

# Sediment transport due to river inflows into large alpine lakes

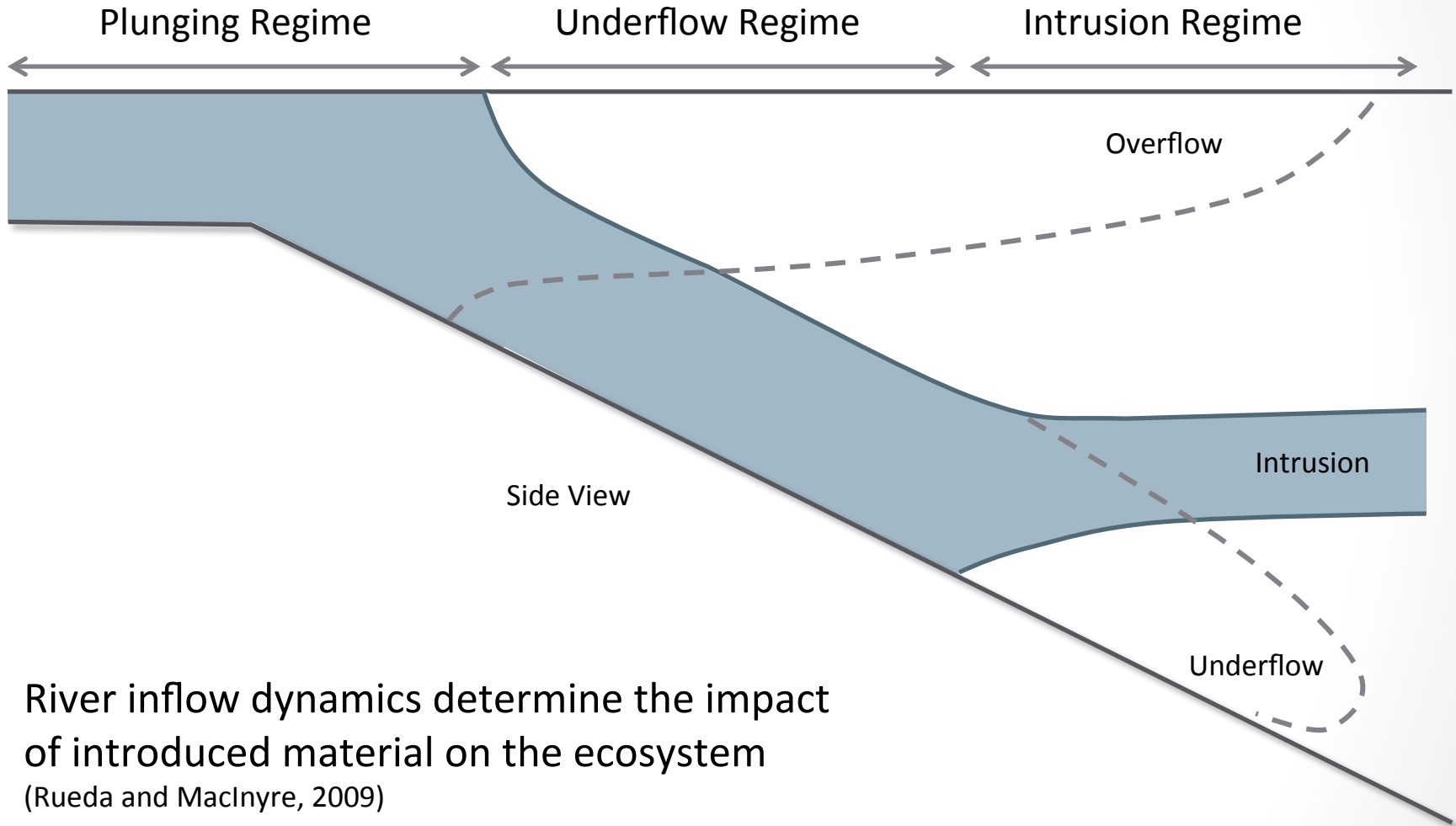
Kara Scheu, Derek Fong, Oliver Fringer, and Stephen Monismith  
Environmental Fluid Dynamics Lab, Stanford University

18 December 2013

Particle-Laden Flows in Nature

Santa Barbara

# Dense river inflows

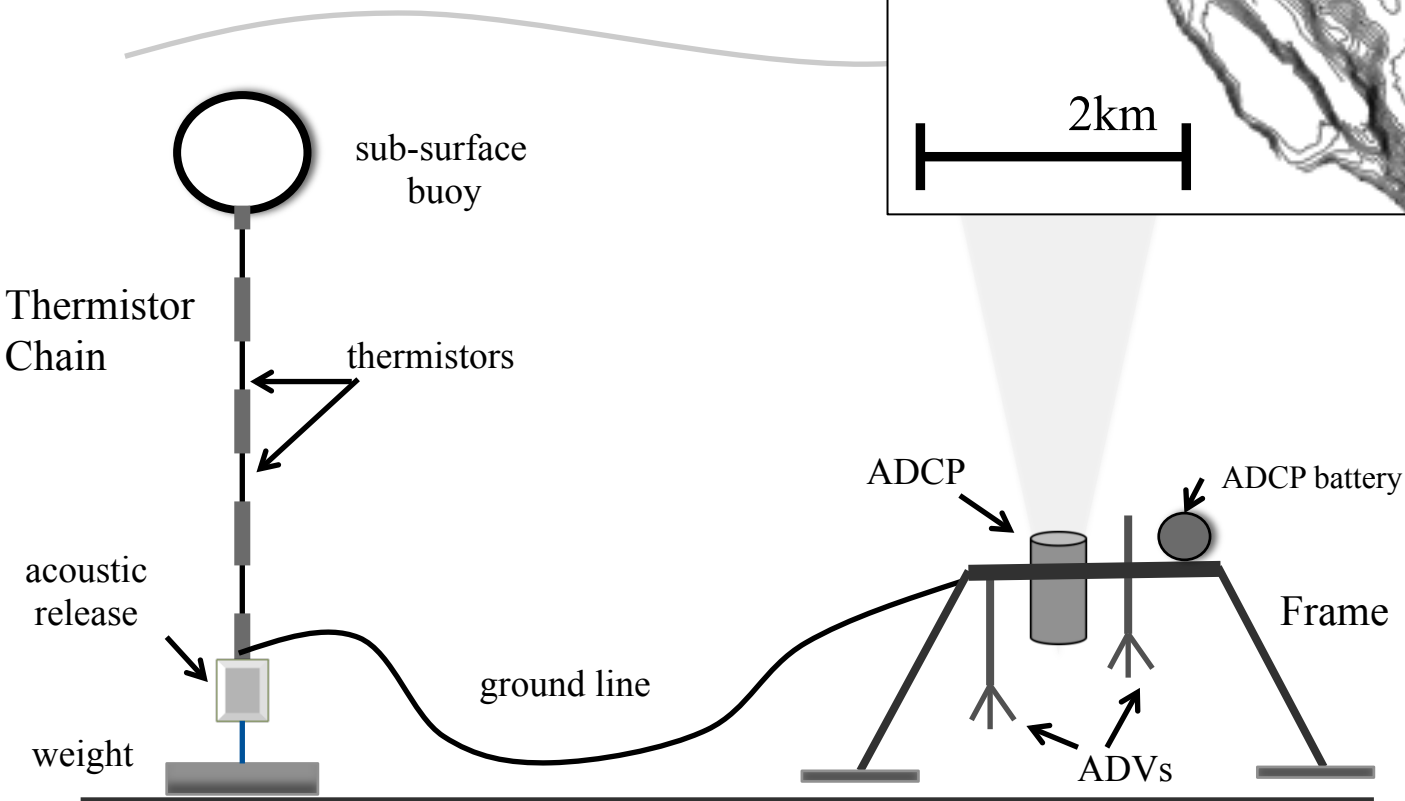
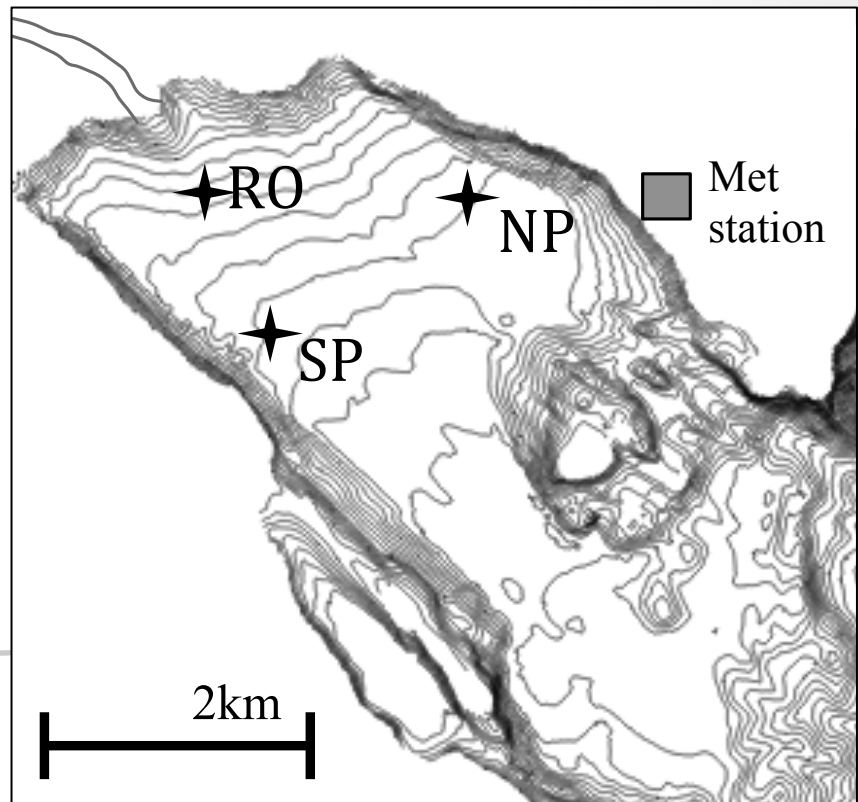


River inflow dynamics determine the impact of introduced material on the ecosystem  
(Rueda and MacInyre, 2009)

# 2012 Field Study

## General Sediment Dynamics

(Oct-Dec)



# Deployment

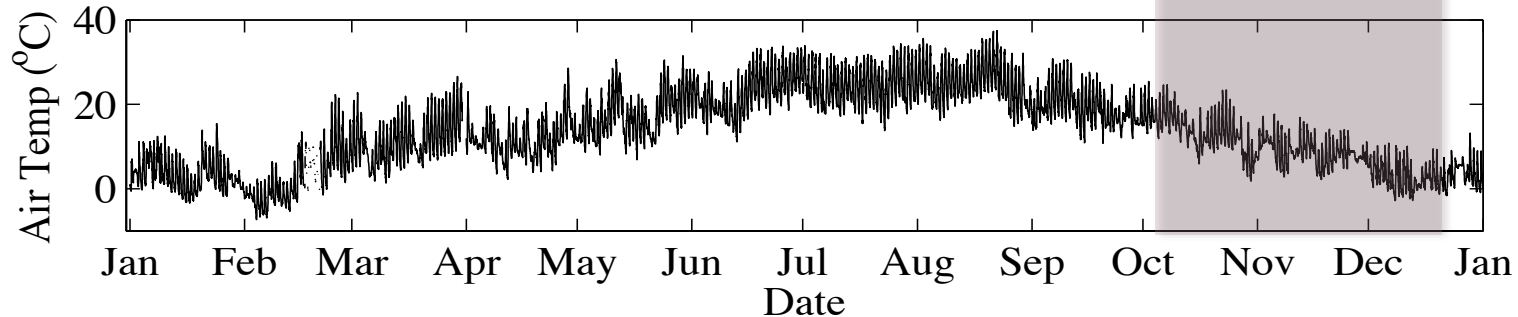
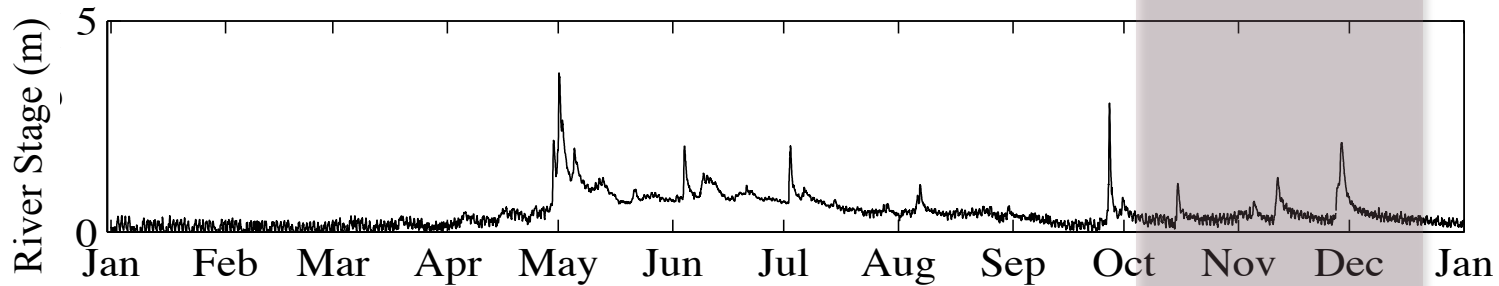
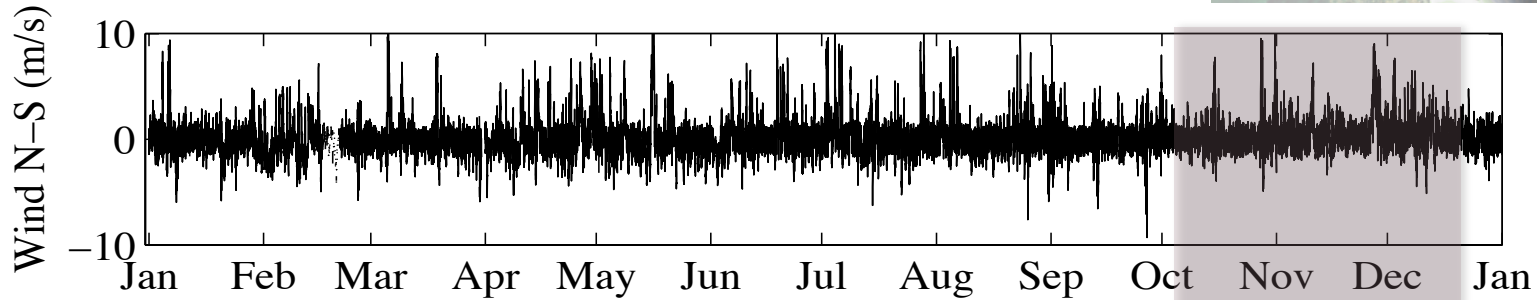
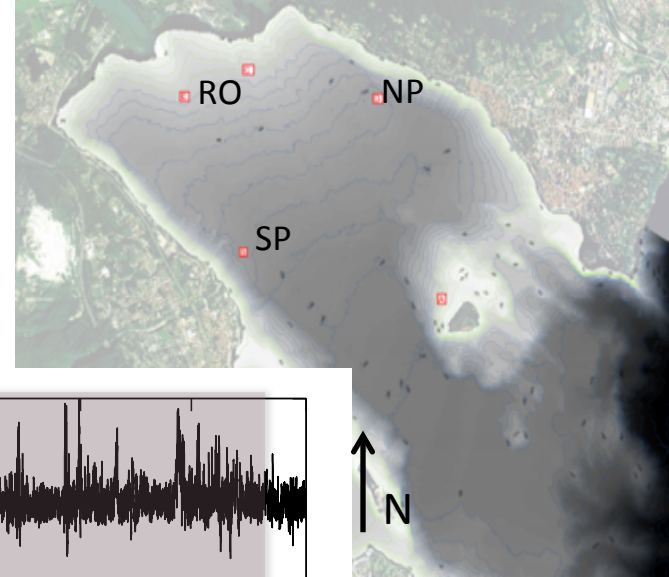




# Retrieval



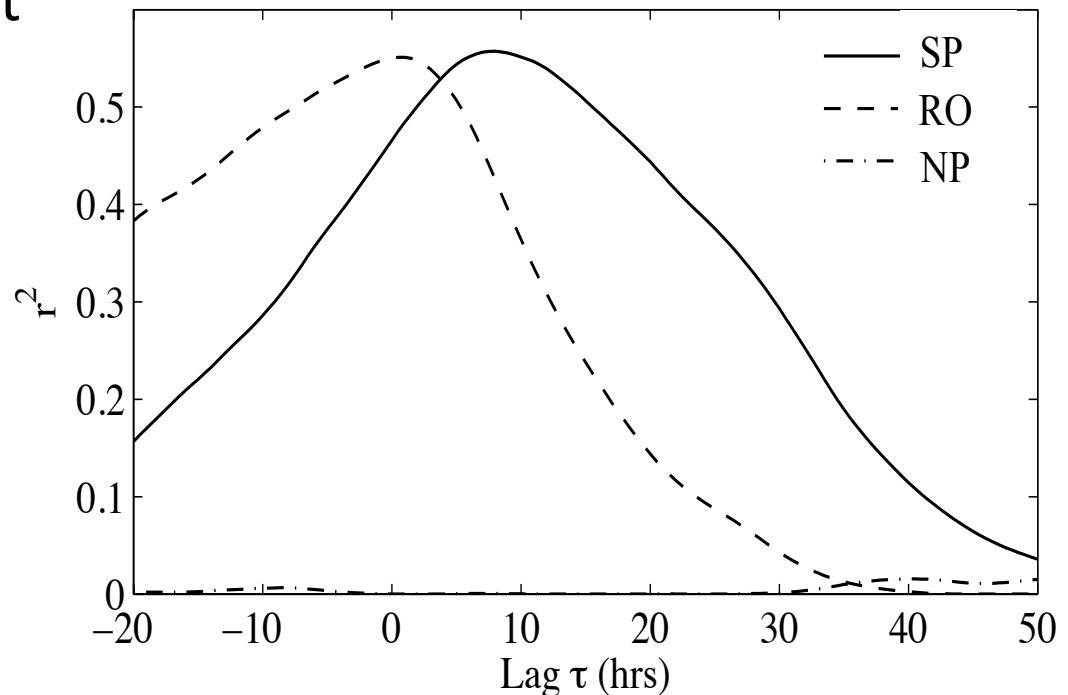
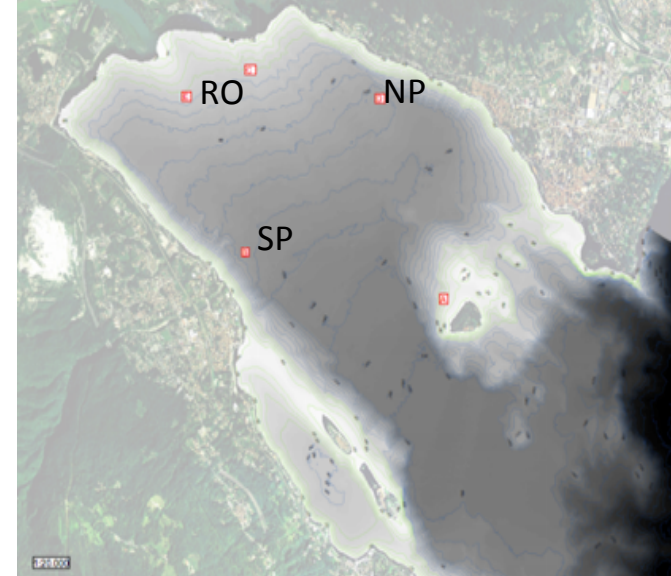
# Meteorological Forcing



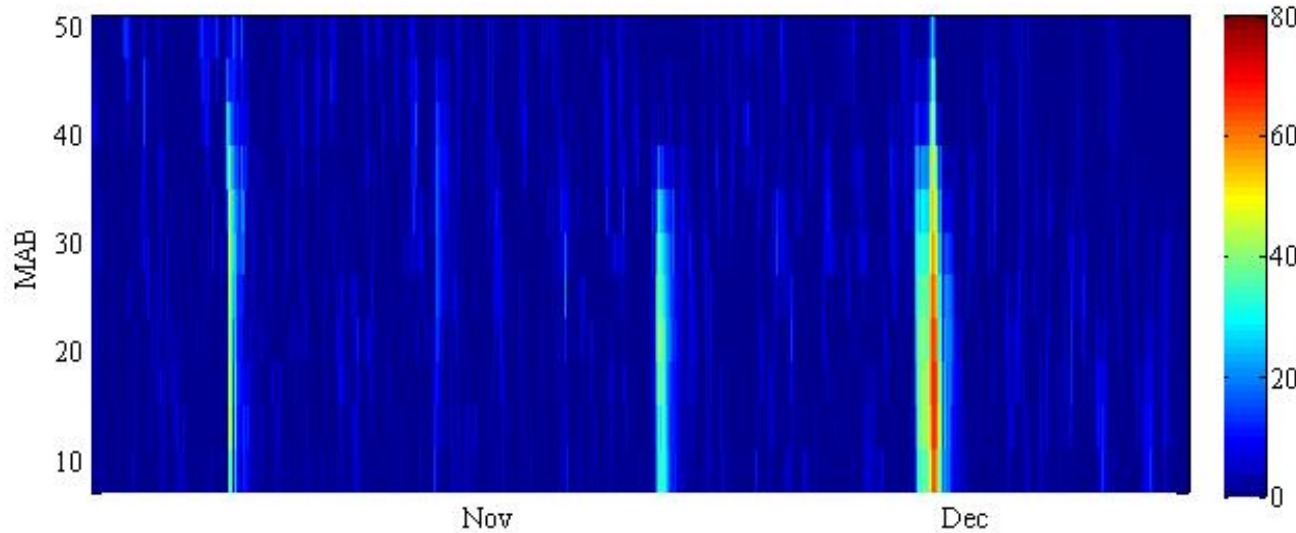
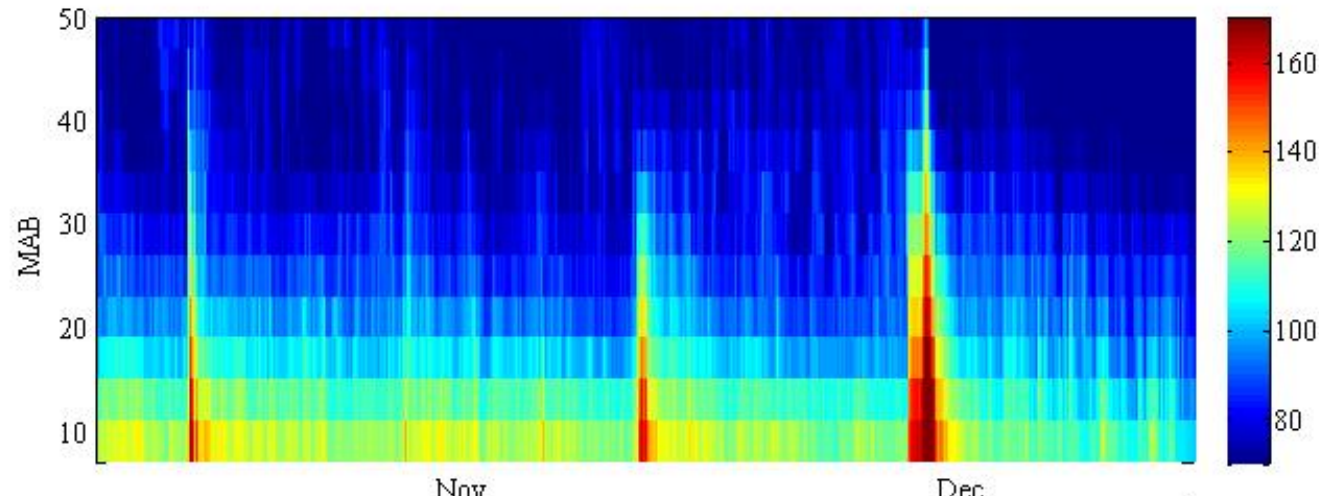
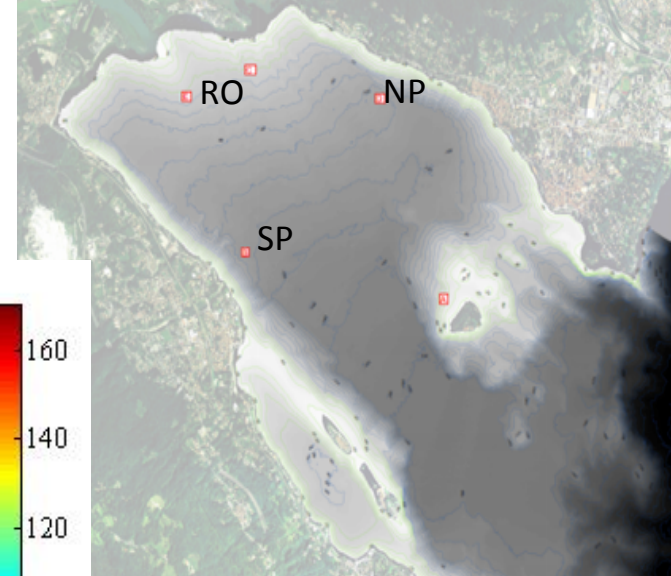


# Depth-averaged correlation

- Lagged correlation between river inflow and depth averaged backscatter intensity at all sites
- Strong correlation between SSC and river inflow



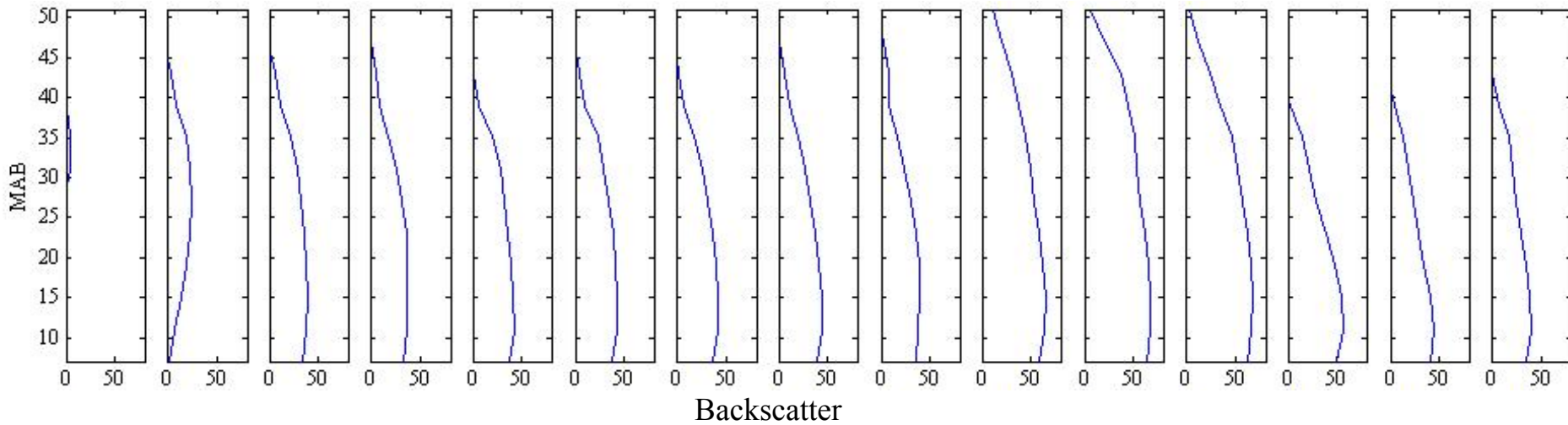
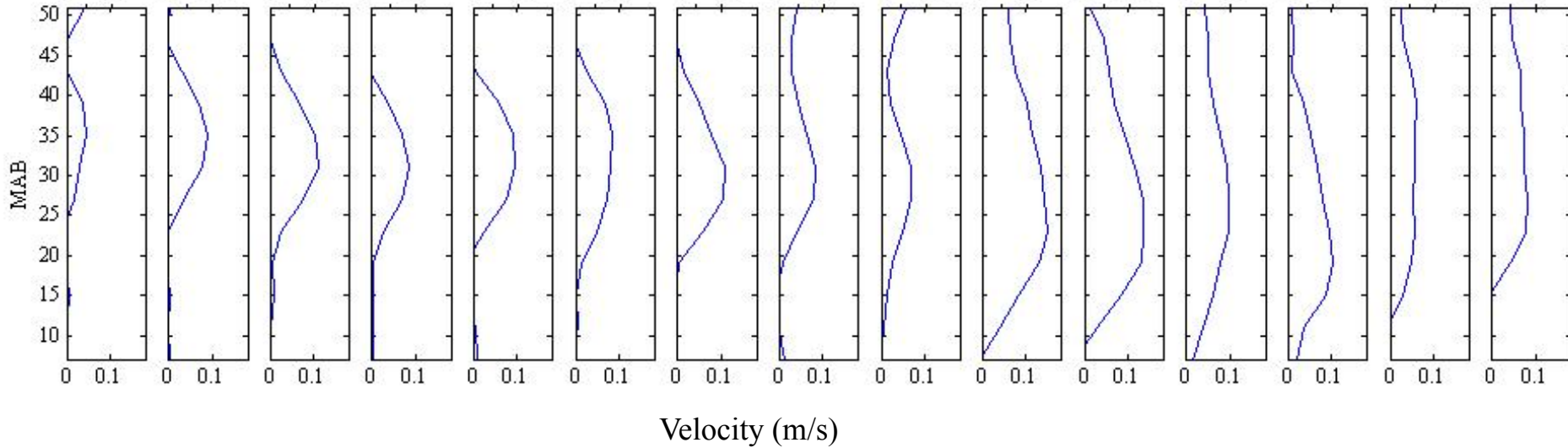
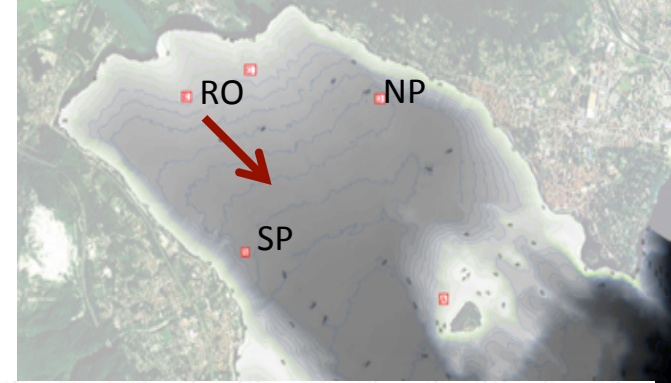
# Depth Variability of SSC



Can account for attenuation of backscatter intensity due to episodic nature of the system

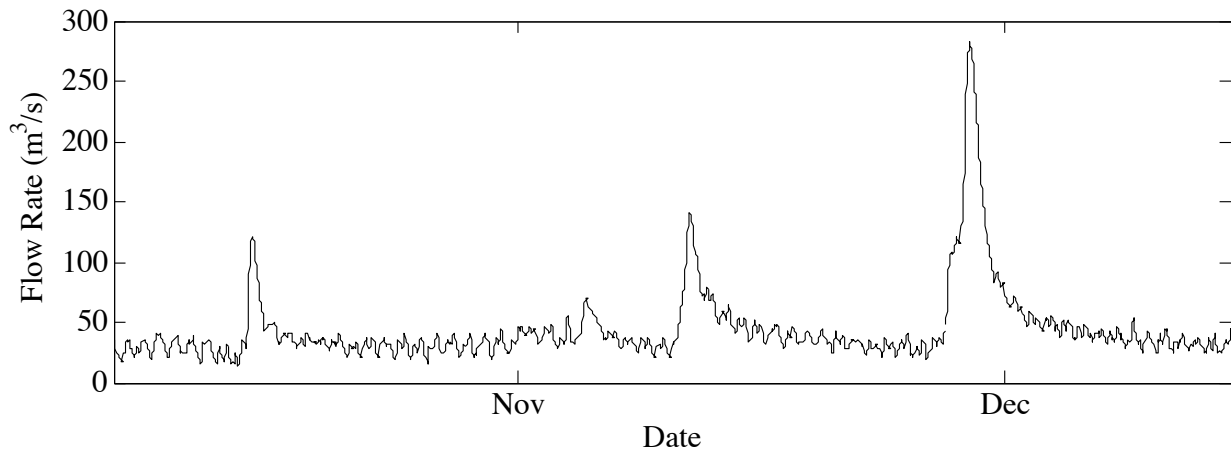
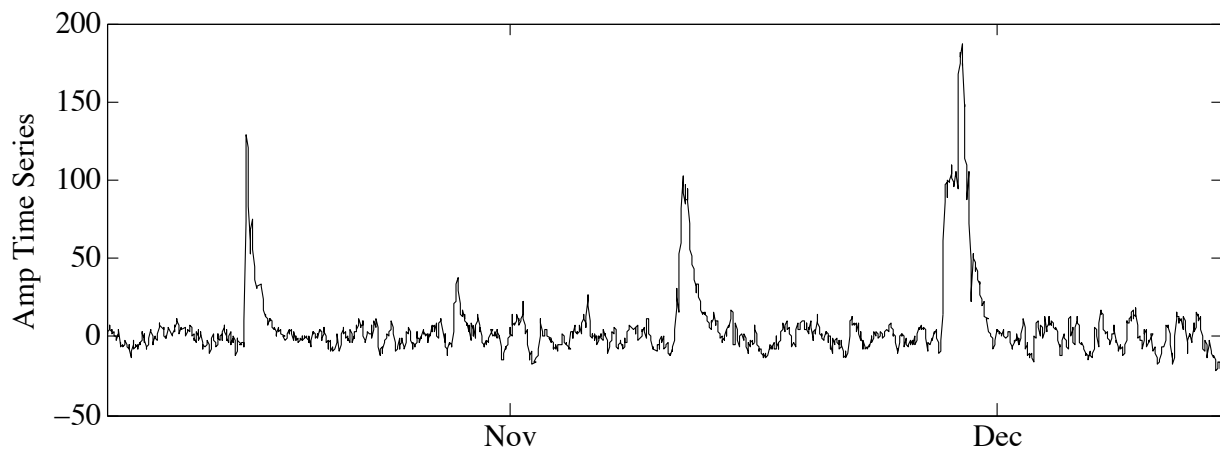
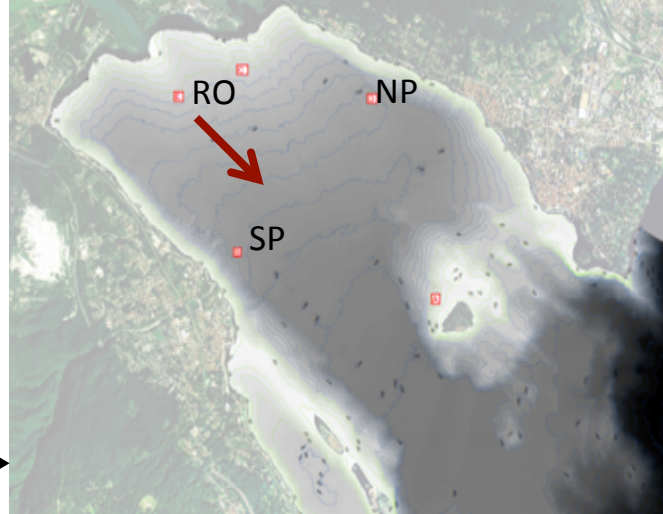
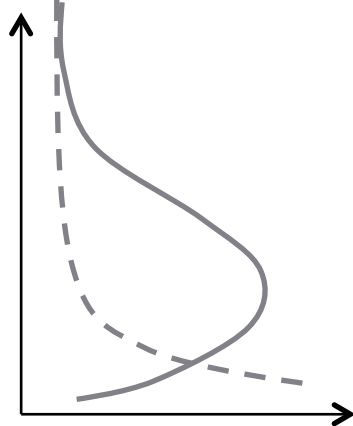
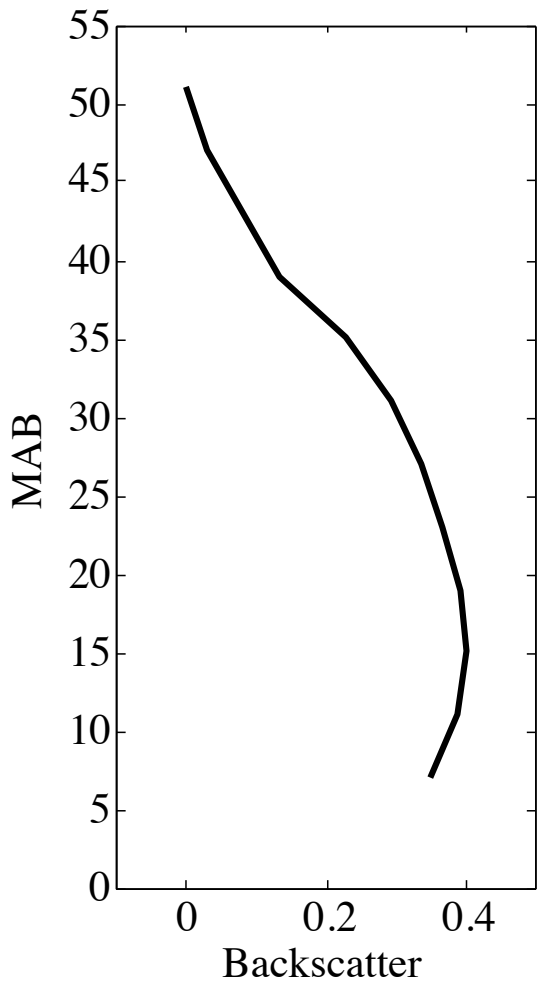


# Depth Variability of SSC

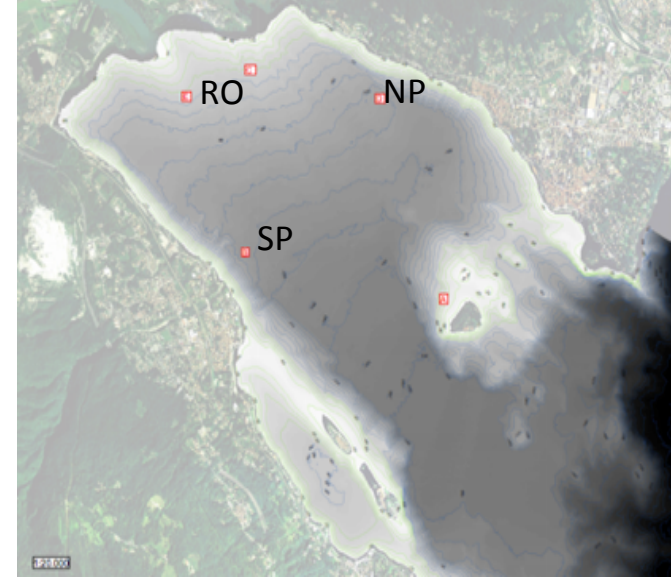


# Depth Variability

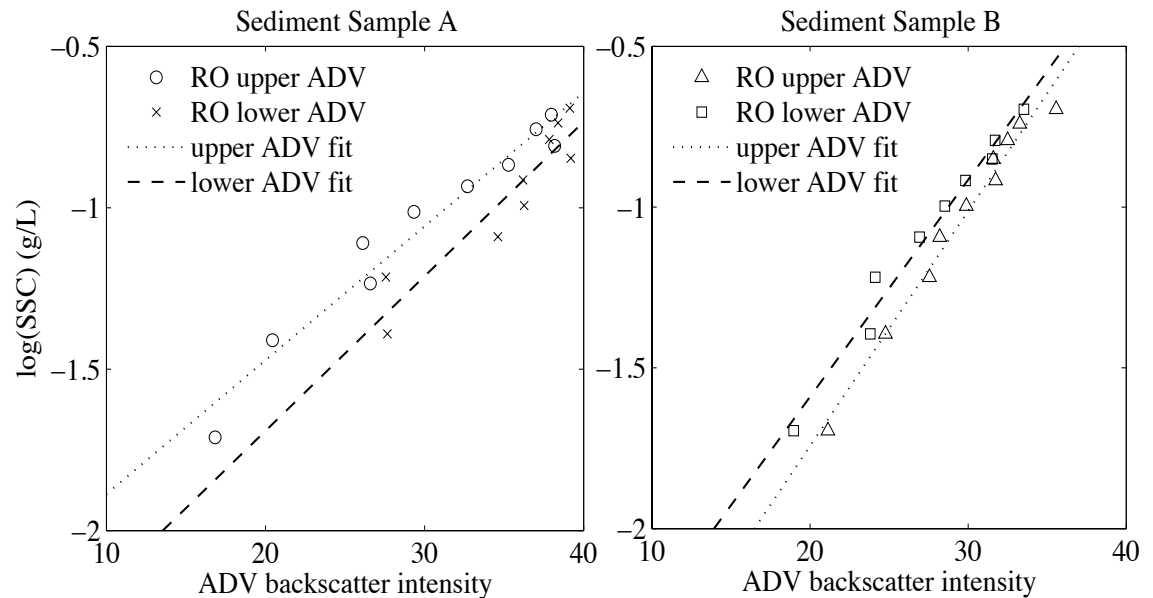
Eigenvector



# ADV calibration



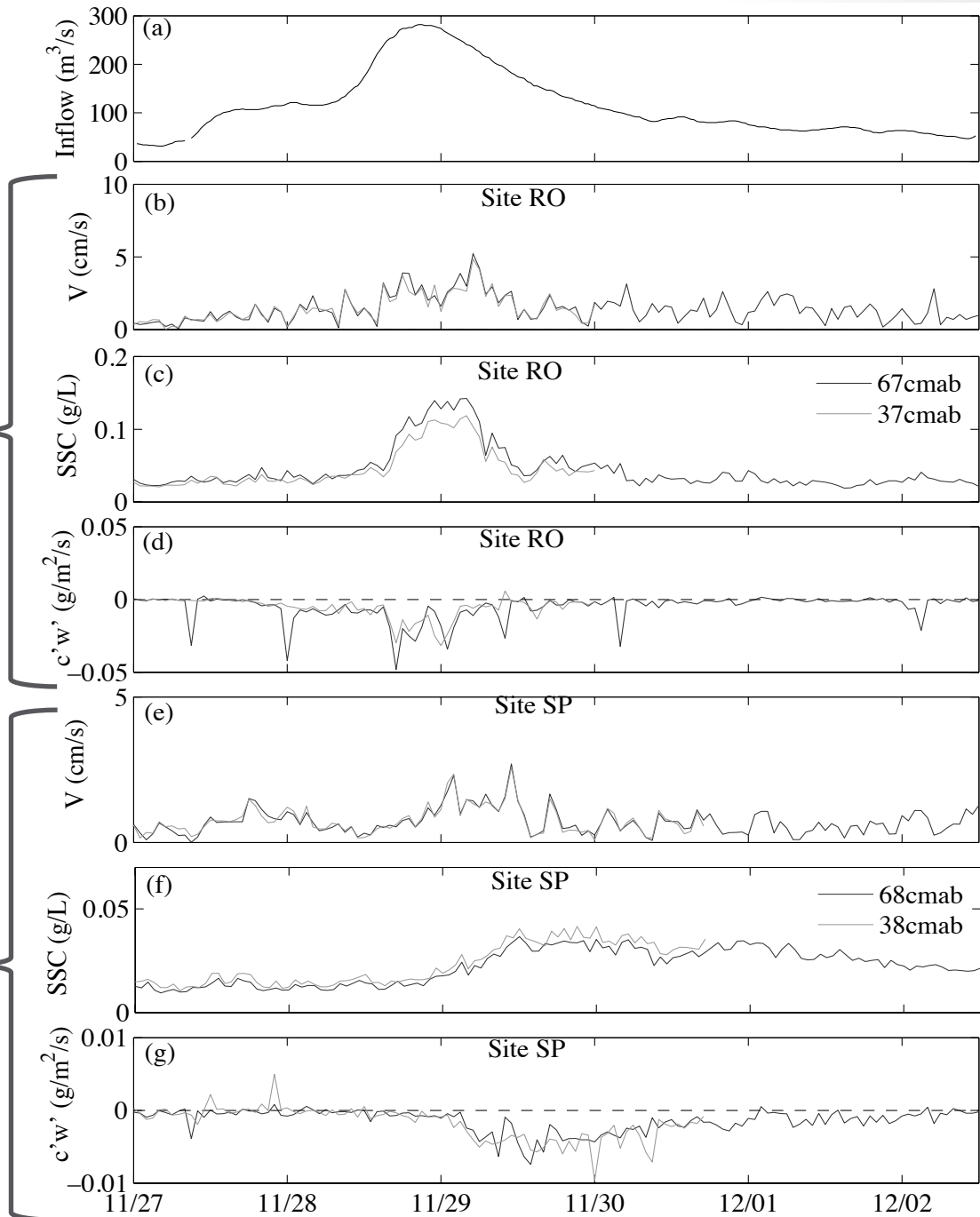
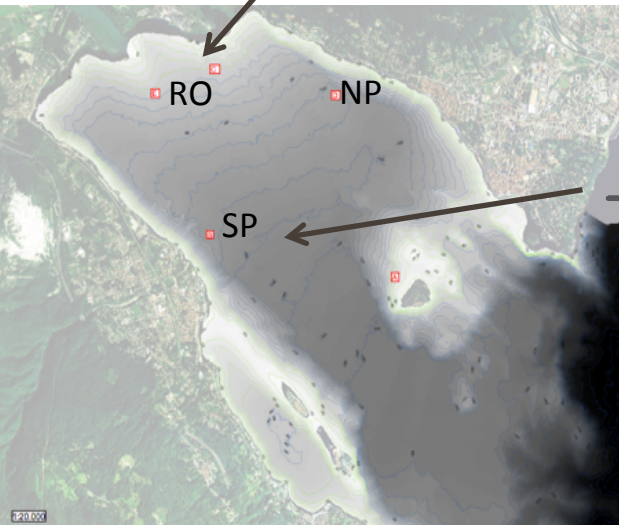
$$\log(SSC) = c_1 SNR + c_2$$





# River Inflow

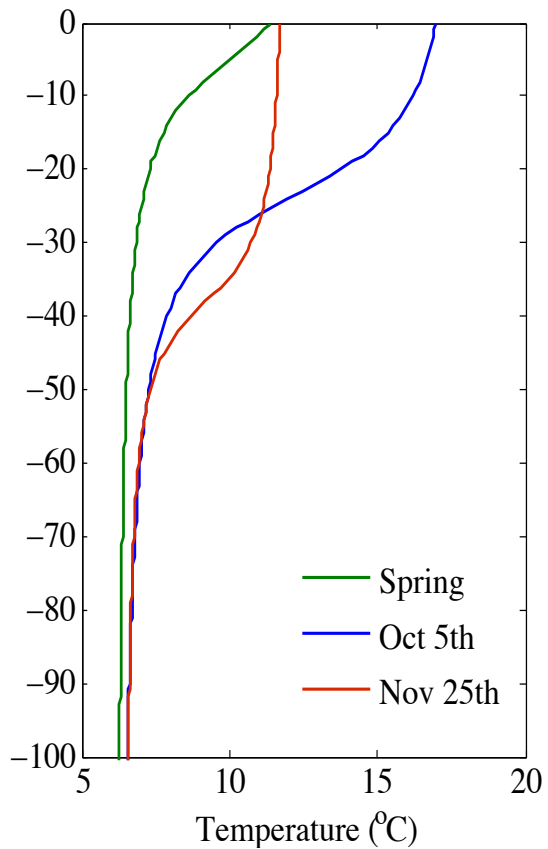
(Nov 28<sup>th</sup>-Dec 1<sup>st</sup>, 2012)



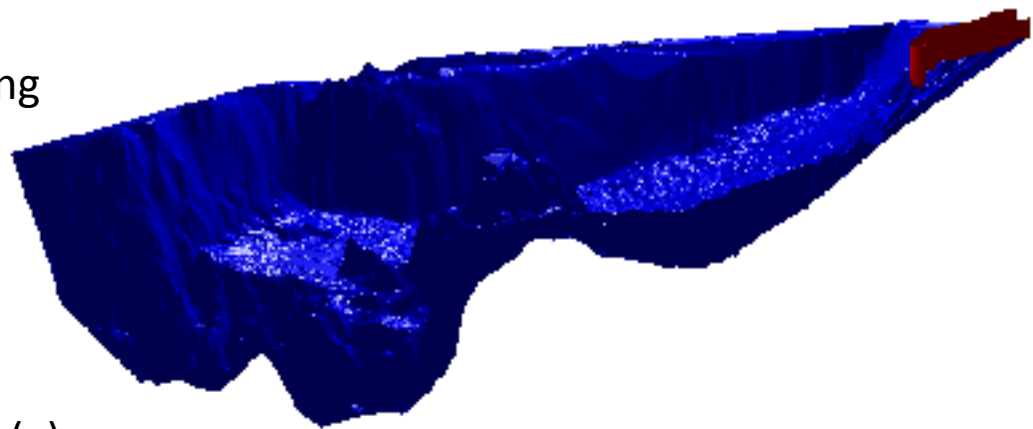
# Numerical modeling

- Hydrodynamic Model
  - SUNTANS\* – a three-dimensional, Navier–Stokes equation solver with the Boussinesq approximation
  - Unstructured horizontal grid with 50m spacing in Pallanza Bay and coarsening to 250m in the rest of the lake
  - 60 vertical non-uniform z-levels
  - Mellor-Yamada 2.5 turbulence model
- Sediment Modeling (for dilute flows)
  - Sediment can modify the density
  - Sediment has prescribed settling velocity (based on Stoke's settling)

# Inflow Simulations

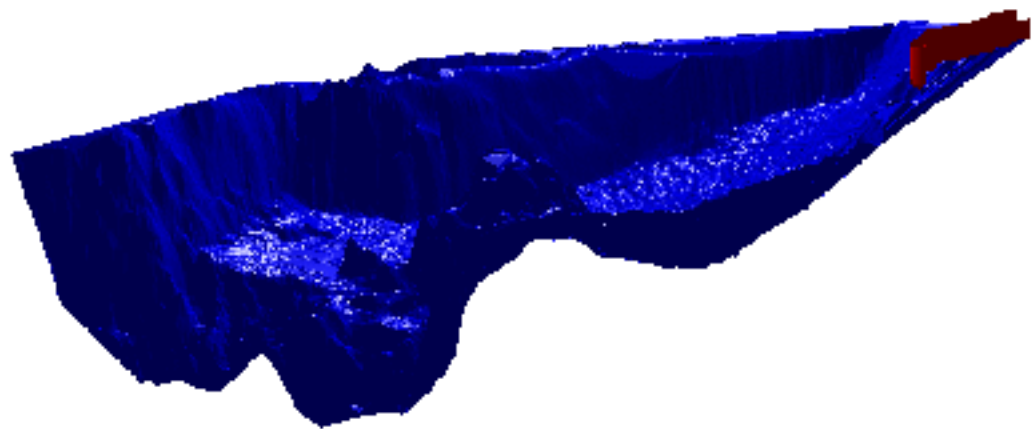


Spring



(a)

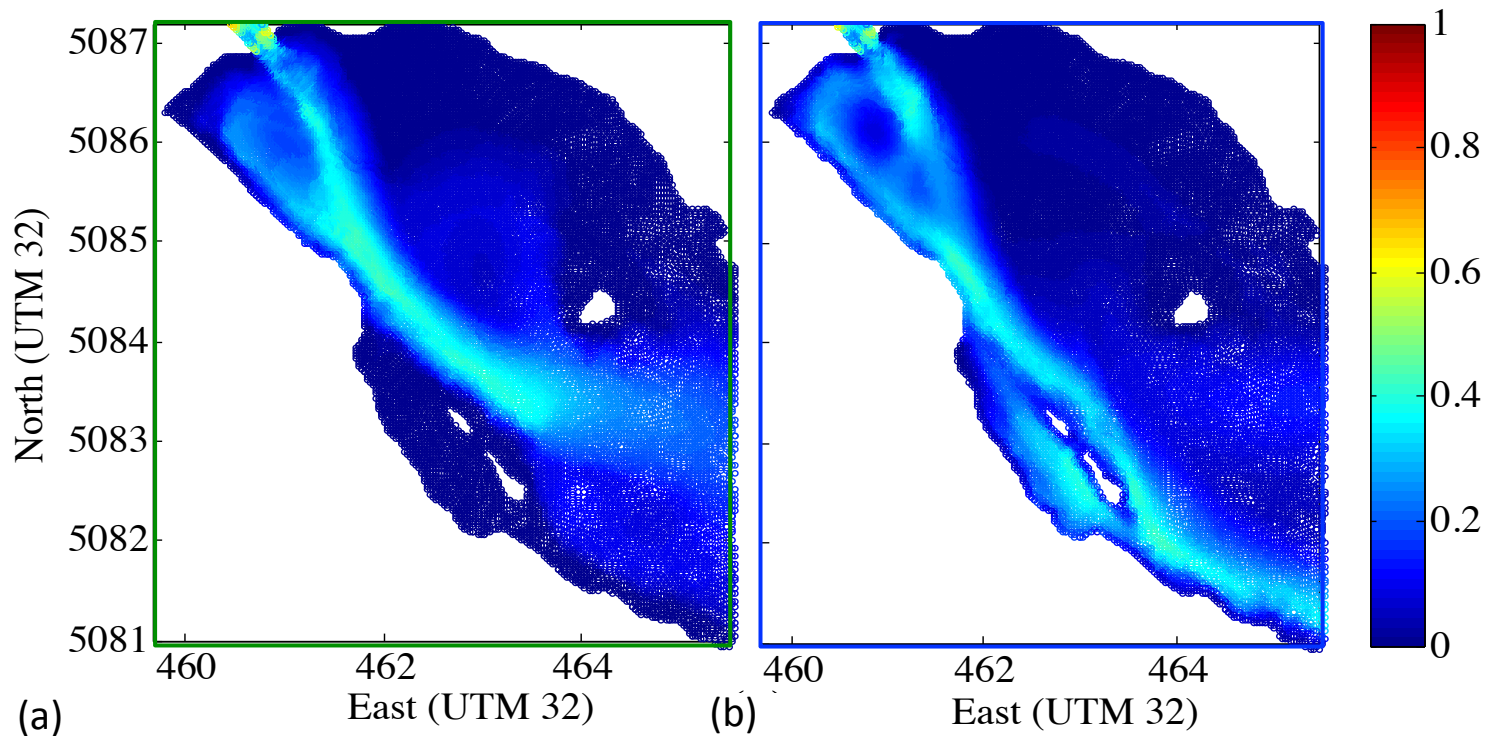
Fall



(b)

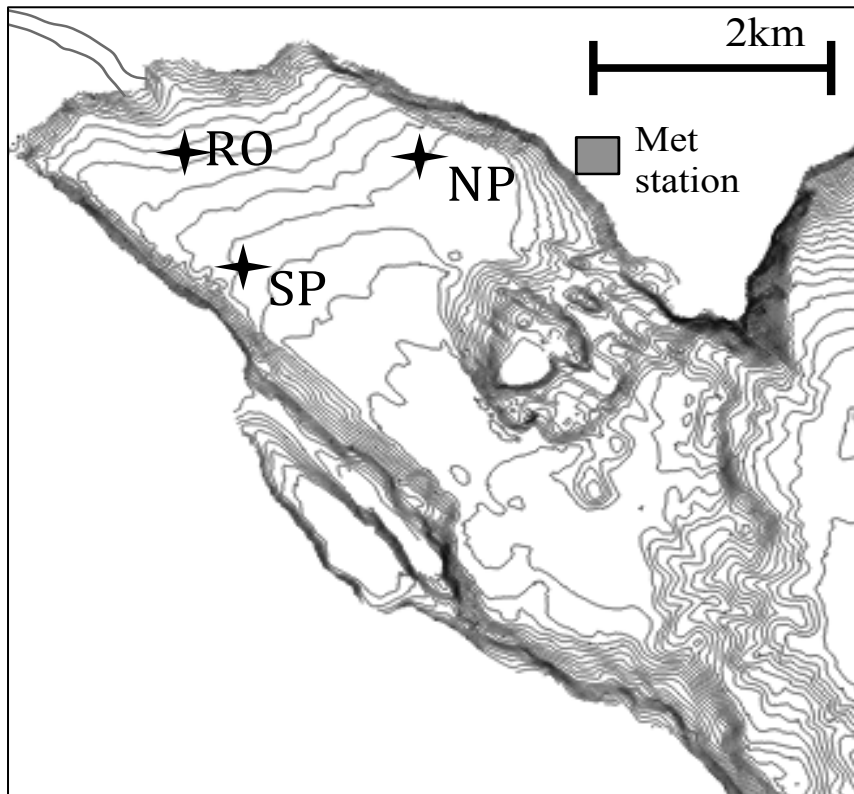


# Implications for sediment transport

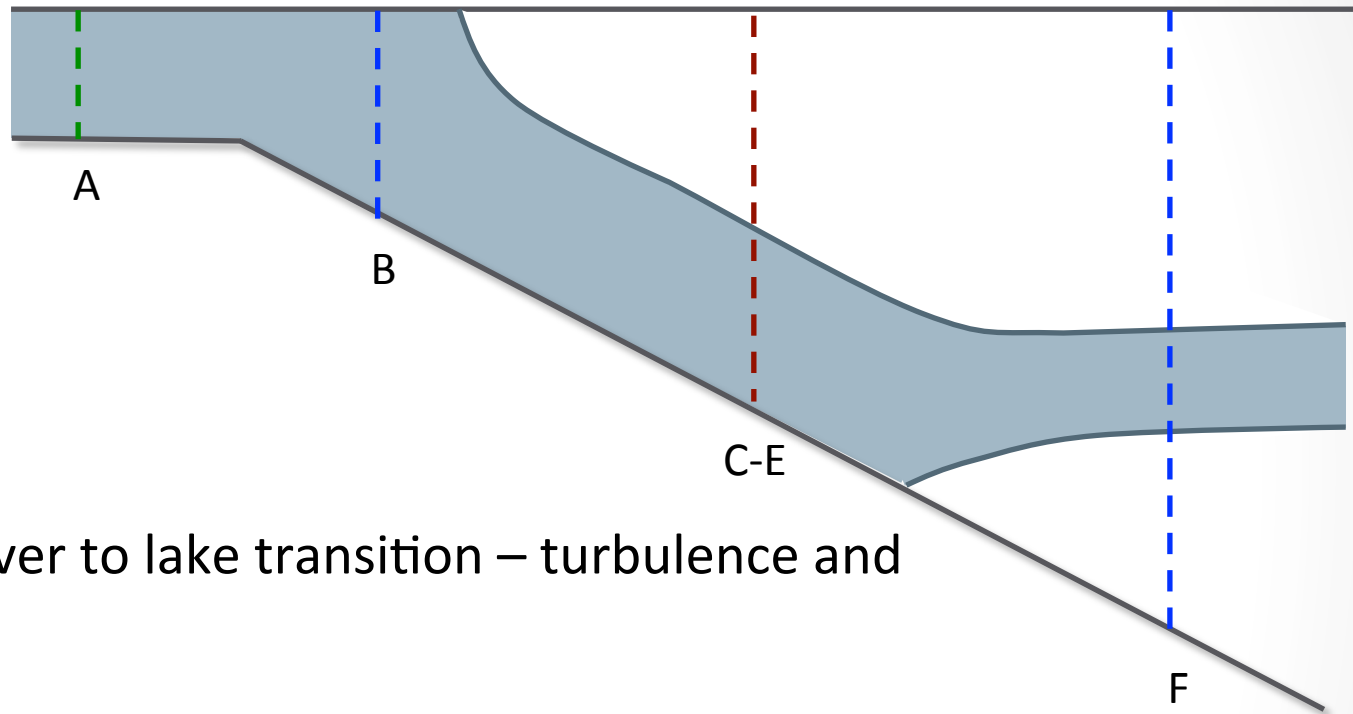


# General sediment dynamics

- **Minimal resuspension** of sediment observed
- **Large river inflows dominate** sediment transport in the bay
- **Rotation and seasonal stratification** affect location of sediment deposition
- Freshly deposited sediment is relatively **clean** (Lin, D. et. al., in prep)



# Upcoming Field Work



- Focus on river to lake transition – turbulence and mixing
- Use variety of instruments to measure SSC (optical, acoustic, LISST, and direct water samples)
- Deploy during spring snow melt season

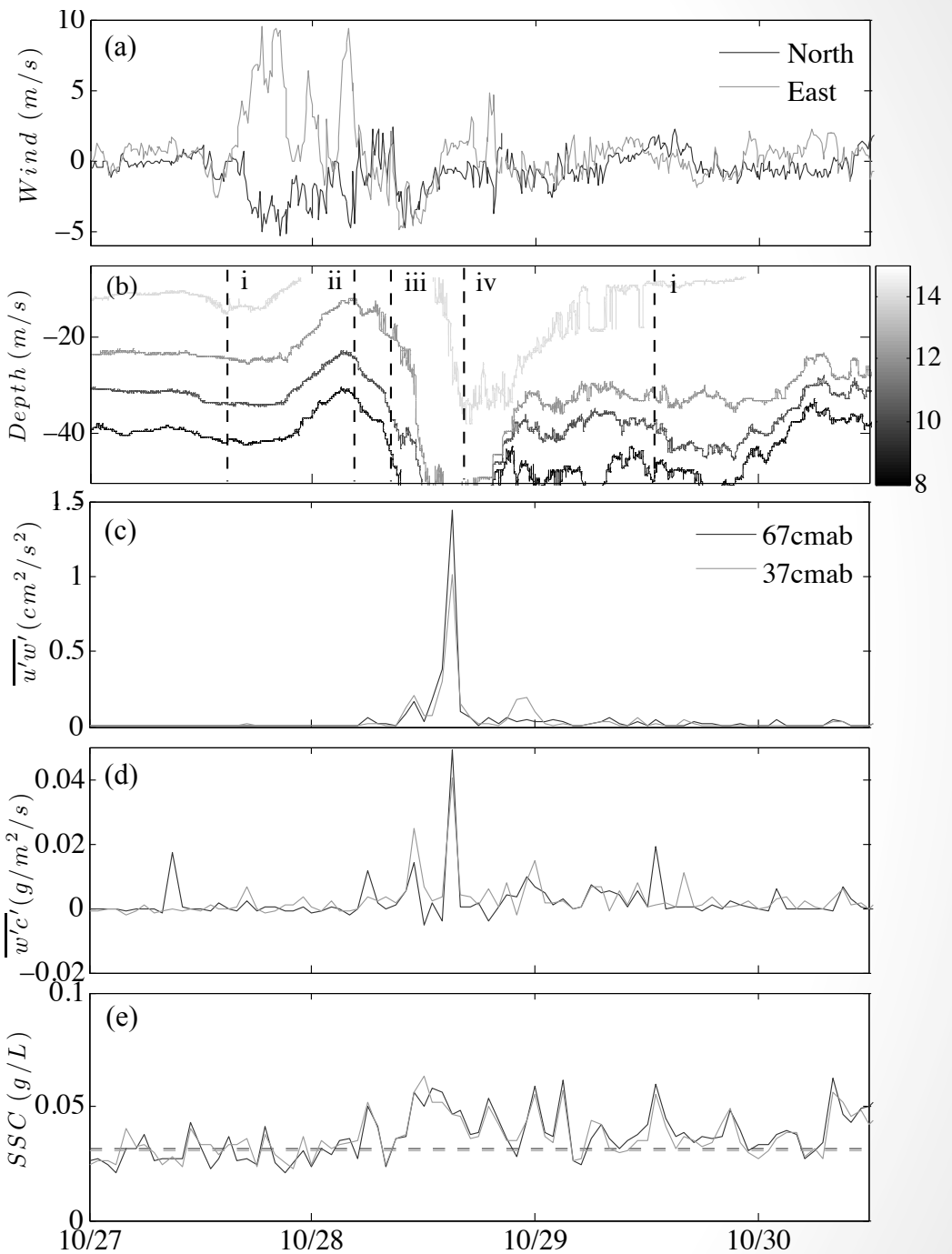
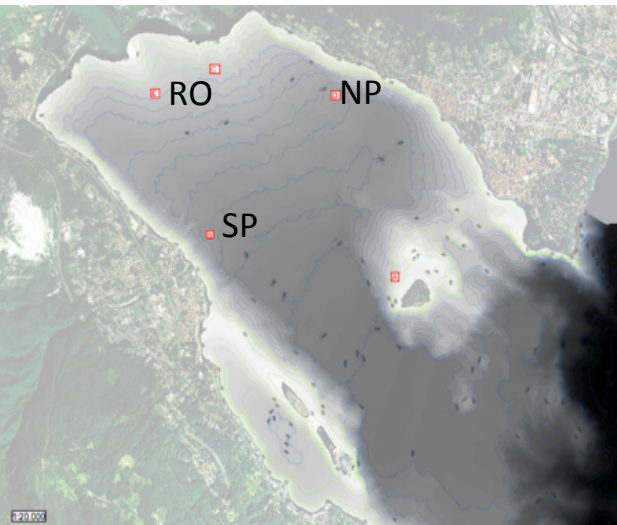


# Questions?

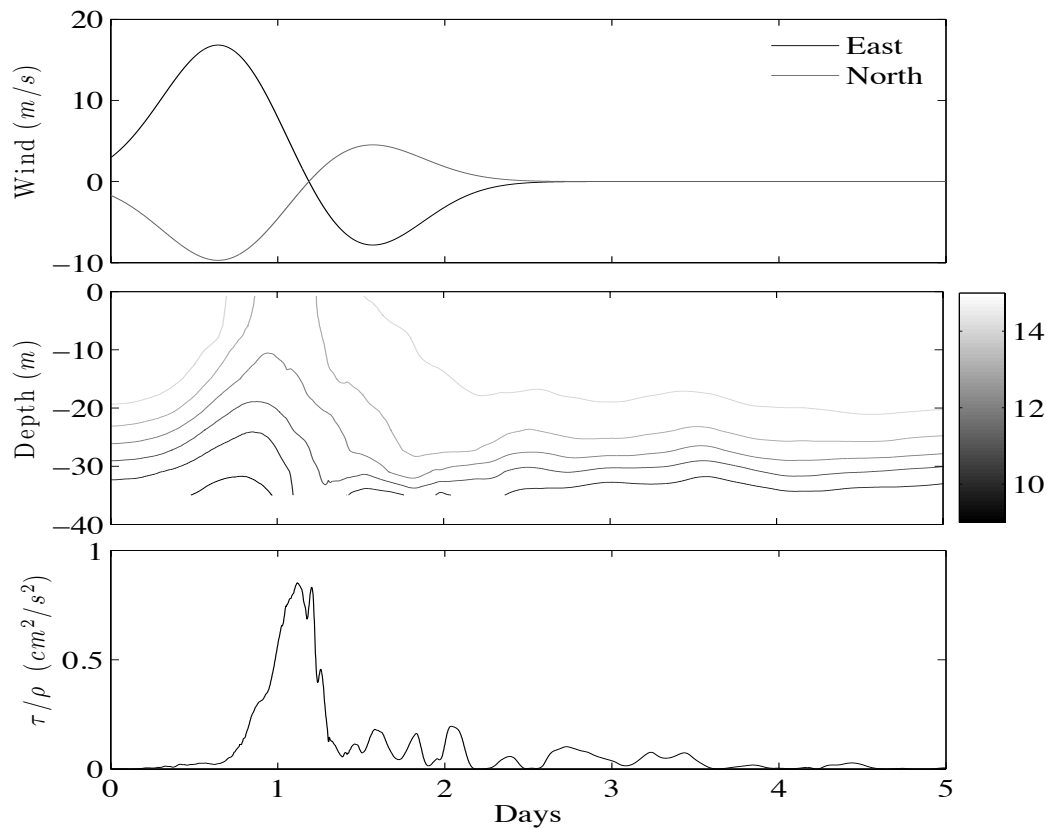
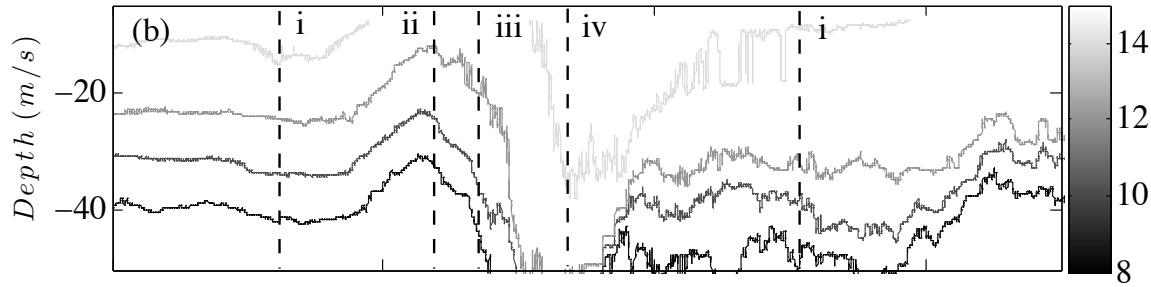
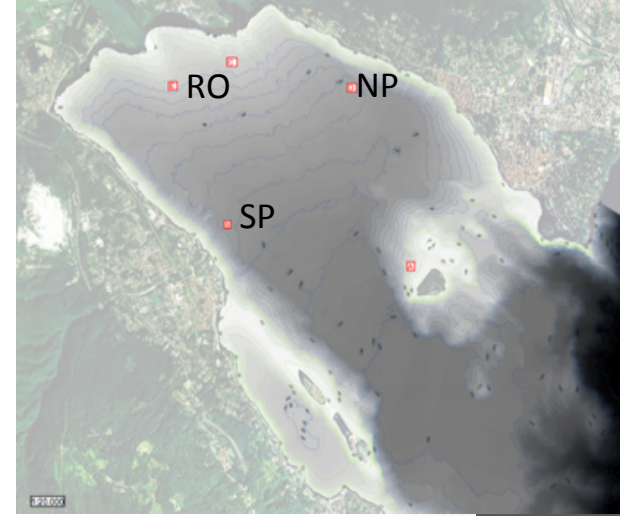


# Sediment Resuspension Event

- Wind driven-upwelling
- Relaxation of the thermocline generates peak in bottom stress

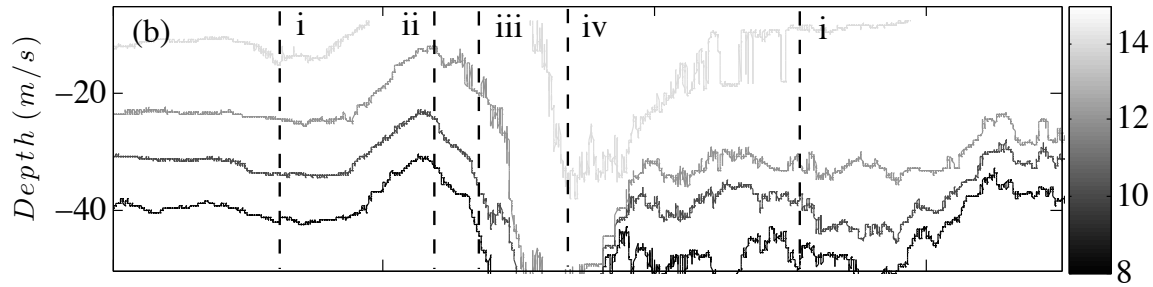
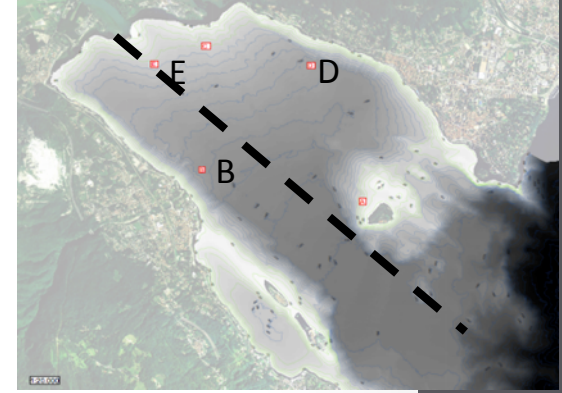


# Modeling of Resuspension Event





# Wind-driven upwelling schematic



i

Wind →

ii

Wind →

Warm, less  
dense water

Cold, more  
dense water

iii

Wind ←

iv

