We would like to thanks the reviewer for the positive criticism and recommendations.

Below you find a point-by-point response to all comments.

C1

The attempt to eliminate overlaps between some of the water masses, and the introduction of the new surface water mass, is appreciated. However, the justification on the need to change the conventional ranges for the gulf's water masses is not convincing, and the way the water masses were defined is weak. Below, I am including a number of scientific issues that need to be addressed for making a more convincing case, and for improving the presentation and readability of the manuscript.

Specific Comments 1. The definition of water mass FISW does not satisfy conventional approaches to name the body of water and delineate its properties. a) Note that a water mass is defined as a body of water with a common formation history. Given that 'FISW' is under the continuous action of highly dynamic and variable forcing (wind stress, in- solation, air-sea fluxes, precipitation, and mesoscale eddy dynamics), is it possible to attribute a common formation history to this body of water? b) Since the name of the water mass usually relates to its major area of residence, the name FISW is not appropriate for this potentially new water mass. c) A water mass is often found in regions well beyond its formation region. Is this condition satisfied in the case of FISW? I do not think so. This condition is difficult to be verified. d) A water mass can be identified away from its formation region because its elements retain its properties, in particular its potential temperature and salinity. Given that FISW extends over surfaces waters where irreversible vertical mixing is continuously changing the temperature of the body of water (diabatic turbulent process), temperature is not a conservative property over these surface body of water. Note that classical water masses that form in the surface usually sink into deeper waters away from surface forcing, which allows them to retain its original properties for long periods of time over grate distances. e) In order to accurately define a water mass, it is necessary to include information about its standard deviation; some water masses only require a single combination of T-S and its standard deviation, while delineating other water masses may require defining a T-S relationship and an envelope for the standard deviation. This requirement must be satisfied in the definition of FISW (no information is given about its standard deviation). Is its standard deviation small enough?

Rejoinder: *We are in complete agreement with the referee in that our newly identified Freshwater Influenced Surface Water (FISW) is not a water mass but a Water Type because it does not fit the description of a Water Mass in almost any sense (Tomczack, 1999; Emery, 2003). Other identifiable waters, termed in the MS as water masses, were so named following the older literature to minimize confusion. (Morrison et al., 1983; Vidal et al., 1994; Rivas et al., 2005; Portela et al., 2018). Also, it is not the intent of this work to trace water masses to their core. Our interest is to better delineate the* ***boundaries*** *of the water masses in the Gulf of Mexico, insofar as possible. New physical and chemical parameters, both conservation and non-conservative, are added in the water mass concept (Tomczak, 1999). These additional variables exhibit different importance in defining a water masses but are complementary to each other and provide a more solid basis for the water mass definition.*

C2

2. The definitions of water masses presented here need to be compared again historic definitions that are well established in the scientific community. Modifying table 2, and creating a new figure showing the different ranges of the water masses reported in the literature, will help in evaluating whether we need a new definition of the Gulf's water masses.

Rejoinder*: With the exception of FISW, we have used the assigned water mass names from the literature (See references above). The referee's comment about using standard deviations of T and S (but largely T) to better characterize the water masses from our measurements and from data available from the literature is intriguing, but is not common practice (Emery, 2003). Water masses are generally typified by a range of T and S values (again, Emery, 2003). This is because the assignment of a volume from which T and S means and standard deviations can be computed is highly subjective, and adjoining water masses differ little in their physical properties. Because of this, an important component of our effort is the addition of chemical parameters to improve water mass identification, especially if there is overlap in the T-S diagrams. New Table 1 (attached file) shows the different ranges of the water masses reported in the literature vs. this work. Nevertheless, for the XIXIMI data, we calculated the mean relationship between temperature and salinity and the standard deviation of salinity as a function of temperature to choose the limits of the "natural" spread of the data and eliminate the outliers.*

Table 1. Comparison from historic data (*Portella et al., 2018)* vs this work data.

Water masses		Temperature (Θ) P	Temperature (Θ) NR	Salinity ($g\cdot kg^{-1}$) P	Salinity ($g\cdot kg^{-1}$) NR	Sigma ($Kg\cdot m^{-3}$) P	Sigma ($Kg\cdot m^{-3}$) NR	Mean depth range (m) P	Mean depth range (m) NR	DO ($ml\cdot L^{-1}$) P	DO ($ml\cdot L^{-1}$) NR
Caribbean Surface Water	CSW	22 - 28	27.1-32.1	< 36.7	36.2 - 37	23.5-25	< 24	50-150	< 90	> 4	4-5
Subtropical Underwater	SUW	20 - 25	19.1 -26.1	> 36.6	36.8 – 37.2	24.5-26.6	24.2-26.6	150-230	100-250	2.5-3.8	3.1-4.1
Gulf Common Water	GCW	20- 22.5	20.1-27.1	< 36.6	36.5 – 36.8	25-26	24 - 26	50-150	Winter 0-200 Summer 50-200	2.5-4.2	2.8-5.3
Freshwater Influenced Surface Water Type	FISW	NI	24.1-31.1	NI	< 36.2	NI	< 24	NI	≤ 20	NI	4-5

Note. P= Portella et al. (2018) classification; NR= New reclassification.
Note. Following Merrell and Morrison (1981), Vidal et al. (1994) and Portella et al. (2018)
Note that Portela et al. (2018) renamed the CSW as CSWr[a] (r[a]: remnant)
NI = Not included

3. Why is the overlap between CSW and GCW a big deal? There is always a transition region between water masses in every ocean (that is why we need a standard deviation in trying to isolate the dominant characteristics of the water mass). In order to justify the idea that we need to get rid of this overlap, this manuscript needs to quantify the error related to the conventional and new definitions, including a quantification of the effects on the density field. Are these errors significant, or are both at the noise level? If errors from both definitions are at the noise level, no new definition is needed.

Rejoinder: In the classification proposed by Portela *et al*. (2018) the overlap in the thermohaline ranges of the CSW and GCW was overlooked. However, we point out that by not including the full range of T & S values from 0 to 50 m, the actual volume of the CSW within the GoM would be underestimated, affect hydrography, and potentially, estimates of productivity. This effect is clearly illustrated in Figure 9a from Portela *et al*. (2018) that shows the loss of information that results when you overlap CSW and GCW. Figure 9b shows the new boundaries proposed in this work with no overlap. Figure 9b also shows that high oxygen values are principally a property of the GCW and not CSW.

The manuscript is missing an in-depth review of the-state-of-the-art on the formation of GCW.

Rejoinder: **We hae added the following paragraph to the MS:** One of the mechanisms of formation of the Common Gulf Water (GCW) was that described by Elliott (1979, 1982), which states that the GCW is formed during the autumn and winter months as a result of the vertical convective mixing induced by the cold fronts (Nortes) that spread over the entire Gulf. On the other hand, Vidal et al. (1992, 1994) points out that the other mechanism of formation of the GCW (σ_θ = 24.5 to 25.5 mg • cm^3; S = 36.3 to 36.4; T ~ 22.5 ° C) is the product of the release of the anticyclonic eddies coming from the CL in the northwestern region of the GoM, as well as in the winter when the wind regime produces a mixed layer of approximately 170 m that dilutes the SUW. Additionally, Vidal et al. (1992, 1994) mentions that the core of the GCW within the western region is heated by solar radiation and reaches minimum values of density σ_θ = 25 mg • cm^3 during the summer. On the other hand, Portella et al. (2018) mentions that the GCW evidences the smoothing of the NASUW properties, which takes place throughout the lifespan of the LCE, mainly during the winter mixing.

4. It is not clear how the LC cycle can be used to eliminate the overlap between CSW and GCW since the LC does not transport GCW. This is an important issue in the approach presented here. Also note that Caribbean anticyclones can also make it into the Gulf transporting CSW. Moreover, atmospheric forcing could erase the CSW signature in winter over the Gulf. Some misleading statements regarding this issue are:

Rejoinder: An important result of our paper is that the DO marks the upper boundary of the GCW. The overlap, a mathematical construct, is not needed, nor needs to be explained.

a) This explanations in 455-459 and 553-554 are convoluted. Since the LC does not transport GCW (water mass originated in the GoM), and the CSW is presumably only found in the LC, how the CSW ends up on top of GCW? Something does not make sense here.

Rejoinder: The CSW is less dense than the GCW at all times largely caused by higher temperatures acquired in the Caribbean basin. In winter, the flow of CSW through the Yucatan Channel is a fraction of its summer flow, causing the retraction of the LC (Delgado et al., 2019 - In Press, and others) and its "signature" becomes dispersed in the GoM by "Nortes" winds as the CSW mixes with the SUW and the GCW.

b) Too much emphasize is put on the idea that the "weakening" of the LC is associated with the absence of CSW in the GoM (423). However, previous studies

(cited in the present article) claim that the absence of CSW is becasue this water is continuously transformed in the GoM by wind forcing. Since the latter idea weakens the hypothesis that the LC cycle can be used in dealing with the overlap between CSW and GCW, this issue needs to be addressed in detail. Is CSW absent in winter in both the GoM and Caribbean Sea? If it is missing also over the Caribbean Sea, then atmospheric processes control the variability of this water mass over both the Gulf and the area of formation.

Rejoinder: There is nothing in the literature about "disappearance" of the CSW in the Caribbean Sea (Corredor and Morel, 2001. JGR, 106:415-417). We have explained its absence in the GoM during winter in the paragraph above.

c) In lines 428-430 it is claimed that there is a salinity contribution to CSW in the GoM. Is not supposed that CSW acquires its distinctive high salinity values over the Caribbean Sea? A local addition of salinity within the GoM is against the conventional definition of water mass.

Rejoinder: No, the CSW acquires its low salinities (relative to its temperature) in the Caribbean basin, due to the influx of fresh water from the Amazon and Orinoco Rivers and from rain. (Corredor and Morel, 2001. JGR, 106:415-417). Inside the GoM the continuous winter mixing and subsequent restratification of the upper layer could be responsible for the increased salinity of the CSW in the GoM as compared to its Caribbean origin. Other possible explanation for this increase in salinity is thermal convective mixing due to the “Nortes” events, which would erode the salinity maximum of the NASUW during winter, with the subsequent salinity increase of the above layer. These two hypotheses are not exclusive, they both could act to increase the salinity of the CSW, and the predominance of one or another process would depend on the season of the eddy shedding (Portella et al. 2018).

C3

5. I understand that water masses formed at the surface at higher latitudes retain its DO because they sink and move away from regions of intense atmospheric forcing. However, in the case of water masses that remain in the surface, is it valid to use DO for characterizing their properties? I am not sure about this, since intense vertical mixing acting over these bodies of water makes them diabatic (their properties are non-conservative). Note that DO is a function of temperature, and temperature is non- conservative in water parcels over the ocean mixed layer and upper thermocline. Also note that the LC cycle is not needed to have the variability in DO documented here (562-564). It needs to be shown the variability in DO is not caused by atmospheric forcing in surface water masses; otherwise, it

cannot be used in characterizing surface water masses.

Rejoinder: The referee is correct in pointing out that that the use of DO has pitfalls; one of them is its dependence on temperature and salinity even when conservative, as in deep waters, and the other is loss or gain across the atmospheric boundary. Nevertheless, we use it in the first 50 m because efflux and influx across the air sea boundary are relatively slow. An example of this "memory" is that the usual DO maximum lies at about 10 m and not at 0 m. Nevertheless, in this work we support our conclusions by calculating AOU over the same DO range. Now, AOU is both temperature and salinity independent, and clearly shows the boundary between net surface production and the net respiration below it.

6. An important analysis and methodology for redefining the water mases are given in Fig. 4 and appendix A. These approaches can be significantly simplified by satisfying the conditions listed in item 1 above; using the standard deviation can be particularly helpful.

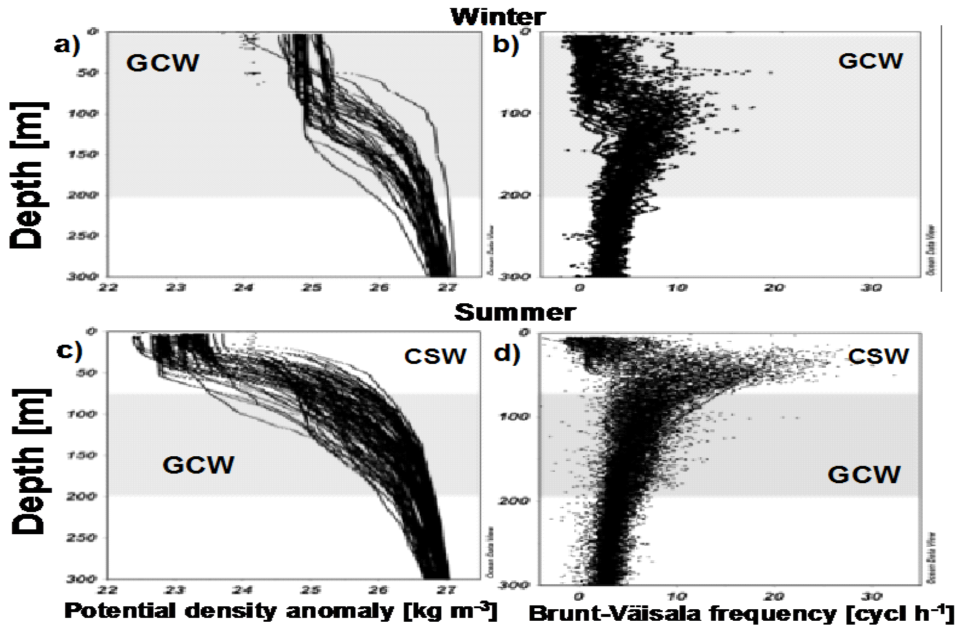
Rejoinder: As we pointed out earlier, away from their core, T & S differences between adjoining water masses are small while differences between biogeochemical variables tend to be larger and independent of temperature. Calculated differences between means are made less significant by the subjective estimation of the volumes considered. Calculations of the standard deviations of water masses are not common.

7. a) What are the source of nitrite and DIC contained in FISW?. Is the seasonal variability in these properties related to vertical mixing (and cooling of the sea surface), since these two chemicals depend on temperature? Because these properties reflect the dynamic and variable characteristics of surface waters (409-412). Can they be used in delineating water masses? They are clearly impacted by the seasonal cycle of insolation and vertical mixing over the upper ocean, and likely also by local biogeochemical processes.

Rejoinder: No, nitrate (combined with nitrite) and DIC are in units of mass/mass, thus temperature and salinity independent. Their sources are variable freshwater and mixing, and we cannot speculate on them. Commonly, they are seen as near conservative properties in the water column, and that changes in their vertical concentrations are caused by the processes of respiration and phosynthesis. Thus, nitrate is non-volatile and reflects them, being very low at the surface when mixing is slow, and somewhat higher when mixing is greater. The same can be said for DIC whose air-sea exchange rate is about 1/5 that of DO. So, while they are only quasi conservative at the surface, below the surface, they are useful for characterizing water masses (think of the oxygen minimum in Tropical Atlantic Central Water). At the surface, the shape of the profiles really has to do with the relative rates of mixing vs. photosynthesis and respiration. If mixing processes dominated, then all profiles would look like straight vertical lines. When this is not the case, biogeochemical processes dominate. How to separate the two? Using salinity as a very conservative property and "normalizing" the other variables to it (Broenkow, W., Limnology and Oceanography, 10:40-52, 1965).

8. Where is the analysis of the Brunt-Vaisala frequency (345-247) being shown? Rather than buoyancy alone, it is the criticality of the Richardson number (Ri<1/4) that is used to identify periods of vertical mixing. In addition to the buoyancy frequency, measurements of horizontal current vertical shear are also needed in the computation of Ri.

Rejoinder: Brunt-Väisälä frequency was calculated to estimate the stability of the water via TEOS-10 (See Fig. a and b in the attach file). The theme of the mixed layer is of great interest in the GoM for primary production studies, but there are several difficulties. In the GoM, mixed layer follows a clear seasonal cycle characterized by a deepening in winter. Under these conditions, we considered useful estimate the stability of the water by Brunt-Väisälä. The figure shows the vertical profiles of potential density anomaly and the Brunt-Vaisala stability parameter during winter (a and b) and summer (c and d). In summer, with the presence of the CSW, the mixed layer lies above the nutricline, as determined by the upper reaches of the GCW (Fig. c y d). As mentioned throughout this work and by observations by other authors (Delgado et., 2019), during the summer months with the entry of LC, the presence of oligotrophic waters dominates in the first 100 m. On the contrary, in winter, in the absence of Caribbean water and greater vertical mixing induced by the Nortes, will favor a deep mixed layer (See Fig. a and b in the attach file). We did have all the data needed to calculate **the Richardson number and we feel** useful enough estimate the stability of the water by Brunt-Väisälä (we can include the figure in the text if needed).



9. Another possibility for explaining the seasonal change in the nutricline and carbo- cline (387-390), is that these properties are a function of the seasonal cycle of the wind stress and insolation since these properties clearly are a function of temperature as per Fig. 8.

Rejoinder: As explained in Rejoinder 7, Nitrate and DIC concentrations are independent of temperature and salinity. What shows in Fig. 8 is the combined result of mixing and *in-situ* processes. Because mixing affects all variables, the concentrations of Nitrate and DIC **appear** to be functions of temperature. This is particularly true in surface waters where wind mixing is rapid.

10. The vertical exchange of chemical properties between water masses discussed in 484-486 can occur by diffusion (very low time scale), or by diapycnal mixing that requires vertical mixing and water mass transformation. What is the more likely mechanism for explaining this conundrum? Again, the introduction is needs an in-depth discussion on the formation of GCW.

Rejoinder: We don't see that there is a problem here. Even at 50 m diffusion, even eddy diffusion is too slow mix the two water masses in question. As pointed out earlier, the influx of CSW into the gulf via the LC is greatly reduced in winter, and what there is mixed into the GCW and SUW by the northerly winds. We also discussed the formation of GCW in depth in our answer for question 3.

11. Note that the Mississippi River plume (508-510) also extends southward into the LC and associated eddy field; this plume can also leave the GoM through the Florida Straits. This topic needs a review of the state-of-the-art, since river runoff can be an important contribution to FISW.

Rejoinder: Yes indeed, the Mississippi River plume can be found in the south and there are other rivers along the Mexican coast to be considered. In the MS we stated that the low salinity characteristics of FISW are largely the result of the fresh water that enters the GoM.

Technical Comments 1. The article is too long, which makes difficult to finish reading it. Maybe it should be divided in two parts (assuming that the specific comments listed above are addressed satisfactorily), one for the definition of water masses, and another for the discussion of the effects of the water masses on biogeochemical properties. This should also take care of the too long discussion section.

2. A substantial review of English grammar is needed; there are too many sentences that need revision as to be listed here.

Thanks, we will do that.

3. line 122: Do you mean surface waters in the interior GoM?

Yes.