



Supplement of

Past and future climate change effects on the thermal regime and oxygen solubility of four peri-alpine lakes

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The supplementary contain Figures S1 to S6 followed by Tables S1 to S7.

Supplementary Figures

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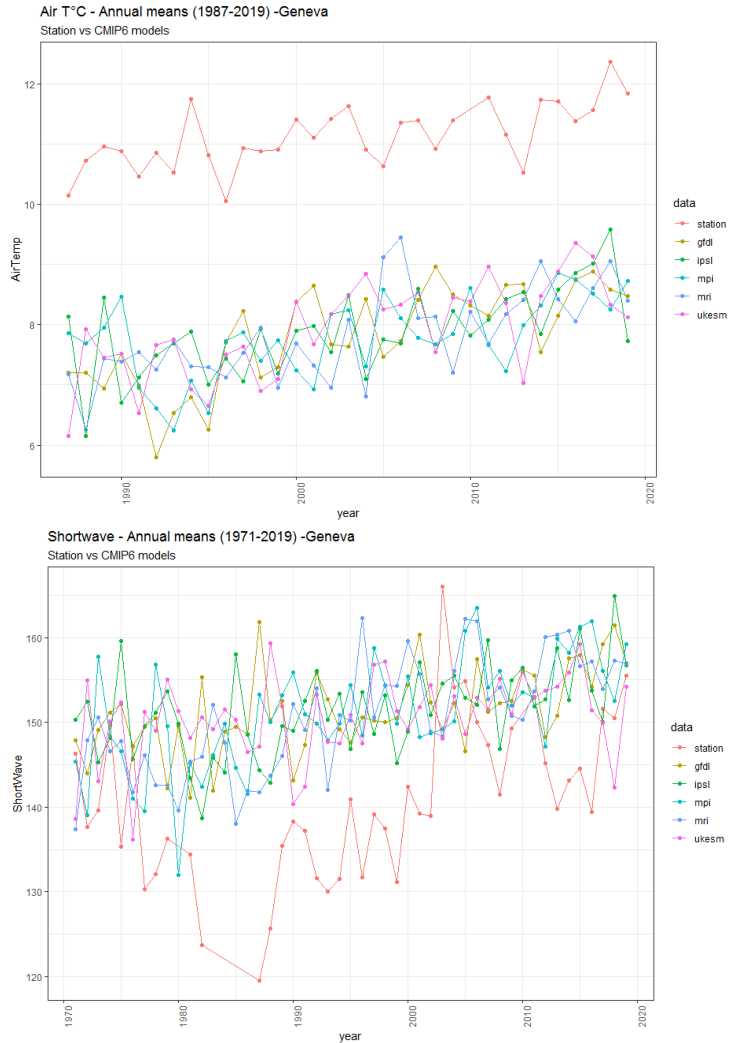
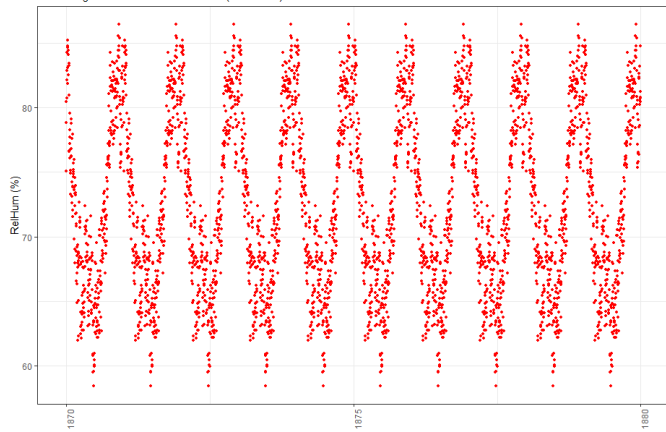
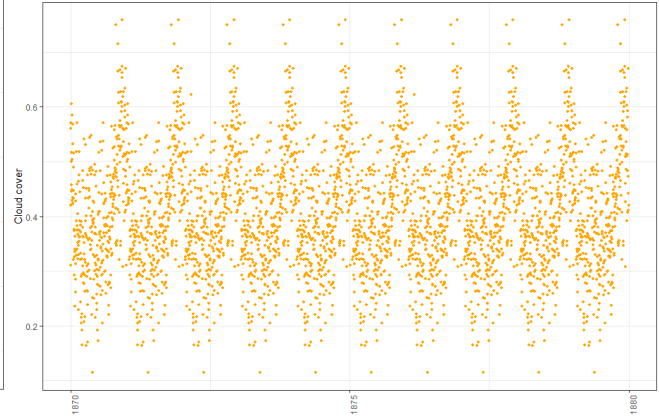


Figure S1. Evolution of air temperature (A) and shortwave radiation (B) of the five climatic models extracted from ISIMIP3b (CMIP6): GFDL-ESM4, MPI-ESM1-2-HR, MRI-ESM2-0, IPSL-CM6A-LR and UKESM1-0-LL. Comparison to the closest meteorological station to Lake Geneva: Thonon-les-Bains station. Correction of the climatic model's data relative to the altitude was applied (c.f. Method section).

Relative Humidity - Geneva (1870-1880)
Meteorological Pattern from station data (2000-2011)

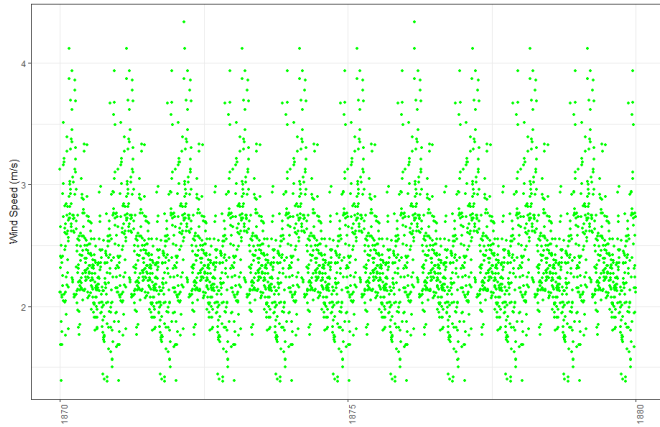


Cloud Cover - Geneva (1870-1880)
Meteorological Pattern from station data (2000-2011)



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Wind Speed - Geneva (1870-1880)
Meteorological Pattern from station data (2000-2011)



Rain - Geneva (1870-1880)
Meteorological Pattern from station data (2000-2011)

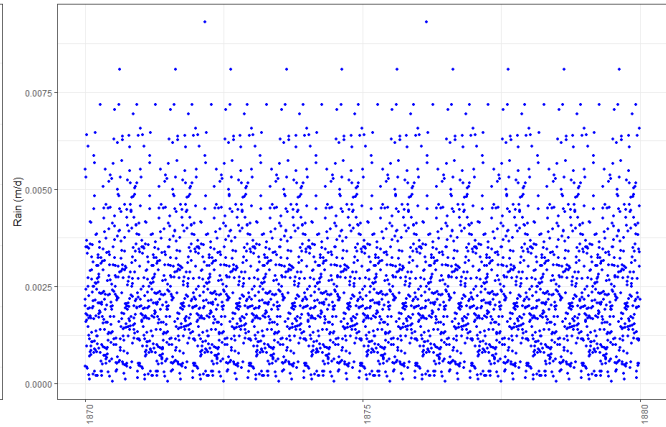


Figure S2. Daily meteorological time series. Relative humidity, Cloud cover, Wind speed and Rain estimated from the longest period with available data are represented here.

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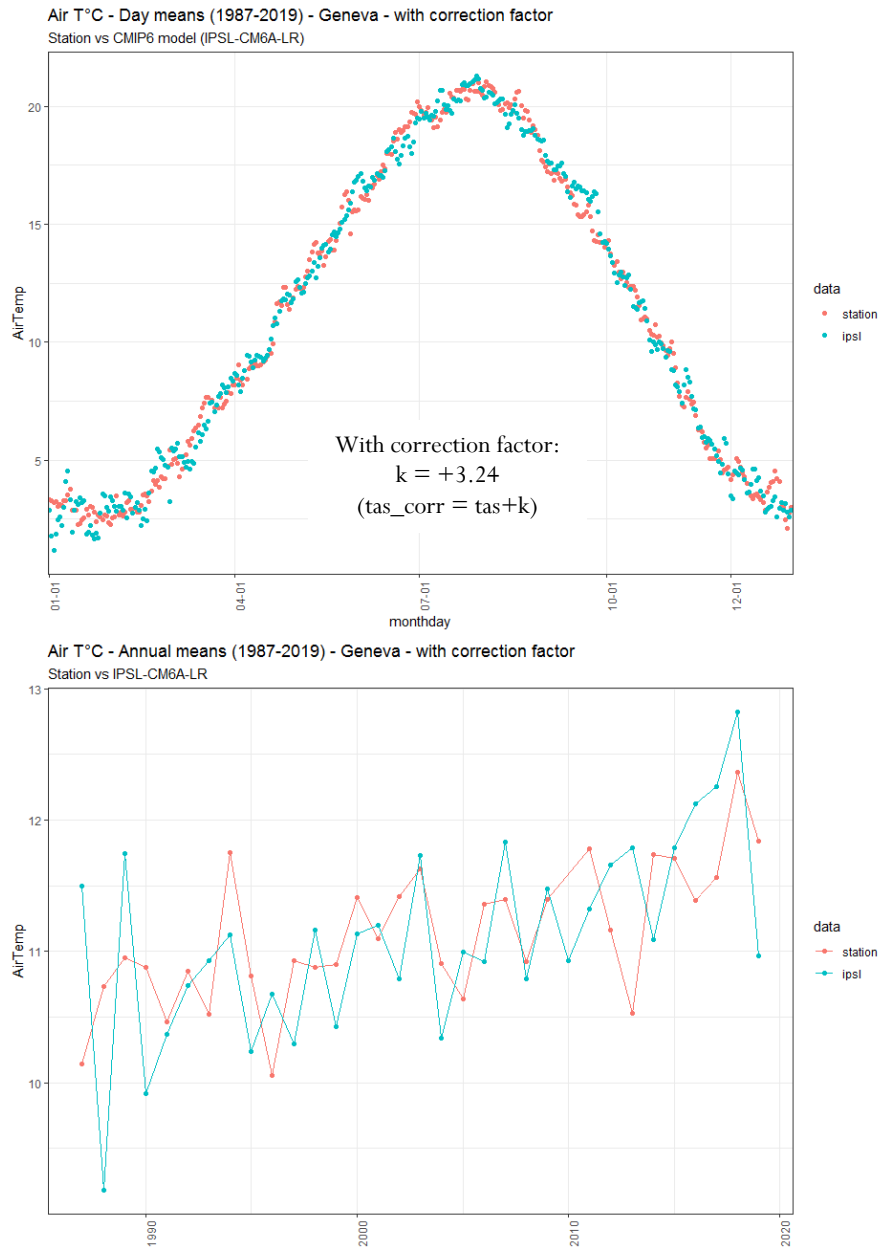
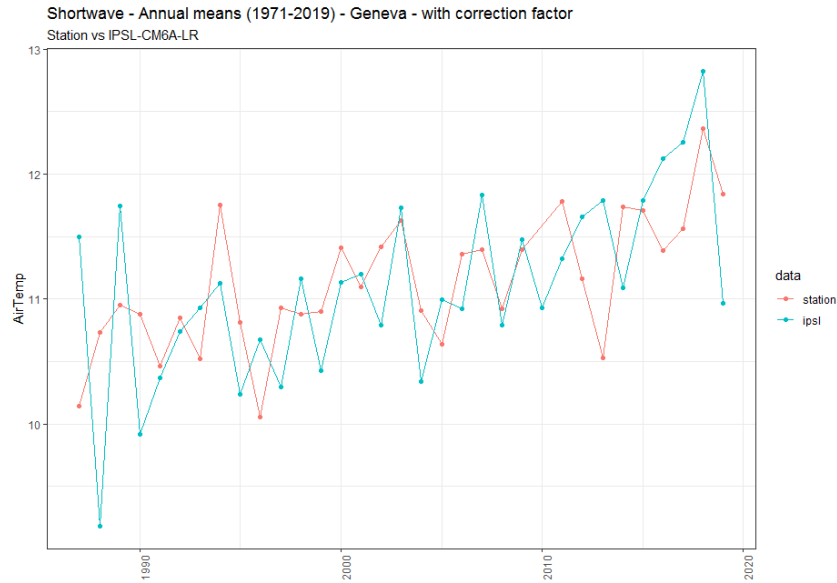
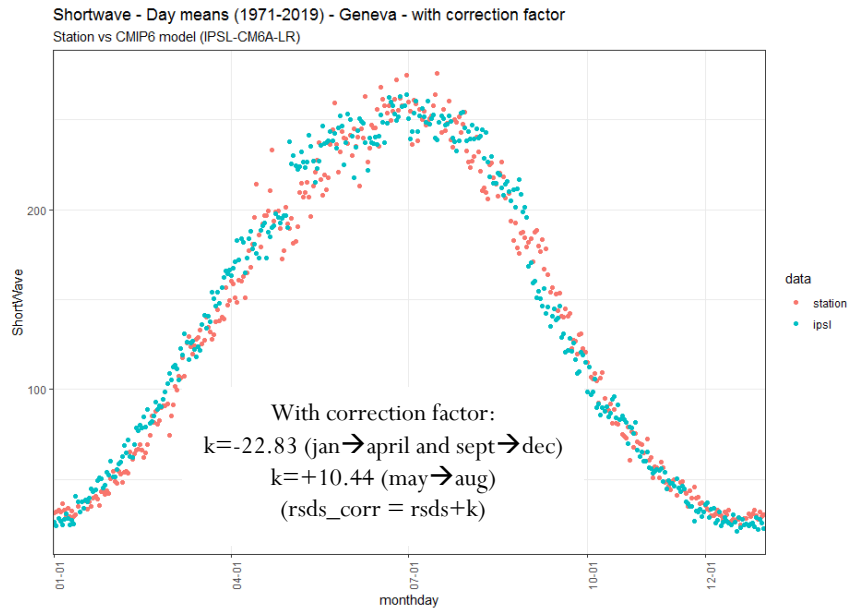


Figure S3. Comparison of annual and daily mean air temperature from meteorological station (red) and IPSL-CM6A-LR model (blue) with correction factor.



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Figure S4. Comparison of annual and daily mean shortwave radiation from meteorological station (red) and IPSL-CM6A-LR model (blue) with correction factor. Correction of the climatic model's data relative to the altitude was applied (c.f. Method section).

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Evolution of lake volume fraction with temp>7°C - Lake Bourget

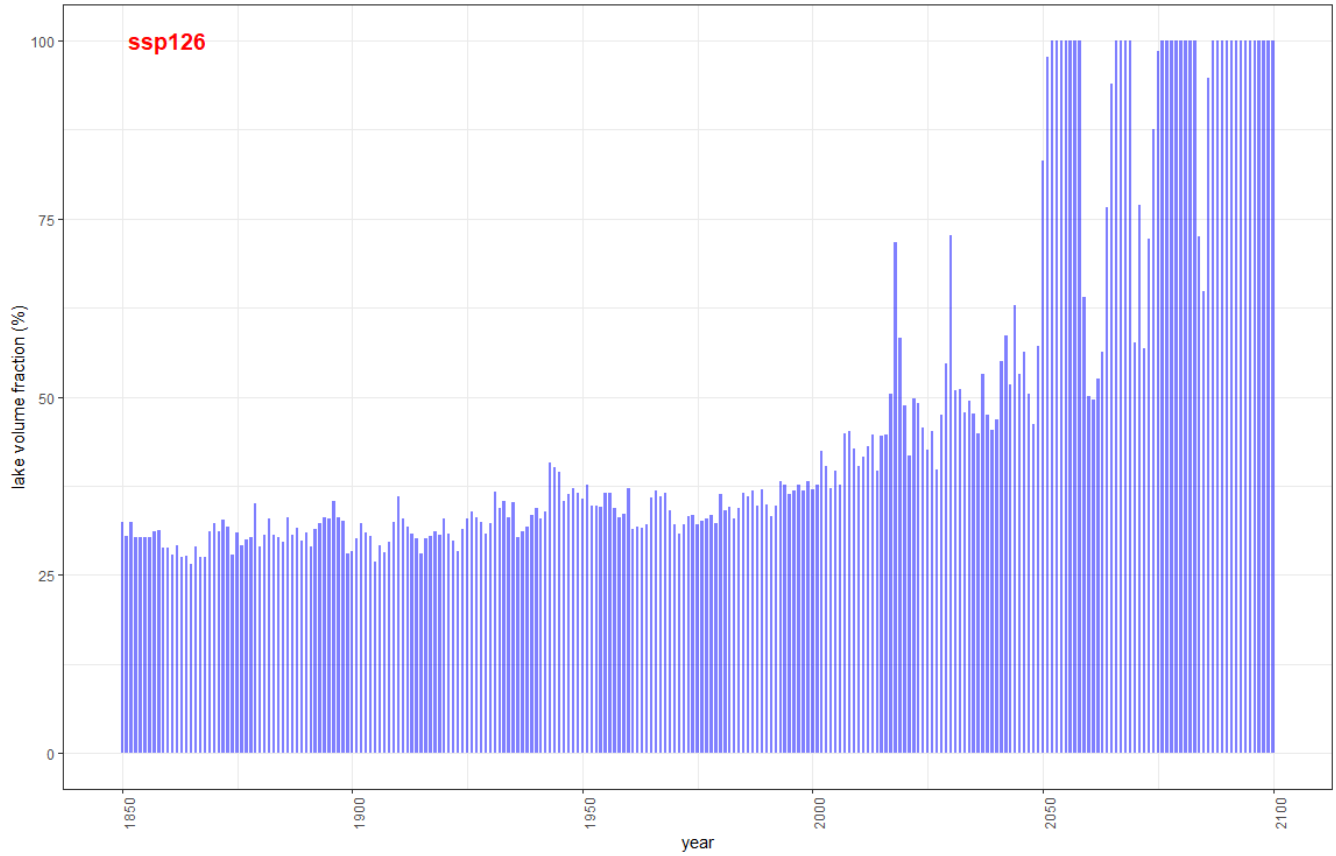


Figure S5. Annual averages of lake volume fraction (%) with temperature above 7 °C in Lake Bourget, over the period 45 1850-2100, according to ssp126 scenario, calculated from MyLake water temperature simulations.

Evolution of lake volume fraction with temp>7°C - Lake Geneva

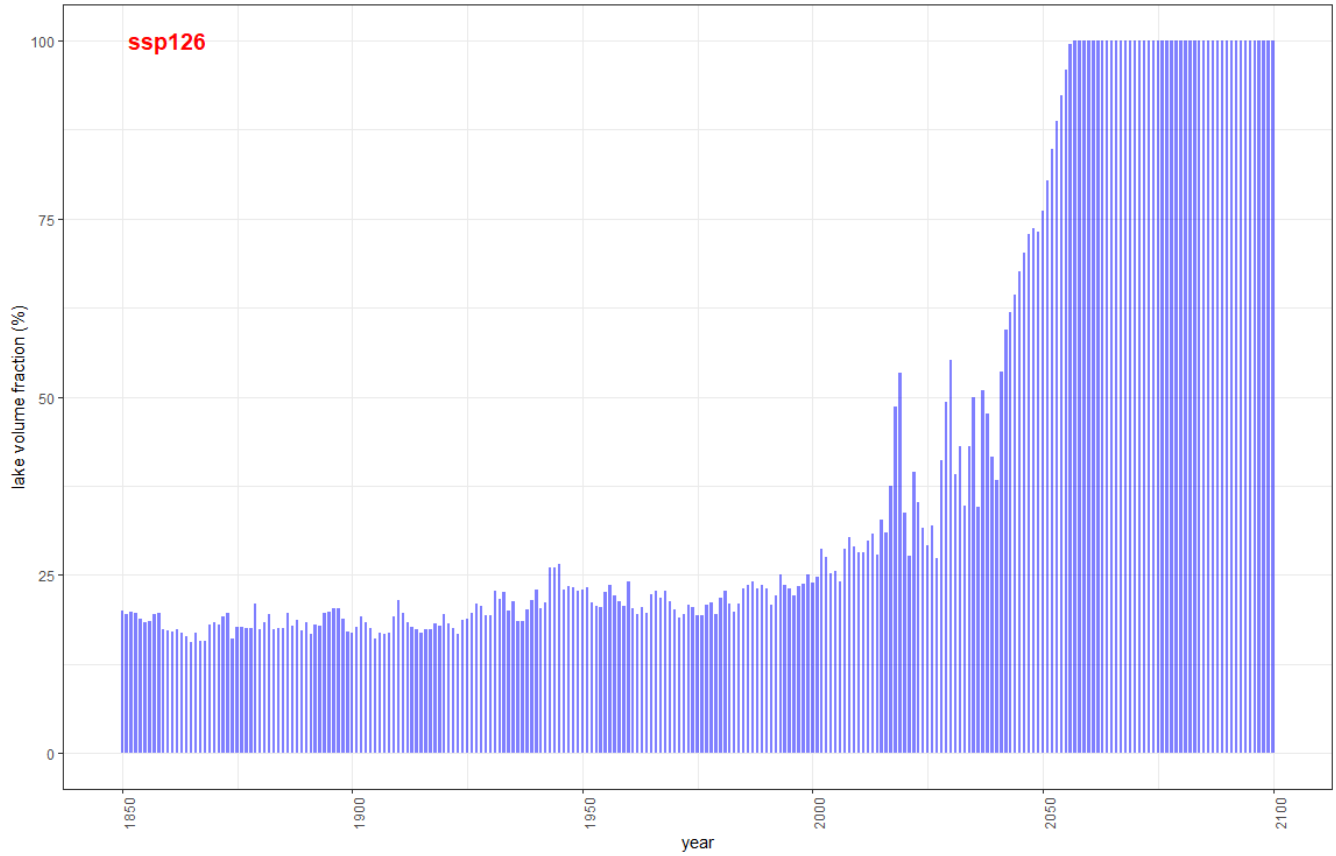


Figure S6. Annual averages of lake volume fraction (%) with temperature above 7 °C in Lake Geneva, over the period 1850-2100, according to ssp126 scenario, calculated from MyLake water temperature simulations.

Supplementary Tables

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Table S1. Performance metrics (Root mean square error, normalized mean absolute error, Pearson correlation coefficient) to select the most performant climate model for air temperature and shortwave radiation predictions.

	Air Temperature			Shortwave		
	RMSE	NMAE	r	RMSE	NMAE	r
GFDL-ESM4	4.40	2.01	0.805	77.74	0.759	0.687
IPSL-CM6A-LR	4.27	1.57	0.814	76.84	2.374	0.692
MPI-ESM1-2-HR	4.39	1.90	0.804	77.20	0.761	0.691
MRI-ESM2-0	4.34	10.28	0.809	78.03	2.453	0.686
UKESM1-0-LL	4.21	4.54	0.811	77.62	2.145	0.686

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Table S2. Climate forcing data

Model title	Institution	Ensemble member
GFDL-ESM4	National Oceanic and Atmospheric Administration, Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA	r1i1p1f1
IPSL-CM6-LR	Institut Pierre Simon Laplace, Paris 75252, France	r1i1p1f1
UKESM1-0-LL	Met Office Hadley Centre, Fitzroy Road, Exeter, Devon, EX1 3PB, UK	r1i1p1f2
MPI-ESM1-2-HR	Max Planck Institute for Meteorology, Hamburg 20146, Germany	r1i1p1f1
MRI-ESM2-0	Meteorological Research Institute, Tsukuba, Ibaraki 305-0052, Japan	r1i1p1f1

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70 **Table S3. Sensitivity tests on climate variables** from MyLake water temperature simulations over a 10-year period, for the 4 perialpine lakes (Geneva, Annecy, Bourget and Aiguebelette). Performance metrics calculation (RMSE and R2) with ± 20 % to each climate variable independently ($\Delta = | \text{RMSE/R2}_{\text{raw data}} - \text{RMSE/R2}_{\pm 20\%} |$)

Lake	Variable	RMSE					R2				
		raw data	+20 %	Δ	-20 %	Δ	raw data	+20 %	Δ	-20 %	Δ
Geneva	Air temperature		1.68	0.28	1.37	0.03		0.912	0.000	0.908	0.004
	Shortwave radiation		2.00	0.60	1.29	0.11		0.895	0.016	0.919	0.008
	Wind speed		1.34	0.06	1.46	0.06		0.913	0.002	0.909	0.002
	Cloud cover	1,40	1.65	0.25	1.22	0.18	0.911	0.900	0.011	0.918	0.007
	Relative Humidity		1.61	0.21	1.27	0.13		0.907	0.004	0.914	0.002
	Rain		1.40	0.00	1.40	0.00		0.911	0.000	0.911	0.000
	Pressure		1.32	0.08	1.49	0.09		0.914	0.003	0.908	0.004
Annecy	Air temperature		1.68	0.29	2.52	0.55		0.880	0.013	0.900	0.007
	Shortwave radiation		1.60	0.37	2.65	0.67		0.898	0.005	0.881	0.011
	Wind speed		2.10	0.13	1.87	0.11		0.894	0.001	0.890	0.002
	Cloud cover	1,97	1.83	0.15	2.24	0.27	0.893	0.891	0.002	0.891	0.001
	Relative Humidity		1.75	0.22	1.97	0.00		0.889	0.003	0.893	0.000
	Rain		2.32	0.35	1.97	0.00		0.894	0.001	0.893	0.000
	Pressure		2.05	0.08	1.90	0.07		0.892	0.001	0.892	0.000
Bourget	Air temperature		2.82	0.58	1.79	0.45		0.901	0.001	0.893	0.006
	Shortwave radiation		3.06	0.83	1.54	0.69		0.878	0.021	0.915	0.016
	Wind speed		1.91	0.32	2.59	0.36		0.908	0.009	0.888	0.012
	Cloud cover	2,23	2.64	0.41	1.83	0.40	0.900	0.885	0.015	0.911	0.012
	Relative Humidity		2.73	0.50	1.77	0.46		0.890	0.010	0.907	0.007
	Rain		2.23	0.00	2.23	0.00		0.900	0.000	0.900	0.000
	Pressure		2.02	0.22	2.47	0.23		0.906	0.007	0.891	0.009
Aiguebelette	Air temperature		3.82	0.62	2.71	0.49		0.896	0.004	0.884	0.008
	Shortwave radiation		3.99	0.79	2.49	0.71		0.892	0.001	0.888	0.005
	Wind speed		2.98	0.22	3.44	0.24		0.894	0.001	0.891	0.002
	Cloud cover	3,20	3.67	0.47	2.75	0.45	0.893	0.885	0.008	0.898	0.005
	Relative Humidity		3.70	0.50	2.73	0.47		0.890	0.003	0.894	0.001
	Rain		3.20	0.00	3.20	0.00		0.893	0.000	0.893	0.000
	Pressure		3.00	0.20	3.43	0.23		0.895	0.002	0.890	0.003

Table S4. Model parameters calibrated over over the 10-years calibration period

Model	Parameters
FLake	Scaling factors for wind speed, and shortwave radiation (wind_factor, sw_factor), depth_w_lk, extincoef_optic, c_relax_C, fetch_lk, depth_bs_lk, T_bs_lk
GLM	Scaling factors for wind speed, and shortwave radiation (wind_factor, sw_factor), Kw, min_layer_thick, max_layer_thick, coef_mix_conv, coef_wind_stir, coef_mix_shear, coef_mix_turb, coef_mix_KH, coef_mix_hyp
GOTM	Scaling factors for wind speed, and shortwave radiation (wind_factor, sw_factor), k_min
Simstrat	Scaling factors for wind speed, and shortwave radiation (wind_factor, sw_factor), a_seiche, f_wind, q_nn, c10, cd
MyLake	Scaling factors for wind speed, and shortwave radiation (wind_factor, sw_factor), C_shelter

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Table S5. Models performance comparison over 10-years calibration and validation periods (depending on each lakes data availability) for Lakes Geneva, Annecy, Bourget and Aiguebelette.

Lake	Measure	Period	GLM	GOTM	Simstrat	Flake	MyLake
Geneva	RMSE	cal	1.74	3.99	1.86	3.09	1.14
		val	1.94	4.24	1.91	3.13	1.11
	r	cal	0.91	0.81	0.89	0.79	0.96
		val	0.91	0.85	0.90	0.73	0.97
	NSE	cal	0.82	-0.01	0.78	0.55	0.92
		val	0.79	-0.08	0.78	0.52	0.93
	MAE	cal	1.13	2.65	1.18	2.37	0.73
		val	1.16	3.11	1.15	2.33	0.75
	Bias	cal	0.41	-2.65	0.36	0.22	0.30
		val	0.22	-3.11	-0.12	0.24	-0.24

Annecy	RMSE	cal	2.72	4.26	3.14	3.25	1.72
		val	3.13	4.57	3.62	3.66	1.95
	r	cal	0.85	0.56	0.91	0.76	0.94
		val	0.86	0.59	0.9	0.71	0.94
	NSE	cal	0.61	0.01	0.46	0.53	0.84
		val	0.55	-0.03	0.4	0.46	0.82
	MAE	cal	1.64	3.04	2.49	2.15	1.17
		val	2.14	3.27	2.94	2.42	1.27
Bias	cal	-1.37	-2.35	-2.47	-1.00	-0.91	
	val	-1.94	-2.59	-2.92	-1.08	-0.99	
Bourget	RMSE	cal	2.07	3.90	2.78	3.32	1.02
		val	2.34	4.61	3.03	2.82	1.11
	r	cal	0.87	0.54	0.81	0.66	0.96
		val	0.89	0.62	0.75	0.84	0.97
	NSE	cal	0.70	-0.08	0.61	0.22	0.93
		val	0.74	-0.03	0.56	0.68	0.94
	MAE	cal	1.20	2.31	1.97	2.86	0.62
		val	1.39	2.78	2.26	2.03	0.67
Bias	cal	-0.43	-2.18	0.99	1.76	-0.05	
	val	-0.83	-2.59	0.38	0.74	-0.03	
Aiguebelette	RMSE	cal	2.65	4.82	4.49	5.25	1.59
		val	2.05	3.70	3.29	4.78	1.59
	r	cal	0.86	0.48	0.72	0.56	0.95
		val	0.86	0.43	0.72	0.62	0.93
	NSE	cal	0.71	0.04	0.17	0.19	0.90
		val	0.73	0.11	0.29	0.15	0.84
	MAE	cal	1.30	3.10	2.69	4.01	1.14
		val	0.92	2.46	1.71	3.38	1.09
Bias	cal	-0.61	-2.16	-2.68	1.43	0.31	
	val	-0.05	-0.86	-1.66	1.86	0.69	

Table S6. Model validation for 15 thermal metrics over 10 years compared to long-term validation (37 to 63 years) for the 90 four lakes (Annecy, Geneva, Bourget and Aiguebelette).

		10 years										
		RMSE					R ²					
		GLM	GOTM	Simstrat	Flake	MyLake	GLM	GOTM	Simstrat	Flake	MyLake	
Annecy	Full profile - water temp	2.3	3.5	3.5	3.07	1.56	0.77	0.27	0.83	0.51	0.86	
	Epilimnion T°C	5.2	6.9	5.1	4.94	2.02	0.77	0.63	0.86	0.59	0.9	
	Hypolimnion T°C	1.58	1.72	1.95	1.12	0.84	0.002	0.0001	0.01	0.07	0.1	
	Metalimnion (m)	<i>Top</i>	6.94	8.96	8.1	15.09	11.6	0.29	0.28	0.01	0.13	0.29
		<i>Bottom</i>	7.23	11.45	8.21	13.41	11.03	0.29	0.13	0.00	0.03	0.20
	Ts (5m) (°C)	3.4	7.5	4.86	4.87	2.6	0.78	0.81	0.60	0.87	0.62	
	Tb (299m) (°C)	0.94	1.89	1.49		0.59	0.03	0.09	0.00		0.31	
	Tm (°C)	1.6	1.91	2.42	1.32	0.96	0.72	0.57	0.77	0.72	0.74	
	Schmidt Stability (J/m ²)	842.3	2025.1	1249.3	1304.8	820.9	0.79	0.61	0.78	0.59	0.86	
	Thermocline depth (m)	7.15	10.27	8.23	14.15	11.7	0.28	0.19	0.00	0.06	0.22	
	Buoyancy frequency (s ⁻²)	0.012	0.003	0.0018	0.0025	0.0018	0.21	0.05	0.21	0.01	0.21	
	Stratification onset (day of year)	50	81	39	42.6	11.4	0.03	0.27	0.13	0.02	0.11	
	Stratification break-up (day of year)	17.1	123.9	22.4	20.5	13.4	0.02	0.23	0.03	0.12	0.00	
	Stratification duration (days)	68.9	162.5	61.3	26.4	19.1	0.00	0.63	0.26	0.79	0.00	
	Day of stratification with intensity max	31.2	34.2	32.4	44.9	35.7	0.06	0.11	0.10	0.03	0.00	
Stratification intensity max (T _{bottom} - T _{top})	4.73	11.29	2.58	5.53	2.62	0.80	0.61	0.82	0.66	0.80		
		54 years										
		RMSE					R ²					
		GLM	GOTM	Simstrat	Flake	MyLake	GLM	GOTM	Simstrat	Flake	MyLake	
	Full profile - water temp	2.53	3.4	2.96	3.04	1.84	0.65	0.24	0.69	0.45	0.75	
	Epilimnion T°C	6.17	6.58	5.45	4.7	3.69	0.57	0.51	0.67	0.5	0.67	
	Hypolimnion T°C	1.44	1.7	1.92	1.28	0.9	0.015	0.04	0.07	0.04	0.13	
	Metalimnion (m)	<i>Top</i>	9.93	10.3	9.63	15.3	11.85	0.07	0.04	0.0001	0.08	0.14
		<i>Bottom</i>	10	12.1	9.5	13.9	11.2	0.09	0.02	0.0003	0.016	0.1
	Ts (5m) (°C)	4.28	6.89	5.27	4.66	3.35	0.62	0.51	0.68	0.53	0.69	
	Tb (299m) (°C)	0.9	1.92	1.45		0.79	0.00	0.09	0.00		0.14	
	Tm (°C)	1.7	2.18	2.48	1.66	1.17	0.53	0.46	0.55	0.59	0.57	
	Schmidt Stability (J m ⁻²)	6214.9	11190.4	7584.7	6553.2	5962.9	0.63	0.50	0.59	0.54	0.69	
	Thermocline depth (m)	9.94	11.03	9.6	14.6	11.8	0.08	0.03	0.00	0.05	0.11	
	Buoyancy frequency (s ⁻²)	0.01	0.003	0.001	0.002	0.001	0.24	0.03	0.18	0.00	0.14	
	Stratification onset (day of year)	57.2	89.6	42.36	48.6	28	0.09	0.03	0.05	0.00	0.00	
	Stratification break-up (day of year)	23.7	102.6	32.3	20.6	18.9	0.03	0.01	0.01	0.07	0.03	

Stratification duration (days)	77.36	172.1	72.1	31.4	27.8	0.00	0.05	0.02	0.01	0.06
Day of stratification with intensity max	63	60.1	64.9	57.3	59.4	0.00	0.01	0.01	0.03	0.00
Stratification intensity max (Tbottom - Ttop)	7.6	11.3	5.35	6.51	5.49	0.03	0.04	0.08	0.01	0.03

		10 years										
		RMSE					R ²					
		GLM	GOTM	Simstrat	Flake	MyLake	GLM	GOTM	Simstrat	Flake	MyLake	
Bourget	Full profile - water temp	1.74	3.00	2.33	2.36	0.79	0.76	0.27	0.54	0.68	0.93	
	Epilimnion T°C	4.02	8.30	5.01	3.05	2.01	0.79	0.62	0.66	0.74	0.90	
	Hypolimnion T°C	1.30	0.97	1.92	1.86	0.51	0.10	0.00	0.30	0.12	0.15	
	Metalimnion (m)	Top	11.38	11.50	21.40	19.60	8.31	0.63	0.38	0.05	0.19	0.69
		Bottom	11.17	12.19	21.20	19.20	6.70	0.64	0.45	0.06	0.15	0.70
	Ts (5m) (°C)	2.98	3.99	4.86	3.34	1.81	0.88	0.63	0.77	0.77	0.93	
	Tb (299m) (°C)	0.98	1.08	1.30		0.45	0.27	0.04	0.40		0.55	
	Tm (°C)	0.98	1.78	1.38	1.31	0.40	0.55	0.38	0.54	0.77	0.76	
	Schmidt Stability (J m ⁻²)	5377.90	15650.50	7437.60	6715.60	3993.60	0.85	0.70	0.61	0.77	0.89	
	Thermocline depth (m)	11.13	11.96	21.25	19.41	7.92	0.64	0.43	0.05	0.16	0.69	
	Buoyancy frequency (s ⁻²)	0.01	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.16	0.13	
	Stratification onset (day of year)	30.70	83.80	47.30	16.60	9.37	0.16	0.33	0.01	0.65	0.33	
	Stratification break-up (day of year)	13.96	119.75	33.68	49.90	10.70	0.00	0.07	0.13	0.18	0.35	
	Stratification duration (days)	19.28	159.60	69.27	57.49	13.09	0.89	0.28	0.00	0.02	0.12	
	Day of stratification with intensity max	29.04	32.60	53.30	40.70	30.92	0.20	0.28	0.16	0.00	0.18	
	Stratification intensity max (Tbottom - Ttop)	2.09	13.90	7.40	4.70	2.12	0.91	0.86	0.93	0.65	0.95	

		37 years									
		RMSE					R ²				
		GLM	GOTM	Simstrat	Flake	MyLake	GLM	GOTM	Simstrat	Flake	MyLake
	Full profile - water temp	1.67	3.18	3.41	3.91	1.02	0.76	0.23	0.26	0.36	0.88
	Epilimnion T°C	4.59	8.82	5.32	4.20	1.90	0.76	0.54	0.61	0.57	0.90
	Hypolimnion T°C	1.21	1.16	3016.00	2.97	0.80	0.00	0.01	0.00	0.02	0.01
Metalimnion (m)	Top	12.70	11.82	22.99	30.95	11.60	0.45	0.16	0.02	0.34	0.39
	Bottom	12.36	12.69	22.72	29.57	10.82	0.45	0.15	0.04	0.30	0.37
	Ts (5m) (°C)	3.20	9.30	4.93	3.35	1.90	0.86	0.58	0.72	0.63	0.92
	Tb (299m) (°C)	0.82	1.33	2.92		0.71	0.01	0.02	0.03		0.02
	Tm (°C)	0.95	2.12	2.66	2.97	0.73	0.64	0.38	0.11	0.50	0.49
	Schmidt Stability (J m ⁻²)	5507.30	15172.20	8172.90	8845.50	4191.60	0.53	0.58	0.51	0.57	0.88
	Thermocline depth (m)	12.44	12.30	22.80	30.12	11.47	0.45	0.15	0.03	0.32	0.37
	Buoyancy frequency (s ⁻²)	0.01	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.01	0.20

Stratification onset (day of year)	42.38	101.50	57.91	45.79	16.71	0.10	0.01	0.04	0.21	0.17
Stratification break-up (day of year)	24.66	99.23	36.56	50.92	25.74	0.00	0.00	0.12	0.02	0.00
Stratification duration (days)	54.24	183.76	88.68	39.98	35.39	0.00	0.00	0.05	0.05	0.04
Day of stratification with intensity max	24.80	28.38	32.12	46.80	27.60	0.02	0.02	0.01	0.01	0.01
Stratification intensity max (T _{bottom} - T _{top})	2.43	14.78	9.20	8.95	2.02	0.09	0.15	0.01	0.02	0.03

		10 years									
		RMSE					R2				
		GLM	GOTM	Simstrat	Flake	MyLake	GLM	GOTM	Simstrat	Flake	MyLake
Aiguebelette	Full profile - water temp	1.96	3.39	3.19	4.17	1.48	0.71	0.2	0.44	0.44	0.86
	Epilimnion T°C	6.2	9.26	9.36	4.8	2.61	0.71	0.6	0.78	0.7	0.89
	Hypolimnion T°C	0.41	1.93	1.1	2.12	1.31	0.2	0.11	0.04	0.05	0.14
	Metalimnion (m) Top	9.66	7.85	10.35	12.9	8.72	0.27	0.2	0.005	0.42	0.65
	Bottom	9.2	8.43	9.12	12.34	8.43	0.26	0.08	0.07	0.24	0.49
	Ts (5m) (°C)	3.84	7.86	7.71	2.82	2.50	0.76	0.7	0.86	0.84	0.90
	Tb (299m) (°C)	0.39	1.73	0.7		0.49	0.14	0.0001	0.04		0.07
	Tm (°C)	0.63	1.89	1.87	2.51	0.95	0.67	0.51	0.7	0.81	0.72
	Schmidt Stability (J m ⁻²)	2184.9	4448	4200.4	3113.2	1536.03	0.75	0.46	0.38	0.81	0.88
	Thermocline depth (m)	9.47	7.9	9.74	12.51	8.80	0.26	0.13	0.03	0.28	0.56
	Buoyancy frequency (s ⁻²)	0.009	0.005	0.0037	0.0038	0.00	0.34	0.03	0.22	0.02	0.21
	Stratification onset (day of year)	62.4	96.3	74.6	30.06	20.32	0.53	0.002	0.14	0.32	0.44
	Stratification break-up (day of year)	20.17	64.2	50.3	14.8	5.45	0.2	0.007	0.09	0.42	0.70
	Stratification duration (days)	75.9	151.1	117.4	17.4	25.93	0.07	0.06	0.001	0.05	0.00
	Day of stratification with intensity max	30.5	27.6	29.1	34.25	40.62	0.15	0.04	0.07	0.59	0.11
	Stratification intensity max (T _{bottom} - T _{top})	4.31	12.43	7.92	2.99	6.17	0.77	0.64	0.78	0.8	0.85

		46 years									
		RMSE					R2				
		GLM	GOTM	Simstrat	Flake	MyLake	GLM	GOTM	Simstrat	Flake	MyLake
	Full profile - water temp	2.21	3.51	3.41	4.29	1.85	0.61	0.14	0.3	0.34	0.74
	Epilimnion T°C	7.19	9.13	9.34	5.26	4.60	0.53	0.45	0.59	0.46	0.65
	Hypolimnion T°C	0.56	1.94	1.38	1.99	1.19	0.001	0.09	0.05	0.002	0.09
	Metalimnion (m) Top	9.85	8.11	10.12	13.6	9.46	0.11	0.03	0.007	0.26	0.30
	Bottom	9.39	8.67	9.31	13.25	9.07	0.11	0.02	0.04	0.12	0.19
	Ts (5m) (°C)	4.74	8.01	8.09	3.92	3.53	0.58	0.51	0.65	0.51	0.65
	Tb (299m) (°C)	0.39	1.76	0.77		0.59	0.0008	0.02	0.009		0.06
	Tm (°C)	0.86	2.26	2.17	2.83	1.12	0.44	0.34	0.48	0.51	0.44

Schmidt Stability ($J m^{-2}$)	23612.4	4251.4	4043.4	3622.9	2398.21	0.59	0.38	0.29	0.53	0.66
Thermocline depth (m)	9.47	8.17	9.66	13.3	9.43	0.11	0.02	0.02	0.2	0.25
Buoyancy frequency (s^{-2})	0.009	0.004	0.003	0.003	0.00	0.37	0.06	0.26	0.001	0.23
Stratif onset (day of year)	73.6	103.4	84.8	37.1	15.83	0.016	0.0004	0.045	0.06	0.14
Stratif break-up (day of year)	30.12	84.3	68.8	13.4	13.17	0.3	0.0002	0.008	0.22	0.18
Stratif duration (days)	100.8	171.1	141.8	35.8	26.20	0.008	0.01	0.03	0.001	0.04
Day of stratif with intensity max	23.6	24	25.2	27.16	28.61	0.004	0.01	0.09	0.11	0.14
Stratif intensity max ($T_{bottom} - T_{top}$)	7	11.8	7.65	4.78	5.03	0.15	0.25	0.15	0.22	0.19

10 years

		RMSE					R ²					
		GLM	GOTM	Simstrat	Flake	MyLake	GLM	GOTM	Simstrat	Flake	MyLake	
Geneva	Full profile - water temp	1.05	2.26	1.06	2.009	0.79	0.76	0.51	0.77	0.45	0.87	
	Epilimnion T°C	2.74	6.89	2.78	3.73	1.92	0.81	0.75	0.79	0.66	0.91	
	Hypolimnion T°C	0.69	1.69	0.76	1.3	0.68	0.07	0.02	0.1	0.12	0.15	
	Metalimnion (m)	<i>Top</i>	30.5	25.6	42.3	49.1	29.04	0.18	0.07	0.002	0.14	0.28
		<i>Bottom</i>	30.4	25.9	42.4	48.8	27.9	0.17	0.06	1.00E-04	0.13	0.25
	Ts (5m) (°C)	2.21	6.86	2.13	3.34	1.41	0.86	0.8	0.87	0.74	0.93	
	Tb (299m) (°C)	0.78	1.46	0.71		0.76	0.06	0.03	0.06		0.08	
	Tm (°C)	0.52	1.86	0.5	0.85	0.56	0.4	0.11	0.37	0.44	0.42	
	Schmidt Stability ($J m^{-2}$)	6064.9	12418.2	6014.3	6484.6	3108.4	0.88	0.74	0.83	0.71	0.89	
	Thermocline depth (m)	30.4	25.8	42.3	49	28	0.18	0.06	0.0008	0.13	0.27	
	Buoyancy frequency (s^{-2})	0.006	0.002	0.001	0.0015	0.001	0.005	6.16E-06	0.09	0.12	0.28	
	Stratif onset (day of year)	39.9	80.01	54.7	25	32.5	0.003	0.07	0.03		0.33	
	Stratif break-up (day of year)	8.7	52.7	4.3		17.04	0.13	0.028	0.44		0.0002	
	Stratif duration (days)	48.05	136.1	51.9		41.9	0.56	0.06	0.03		0.0002	
	Day of stratif with intensity max	20.3	17.2	29.8	25.03	15.2	0.0003	0.41	0.42	0.11	0.46	
	Stratif intensity max ($T_{bottom} - T_{top}$)	3.02	9.8	1.9	5.4	1.15	0.88	0.91	0.85	0.68	0.94	

63 years

		RMSE					R ²				
		GLM	GOTM	Simstrat	Flake	MyLake	GLM	GOTM	Simstrat	Flake	MyLake
	Full profile - water temp	1.02	2.25	1.002	2.25	0.67	0.78	0.53	0.81	0.47	0.89
	Epilimnion T°C	3.08	7.48	3.12	3.75	2.08	0.76	0.62	0.74	0.65	0.87
	Hypolimnion T°C	0.57	1.7	0.78	1.75	0.57	0.10	0.13	0.15	0.3	0.18
	Metalimnion (m)	<i>Top</i>	27.6	26.9	27.2	49.4	0.08	0.02	0.05	0.15	0.23
		<i>Bottom</i>	27.4	27.2	27.24	49.1	23.04	0.07	0.01	0.04	0.13
	Ts (5m) (°C)	2.22	7.19	2.25	3.28	1.51	0.86	0.72	0.85	0.73	0.92

Tb (299m) (°C)	0.71	1.24	0.46		0.45	0.02	0.008	0.17		0.19
Tm (°C)	0.55	1.79	0.5	1.59	0.44	0.48	0.34	0.57	0.45	0.49
Schmidt Stability (J m ⁻²)	5835.4	12947.5	2084.5	7405.5	3433.1	0.86	0.53	0.82	0.59	0.87
Thermocline depth (m)	27.7	27.01	27.2	49.3	21.2	0.08	0.017	0.05	0.14	0.22
Buoyancy frequency (s ⁻²)	0.0059	0.0015	0.0013	0.0012	0.00086	0.02	0.003	0.057	0.08	0.31
Stratif onset (day of year)	29.7	80.2	45.7	32.8	20.9	0.06	0.05	0.016	0.02	0.0006
Stratif break-up (day of year)	30.1	79.4	24.8	41.1	23.7	0.07	0.01	0.1	0.01	0.1
Stratif duration (days)	54.9	148.5	57.7	57.3	35.4	0.07	0.004	0.05	0.05	0.14
Day of stratif with intensity max	22.6	27.03	31.5	36.2	25.3	0.01	0.002	0.008	3.00E-03	0.006
Stratif intensity max (Tbottom - Ttop)	3.12	10.4	2.19	6.6	1.7	0.009	0.02	0.016	0.03	0.001

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Table S7. Annual means of Schmidt stability over the past 30 years (1990-2020) and in the future projections (2070-2100) according to the 3 scenarios (ssp126, ssp370 and ssp585), for the four lakes (Geneva, Annecy, Bourget and Aiguebelette). Increases per decade calculated for the different periods, from MyLake water temperature simulations on the entire water column and on the upper 50 meters of each lake.

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Thermal indice	Lake	Scenario	Period	Significance	Raise per decade (J.m-2)	Means in groups (J.m-2)	Significance
schmidt	Annecy	ssp126	present	significant	163.97	2641.545	significant
schmidt	Annecy	ssp126	future	significant	-100.49	3382.799	
schmidt	Annecy	ssp370	present	significant	192.9	2655.859	significant
schmidt	Annecy	ssp370	future	significant	285.48	4164.041	
schmidt	Annecy	ssp585	present	significant	167	2640.774	significant
schmidt	Annecy	ssp585	future	significant	445	4833.355	
schmidt	Geneva	ssp126	present	significant	1595	22903.51	significant
schmidt	Geneva	ssp126	future	not significant	-577.4	28945.46	
schmidt	Geneva	ssp370	present	significant	2164	23305.7	significant
schmidt	Geneva	ssp370	future	significant	3435	37215.19	
schmidt	Geneva	ssp585	present	significant	1501.5	22916.67	significant
schmidt	Geneva	ssp585	future	significant	4695	45481.73	
schmidt	Bourget	ssp126	present	significant	564	9940.677	significant
schmidt	Bourget	ssp126	future	not significant	-352.6	12654.109	
schmidt	Bourget	ssp370	present	significant	769.1	10061.59	significant
schmidt	Bourget	ssp370	future	significant	1088.7	15489.15	
schmidt	Bourget	ssp585	present	significant	630.6	9956.858	significant
schmidt	Bourget	ssp585	future	significant	1571.3	17837.976	
schmidt	Aiguebelette	ssp126	present	significant	481.7	9204.284	significant
schmidt	Aiguebelette	ssp126	future	significant	-281.3	11467.357	
schmidt	Aiguebelette	ssp370	present	significant	616.7	9283.767	significant

schmidt	Aiguebelette	ssp370	future	significant	927.8	13829.839	
schmidt	Aiguebelette	ssp585	present	significant	470.5	9183.356	significant
schmidt	Aiguebelette	ssp585	future	significant	1264.7	15776.7	
schmidt (50m)	Annecy	ssp126	present	significant	167.08	2640.726	significant
schmidt (50m)	Annecy	ssp126	future	significant	-146.6	3381.143	
schmidt (50m)	Annecy	ssp370	present	significant	170.25	2654.999	significant
schmidt (50m)	Annecy	ssp370	future	significant	319.5	4161.873	
schmidt (50m)	Annecy	ssp585	present	significant	167.4	2639.97	significant
schmidt (50m)	Annecy	ssp585	future	significant	444.8	4830.79	
schmidt (50m)	Geneva	ssp126	present	significant	1181.3	21328.8	significant
schmidt (50m)	Geneva	ssp126	future	not significant	-932.5	26718.66	
schmidt (50m)	Geneva	ssp370	present	significant	1475	21608.1	significant
schmidt (50m)	Geneva	ssp370	future	significant	2237	32403.21	
schmidt (50m)	Geneva	ssp585	present	significant	1347.6	21433.12	significant
schmidt (50m)	Geneva	ssp585	future	significant	2947	37699.55	
schmidt (50m)	Bourget	ssp126	present	significant	556.4	9713.242	significant
schmidt (50m)	Bourget	ssp126	future	not significant	-556.4	12258.272	
schmidt (50m)	Bourget	ssp370	present	significant	667.4	9818.566	significant
schmidt (50m)	Bourget	ssp370	future	significant	1137.8	14897.862	
schmidt (50m)	Bourget	ssp585	present	significant	588.1	9729.521	significant
schmidt (50m)	Bourget	ssp585	future	significant	1516.5	17136.698	
schmidt (50m)	Aiguebelette	ssp126	present	significant	524.5	9188.932	significant
schmidt (50m)	Aiguebelette	ssp126	future	significant	-458.3	11429.127	
schmidt (50m)	Aiguebelette	ssp370	present	significant	577	9267.185	significant
schmidt (50m)	Aiguebelette	ssp370	future	significant	997.8	13775.344	
schmidt (50m)	Aiguebelette	ssp585	present	significant	467.5	9168.792	significant
schmidt (50m)	Aiguebelette	ssp585	future	significant	1263.7	15711.894	