Is dissolved oxygen in Tempe Town Lake mainly driven by abiotic factors?

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Research question

What is the dominant process driving oxygen super saturation at Tempte Town Lake?

Background

- Tempe Town Lake has been supersaturated with O_2 for ~70% of the year over the past 13 years
- 30% of the data is equal to or greater than 120% saturation

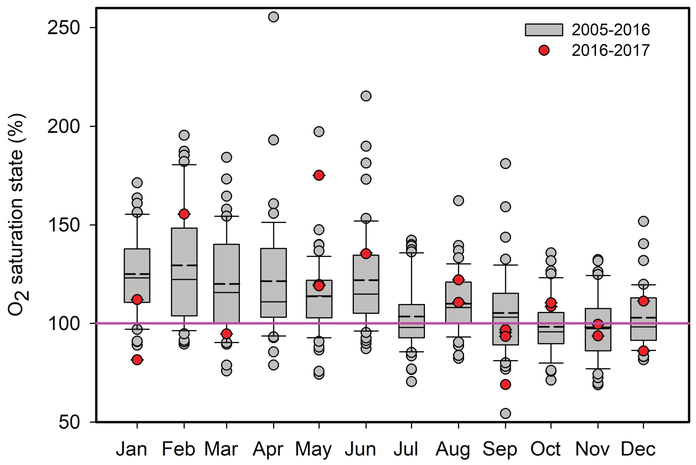


Figure 1. Monthly O_2 saturation state for TTL's surface water. The top and bottom of the box represents the 25th and 75th percentiles, respectively.Dotted line is the mean, n=44-53 data points per month. Data for water samples is overlaid in red.

- Dissolved oxygen (DO) is a property of lakes commonly measured to understand the main biologic processes at play
- But, abiotic processes such as heating and bubble injection can also drive O_2 sat. out of equilibrium (Fig. 2).

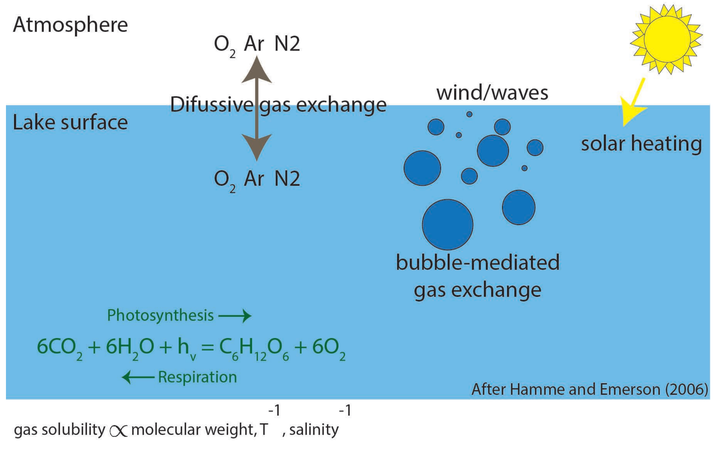


Figure 2. Biotic and abiotic processes affecting O_2 saturation at TTL.

- Therefore, it is important to quantify the effects of each process before interpreting DO measurements

Approach

Abiotic contributions of O_2 can be quantified using Ar as a tracer. Ar has similar solubility as O_2 and is biologically inert. It's concentration in water is only modified by abiotic processes

Figure 3. Top: Sampling location. Bottom: Water samples collected

- O_2 sat. state for the collected samples fall within the values for the past 12 years (Fig. 1)
- The highest supersaturation values occur in early spring when the lake's temperature is increasing and are closer to sat. equilibriumin the fall and early winter (Fig. 1, 4)
- The measured O_2 and Ar sat. anomalies range from -31.01 to +75.07 ± 0.04 and -30.99 ± 0.06 to +76.74 ± 2.41, respectively (Fig. 5)

Methods

- Water samples were collected from the surface in 10 mL glass volumetric flasks and set with 0.1% vol. of $ZnCl_2$
- O_2 and Ar were measured using Membrane Inlet Mass Spectrometry (MIMS)
- Gas saturation anomalies (deviations from equilibrium sat.) were calculated for O_2 and Ar using:

$$\Delta_i\ (\%) = ((C_i/C_i^*)-1) \times 100$$

Δ_i = gas sat. state (%), C_i= measured gas concentrations, C_i^*= equilibrium concentrations.

Results

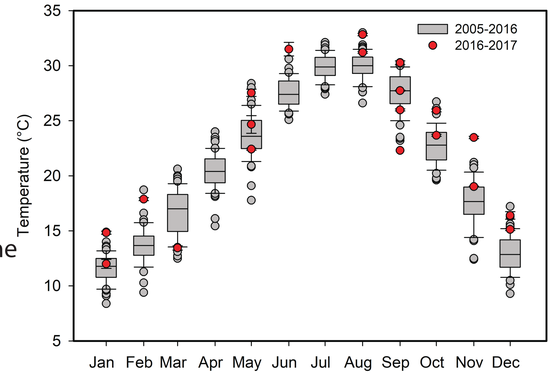
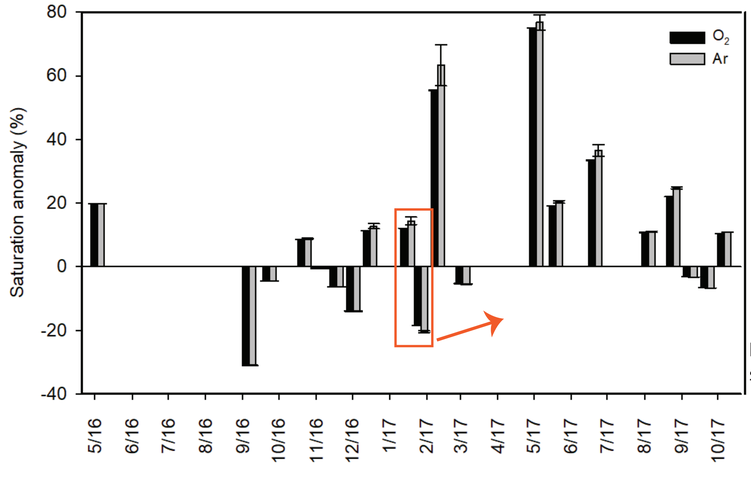


Figure 4. Monthly temperature values for TTL's surface water. Data for water samples is overlaid in red.



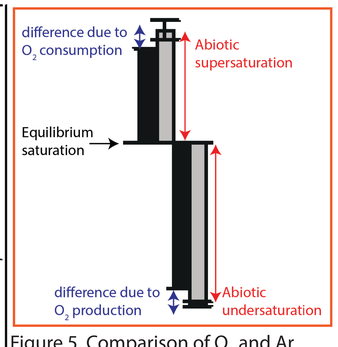
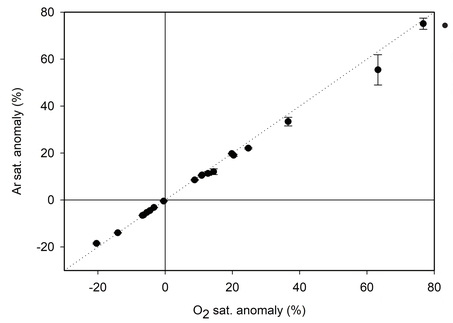


Figure 5. Comparison of O_2 and Ar saturation anomalies.

- 12 of the 20 samples differ by ≤ 5% and the largest percent difference is 16.53 % (Fig. 5)

Our results show that abiotic processes are the main drivers of the observed O_2 saturation

Results (continued)



- O_2 and Ar track each other closely, except at high supersation

Discussion

- The concentration of DO in the surface of TTL is mainly controlled by abiotic processes with modifications by respiration and photosynthesis
- This work suggests that the high supersaturation states observed for the past 12 years were also driven by abiotic processes.
- Although abiotic processes are dominat we still see biotic influences on O_2 (Fig. 6)

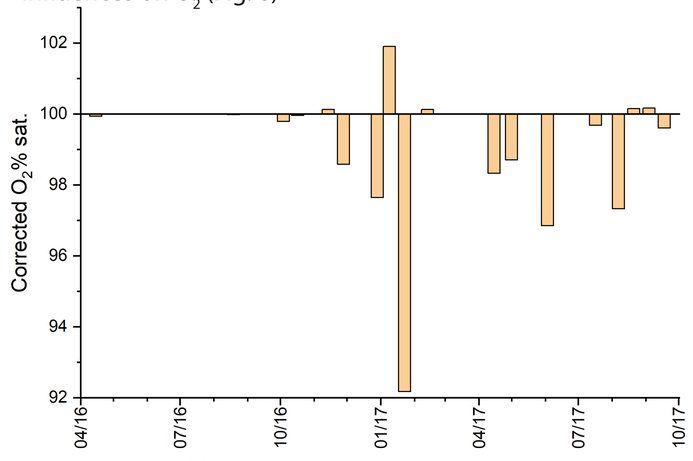


Figure 6. Corrected O_2 saturation states.

- Photosynthesis and respiration affect the lake's oxygen balance but on the scale of a few percent

Summary

- DO concentrations for the past 12 years show that TTL is supersaturated with O_2 for approximately 70% of the year
- Ar was used to constrain abiotic contributions of O_2
- Our time series shows that Ar saturations track those of O_2 closely with the largest difference of 16.53 %
- These results show that abiotic processes are the main drivers of the observed O_2 saturation at Tempe Town Lake.

Future research

This work needs to be reproduced in other lakes to determine how abiotic processes influence their O_2 budget.

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