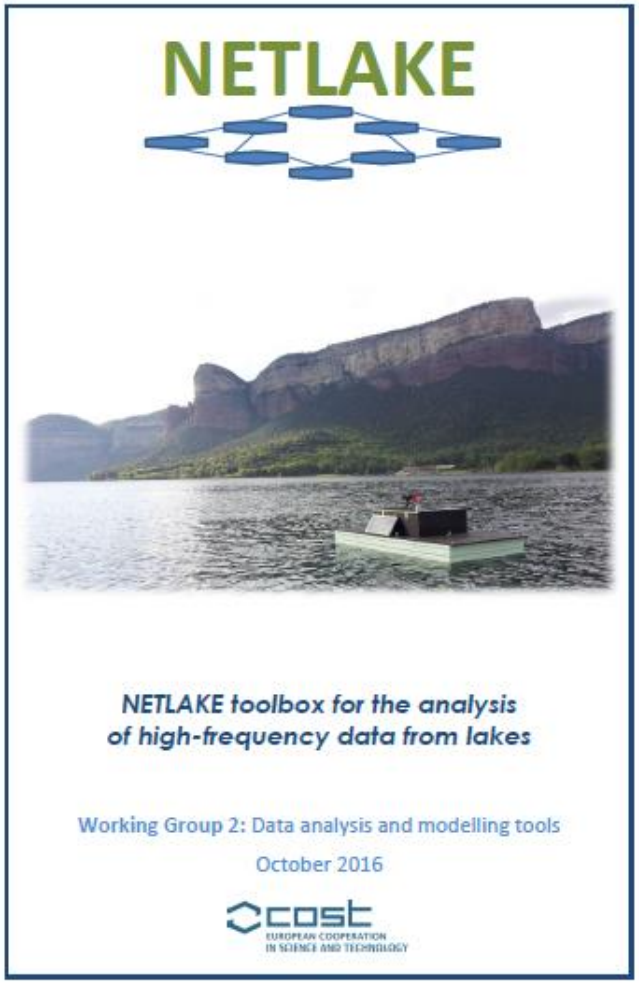


- Currently can query online in Adminer, and QGIS
- Manuals for data entry and querying
- SAFER and La Pampas sites in (N and S America)
- GLEON site input on-going
- A tool for the wider community to promote HFM in lakes and facilitate data sharing and collaborative science

Free and very useful pdfs to download



Laas et al. 2016



Obrador et al. 2016

Metadatabase:
www.dkit.ie/netlake/netlake-resources/netlake-metadatabase

Toolbox
www.dkit.ie/netlake

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Estonia 2017