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Annual cycle reconstitution of pCO_2 over the Western Mediterranean for the year 2011

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Abstract

Many authors tried to determine the annual variation of the pCO_2 in the northwestern Mediterranean using most of the times direct measurements or remote sensing data coupled with modeling (e.g. Hood and Merlivat, 2001; Copin-Montégut et al., 2004; D'Ortenzio et al., 2008). In this study, we tried to reconstruct the annual cycle of pCO_2 over the whole Western Mediterranean by using a new method, which consists of the use of direct carbonate system measurements to deduce multiparametric linear regressions of DIC and TA. This extrapolation to the basin scale allows the pCO_2 computation by applying it to a monthly climatology (T, S, AOU).

The calculated pCO_2 shows that the Western Mediterranean is an overall sink of CO_2 in winter and spring with a minimum pCO_2 of about 320µatm. In summer and autumn, it is a source of CO_2 to the atmosphere with a maximum pCO_2 of about 445µatm. These variations are mostly due to the combined effect of temperature variations (~13 to 26 °C) and biological production. This study results are very close to those obtained by direct observations by Copin-Montégut et al. (2004) where the annual variations in pCO_2 range from 315 to 450 µatm in the Ligurian current.

Keywords : Annual cycle, pCO_2, Western Mediterranean.

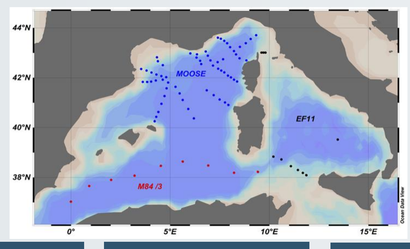
Introduction

Several studies showed that the Mediterranean is an important sink of CO_2 and that it's completely invaded by anthropogenic carbon. Future levels of atmospheric CO_2 depend on the evolution of the regulatory processes within the seawaters; it is for example assumed that a warmer ocean will absorb less carbon. Therefore, a better understanding of pCO_2 annual cycle over the whole Mediterranean will allow us to separate the seasonal natural variability from the effect of CO_2 inputs and thus to predict future trends.

Data and Methods

An attempt to reconstruct pCO_2 annual cycle over the Western Mediterranean surface waters is presented in this study. Multilinear regressions of surface total inorganic carbon (DIC) and surface alkalinity (TA) were performed using three cruises datasets that took place in 2011 (M84/3, MOOSE, EF11). These regressions were tested over existing data from different seasons then applied to a monthly climatology (S, T, AOU) derived from MEDAR/MEDATLAS II data collected over 50 years (1950-2000).

pCO_2 Annual cycle reconstruction (2011)



Liguro-provençal Basin MOOSE (May-July 2011) | **Algerian Basin** M84/3 (April 2011) | **Tyrrhenian Basin** EF11 (April-May 2011)

Multi-parametric linear regressions

$DIC = -5.432\ \theta + 84.471\ S + 0.218\ AOU - 870.726 \pm 10.41$ µmol/kg, $r^2 = 0.95$
$TA = 94.118\ S - 1032.814 \pm 5.01$ µmol/kg, $r^2 = 0.98$

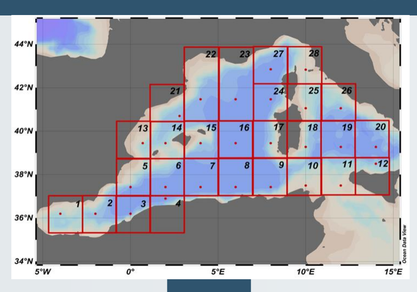
Regressions validation

The regressions were tested over SOMBA cruise data (August-Sept 2014) ± 14.5 µmol/kg for DIC & ± 6.5 µmol/kg for TA

Monthly climatology

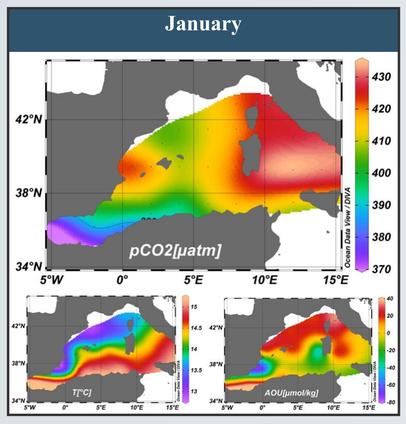
A mean monthly climatology was reconstructed using MEDAR/ MEDATLAS II (1950-2000)

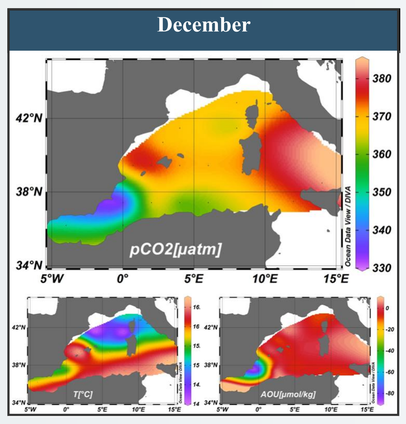
The Western Mediterranean was divided into a grid of 28 boxes

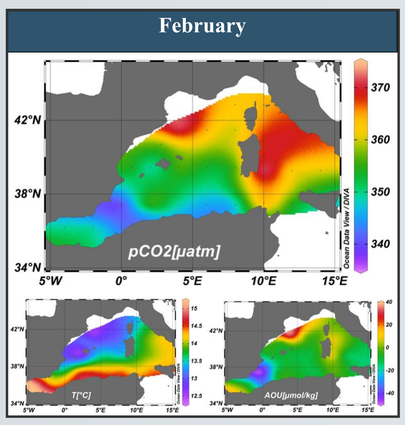


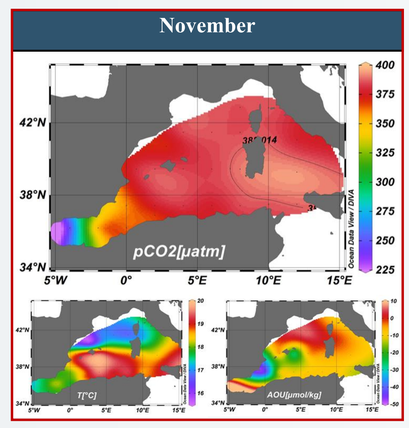
pCO_2 computation

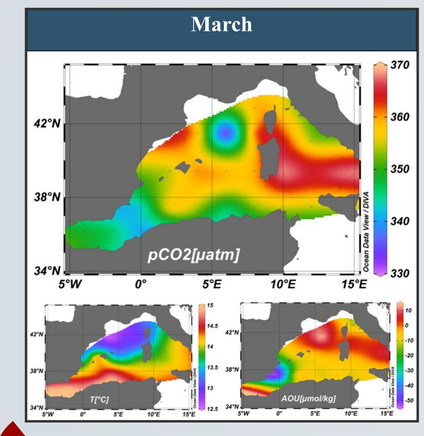
Using CO2Sys_v2.1 and Alvarez et al. (2014) parameterization (K1, K2 from Mehrbach et al., 1973 refit by Dickson and Millero, 1987 ; Total scale pH; Sulphate constant of Dickson (1990); borates parameterization of Uppström , 1974).

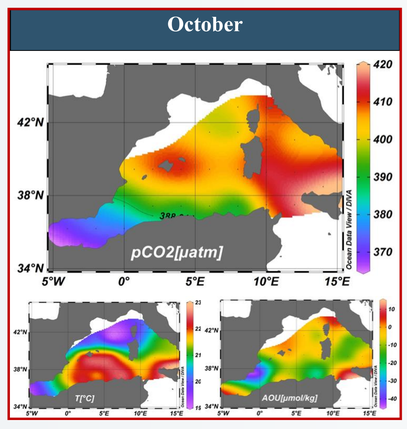






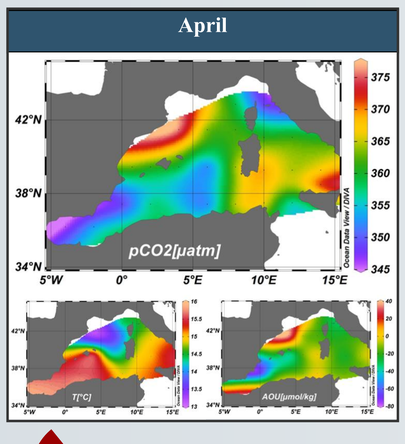


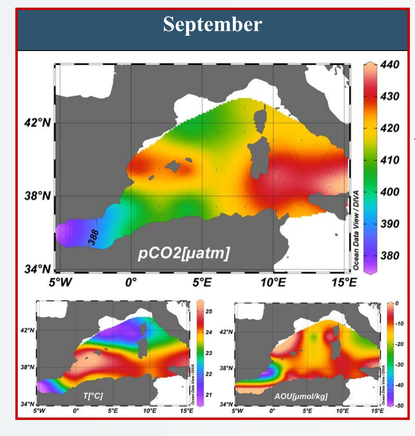




Air
388 µatm
Sea
CO_2 SINK

CO_2 SOURCE
Air
388 µatm
Sea



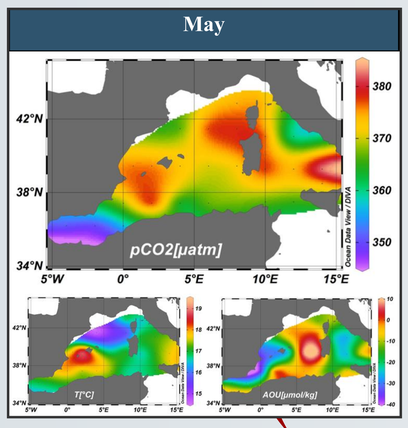


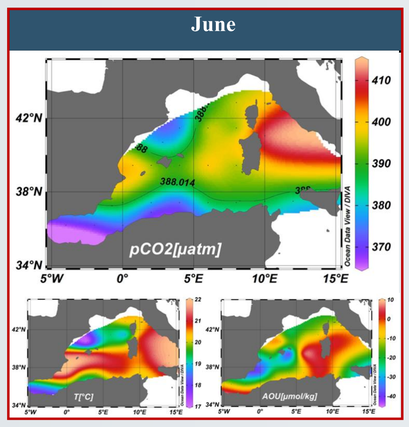
Results

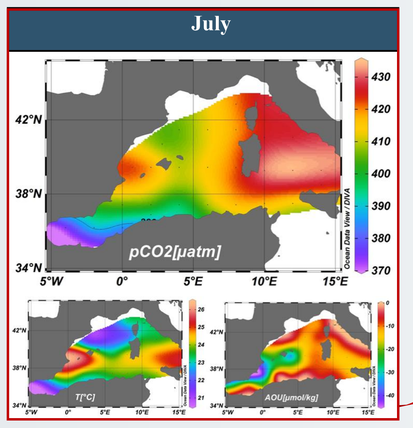
The calculated pCO_2 shows that the Western Mediterranean is an overall sink of CO_2 in winter and spring (from December to May) with a minimum pCO_2 of about 320µatm in January (Algerian basin) and March (Liguro-provençal basin) due probably to thermic effect and photosynthetic activity respectively. In summer and autumn (from June to November), the Western Mediterranean is a source of CO_2 to the atmosphere with a maximum pCO_2 of about 445µatm in August and September, probably because of the thermic effect.

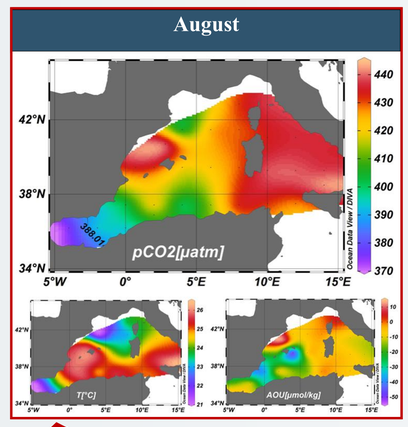
Conclusion & Perspectives

- This approach seems attractive. Nevertheless, further studies and comparisons with other existing approaches (direct measurements, remote sensing) will allow the validation of this method.
- The next step will be the reconstitution of pCO_2 annual cycle of the whole Mediterranean.









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