Supporting information to the paper by Guseva, S., Bleninger, T.,Jöhnk, K., Polli, B.A., Tan, Z., Thiery, W., Zhuang, Q., Rusak, J., Yao, H., Lorke, A. and Stepanenko, V. "Multimodel simulation of vertical gas transfer in a temperate lake"

1 Figures

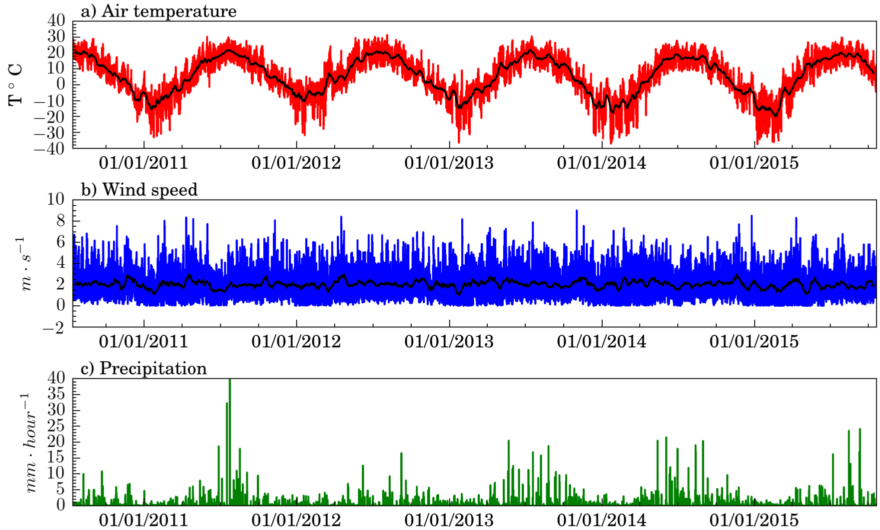

Figure S1. Time-series of meteorological variables: air temperature, wind speed and precipitation. Black line indicates the moving average with a window of half a month.

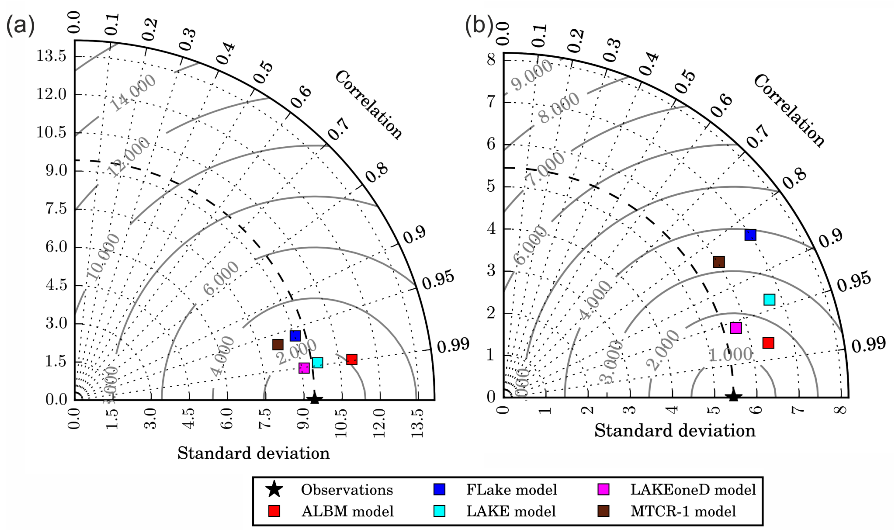

Figure S2. Taylor diagram for the water temperature at (a) surface (b) all depths in RefSim. Grey lines indicate $RMSE_c$ ($^{\circ}C$), the radial distance from the origin is the standard deviation ($^{\circ}C$), an azimutal position denote the correlation coefficient (Taylor et al., 2001).

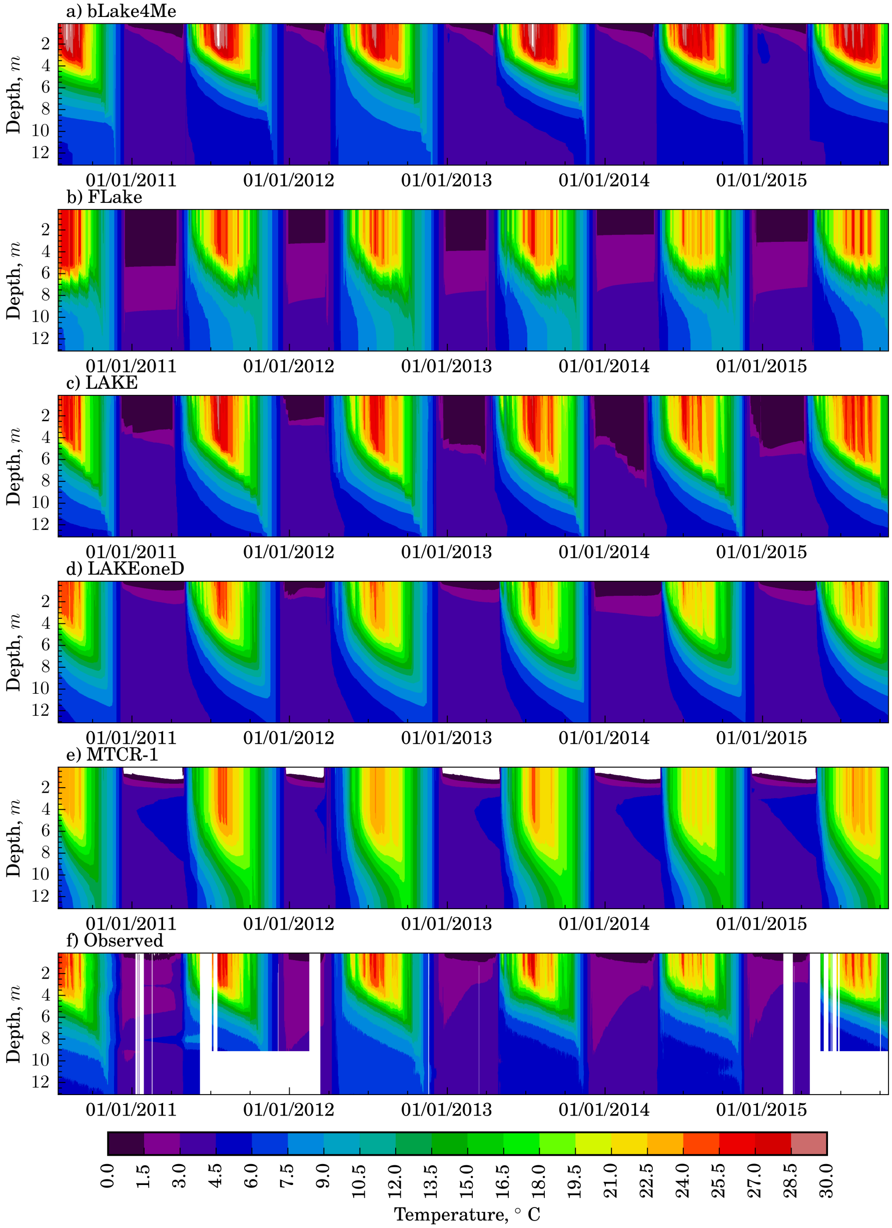

Figure S3. Time-depth pattern of temperature in Harp Lake (14.07.2010-19.10.2015), LDSim and observed data.

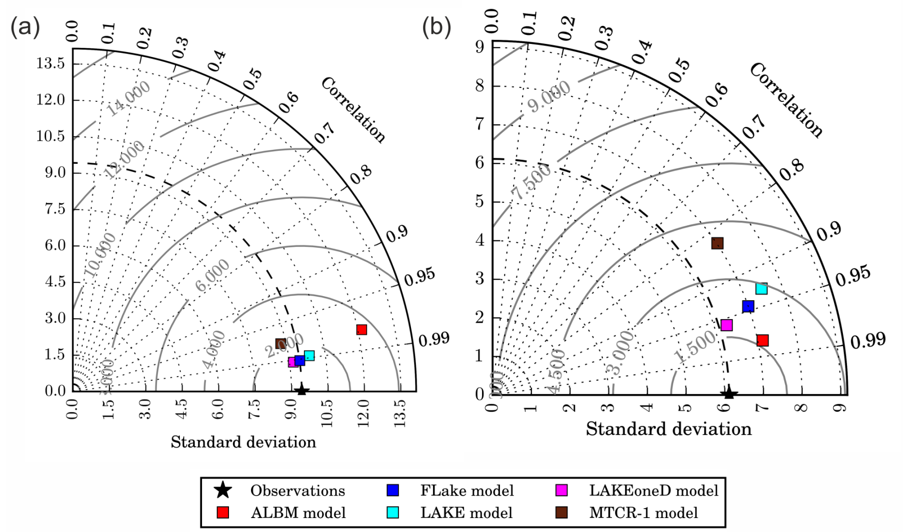

Figure S4. Taylor diagram for the water temperature at (a) surface (b) all depths in LDSim. Grey lines indicate $RMSE_c$ ($^{\circ}C$), the radial distance from the origin is the standard deviation ($^{\circ}C$), an azimutal position denote the correlation coefficient.

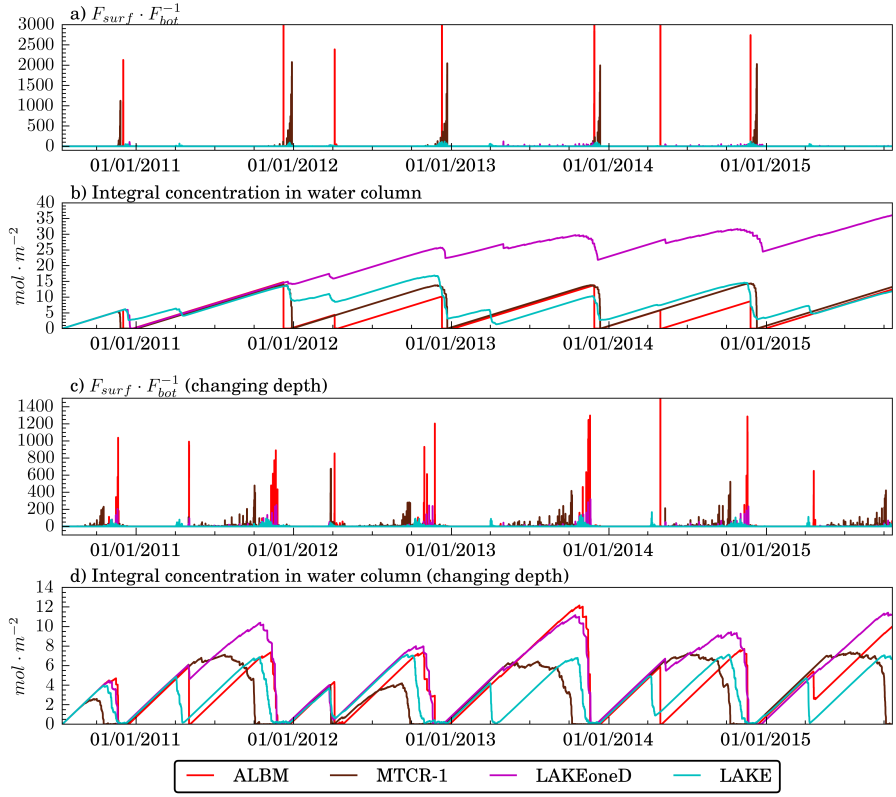

Figure S5. Time-series of the surface flux, normalized by bottom flux, and the total tracer amount in the water column: (a, b) RefSim, 37.5 m, (c, d) LDSim, 13.32 m.

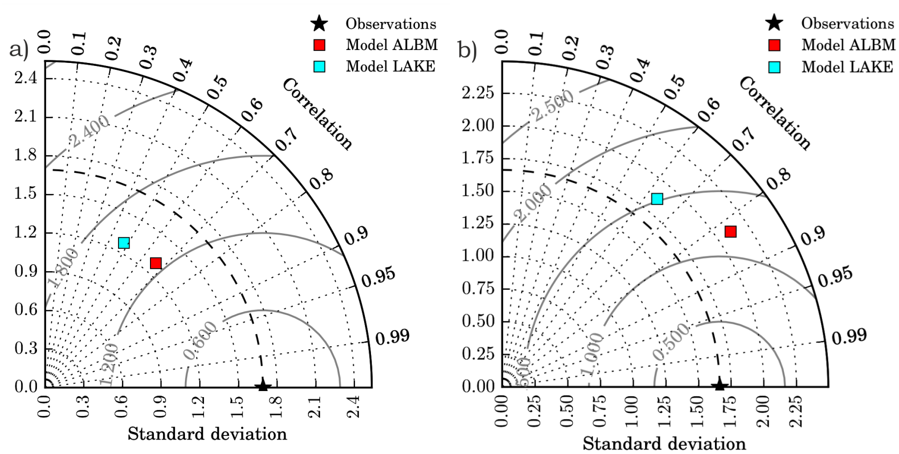

Figure S6. Taylor diagram for the modeled O_2 concentration at depths of (a) 1 m (b) 18 m in GasSim.

2 Tables

Table S1. Biogeochemical processes represented in ALBM, LAKE models.

	ALBM	LAKE
Gas exchange at the air-water interface	Surface renewal model (Heiskanen et al., 2014)	Surface renewal model (MacIntyre et al., 2010; Heiskanen et al., 2014)
Sedimentary oxygen demand	(Hanson et al., 2004; Stefan and Fang, 1994)	(Walker and Snodgrass, 1986)
Photosynthesis	(Tian, 2006; Hipsey et al., 2008; Li et al., 2010)	(Megard et al., 1984; Stefan and Fang, 1994)
Respiration	(Hanson et al., 2004)	(Stefan and Fang, 1994)
Biochemical oxygen demand	(Hipsey et al., 2008; Hanson et al., 2011)	(Stefan and Fang, 1994)
DIC from inflow	(Hanson et al., 2004)	-
DOC and POC	(Hanson et al., 2004)	-

Table S2. Mean depth of mixed layer in models in RefSim and LDSim.

Mean depth of mixed layer, m [1]	ALBM	FLake	LAKE	LAKEoneD	MTCR-1	Observed
RefSim	2.4	5.6	4.8	3.9	5.9	3.6
LDSim	2.1	4.5	4.9	3.7	5.8	3.6

a. [1] is calculated as a mean depth of a maximum for the buoyancy frequency: $N^2 = \dfrac{g}{\rho_0}\dfrac{\partial\rho(T)}{\partial z}$.

b. The period of averaging is starting from spring ice-off and ending at August, 31

Table S3. Dates of ice formation and ice melt in RefSim.

	Ice-	**ALBM**	**LAKE**	**LAKEoneD**	**MTCR-1**	**FLake**	**Observations**
2010-2011	cover	24.12.2010**	15.12.2010	06.12.2010	05.01.2011**	22.01.2011**	10.12.2010
	off	01.05.2011	03.04.2011	02.05.2011	04.05.2011*	09.04.2011 **	27.04.2011
2011-2012	cover	24.12.2011	**28.12.2011**	**10.12.2011***	29.12.2011	15.01.2012 **	28.12.2011
	off	02.04.2012	12.03.2012**	23.03.2012	25.03.2012	21.03.2012 *	30.03.2012
2012-2013	cover	05.01.2013**	27.12.2012**	**28.11.2012****	24.12.2012*	23.01.2013**	12.12.2012
	off	22.04.2013	29.03.2013**	01.05.2013	04.05.2013*	26.03.2013**	25.04.2013
2013-2014	cover	13.12.2013*	12.12.2013*	10.12.2013*	13.12.2013*	01.01.2014**	01.12.2013
	off	29.04.2014	14.04.2014**	11.05.2014*	13.05.2014*	21.04.2014*	30.04.2014
2014-2015	cover	29.12.2014**	22.12.2014**	17.11.2014**	12.12.2014*	05.01.2015**	02.12.2014
	off	17.04.2015	02.04.2015**	04.05.2015**	07.05.2015**	15.04.2015	21.04.2015

a. Difference between the model and observations:* > 1 week ; ** > 2 weeks

b. **10.12.2011** dates denoted by bold indicate multiple freezing-melting events after the date

Table S4. Statistics of the surface temperature of the lake in RefSim, LDSim, ExtMinSim, ExtMaxSim.

Experiment		ALBM	FLake	LAKE	LAKEoneD	MTCR-1
RefSim	$h_{max} = 37.5$ m	2.13 ;	0.36 ;	1.11 ;	0.15 ;	0.68 ;
	DM (°C) ; RMSE$_c$ (°C)	2.17	2.5	1.52	1.32	2.62
LDSim	$h_{ave} = 13.32$ m	1.1 ;	0.28 ;	1.03 ;	0.21 ;	0.16 ;
	DM (°C) ; RMSE$_c$ (°C)	3.5	1.28	1.51	1.25	2.15
ExtMinSim	μ= 0.28 m^{-1}	2.08 ;	0.37 ;	1.15 ;	0.08 ;	0.7 ;
	DM (°C) ; RMSE$_c$ (°C)	2.12	2.7	1.68	1.74	3.07
ExtMaxSim	μ= 0.68 m^{-1}	2.1 ;	0.38 ;	1.13 ;	0.2 ;	0.7 ;
	DM (°C) ; RMSE$_c$ (°C)	2.25	2.48	1.51	1.02	2.03

3 Appendix

Brief description of field data at Harp Lake, Ontario, Canada

Oct. 8, 2015 (by Huaxia Yao)

1. Site and lake facts

Table S5. Chemical status of lake water.

	mg L^{-1}		mg L^{-1}		mg L^{-1}
Salinity	15	DOC	1.8	DIC	1.5
Cl	2.8	TP	4.4	NO_3	0.1
SO_4	6.6	Ca	2.6		
silica	1.8	Na	2.2		

2. High frequency data from a raft buoy (10 minute intervals)

Table S6. Meteorological measurements.

	Height, m	Period of measurements	Instrument
Air temperature	1.75	July 14, 2010 – present	Vaisala HMP45C air temperature and relative humidity sensor
Relative humidity	1.75	July 14, 2010 – present	Vaisala HMP45C air temperature and relative humidity sensor
Wind speed	2	July 14, 2010 – present	RM Young wind monitor model 05103
Wind direction	2	July 14, 2010 – present	RM Young wind monitor model 05103
Atmospheric longwave radiation (earlier data can be got from another land-based station)		Nov. 5, 2012 – present	Kipp & Zonen CGR3 Pyrgeometer
Short-wave radiation (earlier data can be got from another land-based station)		Nov. 5, 2012 – present	Kipp & Zonen CGR3 Pyrgeometer
Precipitation			not measured on the raft, but available from neighboring station
Atmospheric pressure			not measured on the raft, but available from neighboring station

Table S7. Measurements in lake water.

	Depth, m	Period of measurements	Instrument
Chlorophyll-a	1	Sept. 7, 2011 –present	YSI 6025 Chlorophyll sensor
CO2 concentration	0.39	Mar. 12, 2012 –present	Vaisala GMP343 CO2 Probe with sintered PTFE filter
Electrical conductivity	1, 18	Sept. 11, 2011 –present	YSI 6560 temperature and conductivity sensor
DO concentration	1, 18	June 30, 2011 – present	YSI 6150 optical oxygen sensor
Water temperature	0.1 to 10.1 (every 0.25 m intervals between 0.1 to 10.1 m)	July 14, 2010 –present	PME thermistor T-chain with pressure transducer
Water temperature	0.1 to 27.1 (1m interval)	Mar. 12, 2012 - present	Campbell Scientific custom thermistor string of model 109 temperature probe

3. Low frequency lake data (regular monitoring) (weekly or bi-weekly for ice-free seasons)

Lake profile data: temperature and DO, at 1m interval from 0.1 m to 35m. Started late 1970s. For our selected years 2010-2015, these weekly profile measurements do not cover the winter or ice seasons. Secchi disk depth (bi-weekly or monthly): since 1978

Ice date: 1978 to 2015 Ice thickness (monthly): 1978-1993; and 2013-2015

Regular meteorology data (daily or hourly): land-based stations, 1978-2015.

4. Hydrology data

Stream flow discharge (daily): at 5 inlet streams (HP3, HP3a, HP4, HP5, HP6a), and the outlet (HP0), long-term data Stream water chemistry (weekly or bi-weekly): at all streams

5. Gap filling, QA/QC

The data are basically from raw data of the raft/buoy sensors, with a simple quality check and gap filling.

For our LMIP project, the data have been edited and gap-filled. Missing data (gaps) in atmospheric forcing are infilled mainly by using another dataset of a neighbouring climate station (backyard of DESC office site). Except for air temperature, any missed hourly data at the raft is provided by the values at the neighbouring station. The missings in air temperature are filled by regressions between the two stations which are established for each month (using available hourly data). Any doubt and concern with data are kindly reported to participants and Huaxia Yao for a solution.

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