

CPD Interactive discussion on “Changes in Holocene meridional circulation and poleward Atlantic flow: the Bay of Biscay as a nodal point” by Yannick Mary et al.,

We acknowledge the positive review of James Scourse on our paper and thank him for all the good suggestions and perspectives his review brings to our study.

All the comments done have been considered for the revision but as some details and complements will not be directly included in the revised manuscript, we have listed below the significant elements which sustain our results and findings, and could help readers to appreciate these interactive discussion and its topics at the best.

CPD Interactive comment on “Changes in Holocene meridional circulation and poleward Atlantic flow: the Bay of Biscay as a nodal point” by Yannick Mary et al., by J. Scourse (Referee)

Received and published: 17 August 2016

Topic of the discussion: general comments

JS: Mary et al. present an excellent high resolution record of Holocene palaeoceanographic changes (SST) from the southern Bay of Biscay based on two closely positioned cores. The SST record is based on MAT transfer functions on planktonic foraminiferal assemblages and is compared with other palaeoceanographic records from the Biscay/Iberian margin and the wider North Atlantic. The raw planktonic foram dataset is excellent and the way in which the transfer function has been applied is well explained. The data for the Roman Warm Period interval and their correlation with the wider North Atlantic datasets for this period are impressive. Records of this quality covering the entire Holocene are not common and it is important that the data are published. **However,**

- 1. in places I feel there is a tendency to over-interpret the record,**
- 2. Sometimes the explanation is not as clear as it might be,**
- 3. some fundamental contextual information is lacking,**
- 4. independent lines of evidence to corroborate the transfer function SST reconstruction are lacking, and**
- 5. most importantly, there are some generalized statements not supported by either numerical model simulations or tests of statistical significance.**

Reply: all these flaws are now corrected based on the whole review procedure. We have especially introduced new Figures and text sections to reinforce our observations and findings.

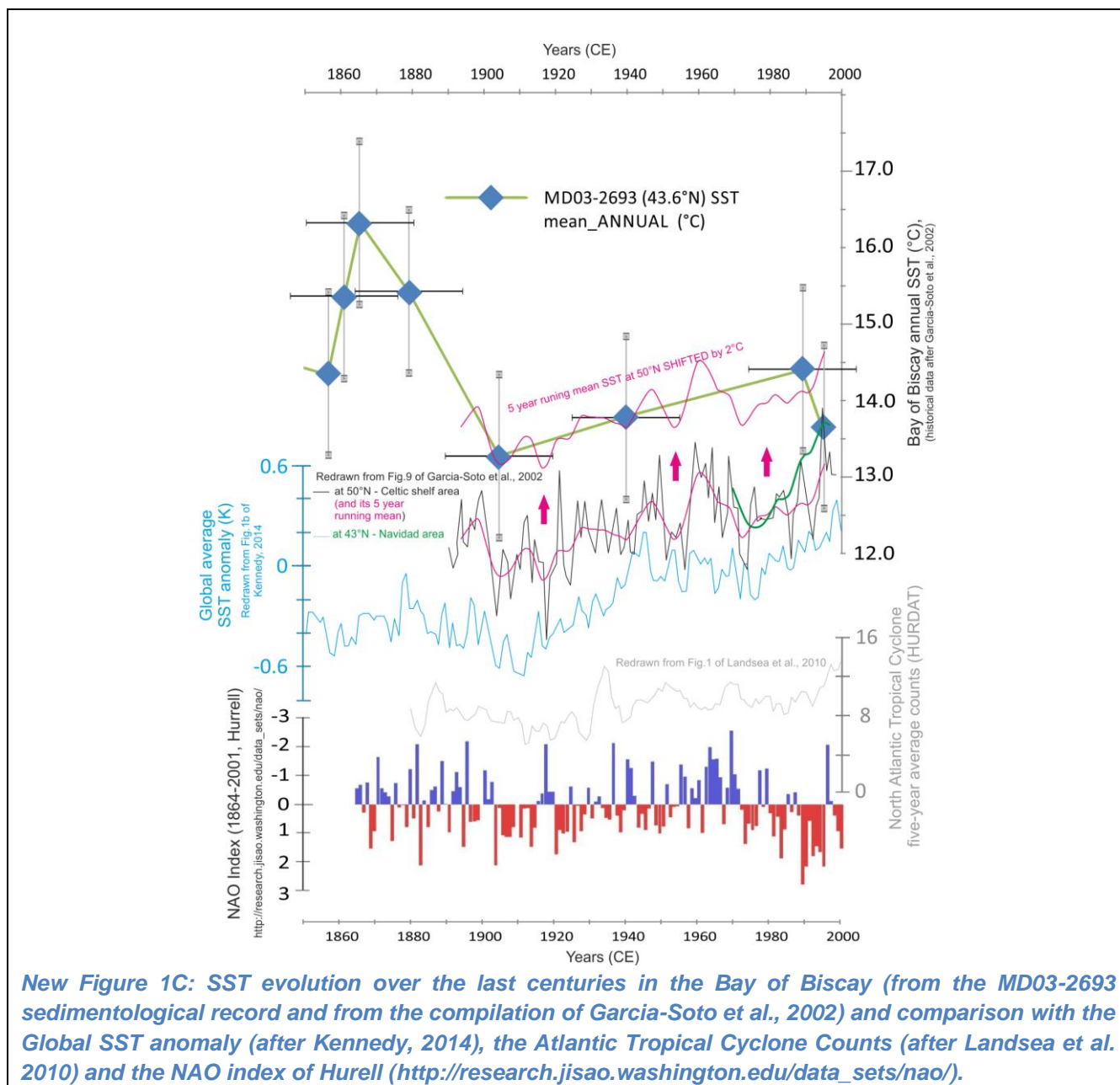
Topic of the discussion: about the study site (hydrography and climatology)

JS: At the outset (and in the Abstract) the authors emphasize **the strategic location of the core sites in the context of the wider North Atlantic circulation/AMOC**. It would be good to support this assertion with some spatial correlation plots between this site and wider North Atlantic SST/SSS fields over the calibration period. **What key elements of the surface circulation correlate with SSTs at this location?** The core locations are actually quite distal from the main centres of North Atlantic hydrographic variability so firming up this relationship with evidence is important. There is significant discussion in the Introduction on the relationships between the regional hydrography and the wider North Atlantic circulation, and with modes of North Atlantic climate variability (AMO/NAO) but this remains (and feels) speculative unless it can be supported by evidence.

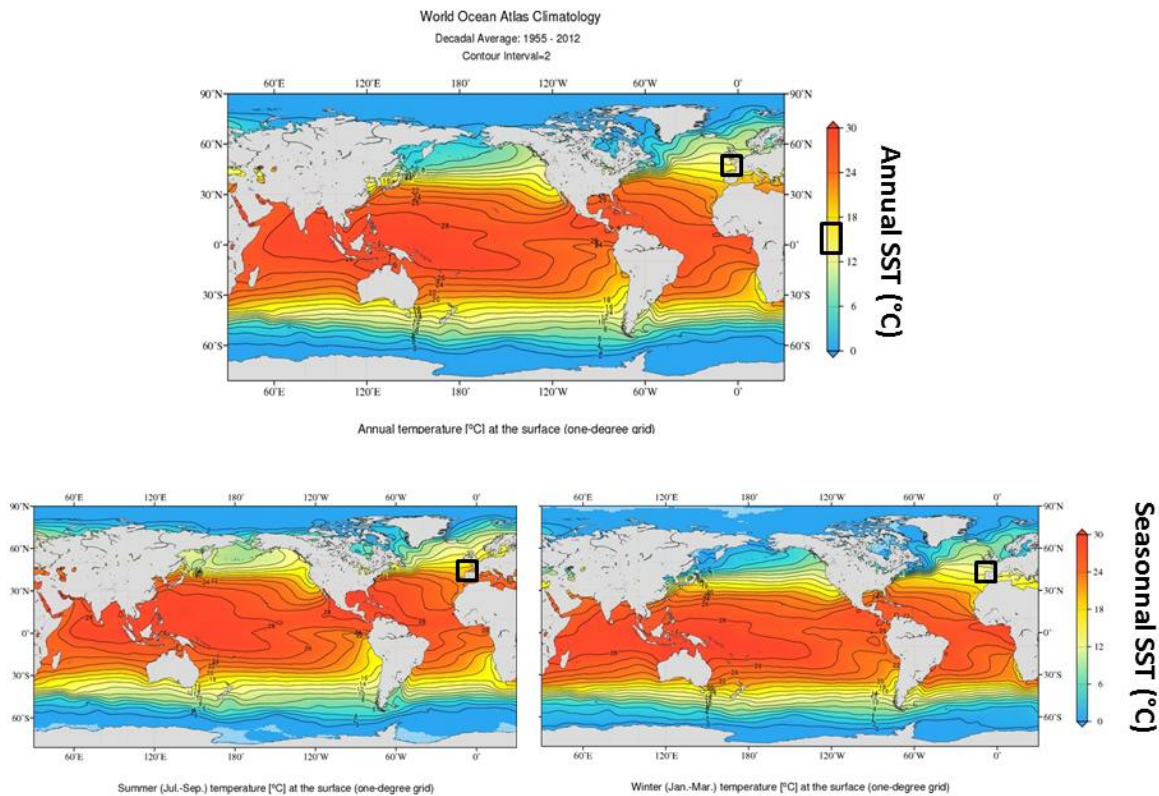
Reply: many of the questionings legitimately raised by James Scourse about the context of the sites and the related forcings were in fact already considered in details in the Mary et al. (2015) paper - ref: *The Holocene Vol. 25(2) 348-365, DOI: 10.1177/0959683614558647*- which focusses on the MD03-2693 record. A very detailed description of the hydrological and sedimentological contexts is published in this article and we wanted to avoid repetitions in this new paper; we have however documented the modern hydrography and its modulation in the present article as a summary based on modern oceanographer's works (see line 63 to 88). The work of Garcia-Soto, Pingree et al. over the last 15 years are especially worth to consider as tests against the dominant

climatic modes were done regarding regional SST data (“Navidad structure and timing”, e.g. Garcia-Soto et al. 2002).

To reinforce the idea of the Bay of Biscay strategic location, an additional Figure has been included within Figure1 (i.e. Figure 1C below) and the citation of Mary et al. 2015 synthesis introduced when needed in the text.



This new Figure 1C is built upon the last centuries and thus compiles the modern contextual hydrography and climate trends. To further test our reconstructions (even of very low resolution at this time scale, done on core MD03-2693, see Mary et al., 2015 for further elements), a 2°C shift in the modern annual SST mean (5 year running average after Garcia-Soto et al., 2002) has been applied for stressing the comparison with our study area. This value of 2 °C is justified by the southern and confined position of our sites within the Bay of Biscay which register the warmest oceanic conditions at this latitude in the North Atlantic (see especially the decadal average registered for summer months at <http://www.nodc.noaa.gov/cgi-bin/OC5/woa13fv2/woa13fv2.pl?parameter=t>, extracted images below).



We tested also this shift with the WOA sample tool (Table below, <http://www.geo.uni-bremen.de/cgi-bin/woasample.pl>):

	LONG	LAT	Modern mean Annual SST (°C)	Modern mean JFM SST (°C)	Modern mean AMJ SST (°C)	Modern mean JAS SST (°C)	Modern mean OND SST (°C)	Nb point	SST Seasonality modern range (°C)
PP10-07	-2.23	43.68	15.63	11.95	15.09	20.08	15.42	1	8.135
Celtic margin area	-4	50	12.322	9.705	11.078	15.369	13.135	2	5.66

FROM: <http://www.geo.uni-bremen.de/cgi-bin/woasample.pl>, last consult 05/12/2016

This compilation shows that (as already stated by physical oceanographers) a poor link exist with the NAO, even if modulations in SST oscillations seem to be coherent from a region to another. Not added on this Figure, but tested also, is the link with the Atlantic Multidecadal Oscillation (AMO) which, as stated by Garcia-Soto & Pingree (2012) is not straightforward but, probably, the most coherent driver of SST changes in the area.

New Citations introduced:

- Kennedy, J.J., 2014. A review of uncertainty in in situ measurements and data sets of sea surface temperature: IN SITU SST UNCERTAINTY. *Reviews of Geophysics* 52, 1–32. doi:10.1002/2013RG000434
- Landsea, C.W., Vecchi, G.A., Bengtsson, L., Knutson, T.R., 2010. Impact of Duration Thresholds on Atlantic Tropical Cyclone Counts*. *Journal of Climate* 23, 2508–2519.

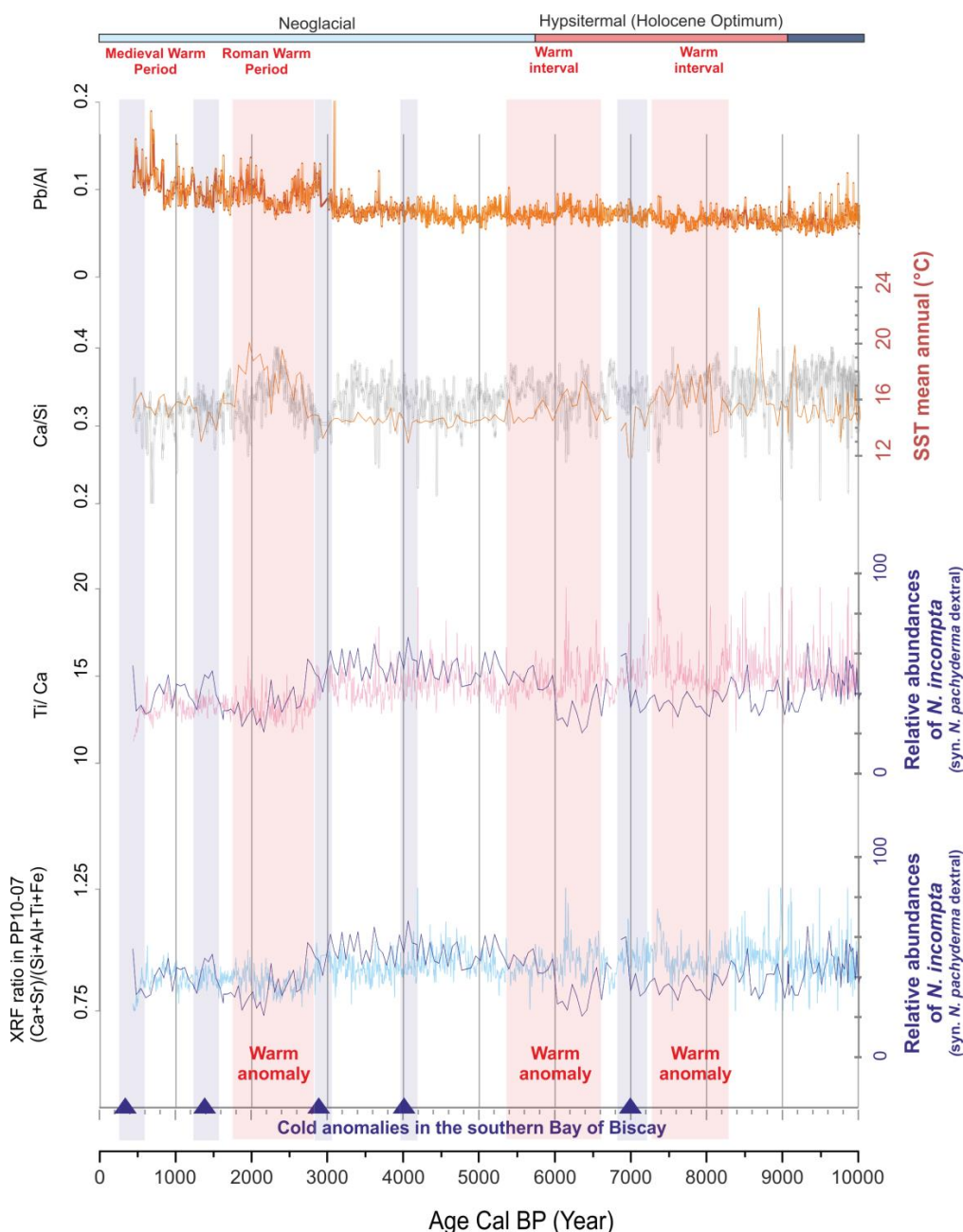
Topic of the discussion: about the reconstructions

JS: In terms of the excellent reconstructed time-series for the last 2000 years, how do these compare with the CMIP5 simulations, and the earlier data with the CMIP5 mid-Holocene simulations?

Reply: This very stimulating question is not trivial as our reconstructed data are regional sea-surface temperatures and none of the products released up to now by CMIP5 (or the related PMIP3 experiment) are thus directly comparable. However, this is also one of the targets of the French ANR HAMOC project – see <http://hamoc-interne.epoc.u-bordeaux1.fr/doku.php?id=start&#news> - and works are thus going on within the involved French teams. This was not possible at this step to include a model-data comparison.

JS: Whilst the quality/resolution of the foram-based transfer function SSTs are not in question, **I would have liked to see some corroboration from independent data (e.g. oxygen isotopes, trace element ratios, alkenones) of at least sections of the record.**

Reply: Additional independent data (here XRF elemental ratio) have been added on the new Figure 5 (built to support mechanical interpretations as required by Rev.1). In addition, on the illustration below, are compiled key XRF data (some will be included in the revised version) compared to those of foraminifera counts (relative abundance and SST) to highlight the sensitivity of this last tracer.

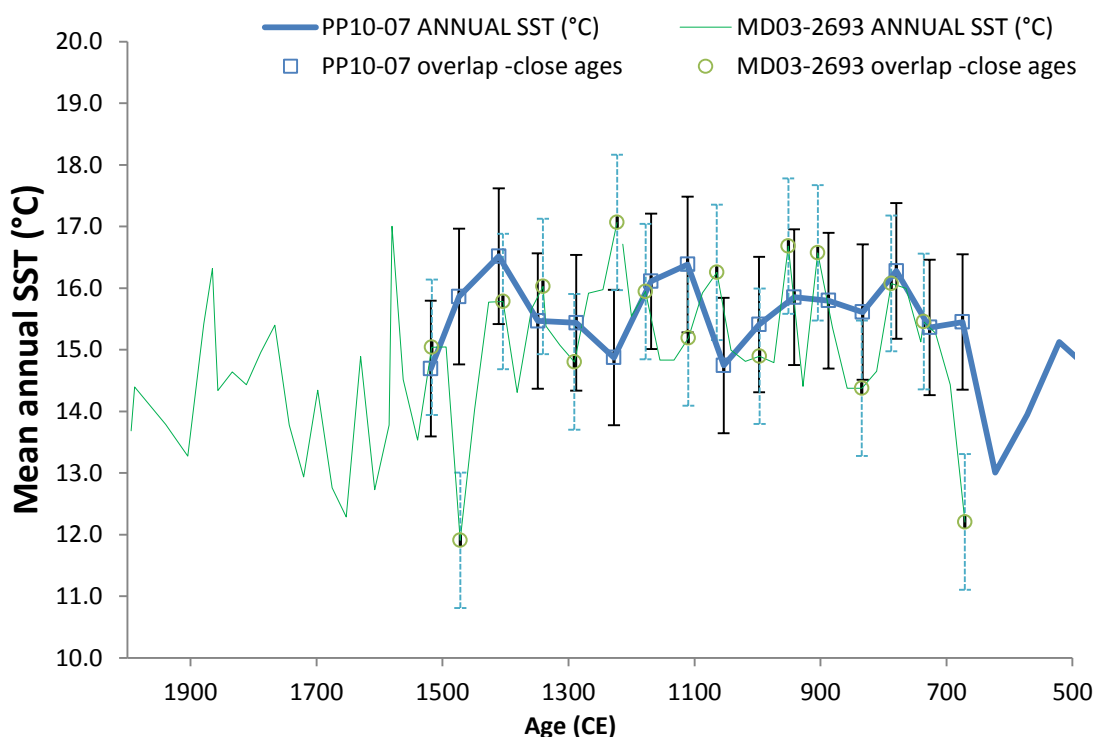
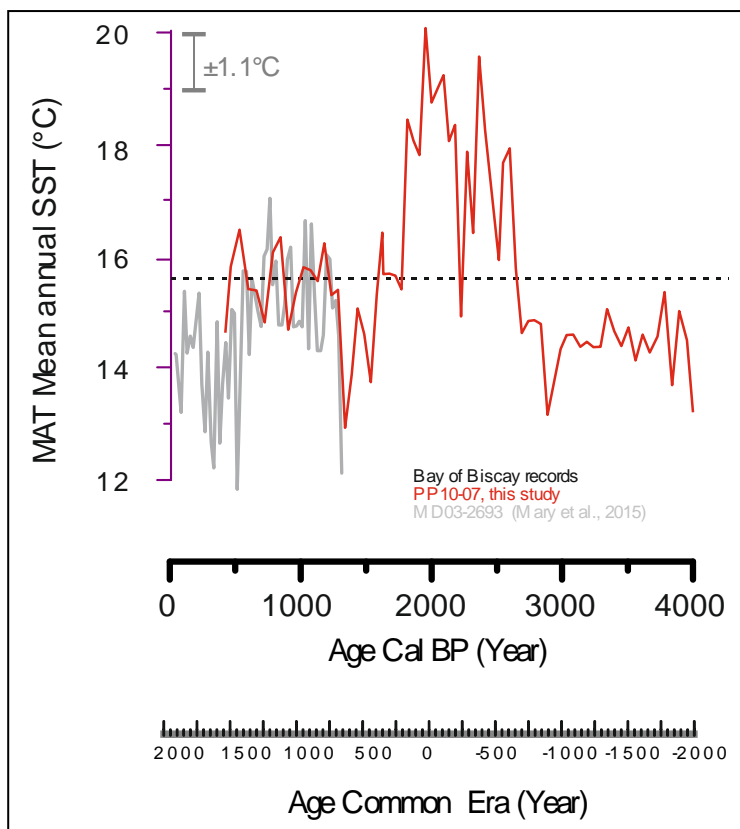


JS: The PP10-07 long Holocene record is spliced with data for the last 2000 years from MD03-2693; what are the correlation statistics for this overlap?

Reply: The overlap is absolutely not “forced”: we have not changed anything in the age models to fit or tie our records. The statistics of the recovery are thus poor but that was not the purpose of the present work. For sure, with additional data and datings a composite record could be built since the coherency of the reconstructed SST is very strong and within the error bar (see the Table and Figures below where core to core results are compared within a time precision < 10 years).

Zooming on the overlap:

Age (CE)	PP10-07 overlap -close ages	Age (CE)	MD03- 2693 overlap -close ages	Delta
675	15.5	671	12.2	3.2
727	15.4	736	15.5	0.1
780	16.3	788	16.1	0.2
833	15.6	834	14.4	1.2
887	15.8	904	16.6	0.8
942	15.9	951	16.7	0.8
997	15.4	997	14.9	0.5
1054	14.7	1065	16.3	1.5
1111	16.4	1110	15.2	1.2
1169	16.1	1178	15.9	0.2
1228	14.9	1223	17.1	2.2
1288	15.4	1291	14.8	0.6
1349	15.5	1341	16.0	0.6
1411	16.5	1404	15.8	0.7
1474	15.9	1472	11.9	4.0
1519	14.7	1517	15.0	0.3



Topic of the discussion: about the study site (sedimentology)

JS: It is essential to provide some key information about the cores at the start of the Methods section. I note that the water depths are included in Table 1, but what is the geomorphological context of the core locations, why does the sedimentation rate differ so much between the two cores, what are the sediment sources to these locations including biogenic/lithic ratios and, in particular, what is the local hydrographic regime at this location and how does it relate to the wider North Atlantic circulation discussed above? It is also essential at this point to present lithostratigraphic logs for the cores. **Unless these data have been published elsewhere they should be included here, or in the Supplementary info.**

Reply: All the geomorphological and sedimentological contexts, as well as the lithostratigraphic descriptions of the cores have already been provided in details in the following references (cited in our article):

- Gaudin, M., Mulder, T., Cirac, P., Berne, S., and Imbert P.: Past and present sedimentation activity in the Capbreton Canyon, southern Bay of Biscay, *Geo-Marine Letters* 26, 331–345, 2006.
- Brocheray, S., Cremer, M., Zaragosi, S., Schmidt, S., Eynaud, F., Rossignol L., and Gillet, H.: 2000 years of frequent turbidite activity in the Capbreton Canyon (Bay of Biscay), *Marine Geology*, 347, 136–152, doi:10.1016/j.margeo.2013.11.009, 2014.
- Mojtahid, M., Jorissen, F.J., Garcia, J., Schiebel, R., Michel, E., Eynaud, F., Gillet, H., Cremer, M., Diz Ferreiro, P., Siccha, M., and Howa, H.: High resolution Holocene record in the southeastern Bay of Biscay: Global versus regional climate signals, *Palaeogeography, Palaeoclimatology, Palaeoecology*, 377, 28–44. doi:10.1016/j.palaeo.2013.03.004, 2013.
- Mary, Y., Eynaud, F., Zaragosi, S., Malaizé, B., Cremer, M. and Schmidt, S.: High frequency environmental changes and deposition processes in a 2 kyr-long sedimentological record from the Cap-Breton canyon (Bay of Biscay), *The Holocene*, 25, 348–365, doi:10.1177/0959683614558647, 2015.

Furthermore, calibration on modern planktonic foraminifera populations have been conducted within the following papers:

- Retailleau S., Eynaud F., Mary Y., Schiebel R., Howa H., 2012. An Ocean - Canyon head and river plume: how they may influence neritic planktonic foraminifera communities in the SE Bay of Biscay?, *Journal of Foraminifera research* 42(3), 257–269
- Retailleau S., Howa H., Schiebel R., Lombard F., Eynaud F., Schmidt S., Jorissen F., Labeyrie L., 2009. Planktic foraminiferal production along an offshore-onshore transect in the south-eastern Bay of Biscay. *Continental Shelf research* 29 (8), 1123-1135

These last references have been added in the text.

Detailed comments: all the detailed comments have been considered for the revision, but we just wanted to reply to one comment raised by both reviewers about the resolution of our record.

JS: Line 30 (and elsewhere): the records are described as being of “unprecedented” resolution. This has to be more specific – unprecedented for this region, for the North Atlantic? There are certainly sediment-based records of comparable resolution elsewhere and this record does not compare with annual-banded records of SST (coral, bivalves).

Reply: we agree that we have to be more specific but wanted to stress out that, up to now, none comparable SST record exists for a 10 ka long and continuous interval (with such a regular time slice). It is obvious on the Figure below where some records (those of the highest resolution have been selected and digitized from each related citations) were added for comparison on the basis of anonymous Rev1’s suggestions.

This is a consideration that we will introduce in our text with some graphical supports in the new Figure 5.

