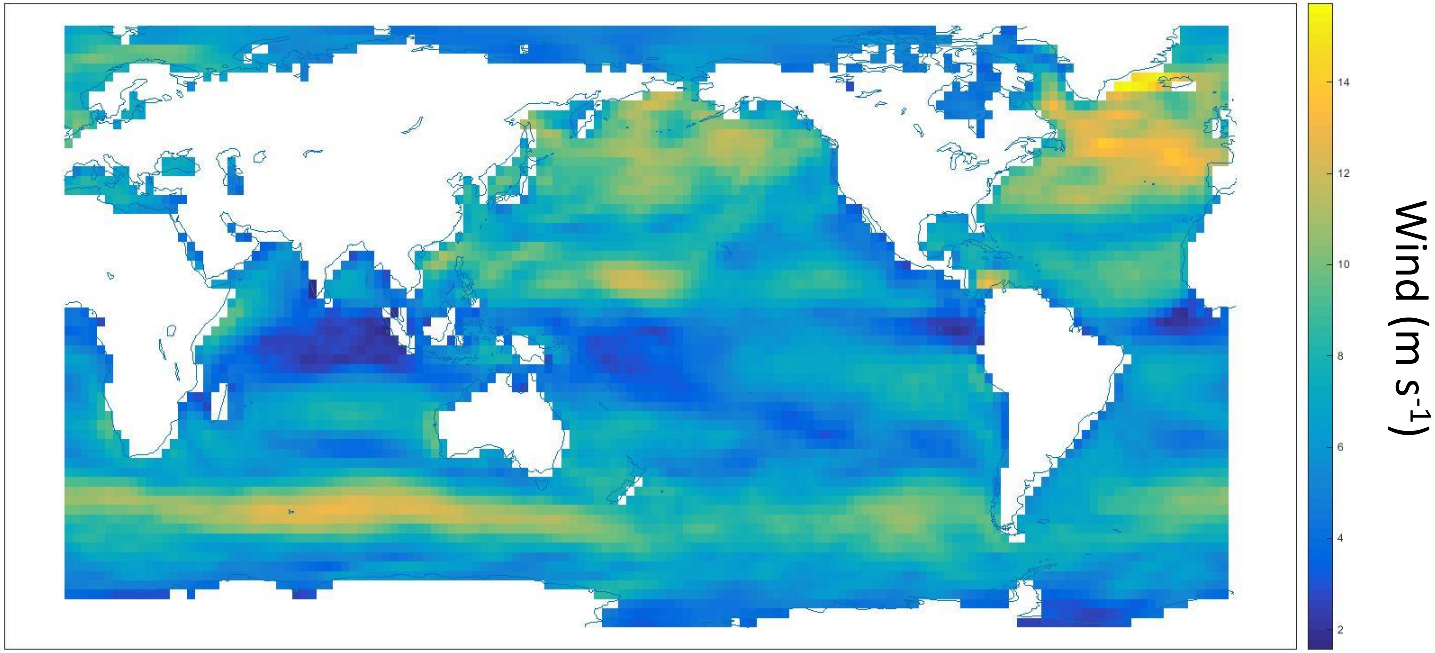
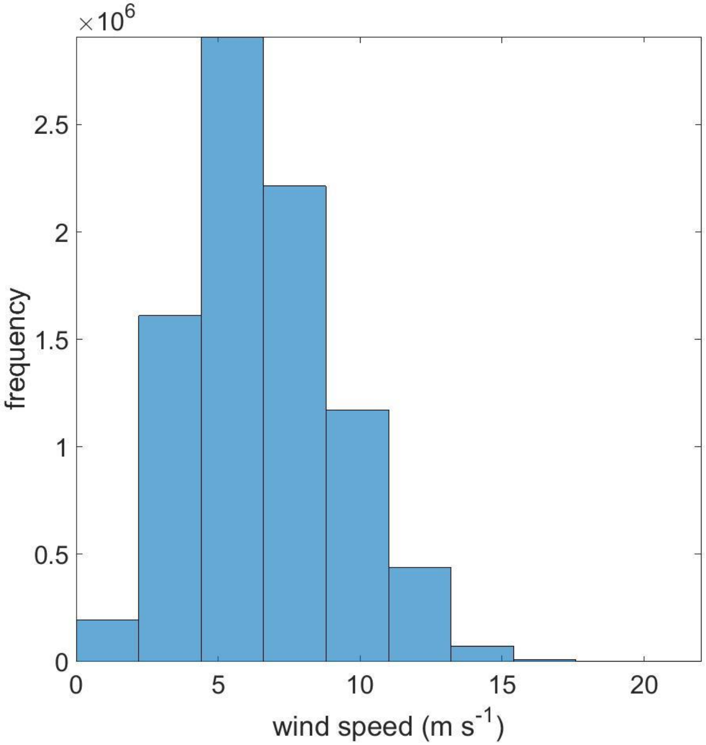
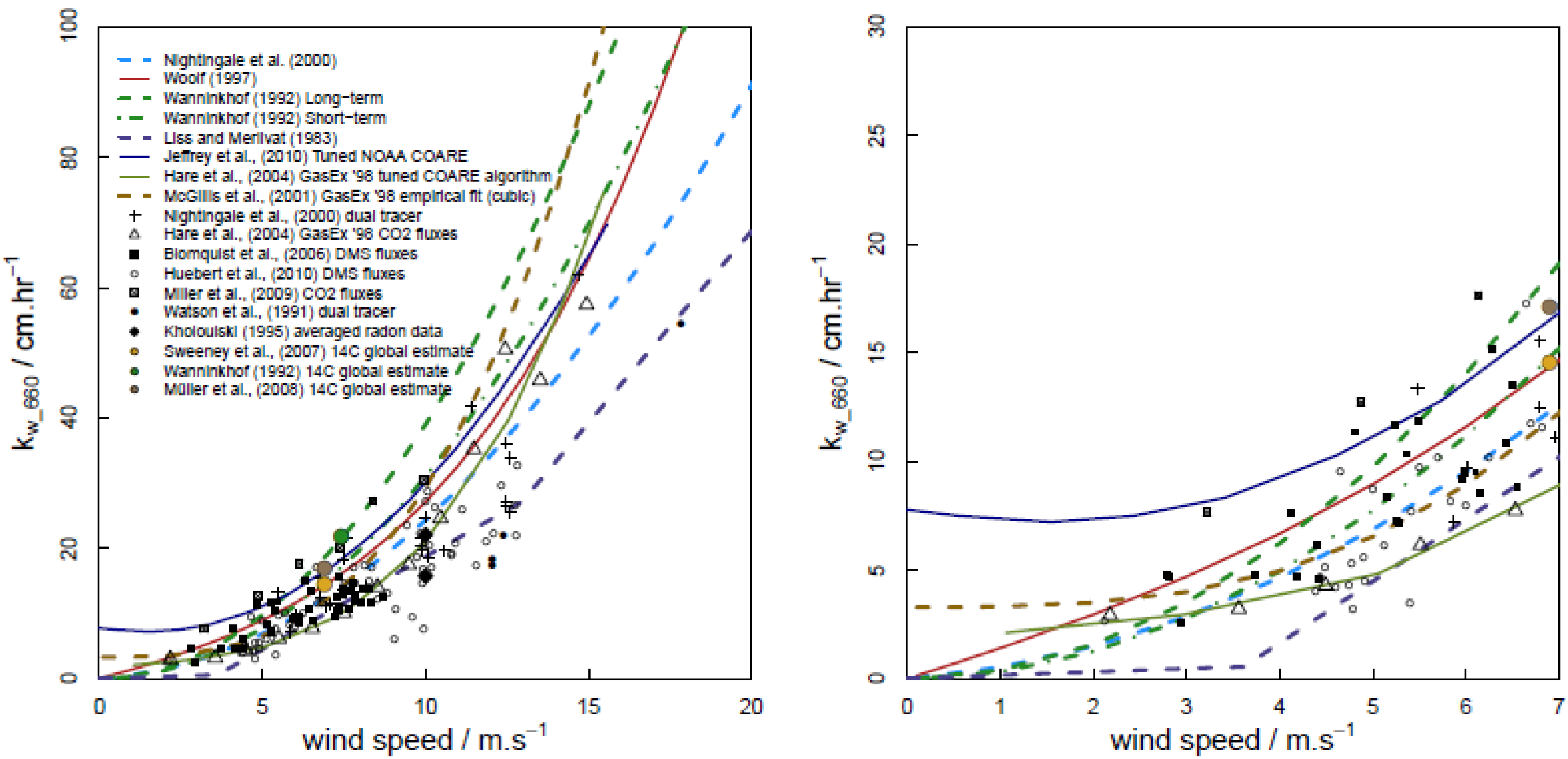
FILLING THE GAP OF IN SITU CO_2 FLUXES DURING LOW WIND CONDITIONS

Mariana Ribas Ribas
WG Sea Surface





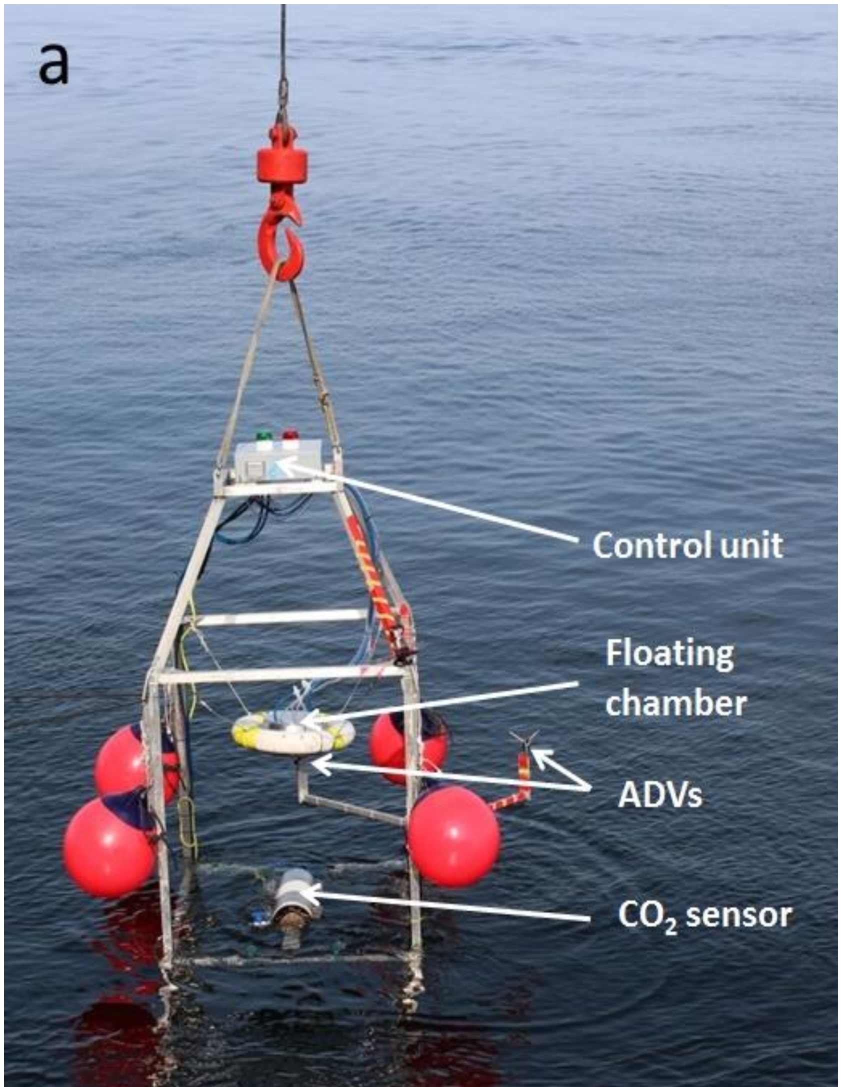
http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.derived.html



Parametrizations available but missing values for low and high winds

Johnson, 2010

AN AUTONOMOUS DRIFTING BUOY TO MEASURE AIR-SEA CO_2 FLUXES



PROBLEM with floating chambers: overestimate fluxes due to the creation of additional turbulence at the water surface.

We correct fluxes by measuring turbulence with two Acoustic Doppler Velocimeter (ADVs).

OBJECTIVE: Develop an autonomous drifting buoy to measure *in situ* air-sea CO_2 fluxes with high temporal resolution and minimizing known biases.

General information:

Height and width 2.5 m x 1.2 m

Weight 150 kg

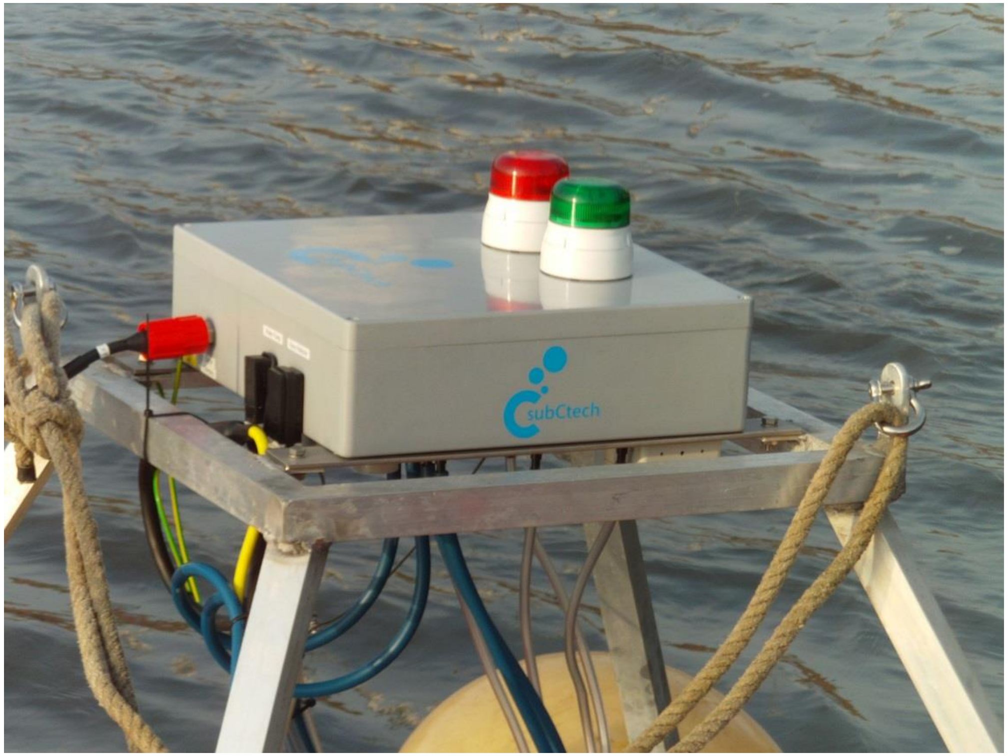
Operation time up 20 hours

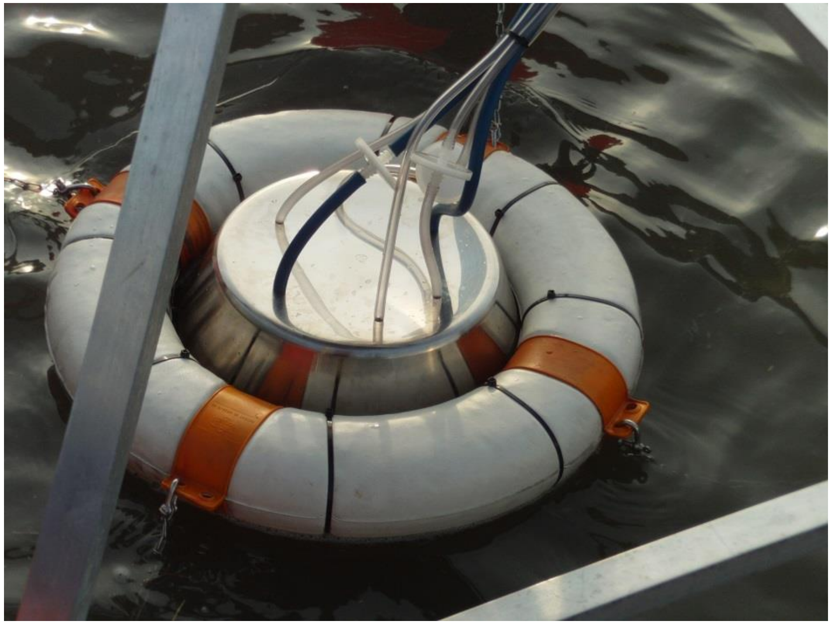
Deployment tested with wind up to 10 m s^{-1}

Buoys were place at each corner for buoyancy

Control unit:
Code by lights provides information which measurement is taken.

1. Ambient air measurement + chamber flushing with ambient air: 10 minutes
2. Inside floating chamber measurement: 15 minutes
3. Water measurement: 20 minutes



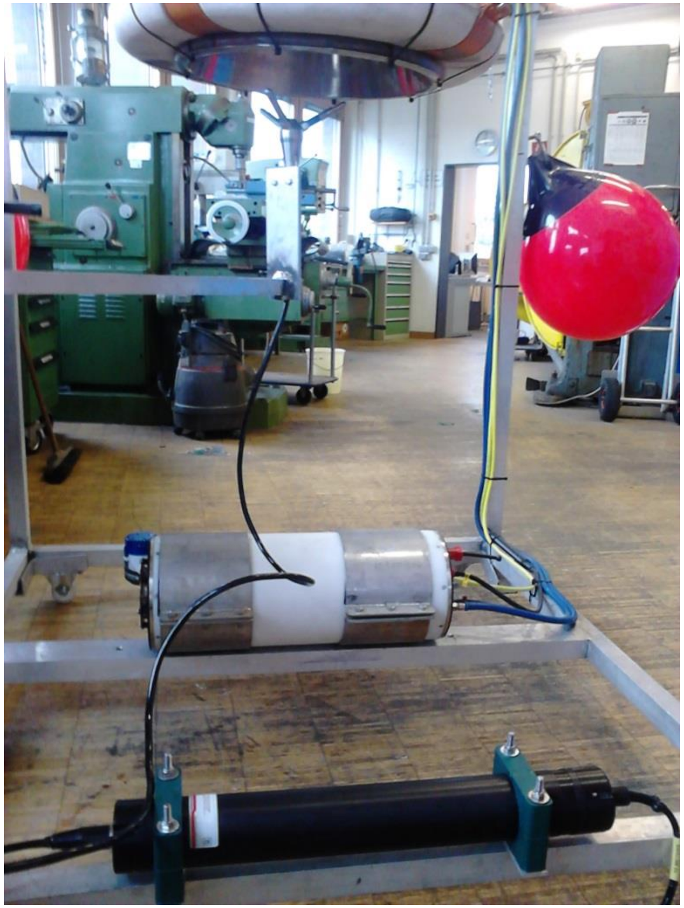


Floating chamber:
To measure the rate of CO_2 accumulation.

- Volume 7 L
- Diameter: 38 cm
- Surface area: 0.1 m^2
- Made of aluminum.
- 4 cm wall penetrating into water.
- Temperature, pressure and humidity sensor inside.

CO_2 sensor:
Infrared gas analyzer (IRGA) (SubCtech OceanPack™, LI-COR LI-840x)

The IRGA calibration was checked before and after the sampling campaign with five standard gases. The accuracy was better than 1.5 %.



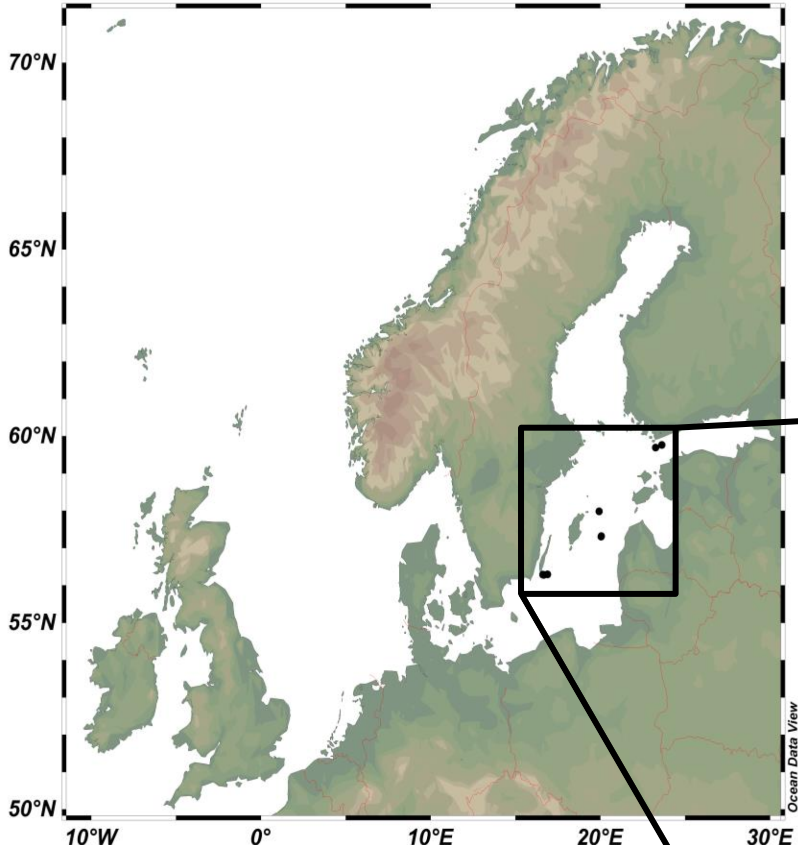

IMU-Head
SLAVE-Head
SLAVE
IMU

Acoustic Doppler Velocimeters (ADVs) (Nortek Mhz):

ADV#1: 10 cm directly underneath the center of the floating chamber, equipped with Microstrain 3DM-GX3 inertial measurement unit (**IMU**) with synchronous data acquisition.
ADV#2: 55 cm outside the perimeter of the chamber, positioned sideways (SLAVE).

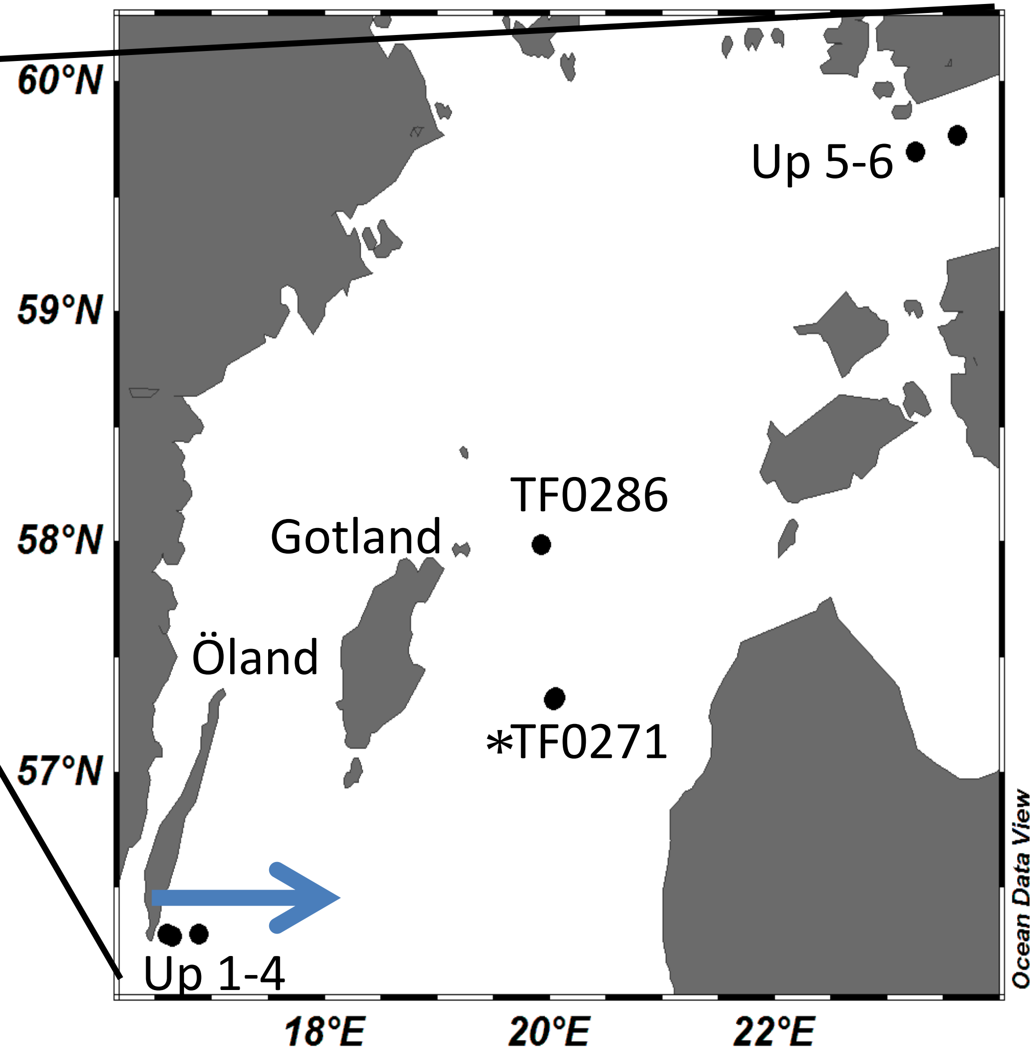
Sampling frequency: 32/16 Hz in the local XYZ coordinate system
Nominal velocity range: 2 m s^{-1}
Sampling volume: 0.01 m diameter measured above the sensor.

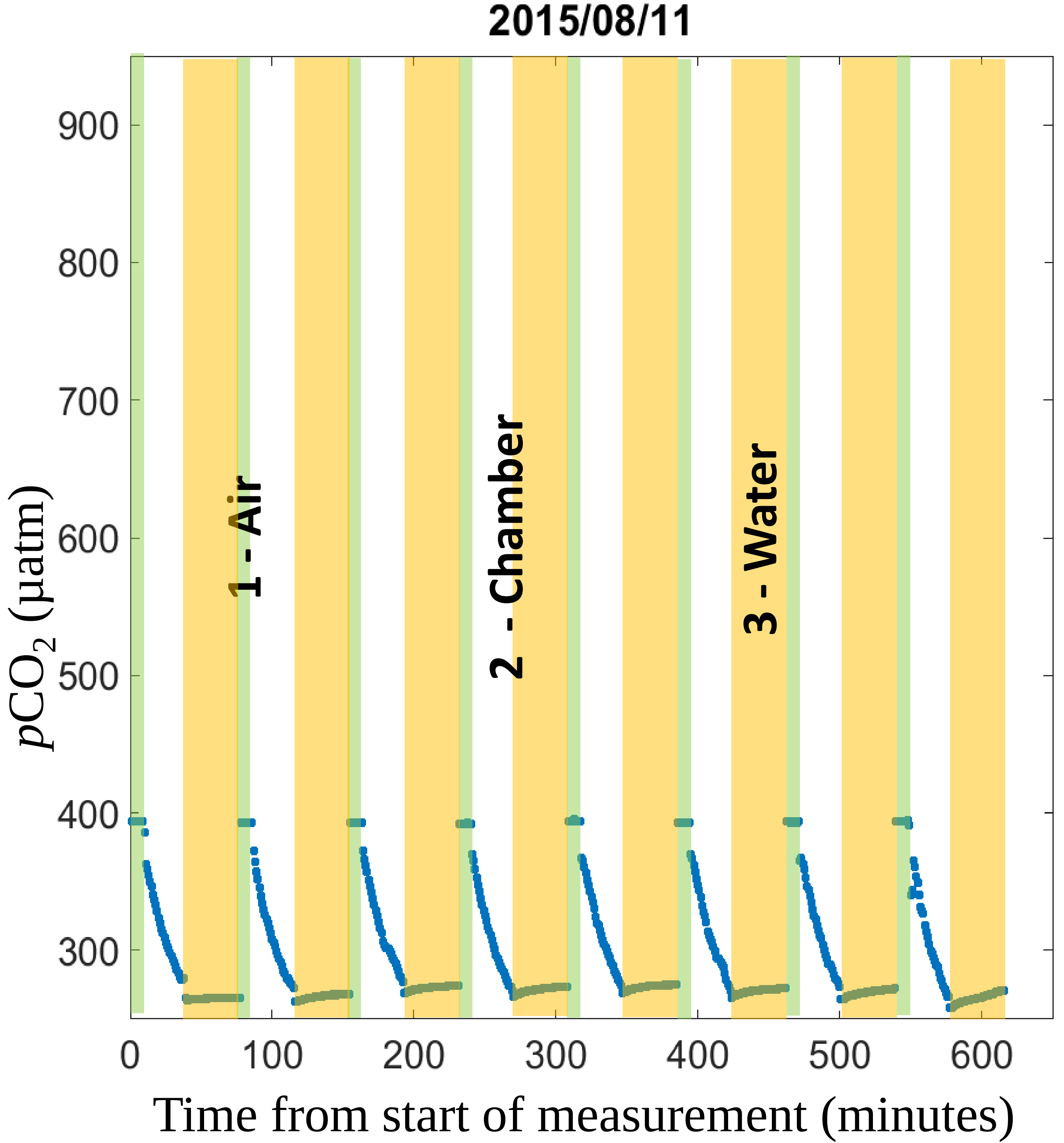
3- Preliminary results: Baltic Sea cruise (summer 2015)

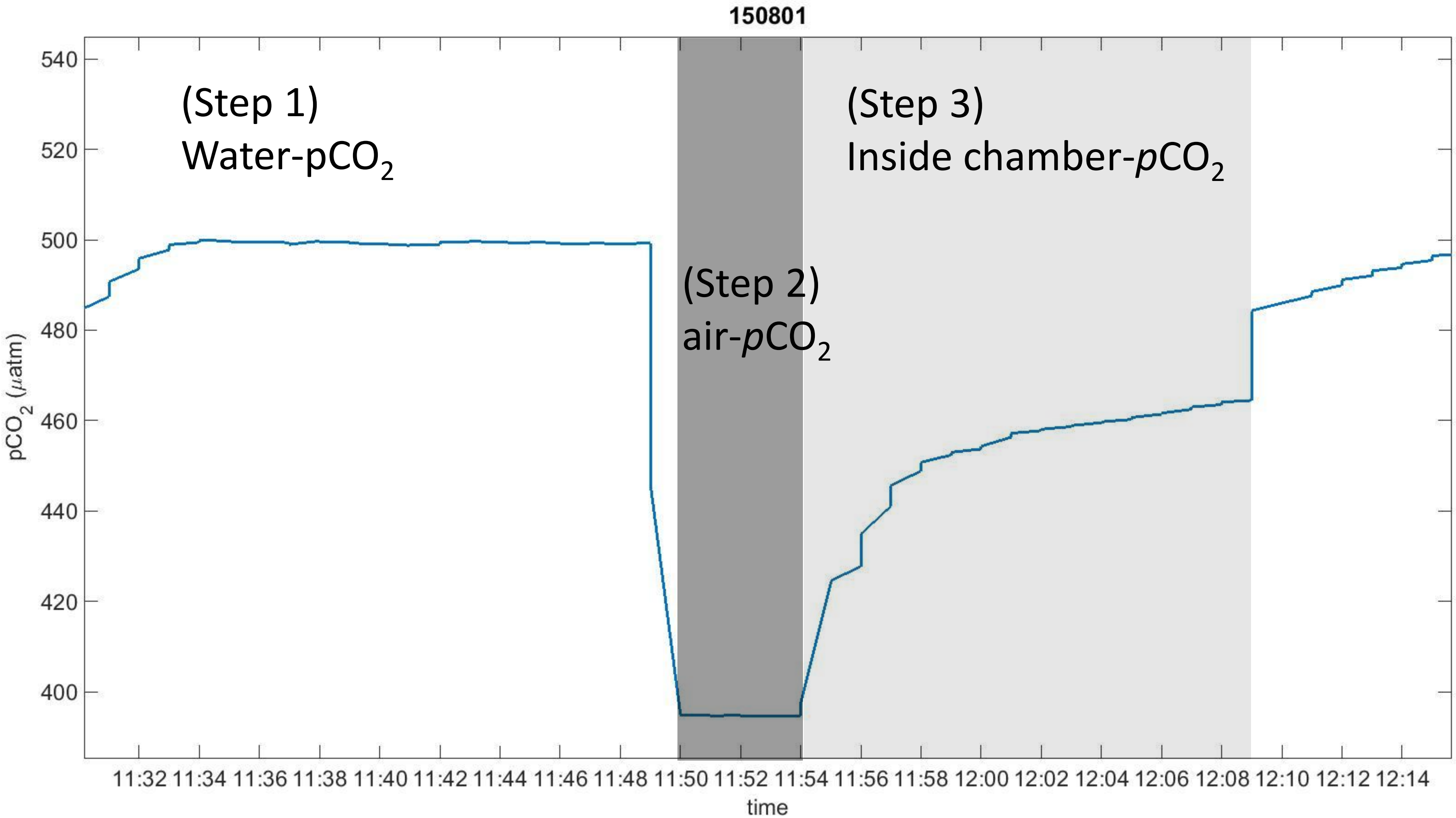


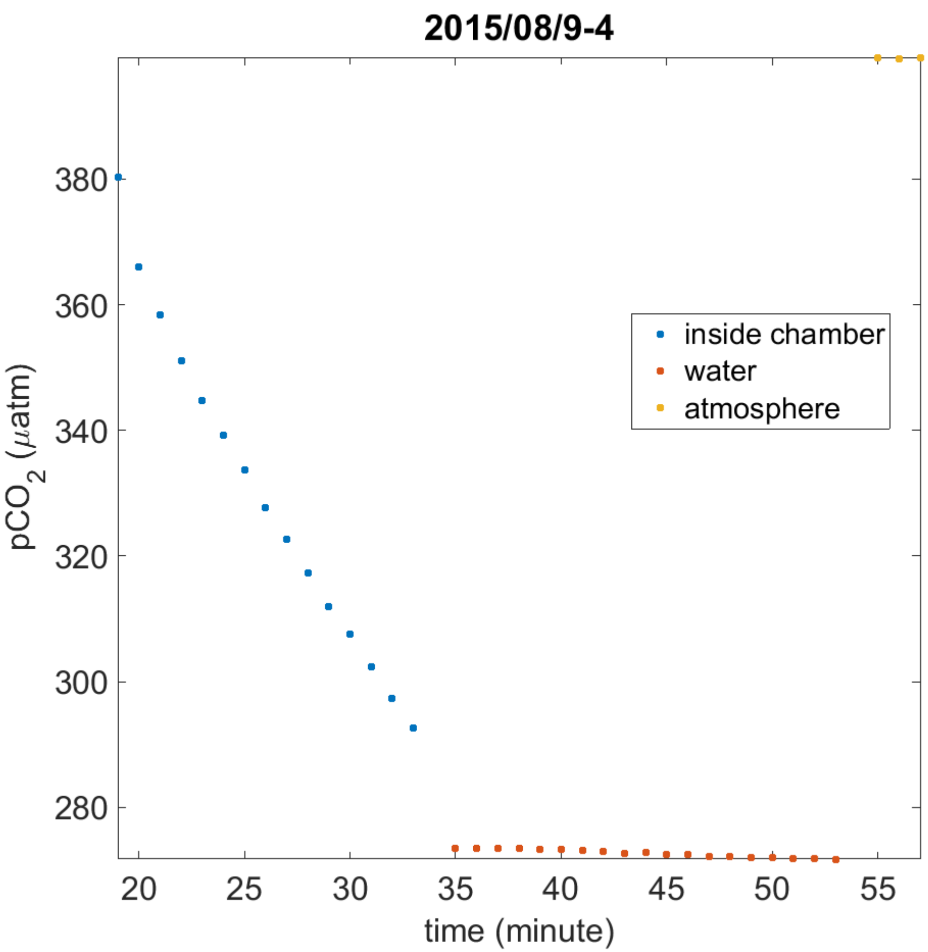
U_{10}-> 2.8: 8.9 m/s

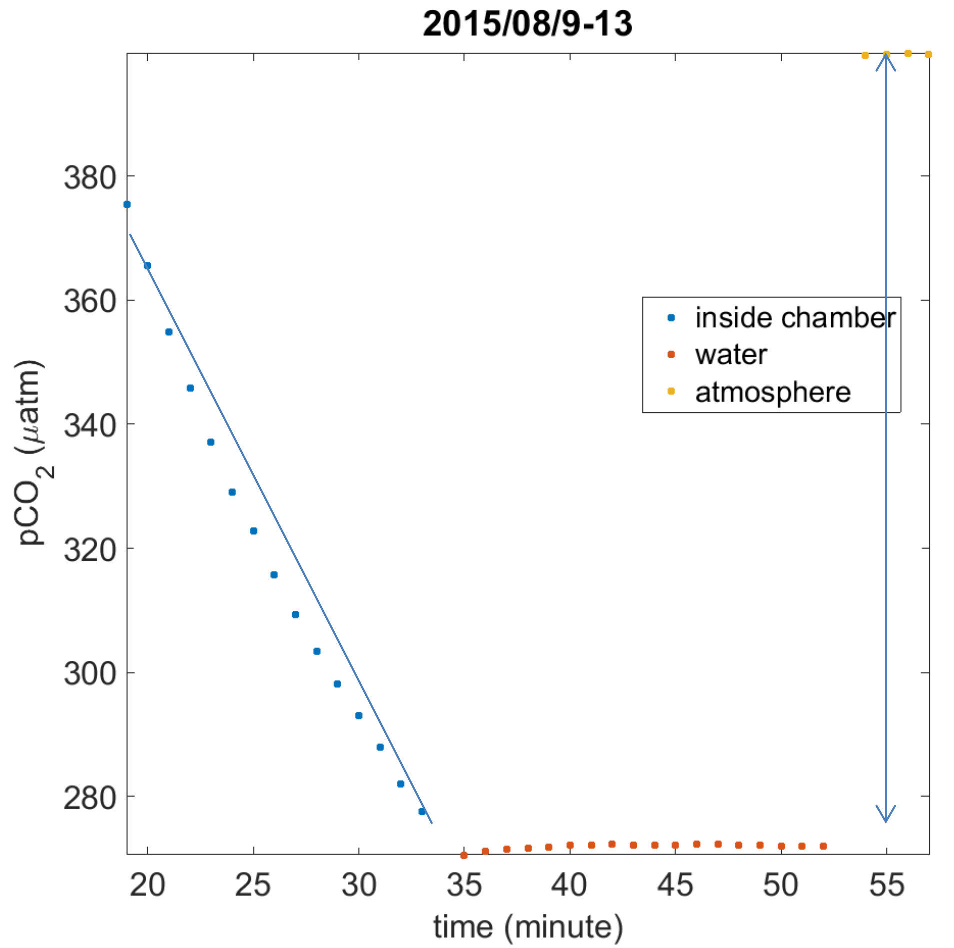
ΔpCO_2-> 64.7: -123.0 µatm




2015/08/11
900
800
700
600
500
400
300
0
100
200
300
400
500
600
1 - Air
2 - Chamber
3 - Water
pCO2 (µatm)
Time from start of measurement (minutes)


150801
(Step 1)
Water-pCO2
(Step 2)
air-pCO2
(Step 3)
Inside chamber-pCO2
pCO2 (μatm)
540
520
500
480
460
440
420
400
11:32 11:34 11:36 11:38 11:40 11:42 11:44 11:46 11:48 11:50 11:52 11:54 11:56 11:58 12:00 12:02 12:04 12:06 12:08 12:10 12:12 12:14
time





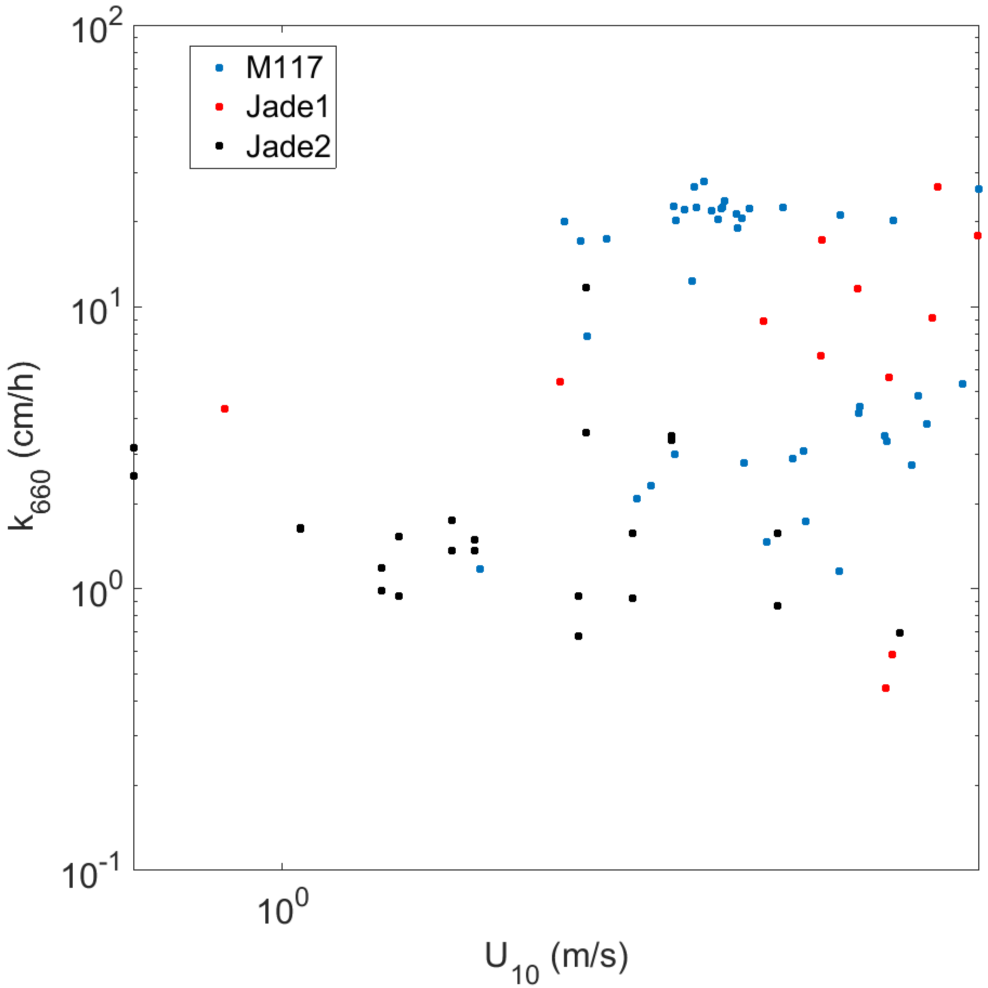
- Calculate the slope (b)
- Calculate ΔpCO_2

- Schmidt number exponent:

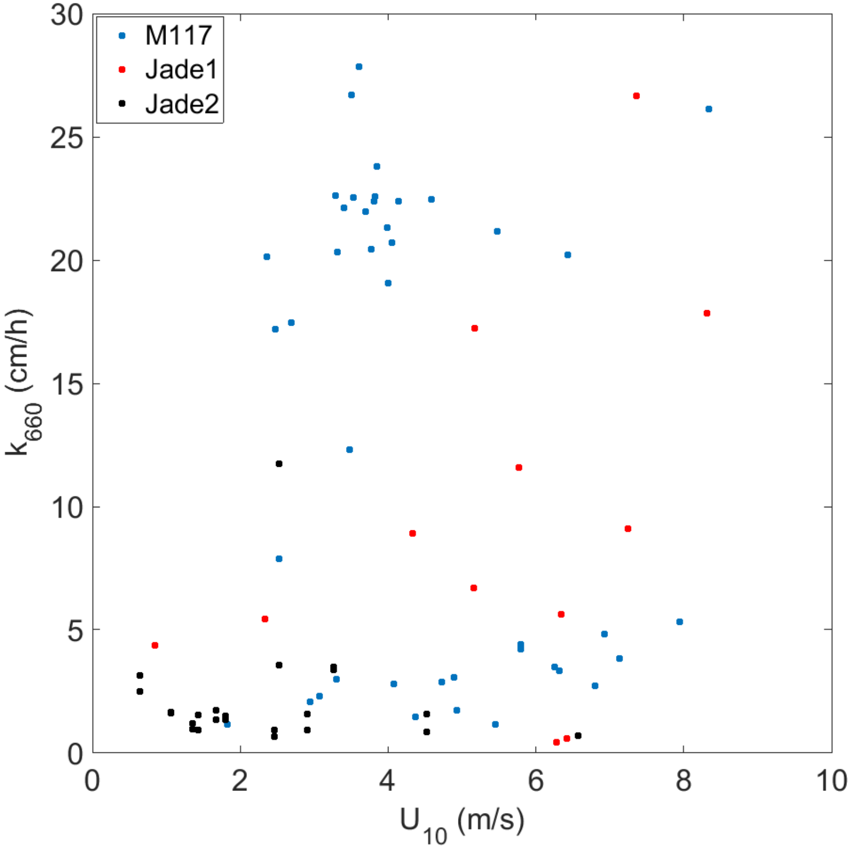
if $U_{10} \geq 5$ $n = 1/2$;

if $U_{10} < 5$ $n = 2/3$;

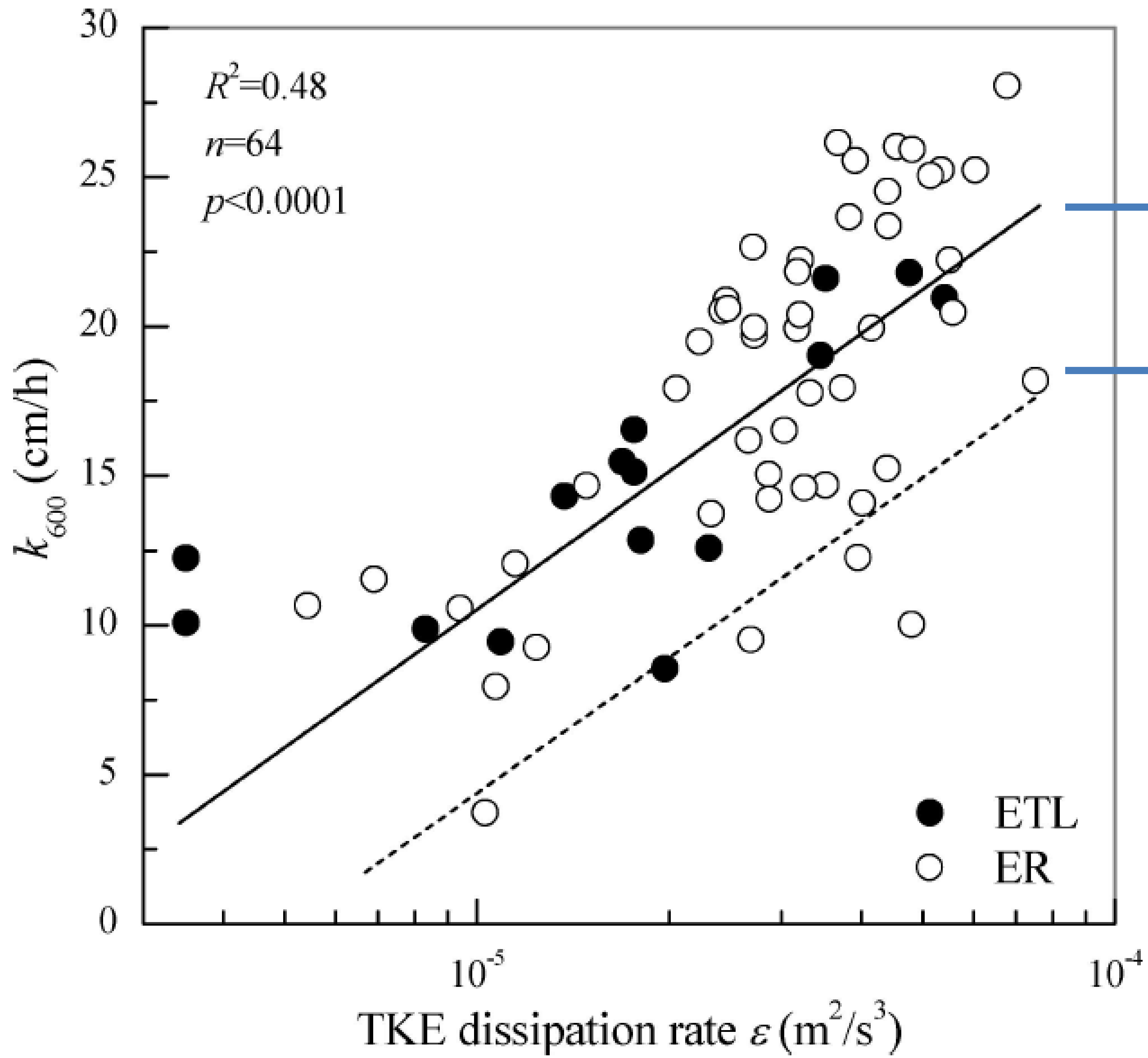
- Solubility (S) [mol/ L atm]
- $k = \frac{V}{A}\frac{b}{TS\Delta pCO_2}$



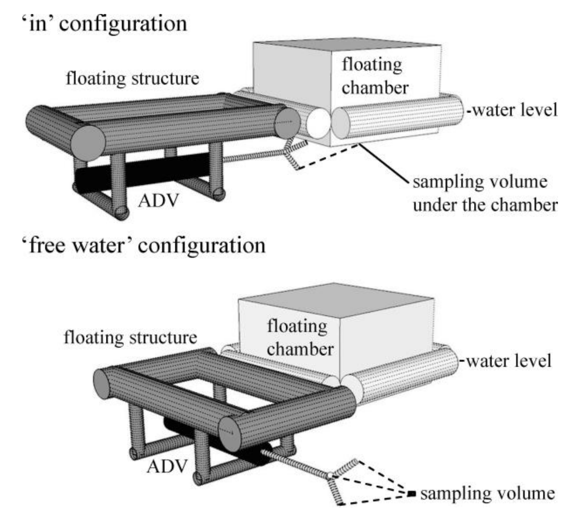
M117
Jade1
Jade2
10^{2}
10^{1}
10^{0}
10^{-1}
k_{660} (cm/h)
10^{0}
U_{10} (m/s)



M117
Jade1
Jade2
30
25
20
15
10
5
0
k_{660} (cm/h)
0
2
4
6
8
10
U_{10} (m/s)



R^2=0.48
n=64
p<0.0001
ETL
ER
k_{600} (cm/h)
TKE dissipation rate ε (m^2/s^3)
Free water
In configuration



'in' configuration
floating structure
floating chamber
water level
ADV
sampling volume under the chamber
'free water' configuration
floating structure
floating chamber
water level
ADV
sampling volume

Importance

- New drifting buoy is a powerful tool to improve our understanding of gas transfer velocity through *in situ* measurements.

- Integrated ADVs + IMU to correct for artificial turbulence and buoy's own movement.

- High temporal (every 40 minutes) and spatial resolution.

- Providing new insights in k parametrization, especially for low wind speeds, where most parametrizations fail.

- $k \neq 0$ cm/s + $\uparrow \Delta pCO_2$ (@ low wind speed, during Summer in Baltic Sea for example) $\rightarrow$ different sink capacity and carbon budgets.

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#PassMeProject

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