GARDEN 2018 lake GARDa
ENvironmental system

First observations of oxycline oscillations in Lake Iseo

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Manerba del Garda

1 – Motivations - eutrophy and oxygen deficit due to anthropogenic stressors

1967

Prof. m	Temp. °C		mg O_2/l		pH		Cond. µS 18 °C		µg $P(PO_4''')$/l	
	V	XI	V	XI	V	XI	V	XI	V	XI
0	13,1	10.6	11,9	10,1	8,46	8,15	260	238	1	0
5	11,1	10,6	12,2	10,2	8,40	—	258	—	0	—
10	9,4	10,6	12,0	10,3	8,30	—	263	—	0	—
20	8,3	10,5	10,9	10,4	8,11	8,21	268	239	0	1
30	7,5	8,7	10,6	8,3	8,01	8,00	268	258	0	1
60	6,0	6,0	10,0	9,3	7,93	8,02	268	271	3	6
100	5,85	5,8	9,7	9,1	7,91	8,08	269	269	6	4
150	5,75	5,7	9,5	9,0	7,92	8,08	271	272	1	8
200	5,75	5,75	9,1	8,5	7,82	8,04	272	273	3	12
245-7	5,75	5,75	8,2	7,8	7,88	7,98	278	279	30	15

Source: Bonomi and Geerletti (1967)

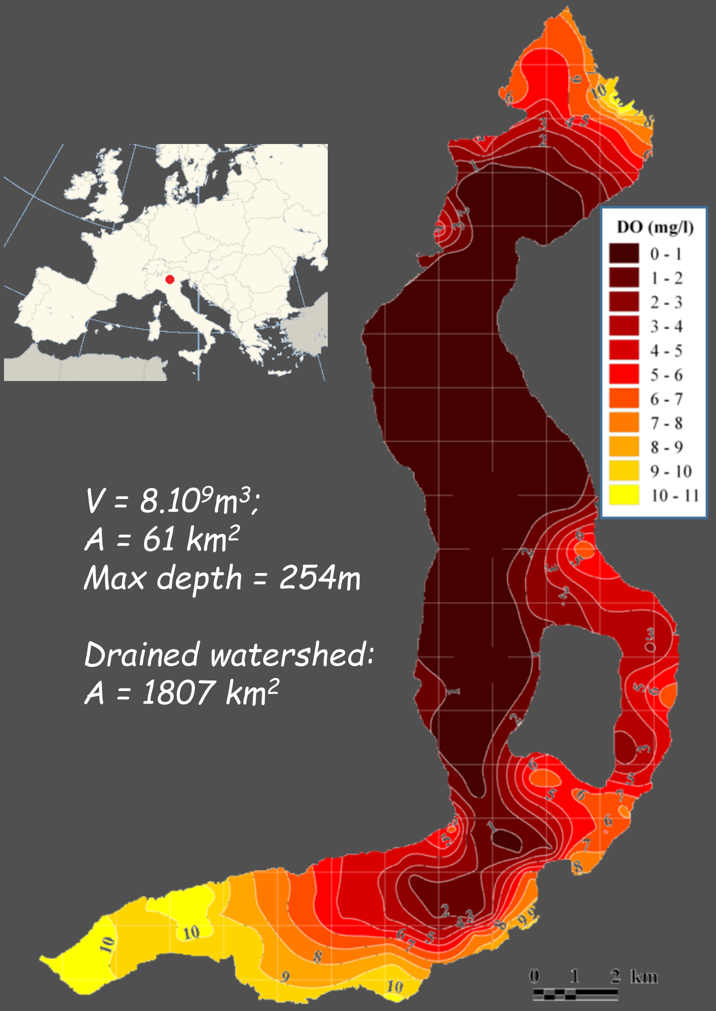
2016

Depth (m)	Temp °C		mg O_2/l		Cond. 20° (µS/cm)		µg SRP/l		µg TP/l	
	IV	X	IV	X	IV	X	IV	X	IV	X
0	12.0	17.4	11.0	10.1	248	254	5	5	10	10
25	7.8	9.9	11.1	6.0	226	240	6	3	10	10
50	7.2	6.7	7.3	4.5	230	244	17	17	19	17
150	6.5	6.6	0.1	0.1	248	248	98	99	104	101
200	6.5	6.6	0.1	0.1	250	250	105	101	106	102
250	6.5	6.6	0.1	0.1	252	253	112	125	112	122

Data measured by Dr. Michael Hupfer (IGB)

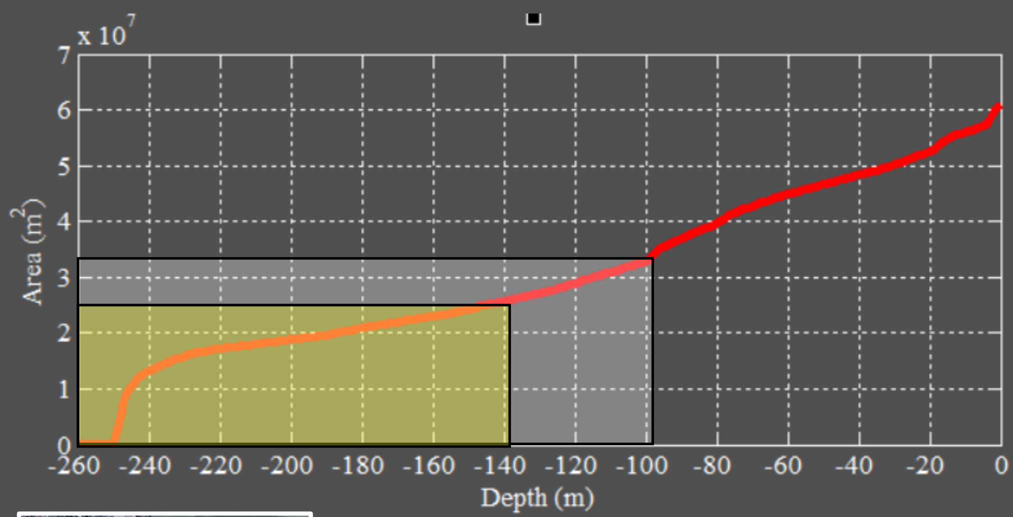
$V = 8.10^9 m^3$;
$A = 61\ km^2$
Max depth = 254m

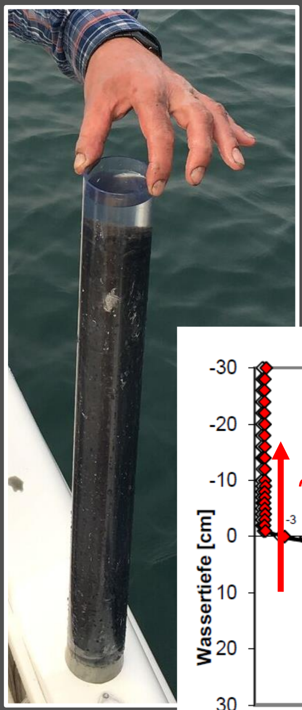
Drained watershed:
$A = 1807\ km^2$

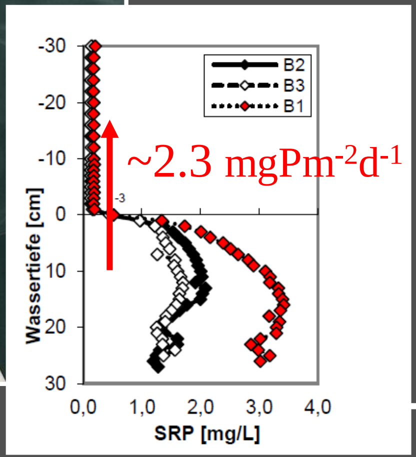


Dissolved oxygen measured in the 10m of water above the sediments

July 2012



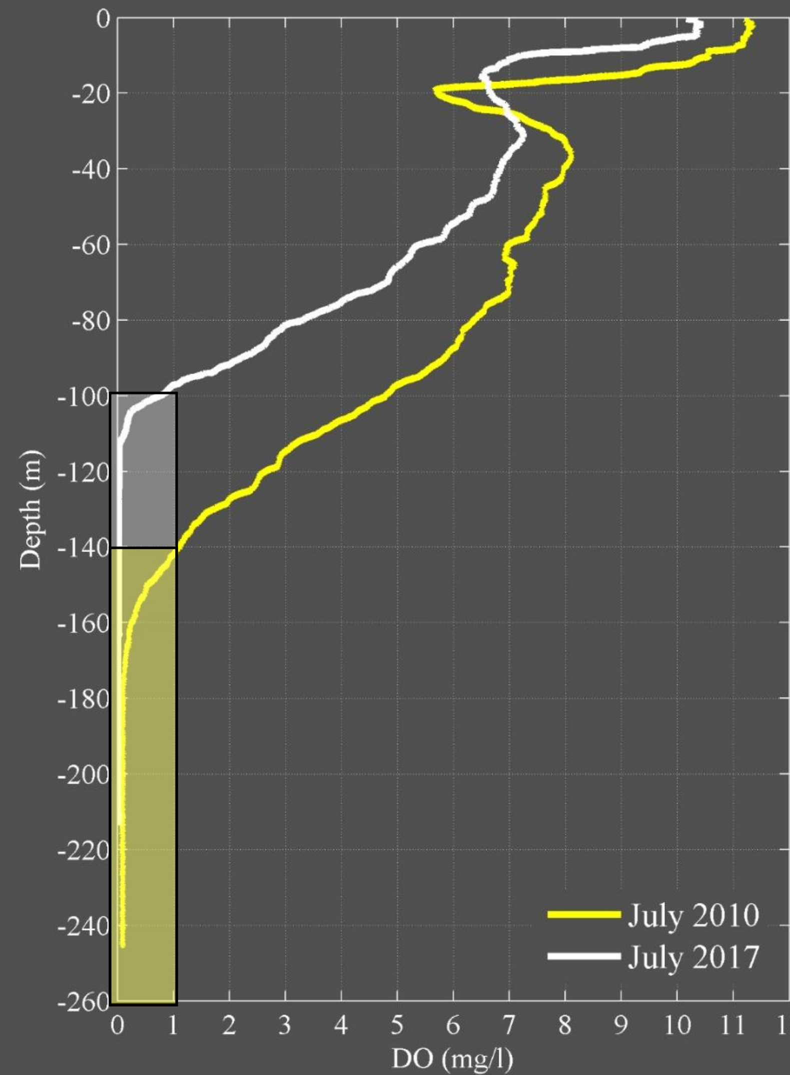




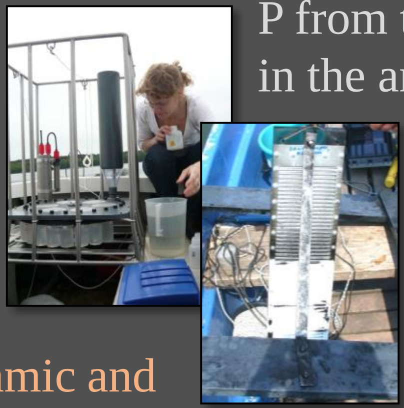
Additional **<u>1.4 km^2/year</u>** area of sediments are in contact with water with DO < 1mg/l (+ 35% / 7 years)

↓

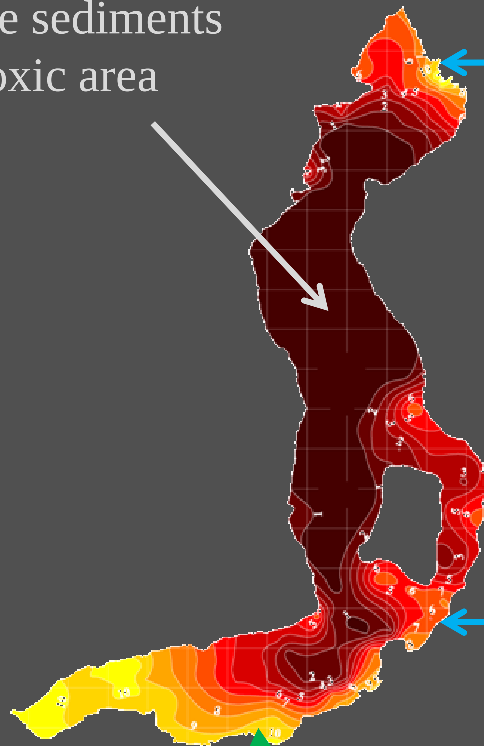
Additional SRP from monimolimnion **<u>~ 1 tonn/year</u>**



General objective: quantitative assessment of local pressures on the overall P load to clarify how effective will external nutrient load reductions be on the trophic evolution of Lake Iseo.



P from the sediments in the anoxic area



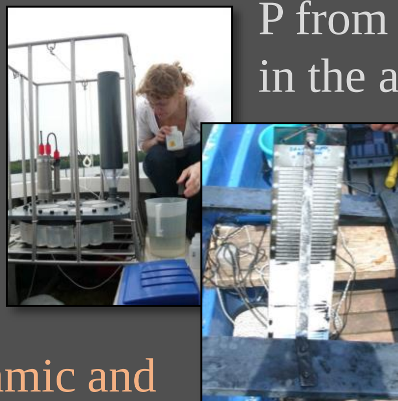
P from the main tributaries

Hydrodynamic and ecological modeling

P from the CSOWs

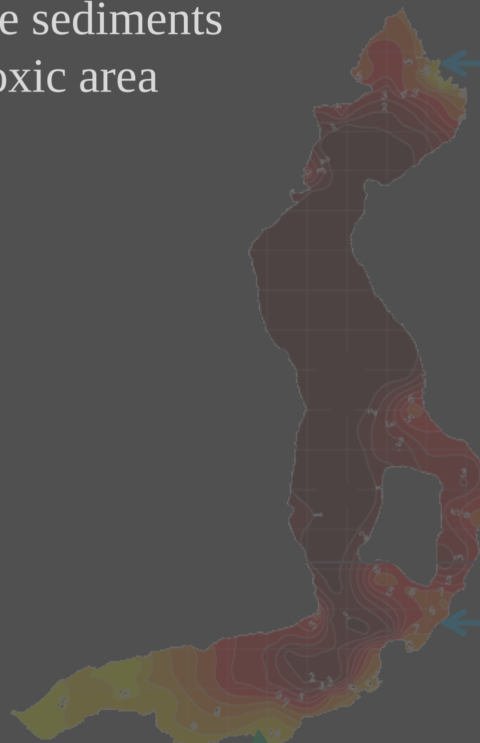
Role of the macrophytes in the shallower areas

Specific sub-objective: what are the effects of the internal waves on the release of the P from the sediments in the monimolimnion?



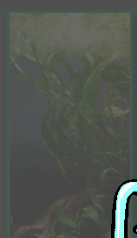
P from the sediments in the anoxic area

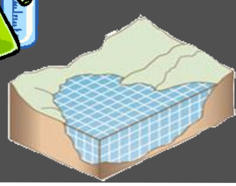
Hydrodynamic and ecological modeling



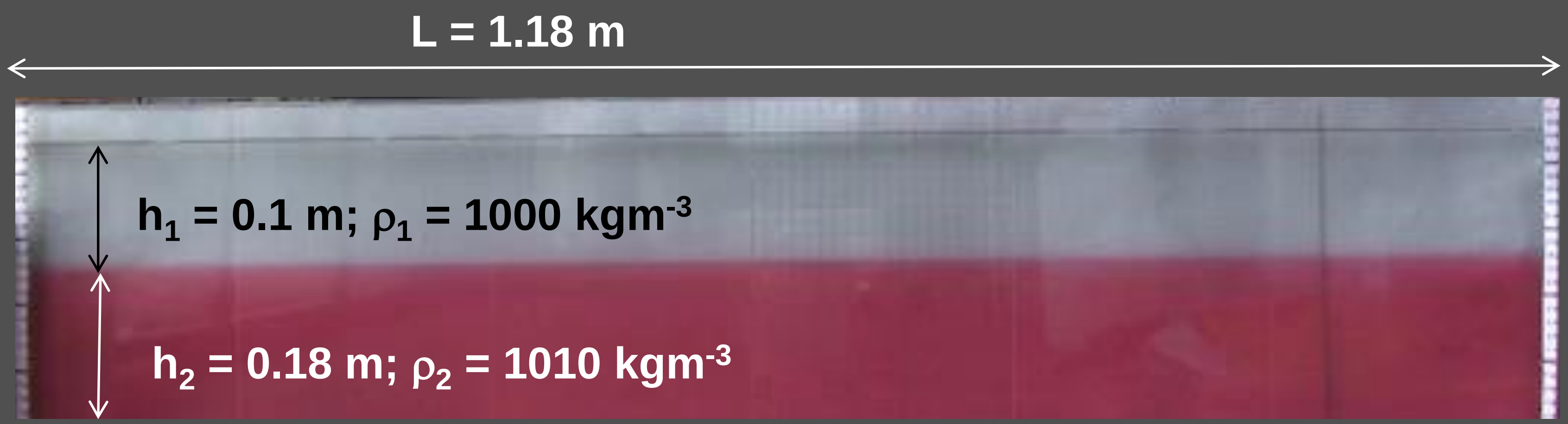
P from the main tributaries

P from the CSOWs





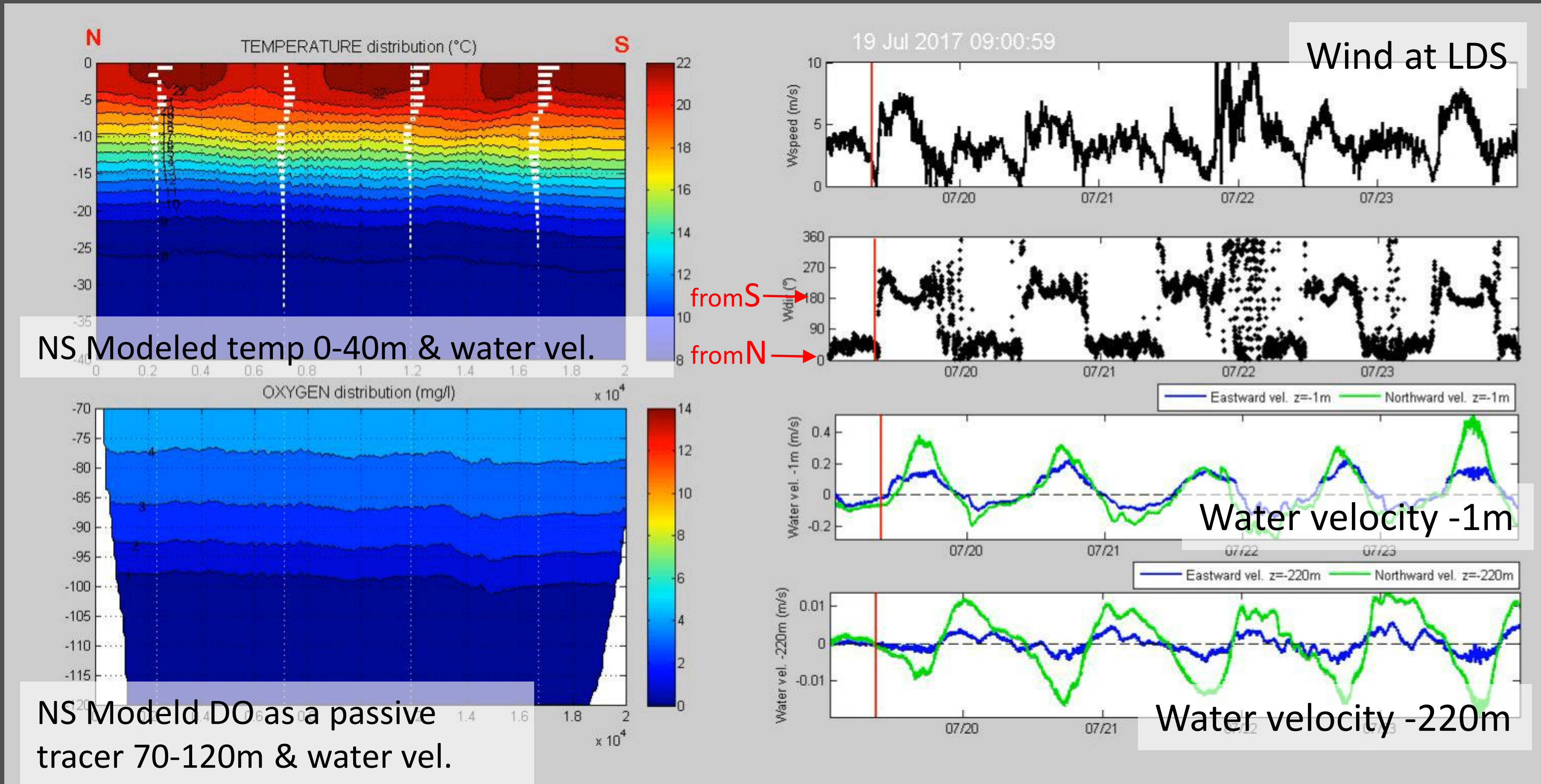
Lake model in the laboratory (V1H1)

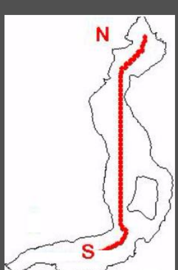


$$T = \frac{L}{\sqrt{g\,\frac{\rho_2 - \rho_1}{\rho_2}\,\frac{h_2 h_1}{h_2 + h_1}}} = 30s$$

2 – Internal waves - model

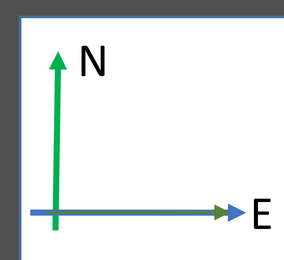
see Valerio et al. 2012 L&O, Valerio et al. 2017 WRR





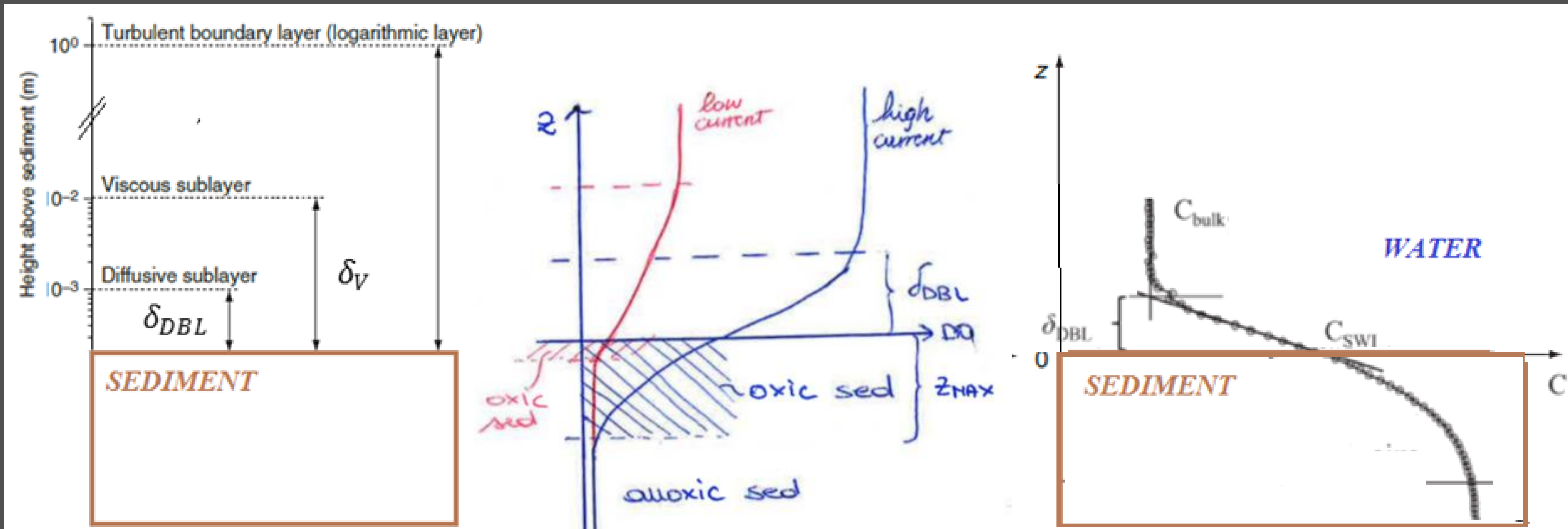
At the bottom:

- alternating bottom currents
- alternating REDOX conditions around the oxycline



3 – Research questions

- Temporal variations of the redox conditions across the oxycline

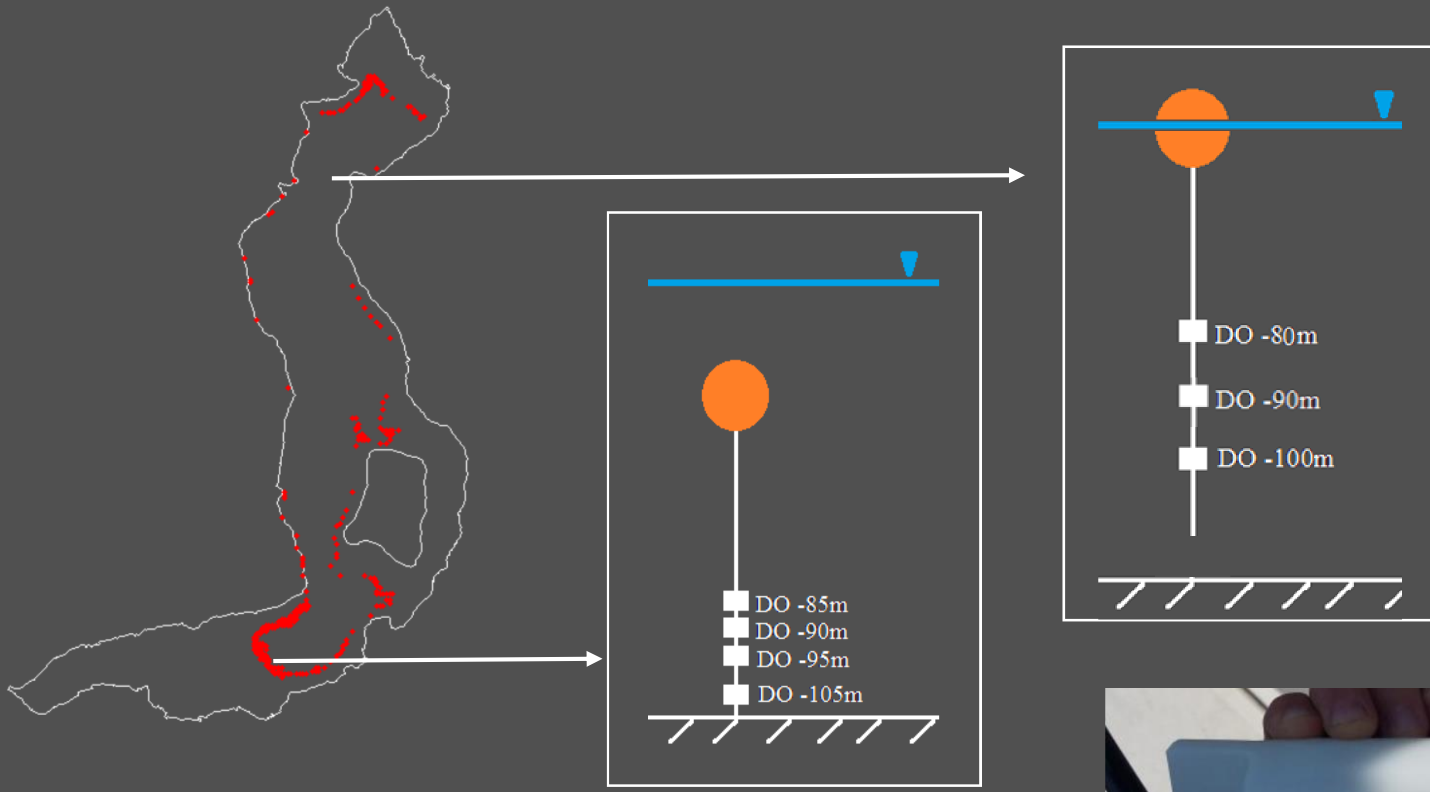


See e.g. Bryant et al. 2010 L&O
Hupfer et al. 2007 Aquat Microb Ecol

Fluctuating redox conditions could imply:

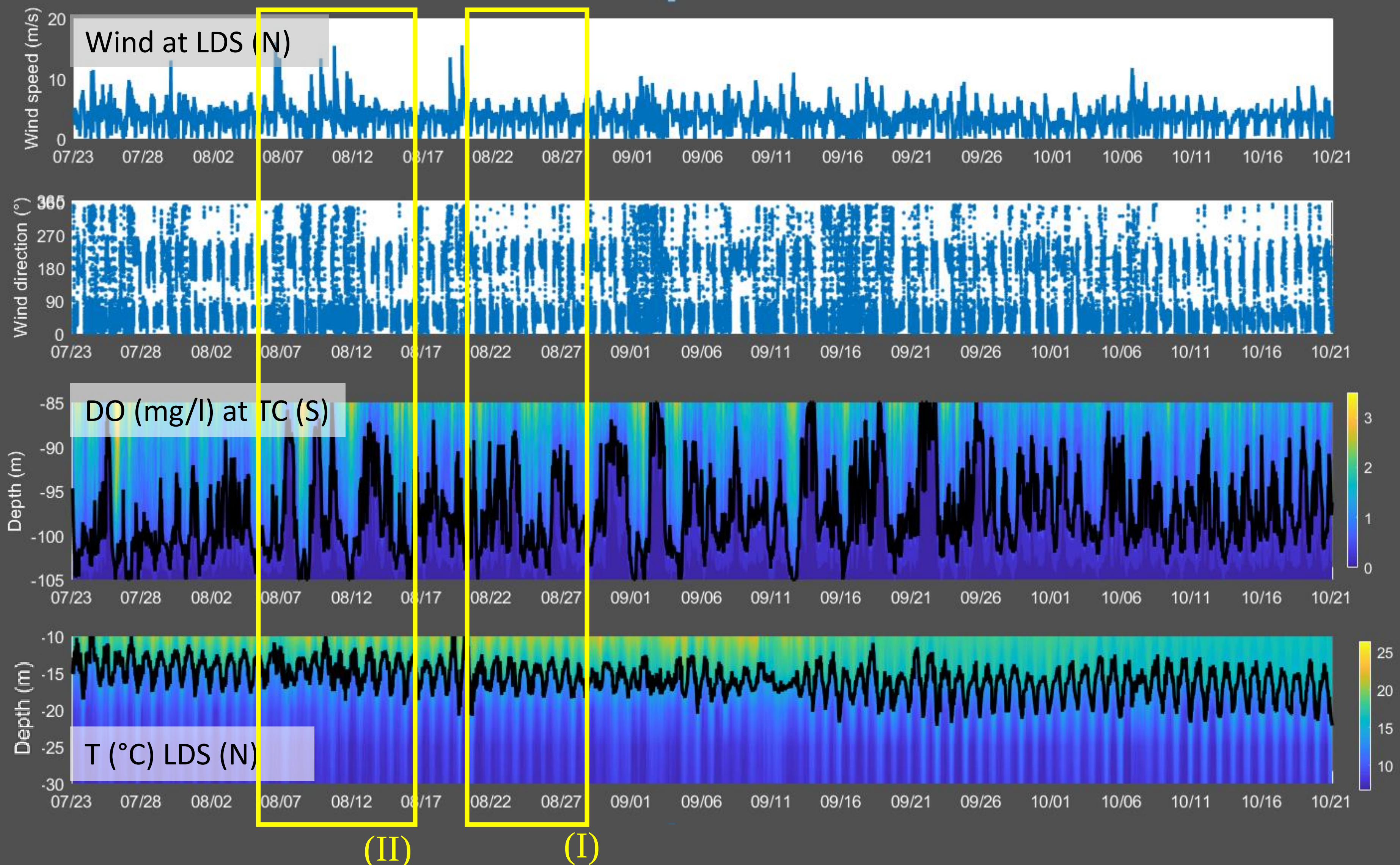
- Oxic conditions: higher mineralisation of organic bound P and temporary fixation at FeOOH
- Anoxic conditions: strong release of P due to reductive dissolution of Fe(III)

- Monitoring oxygen just above the sediments and at the same depths in the northern chain

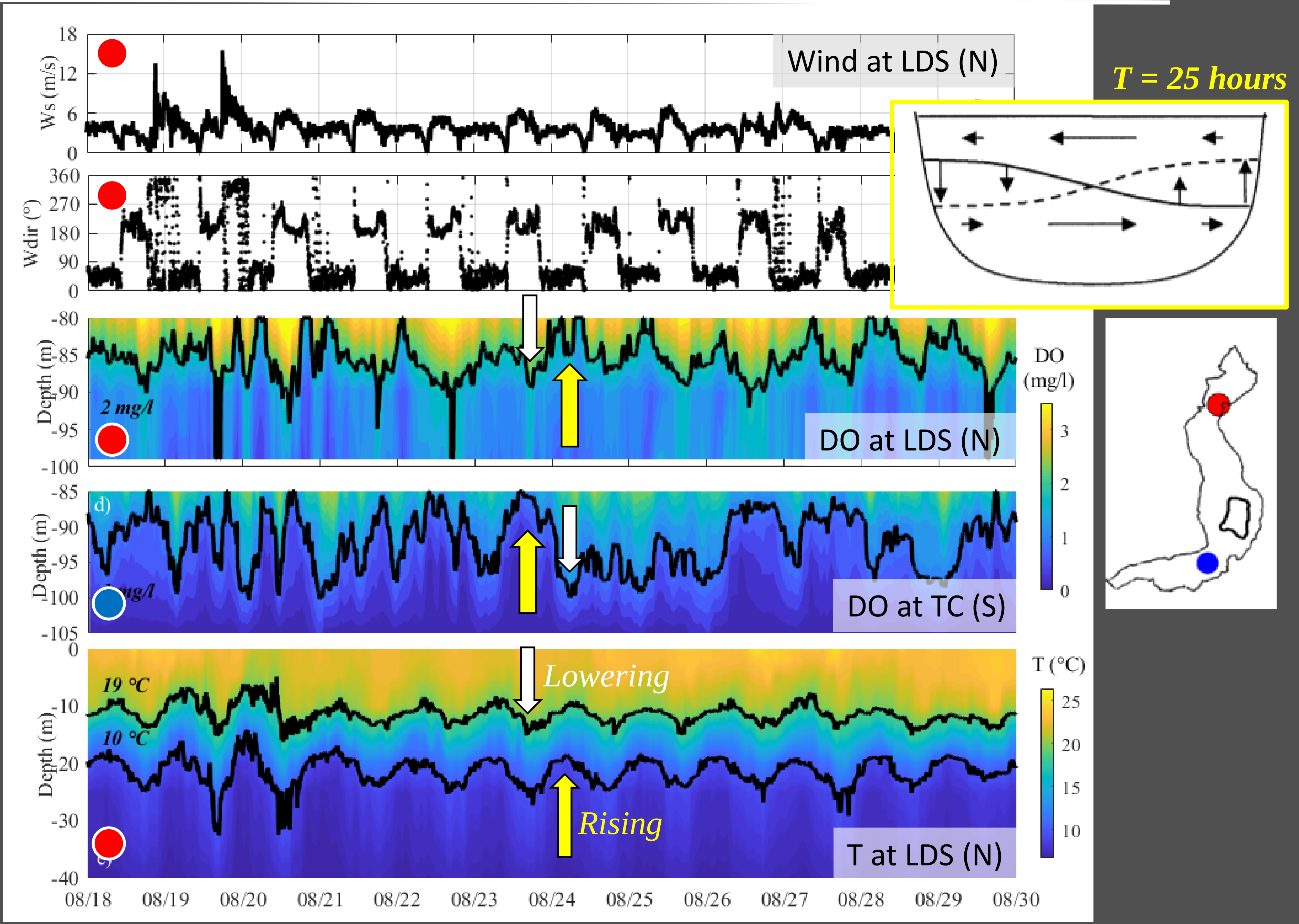


Real-time data available at:
http://hydraulics.unibs.it/hydraulics/il-monitoraggio-del-lago-diseo/real-time-data-from-lake-monitoring-system/

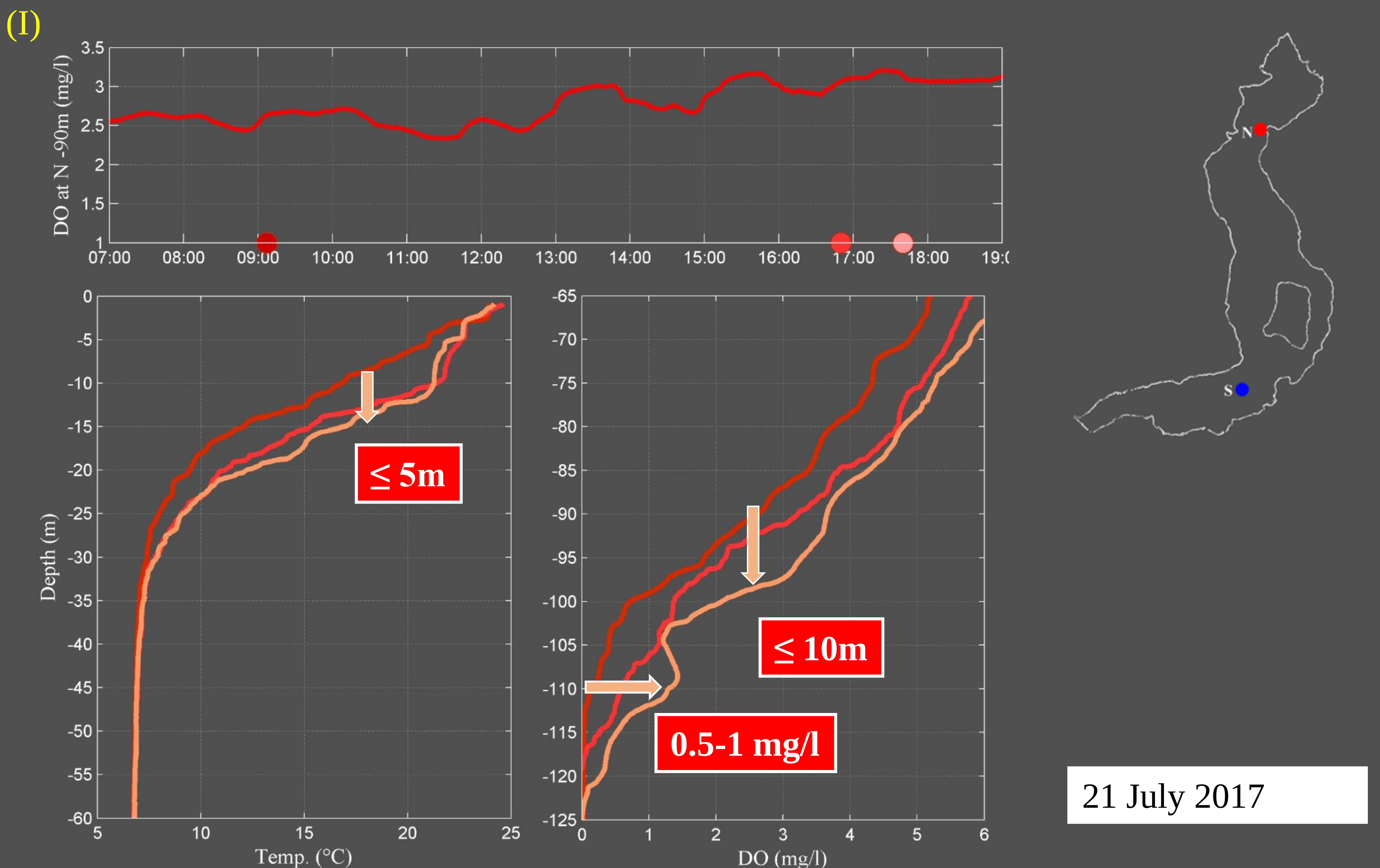
Dominant V1H1 mode in resonance with the wind and occasional V2H1 by long-lasting wind



4 – Field observations *(I)*



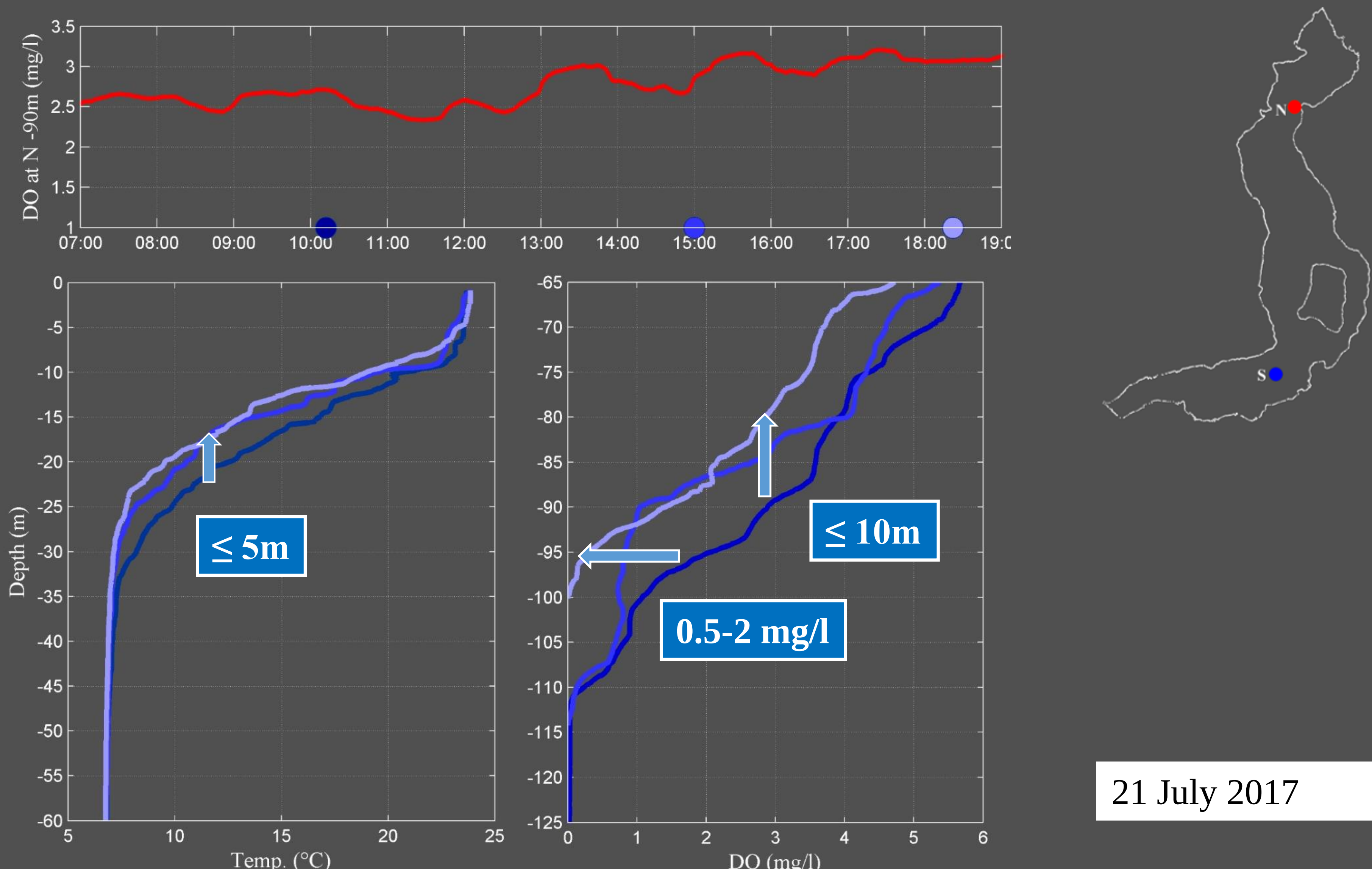
3 – Internal waves in Lake Iseo – measurements



21 July 2017

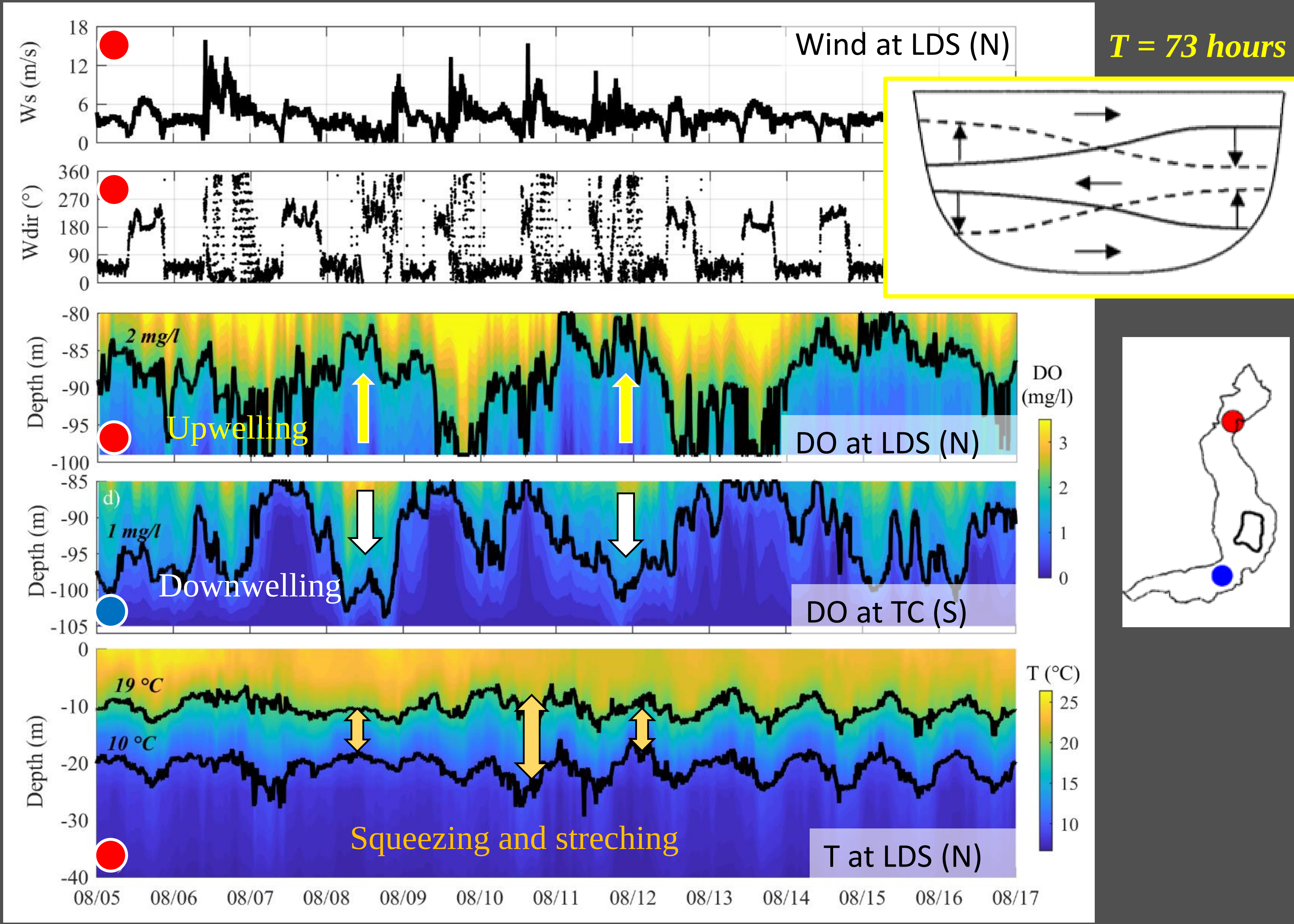
4 – Field observations (I)

(I)



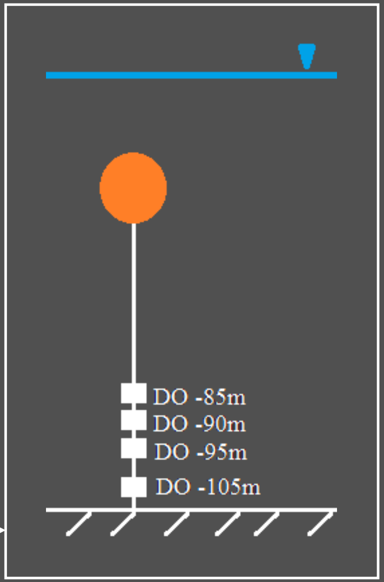
21 July 2017

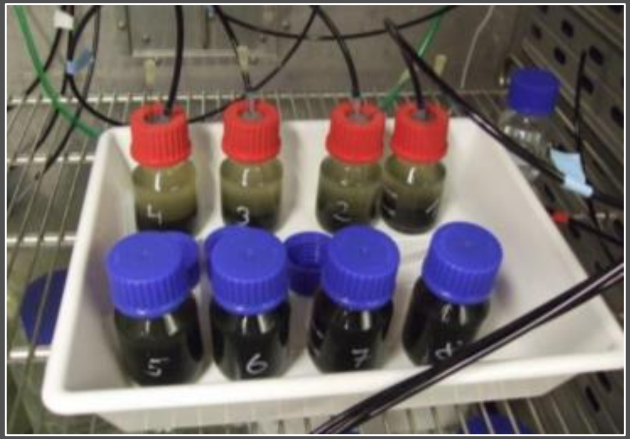
4 – Field observations *(II)*



5 – Conclusions and future work

We estimated about 2 km^2 with 1-3 days intermittent redox conditions, and identified maximum redox changes in correspondence of the excitation of V2H1 motions.





- ✓ Planning specific lab. experiments to quantify the effects of the alternation of the redox conditions on the P fluxes
- ✓ Quantifing the effect of the V1H1 velocity field in the monimolimnion on the thickness of the diffusive boundary layer

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