

Interactive comment on “Holocene evolution of the North Atlantic subsurface transport” by Janne Repschläger et al.

Anonymous Referee #1

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The authors investigate the dynamics of the subtropical vs. subpolar gyres in the North Atlantic focusing on the transport pathways between both circulation systems. They find that subsurface transport plays a so far underestimated role for the heat and salt exchange between high and low latitudes. It is inferred that freshwater forcing is the dominant process governing the reconstructed (sub)surface temperature and salinity changes. The distinct subsurface variability is an important outcome of the study and sheds new light on the dynamics of the subtropical and subpolar gyre interaction. As such the paper merits publication, however, there are some issues that should be considered before final publication:

General comments:

1) Wind forcing is clearly an important driver of subtropical gyre dynamics, in partic-

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ular for the location of the Azores Front/Current (AF/AC). However, modelling studies suggest that the Mediterranean Outflow Water (MOW) exerts a pivotal influence as well, with indications that there would be no AC without MOW (Özgökmen et al., 2001; Volkov and Fu, 2010). MOW strength varies significantly during the Holocene with a weak outflow during the early Holocene (e.g. (Rogerson et al., 2012)) – how does this affect the position of the AC/AF? Could the northward shift of the AF indicated by increased *G. ruber* abundances until 4 ka might be at least in parts also due to a less strong MOW giving rise to a more northern location of the AF? Although I agree that wind-fields are most important for the positioning of the AF, the authors should at least briefly discuss the potential influence of the MOW.

2) The authors discuss at length the inverse relation of the STG variability to paleoenvironmental reconstructions from the Labrador Sea without showing any record from Labrador Sea such as P-012 and p-094 from Fig. 4. Given the importance of this point for the entire reasoning within the manuscript the discussed records from the Labrador Sea must be included in the figures.

3) It is not stated whether the right or left-coiling variety of *G. truncatulinoides* was picked or whether both were pooled. Studies clearly show that both morphotypes have different temperature preferences (Billups et al., 2016; Thiede, 1971), hence, it is therefore important not to pool right and left coiling *G. truncatulinoides*. Furthermore, in the methods it should be stated from which size fractions the foraminifera (both, *G. ruber* and *G. truncatulinoides*) were picked. Particularly Mg/Ca shows distinct ontogenetic effects and size-dependent offsets (Elderfield et al., 2002; Friedrich et al., 2012).

Specific comments:

ABSTRACT Line 2, "... interactions with the subtropical gyre..." is quite unspecific. Maybe replace by "... advection of saline water from the subtropical gyre". l. 11, "published data": specify which type of data (salinity and temperature). l. 13/14, "Subsurface warm water transport started at about 8 ka with subtropical heat storage,..." this

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sentence is again quite unspecific. Specify: What is the direction of the heat transport and what is the exact relation to heat storage?

INTRODUCTION p. 1, l. 21: remove comma after “due to” p. 1, l. 30: replace “ocean” with “oceanic” p.2., l. 29: “entertained” is an odd phrasing here. Better replace with e.g. “discussed”.

REGIONAL SETTING p. 3, l. 10 (and elsewhere): “G. ruber w.”: “w.” should not be in italics.

METHODS This section is quite superficial regarding the analytical details: - please state the number of individual forams picked for stable isotope and trace element analyses. - were Mg/Ca measurements monitored for contamination by checking e.g. Al, Fe, Mn vs. Ca ratios? - How were the samples cleaned? With or without reductive cleaning? These are quite elementary analytical information! - Which machine was used for $\delta^{18}\text{O}$ and Mg/Ca analysis at which laboratory? - It would be good to have a brief reference to the age model. p. 3, l. 24 - : please state the equations used for Mg/Ca – temperature conversion explicitly. p. 3, l. 26: “(Repschläger et al., 2015)” please check for the format of the citation (also in other parts of the text). p. 4, l. 7: there are two “.” after “comparison”. p. 4, l. 9: instead of using the low-resolution sea level correction after Waelbroeck et al. (2002), a more recent sea level curve should be used such as Austermann et al. (2013) p. 4, l. 9: check format of “Cleroux 2011” p. 4., l. 10: explicitly state the equation (S8) from Cleroux et al. (2011) here. p. 4, l. 11: “5- point”: remove blank p. 4, l. 13: Weinelt et al. (2015) is missing in the reference list. general: please introduce “w-ivc” as abbreviation. Note that the respective x-axis in Fig. 2C is labeled with “SW-IV”.

RESULTS p. 4, l. 21: add “,respectively” after “8 ka BP”. p. 4, l. 22-23: the positive excursion in $\delta^{18}\text{O}$: might there be a relation to the discontinuity mentioned later in the text? p. 4, l. 24 (and elsewhere): check for consistency that there is no blank before “°C” p. 4, l. 29: “single points cannot be interpreted”: this sentence is somewhat

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nonsensical as single points should be not interpreted in general. p. 4, l. 29: “indicate a evolution”: insert a reference to Fig. 3 here. p. 4, l. 30: there seems to be a number missing after “10.5 and” p. 5, l. 1: there seems to be an “and” missing in “1.5‰ 1.7‰” p. 5, l. 10: insert an “in” after “any changes”

DISCUSSION p. 5, l. 12-13: as mentioned for the introduction there is no need to introduce the INTIMATE stratigraphy here. p. 5, l. 25 (and Fig. 3): site ODP 1058 and core MD99-2203 are from subtropical waters, not tropical sites. Both are also not from the Caribbean as stated in the Fig. 3 caption. Better refer to western subtropical Atlantic. p. 6, l. 3: delete comma after “above” p. 6, l. 5: insert “.” after “trends” p. 6, l. 7: “very similar” is an overstatement in my opinion p. 6, l. 8: not sure what is meant by “12/10°C”. Does this refer to the temperature range of T_{sub} ? p. 7, l. 4: insert a blank before “(Repschläger et al., 2015)” p. 7, l. 29-31: this paragraph is too speculative and should be omitted, unless the authors prove the existence of the 1500 yrs-cycle by spectral analysis. p. 8, l. 10: the reference to “AMOC evolution” is somewhat misleading in this context as the authors reconstruct in the first place the dynamics of the STG and SPG.

FIGURES Fig. 1: Indicate the position of core MD99-2203. Please place the circle indicating the position of ODP 1058 above the red arrow. The blue arrow is at places hard to see, a darker tone would help here. Fig. 2: In the caption a reference is missing to the source of the G. ruber abundance data (Weinelt et al., 2015). The readability of the caption would benefit if the listing of items is separated by comma (e.g. “..., c)...” and a full stop at the end. In general, the error bars at individual points suggest that they represent individual replicates which is not the case. It would be better to state the 2sigma-error next to the respective y-axis. Fig. 3: Please put “18” in $\delta^{18}\text{O}$ into superscript. Fig. 4: The listing of items in the caption should be separated by comma (e.g. “..., c)...” , also insert a full stop at the end.

References: Austermann, J., Mitrovica, J. X., Latychev, K., et al., 2013, Barbados-based estimate of ice volume at Last Glacial Maximum affected by subducted plate:

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Nature Geosci, 6, 553-557. Billups, K., Hudson, C., Kunz, H., et al., 2016, Exploring *Globorotalia truncatulinoides* coiling ratios as a proxy for subtropical gyre dynamics in the northwestern Atlantic Ocean during late Pleistocene Ice Ages: Paleooceanography. Elderfield, H., Vautravers, M. J., and Cooper, M., 2002, The relationship between shell size and Mg/Ca, Sr/Ca, $\delta^{18}\text{O}$, and $\delta^{13}\text{C}$ of species of planktonic foraminifera: Geochem. Geophys. Geosyst., 3. Friedrich, O., Schiebel, R., Wilson, P. A., et al., 2012, Influence of test size, water depth, and ecology on Mg/Ca, Sr/Ca, $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ in nine modern species of planktic foraminifers: Earth and Planetary Science Letters, 319-320, 133-145. Özgökmen, T. M., Chassignet, E. P., and Rooth, C. G., 2001, On the connection between the Mediterranean outflow and the Azores Current: Journal of Physical Oceanography, 31, 461-480. Rogerson, M., Rohling, E. J., Bigg, G. R., et al., 2012, Paleooceanography of the Atlantic-Mediterranean exchange: Overview and first quantitative assessment of climatic forcing: Rev. Geophys., 50, RG2003. Thiede, J., 1971, Variations in coiling ratios of Holocene planktonic foraminifera: Deep Sea Research and Oceanographic Abstracts, 18, 823-831. Volkov, D. L., and Fu, L.-L., 2010, On the reasons for the formation and variability of the Azores Current: Journal of Physical Oceanography, 40, 2197-2220.

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