Circulation, Temperature and Dissolved Oxygen in Lake Erie

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Objectives of Field Experiments (2004 & 05)

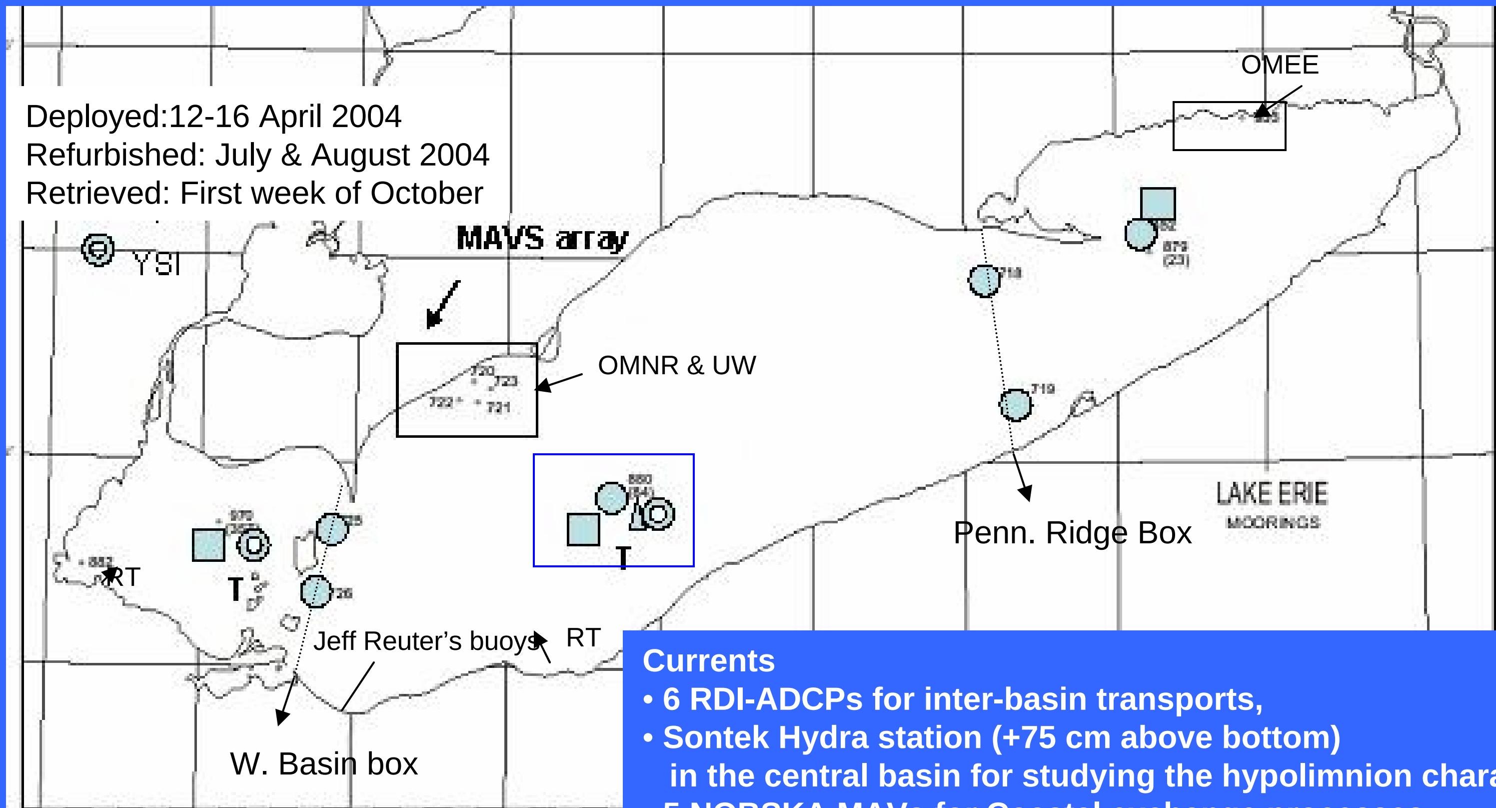
Provide hydrodynamic and temperature observations required to assess/predict changes in water quality

- **Data base for calibration and verification of hydrodynamic and water quality models**

Physical Processes for nutrient status, hypoxia in the lake

- **Circulation, horizontal and vertical mixing**
- **Estimate water and nutrient residence times**
- **Estimate Inter basin transports on daily scale for model input**
- **Estimate onshore-offshore exchanges during summer episodic events (upwelling) along the north shore of the central basin**

Experimental Set-up (2004)



Currents
- **6 RDI-ADCPs for inter-basin transports,**
- **Sontek Hydra station (+75 cm above bottom) in the central basin for studying the hypolimnion characteristics.**
- **5 NOBSKA MAVs for Coastal exchange processes**

Temperature

Thermistor chain moorings near all ADCP and Met stations.

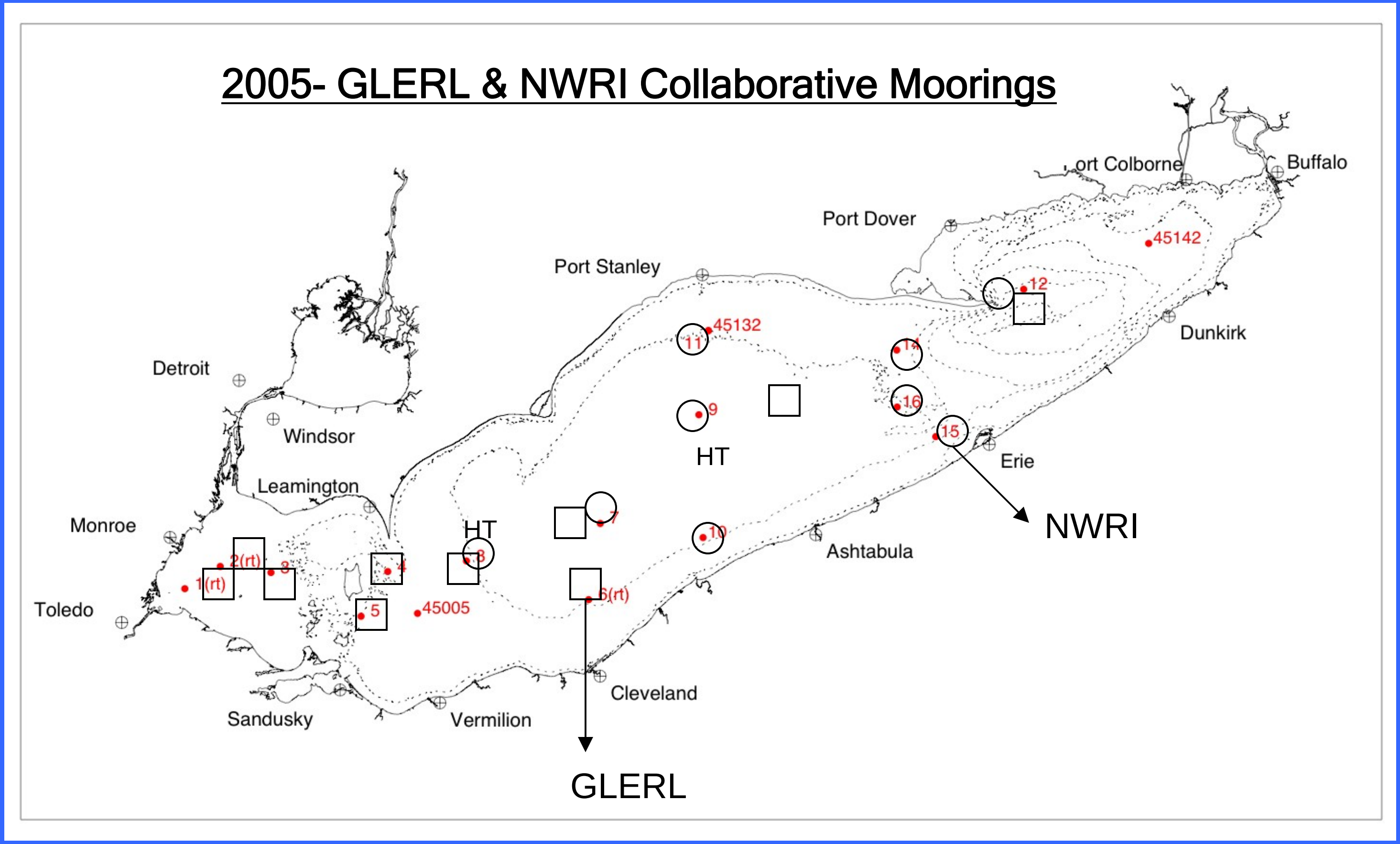
Meteorology

3 Meteorological buoys in three basins with Radiation sensors

Water Quality

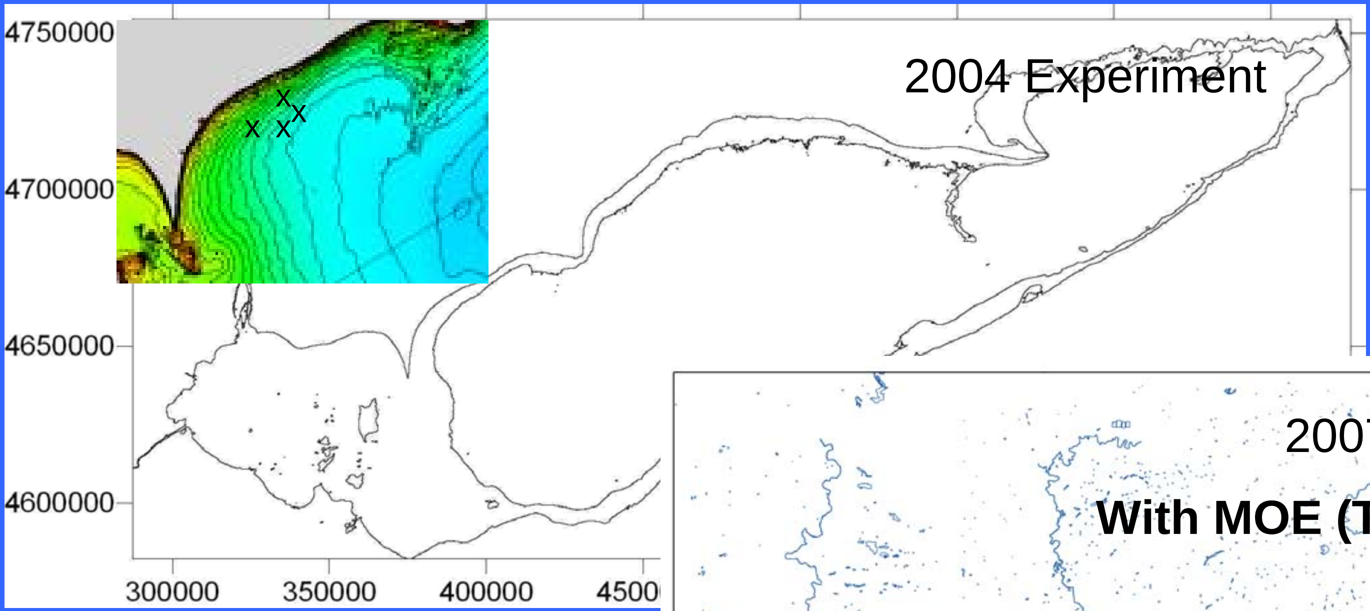
2 Stations with transmissometers at two depths
3 YSI 6600 (2 in the central basin)
Hydrolab stations in the western basin

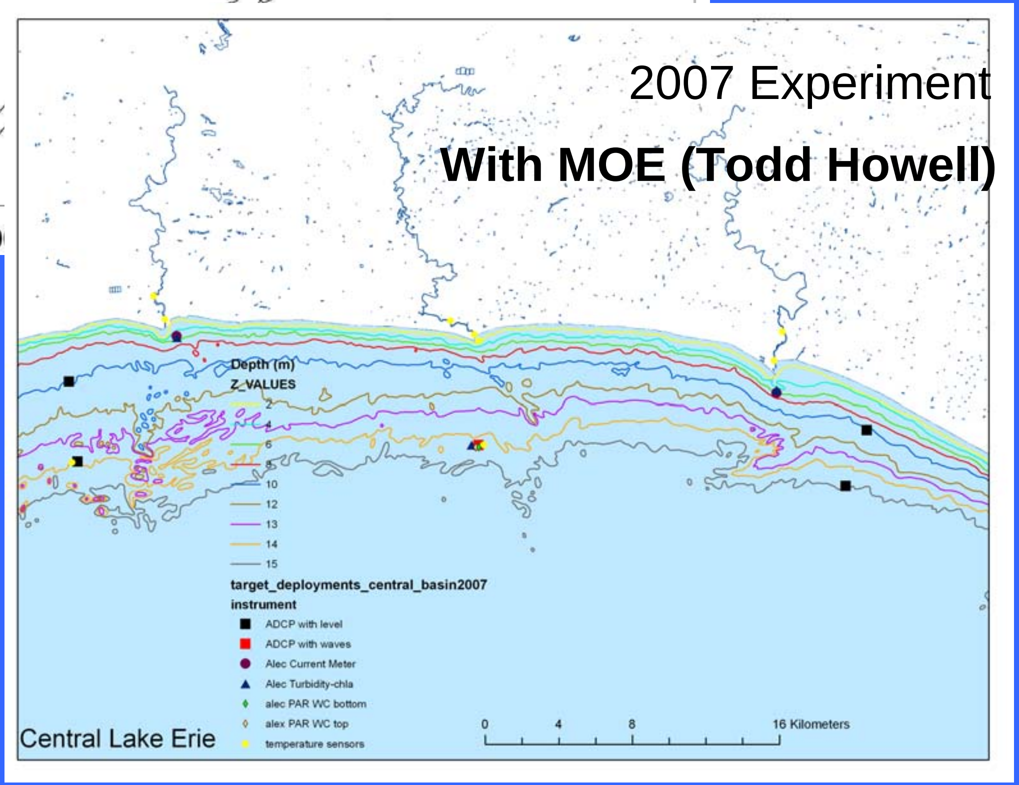
International Field Year on Lake Erie

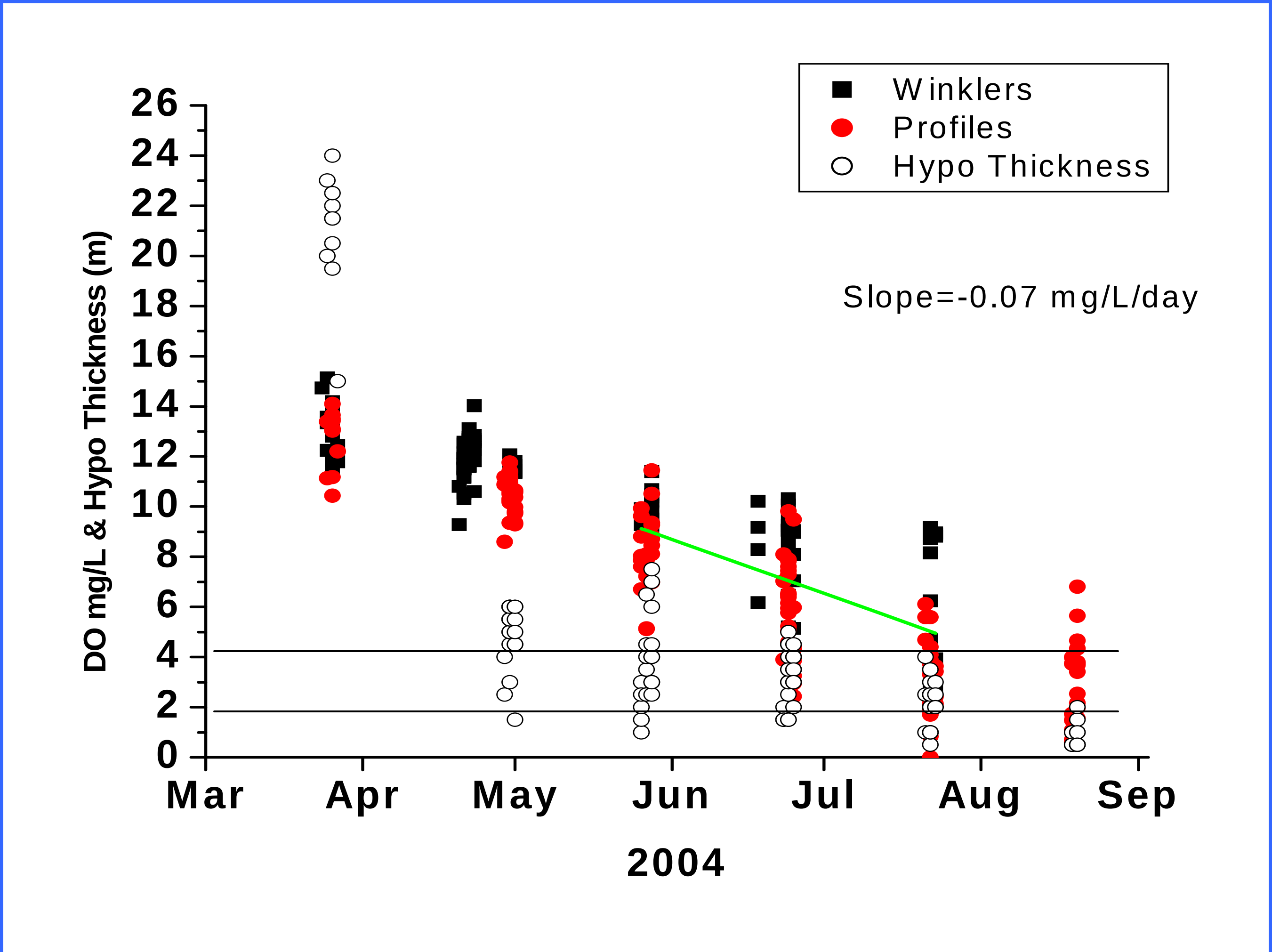


- More Coverage of instruments & water sampling
- Maintained interbasin transport moorings & High frequency temperature

Nearshore/Offshore Exchanges

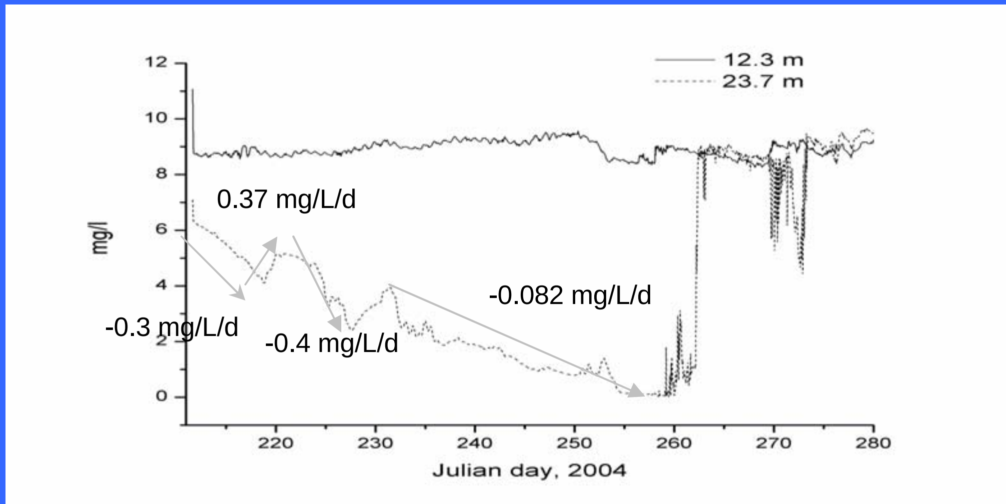






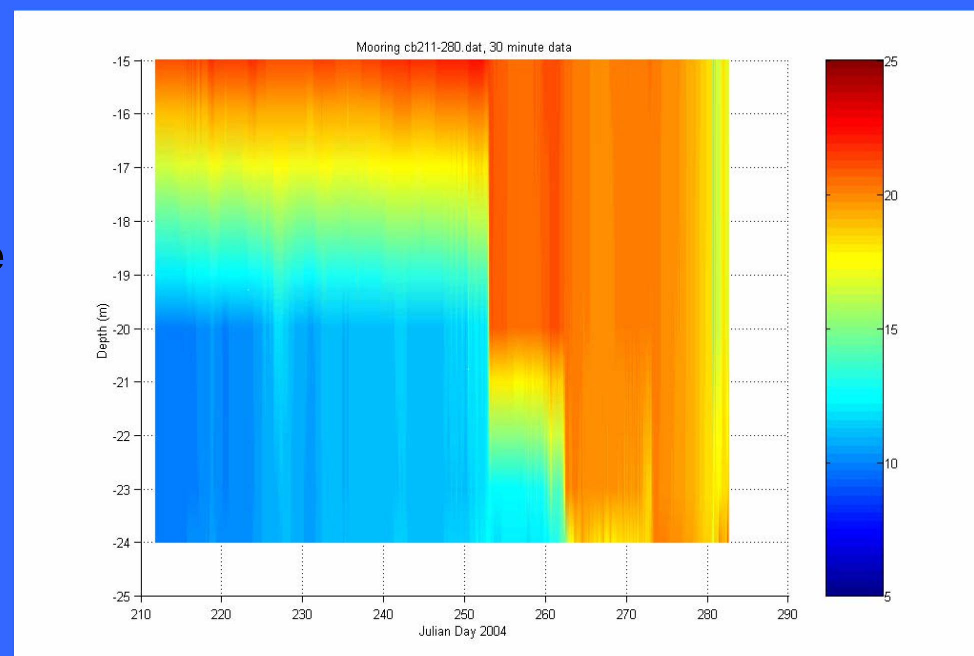
1. The linear slope shows a depletion of 0.07 mg/L/d.
2. Some stations show anoxic conditions from mid-July to the middle of August.
3. Relation between low hypo volume and DO

Temporal Variability of DO & Stratification (2004)

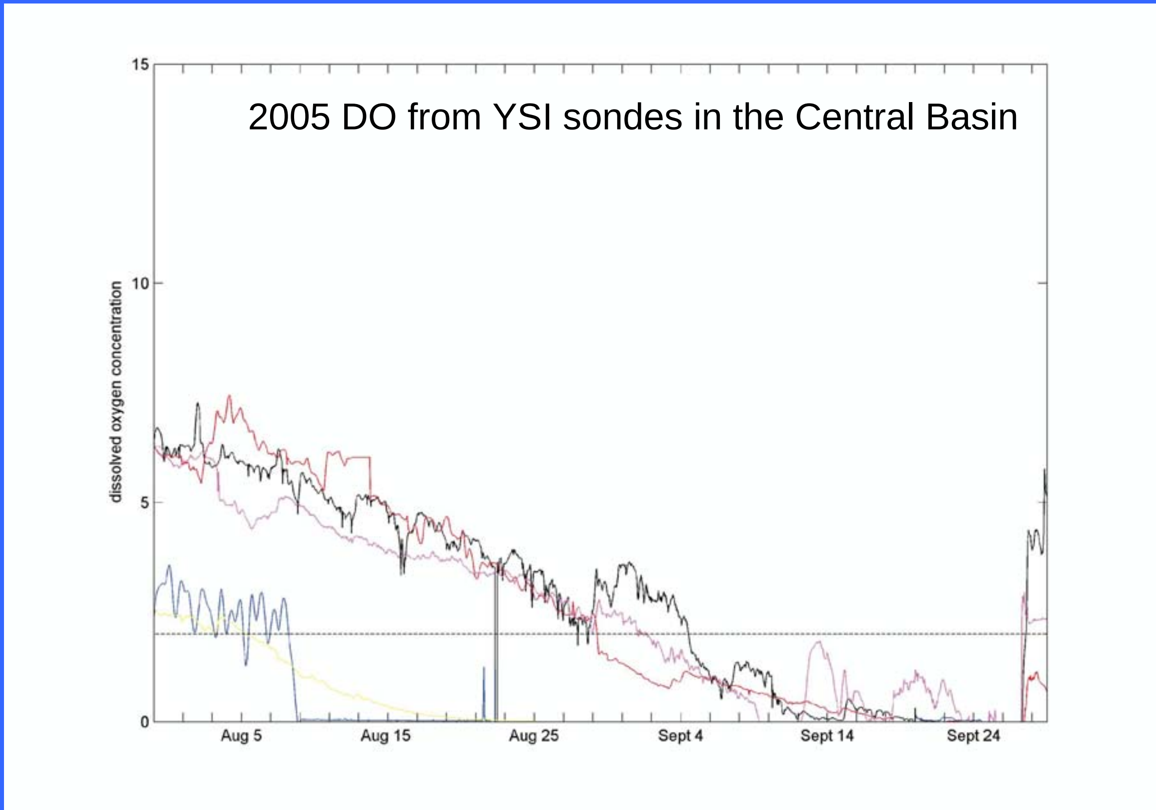


- ➢**Effects of physical processes on DO**
- ➢**Differences from time series and ship**

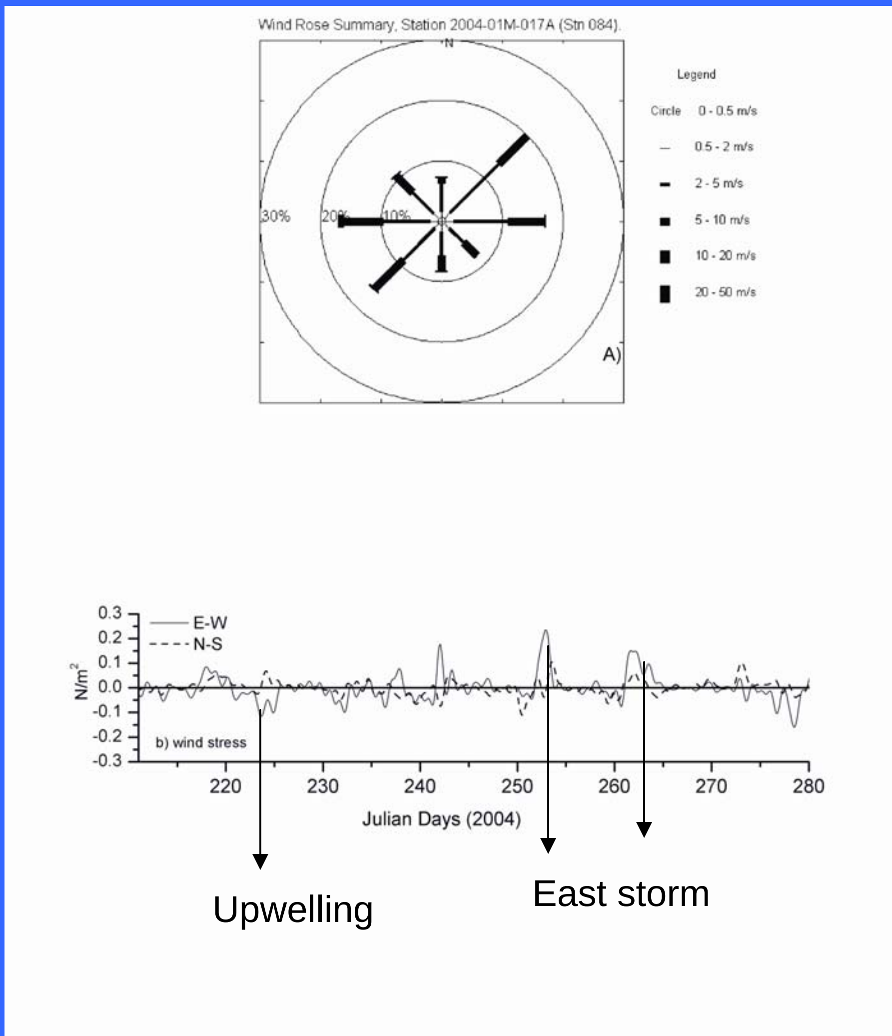
- •**Stratification started from middle of June**
- •**Hypolimnion Volume and DO**

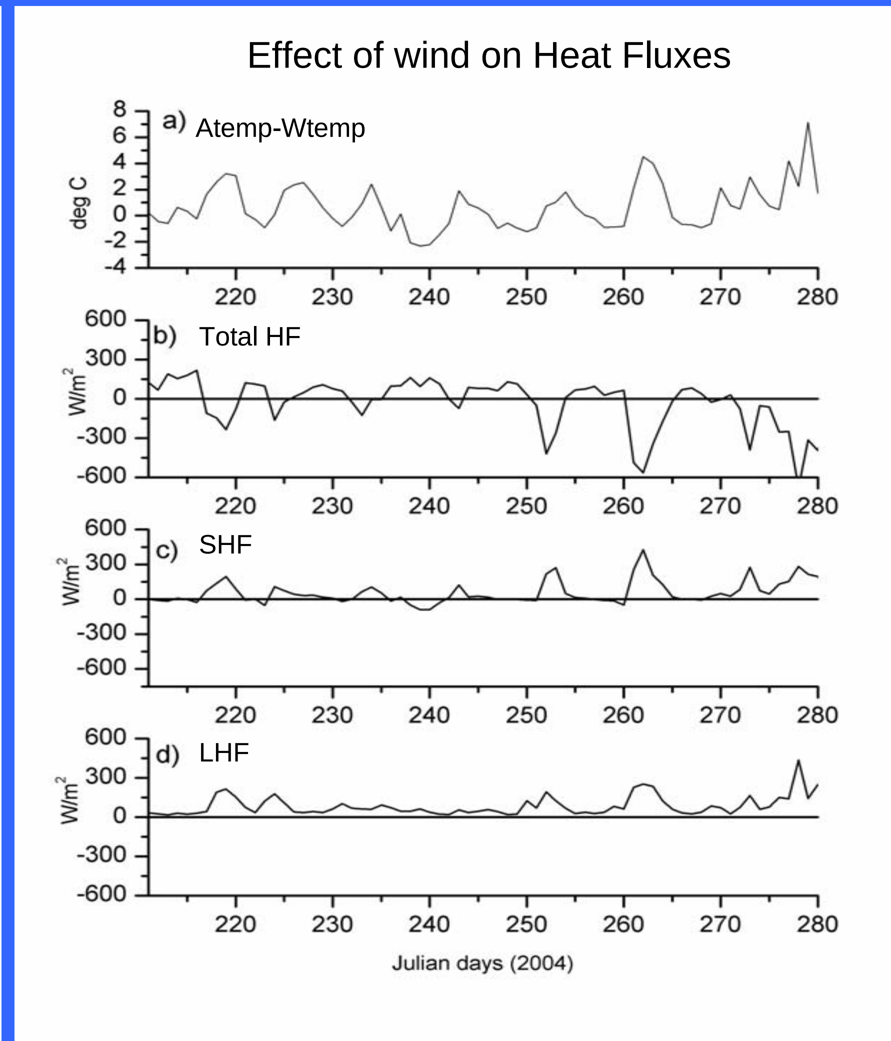


Similar Variability in 2005

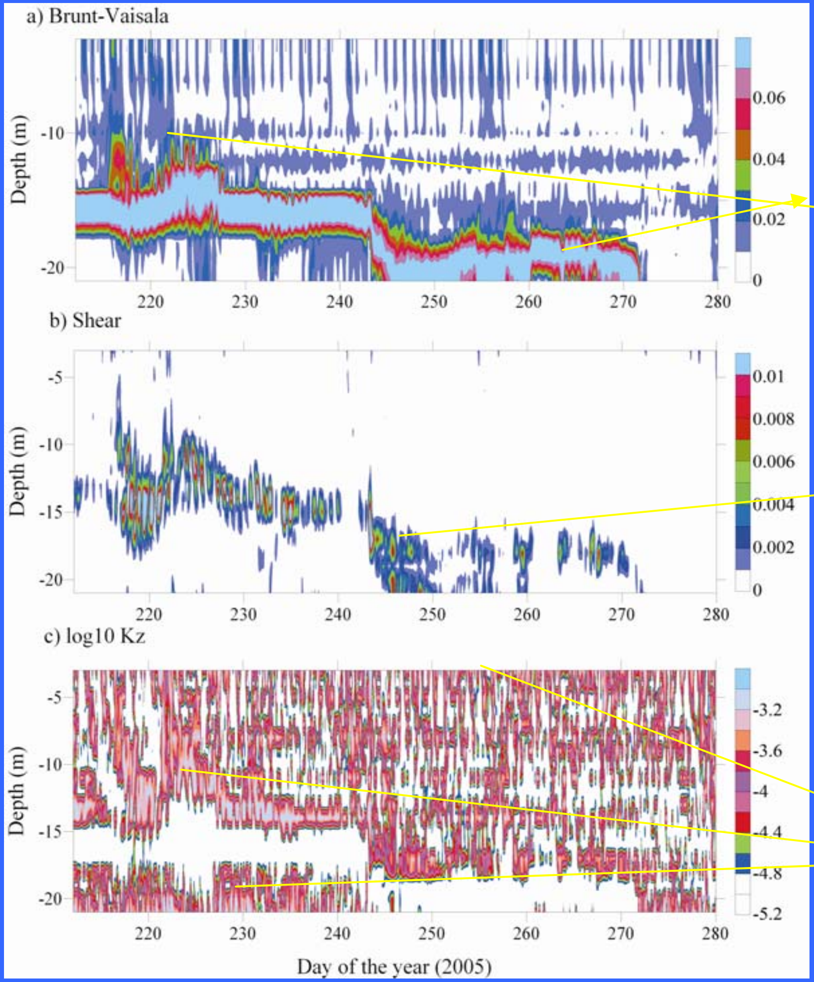


Influence of Meteorology (Central Basin buoy)





Influence of Vertical Mixing on Hypoxia



Strong stability in the thermocline
Secondary thermoclines?

Inertial shear

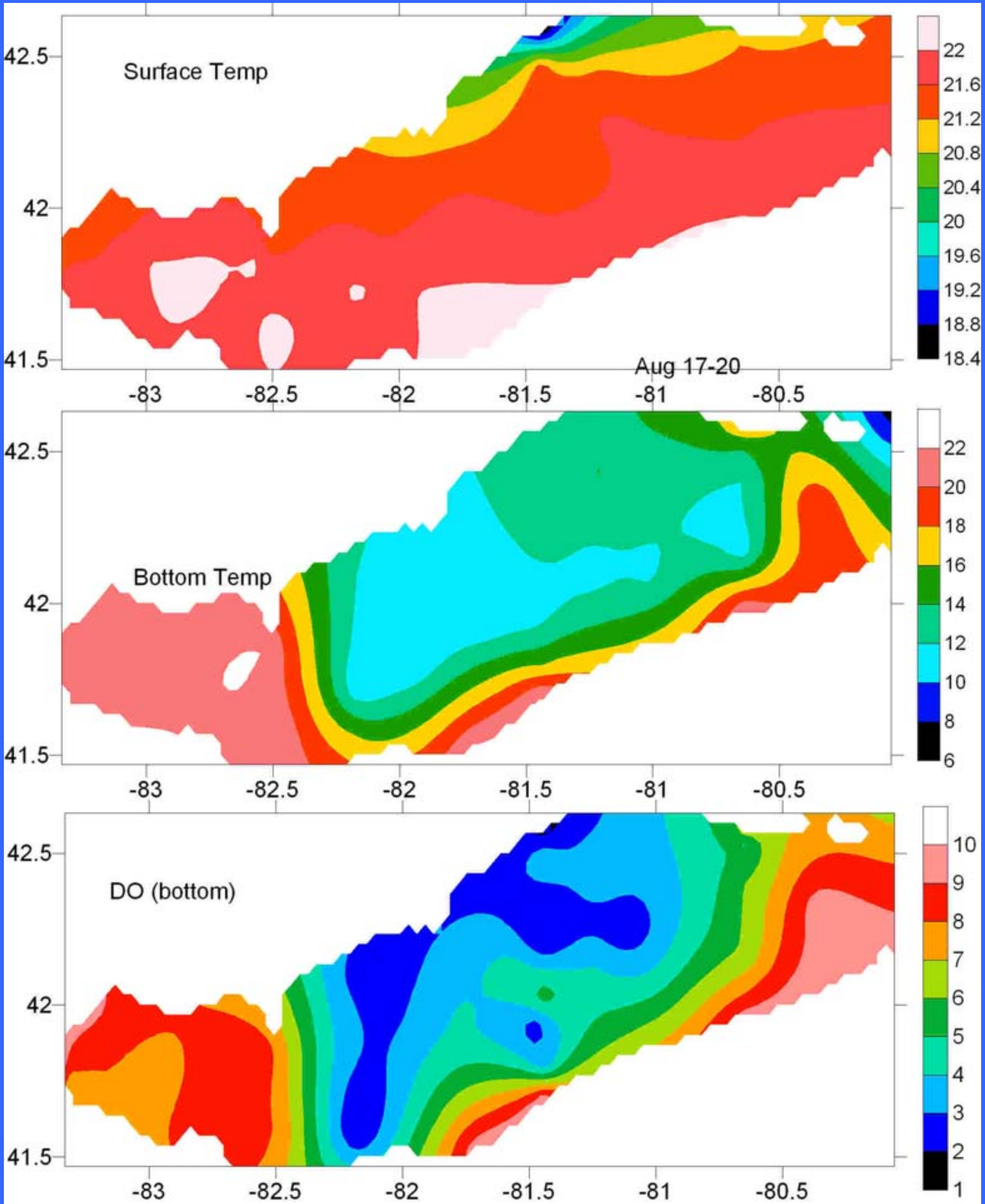
K_z varied from .1 to 8 cm^2/s

Higher K_z (surface, bottom and above thermocline

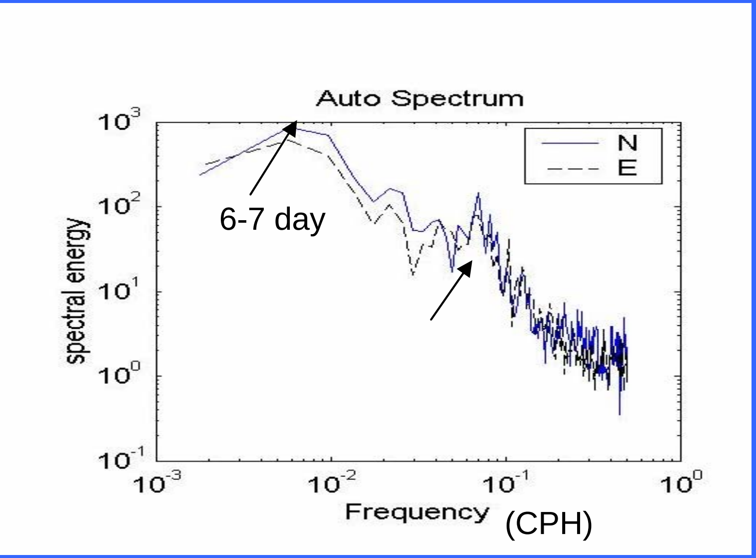
- **Persistence of strong N2**
- **Kz < 1 cm2 s-1**
- **This doesn't explain all**

Summer Episodic Events and DO

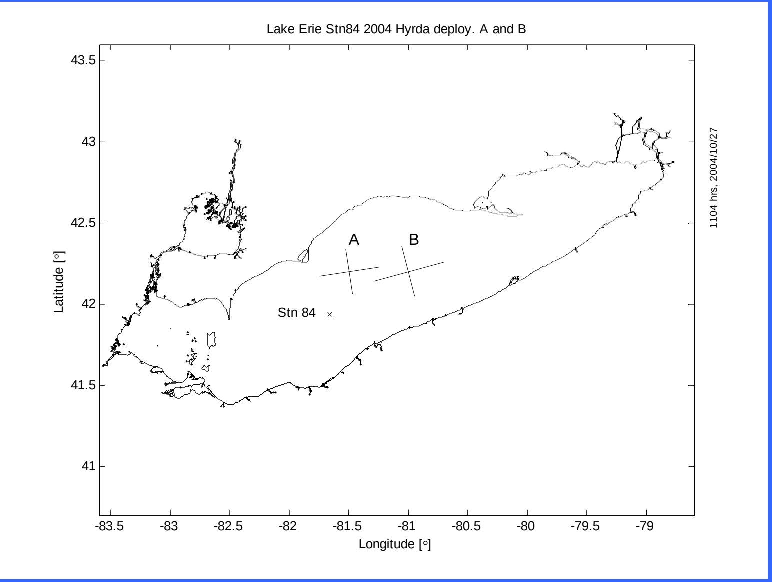
Westerly winds forced upwelling



Meteorological forcing influences currents/mixing

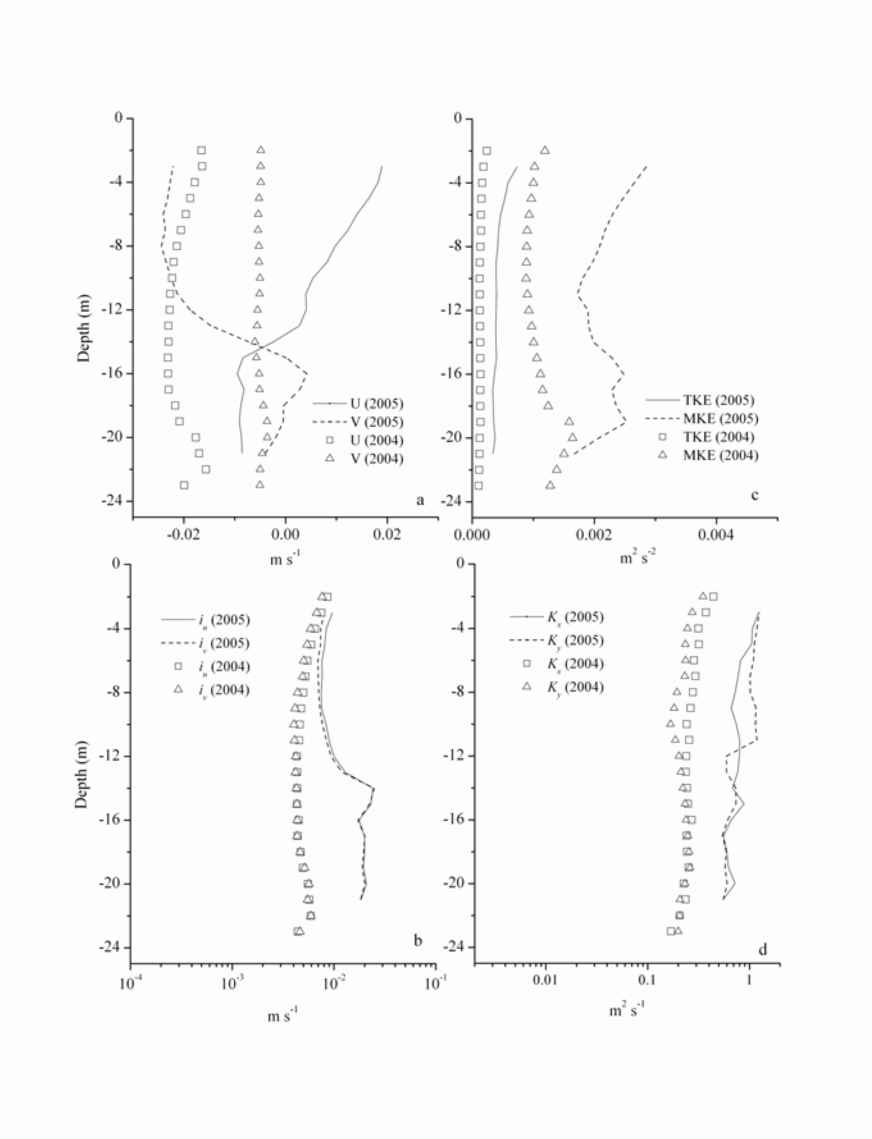


Surface currents are in the order of 20-30 cm/s



Bottom currents are as high as 8-10 cm/s

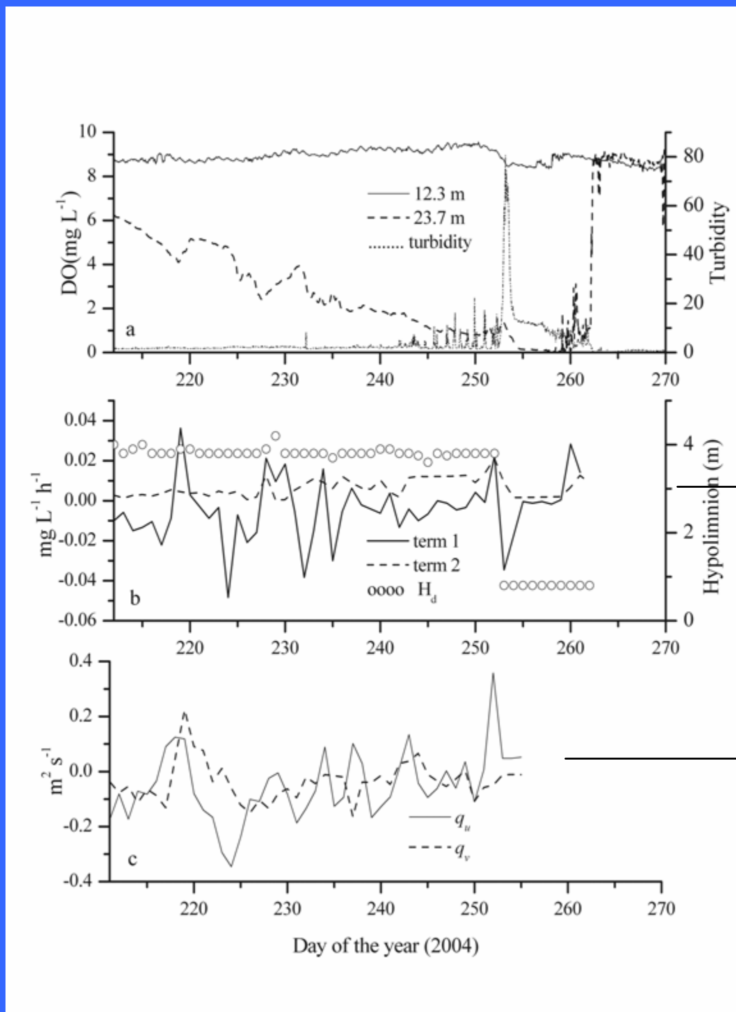
Horizontal Exchanges in the Central basin



- Difference between the years
- Shear in the u comp is because of inertial oscillations

- Horizontal exchange (0.5 m^2/s at the surface to 0.25 m^2/s at bottom)

Dissolved Oxygen Balance in the Hypolimnion



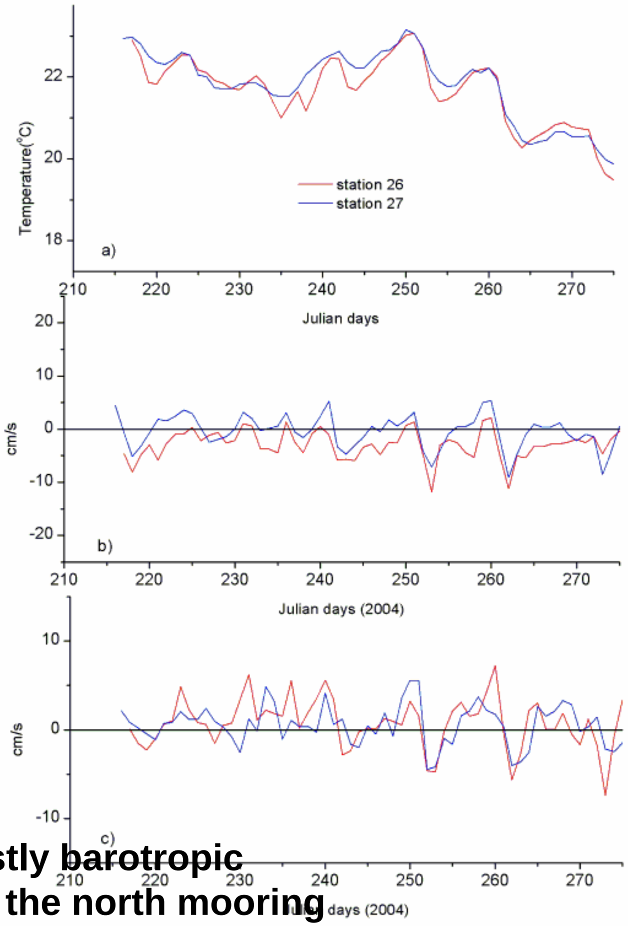
$$\frac{dO_h}{dt} = \frac{K_z}{H_d}\left(\frac{O_e - O_h}{\Delta z}\right) - \left(SOD + P - R\right)$$

Vertical Mixing + low hypolimnion vol
+ typical SOD do not balance DO variability

Horizontal Transport is also important

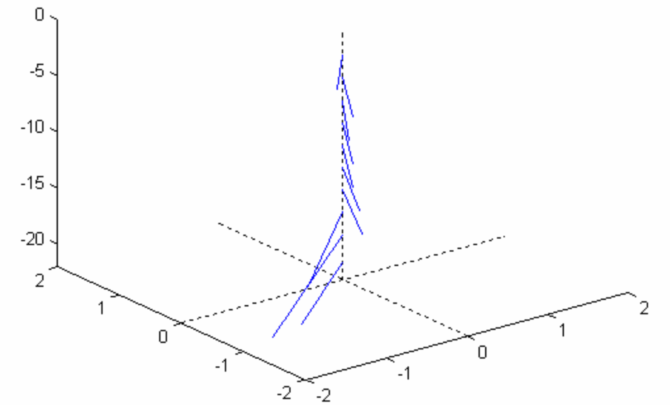
Inter-basin Exchange flows

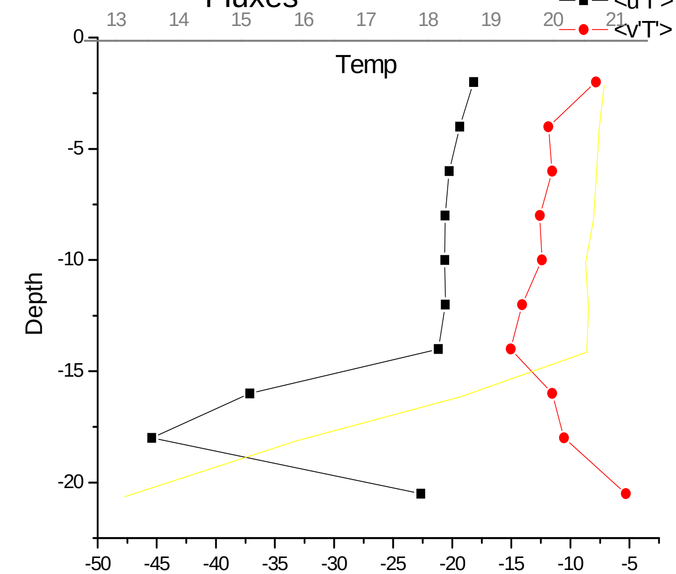
West-Central



Currents are mostly barotropic
Mean currents at the north mooring is equivalent of Major inflow

Mean currents @ Penn. Channel





Difference in thermocline level between the CB & EB

EC-University (NSERC-SPG) Collaborative Study 2008 - 2009

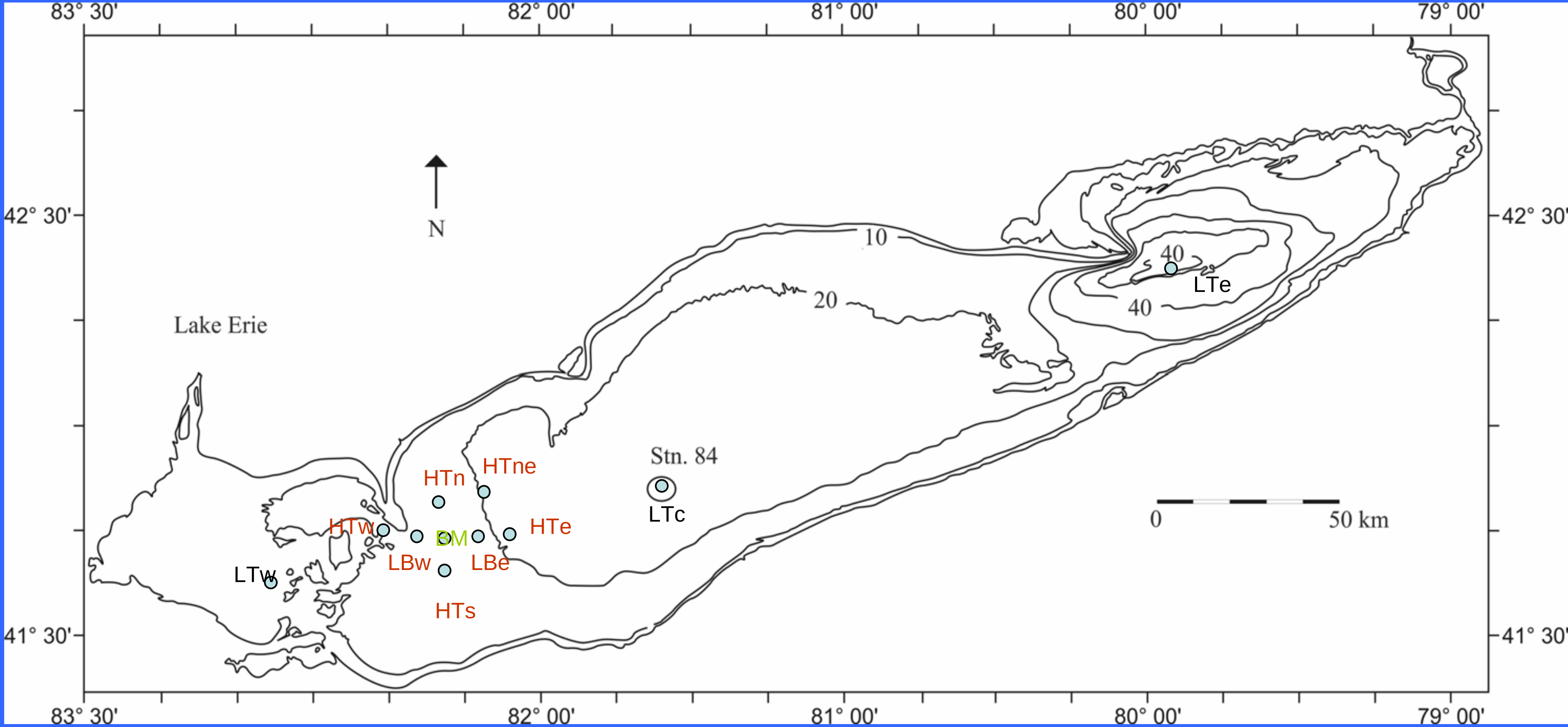
NSERC SPG (Kevin Lamb/ U Waterloo- PI, Ralph Smith- U Waterloo, Joe Ackerman- U Guelph, Leon Boegman- Queens University)

Environment Canada (Ram Yerubandi, Sue Watson, David Lam)

Goals:

1. **Understand the implications of internal wave induced mixing in hypoxia and other biogeochemical processes**
2. **High resolution models require detailed field measurements**
3. **Provide improved understanding on how the nutrients are assimilated from west basin to the central basin (GLWQA & Lake Erie LaMP)**

Lake Erie 2008 Physical & Water Quality Moorings



1. 8 High Frequency thermistor moorings (10 sec @ 1m)
2. 3 Hourly temp mooring
3. Multi-level oxygen/Turbidity moorings at several stations
4. High frequency and hourly current profiles (ADCPs, ADVs)
5. Sediment Traps, Meteorology, Waves
6. Water sampling/ Microstructure profiling

Summary

- Large experiments after 20 years in the lake
- Data analysis & Hydrodynamic and water quality modeling ongoing

Results so far!

- Physical limnology and surface meteorology parameters are analysed
- Physical Processes play a major role in the central basin hypoxia (nothing new!)
- Importance of bottom currents and turbulence measurements
- Estimation of horizontal and vertical mixing
- Interbasin and coastal exchanges
- Basin scale and small scale internal oscillations
- New physical limnology experiments in 2008 & 2009 (Lake Erie Surveillance Year)