Initialization, simulation results, and comparison of FLake and LAKE numerical models

Maksim Iakunin, Rui Salgado, Miguel Potes, Alexandra Penha
Universidade de Évora, ICT

miakunin@uevora.pt

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Motivation

Aim:

ALOP project (ALentejo Observation and Prediction system). One of the goals is:

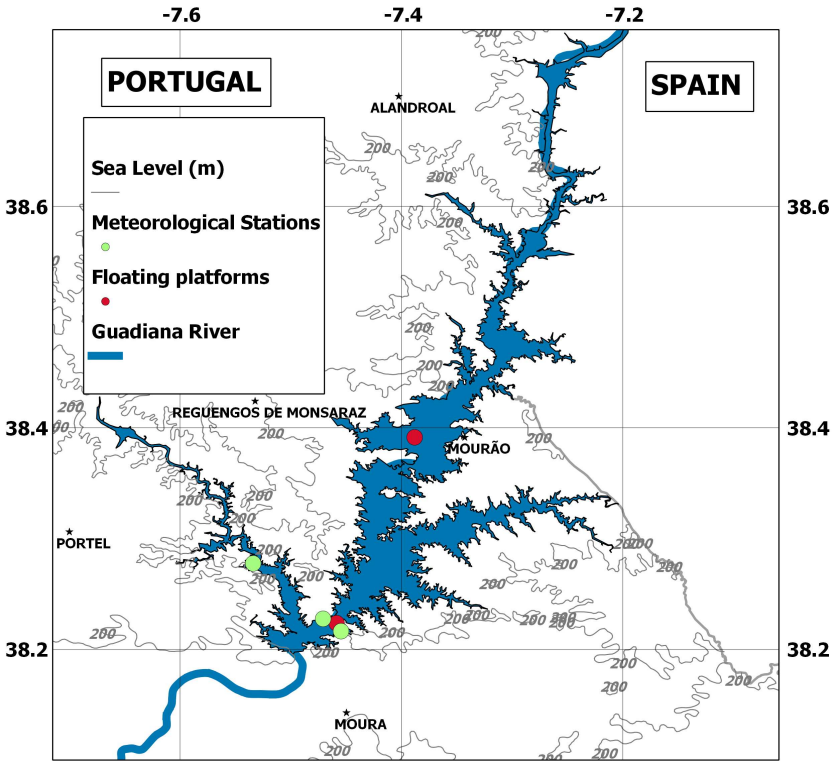
To test, develop, and apply models that can help predict the quantity of water and the evolution of the biological and chemical quality of water in reservoirs

Lake models to work with:

- **FLake** *(D. Mironov, 2008)*: standalone version and coupled with **SURFEX** model;
- **LAKE2.0** *(V. Stepanenko et al, 2016)*: standalone version.

Object of study

Alqueva lake



Basic info:

- Largest artificial lake in Western Europe (250 km^2);
- up to 92 meter depth;
- fully filled in 2004;
- could affect local weather conditions and environment.

Real-time data are avaliable at `http://www.alop.ict.uevora.pt`

FLake initialization

Constants:

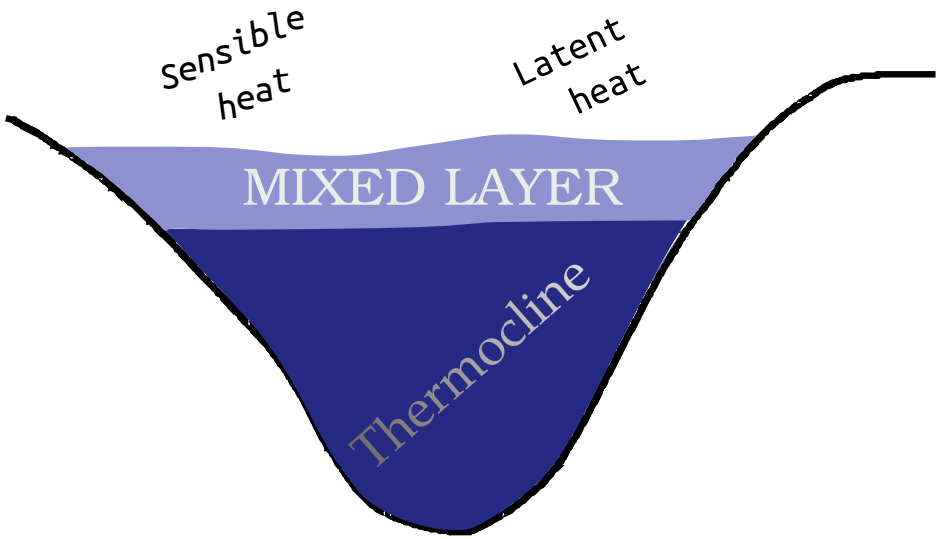
- lake depth;
- water extinction coefficient;
- wind fetch, etc.

Input variables:

- air temperature;
- pressure;
- wind speed;
- LW and SW radiation;
- humidity.

Initial conditions:

- bottom temperature;
- mixing layer depth;
- temperature of mixing layer;
- thermocline shape factor.



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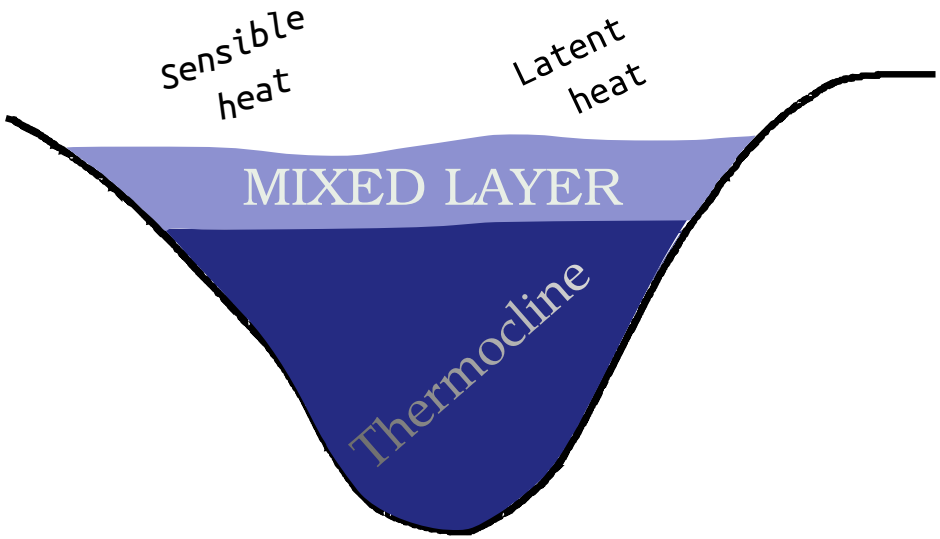

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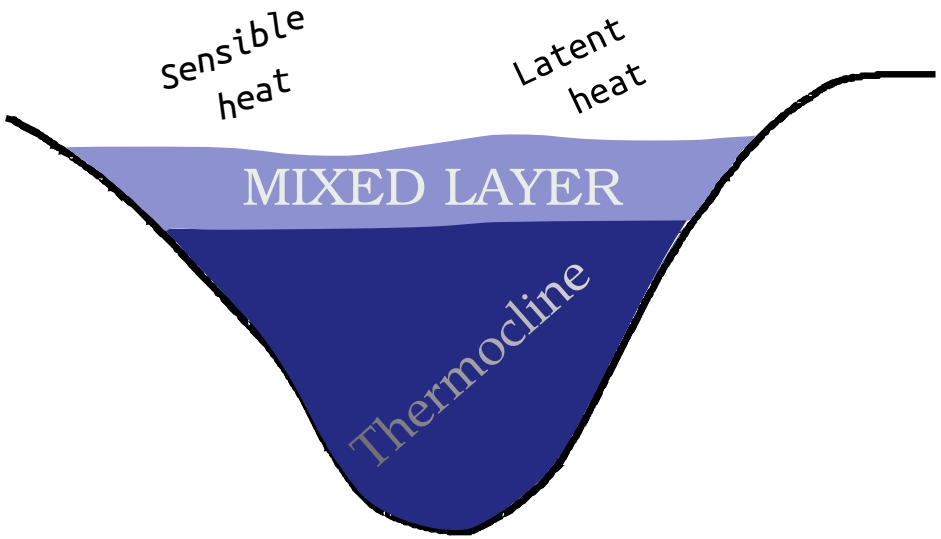
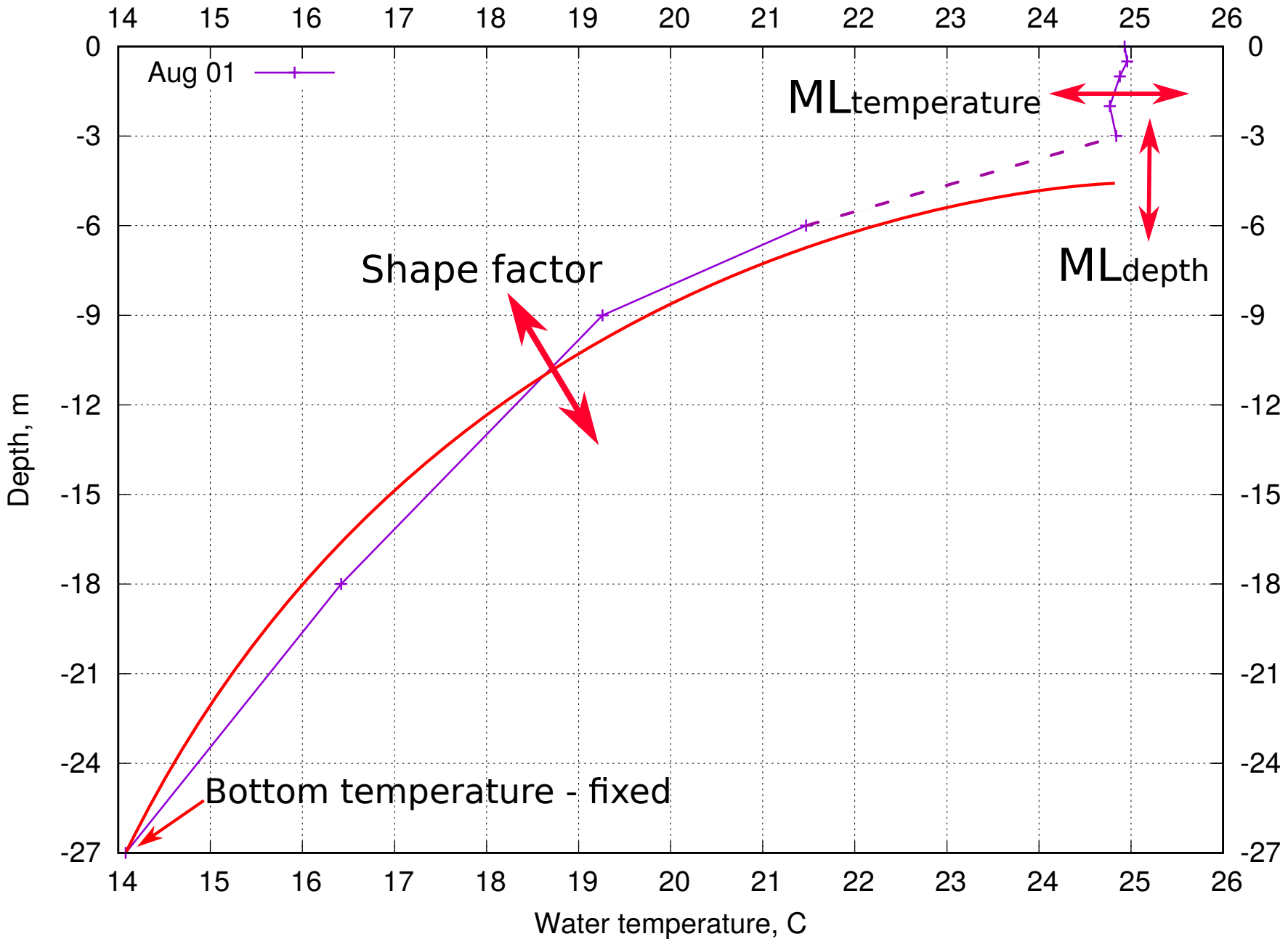
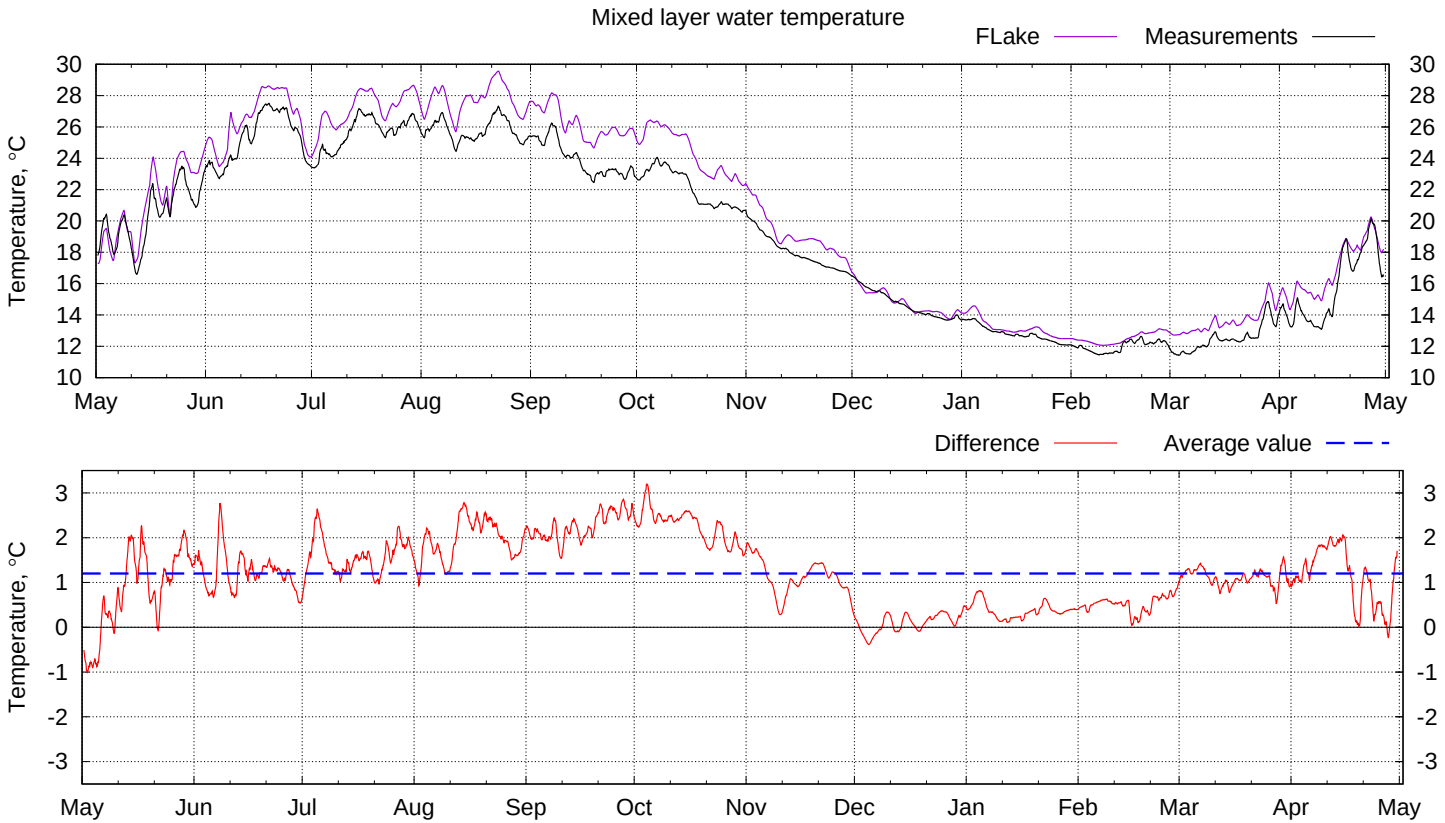


3 point fitting



FLake simulation

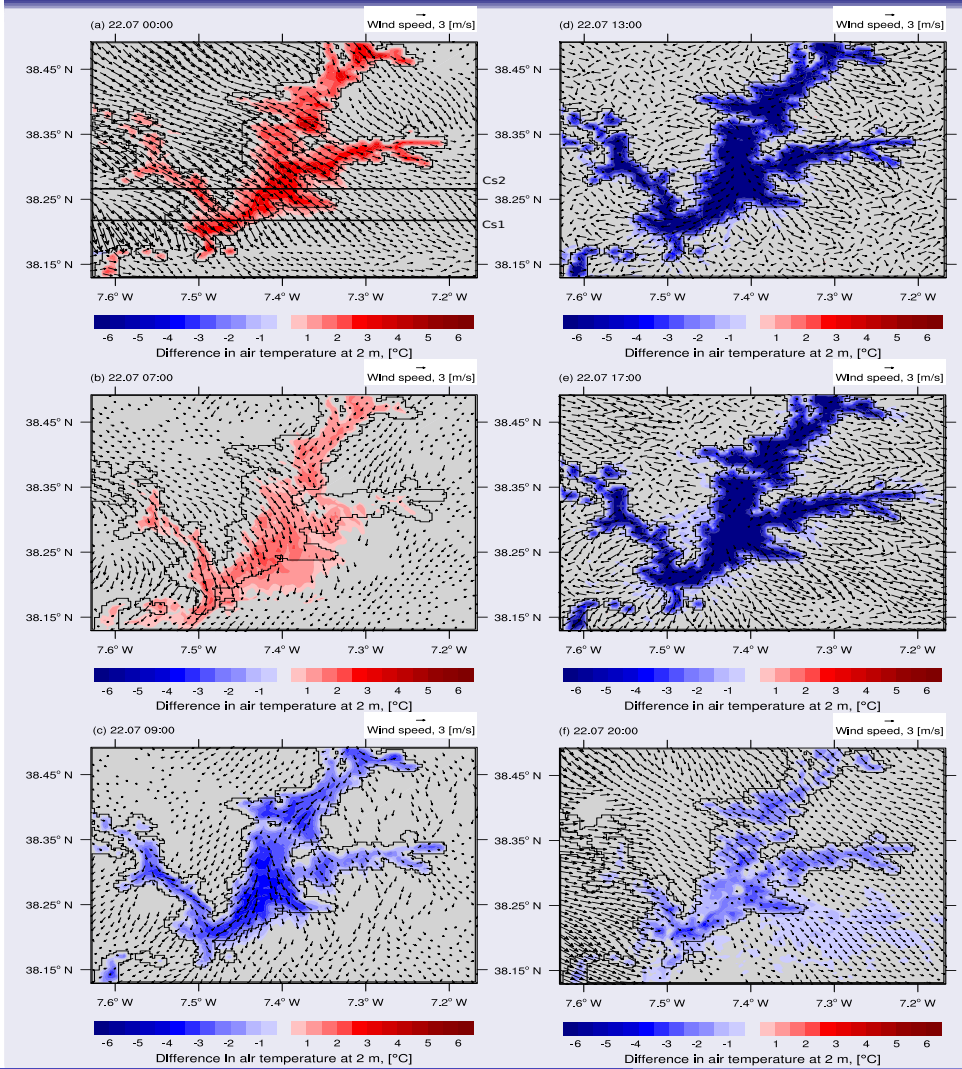


- while the lake is stratified FLake overestimates water temperature (1-3 °C);
- during cold period FLake demonstrates exceptional results;
- average annual difference is 1.2 °C.

FLake operational use

Tracing daily lake breeze and its effects / Meso-NH+FLake simulation results

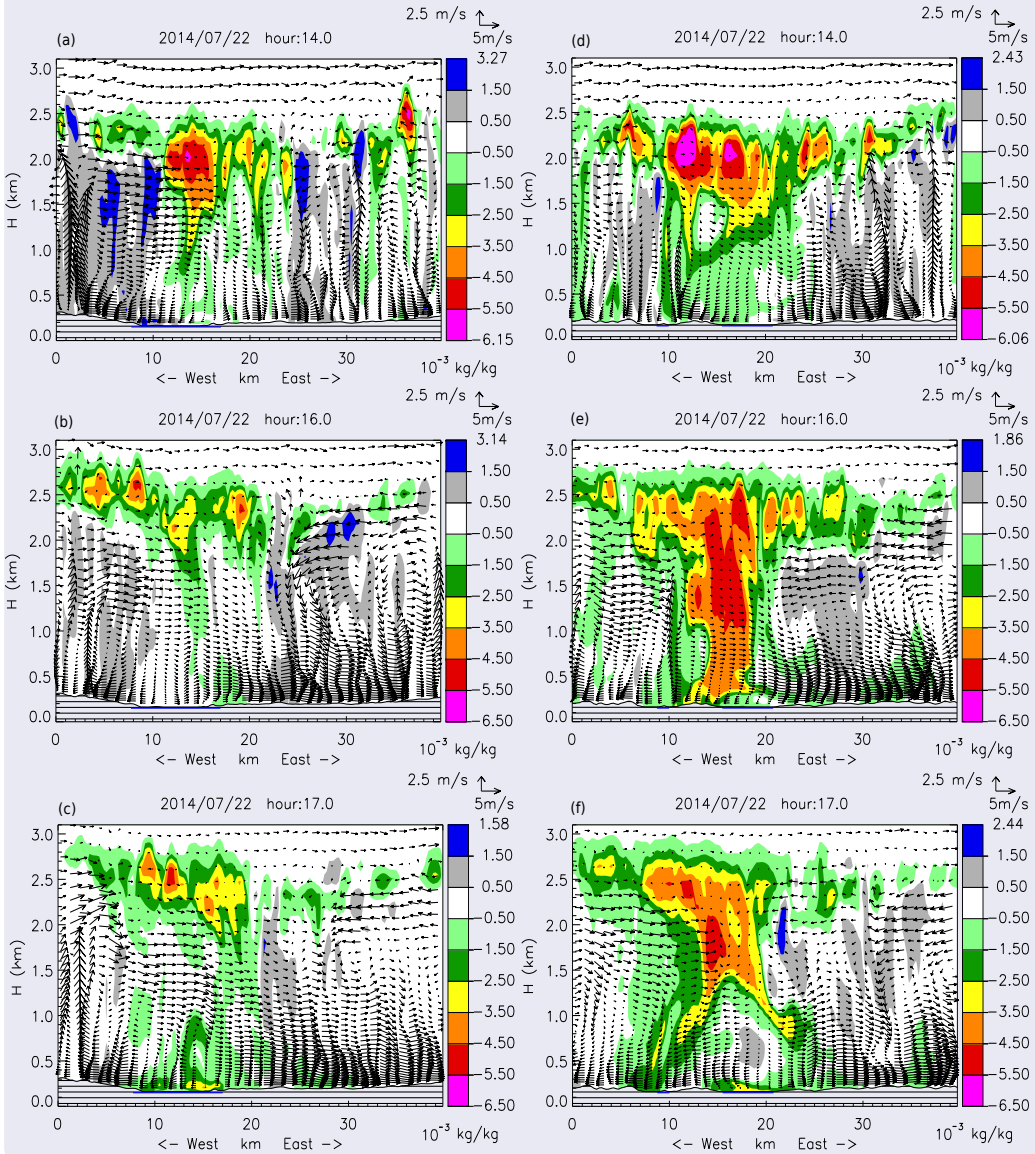
Breeze formation



- Breeze system starts to form at 8:00 local time, develops and intensifies afternoon, and dissipates by 19:00 local time;
- wind speed can reach 7 m/s.

Flake operational use

Vertical effects

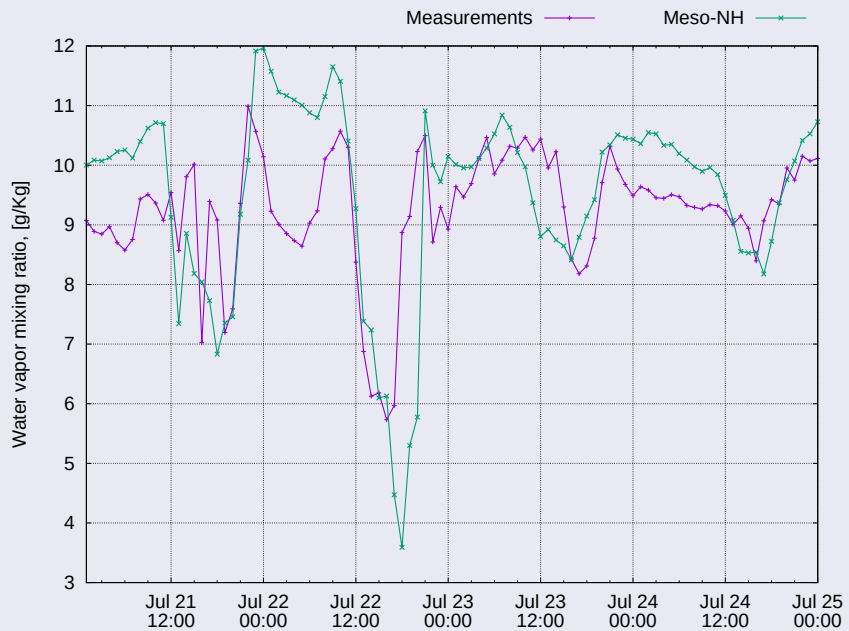


- Breeze system includes vertical air movement;
- circulation above the lake transports dry air from the top of boundary layer down which makes air over the water surface relatively drier.

Flake operational use

Results

- This simulated effect is proved by the measurements of mixing ratio of water vapor over the lake (*figure* –>);
- ability of **FLake** model to simulate water temperature and heat fluxes allows to conduct such kind of experiments.



More information about this work can be found in the article:

M. Iakunin, R. Salgado, M. Potes, **Breeze effects at a large artificial lake: summer case study**. Hydrol. Earth Syst. Sci., 22, 5191–5210, 2018.

LAKE2.0 model initialization

Constants:

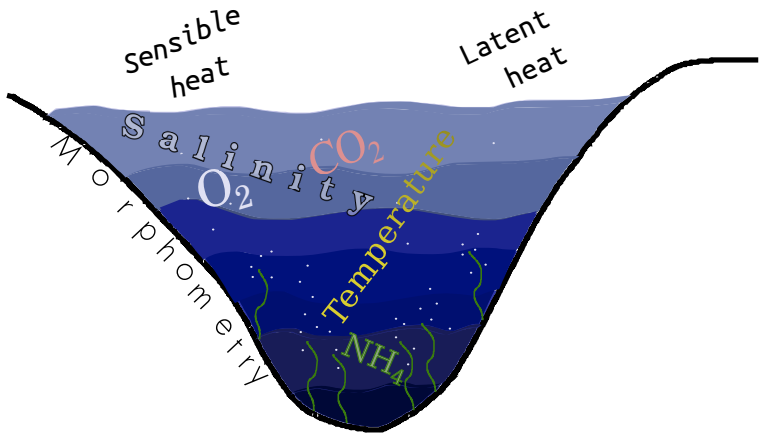
- lake form, depth, area, and morphometry;
- water extinction coefficient and pH
- and more ...

Input variables:

- air temperature, pressure, wind speed components, LW and SW radiation, humidity;
- precipitation.

Initial conditions:

- profiles for water temperature;
- CO_2;
- O_2;
- CH_4,



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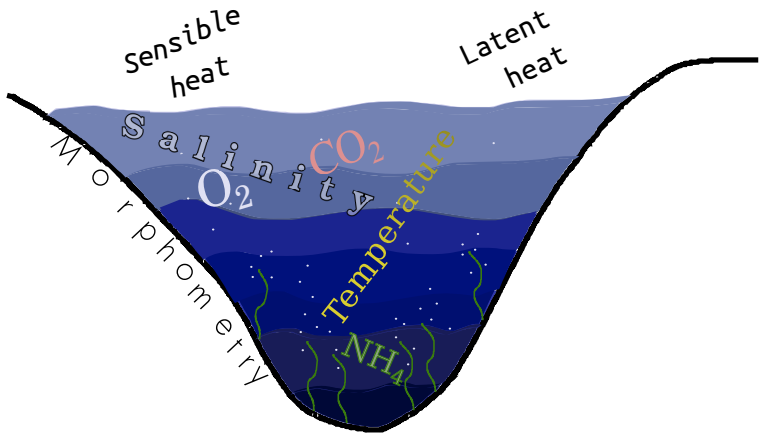

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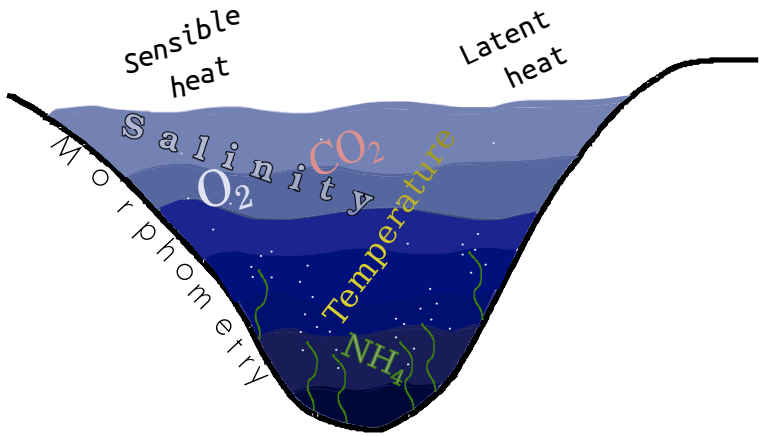
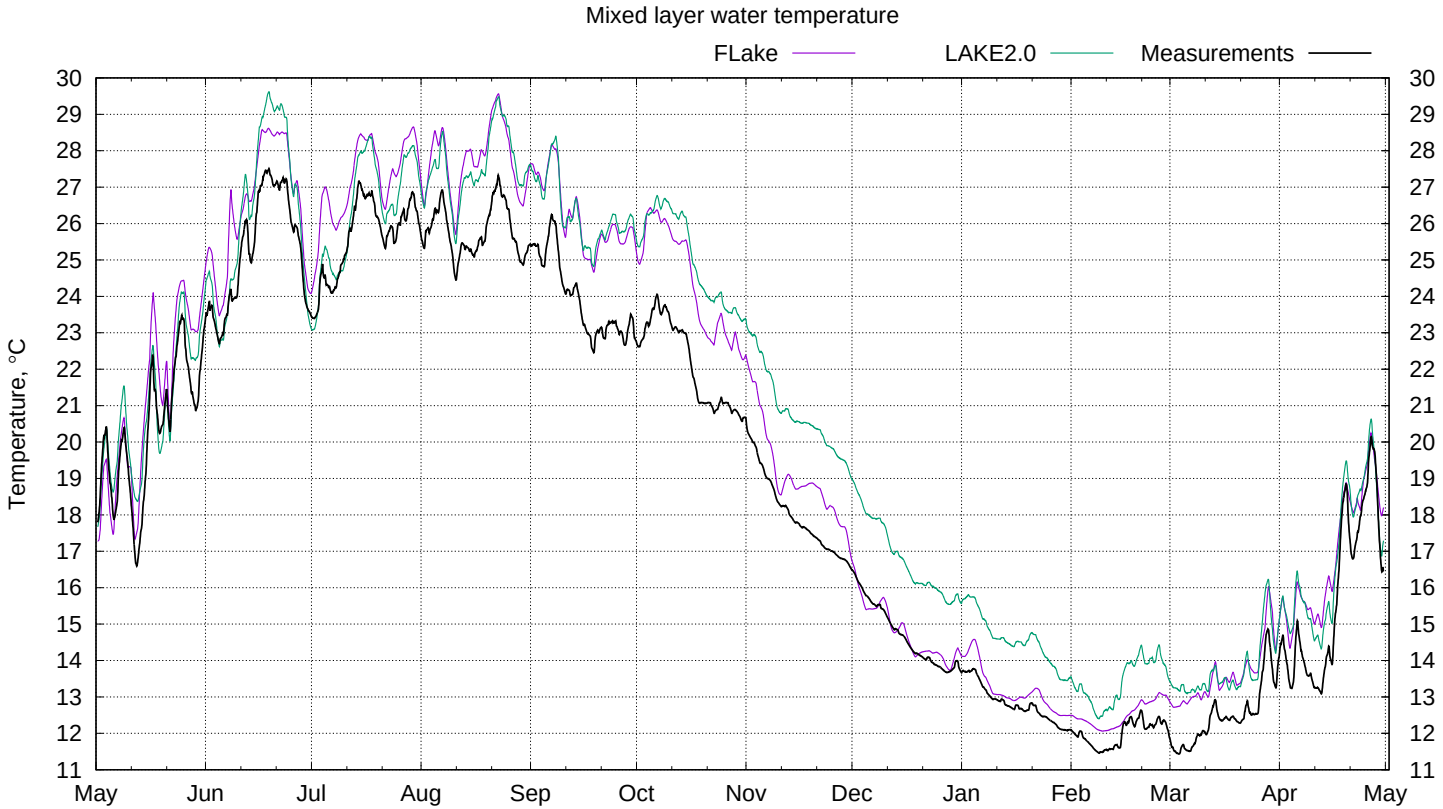
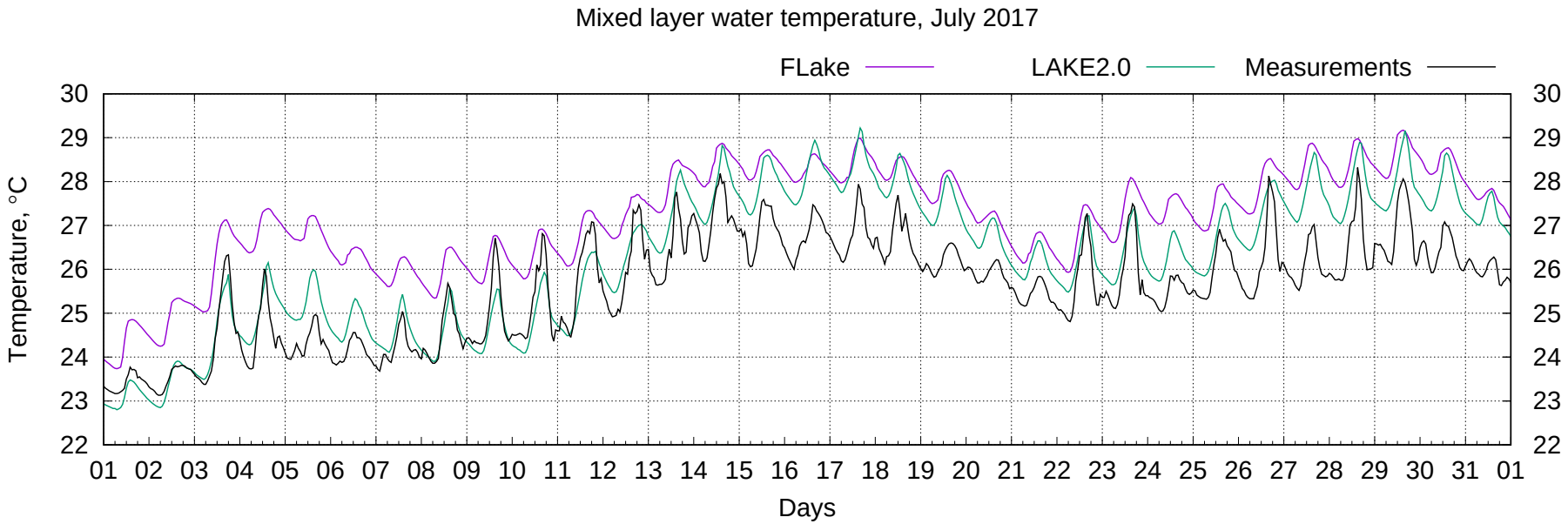


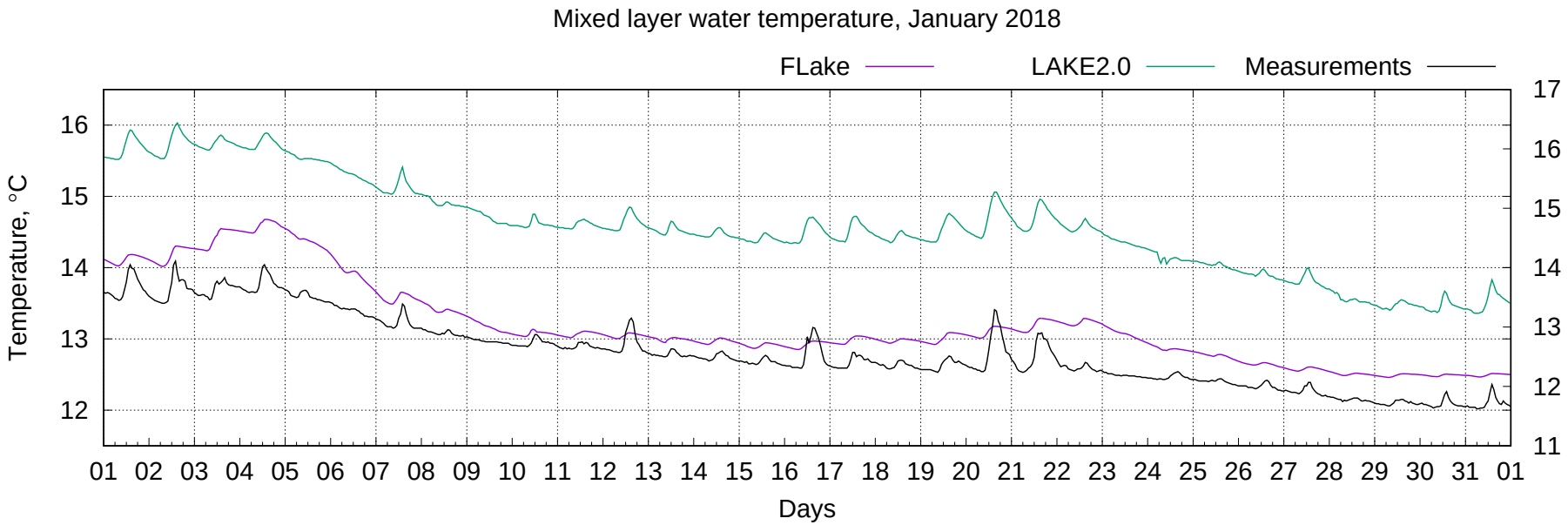
LAKE simulation and model comparison



- while the lake is stratified LAKE model shows the same result as FLake;
- during cold period LAKE overestimates water temperature.

LAKE/FLake comparison





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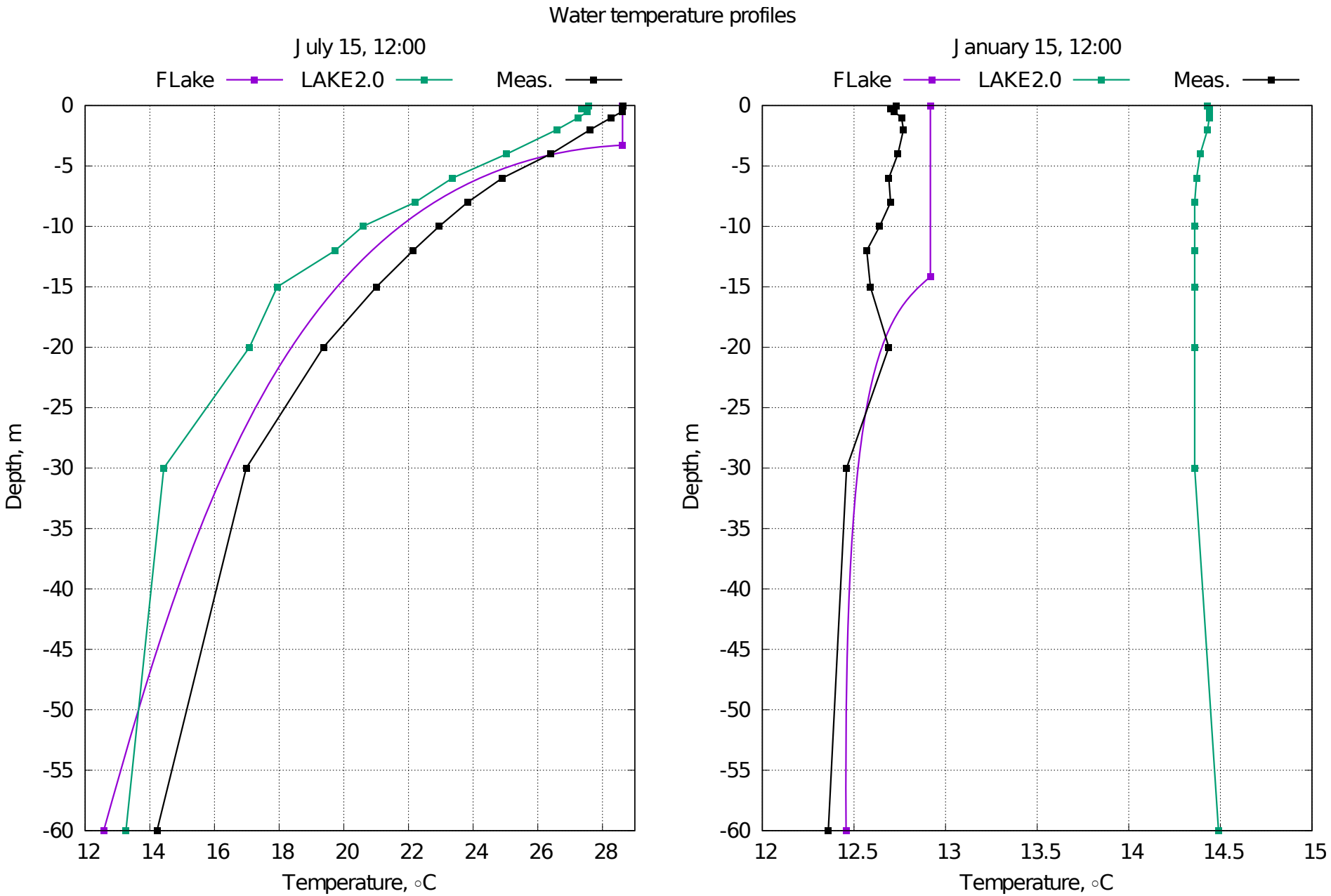
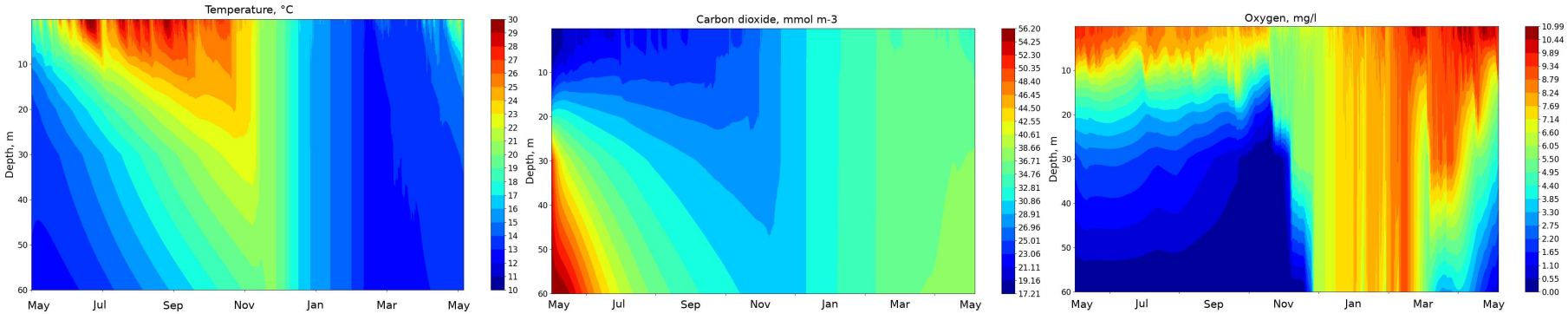


LAKE biochemistry



LAKE2.0 able to calculate also:

- methane;
- oxygen;
- carbon dioxide;
- salinity;
- density;
- ...taking into account inflows, outflows, shape, form, and morphometry.

Conclusion

FLake

- FLake model shows impressively good result for one year simulation;
- lake-atmosphere interaction related tasks may be solved using FLake.

LAKE2.0

- Simulation of water temperature results are slightly worse than FLake but still acceptable;
- the model much more versatile and adjustable;
- should be used for studies and prediction of **water quality**.

THANK YOU FOR ATTENTION