

Response to reviewer comments

In the following sections we respond to the comments from the reviewers and indicate where changes have been made to the manuscript. The reviewer's comments are given in italic font, our responses in normal font. Page and line numbers mentioned in this document refer to page and line numbers in the revised manuscript.

Reviewer #1

Line 3: of the present day

Corrected.

Lines 225: and 395: Why gives longitudes as negative east instead of west?

It's consistent with the figures which show °E as the unit for longitude.

Line 325: provides not provided

Corrected.

Line 341: phrase near Western Mediterranean is incomplete and missing a word(s).

Corrected.

Line 411: over a broad range

Corrected.

Line 459: Instatement means to install in (political) office, so is not the correct word here!

Indeed not the correct word, it should be 'appearance'.

Line 515: missing the before inflow

Corrected.

Line 618 and 620: Prefer shallower instead of lower.

Corrected.

Line 624: percentual is not an English word.

Corrected.

Last paragraph of page 20: But would the river freshwater get to the convection and/or intermediate water sites to have the impact speculated here?

This is one of the uncertainties already mentioned in lines 694 – 695.

Line 708: Prefer deeper to higher.

Corrected.

Line 722: Think can is too strong since it is speculation. Would prefer to see could used instead.

Changed as suggested.

Reviewer #3

The explanation for the mixed layer depth changes in SD100 is not convincing and needs to be improved. Some of the other conclusions based on a comparison between SD500 and SD100 might be affected by a drift in SD100 (see Fig. 8). major point.

line 456: Checking the effect of increasing salinities on the density effect of a cooling I found a (very small) increase with increasing salinities (UNESCO equation of state ρ/ρ_0 around 18 deg for salinities between 35 and 45). This directly contradicts the following sentences 'At higher salinities, the changes in density caused by cooling of surface water is comparably smaller. As a consequence, lateral and vertical density differences at the surface are smaller and mixed layer depth increases significantly throughout the eastern basin.' Please demonstrate your point by density calculations! An alternative explanation for the deeper mixed layers could be a slight model drift towards saltier water, which would destabilize the water column (and thus favour enhanced mixed layer depths).

The 'drift' mentioned by the reviewer is not an actual drift. As mentioned at the start of section 3, experiments SD5 - SD50 haven't reached a steady state yet after 800 years. SD100 reaches a steady state near 800 yr, hence the overturning circulation still changes between 400 yr (orange/lightblue points) and 800 yr (red/darkblue points).

With regards to the increasing mixed layer depth at higher salinities, the reviewer has already found half the reason: the change in density due to cooling of surface water is indeed larger at higher salinities. The denser water wells down further before it reaches water with the same density, i.e. the mixed layer depth increases.

A second reason for the increased mixed layer depth at high salinities is the surface temperature that is slightly higher in experiments with a shallower sill depth. Due to the slightly higher SST, the relaxation to the annual mean air temperature results in a stronger heat loss, a larger increase in density, and again a deeper mixed layer.

The manuscript has been adapted to include this reasoning.

minor points

line 255... /Fig. 4 - the forcing is very smooth and the restoring very strong. What causes the east west wave like structures in SST off Libya (approx. 4 delta x)? As the plot shows 10yr mean data, it cannot be a traveling wave.

The feature the reviewer refers to is strongly emphasized by the colour scale since it falls in the range where green switches to yellow. The wave-like structure is indeed not caused by a travelling wave, it is caused by a few local upwelling zones along the coast that bring up slightly colder water from depth. We don't think it is relevant to mention this in the manuscript.

- Please use the full colour scale in the salinity plots. That may make it easier to see the structures, especially in the horizontal plots.

The colour scale used in Fig 4 was able to show the variation in salinity in all experiments. Since we just show cross sections of SD300 it indeed makes sense to lower the maximum salinity in the scale. Fig 4 has been updated with a colour scale up to 41 psu.

Fig. 4 caption Two horizontal and a vertical cross section... I never heard the expression 'horizontal cross section' before.

A cross section is the intersection of a body in three-dimensional space with a plane, where in this case the plane is horizontal. A quick search shows it is commonly used in recent literature. We therefore see no need to change this.

line 312-315 SST and SAT are different quantities, which are somehow related but not identical. Therefore it is not clear to me, why this indicates that water characteristics do not respond linearly to surface forcing.

We have evaluated the relevance of lines 312 - 315 and have decided to remove them. A proper explanation of our line of thought would add too much text while the main message is already present in the next paragraph.

line 343 near western -¿ in the western

Already corrected in response to the first reviewer's comments.

line 423 Fig. 6 → Fig. 5

Corrected.

line 535 The new section dealing with the effect of the idealized forcing is definitely an improvement in relation to the original paper. What is still missing here is the discussion of the potential effect of too warm Mediterranean deep and intermediate water (due to the unresolved seasonal cycle) on the net heat budget. This effect should lead to to an underestimation of the temperature difference between inflowing Atlantic and outflowing Mediterranean water.

Section 3.2.1 and 4.1 already describe and discuss the impact of the lack of a seasonal cycle on the heat budget. We have added a couple of lines to the discussion to emphasize the changes in the heat budget expected in a model with a seasonal cycle.

Table 2 Which reference temperature has been used for the heat transport calculations? Has the heat effect of the net freshwater flux of the surface been taken into account? If not, why not?

Heat transport has been calculated directly from the transport in the Strait of Gibraltar, i.e. with the actual temperatures, densities, and velocities. This is explained in the first paragraph on page 15.