

# REPLY LETTER FOR THE EDITOR

Date of reply: October 27, 2017

The last changes made by the authors, relative to the submitted version of the manuscript of number os-2017-9 are described in details. Sentences from the manuscript are in *Italics*. Additions within the manuscript are also **bold**.

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During the typesetting process, some sentences and references were added to the text. This reply letter describe those changes, in order to make those changes available for the scientific community. All the authors would like to thank the editor and typesetters for the opportunity to describe the changes done in the manuscript. It follows a list of changes done in the manuscript:

→Page 2, Lines 8-10 – It came to our attention that a reference is missing here. The appropriate reference was added:

*“The dense bottom waters in the Southern Ocean are mainly formed by two mechanisms. The first mechanism is through (i) a complex interaction of deep and shelf waters and starts with deep waters, originally formed in the North Atlantic, being transported to the south through the AMOC (Ferreira and Kerr, 2017).”*

→Page 2, Lines 27-29 - Recently, a new open ocean polynya in the prime meridian has appeared (2016 and 2017), and we believe that not mentioning that polynya in this phrase might convey an erroneous information. The sentence was then changed from:

*“Although smaller ocean polynyas occurred in the 20th century (Comiso and Gordon, 1987), no winter ice-free areas in the Southern Ocean with the dimensions and persistence of the Weddell Polynya have been reported since the 1970s.”*

To the following:

*“Although smaller ocean polynyas occurred in the 20th century (Comiso and Gordon, 1987) **and in 2016 and 2017**, no winter ice-free areas in the Southern Ocean with the dimensions and persistence of the Weddell Polynya have been reported since the 1970s”*

→Page 3, Lines 21-23 – The correct date of the reference is 2008. The text now is:  
*“A Green’s function method is used to calibrate the control variables (Menemenlis et al., 2008) and the initial parameters, which include initial temperature and salinity condition...”*

→Page 4, Lines 22-23 – The communication year was missing. The text now is:  
*“Furthermore, neither the OCCA nor the SoSE were optimized to eliminate spurious drifts (M. Mazloff, personal communication, 2017).”*

→Page 6, Lines 20-21 – Plural is missing. The phrase now is:

*“In this section, we first describe the average sea ice patterns in the Southern Ocean **sectors**, its spatial signature and evidence that this property is related to the AABW formation in the reanalysis products investigated (Sect. 3.1).*

→Page 6, Lines 21-23 – The information in the parenthesis is redundant, and we chose to remove from the phrase. The sentence was changed from:

*“Section 3.2 discusses the water mass volume transformations in each sector, and attempts to identify the AABW formation in the different products (Sec. 3.2).”*

To the following:

*“Section 3.2 discusses the water mass volume transformations in each sector, and attempts to identify the AABW formation in the different products.”*

→Page 6, Lines 28-30 – The sector name is incomplete. The phrase was changed to:

*“All three reanalysis products overestimate the annual mean SIC compared to the National Snow and Ice Data Center observations (hereafter referred to as NSIDC) in all sectors until 2004, except in the Ross and Bellingshausen **and Amundsen**, where the concentrations are similar to the observations obtained from the NSIDC (Figure 2a-f).”*

→Page 8, Lines 12-13 – The preposition is miswritten, and changed from *in* to *after*. The sentence now is:

*“This change leads the decrease of WDW to volume percentages lower than 10% **after** 2012 (Figure 3 – WDW).”*

→ Page 10, Lines 15-18. It came to our attention that one important reference used that describe oceanographic processes in the Bellingshausen and Amundsen sector is missing. Hence the following reference in Bold was added:

*“Finally, no pulse of AABW is seen in any of the three reanalysis in the Bellingshausen and Amundsen sector (Figure 7 - AABW), which is expected since this sector in the Southern Ocean lacks hydrographic, shelf morphology and cryosphere conditions required to create AABW varieties (Potter and Paren, 1985; **Whitworth III et al., 1998**; Orsi et al., 1999).”*

→Page 11, Line 28-30. The word *into* was misplaced, and changed to *from*. The sentence now is:

*“The bottom layers of both the Western Pacific and Indian Ocean sectors show an increase in salinity between May and September of 2004, which denotes a downward propagation of saline waters **from** the intermediate layer (Figure 9f).”*

→Page 12, Line 15-16. The word *Finally* is repeated. This word was deleted. The full sentence now is:

*“The second alteration evident in the UR05.4 anomalies was a warming of the Western Pacific and Indian Ocean sector bottom layers between May and October of 2004 (Figure 9c).”*

→Page 13, Lines 2-4. The preposition *in* was missing. Now the sentence is:

*“The anomalous signals identified by the average SIC and SIT distribution in ECCO2 are mainly connected to the appearance of a large-scale sensible heat polynya **in** the Weddell Sea sector (Figure 11a-c) and the neutral density alterations (Figure 11d-f), as previously pointed out by Azaneu et al. (2014).”*

→Page 13, Lines 6-8. The word monthly was miswritten, since we analyzed annual means. Now the sentence is:

*“This low sea ice content signal is extreme enough to decrease the **annual** mean sea ice concentrations and thicknesses in the Weddell Sea and Indian Ocean sectors, and even the whole Southern Ocean average (Figure 2a,b,e).”*

→Page 13, Lines 25-28. The abbreviation eOMP was no longer used in the text, so it was removed:

*“Pardo et al., (2012) used extended Optimum Multiparameter Analysis to quantify the volumes of the Southern Ocean water masses and found that the longitudinal limits of our Weddell Sea sector was filled with approximately  $26\pm 0.2\%$  of WSBW, a percentage substantially lower than the 70% of WSBW estimated by ECCO2 in 2013.”*

→Page 15, Lines 21-23. The abbreviation KCM was no longer used in the text, so it was removed:

*“Furthermore, a simulation with the Kiel Climate Model have shown that warm waters built-up in Weddell Sea deep layer during non-convective periods, and after decades the heat buffered interact with sea ice opening the Weddell Polynya (Martin et al., 2013).”*

→Page 16, Lines 9-12. The communication year that was missing is now added:

*“Finally, because the polynya in SoSE occurs at the beginning of the reanalysis output, we cannot assure its opening is a result of an initial adjustment process, even though a one year spin-up procedure is conducted in the prior year (2004) to bring the SoSE to its equilibrium conditions (M. Mazloff, personal communication, **2017**).”*

→Page 18, Lines 28-29. The word *Finally* was repeated, and is removed from the sentence in this version of the manuscript:

*“Pulses of WSDW production were described in Weddell Sea sector from 2005 until 2008, however their magnitude were too small to print signatures in temperature and salinity mean values.”*

→Page 19, Lines 21-23. The word *propagation* was misused here, and it was changed to *appearance* in this version of the manuscript:

*“The **appearance** of spurious open ocean deep convection in the Southern Ocean simulations can go even further and cause the warming of the abyssal layer, the cooling of surface waters and atmospheric warming (Latif et al. 2013; Pedro et al. 2016).”*

→Page 19, Lines 26-29. The reference year is wrong, and was corrected to 2014:

*“Especially in ECCO2, the mechanism of AABW formation resulted in erroneous representations of the Southern Ocean, such as high AABW volumes and lower sea ice concentrations and thicknesses, reinforcing that open ocean deep convection inserts errors in the simulation (e.g., Azaneu et al., **2014**; this study).”*

→Page 20, Lines 5-7. The word *consistent* was changed to *slight* in this sentence.

*“However, the WDW increase reported here is consistent with the observed results reported by Kerr et al. (2017 - under review), who found a **slight** increase of the WDW contribution to the total mixture of deep and bottom waters in the Weddell Sea from 1984 to 2014, despite the high degree of interannual variability.”*

→Page 20, Lines 8-10. The phrase was changed from:

*“However, since no real open ocean polynya has been reported since the 1970s (Gordon 1978), a critical analysis of the model mechanisms of heat exchange between the surface waters and sea ice is required in the future to efficiently understand the role of WDW in open ocean polynya establishment.”*

To the following:

*“However, since no real open ocean polynya has been reported for this period, a critical analysis of the model mechanisms of heat exchange between the surface waters and sea ice is required in the future to efficiently understand the role of WDW in open ocean polynya establishment.”*

→Page 20, Lines 10-12. A missing reference was added.

*“In addition, since bottom layer warming and intermediate layer cooling are the possible mechanisms that diminished stratification in ECCO2, further evaluation of the causes of those trends is needed to understand the primary factors leading to the weak ocean surface stratification (**Azaneu et al., 2013**).”*

→Page 20, Lines 12-14 - Again, the authors see that is necessary to point out the recent polynya appearance in 2016 and 2017. This occurrence is strictly linked to the subject of this study, and cannot be ignored in the paper. Hence, the authors have added the following phrase:

*“Finally, the appearance of a real open ocean polynya in October 2016 and September 2017 on Weddell Sea will also furnish a study scenario to understand heat exchange between sea ice and warmer waters, and compare with ocean reanalysis products.”*