High frequency study of processes controlling air-sea CO_2 fluxes in the Western Channel

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Objectives

The main objectives were to use statistical tools to :

- Distinguish different regimes controlling air-sea CO_2 fluxes in a coastal environment strongly influenced by the tidal regimes
- Separate the signals of different coastal water masses
- Detect the different phases of the bloom

Origin of the data set

To study air-sea CO_2 exchanges in coastal environments, a CTD (SeaBird SBE16+) and a SAMI-CO_2 sensor were installed underneath the ASTAN buoy, located in the south of the Western English Channel (WEC) off Roscoff (48°44'55N 3°57'40W, depth 5m). During the year 2015, five environmental parameters are measured, supplemented by external data.

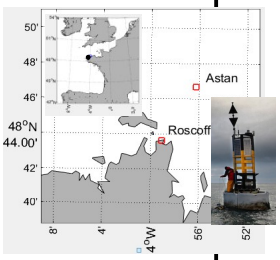


Fig. 1 Location of the study site

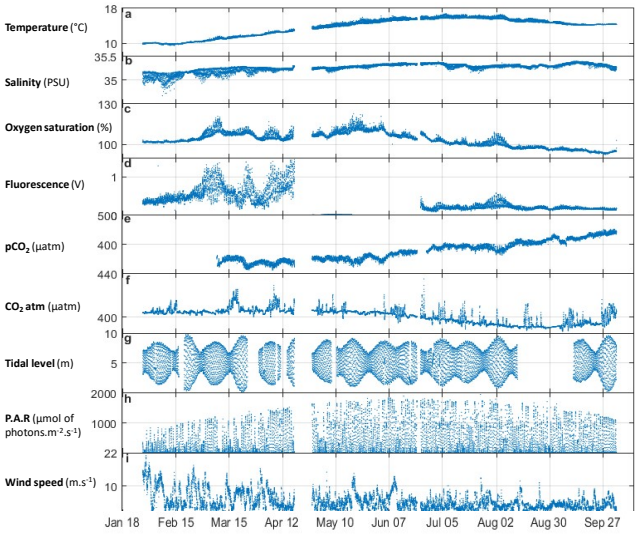


Fig. 2 Data set

Separation of signals by frequency analysis

A wavelet analysis of the CO_2 fluxes makes permits to highlight the periodicities as well as the modifications of these periods over time.

A differentiation between levels of distinct fluxes is observed from March to June. It corresponds to the difference between spring tide and neap tide, indicating two distinct water masses at the observation buoy.

From June, this signal disappears. So, we can notice that the two masses have similar properties, caused by favorable physicochemical conditions (temperature increase, significant respiration, degradation of organic matter…)

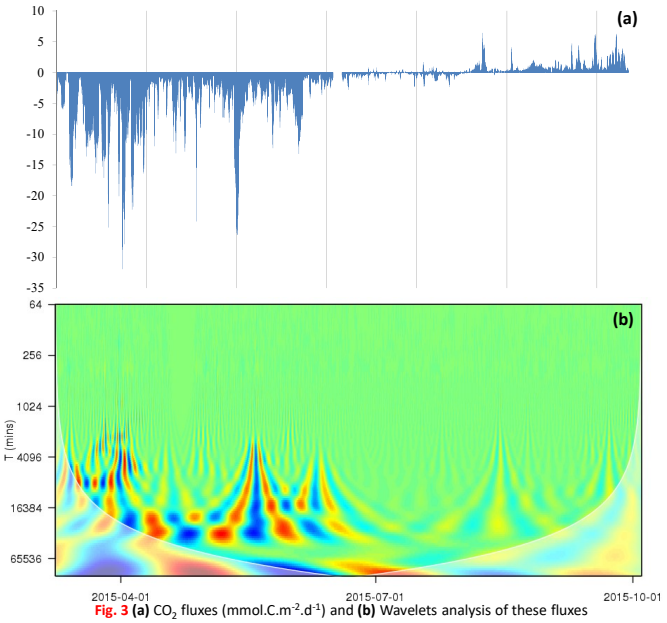


Fig. 3 **(a)** CO_2 fluxes (mmol.C.m^{-2}.d^{-1}) and **(b)** Wavelets analysis of these fluxes

Separation of signals by multivariate analysis

The Hidden Markov Model (HMM) allows to separate the signal. From the data of selected parameters (surface sea temperature, surface sea salinity, dissolved oxygen, fluorescence, pCO_2 and P.A.R) five clusters are determined. This clusters separate the signal in the different parts of the bloom. During the 2nd bloom, the day-night signal of the different parameters is significant allowing to differentiate two clusters.

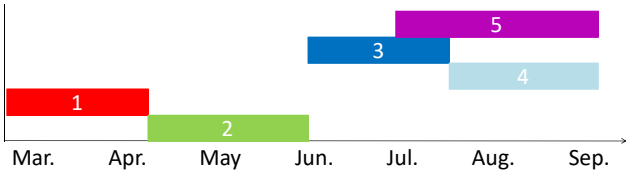
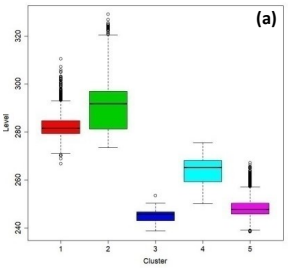


Fig. 4 Clusters obtained by HMM with **(1)** pre-bloom, **(2)** bloom, **(3)** after bloom, **(4)** day of the 2nd bloom and **(5)** night of 2nd bloom.



It is possible to distinguish the day with higher dissolved O_2 contents and lower concentrations of CO_2 from the night. It shows the importance of biology during daytime cycles on these parameters.

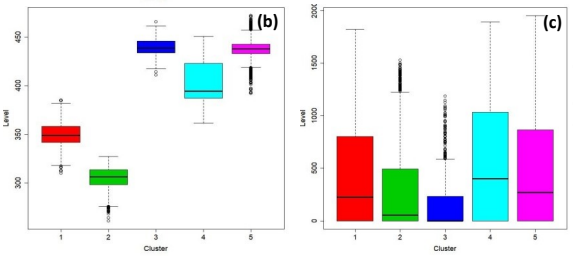


Fig. 5 Cluster boxplot for **(a)** dissolved O_2 (µmol/mL) **(b)** pCO_2 (µatm) and **(c)** P.A.R. (µmol photons.m^{-2}.s^{-1})

Conclusions

In order to understand processes controlling air-sea CO_2 fluxes in the coastal environment, signals processing tools were used to analyze the signals obtained by high-frequency sensors.

A signal analysis allowed to understand the different physical and biological schemes. Without indicating to the model information on the environment, it is possible to find the different regimes controlling the levels of pCO_2.

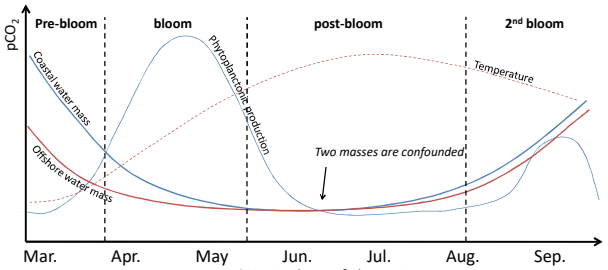


Fig. 6 Synthesis of observations