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Biogeosciences Discussions



# *Interactive comment on* "The northern European shelf as increasing net sink for $CO_2$" *by* Meike Becker et al.

**Anonymous Referee #1**

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MAJOR COMMENTS

The authors use a MLR approach applied to the SOCAT CO2 data-base to reconstruct a spatially and temporally resolved data-set from 1998 to 2018 in the European continental shelf. From this data-set the authors analyze the temporal trends of pCO2 during winter in different regions (North Sea, Baltic Sea, Norwegian coast & Barents seas) that are compared to the increase of atmospheric CO2.

A more detailed and in-depth analysis could be made. For instance, the authors compute the trends based on winter-only data. However, since they have a fully seasonally resolved reconstructed data-set, they could also analyze the temporal trends using summer-only data. Are the trends the same ? In addition, they could compute the trends using the full annual average, which in principle should provide the most robust



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estimate of inter-annual variations since it integrates all components of seasonal variations. Are the results for the full annual average the same as the winter-only or the summer-only trends?

The other question that the authors could attempt to address is how useful is this MRL approach compared the raw SOCAT data-set to compute temporal trends. So, would the analysis of temporal trends of the raw SOCAT data give the same results as the MRL expanded data-set ? Of course this would require to aggregate the raw data into larger boxes (for instance 3 large boxes for the North Sea: southern bight of the North Sea, Central North Sea and Northern North Sea) to overcome the lower coverage of the raw SOCAT data. This question is motivated by the fact that the European Shelf is one of the areas which is most dense in CO2 data, so that you need to address the question of the usefulness of using a complex MRL approach to reconstruct and gap-fill for an original data-set that is one of the most dense for continental shelves.

Figure 9 shows that in the Southern bight of the North Sea (<53°N) there's a very strong difference between the part along the UK coast (red color = strong increase of pCO2 in time) and the part along the Dutch coast (blue color = very low increase of pCO2 in time). The two regions are clearly separated along a line that seems to correspond approximately to the 2° meridian. This line seems to also separate the Central and Northern North Sea although the differences in pCO2 trends are not as marked. But this is really strange as the spatial pCO2 distributions in the Southern Bight of the North Sea are relatively homogeneous horizontally (Thomas et al. 2004; Schiettecatte et al. 2007) so it's really odd that the temporal trends should be so different. This seems to be related to the way the MRL was implemented in the North Sea that seems to have been divided into East and West regions (along the 2° meridian) in the computation scheme (I guess). Anyway this needs to be addressed, either change the computation scheme to avoid this spatial artefact, or if this is "real" then please provide an explanation for this odd looking spatial difference.

MODERATE COMMENTS

P2 L9 : "small currents caused by the topography" does not cover the full spectrum and complexity of physical processes in continental shelves. In continental shelves there are difference buoyancy sources (thermal and haline stratification) and mixing processes (tides, upwelling, internal waves) that lead to contrasted physical settings. Please refer to classical paper by Blanton (1991).

P2 L5-14 : The introduction on the differences between coastal and open ocean waters seems to miss some important elements. CO2 patterns in costal environments are more complex that in the open ocean because overall coastal waters are more productive than open ocean, because there are several sources of nutrients such as mixing processes at continental margins (upwelling and internal wave mixing) and riverine-estuarine inputs. In addition shallow areas are vertically mixed while deeper areas are seasonally stratified. Please refer to classical paper of Wollast (1998). Overall this leads to important spatial heterogeneity and strong horizontal gradients of productivity that are reflected in equivalent gradients in surface CO2.

P2 L 15 : Please briefly explain why methods for open ocean are inadequate for coastal waters and provide references if available.

P 3 L 20 : define "winter season" in the southern north sea diatom blooms can start as early as February.

P8 L 13 Nondal et al. (2009) report a TA-salinity relation for the Northern North Atlantic Ocean that should be applicable for Norwegian coast and Barents sea but it could useful to check if it is applicable in the North Sea (e.g. Salt et al. 2013), and in particular in the Southern North Sea (Hoppema et al. 1990).

P 13 L 9-10 : Calling this comparison "validation" is a bit surprising. The authors used the SocatV5 data to generate a fCO2 data using MLR and then compare it again to the original SocatV5 data. This is not a real validation.

P14L8 you discuss data in 2017 and 2018 but at the end of the introduction (P4L3) you





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say that you look at trends from 1998 to 2016.

P18L4: Paper of Sharples covers the period 1974 and 2003, so it's a stretch to assume that the trend for the 1974-2003 was continued over the period of 1998 to 2016. There are several other papers that have addressed recent changes of phytoplankton phenology in the North Sea.

P20L6: "The lower trend stems most likely from an earlier onset of spring bloom" The authors have the data to test this, since they have reconstructed a temporally resolved data-set. If the onset of the bloom is earlier in the year, then so should the peak of the bloom. The seasonal CO2 minimum is a good proxy for peak spring phytoplankton, so the authors can check if this has changed in time and occurred earlier in the year.

P20L24: "The sea-air CO2 fluxes (Figure 12) show that most regions are a net and increasing sink for CO2. The only source net regions are the southern North Sea and the Baltic Sea. The two different regimes in the North Sea with the southern, nonstratified part being a source and the northern temporarily stratified part a sink for CO2, are well described in the literature (Thomas et al., 2004)." Thomas et al. (2004) only sampled the North Sea during 4 cruises, and their "spring" cruise was in mid-May, when the spring phytoplankton in the Southern Bight of the North Sea is over. So Thomas et al. (2004) missed the peak of the spring bloom (and minimum of CO2) that occurs in April, as clearly shown by the work of Schiettecatte et al. (2007) and Omar et al. (2010). This is why Thomas et al. (2004) reported the Southern Bight of the North Sea as a source of CO2 to the atmosphere, since their data-set does not represent the period of strong CO2 under-saturation during spring. The better seasonally resolved data-set of Schiettecatte et al. (2007) shows in fact that the Southern Bight of the North Sea is a small sink of atmospheric CO2, although admittedly lower than the Northern North Sea.

MINOR COMMENTS

The text contains several typos and inadequate terminology.

P 2 L 5 : terms like coastal seas, coastal seas or continental shelves would be more adequate than "coasts"

P8 L 12 : "calculating ocean acidification" is an awkward expression. You calculated pH from which you compute a trend. This trend is not necessarily negative (acidification). In some coastal areas an increase of pH has been reported, in other areas there is no trend (Duarte et al. 2013).

P 8 L16: "river moths" => river mouths

P19L4: "eutrification" => eutrophication

Legend of Figure 4. Is incorrect. The figures show deltafCO2 not fCO2

P17L8 : "to validate this to validate this"

P19L5 : Can you provide a reference showing the effect of eutrophication on CO2 ?

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