Answer to Referee#2 and corrections to the manuscript "Palaeoclimatic oscillations in the Pliensbachian (Lower Jurassic) of the Asturian Basin (Northern Spain)", by J.J. Gómez, M.J. Comas-Rengifo and A. Goy

Thanks very much to anonymous Referee #2 for the valuable comments and corrections of the manuscript. All the suggestions and corrections have been incorporated into the manuscript or have been discussed in the following paragraphs. All of them have substantially contributed to the improvement of the manuscript.

Page 4043

Referring the discussion on the use of δ_w and Mg/Ca ratios, the following paragraph will be included in the Material and Methods section.

According to the recommendations of Shackleton and Kennett (1975), the standard value of δ_w=-1‰ was used for palaeotemperature calculations under non-glacial ocean water conditions. If the presence of permanent ice caps in the poles is demonstrated for some of the studied intervals, value of δ_w=0‰ would be used and consequently calculated palaeotemperatures would increase in the order of 4ºC. The Mg/Ca ratio was not used in this study to evaluate the δ_w because, according to some authors, the negative correlations in some belemnites populations between $\delta^{18}O$ and Mg/Ca indicates that Mg/Ca is not a useful palaeotemperature indicator (McArthur et al., 2000; Rosales et al., 2004; McArthur et al., 2007; Li et al., 2012)

Page 4042: Line 9. 562 layers will be replaced with 562 beds

Ammonites biochronostratigraphy is an important part of the study. It summarizes the result of more than ten years of sampling of ammonites of the Rodiles section and, except for some partial and preliminary published results; this is the first time that the biochronostratigraphycal succession of ammonites is published. The complete biochronostratigraphycal study is beyond the objective of this paper, but is under preparation to be published in other article.

At this respect Section 3.2 is now:

3.2 Biochronostratigraphy

The ammonite-based biochronostratigraphy of these deposits in Asturias have been carried out by Suárez-Vega (1974), and the latest Pliensbachian and Toarcian ammonites by Gómez et al. (2008), and by Goy et al. (2010 a, b). Preliminary biochronostratigraphy of the Late Sinemurian and the Pliensbachian in some sections of the Asturian Basin has been reported by Comas-Rengifo and Goy (2010), and the result of more than ten years of bed by bed sampling of ammonites of the Rodiles section, which allowed precise dating of the climatic events described in this work, are here summarized.

Collected ammonites allowed the recognition of all the standard Late Sinemurian, Pliensbachian and Early Toarcian chronozones and subchronozones defined by Elmi et al. (1997) and Page (2003) for Europe. Section is generally expanded and ammonites are common enough as to constrain the boundaries of the biochronostratigraphical units. Exceptions are the Taylori−Polymorphus subchronozones that could not be separated, and the Capricornus−Figulinum subchronozones of the Davoei Chronozone, partly due to the relatively condensed character of this Chronozone. Most of the recorded species belong to the NW Europe province but some representatives of the Tethysian Realm are also present.

The phrase “A total of 191 analyses of stable isotopes were performed on 163 belemnite calcite samples” will be included in the Materials and Methods section.

Referring the figure showing examples of the well-preserved/poorly preserved samples, if editor agrees, the following Figure 2 and its figure caption could be included in the manuscript. As can be seen most of the belemnites show dark non luminescent areas where sampling has been performed.

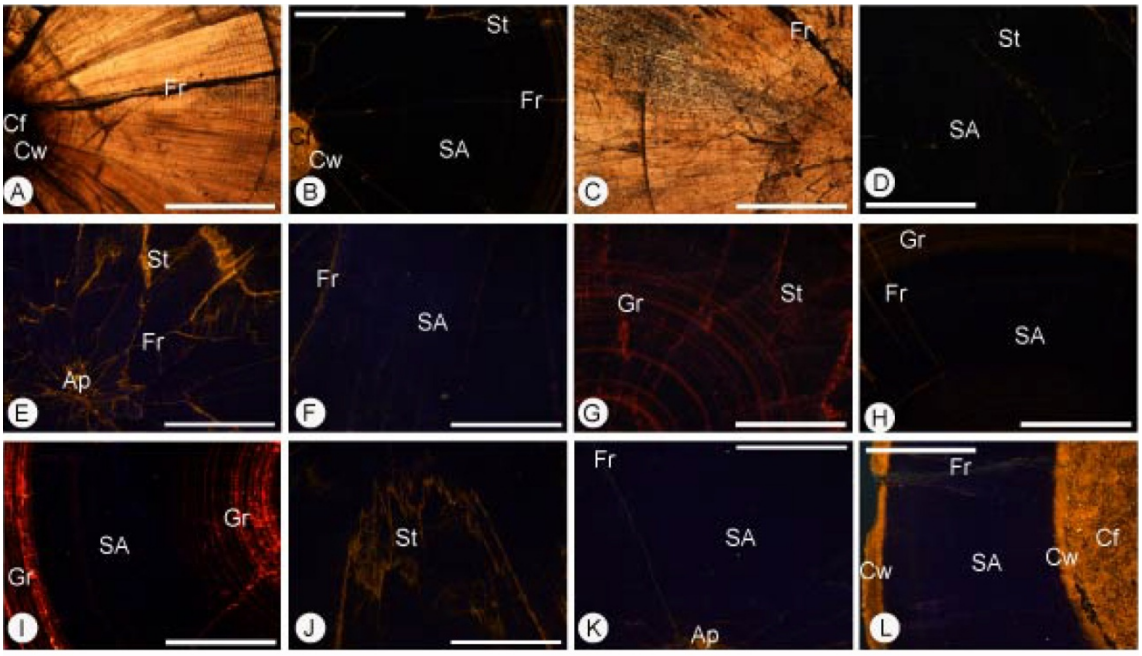

Fig 2. Gómez, Comas and Goy

Fig. 2. Thick sections photomicrographs of some of the belemnites sampled for stable isotope analysis from the Upper Sinemurian and Pliensbachian of the Rodiles section. The unaltered by diagenesis non luminescent sampling areas (SA), where the samples have been collected, are indicated. A and B Sample ER 351, Upper Sinemurian Raricostatum Chronozone, Aplanatum Subchronozone. A: optical transmitted light microscope, showing the carbonate deposit filling the alveolous (Cf), the outer rostrum cavum wall (Cw) and fractures (Fr). B: cathodoluminescence microscope photomicrograph, showing luminescence in the carbonate deposit filling the alveolous

(Cf), in the outer rostrum cavum wall (Cw) and in the fractures (Fr). SA represents the unaltered sampling area. C and D: Sample ER 337, Lower Pliensbachian Jamesoni Chronozone, Taylori-Polymorphus Subchronozones. C: optical transmitted light microscope, showing fractures (Fr). D: cathodoluminescence microscope photomicrograph, showing luminescence in stylolites (St). SA is the unaltered sampling area. E and F: Sample ER 589a Upper Pliensbachian Margaritatus Chronozone, Subnodosus Subchronozone. E: cathodoluminescence microscope, showing luminescence in the apical line (Ap), fractures (Fr) and stylolites (St). This area of the section was not suitable for sampling. F: another field of the same sample as H showing scarce fractures (Fr) and the unaltered not luminescent sampled area (SA). G and H: Sample ER 549a, Upper Pliensbachian Margaritatus Chronozone, Stokesi Subchronozone. G: cathodoluminescence microscope showing luminescent growth rings (Gr) and stylolites (St). Area not suitable for sampling. H: cathodoluminescence microscope photomicrograph, of the same sample as G, showing luminescent growth rings (Gr) and fractures (Fr), with unaltered sampling area (SA). I: Sample ER 555 Upper Pliensbachian Margaritatus Chronozone, Stokesi Subchronozone. Cathodoluminescence microscope photomicrograph showing luminescent growth rings (Gr) and the unaltered sampling area (SA). J and K: Sample ER 623 Upper Pliensbachian Spinatum Chronozone, Apyrenum Subchronozone. J: cathodoluminescence microscope photomicrograph showing luminescent stylolites (St). K: Another field of the same sample as J showing luminescence in the apical line (Ap) and fractures (Fr) as well as the non luminescent unaltered sampling area (SA). L: Sample ER 597, Upper Pliensbachian Margaritatus Chronozone, Gibbosus Subchronozone. Cathodoluminescence microscope photomicrograph showing luminescent carbonate deposit filling the alveolous (Cf), the outer and inner rostrum cavum wall (Cw), the fractures (Fr) and the non luminescent sampling area (SA). Scale in bar for all the photomicrographs: 1mm.

No trace element to evaluate preservations was needed given the visible excellent preservation of belemnite calcite samples, as can be seen in Figure 2, which was also supported by the lack of correlation between $\delta^{18}O$ and $\delta^{13}C$ values, as shown in the cross-plot of Figure 3.

A table showing the biochronostratigraphy (biochronozone and biochronosubzone) as well as the $\delta^{18}O$ and $\delta^{13}C$ values is available and could be included in the publication as complementary information if required.

The instrument used in the stable isotope laboratory of the Michigan University was a Finnigan MAT 253 triple collector isotope ratio mass spectrometer, and reproducibility reported by the lab is better than 0.02 ‰ PDB for $\delta^{13}C$. The used instrument has been incorporated into the text.

Page 4044.Biochronostratighraphy will be replaced with Biochronostratigraphy

Referring the use of decimals, only 1 decimal place has been used and, as a consequence:

Page 4042. Line 18. -0.11 will be replaced with -0.1

Page 4046. Line 5. -2.98‰ will be replaced with -3‰

Page 4046. Line 14. 0.67 will be replaced with 0.7

Respect to the positive 13C we are reproducing the phrase by Payne and Kump (2007). We agree with Referee#2, and that is what we say "this $\delta^{13}C$ positive shift cannot necessarily be the consequence of the widespread preservation of organic-rich facies under anoxic waters, as no anoxic facies are present in the Spanish Lower Toarcian sections (Gómez and Goy, 2011)."

References with respect to the Toarcian mass extinction (Gómez and Arias, 2010; García Joral et al., 2011; Gómez and Goy, 2011; Fraguas et al., 2012; Clémence, 2014; Clémence et al., 2015; Baeza-Carratalá et al., 2015) have been included in section 4.2.

The paragraph on Palaeolatitudes (Palaeogeographical reconstruction based on comprehensive palaeomagnetic data, carried out by Osete et al. (2010), locates the studied Rodiles section at a latitude of about 32º N for the Hettangian–Sinemurian interval and at a latitude of almost 40º N (the current latitude of Madrid) for the Toarcian–Aalenian interval.) has been transferred to Section 3.

Hesselbo et al. (2000) do not specifically mention the presence of a Late Sinemurian Warming, but this study is not a palaeoclimatological study, as it is referred to the proposal of the Robin Hood's Bay as a potential global stratotype for the Sinemurian–Pliensbachian boundary. However, they mention a decrease of about 5ºC across the boundary. On the other hand, isotopic results presented by Korte and Hesselbo (2011) show 18O values in belemnite calcite between -1 and -3, which represent a quite high seawater temperatures for the Late Sinemurian, representing the Late Sinemurian Warming.

Some orientation figure should be taken to know what is above and below a "normal" temperature. In this case 16ºC, which is the average palaeotemperature for the studied interval (Late Sinemurian, Pliensbachian and Early Toarcian), has been taken as a reference. Temperatures above this figure are considered as warming intervals and palaeotemperatures below this 16ºC, which curiously is also the current average seawater temperatures in the Atlantic for the latitude of Madrid, have been taken as cooling intervals.

Warming in the Pliensbachian is referred in the text and figures as the the Early Pliensbachian Warming interval, affecting to Most of the Early Pliensbachian Ibex Chronozone and the base of the Late Pliensbachian.

Pliensbachian Cooling is referred as the Late Pliensbachian Cooling interval in the text and in the figures.

Corrections respect the use of Lower/Early and Upper/Late follow:

Page 4039:

Line 2. Lower Jurassic should be replaced with Early Jurassic

Page 4040:

Line 4. Lower should be replaced with Early

Line 13. uppermost should be replaced with latest

Line 14. Lower should be replaced with Early

Line 17. Upper should be replaced with Late

Line 18. Lower-Upper should be replaced with Early-Late

Line 19. Upper should be replaced with Late

Line 21. Lower should be replaced with Early

Line 22. Lower should be replaced with Early

Page 4041:

Line 11. Upper should be replaced with Late

Line 12. Lower Toarcian warming should be replaced with Early Toarcian Warming

Line 12. Lower should be replaced with Early

Line 21. Upper should be replaced with Late

Line 27. uppermost should be replaced with latest

Line 28. Upper Pliensbachian cooling should be replaced with Late Pliensbachian Cooling

Line 28. Lower Toarcian warming should be replaced with Early Toarcian Warming

Page 4042:

Line 3. Upper Sinemurian should be replaced with Late Sinemurian

Line 3. Lower should be replaced with Early

Page 4044:

Line 24. uppermost should be replaced with latest

Page 4045

Line 1. Upper should be replaced with Late

Line 3. Upper should be replaced with Late

Line 4. Lower should be replaced with Early

Lines 14-15. Upper should be replaced with Late

Lines 15-16. uppermost should be replaced with latest

Line 17. Lower should be replaced with Early

Line 19. upper should be replaced with late

Line 20. upper part of the Ibex should be replaced with latest Ibex

Line 21. lower part of the Davoei should be replaced with earliest Davoei

Line 22. Upper should be replaced with Late

Line 23. upper part of the Spinatum should be replaced with latest Spinatum

Line 24. Lower should be replaced with Early

Page 4046:

Line 2. Upper should be replaced with Late

Line 3. Lower should be replaced with Early

Line 3. Upper should be replaced with Late

Line 3. lowermost should be replaced with earliest

Line 7. Lower should be replaced with Early

Line 9. Lower should be replaced with Early

Line 10. Upper should be replaced with Late

Line 11. Upper should be replaced with Late

Line 11. Lower should be replaced with Early

Line 15. Lower should be replaced with Early

Page 4047.

Line 2. Upper should be replaced with Late

Line 7. The Lower Pliensbachian negative $\delta^{13}C$ excursion should be replaced with Early Pliensbachian $\delta^{13}C$ negative excursion
Line 8. uppermost should be replaced with latest
Line 8. Lower should be replaced with Early

Line 15. Lower should be replaced with Early

Page 4048.

Line 15. Lower should be replaced with Early

Page 4049

Line 12. uppermost should be replaced with latest
Line 12. Lower should be replaced with Early

Line 15. Upper should be replaced with Late

Lines 15-16. lowermost should be replaced with earliest
Line 15. Lower should be replaced with Early

Line 18. Lower-Upper should be replaced with Early-Late

Line 19. Upper should be replaced with Late

Line 19. Lower should be replaced with Early

Line 26. uppermost should be replaced with latest
Line 26. Lower should be replaced with Early

Page 4050

Line 1. Upper should be replaced with Late

Lines 2-3. Upper should be replaced with Late

Line 3. base of the Lower should be replaced with earliest
Line 8. uppermost should be replaced with latest
Line 8. lowermost should be replaced with earliest
Line 12. uppermost should be replaced with latest

Line 12. lowermost should be replaced with earliest
Line 14. Upper should be replaced with Late

Line 15. Upper should be replaced with Late

Line 21. Upper should be replaced with Late

Line 21. Upper should be replaced with Late
Line 22. Lower should be replaced with Early

Page 4501.

Line 1. Lower should be replaced with Early

Line 3. Upper should be replaced with Late
Line 15. Lower should be replaced with Early

Line 20. Lower should be replaced with Early

Page 4052

Line 5. Lower should be replaced with Early

Line 7. Upper should be replaced with Late
Lines 8-9. Upper should be replaced with Late
Line 9. lowermost should be replaced with earliest
Line 11. Upper should be replaced with Late
Line 11. lowermost should be replaced with earliest
Line 19. base should be replaced with onset
Line 19. Upper should be replaced with Late
Line 20. Lower should be replaced with Early

Page 4053
Line 8. Upper should be replaced with Late
Line 8. lowermost should be replaced with earliest

Page 4055.

Line 2. Upper should be replaced with Late
Line 3. lowermost should be replaced with earliest
Line 5. Upper should be replaced with Late
Line 5. Lower should be replaced with Early

Line 12. Upper should be replaced with Late
Line 14. lowermost should be replaced with earliest
Line 16. Upper should be replaced with Late

Page 4057
Line 3. Lower should be replaced with Early

Line 4. Base of should be replaced with earliest
Line 5. Upper should be replaced with Late
Line 6. lowermost should be replaced with earliest
Line 12. Lower should be replaced with Early
Line 16. Upper should be replaced with Late

Page 4058

Line 2. Upper should be replaced with Late
Line 3. Lower should be replaced with Early
Line 5. Upper should be replaced with Late
Line 8. Lower should be replaced with Early
Line 10. Lower should be replaced with Early
Line 12. upper should be replaced with latest
Line 12. Lower should be replaced with Early
Line 13. Upper should be replaced with Late
Line 15. Lower should be replaced with Early
Line 19. Upper should be replaced with Late
Line 23. uppermost should be replaced with latest
Line 28. Upper should be replaced with Late

Page 4059

Line 1. Upper should be replaced with Late
Line 5. Upper should be replaced with Late
Line 12. Lower should be replaced with Early
Line 17. lowermost should be replaced with earliest
Line 21. Lower should be replaced with Early
Line 23. Lower should be replaced with Early

Page 4074.

Line 2. lowermost should be replaced with earliest
Line 2. Upper should be replaced with Late
Line 3. Lower should be replaced with Early
Line 4. Upper should be replaced with Late
Line 6. Lower should be replaced with Early

Page 4075

Line 1. Upper should be replaced with Late
Line 2. Lower should be replaced with Early
Line 3. Upper should be replaced with Late
Line 3. Lower should be replaced with Early

Line 4. Upper should be replaced with Late
Line 5. Lower should be replaced with Early

Page 4076

Line 2. uppermost should be replaced with latest
Line 3. Lower should be replaced with Early
Line 3. lowermost should be replaced with earliest
Line 4. Upper should be replaced with Late
Line 6. negative $\delta^{18}O$ excursion should be replaced with $\delta^{18}O$ negative excursion

Line 6-7. lowermost should be replaced with earliest
Line 7. Lower should be replaced with Early
Line 9. Upper should be replaced with Late

Line 10. Lower should be replaced with Early
Line 12. Lower should be replaced with Early
Line 13. Lower should be replaced with Early

The phrase “Causes of the exceptional Late Pliensbachian Cooling are still unknown” has been deleted.

Version of figure 1 received by Referee#2 is too small and impossible to be read. In the final version this figure will occupy the all wide of the page and text will be legible. A JPG version of figure 1 more similar to the final figure follows.

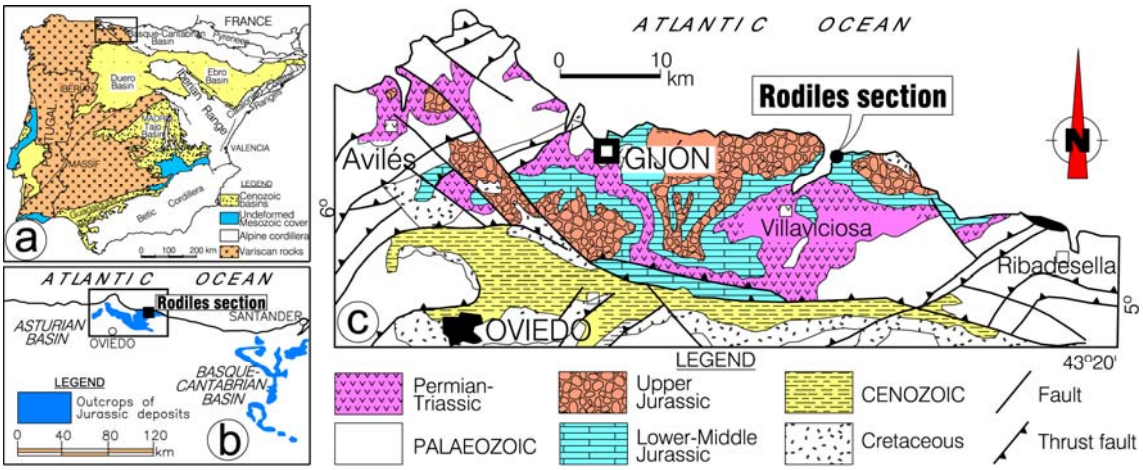

Fig. 1. Gómez, Comas-Rengifo and Goy