Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2019-119-RC1, 2019

Interactive comment on “Ocean carbonate system variability in the North Atlantic Subpolar surface water (1993–2017)” *by* Coraline Leseurre et al.

Anonymous Referee #1

Received and published: 18 April 2019

Reference: bg-2019-119 Ocean carbonate system variability in the North Atlantic Subpolar surface water (1993-2017) Coraline Leseurre, Claire Lo Monaco, Gilles Reverdin, Nicolas Metzl, Jonathan Fin, Solveig Olafsdottir and Virginie Racapé.

General Comments This short manuscript describes the different trends in CO2 fugacity (fCO2) in the North Atlantic Subpolar Gyre (50°N-64°N) considering three different periods based on the observations of the long-term monitoring program SURATLANT. Reverdin et al. (2018) have previously described these observations in an article in ESSD. Changes in pH and aragonite saturation, variables quasilinear dependent on CO2 fugacity, are also described. As shown in the manuscript itself (p.2 l.25) is this an extension of the previous analyses made by Corbière et al., 2007; Metzl et al., 2010, there was practically nothing new. The new data given in figure 3 only represents 1/3

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Discussion paper

of the complete serie. A large part of the data and the half of figures come from the article by Reverdin et al. (2018). The description of the seasonal cycles shown by Reverdin et al. (2018) are different from those shown here without showing the reason for it. This puts in doubt that the interannual changes given for winter and summer cannot be affected by a poor quantification of the annual cycle in part due to low temporal coverage that can generate aliasing problems. The manuscript tries to describe the main drivers associated with CO2 chemistry using the same methodology shown in Metzl et al. (2010) for fCO2 and also García-Ibañez et al (2016) for pH. However, the relationship between the drivers and the main processes occurring in North Subpolar gyre is unfortunately very poorly developed. Partly because the authors seem to be unaware of key articles that have demonstrated the main patterns of variation linked to the NAO (Thomas et al. 2008, Keller et al. 2012, Schuster et al. 2013 and Pérez et al. 2013). In terms of acidification rates, the article by Garcia-Ibañez et al. (2016) is also ignored. Very imprecise in the description of the processes involved, mixing anthropogenic factor with natural processes without a clear target. The manuscript cites the well-known key processes of water mass transformations. Besides, the drivers are disjointed way with any change with the water column chemistry. It continuously mixes the anthropogenic and non-anthropogenic changes or flows of CO2. Methodology poorly described. For interannual estimates the seasonal variability is not eliminated, which calls into question whether rates of change can be affected by changes in the annual cycle or biases in the relatively low frequency of observations.

Specific remarks P.1 Line 25 “As a consequence, the future evolution of air-sea CO2 fluxes, pH and the saturation state of surface waters with regards to aragonite and calcite remain highly uncertain in this region”. This is a very weak point of the manuscript, since despite analyzing the drivers does not allow them to make future evolutions. P.2 Lines 3-4 “ covering 5% of the global surface ocean, is responsible for 20% of the oceanic uptake of anthropogenic CO2 (Khatiwala et al., 2013), with a mean annual air-sea CO2 flux estimated at 0.27 PgC/yr (Takahashi et al., 2009).” This is misleading. North Atlantic accumulates 20% anthropogenic CO2. The uptake can be produce in the subtropical regions and transported northwards. The rate given by Takahashi et al. 2009 included a big component of natural CO2 mostly due to the cooling of northward advected subtropical water and by biological carbon fixation in the subpolar gyre (Thomas et al. 2008; Perez et al. 2013) P.5 Line 25 “The seasonal changes in fCO2 and pH are anticorrelated” This a consequence of the marine carbonic system when the alkalinity variability is so low as occurs in the North Atlantic. P.6 Line 27 ”but it is due to a large increase in DIC rather than warming (Table 2), and as a consequence, it is accompanied by a rapid decrease in Ω” Why? Reduction of the vertical winter missing by cooling typical of the Irminger? P.6 Line 30 “a need to further investigate the drivers of TA variability, which seem partially decoupled from surface” : However, Reverdin et al. 2018 show a perfect linear regression between TA and salinity, and the manuscript used this relationship to fill the gap of many observations without a second carbonic system variable. P.8 Line 20 “saturation with respect to calcium carbonate (Ω)”. This is a speculative addendum given the strong uncertainties and possible aliasing due to the seasonal coverture of the data. Fig 1 and Fig 2 come from Reverdin et al. 2018.

References : Thomas, et al. 2008. Changes in the North Atlantic Oscillation influence CO2 uptake in the North Atlantic over the past 2 decades, Global Biogeochem. Cycles, 22, GB4027, doi:10.1029/2007GB003167 Keller et al. 2012 Variability of the ocean carbon cycle in response to the North Atlantic Oscillation. Tellus B 2012, 64, 18738, http://dx.doi.org/10.3402/tellusb.v64i0.18738 Schuster et al. 2013 An assessment of the Atlantic and Arctic sea–air CO2 fluxes, 1990–2009. Biogeosciences, 10, 607-627, https://doi.org/10.5194/bg-10-607-2013. Perez et al. 2013, Atlantic Ocean CO2 uptake reduced by weakening of the meridional overturning circulation Nature Geoscience, 6 doi: 10.1038/ngeo1680 García-Ibáñez et al. 2016 Ocean acidification in the subpolar North Atlantic: rates and mechanisms controlling pH changes . Biogeosciences, 13, 3701–3715, 2016, doi:10.5194/bg-13-3701-2016

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2019-119, 2019.