# Application of the eddy covariance technique for estimating oxygen fluxes in aquatic sediments

Lindsay Chipman
Center for Limnology
CIRES
July 23, 2013

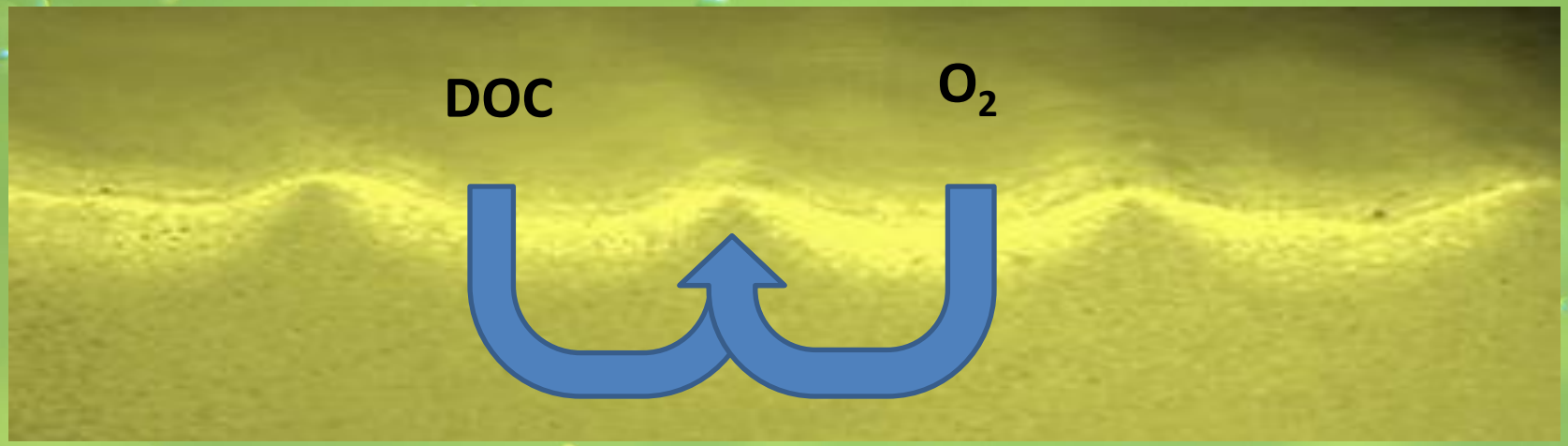
# Outline

- Oxygen in aquatic sediments
- Sediment transport dynamics
- The eddy correlation technique
- Field work in the Gulf of Mexico
- Current/future work

# Oxygen flux as proxy for metabolism

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$$

**$e^-$ donor** **$e^-$ acceptor**



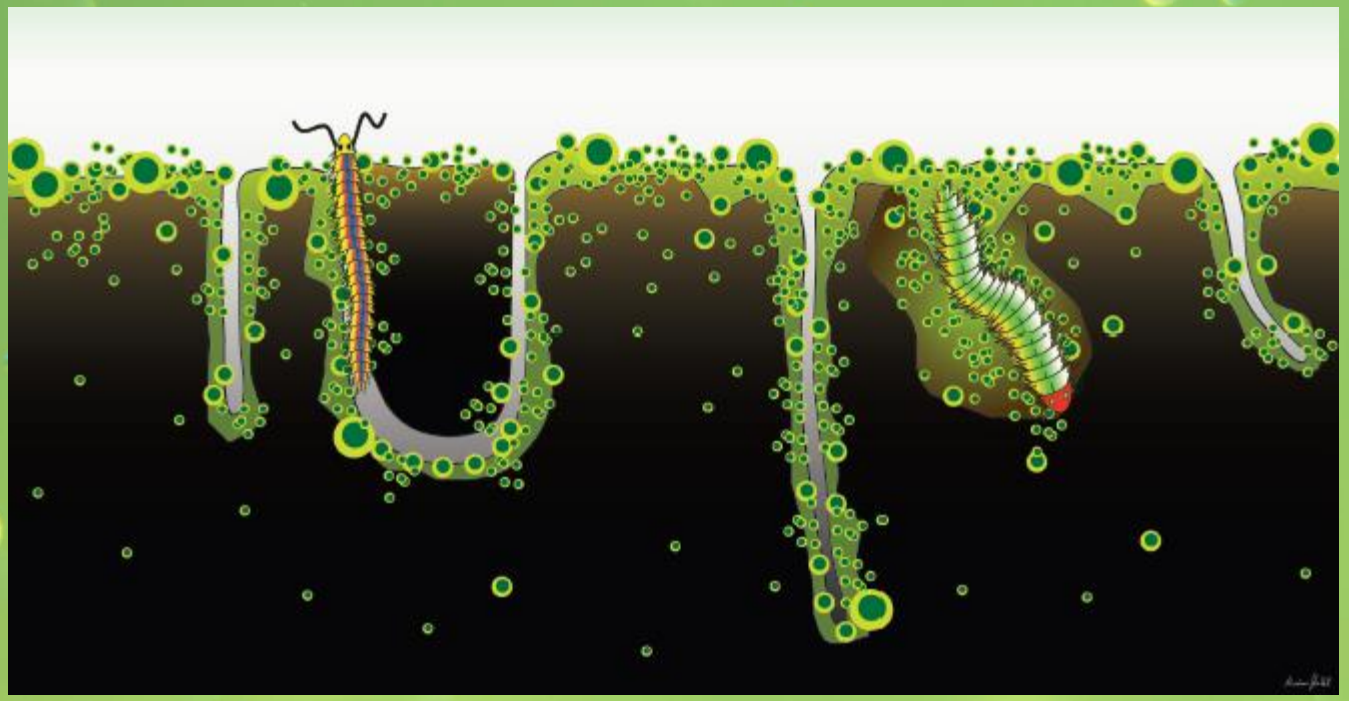
# Oxygen production and consumption in aquatic sediments

- Production: photosynthesis
- Consumption:
  - Aerobic respiration
  - Aerobic decomposition of organic matter
  - Oxidation of reduced products of anaerobic decay

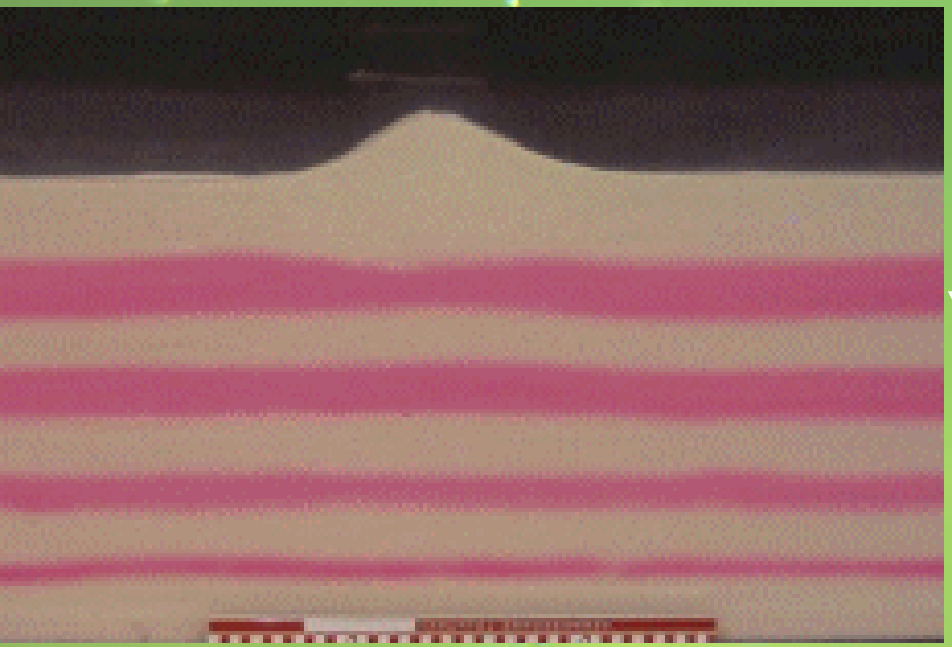
# Permeable sediments as solute filters

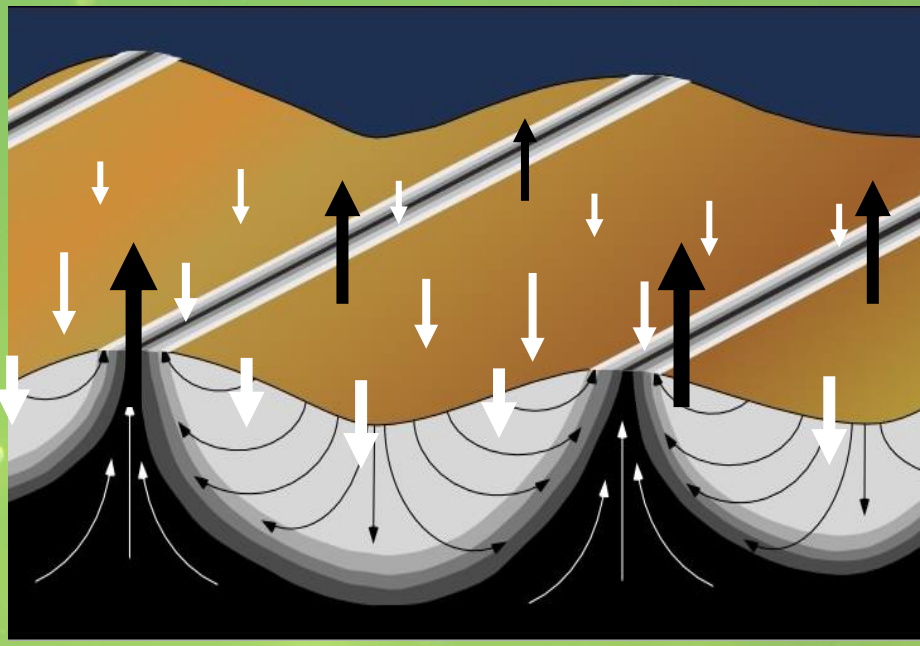
- High permeability ($k>10^{-11}$ $m^2$) = increased porewater flow
- Higher surface area for microbial colonization

# Solute transport dynamics: diffusion and bioirrigation



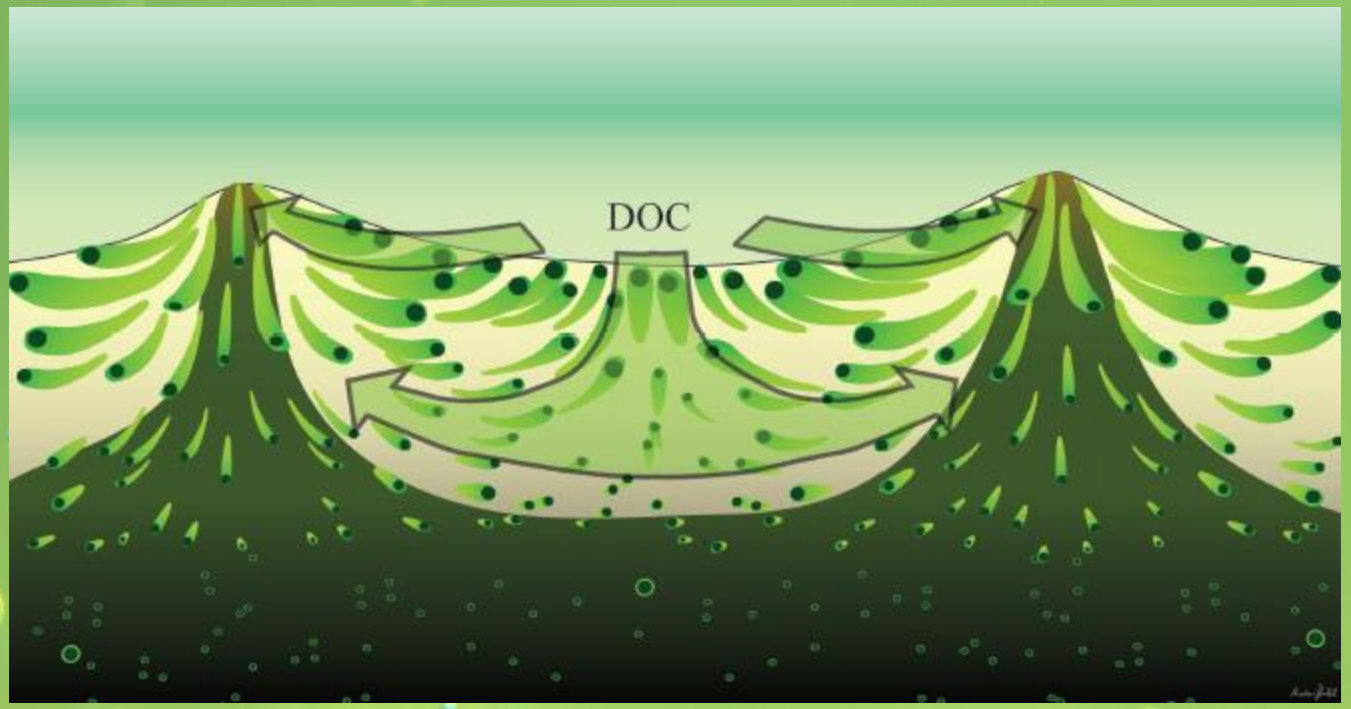
# Solute transport dynamics: advection





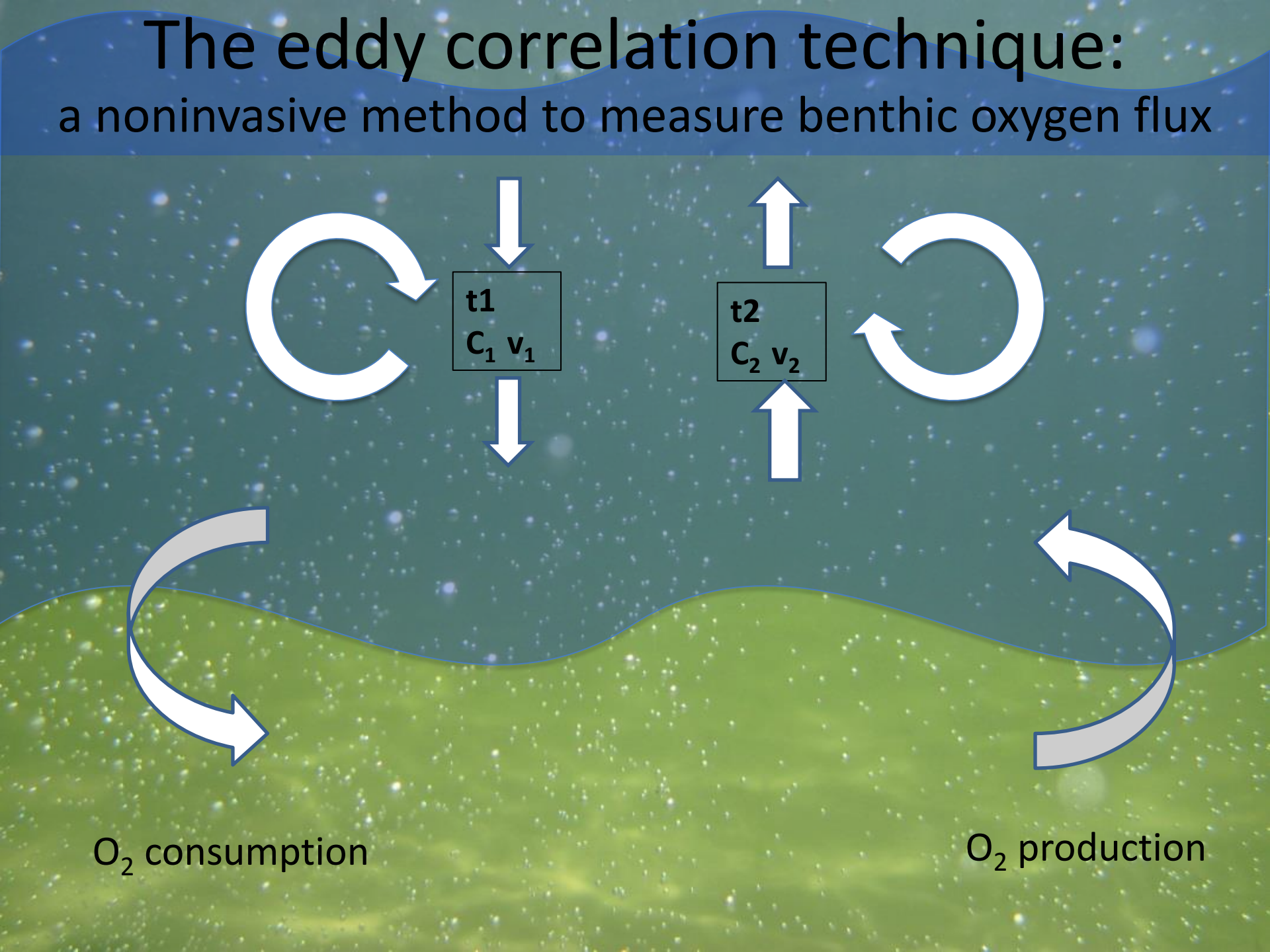
Markus Huettel

# Solute transport dynamics: advection



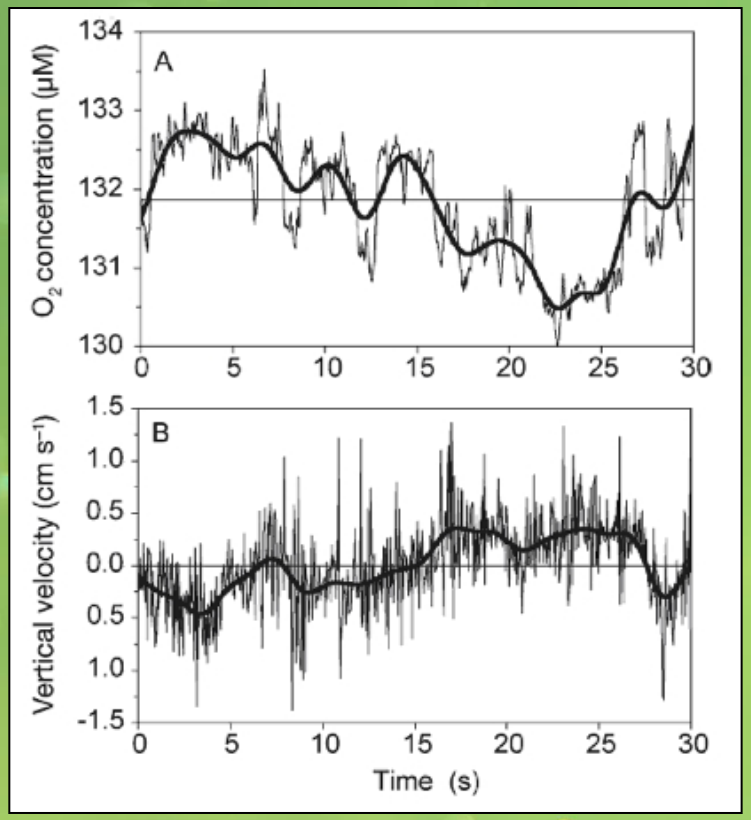
# The eddy correlation technique:

## a noninvasive method to measure benthic oxygen flux



# The eddy correlation technique:

## a noninvasive method to measure benthic oxygen flux



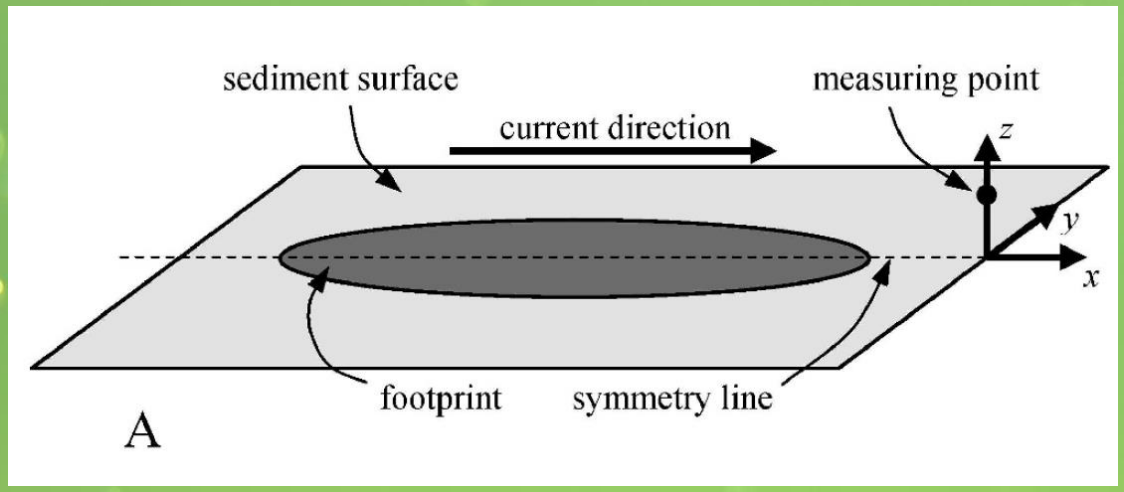

Berg et al. 2003

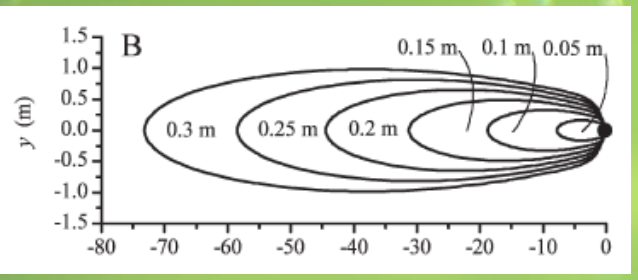
$$\text{Flux} = u_z C - D\frac{dC}{dz}$$

- Net vertical transport results exclusively from turbulent motion
- Terrain is horizontal and uniform: average fluctuations are zero; no convergence or divergence
- Instruments are adequately fast and sensitive
- Point measurements can represent the upstream flow

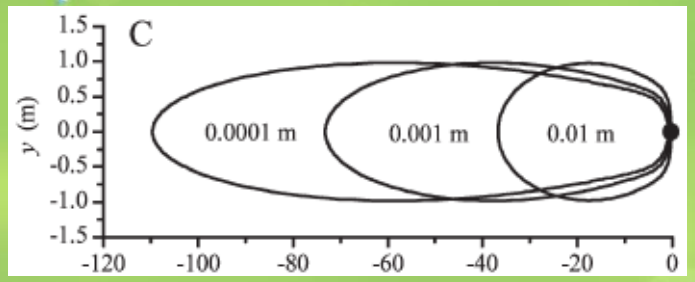
$$\overline{\text{Flux}} = \overline{u'_z C'}$$

# The measuring footprint:
## Area contributing to the measured flux

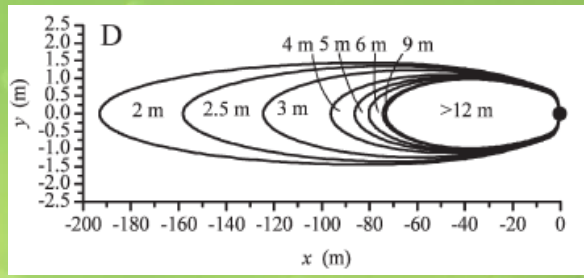



Measuring height



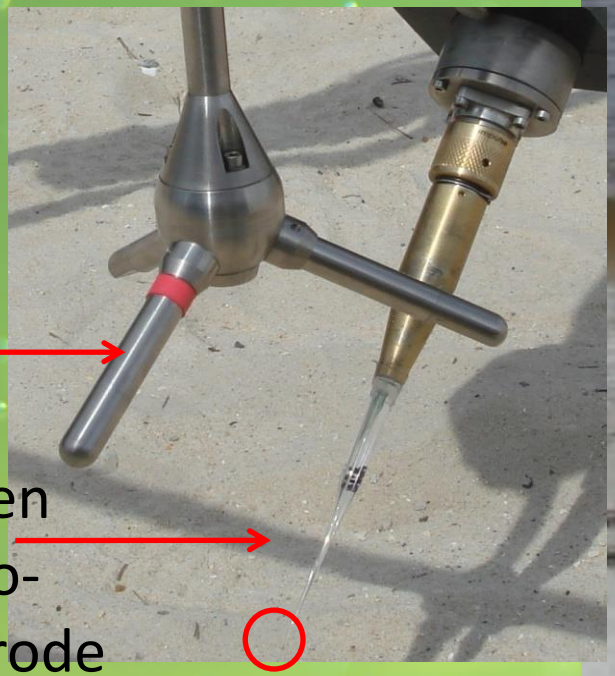

Surface roughness



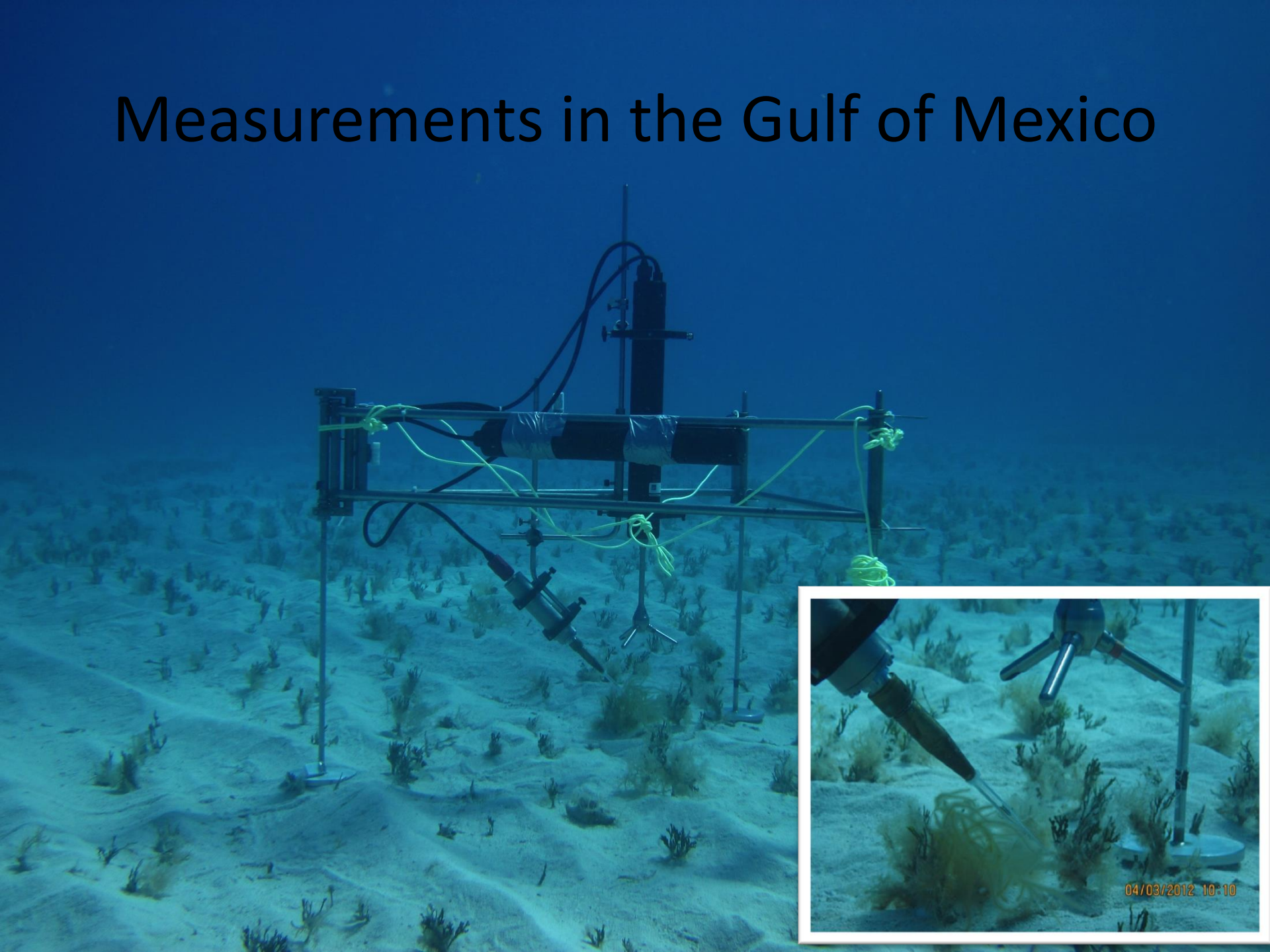

Water height

Berg et al. 2007

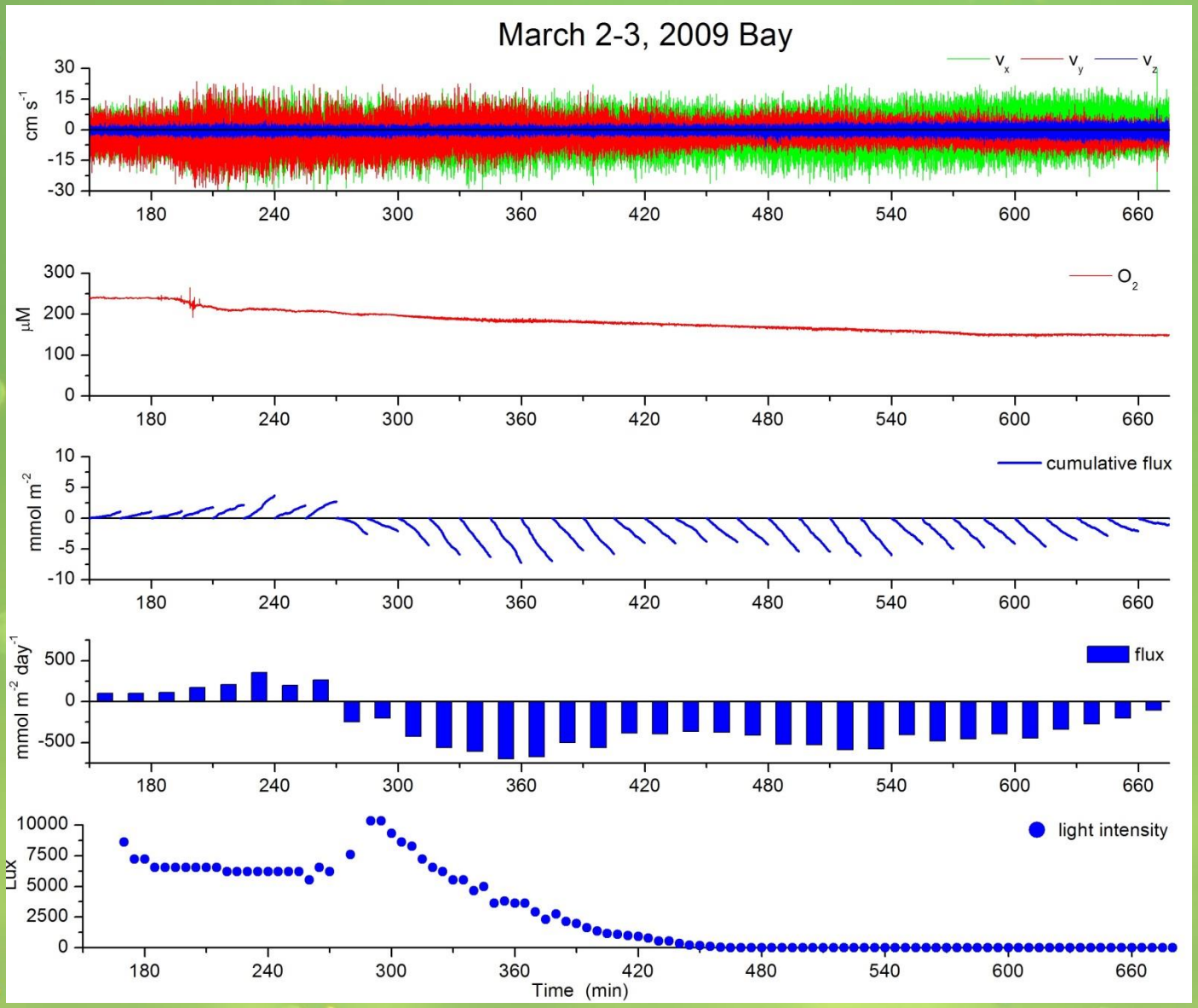
# Eddy correlation: electrode-based setup



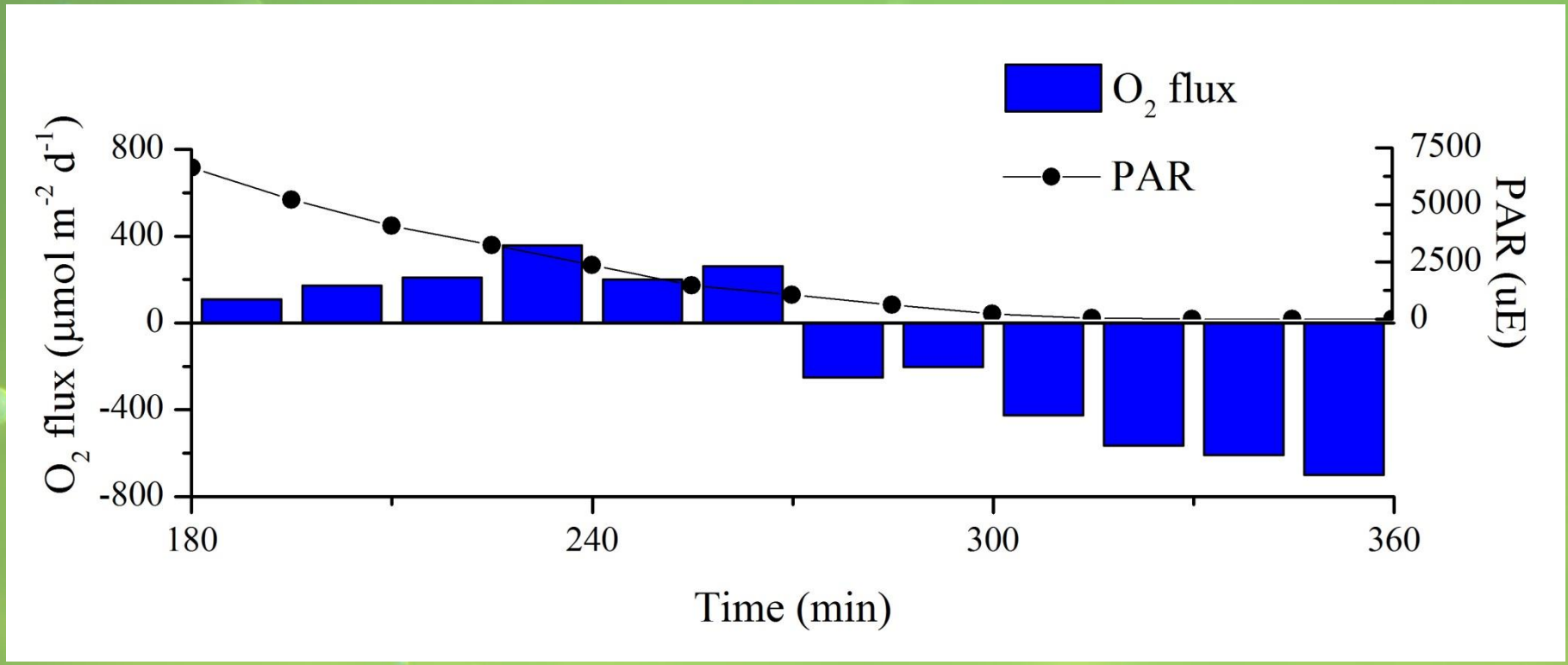

# Measurements in the Gulf of Mexico



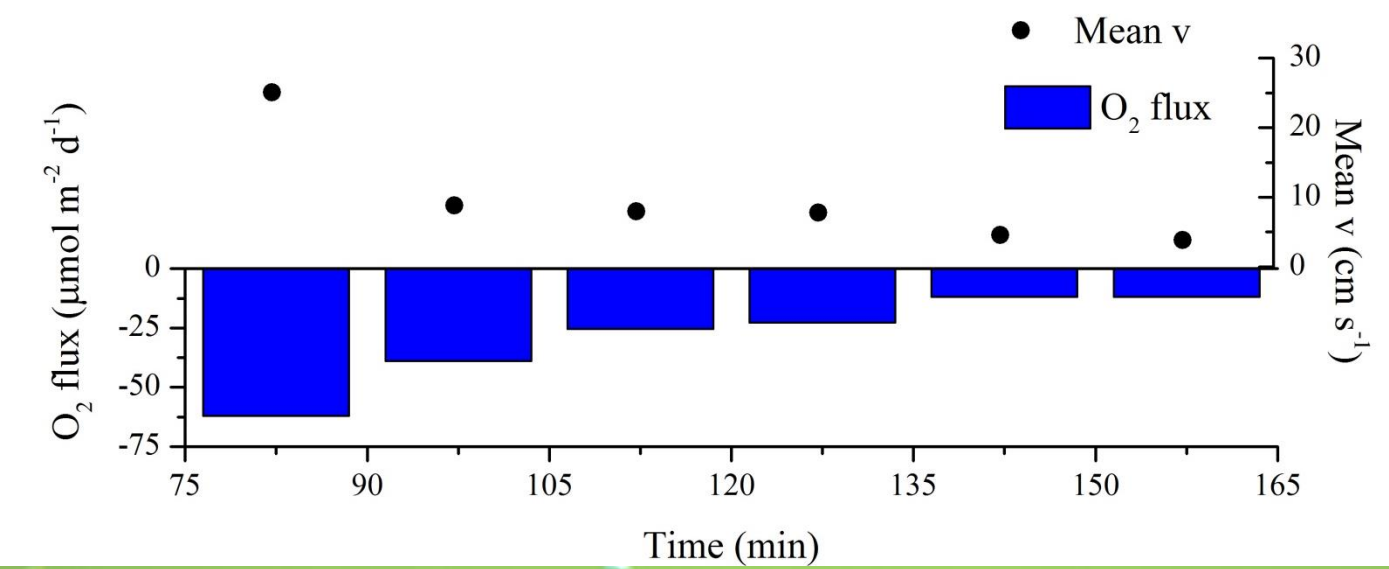
# Measurements in the Gulf of Mexico

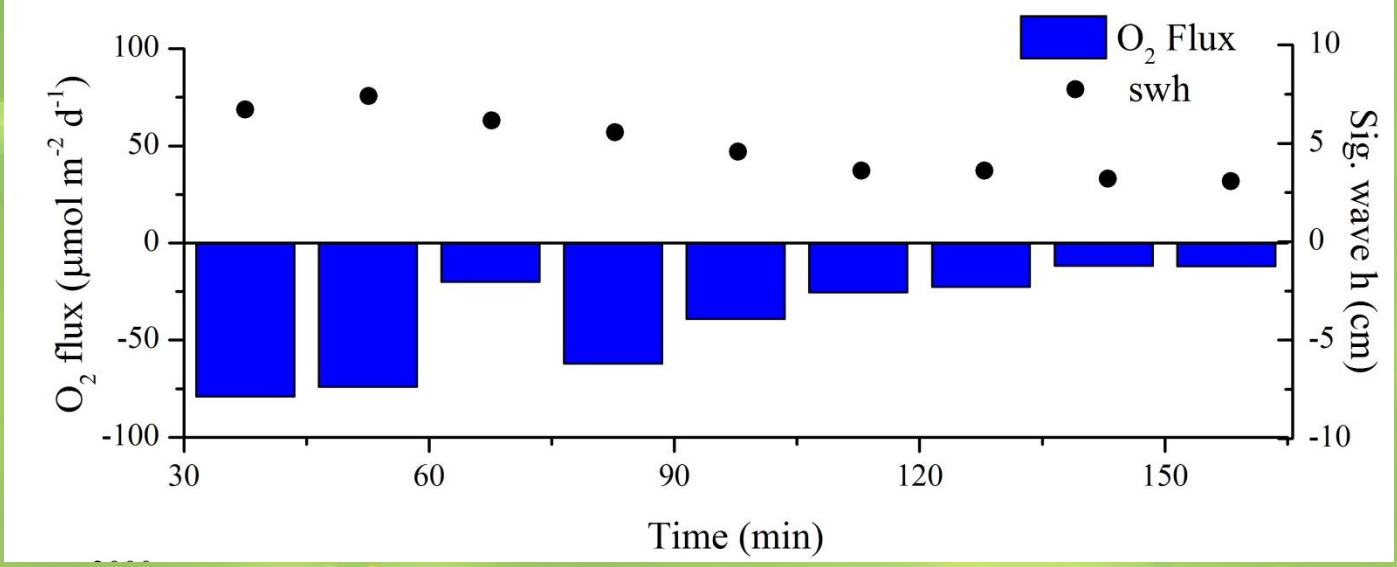


# Light effects

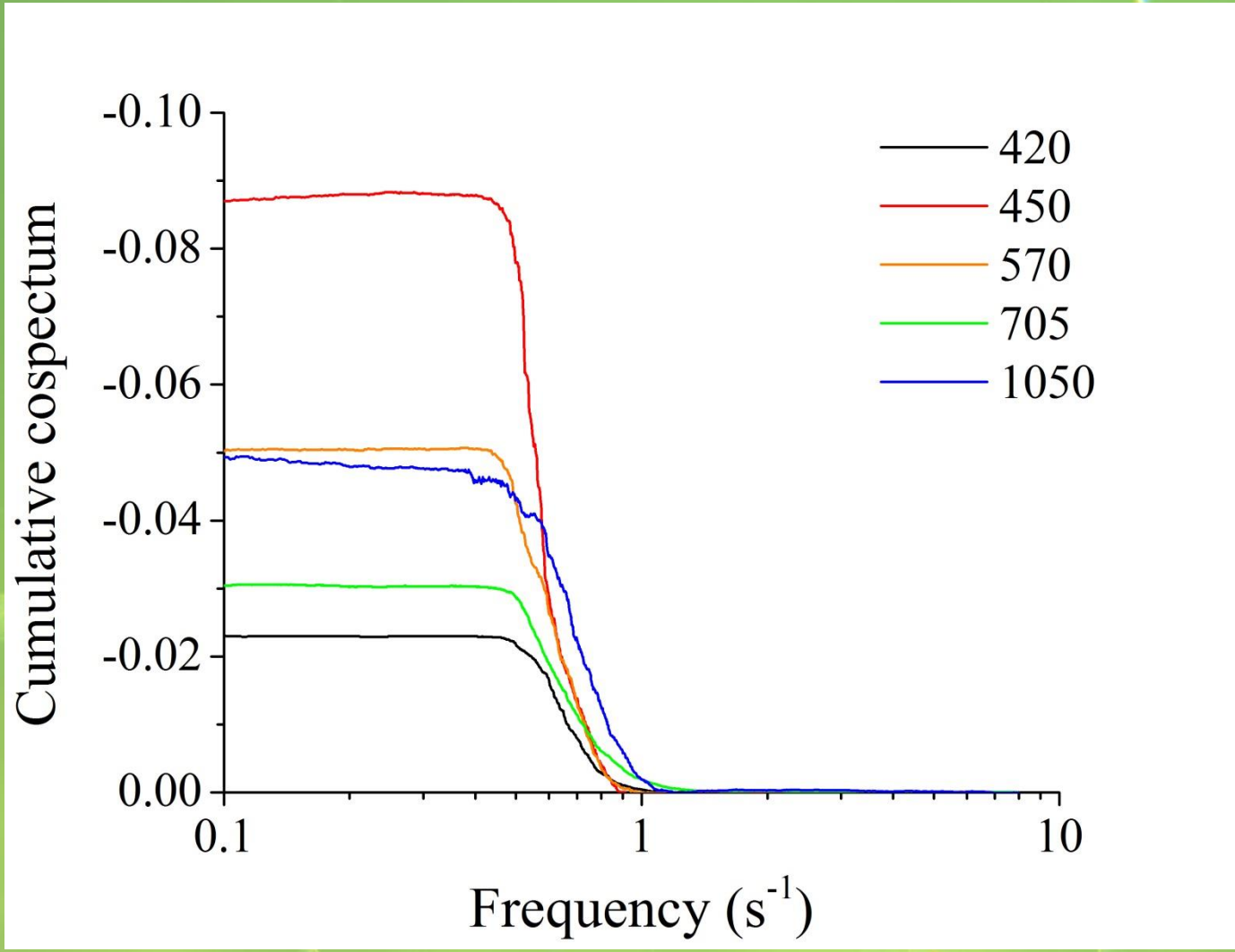


# Hydrodynamics

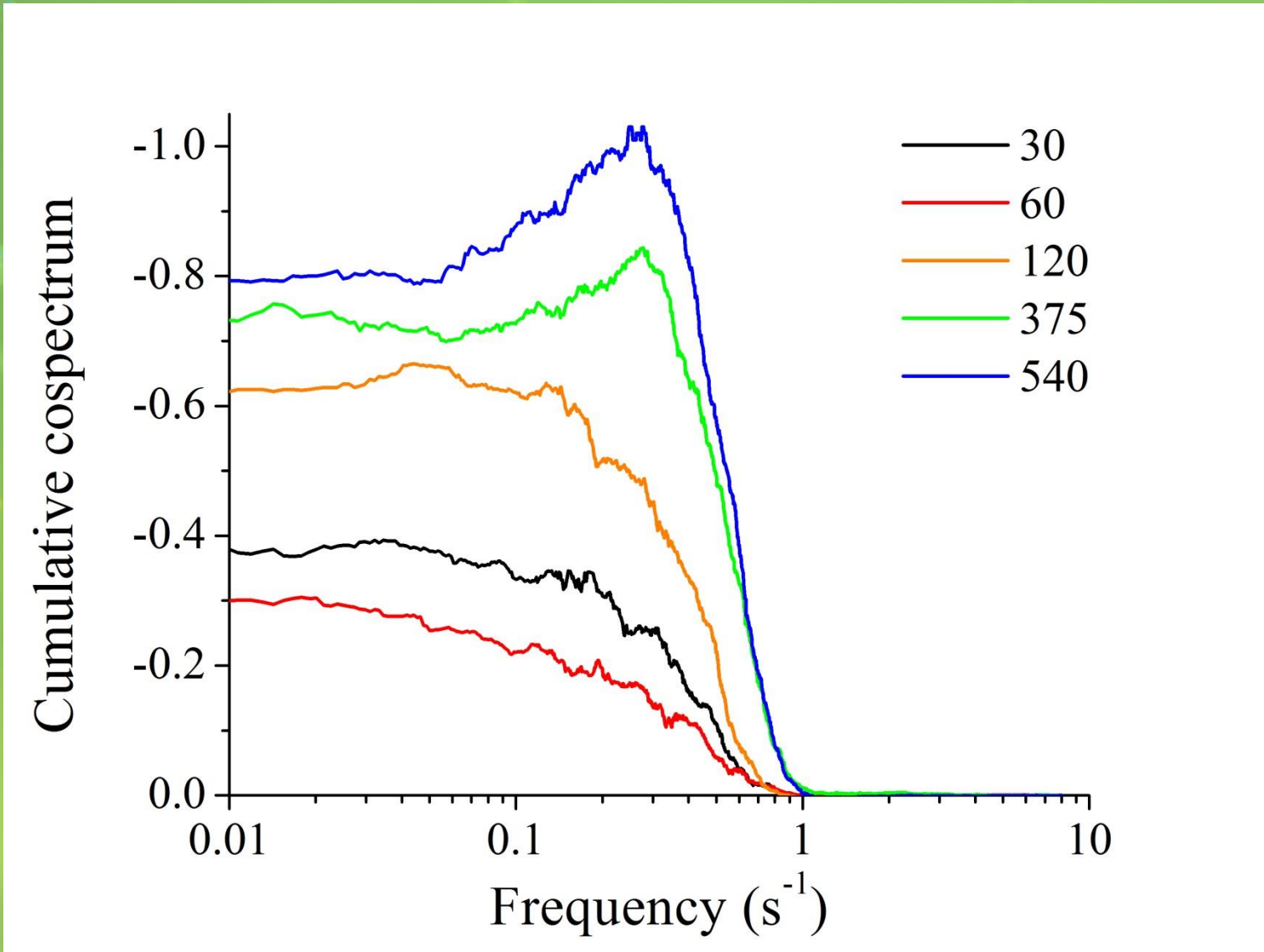


# Cumulative cospectra

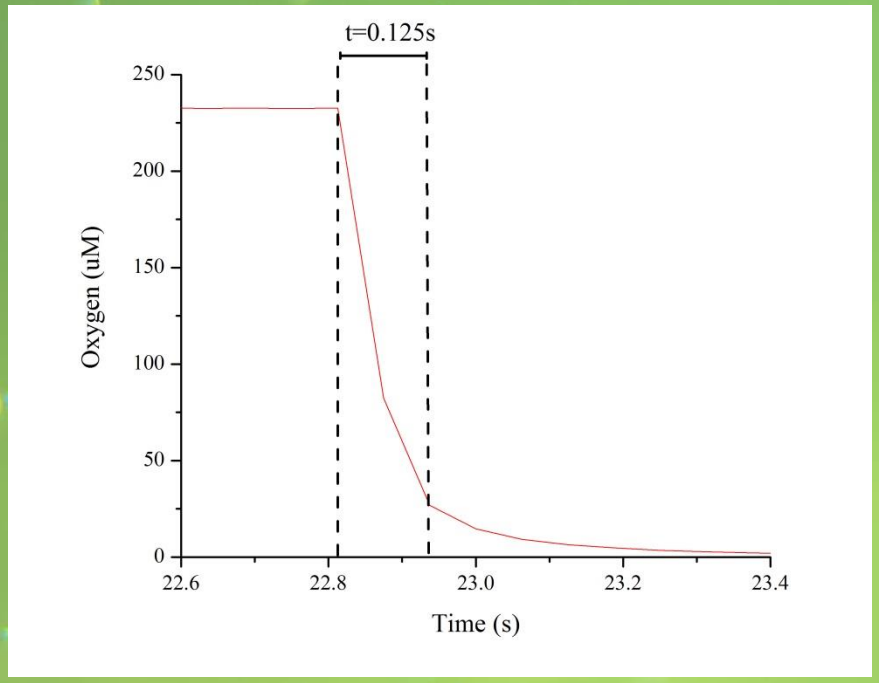


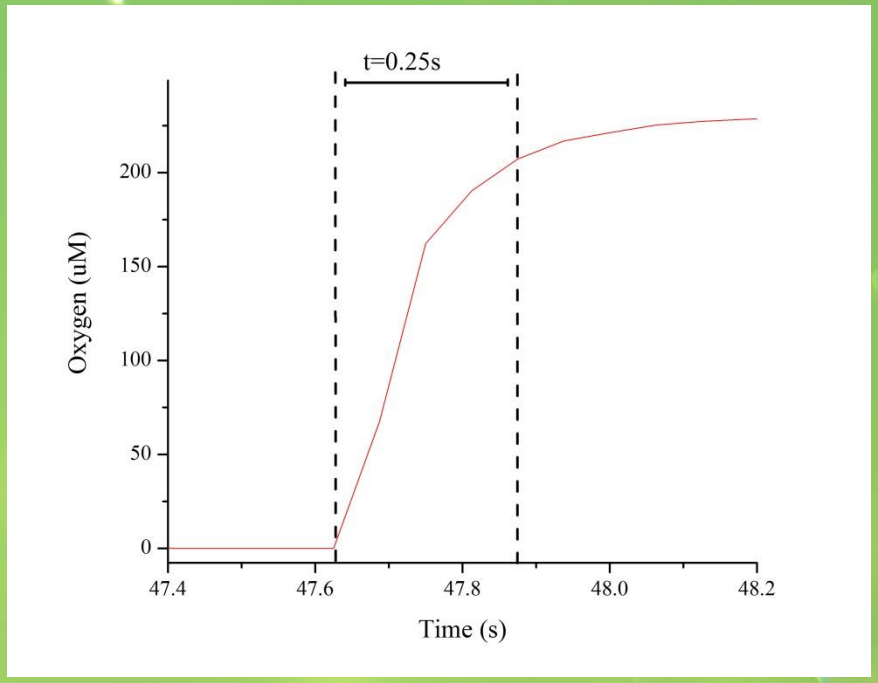
# Cumulative cospectra



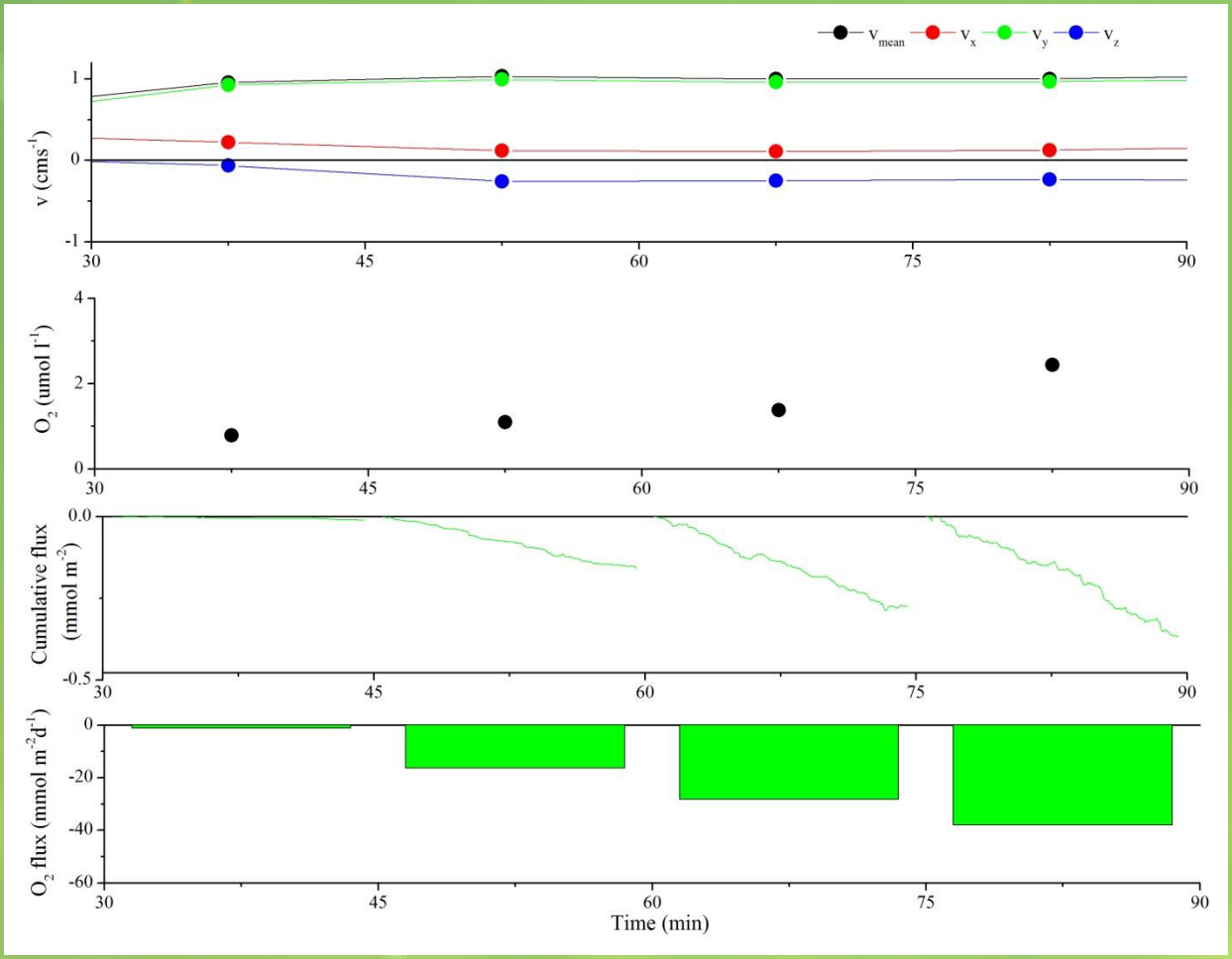
# Current/future work: eddy correlation optode-based setup

# Optode response times

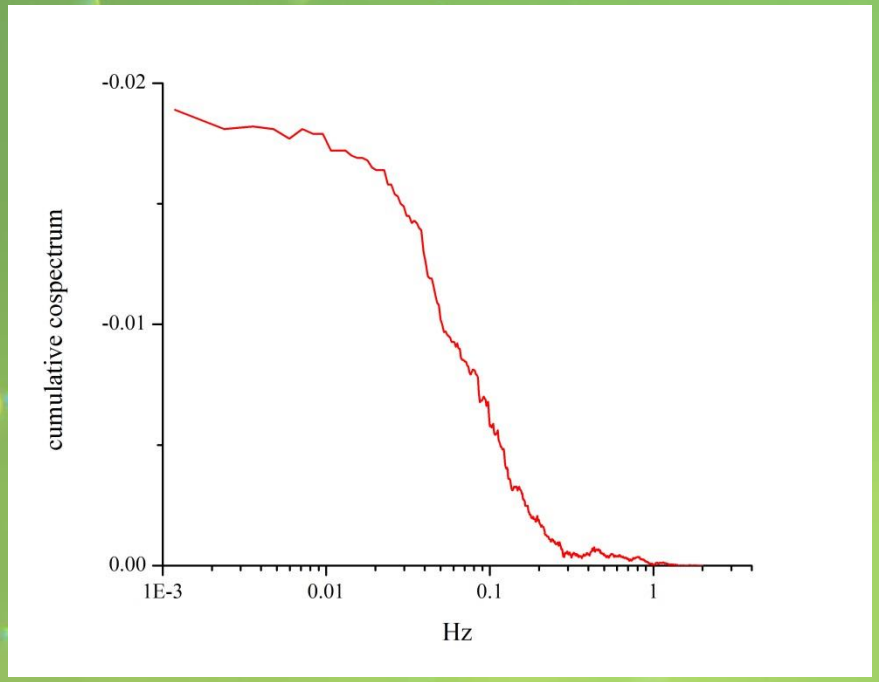


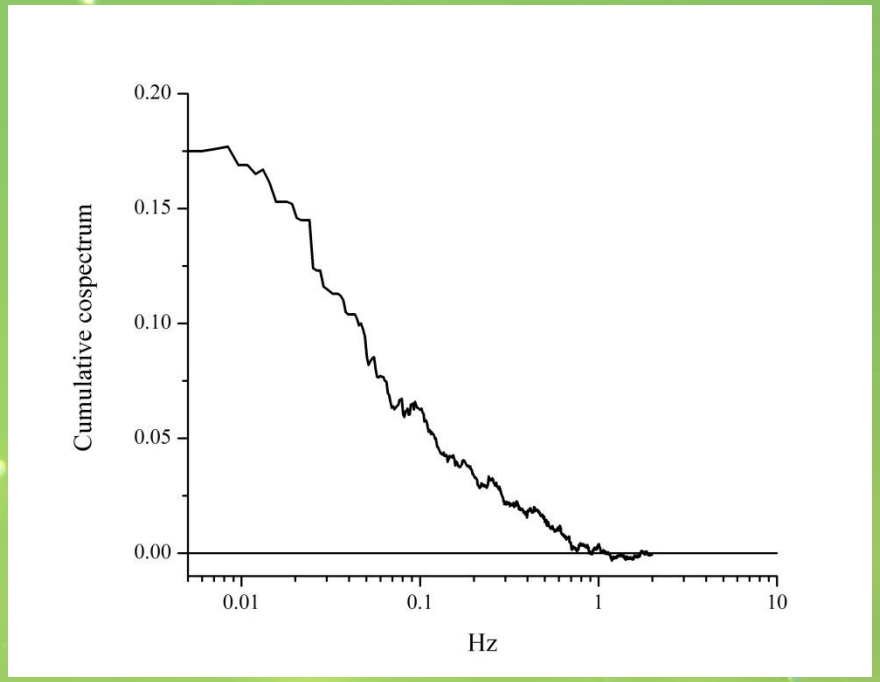



# Optode performance



# Optode performance



# Current/future work: measurements in the S. Platte River

Goals: to examine spatial variation and effects of increased labile carbon on oxygen flux in the river

# Conclusions

- Oxygen fluxes are dynamic in coastal environments where they are influenced by light, wave action, and flow
- Optical sensors are suitable for fast measurements and resolution
- Shallow rivers present challenging environments for EC measurements; resolving spatial heterogeneity may be important

# Questions?

lindsay.chipman@colorado.edu

Thanks to: William Lewis, James McCutchan, John Crimaldi, Markus Huettel, Peter Berg, Chiu Cheng, Mike Santema, Thomas Detmer, Jennifer Robison, Arian Maggart, Ryno DeVilliers, Marion Loubiere, CIRES postdoctoral fellowship