Metalimnetic oxygen minimum zones decouple diffusive methane and carbon dioxide fluxes from seasonal turnover in a eutrophic reservoir

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Question: How do metalimnetic oxygen minimum zones alter carbon dynamics and surface efflux in a eutrophic reservoir?

Introduction

- As a result of anthropogenic change, oxygen dynamics in some waterbodies are changing, potentially resulting in metalimnetic oxygen minimum zones (OMZs)
- Metalimnetic OMZs may alter the carbon balance of a waterbody by generating reducing conditions that result in methane (CH_4) production in the water column, a process that normally occurs at the sediment-water interface
- In summer 2015, we conducted a whole-ecosystem manipulation of oxygen and thermal conditions to allow metalimnetic OMZs to form in a eutrophic reservoir

Methods

Falling Creek Reservoir (FCR)

- Z_{max} = 9.3m, Area = 1.19 10^{-1} km^2 ,GLEON site; Vinton, VA USA

Thermal stratification and oxygen concentration manipulation

- Thermocline deepened using epilimnetic mixer
- Oxygenated hypolimnion with 95% supersaturated dissolved O_2

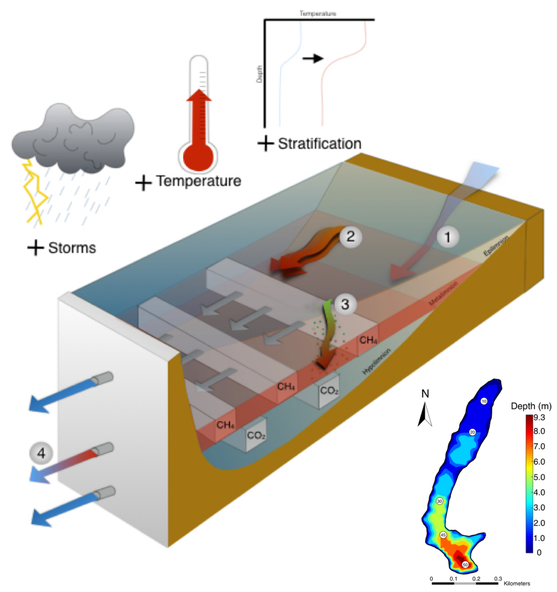
Gas Efflux:

- GHG effluxes calculated with the diffusive transfer equation:

$$FLUX = k([GAS_{surface}] - [GAS_{atmosphere}])$$

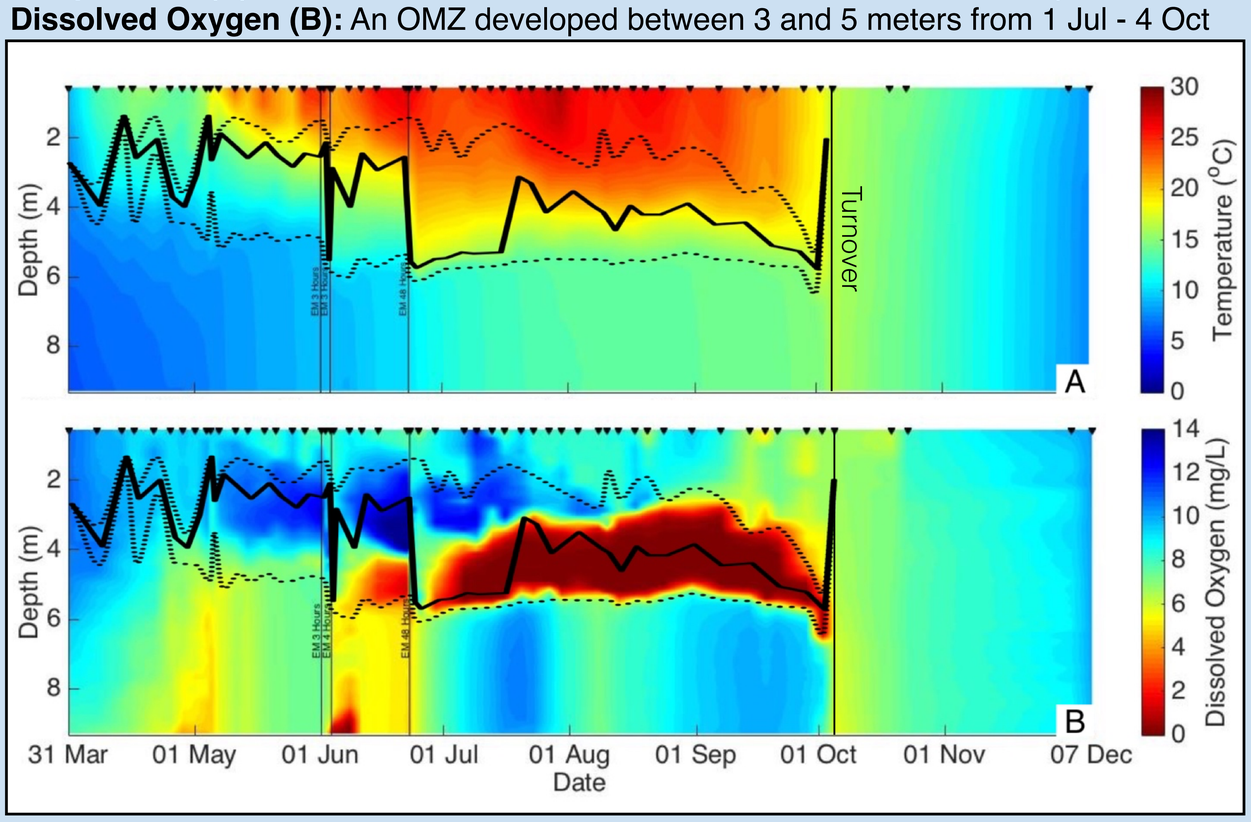
- *k* values were calculated using LakeMetabolizer package in R
- Tested 5 separate *k* models:
  Cole Model, Read Model, Soloviev Model, MacIntyre Model, Vachon Model

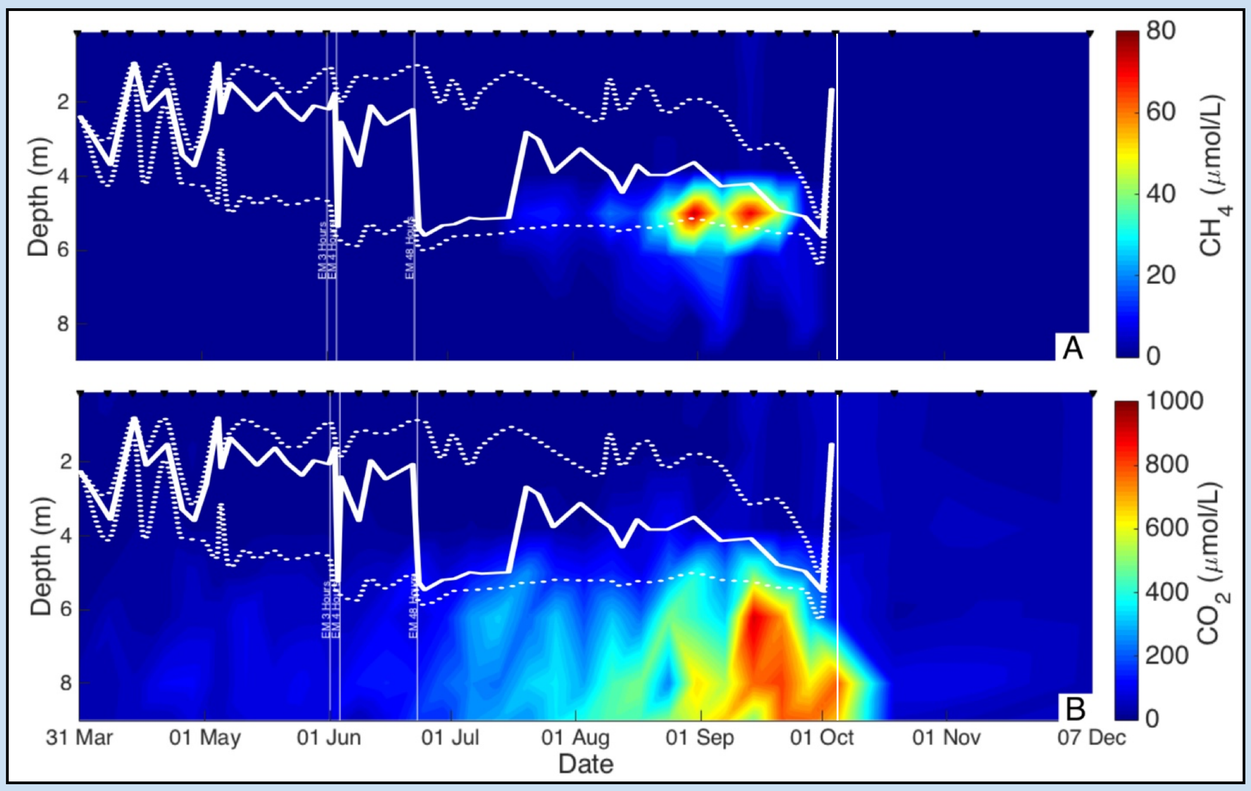
A Metalimnetic OMZ



What is the fate of elevated metalimnetic CH_4 and hypolimnetic CO_2?

Temperature (A): FCR maintained thermal stratification as the OMZ developed
Dissolved Oxygen (B): An OMZ developed between 3 and 5 meters from 1 Jul - 4 Oct

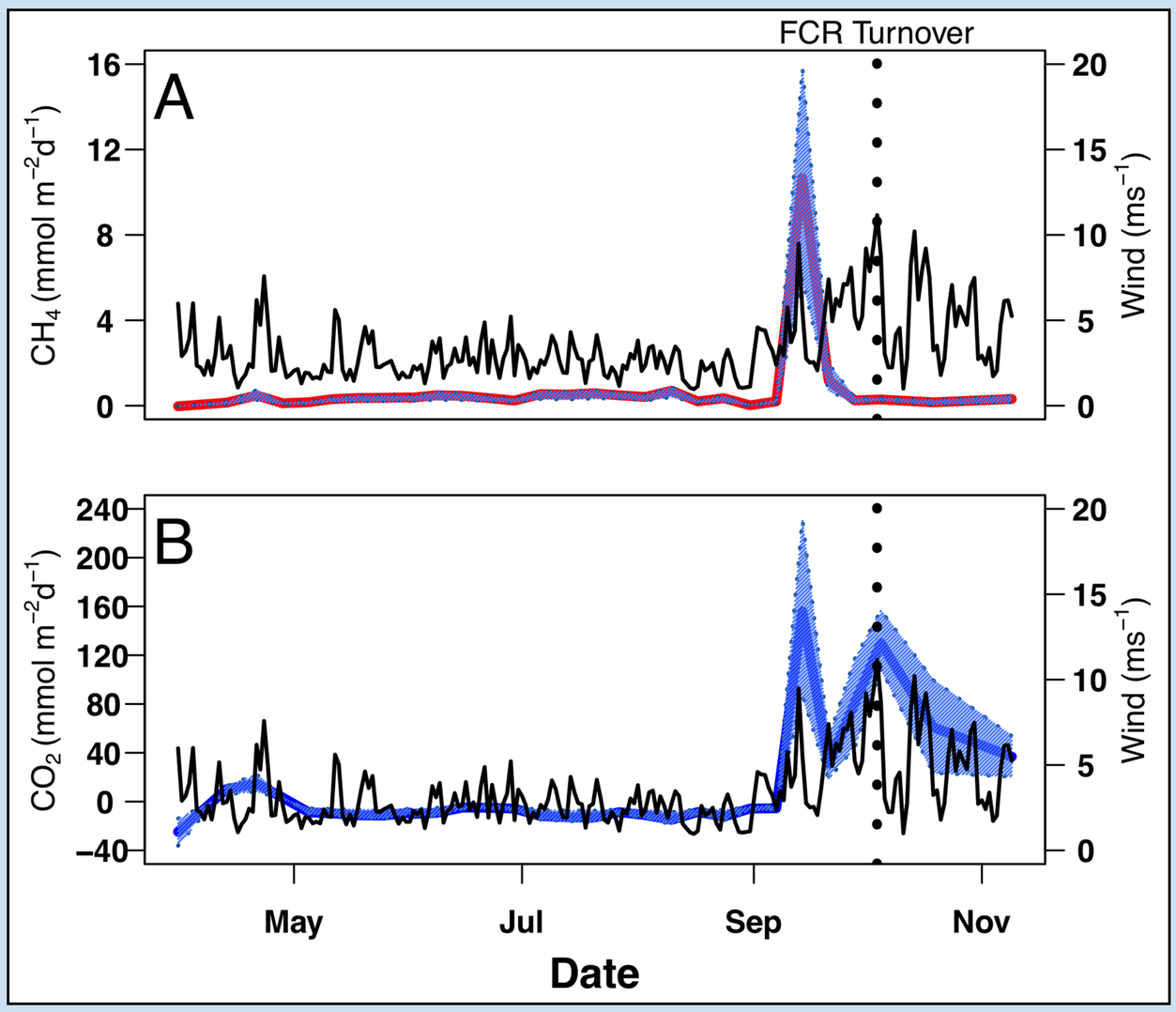




Dissolved CH_4 (A): 1 month after the OMZ developed, CH_4 concentrations rose sharply
Dissolved CO_2 (B): Hypolimnetic oxygenation increased CO_2 in the hypolimnion

CO_2 and CH_4 diffusive emissions

Regardless the *k* model, the largest efflux of CH_4 (A) into the atmosphere occurred 20 days before fall turnover during a strong wind event, while the largest CO_2 efflux (B) from the hypolimnion occurred during turnover



Next Steps

- Apply observed FCR data from 2015 to the general lake model (GLM-AED)
- Use GRAPLEr to generate different climate scenarios for FCR guided by IPCC predictions for the region, and explore how reservoir GHG dynamics may change in response to climate
- **Applying GLM-AED and GRAPLEr to freshwater reservoirs is critical to assess how GHG production and emissions in waterbodies across different regions will respond to climate change**

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