We thank the anonymous reviewer #1 for her/his constructive comments on the manuscript. We have carefully considered all questions and concerns raised. The structure of our reply is as follows; each comment from the anonymous reviewer is recalled in blue, and our reply in black.

Ayache et al. present a basin-wide model simulation of anthropogenic tritium (3H or T) and its decay product helium-3 (3He) in the Mediterranean Sea by using a high resolution regional model (NEMO-MED12) for the past several decades. They compared the model results with the observation data collected at various times during this time period along the main E-W axis of the Sea throughout the water column. From this study they can analyze the decadal-scale ventilation and mixing processes in the thermocline, intermediate and deep waters, and better delineate the effects of episodic deep water formation events (i.e. The Eastern Mediterranean Transient: EMT in the eastern part in 1995 and the Western Mediterranean Transient: WMT, the deep convection event in the Gulf of Lions in the west in 2005). A combined use of two transient tracers (T and 3He) allow the investigators to estimate the T-3He tracer age fields along the model-data comparison sections and infer the ventilation time scales for different water masses. The evolution of the tracer age fields also allow the investigators to infer the effect of renewal of deep water by the episodic deep water convection events. The reviewer recommends minor revision for this manuscript before it should be accepted for publication. Below are detailed comments for the manuscript.

We thank Referee #1 for its positive comments on our manuscript, we will cautiously reply to its remarks.

Although the authors cite the other paper about the model performance, it would be helpful to give some basic information along with the quantified data of model-data differences (e.g. P2703 L10-12).

We agree with the referee that a more quantitative analyses would be of interest. However the paper published for describing the observations (Roether et al, 2013) is also very descriptive, which not allowed to do many quantitative comparisons with the simulation. In order to make a more quantified analysis of the model results against observations we will provide additional comparison of average vertical profiles along different METEOR section (see Fig, example for 1999 cruises). We will provide quantified estimations of the deviation against observations, for the different water masses identified along the profiles (LIW, deep water,..).

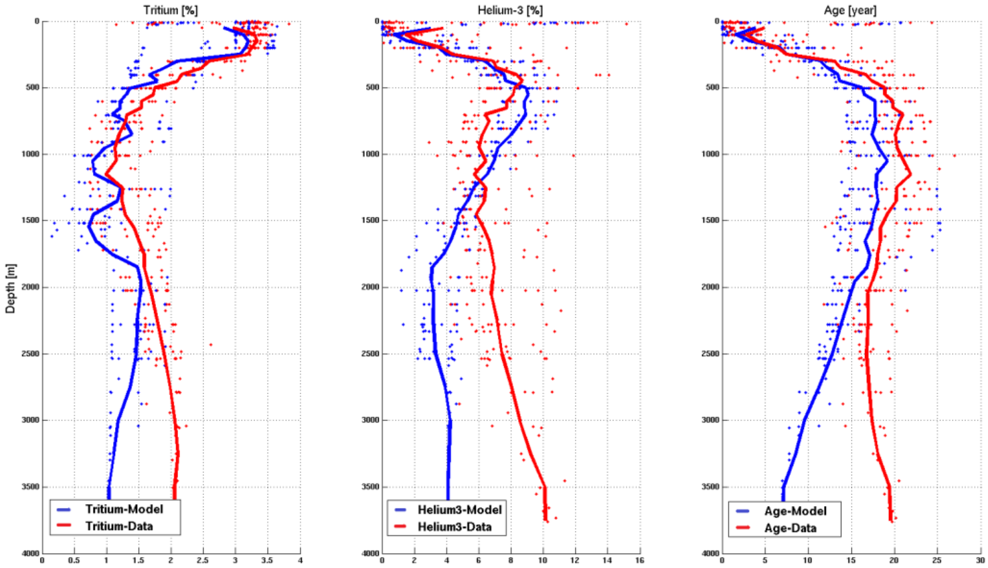

Fig. 9. Comparison of average vertical profiles along the METEOR M44/4-1999 section for (left) tritium (in TU), (middle) helium-3 (in %), and (right) the tracer age (in years). Model results are in blue, while red indicates the in-situ data.

It is not immediately clear whether the model was calibrated by the transient T-3He tracers (i.e. constrained by data), or just run by the prescribed conditions for the given time period and compared with the observations along the select locations and times?

The model is not calibrated by the transient ^{3}H-^{3}He tracers concentrations, only the tracer boundary condition at the surface are prescribed. The propagation of the tracers was done on off-line mode, using circulation fields from the dynamical NEMO-MED12 model (Beuvier et al ., 2012) which were produced without consideration (independently) from our tracer simulation. A sentence was added to the text to make this perfectly clear in the revised manuscript.

I would suggest to include some basic information of the transient tracer age concept & its implication and limitations (P2697).

In addition to what we have already introduced in our manuscript (P2697-2698), we will add this part on the tracer age concept in the review:

Chemical tracers whose spatial gradients are primarily due to the time dependence of sources and/or sinks are often used to define "tracer ages" in an effort to diagnose transport (Waugh, et al. 2003).
Transient tracers such as ^{3}H, ^{3}He and CFC (tracers with known sources and sinks) can potentially give us valuable information on the time scales on which the ocean is ventilated. These tracers are often used to estimate an age which, ideally, represents the time elapsed since a water parcel was last at the surface.

^{3}H-^{3}He ages give us a first-order estimate of renewal rates and residence times in years, however the ^{3}H-^{3}He ages are not conservative with respect to mixing and are typically biased towards younger values. For example, a mixture between two water masses with differing tritium concentrations produces an "average" age which is weighted toward the water mass with more tritium.

I think it would be helpful to include a brief background of EMT and WMT, as they serve as significant benchmark timings for the model design and performances.

We thank the referee for this suggestion, and we will include more description on the EMT/WMT events in the revised manuscript.

The Eastern Mediterranean Transient (EMT) was a major climatic event in the circulation and water mass properties of the Mediterranean in the last century.

The Adriatic has been historically considered as the main contributor to the deep and bottom waters of the Ionian and Levantine Basins. However, the Aegean has also been reported as a possible secondary source of dense waters, lower intermediate and/or deep (Nielsen, 1912; Miller, 1963; Schlitzer et al., 1991) that affected mainly the area adjacent to the Cretan Arc in the eastern Mediterranean.

From 1988 onwards, started the most important changes in the thermohaline circulation and water properties basin-wide ever detected. A shift in the formation site of the deep and bottom waters from the Adriatic to the Aegean Sea occurred (Roether et al., 1996, 2007; Malanotte-Rizzoli et al., 1999; Lascaratos et al., 1999; Theocharis et al., 1992, 1999a).

The new source has produced large quantities of a very dense water mass, namely the Cretan Deep Water (CDW) that after its overflow through the Cretan Arc Straits provided the eastern Mediterranean with waters denser than the previously existing deep and bottom water mass (EMDW).

Different hypotheses concerning the preconditioning of the EMT and its timing have been proposed in the literature, mainly based on the available observations, such as:

(i) changes in circulation patterns leading to blocking situations concerning the Modified Atlantic Water (MAW) and the LIW (Samuel et al., 1999; Theocharis and Kontoyiannis , 1999; Malanotte-Rizzoli et al., 1999); (ii) changes in the local atmospheric forcing over the Aegean combined with long-term salinity change (Theocharis et al., 1999a; Lascaratos et al.,1999); (iii) a decrease in the Black Sea freshwater input due to a reduction of the river runoff which flow into it (Zervakis etal.,2000; Stanev and Peneva, 2002); (iv) internal redistribution of salt (Klein et al.,1999); (v) the start of the intense winter convection in 1987 in the northern Aegean Sea (Zervakis et al., 2000; Gertman et al., 2006); and (vi) the occurrence of two successive winters (1991–1992 and 1992–1993) with strong and deep convection in all the Aegean Sea;these convection events are triggered by strong surface heatlosses during these winters (Josey, 2003).

All these preconditioning factors (or at least some of them) could have changed the Aegean Sea stratification, leading to a less stable water column that was then easily mixed during the very cold 1992 and 1993 winters.

The WMT started during the mid-2000s (winter 2005) in the Gulf of Lions, during which a huge volume of Western Mediterranean Deep Water (WMDW) was formed with unusually high temperature and salinity. Winter 2005 was one of the coldest and driest winters in the 40 last years, the strong surface cooling and evaporation with highly favourable preconditioning triggered deep convection. Lopez-Jurado et al. (2005) suggested that the unusual characteristics of the 2005 convection event could be due to a change in characteristics of the water masses advected until the forming zone of WMDWs after EMT. Herrmann et al. (2010) rather suggest that the higher temperature and salinity of the new WMDW formed in 2005 are due to the absence of intense convective winter in the 1990's and early 2000s in the NWMed, leading to an accumulation of heat and salt in the intermediate and deep layers of this area.

We have also discuss in more detail the atmospheric forcing to simulate the EMT event in our response to reviewer #2.

The authors should use certain terms in consistent manner (e.g. model produced/ reproduced / simulated). What does it mean by the model 'correctly' reproduced? Model can only simulate certain patterns of actual condition.

We thank the referee for this suggestion, you are right model can only simulate certain patterns of actual condition. We will change this sentence accordingly in the revised manuscript.

I wonder if the authors checked the physical water mass structure in different years by looking at the distributions on density surfaces as well. What were the tracer distributions on isopycnal surfaces (besides the distributions in depth layers as shown in the figures)? Since there were episodic deep water formation events and apparent water mass structures during the study period, it would be useful to discuss the tracer ventilation signature in context of non steady-state conditions of water mass structure in the Sea.

The objective of these figures is to provide a general description of the results of the simulation of the tracers, and identify the region of formation of intermediate and deep water. We have chosen to average between 350 and 550 that include the LIW layer signal, and better represent the tracer distribution on this entire layer, to have the same comparative approach between the intermediate and deep water (average between 1000 and 1600 m for the deep water). It represents a useful integrated vertical diagnostic that allows to identify changes in intermediate and deep water masses ventilation in non steady-state conditions. This diagnostic is similar for the different period of observation and avoid providing diagnostic on different isopycnal surfaces representing water masses characteristics evolution at different time period.

The observation data and model outputs look 'reasonably' similar (Figs. 7-8) but what are the quantitative differences? Can the authors provide more quantitative information about the model's performance by estimating the model-to-observation differences and their uncertainties of the tracer data on select density surfaces or at certain water mass layers?

We thank the referee for this suggestion; the qualitative comparisons against the relatively large number of in situ measurements available from different Meteor cruises (between 1987 and 2011) allow to identify the main shortcomings of NEMO model.

We will add a comparison of average vertical profiles along different METEOR section (see Fig.9, example for 1999 cruises), and provide a quantitative comparison between model and observation along those vertical profiles allowed the identification of the main water masses present in the Med sea (like the LIW).

Specific Comments:

P2694 L12/13: peaks/peak alone - Please be more specific what the 'peaks/peak' is

We wanted to identify the specific concentration of the water masses. For the sake of clarity, we will change this expression by "signature" in the manuscript.

P2694 L26: WMDW - Please define when the acronym was first used

Done.

P2695 L10: Broecker and Peng, 1982 -> I would suggest to use a more recent reference

We appreciate the suggestion to use a more recent reference, and we will add this more recent reference:

Sarmiento, J. L. and Gruber, N.: Ocean Biogeochemical Dynamics, Princeton University Press,Princeton, NJ, 526 pp., 2006.

P2695 L10: These geochemical tracers -> I would suggest to state "These geochemical transient tracers"

We agree with the referee, and we will change this sentence in the revised manuscript.

P2695 L22: particularly 'suitable' for -> Please explain why anthropogenic tritium and helium-3 are good for evaluating the large scale ocean dynamics

Transient tracers such as tritium and tritiugenic helium 3, produced by nuclear bomb tests have entered the oceans primarily during the past 40 years. The inherent time scale of these tracers matches very well typical time scales for thermocline ventilation as well as other important oceanic processes such as deep water formation. They have been used to study the time scales of thermocline ventilation in many studies (e.g., Sarrniento, 1983; Jenkins, 1987; Roether et al,.2013).

The potential of using tritium and ^{3}He data jointly is based on the fact that these two tracers form a radioactive mother-daughter pair, which allows one to deduce ages, providing constraints on subsurface water transport and mixing. This methodology was pioneered by W. Jenkins (e.g., Jenkins, 1980; 1987).

Moreover, tritium and helium3 are also particularly adapted to investigate large scale ocean dynamics because their observations are available along basin-wide transect that allow investigating water masses ventilation and redistribution along large spatial scale.

We will clarify that in the manuscript.

P2696 L22: Tritium Units (TU) -> Can you provide the reference scale year for TU (e.g.TU-81)?

Tritium concentrations are reported in tritium units (TU), where 1 TU equals 1 tritium atom per 10^8 hydrogen atoms.

TU 81 is the same unit but concentrations are decay corrected to a common date, 1 January 1981.

P2696 L24: Please add "at the peak time of atmospheric nuclear weapons tests" after "25-30 TU in 1964"

We thank the referee for this suggestion; we will add this sentence in the revised manuscript.

P2696 L26: Please insert "cessation of new bomb tritium from the atmosphere" between "combination of" and "its radioactive decay"

This will be added in the revised manuscript.

real age -> What is the definition for this term? Please specify.

Timescales or rates deduced from tracers do not represent an intrinsic property of the flow; they indeed reflect the age of the tracer not of the water (Haine and hall, 2002, Delhez et al., 2003).

This will be clarified

P2699 L1-3: What is the time steps used in the numerical model?

Tracers are driven by the physical fields using an advection-diffusion equation computed on the grid of physical fields. The time step is 20 minute, and we use dynamical output fields with a temporal resolution of one day.

This information will be added in the revised manuscript.

P2703 4.1 Global distributions -> This should be 'Basin-wide distributions' as 'global' means worldwide.

We thank the referee for this suggestion; we will change this sentence in the revised manuscript.

P2705 4.2 Model evaluations against in situ data -> I would suggest 'observation data' or 'observations' instead of 'in situ data.'

Done

P2705 L22: 1997. -> I would suggest to state "1997 along the actual cruise sections in the E-W main axis of the Mediterranean Sea."

Rephrased in the revised manuscript

P2706 L3: contrasted -> I would suggest to use a different word

We will change this sentence by "Deeper the analyses reveal a more pronounced disagreement between model and observation"

P2706 L8-13 (and other related parts): Please make a clear distinction of descriptions for observation vs. that of model

We thank the referee for this suggestion, and will do so in a revised manuscript

P2709 L15: lower ages -> I would suggest to use 'young ages' instead

We will change this sentence in the revised manuscript.

P2711 L28: tracer-age -> is it model-based?

It's the derived age calculated from the modelled tracer distribution.

Clarified in the manuscript.

P2712 L2-3 transit time of 12+/-2 years (by Roether et al. 2013) -> Is it based on data-based estimates or model-derived? Please clarify.

The transit time of 12+/-2 years by Roether et al. 2013 in Levantine Intermediate Water (LIW) were directly estimated from the repeated observation, defining transit times from the LIW source region east of Rhodes based on in-situ data from different Meteor cruises (between 1987 and 2011). It will be clarified in the manuscript.

P2714 L14: true age as about 150 years -> Please specify the meaning of 'true age.' The model can only generate certain age estimates but it shouldn't claim it as 'true'age, I suppose.

You are right, the model can only generate certain age estimates but it shouldn't claim it as 'true'age.
Timescales or rates deduced from tracers do not represent an intrinsic property of the flow; they indeed reflect the age of the tracer not of the water (Haine and hall, 2002; Delhez et al ., 2003)
In this sentences we mean by "true age" the renewal rate of deep water in the Med Sea (estimate to be more than 100 year) compared to tracer age (no more than about 30 years).
We will change true age by "renewal rate" in the revised manuscript.

Figure 7: Please explain the circle symbols (are the colors of the symbols coded by concentrations? same as that of the model outputs?)

Colour filled contours represents simulated tracer concentration (tritium, helium3, and the tracer age), whereas colour-filled dots represents in-situ observations. Both use the same color scale and are taken at the same period.
The figure legend will be modified for the sake of clarity.

Technical Corrections:

P2698 L11: age tracer -> tracer age

Corrected.

P2696 L12: “isotopes of helium with” -> “isotope of helium, with”

Done.

P2699 L2-3: move “in latitude” at the end of “46N to 30N”

Done.

P2703 L9 and all other same expressions: maps -> The indicated images are not maps but figures. I would suggest to use “figures” instead

We thank the referee for this suggestion; we will change this sentence in the revised manuscript.

Fig.1: scale bar needs a legend (Depth [m]); insert “(solid lines)” between “The trans Mediterranean section” and “from the Meteor”.
Done.

Figs. 3-8: All scale bars show increase in numbers toward left, which may confuse the readers. I would suggest to keep the gradient of the scale bars increasing toward right

We thank the referee for this suggestion; we will change this in in the revised manuscript.

Figs. 7 & 8: Change “and the racer age” to “and the tracer age”
Done.

Lastly, we thank the anonymous reviewer again for the helpful comments towards improving the manuscript, and look forward to comments on a revised version.

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