Answer to Referee #3

Thanks very much to anonymous Referee #3 for critically reading the manuscript and for the valuable comments and corrections. All the suggestions and corrections have been taken into account and incorporated into the manuscript or have been discussed in the following paragraphs. All of them have substantially contributed to the improvement of the manuscript.

All text concerning ice caps during the Late Pliensbachian in the different sections has been erased.

The objectives of the article are clearly expressed in Page 2 of the manuscript as "The objective of this paper is to provide data on the evolution of the seawater palaeotemperatures and the changes in the carbon isotopes through the Early Jurassic Late Sinemurian, Pliensbachian and Early Toarcian; to constrain the timing of the recorded changes through ammonite-based chronostratigraphy and to compare the changes in seawater palaeotemperature during the mentioned time interval with other sections, in order to assess whether the observed environmental changes have a local or a global extent

We consider that the correlations between isotope profiles from Asturias and other NW Tethyan basins are fundamental tools to discriminate between local, regional and global events.

Respect to the discussion about processes, a new paragraph concerning the data published by Martinez and Dera (2015) has been introduced into Chapter 4.2. Carbon isotope curve. The new paragraph says: "Martinez and Dera (2015) proposed the presence of fluctuation of the carbon cycle during the Jurassic and Early Cretaceous, due to a cyclicity of ~9 My linked to a great eccentricity cycle, amplified by cumulative sequestration of organic matter. Nevertheless, this ~9 My cycle has not been evidenced in the Pliensbachian deposits of several parts of the World (Ikeda and Tada, 2013, 2014) and cannot be evidenced in the Pliensbachian deposits of the Asturian Basin. The disruption of this ciclicity recorded during the Pliensbachian could be linked to chaotic behaviour in the solar system (Martinez and Dera, 2015) possibly due to the chaotic transition in the Earth–Mars resonance (Ikeda and Tada, 2013). Data from Japan suggests that this disruption developed from the Hettangian to the Pliensbachian (Ikeda and Tada, 2013, 2014) possibly linked to the massive injection of CO_2 from the eruptions of the Central Atlantic Magmatic Province to the Karoo-Ferrar eruptions (Prokoph et al. 2013) which destabilized the carbon fluxes, reducing or dephasing the orbital imprint in the $\delta^{13}C$ over millions of years (Martinez and Dera, 2015)." That explains what the new carbon isotope data from Aturias brings in this debate.

Palaeotemperatures are calculated on the basis of reliable diagenetically screened $\delta^{18}O$ data from belemnite calcite and the link between temperature changes and carbon cycle are mentioned in the manuscript. Probably due to the disruption of the ~9 My ciclicity during the Early Jurassic and specially the Pliensbachian mentioned before (Martinez and Dera, 2015) there is not a clear correspondence between the

$\delta^{13}C$ values and the palaeotemperature variations, but both data are reliable and the no correspondence of the expected relationship between $\delta^{13}C$ values and palaeotemperature oscillations can be explained by the mentioned disruption in the $\delta^{13}C$ ~9 My ciclicity shown by Martinez and Dera (2015) and Ikeda and Tada (2013, 2014) but more related to the water mass exchange (Dera et al., 2009) and with the pCO_2 (Berner, 1994; Berner and Kothavala, 2001) as mentioned in the text.

General remarks

To be homogeneous in the definition of isotopic excursions, the name of Ibex-Davoei positive peak has been replaced with Ibex-Davoei positive excursion in text and figures.

The Late Sinemurian is a warming interval because measured seawater palaeotemperatures are well above average (up to 21ºC), even temperature decreases from Late Sinemurian to earliest Pliensbachian, as added now in Chapter 4.3.1.

$\delta^{13}C$ values in most of the Upper Sinemurian are positive with peak values up to ~3‰. We do not believe that this values are valid to define a negative excursion during the Raricostatum Zone.

The $\delta^{13}C$ data from Caruthers et al. (2014) have been incorporated into the text in Chapter 4.2. Other data from North America (i.e. Porter et al., 2014) cannot be used in our correlation because they are made on older rocks (Lower Sinemurian and Upper Sinemurian up to the equivalent to the Obtusum Zone) than the deposits considered in this work.

Introduction of the new paragraph mentioned above, takes into account the recent literature linking the Jurassic carbon cycle and climate changes, and explain the obtained $\delta^{13}C$ values in Asturias.

<u>Minor remarks</u>

Line 156 and 157. Sections of the belemnite rostra for cathodoluminescence microscope are thicker than the usual thin sections for optical microscope as they will be used for sampling.

The palaeoecology of belemnites has been placed into a new chapter 4.1. Reliability of belemnite isotope record.

Line 183. discrepancies has been replaced with conflicts

Line 187. mode of life has been replaced with life habitats

Line 189 and elsewhere. Necktonic and necktobentic have been replaced with Nektonic and nektobentic in all text.

Line 194. It is unclear has been replaced with it is unclear.

Line 198. This phrase is taken from Li et al. (2012) “Similarly, Li et al., (2012) concluded that belemnites were mobile and experienced a range of environmental conditions during growth. Some belemnite species inhabited environmental niches that remain unchanged, while other species had a more cosmopolitan lifestyle inhabiting wider environments.” To make it clear it has been changed to “Similarly, Li et al., (2012) concluded that belemnites were mobile and experienced a range of environmental conditions during growth and that some belemnite species inhabited environmental niches that remain unchanged, while other species had a more cosmopolitan lifestyle inhabiting wider environments.

Line 204. I agree that the Ullman et al. (2014) work is awkward but I do not find another way to write the sentence.

Line 233. We could not find any error concerning “diagenetic”

Lyne 234. “analyzed” has been removed

Line 313. well-marked has been removed

Line 327-328. We are not talking about a “Sienemurian positive CIE” but a “Late Sinemurian positive CIE”. As Referee#3 mentions, we do not know what happens in the Early and Middle Sinemurian in Asturias and in the UK, but it is evident that $\delta^{13}C$ values recorded in both areas reflect quite positive values indicating the presence of a positive CIE. Values of Porter et al. (2014) cannot be applied to this work because their positive $\delta^{13}C$ excursion refers to the Middle Sinemurian.

Line331. negative excursion has been replaced with decrease of values.

Lines 345-349. The alternative scenario presented by Martinez and Dera (2015) has been introduced into Chapter 4.2. and commented as stated above.

Lines 350-354. Data have been compared with Panthalassa (Caruthers et al., 2014), Portugal (Silva and Duarte, 2015) and Italy (Moretinni et al., 2002). The following phrase has been introduced into the text: “(the Late Pliensbachian positive excursion in Fig. 6) and in bulk carbonates of the Lusitanian Basin (Silva et al., 2011; Silva and Duarte, 2015) and in the Apennines of Central Italy (Moretinni et al., 2002). This CIE also partly coincides with the $\delta^{13}C_{org}$ reported by Carhuters et al. (2014) in Western North America.”

We do not know if there is a global positive CIE during the Ibex biochronozone. Records from many different parts of the World are lacking

Lines 355-367. As stated by Martinez and Dera (2015), it seems that extent of the $\delta^{13}C$ excursions at a global scale is problematic due to the disruption of the ~9 My ciclicity recorded during the Early Jurassic probably linked to chaotic behaviour in the solar system (Martinez and Dera, 2015). However, it seems that the successive excursions found in Asturias can be correlated at the scale of Western Europe. Data from other parts of the World are needed to test the global extension of these excursions.

Line 374. The paragraph has been attached to the previous one.

Line 385. We agree that the geochemical expression of the global carbon cycle may be recorded at regional scale, but if global carbon signal has been altered during part of the Early Jurassic due to the CAMP and Karoo-Ferrar volcanic eruptions as sustained by Martinez and Dera (2015) and Ikeda and Tada (2013, 2014), more data around the World are needed to discriminate between local, regional and global signals.

Line 409. As mentioned in section 4.3, "Most of the Early Pliensbachian is represented by a period of "normal" temperature, close to the average palaeotemperatures of the studied interval"..... "The average palaeotemperature of the latest Sinemurian, Pliensbachian (palaeolatitude of 32ºN) and Early Toarcian (palaeolatitude of 40ºN), calculated from the $\delta^{18}O$ values obtained from belemnite calcite in this work, is 15.6ºC.". That is why we consider "normal" the temperature of 16ºC calculated for the Early Pliensbachian. Not mentioned in the manuscript, but curiously 16ºC is also the current average temperature of the Atlantic Ocean at the latitude of Madrid.

Line 419. We agree that the Late Sinemurian is a warm period with a general decreasing trend towards the Early Pliensbachian "normal" temperature period. That is now said in Chapter 4.3.1.

Line 420-421. We agree that the $\delta^{18}O$ values decrease trough the Late Sinemurian but they are still in quite negative values (up to -3‰), the majority below average, marking a warming interval, even they tend to be less negative towards the Early Pliensbachian.

Line 427. Raricostaum has been replaced with Raricostatum.

Line 431. Warming has been replaced with warm.

Line 439-444. The phrase "on which the general trend is a decrease in palaeotemperature from Late Sinemurian to earliest Pliensbachian" has been added to the paragraph. A thin interval of black shale facies has been recorded at the base of the Jamesoni Chronozone of the earliest Pliensbachian, but no higher burial rates of organic matter have been documented in the Densinodulum Subzone. As a consequence no evidences have been found to think that higher burial of organic matter could have decrease pCO_2 and triggered the long term cooling.

Line 463. As mentioned in the text, the Ibex-Davoei positive $\delta^{13}C$ peak coincides only partly with the Early Pliensbachian Warming interval.

Line 476. The paper by Dera et al. (2009) has been taken into account and the following phrase has been added to the text: "Data on neodymium isotope presented by Dera et al. (2009) indicate the presence of a generalized southwards directed current in the Euro-boreal waters for most of the Early Jurassic, except for the Early–Late Pliensbachian transition, where a positive ε_{Nd} excursion suggests northward influx of warmer Tethyan or Panthalassan waters which could contribute to the seawater warming detected in the Early Pliensbachian."

Lines 478-479. “is recorded at the Late Pliensbachian and the earliest Toarcian” has been replaced with “is recorded by belemnites from the Late Pliensbachian to the Early Toarcian”

Lines 483-485. The phrase “by supposing the absence of ice caps” has been included in section 4.3.4.

Lines 509-511. The reference Dromart et al., 2003 has been replaced with Suan et al., 2010 and Silva and Duarte, 2015.

In the Asturian Basin there are black shale facies in the Ibex Chronozone, Valdani Subchronozone, but it does not correspond with any rising of the $\delta^{13}C$ values, so we cannot explain the decrease of CO_2 levels by high burial rates of organic matter. It is true that there is a general trend of decreasing $\delta^{13}C$ values from the Late Sinemurian positive excursion and the top of the Early Pliensbachian $\delta^{13}C$ positive excursion, but in this part of the section there are two intervals of black shales (>5%TOC) located in the earliest Jamesoni Chronozone and the middle part of the Ibex Chronozone. Between the two black shales most of the deposits are “organic rich” deposits (2.5-5% TOC), but no clear relationship between decrease in $\delta^{13}C$ and decrease of productivity rates can be established.

Line 623. This is true, but data and discussion referring the presence of ice has been erased.

Line 522-623. As mentioned above the discussion about glendonites, ice-rafted clasts, glacioeustasy and temperature gradient has been deleted.