FILLING THE GAP OF IN SITU CO$_2$ FLUXES DURING LOW WIND CONDITIONS
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 CO₂ 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 to 20 hours  
Deployment tested with wind up to 10 m s\(^{-1}\)  
Buoys were placed 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.
**CO₂ 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 %.
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)

$U_{10} \rightarrow 2.8: 8.9 \text{ m/s}$

$\Delta p\text{CO}_2 \rightarrow 64.7: -123.0 \mu\text{atm}$
2015/08/11

Time from start of measurement (minutes)

$\text{pCO}_2 (\mu \text{atm})$

1 - Air

2 - Chamber

3 - Water
(Step 1)
Water-$p$CO$_2$

(Step 2)
air-$p$CO$_2$

(Step 3)
Inside chamber-$p$CO$_2$
- Calculate the slope (b)
- Calculate $\Delta pCO_2$

- Schmidt number exponent:
  - if $U_{10} \geq 5$  \( n = 1/2; \)
  - if $U_{10} < 5$  \( n = 2/3; \)

- Solubility (S) [mol/ L atm]
- \( k = \frac{V}{AT S \Delta pCO_2} b \)
Free water

In configuration

$R^2 = 0.48$
$n = 64$
$p < 0.0001$

$k_{600} \text{ (cm/h)}$

$TKE \text{ dissipation rate } \varepsilon \text{ (m}^2/\text{s}^3\text{)}$
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.

• $k \neq 0 \text{ cm/s} + \Delta p \text{CO}_2$ (@ low wind speed, during Summer in Baltic Sea for example) $\rightarrow$ different sink capacity and carbon budgets.
@MarianaSquare
#PassMeProject

Web: https://www.icbm.de/en/sea-surfaces
Email: mariana.ribas.ribas@uni-oldenburg.de
Blog: https://marianaribasribas.wordpress.com/