INVESTIGATION OF THERMAL STRATIFICATION OF A LAKE BASED ON LOW-COST OBSERVATIONAL DATA

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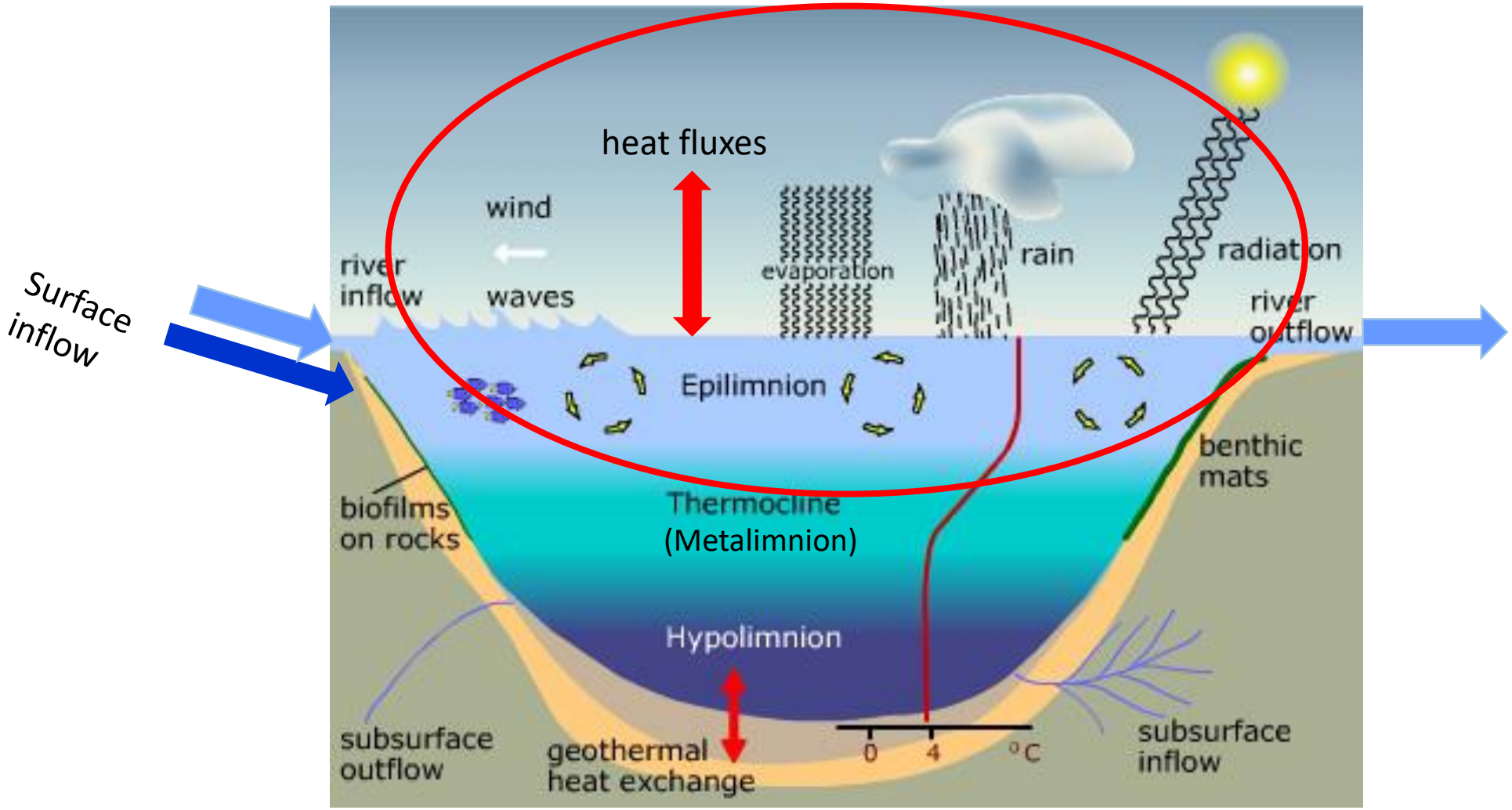
STRATIFICATION EVOLUTION AND LAKE DYNAMICS

Outline

1. Introduction – lake stratification
2. Kozjak, Plitvice Lakes, Croatia & motivation
3. Experimental data
4. Results
5. Discussion and conclusions

1.Introduction – lake stratification

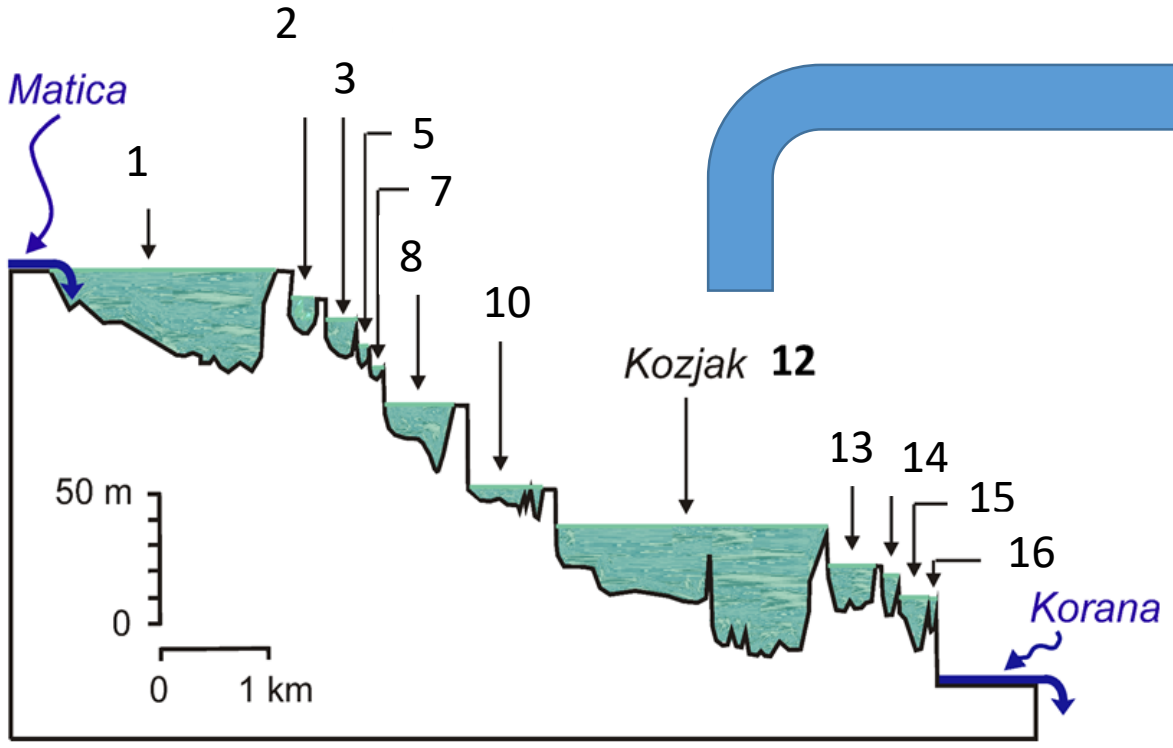
Lake surface ↔ atmosphere



Summertime stratification

2. Kozjak, Plitvice Lakes, Croatia & motivation

Plitvice Lakes



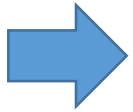
← S

N →

Kozjak Lake	12
Altitude (m)	535.0
Area (ha)	82.0
Average depth (m)	17.3
Maximum depth (m)	46.4
Volume (km^3)	0.012 71

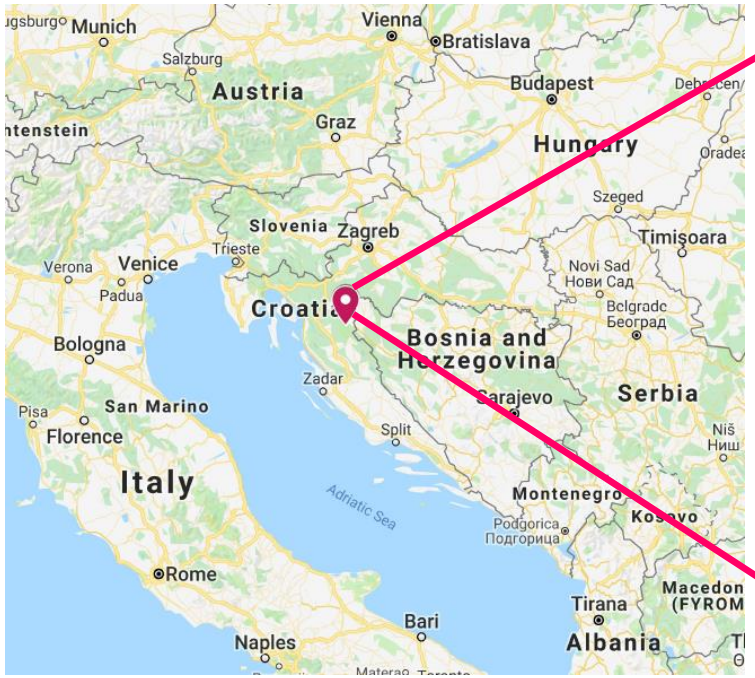
- Oligotrophic
- Dimictic

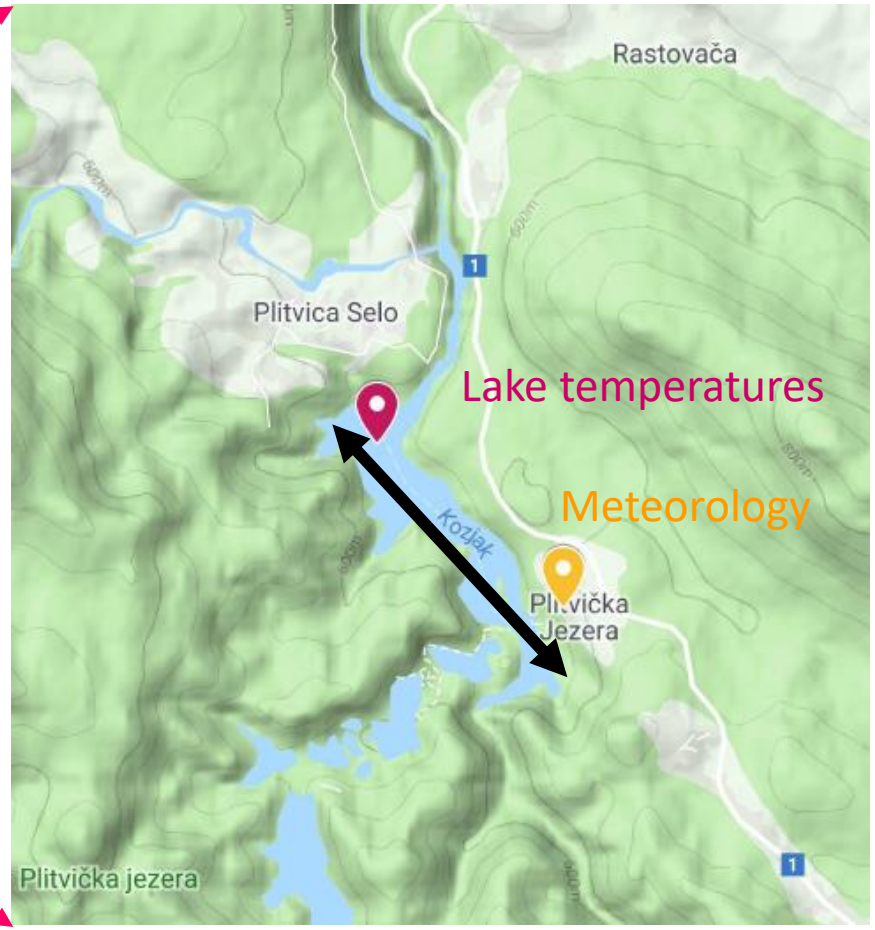
- Tufa formation (fragile) - a narrow range of the physical, chemical and biological conditions
- Physics of Plitvice Lakes poorly investigated
- UNESCO heritage (1979)



Motivation

3. Experimental data


Munich
Vienna
Bratislava
Salzburg
Austria
Budapest
Graz
Hungary
Szeged
Slovenia
Zagreb
Timişoara
Trieste
Verona
Venice
Padua
Novi Sad
Нови Сад
Croatia
Bologna
Bosnia and
Herzegovina
Zadar
Serbia
San Marino
Pisa
Florence
Split
Niš
Ниш
Italy
Adriatic Sea
Montenegro
Kosovo
Podgorica
Подгорица
Rome
Tirana
Bari
Albania
Naples


Rastovača
Plitvica Selo
Lake temperatures
Meteorology
Kozjak
Plitvička
Jezera
Plitvička jezera

Lake temperatures

HOBO TidBit 400, 1 s resolution
(≈ 145 $ + VAT / per piece)

measurement accuracy :

±0.25°C from -20° to 0°C
±0.20°C from 0° to 70°C

2-min mean T, 15 depths

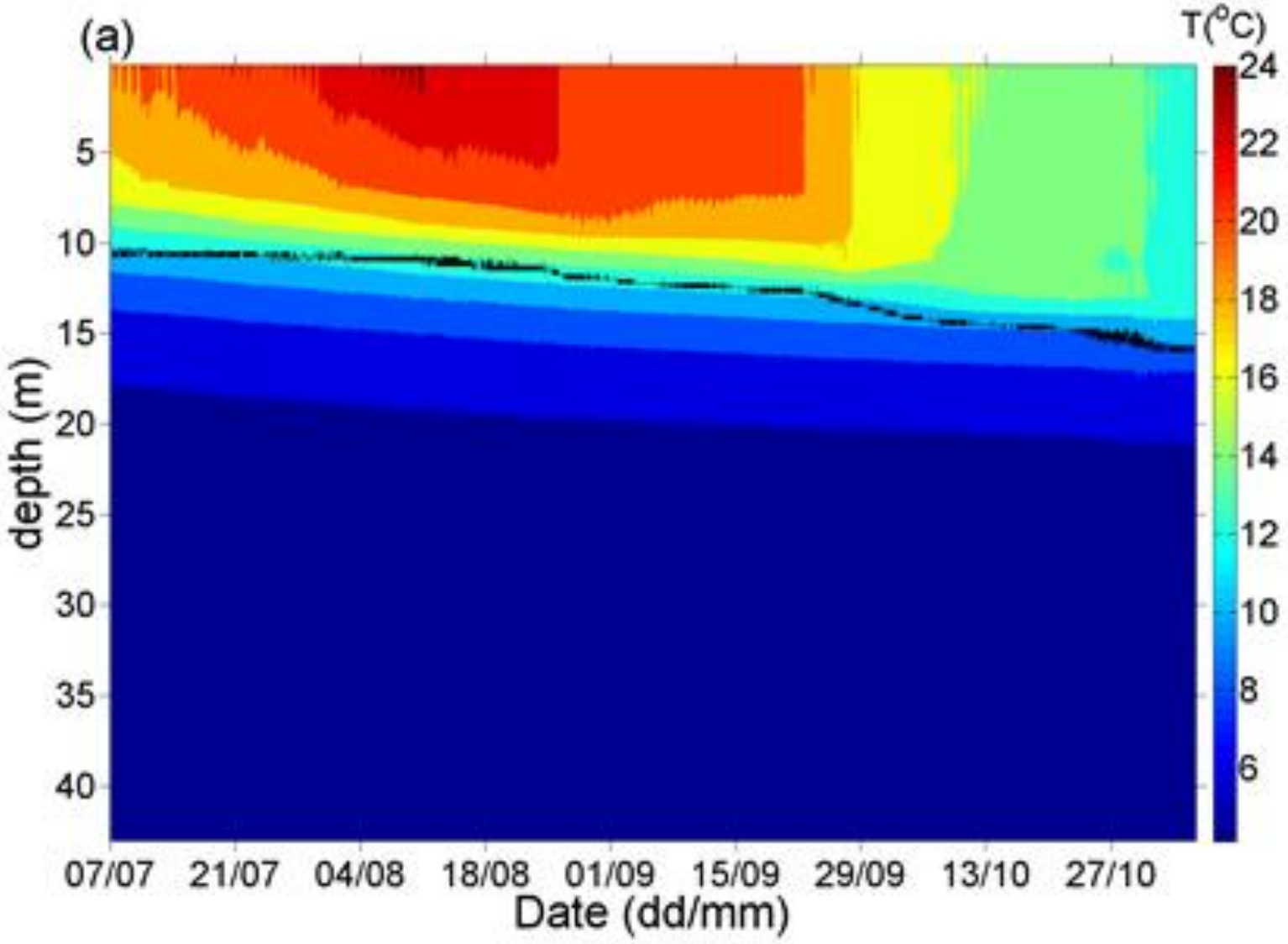
6 July –5 November 2018

4. Results

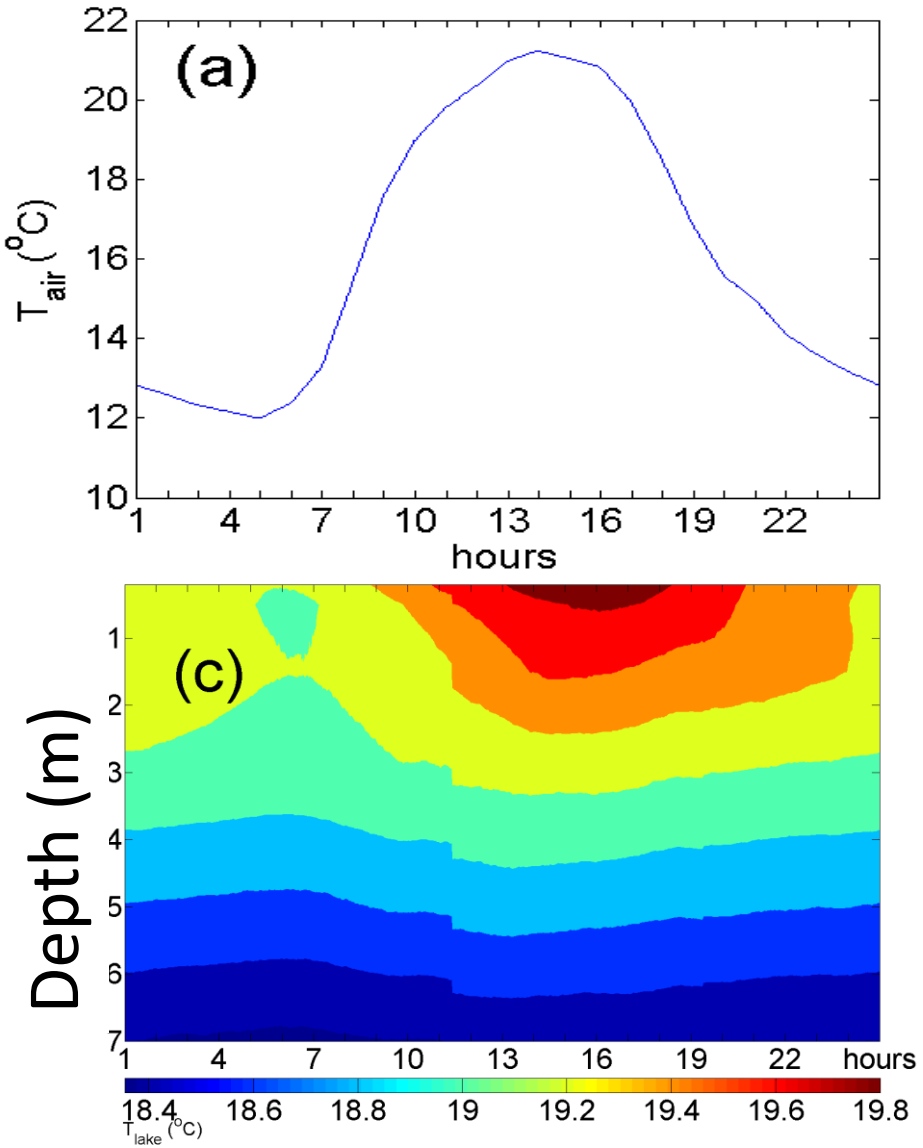
Before submerging

After 4 months

Thermocline (pycnocline) evolution



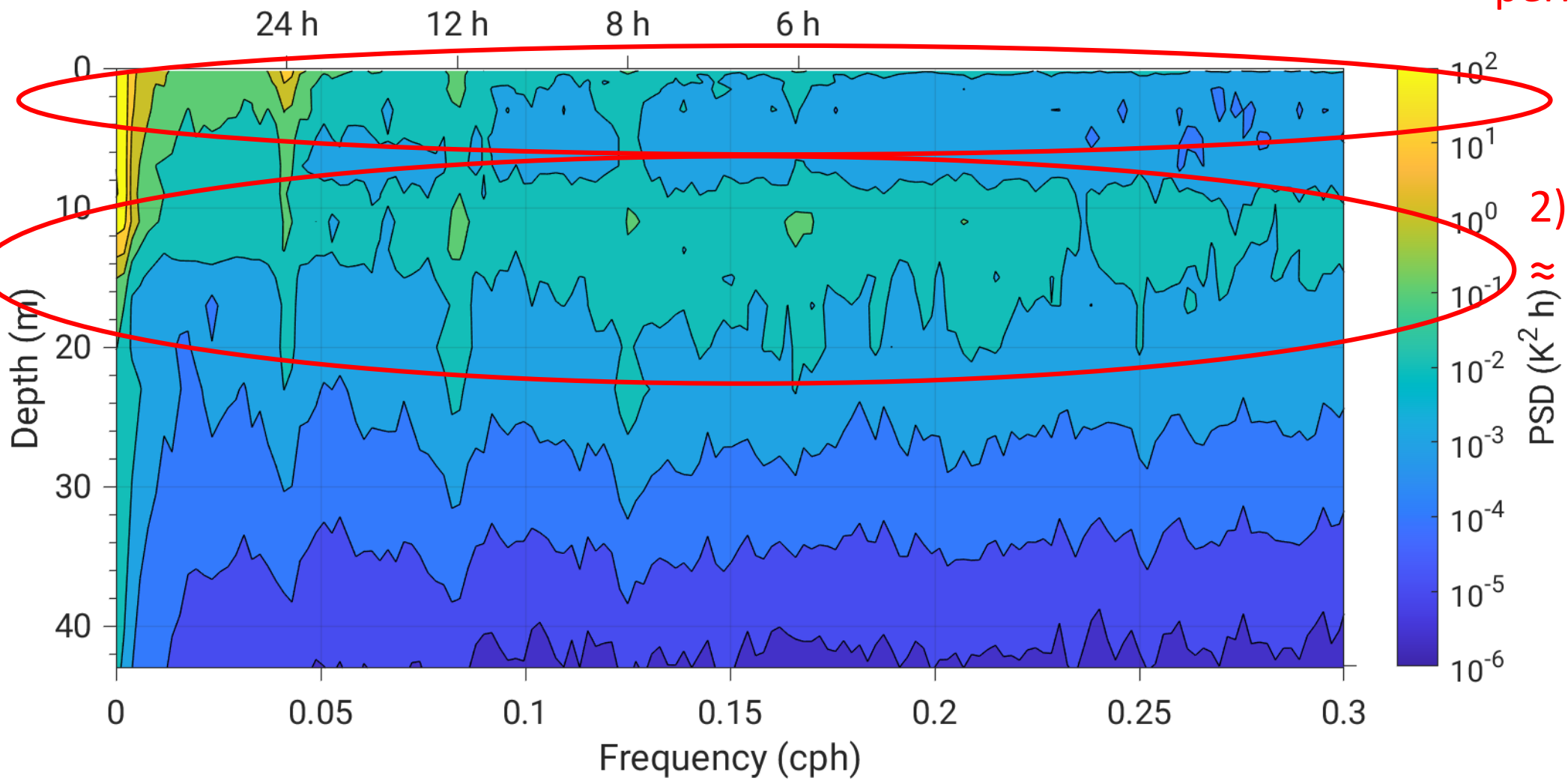
Diurnal variations



Air temperature

Lake temperature

Periodicity
Spectral analysis – hourly time series



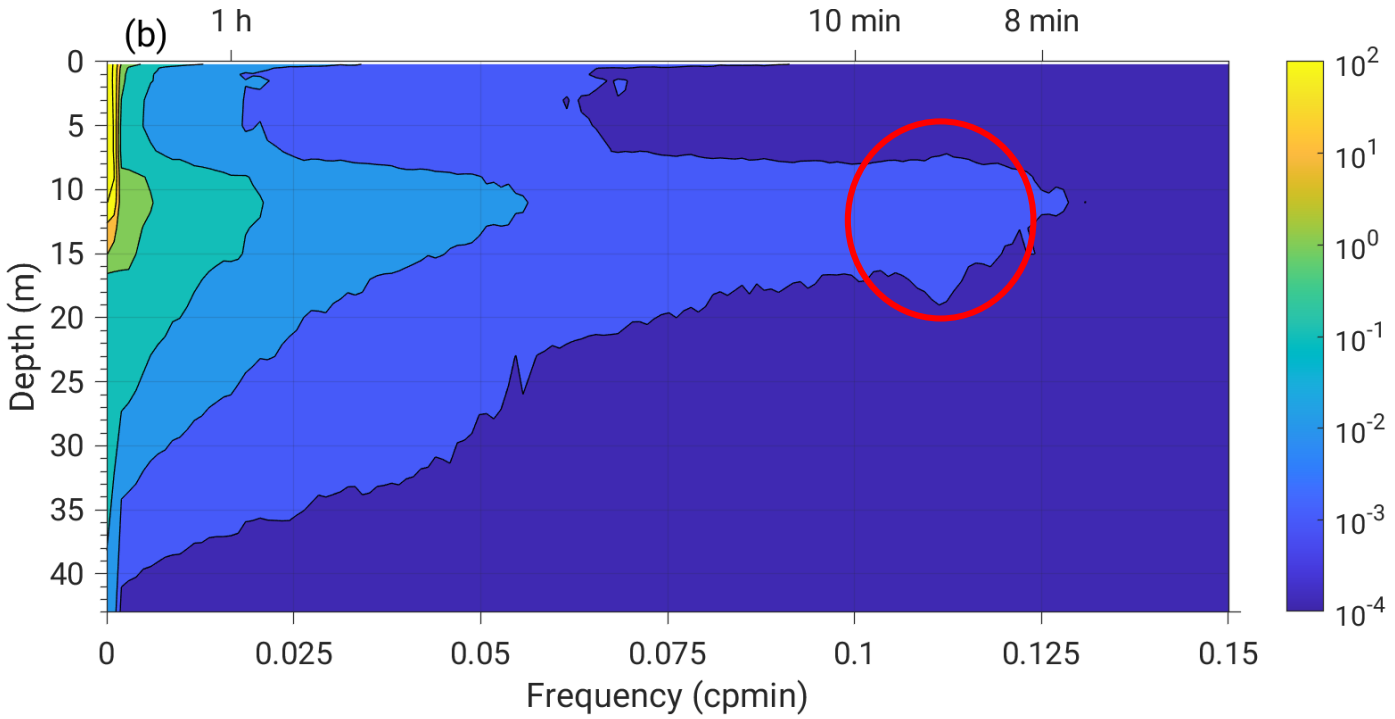
1) Entire observational period:

0 – 5 m

2) Occasionally:

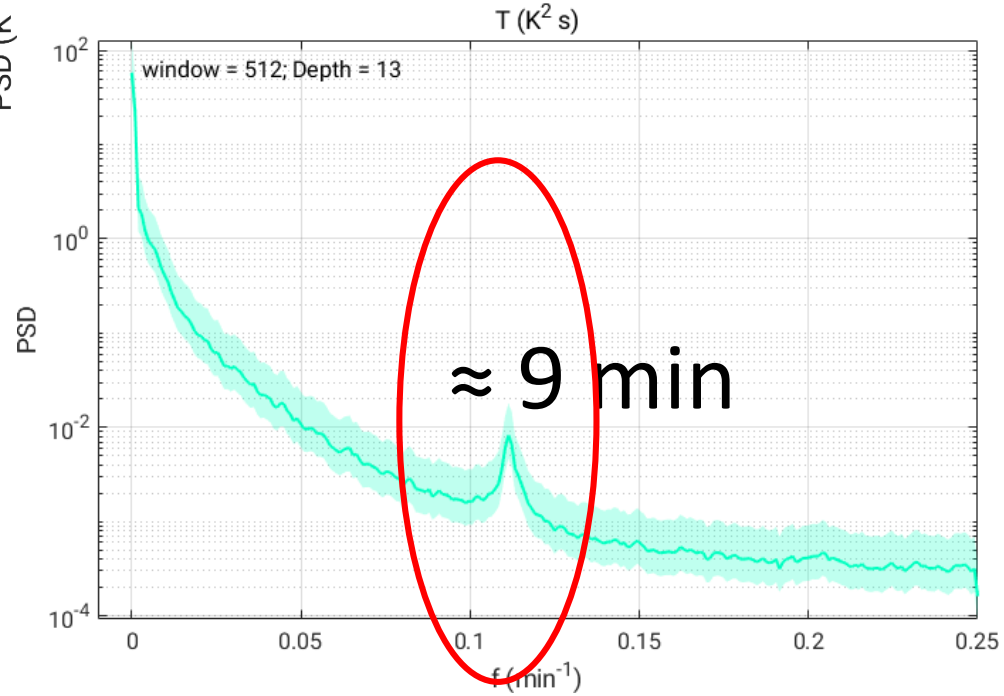
≈ 7 – 20 m

Periodicity
Spectral analysis – 2-min means



3) Occasionally:

≈ 9 – 17 m



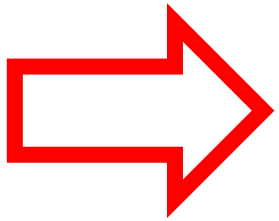
5. Discussion and conclusions

3 types of forcings of the lake surface:

(1) Continuous, periodic (24 h) due to heat fluxes

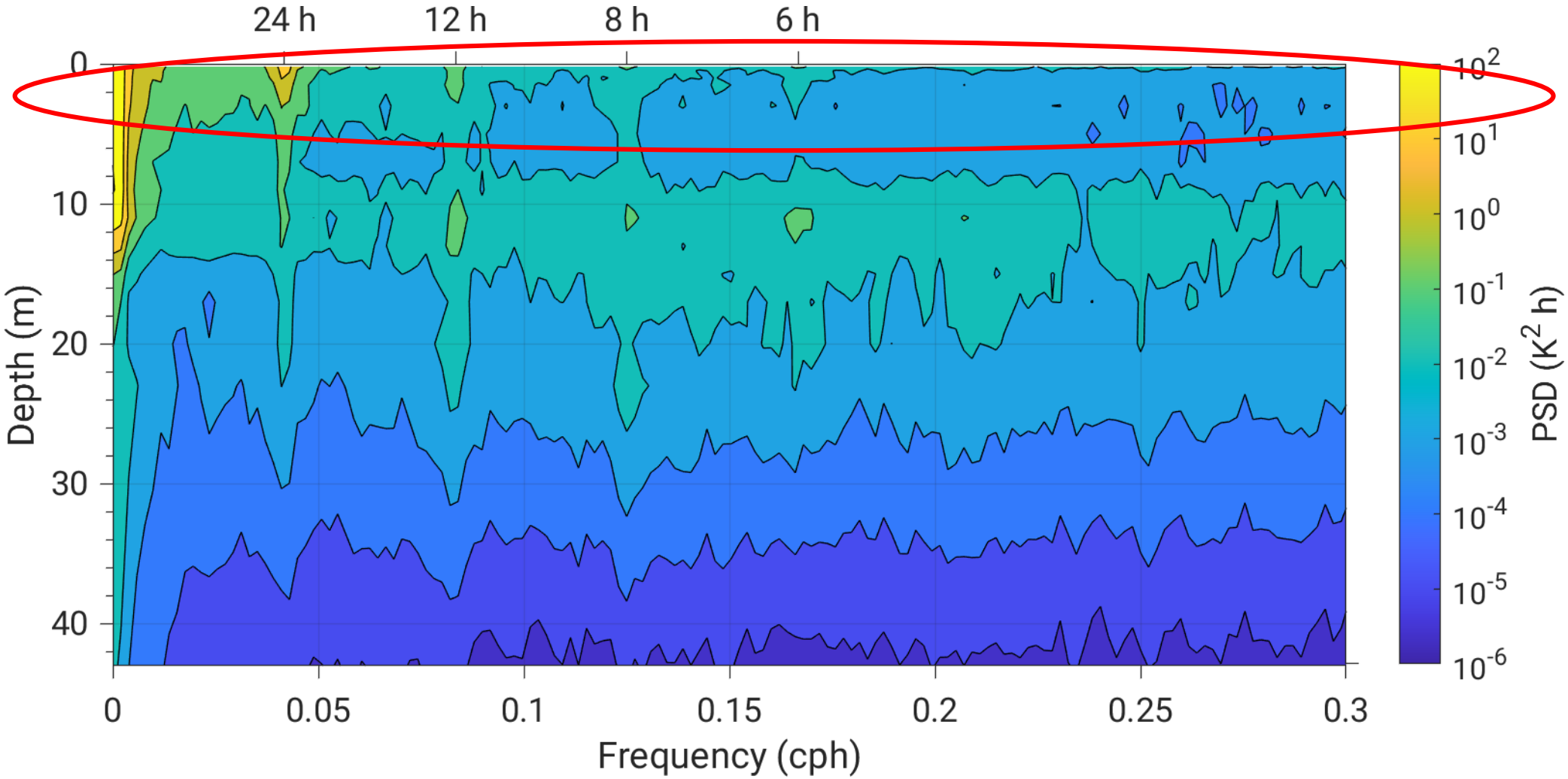
(2) Occasional, periodic (24 h) due to periodic stronger winds

(3) Occasional, nonperiodic due to persistent, along-the-basin stronger winds



Oscillations of lake temperatures

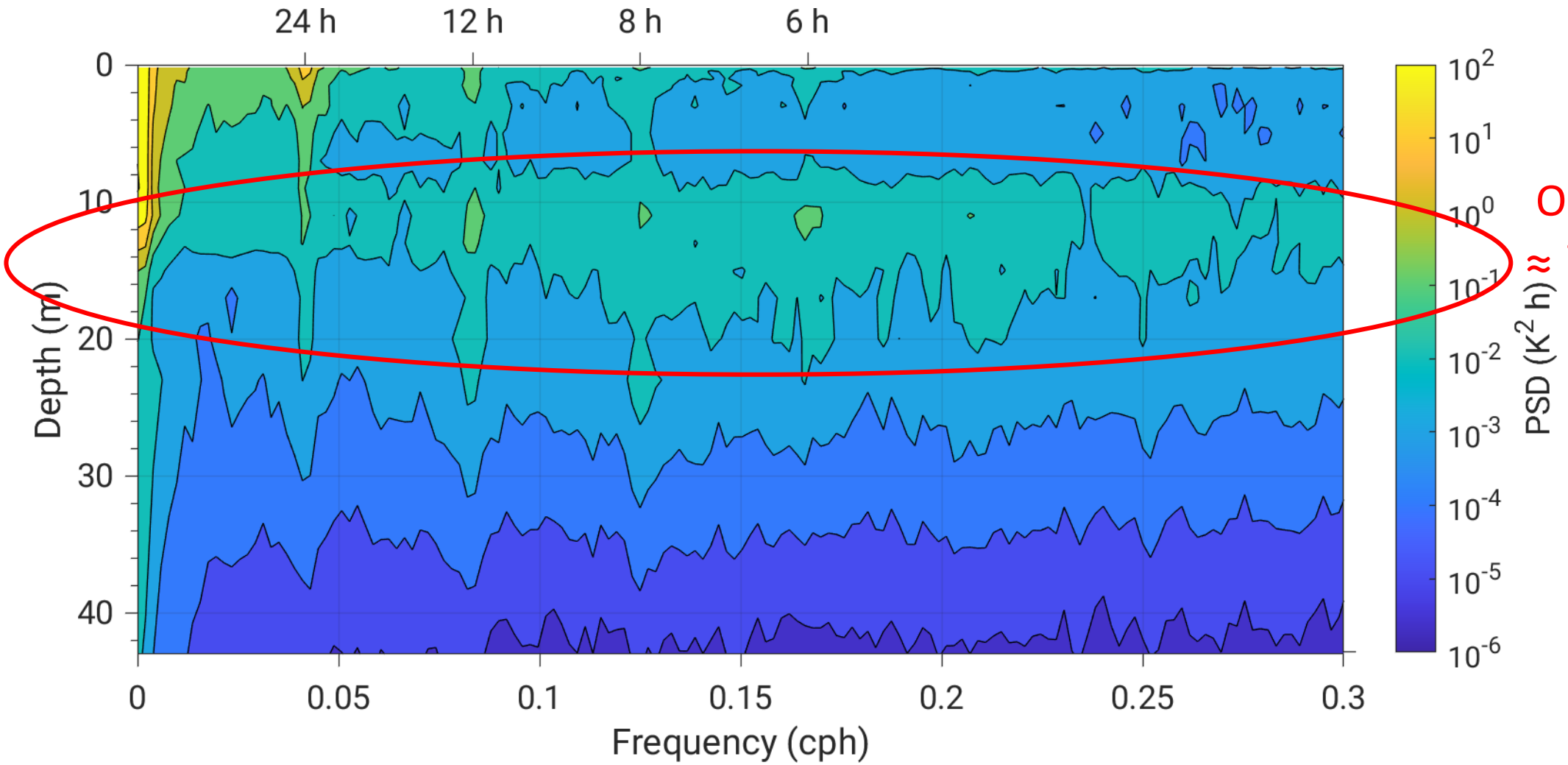
(1) Continuous, periodic (24 h) due to heat fluxes → forced oscillations of ≈ first 5 m of the lake



0 – 5 m

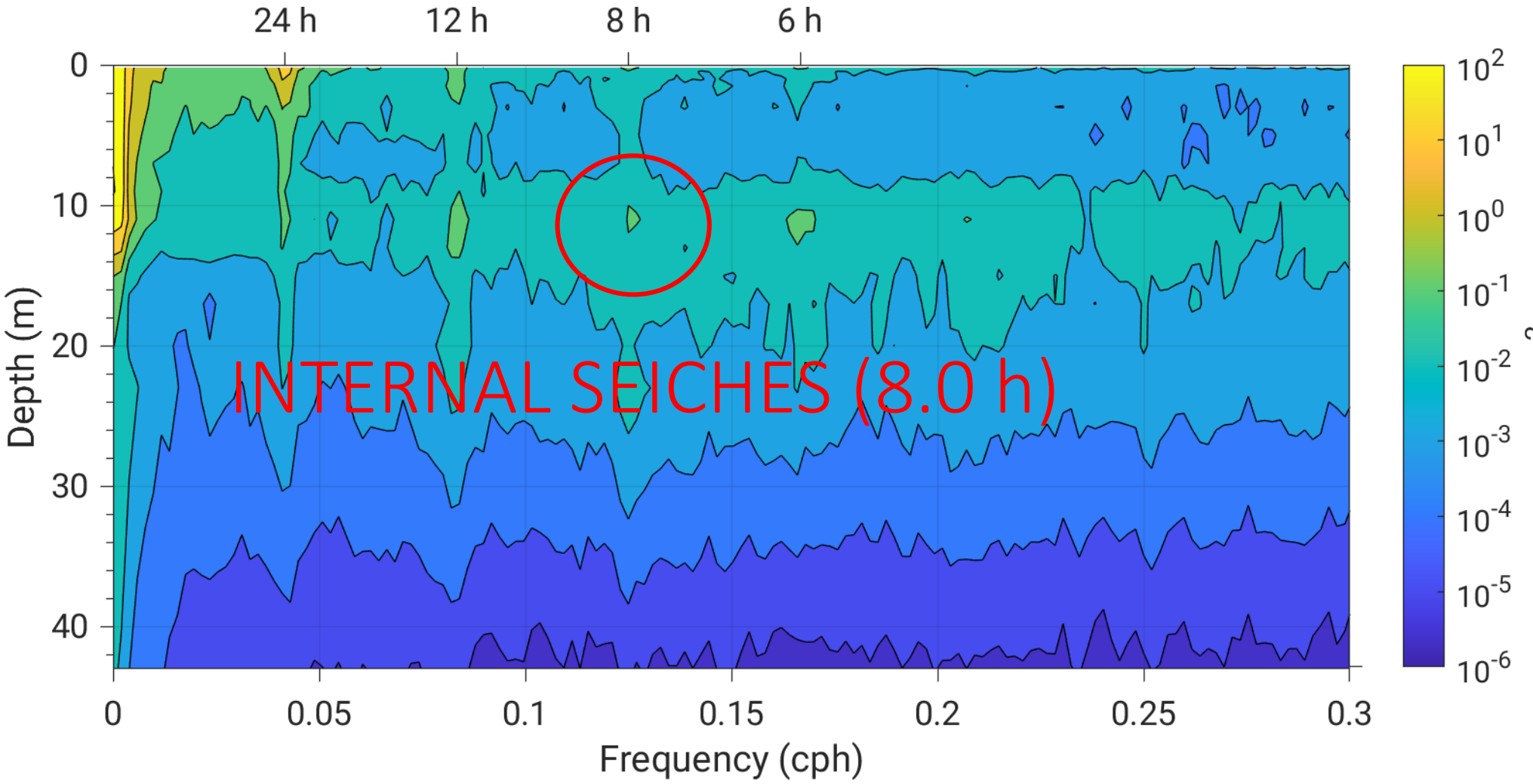
Entire observational period

(2) Occasional, periodic (24 h) due to periodic stronger winds → forced oscillations of greater depths



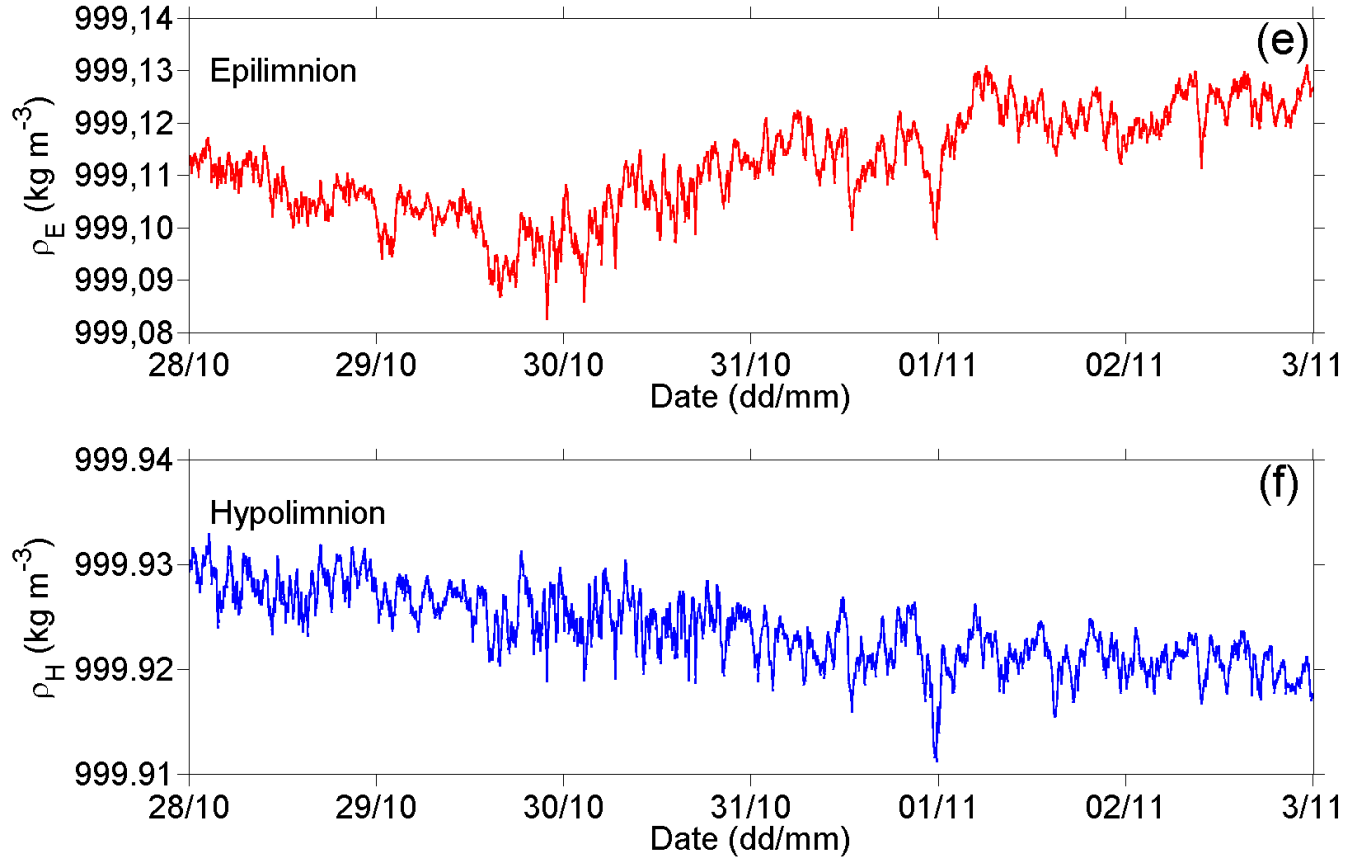
Occasionally:
≈ 7 – 20 m

(3) Occasional, nonperiodic due to persistent, along-the-basin stronger winds → free oscillations of termocline



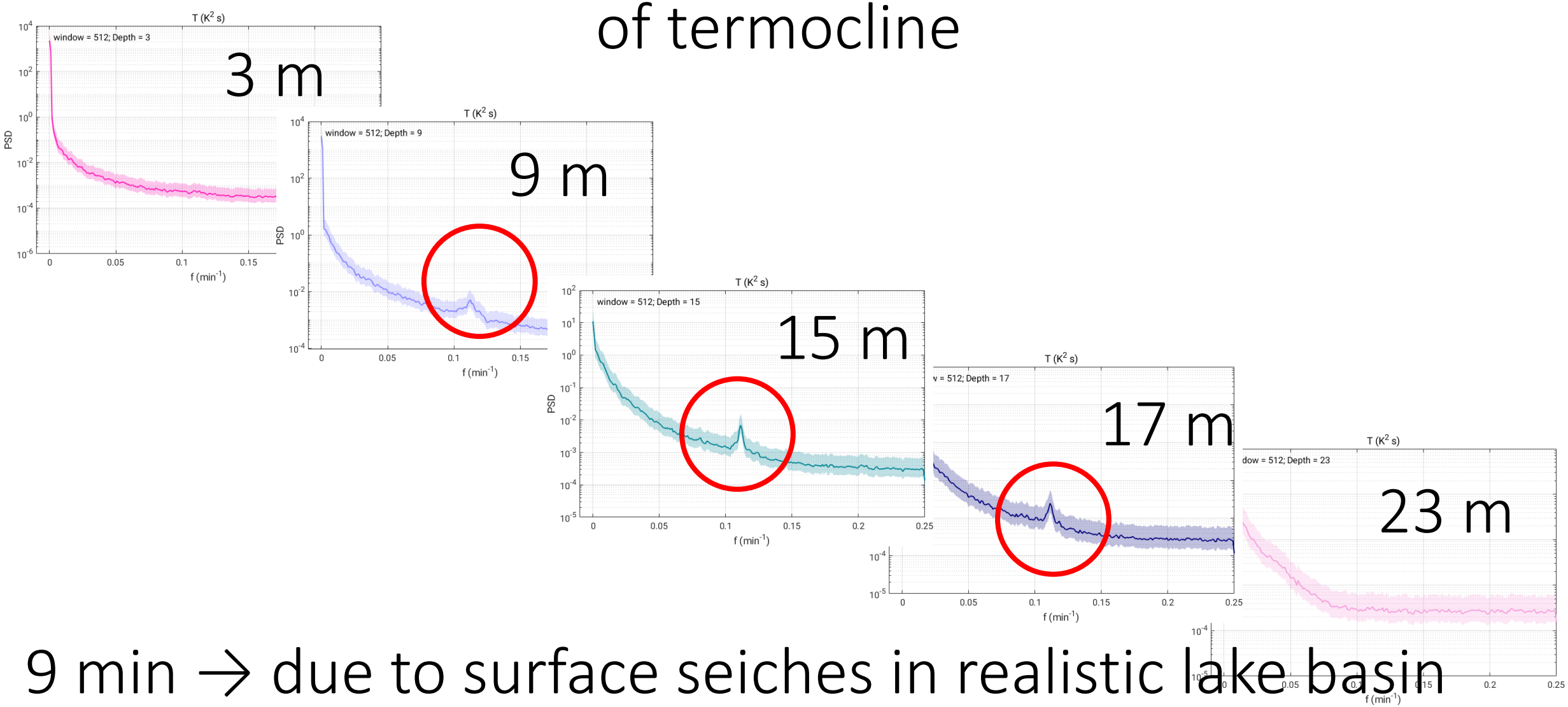
Occasionally in thermocline region:
≈ 9 – 17 m

Internal seiches → water exchange between the epilimnion and hypolimnion



Water density

(3) Occasional, nonperiodic due to persistent, along-the-basin stronger winds → free high-frequency oscillations of termocline



9 min → due to surface seiches in realistic lake basin

MERCI!