DYNAMO Leg IV: Observation of Horizontal Variations in Diurnal Surface Heating Layer, Nocturnal Convections, and Internal Waves using Wirewalkers

Cruise date: 14 Dec. 2011 – 06 Jan. 2012

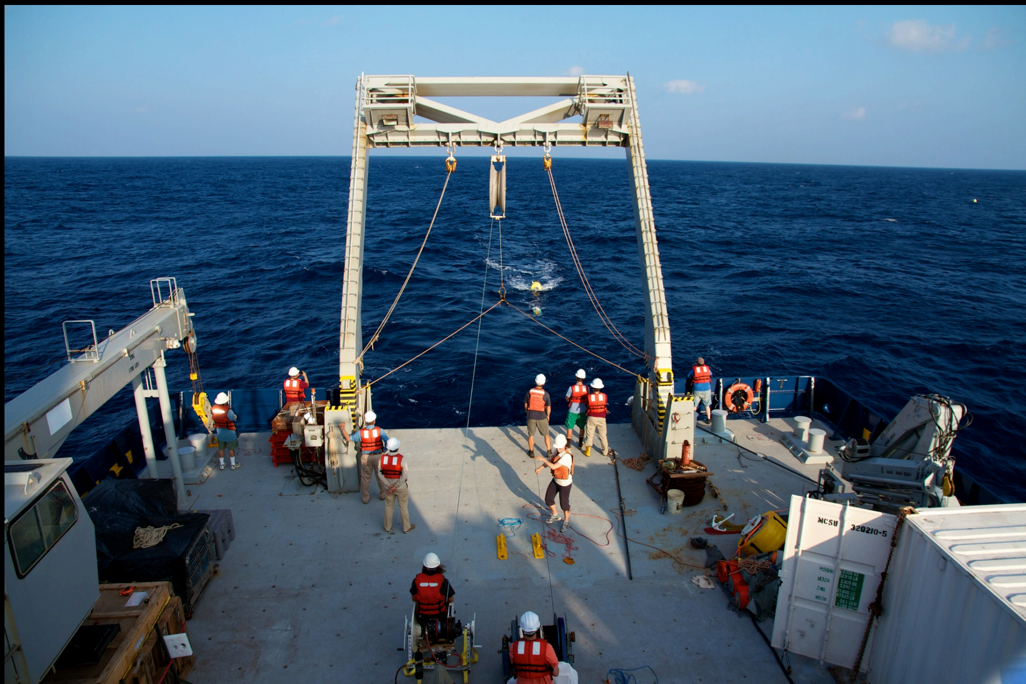
San Nguyen
Robert Pinkel
Jerome Smith

Scripps Institution of Oceanography

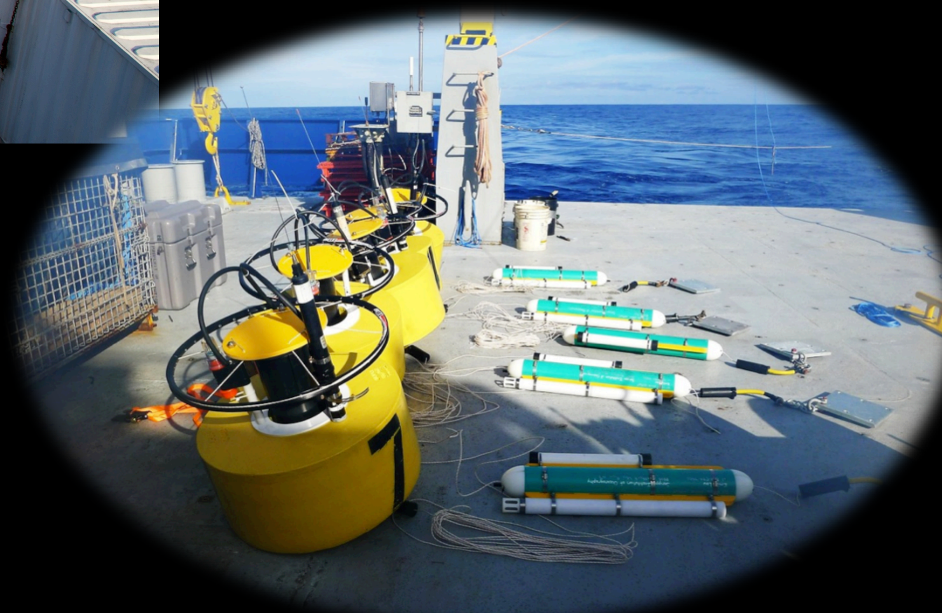
03 December 2012

Email: snguyen@opg1.ucsd.edu

DYNAMO Leg IV: 12/14/2011 – 01/06/2012



Deployed free-drifting, wave powered **wirewalkers**

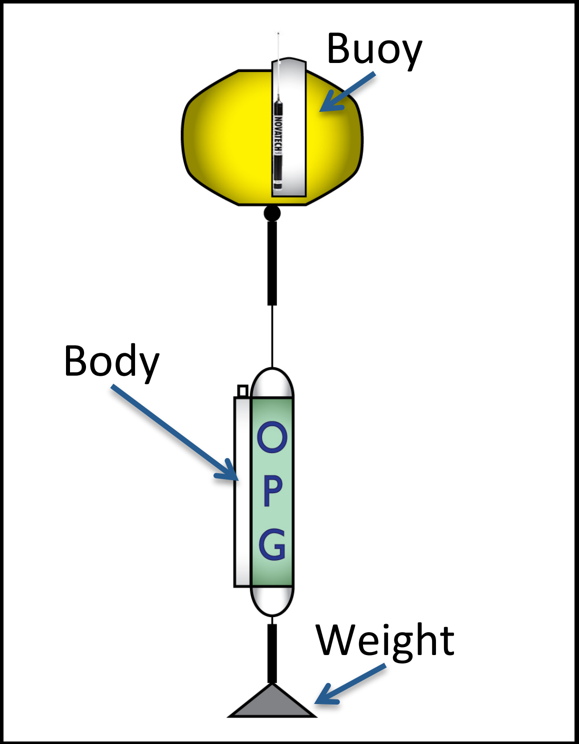


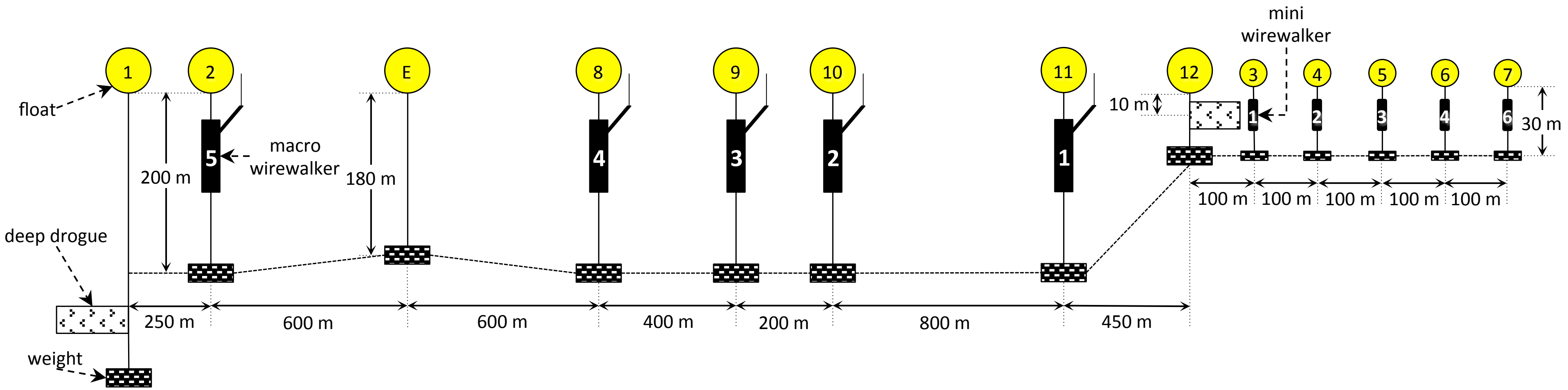
Introduction

- Questions:
  - What are the horizontal scales of the diurnal surface layer and nocturnal convections in the ocean?
  - How are these scales dependent on the surface conditions?
  - What is the lateral variation of the internal waves?

Instrumentation: Wirewalkers

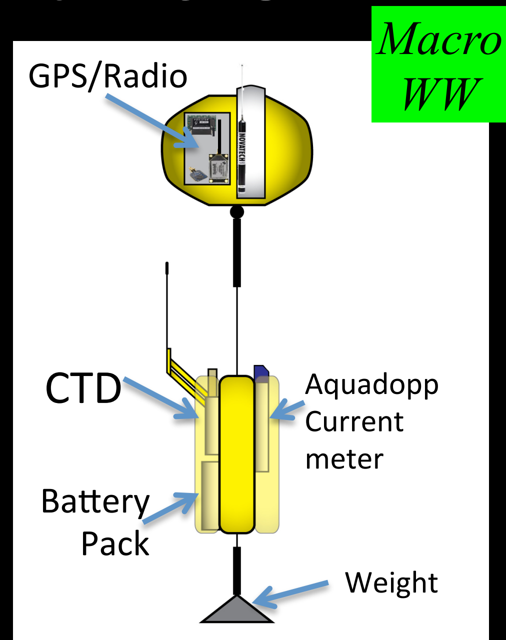
- **Macro wirewalkers**
  - CTD (SeaBird 49, 16Hz)
  - Depth range: ~ 200 m
  - Average profiling time: 15 minutes
  - Horizontal separation: 1 km - 20 km
- **Mini wirewalkers**
  - Temperature-Pressure Recorder (SeaBird 39, 2Hz)
  - Depth range: ~ 20 m
  - Average profiling time: 5 minutes
  - Horizontal separation: 100 m - 400 m

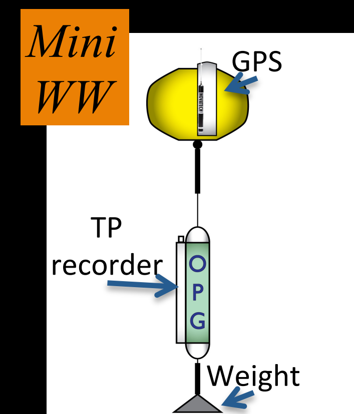


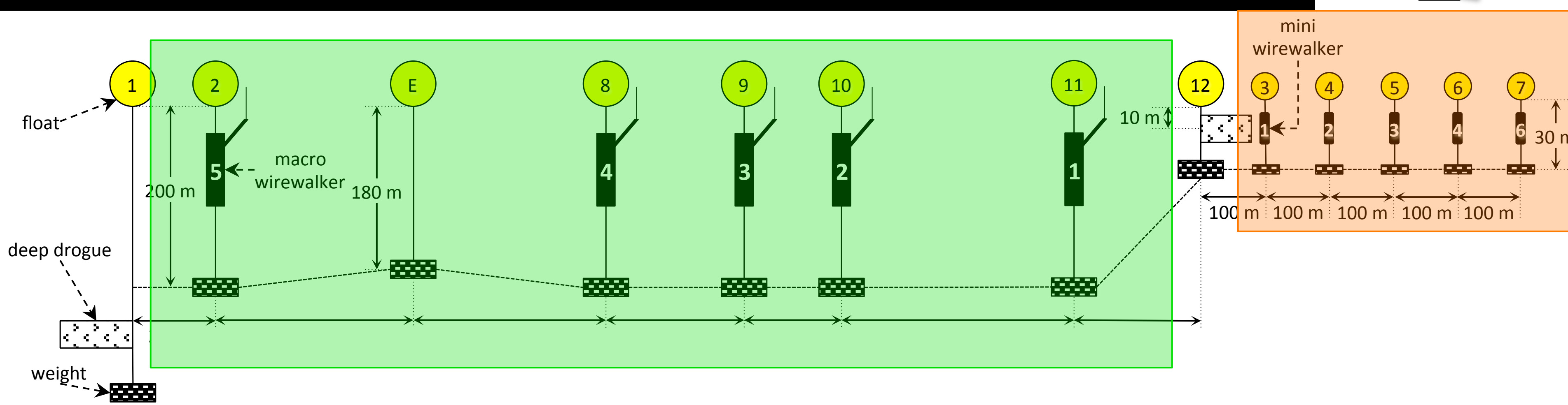


Instrumentation: Wirewalkers

- **Macro wirewalkers**
  - CTD (SeaBird 49, 16Hz)
  - Depth range: ~ 200 m
  - Average profiling time: 15 minutes
  - Horizontal separation: 1 km - 20 km
- **Mini wirewalkers**
  - Temperature-Pressure Recorder (SeaBird 39, 2Hz)
  - Depth range: ~ 20 m
  - Average profiling time: 5 minutes
  - Horizontal separation: 100 m - 400 m



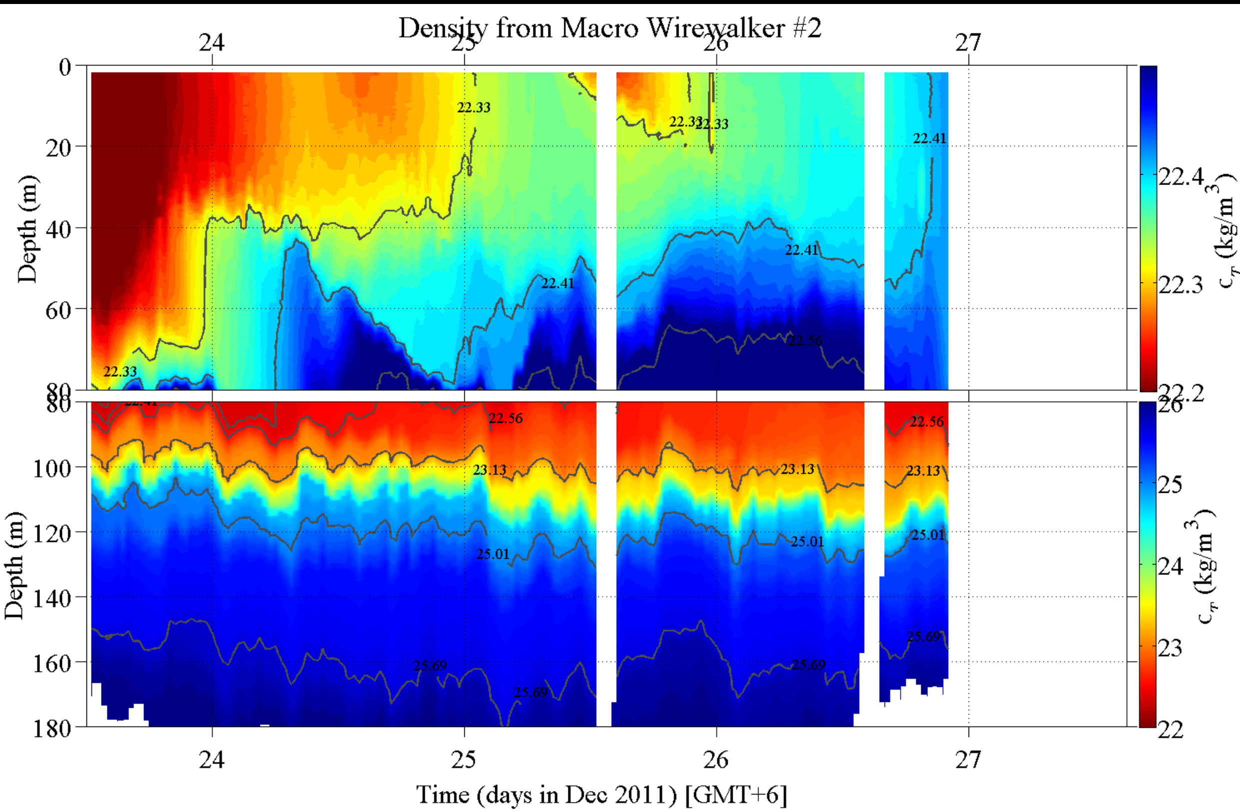


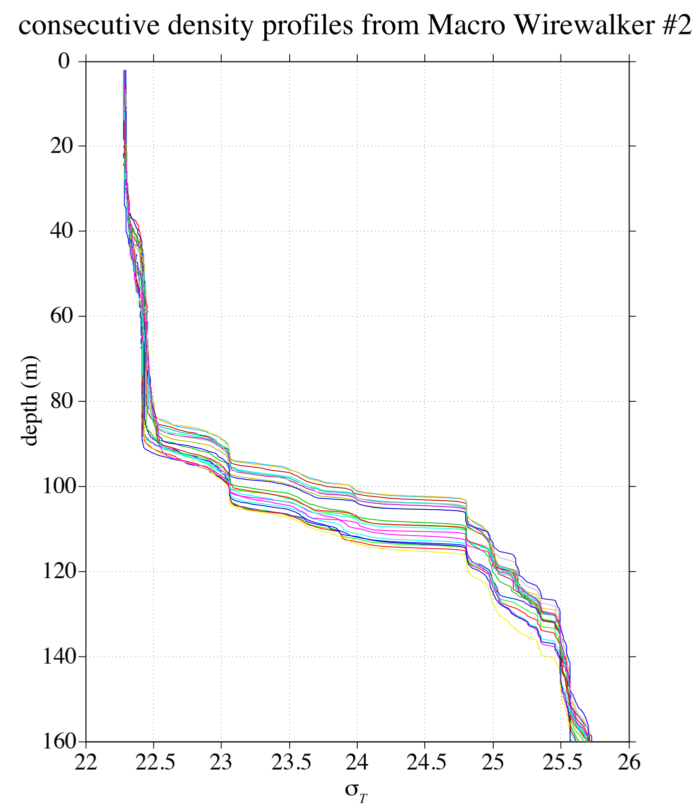


Outline

- Lateral variations of internal wave field using macro wirewalkers
  - Isopycnal slope as a function of distance of separations
  - Variation of function of isopycnal slope versus stratification and shear
- Horizontal structure of diurnal heating layer and nocturnal convective layer using mini wirewalkers
  - Variance of temperature field
  - Horizontal thermal structure functions
    - Variability difference between night and day
    - Variability due to wind
- Summary

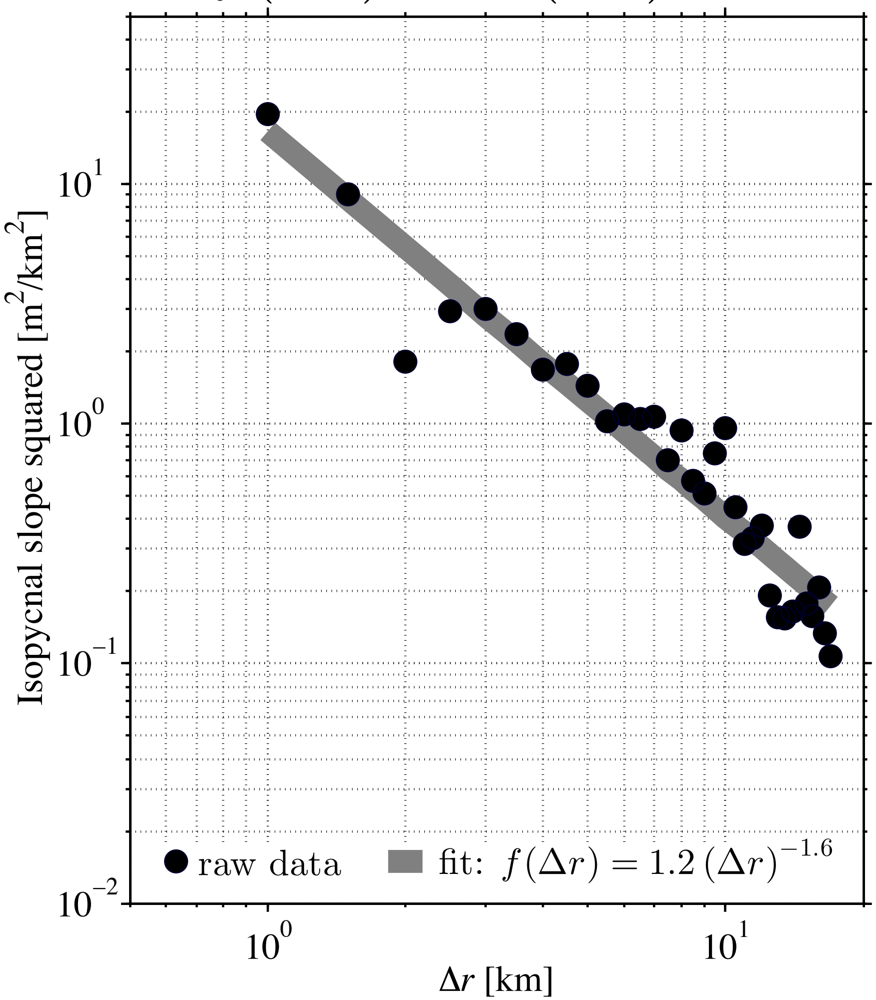
Macro Wirewalkers: Sample data σ_T

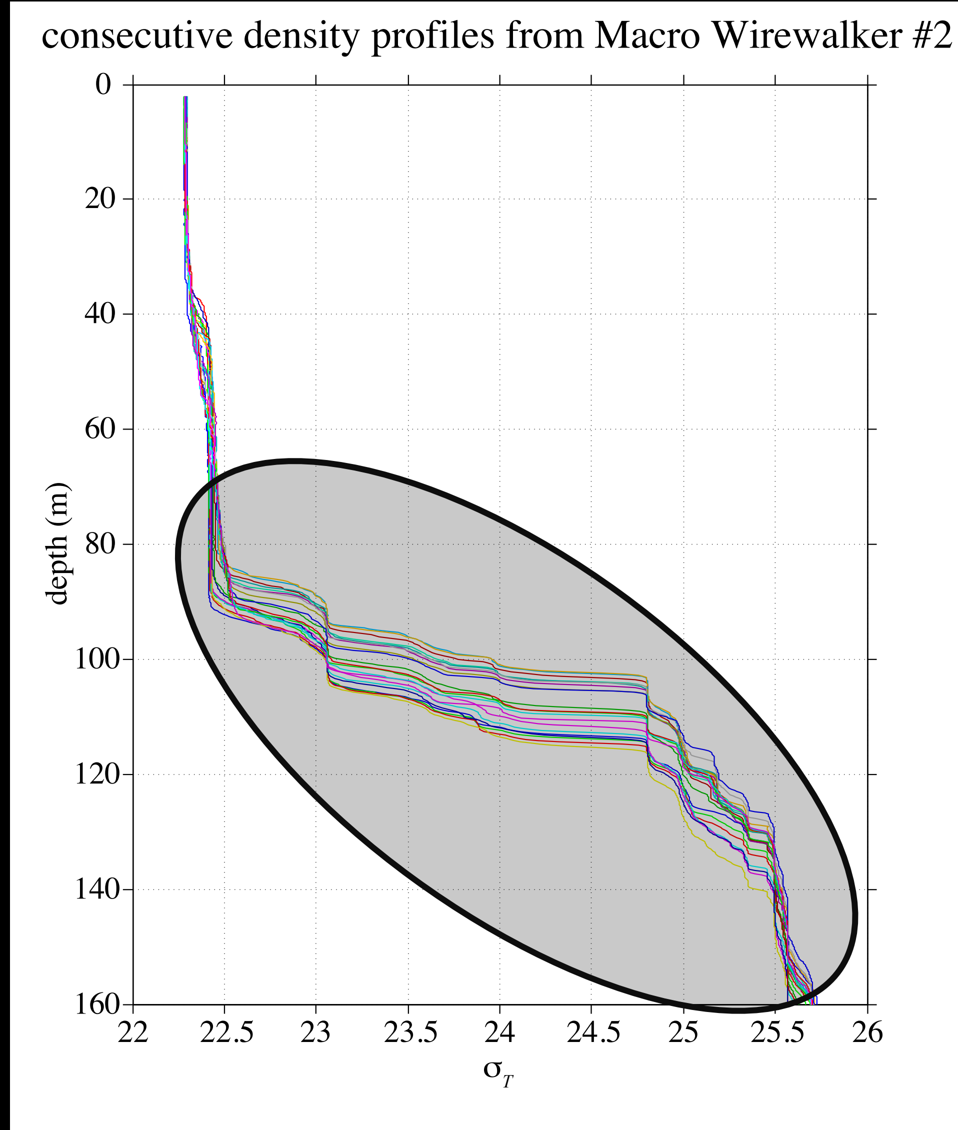




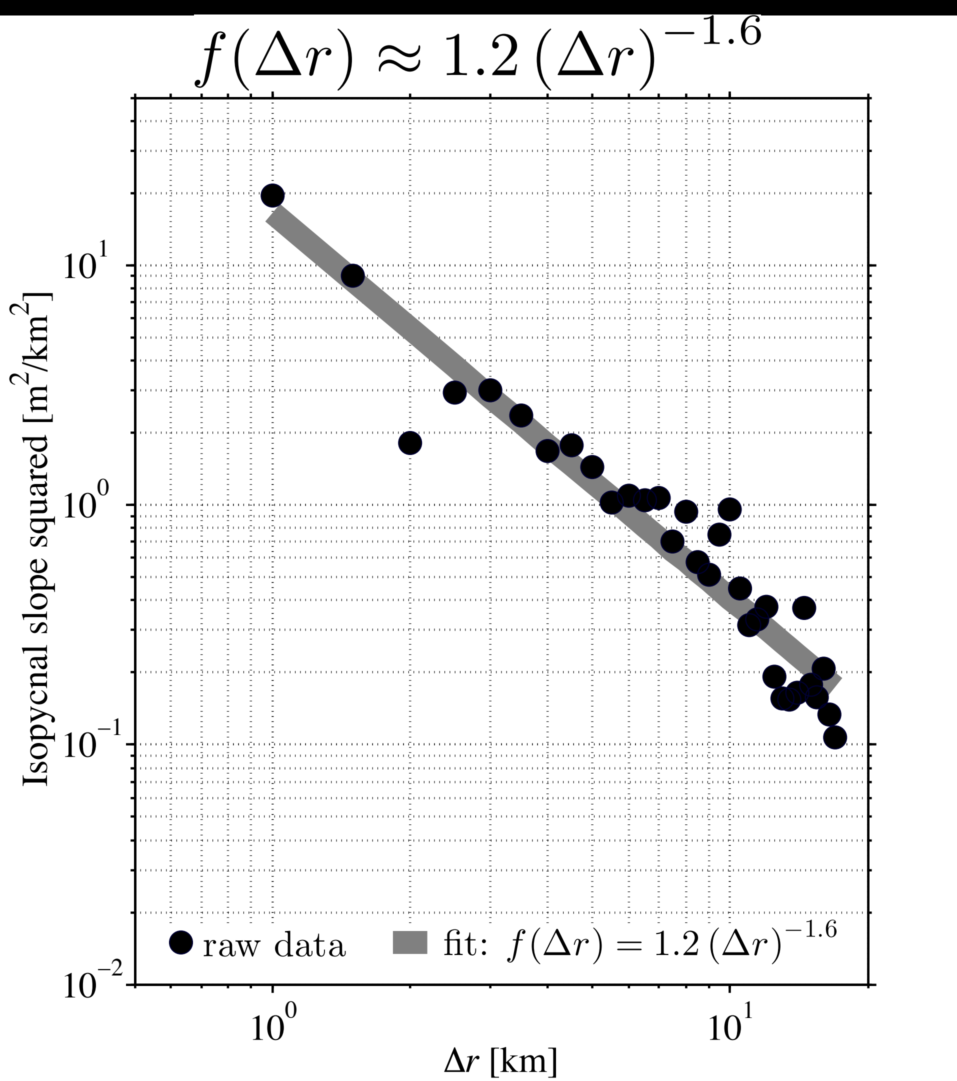
Isopycnal slopes versus separations

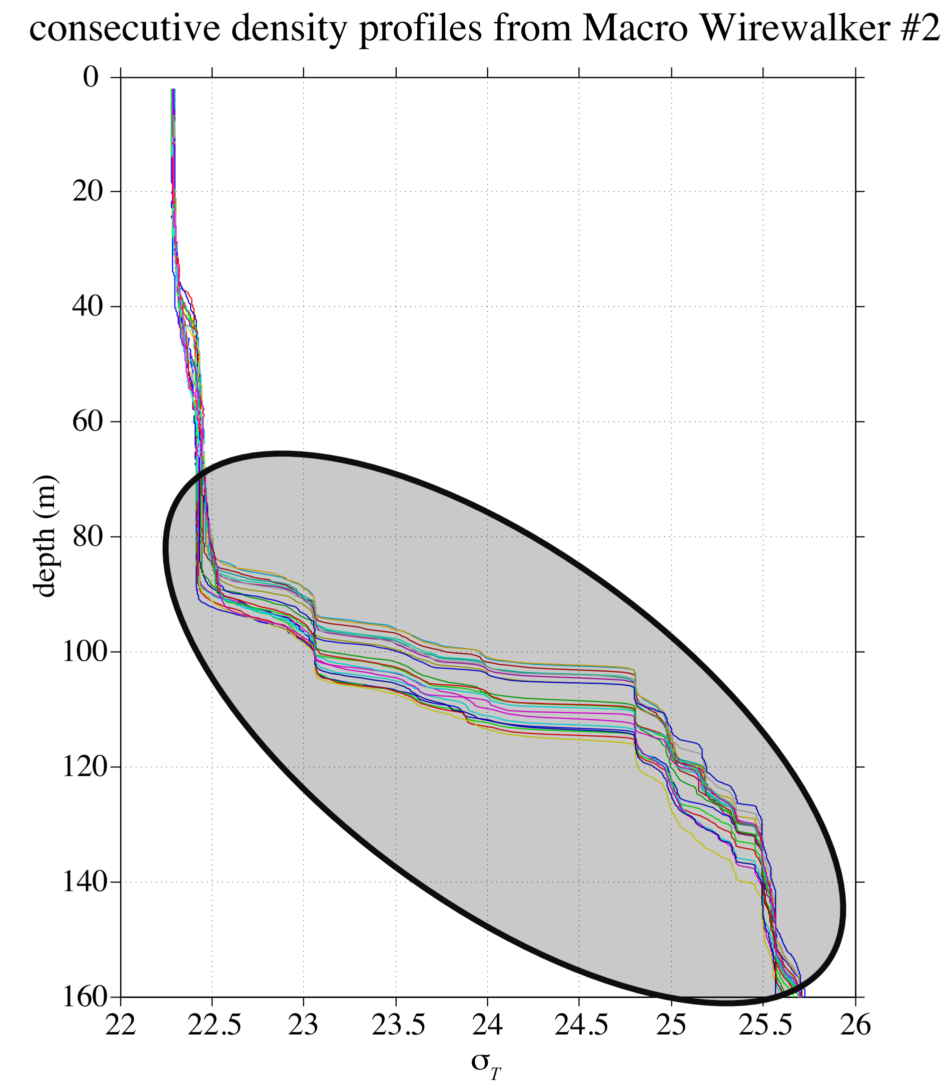
$$f(\Delta r) \approx C\,(\Delta r)^{-p}$$





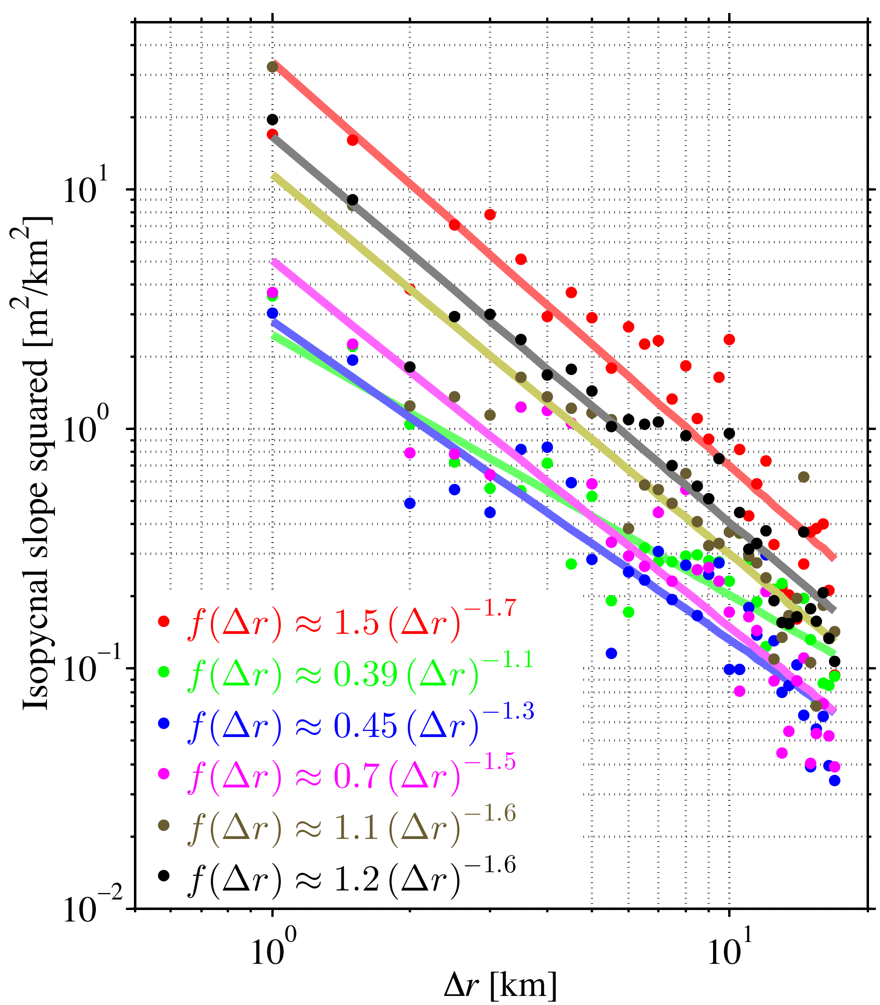
Isopycnal slopes versus separations



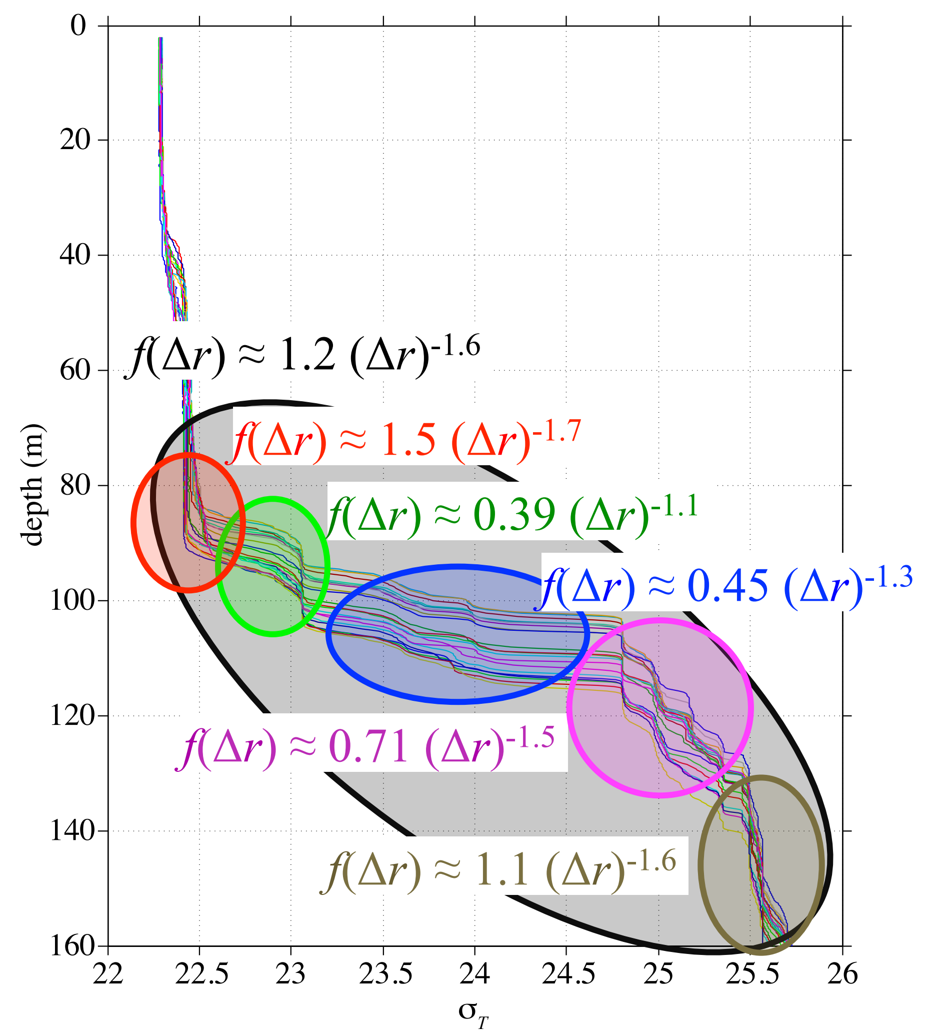


Isopycnal slopes versus separations

in different stratification regimes

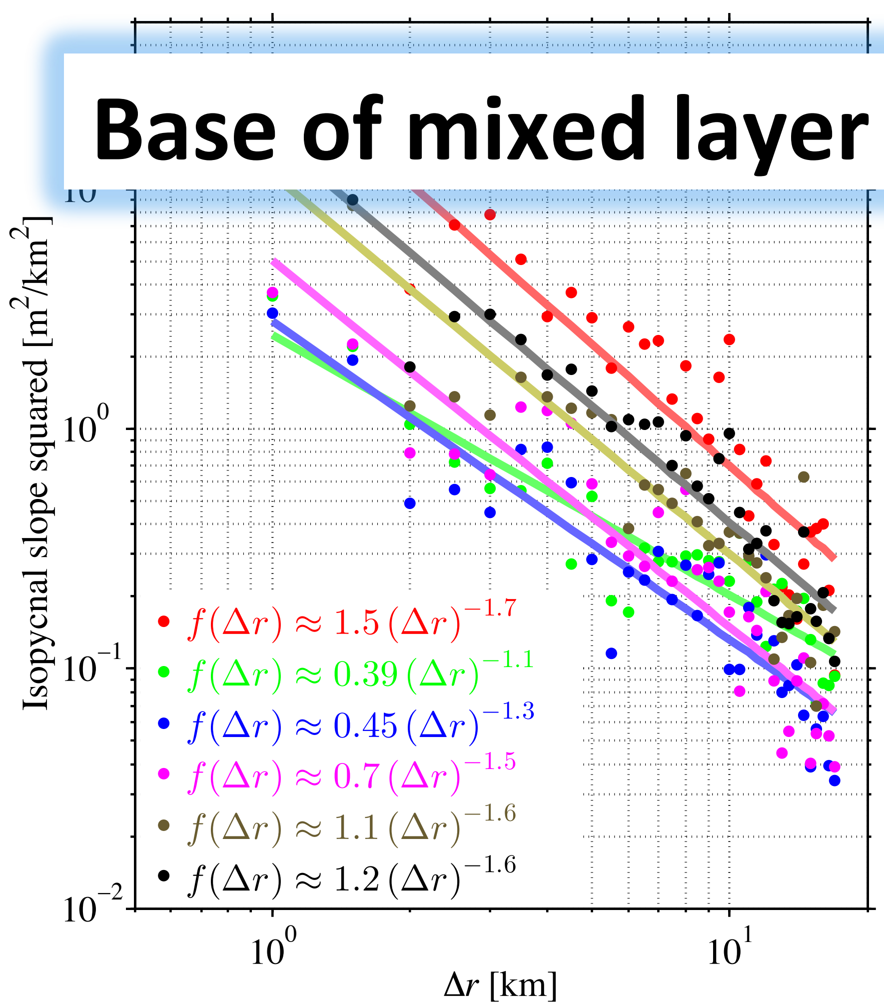


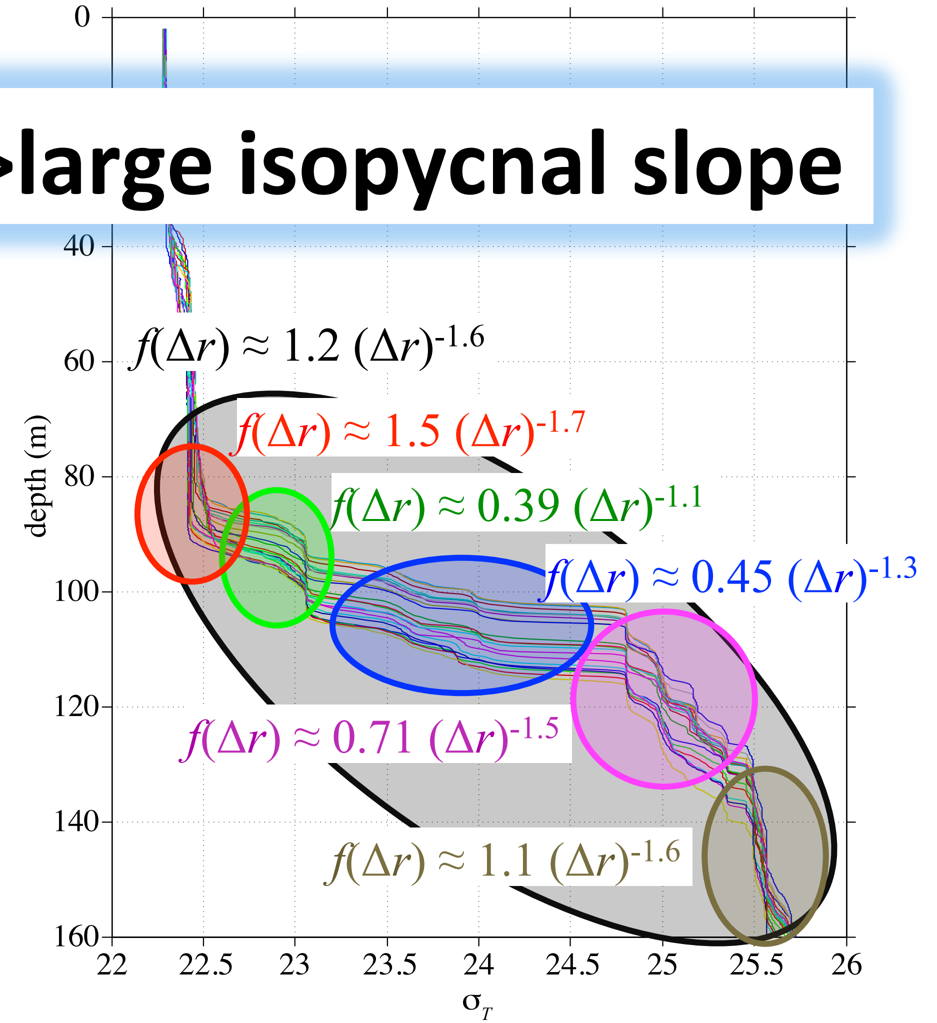
consecutive density profiles from Macro Wirewalker #2



Isopycnal slopes versus separations

in different stratification regimes





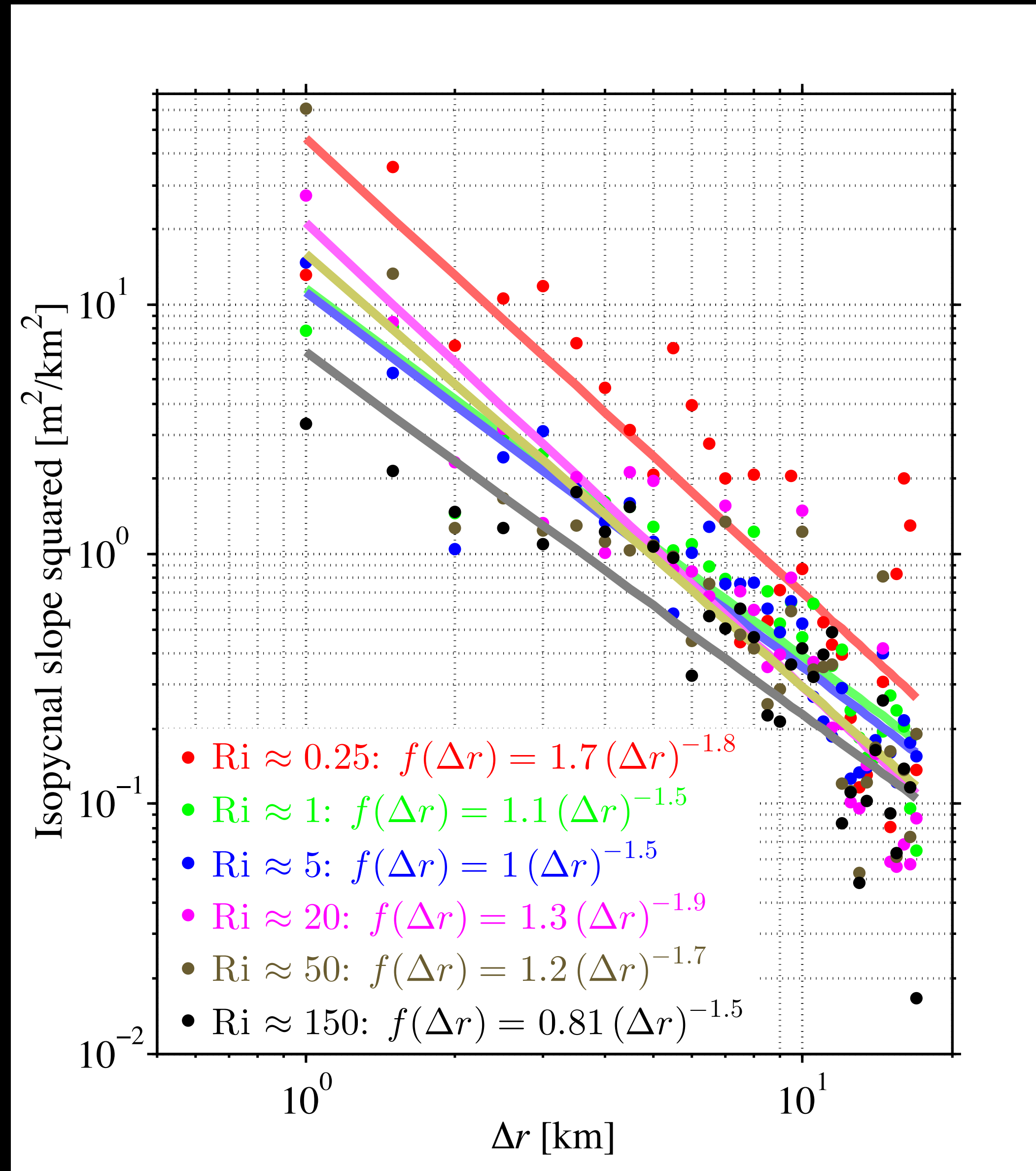
Base of mixed layer -->large isopycnal slope

Isopycnal slopes versus separations

versus
Richardson number

$$\frac{(\text{Buoyancy})^2}{(\text{Shear})^2}$$

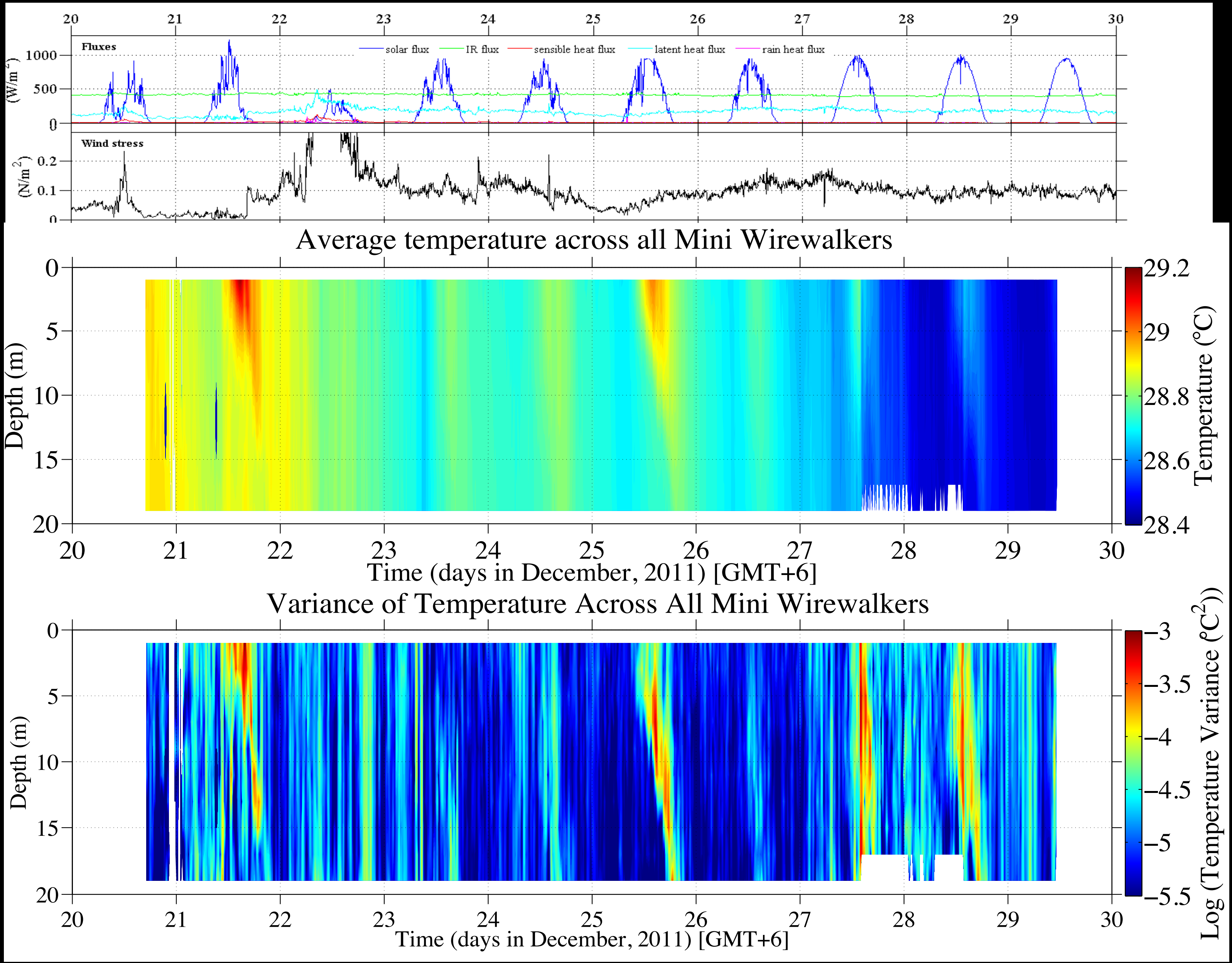
Ri ≈ *O*(0.25) -> large slope



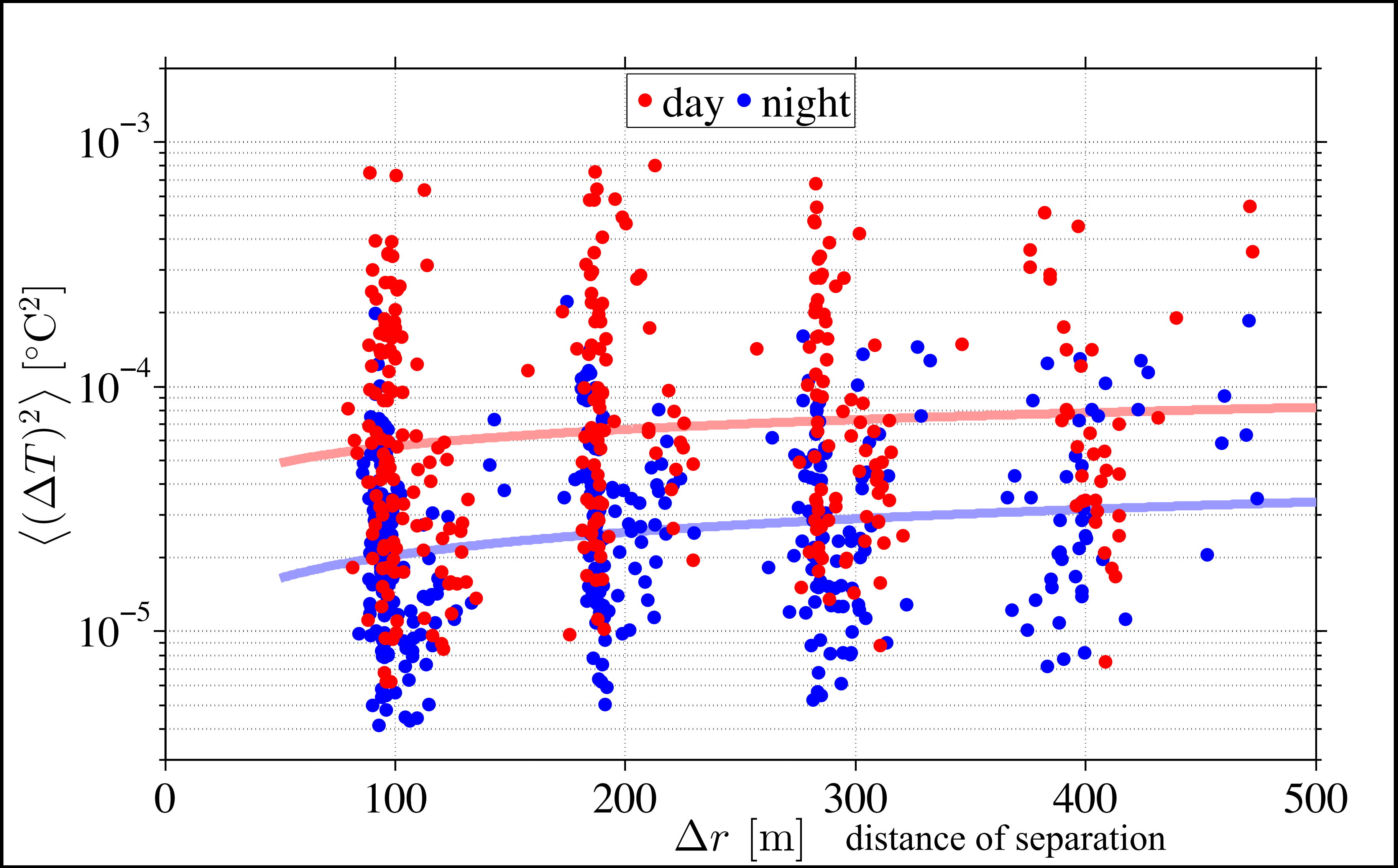
Outline

- Lateral variations of internal wave field using macro wirewalkers
  - Isopycnal slope as a function of distance of separations
  - Variation of function of isopycnal slope versus stratification
- Horizontal structure of diurnal heating and nocturnal convective layers using mini wirewalkers
  - Variations in the near surface ocean
  - Horizontal thermal structure functions
    - Variability difference between night and day
    - Variability due to wind
- Summary

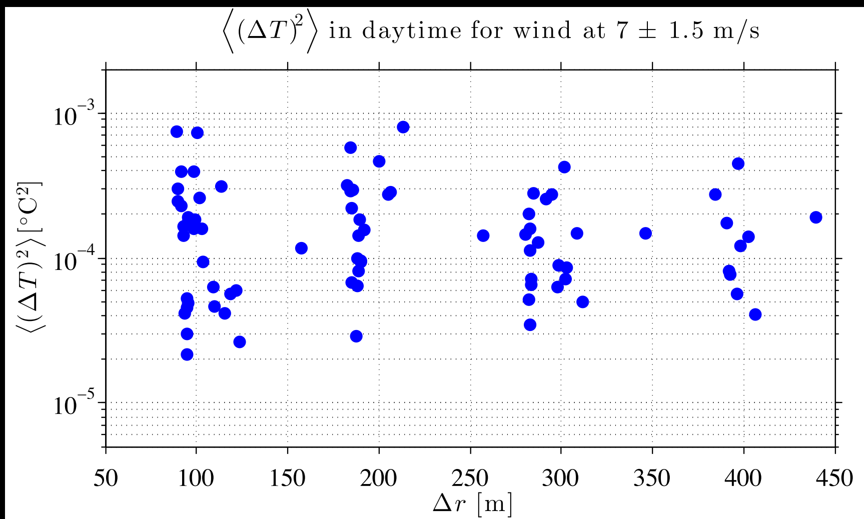
Sub-surface temperature: mean & variance

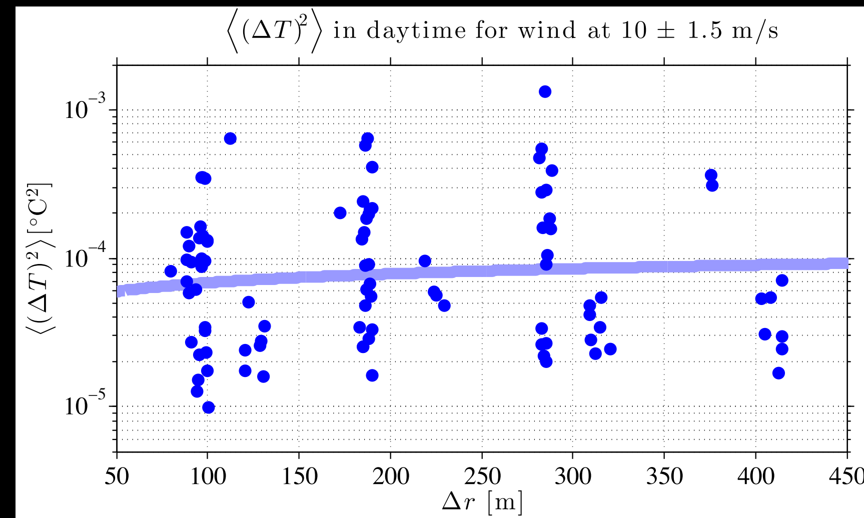


Temperature structure function $<(\Delta T)^2>$

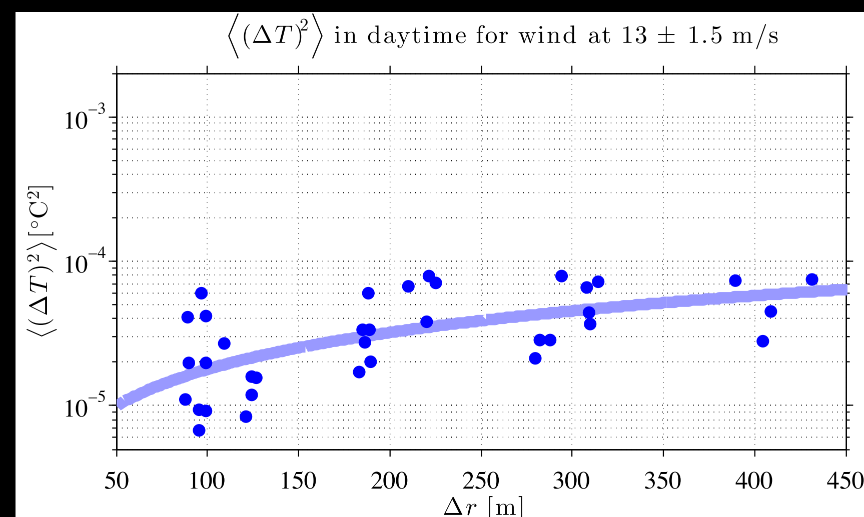


Daytime <(ΔT)^2> versus wind speeds

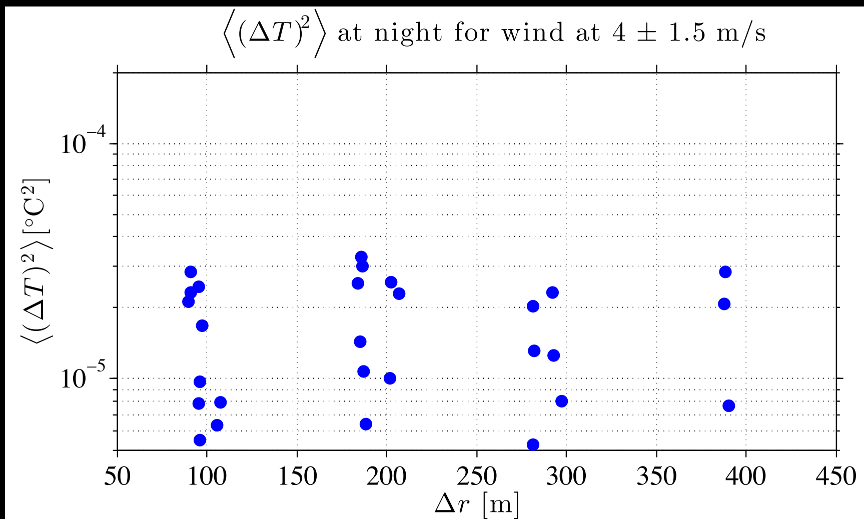


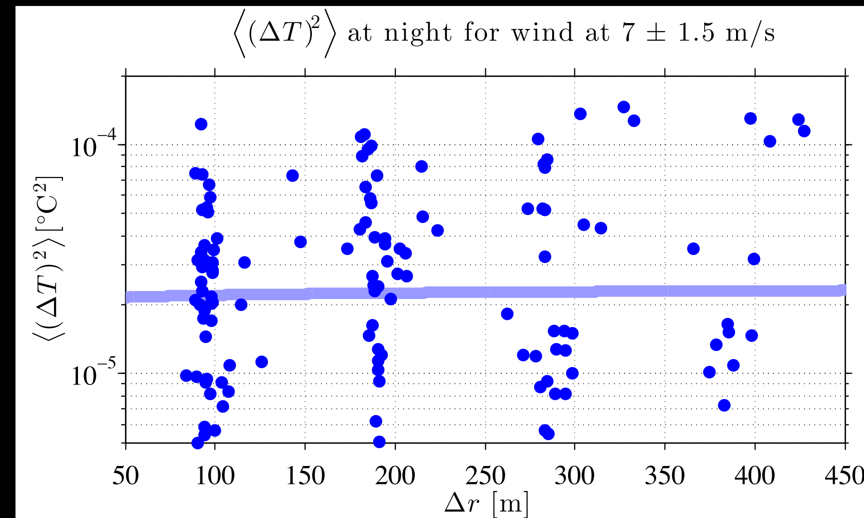


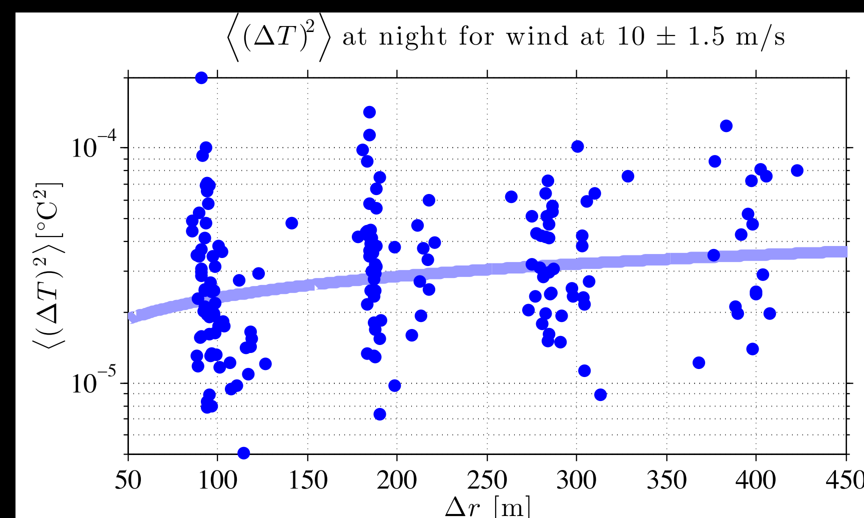
coherent structures
with scale of O(100 – 400 m)
for strong wind



Nighttime <(ΔT)^2> versus wind speeds







coherent structures
with scale of O(100 – 400 m)
for strong wind

Summary

- Isopycnal slopes during DYNAMO Leg IV has a $(\Delta r)^{-p}$ relationship, where p range from 1.1 to 1.9.
- Isopycnal slopes are largest at the base of the mixed layer associated with low Richardson number.
- In the diurnal heating layer, temperature variance is higher during the day.
- Higher wind speed results in more coherent structures of O(100-400m) diurnal heating and nocturnal convections.
- Further observations on horizontal scales of 10 m to 1 km needed.

Future work for data from DYNAMO Leg IV

- Develop a ***spectral model*** fit to isopycnal slopes versus horizontal spatial variations in the internal wave field.
- Explore the dependence of temperature structure function on the state of the ocean.