

Interactive comment on “Millennial-scale climatic variability between 340 000 and 270 000 years ago in SW Europe: evidence from a NW Iberian margin pollen sequence” by S. Desprat et al.

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GENERAL COMMENTS

This manuscript provides an additional pollen dataset for a time span which is reasonably well known in southern European latitudes but constitutes a kind of *mystery* interval in northern European lands. The results presented in the paper support the interpretations and conclusions. They provide reference patterns for other northeast Atlantic continental margins during the interval studied. This should certainly be of interest to the reader.

Palynological studies performed in marine sediments are technically more difficult than

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those made in continental archives, mainly due to that less material is available to characterise the pollen zones. However, it is worth promoting this combination of pollen biostratigraphy with marine proxies in the same core strata; it definitely enriches the description of events. Without doubt, a multiproxy approach is crucial before making comparison with other paleoarchives close to the areas studied, or before establishing any long distance connection.

My overall conclusion is that this paper has potential for publication in *Climate of the Past*, once the structure of the discussion section is improved and a few precisions and clarifications are added. My suggestions mainly are not for the substance, but for the form (see below for specific and technical constructive comments).

SPECIFIC COMMENTS

References are made to the text by giving [page number, line number: “text quote”].
I group the specific comments in three main aspects:

ONE THE NOMENCLATURES OF LONG CLIMATIC RHYTHMS ARE NOT INTER-CHANGEABLE

***TWO A PRECISE, TRANSPARENT DESCRIPTION OF EVERY EVENT IS NEEDED
THREE COMPLETE TABLE 1, FIG. 2 AND FIG. 3; MERGE FIG. 4 AND 5; ADD
NEW FIGURE?***

ONE THE NOMENCLATURES OF LONG CLIMATIC RHYTHMS ARE NOT INTER-CHANGEABLE

[377, 23: “MIS 8.6 or 9b”]; [378, 23 to 25: “during MIS 8.5 terrestrial equivalent (etc.) substage 8.5 should belong to MIS 9”]; [378, 29: “during MIS 8.6 and 3”]; [379, 1 to 2: “during MIS 8.5 as high or higher than during the previous deglacial substage 9.1”]; [379, 3: “to the MIS 5.1 or 5.3”]; [379, 6 to 8: “isotopic substages 8.5 and 8.6 in MIS

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9”]; [395, 4: “during MIS 9b (8.6, ~290-310 kyr) millennial”]

As already mentioned in the discussion (L. M. Dupont, interactive comment), it is essential to distinguish between the nomenclature of sub-stages (e.g. substage 5a, 5b, etcetera; Shackleton N. J., 1969. P. Roy. Soc. London, B174: 135) and the isotope events (e.g. events 5.1, 5.2, etc.; Pisias N. G., et al., 1984. Mar. Geol., 56: 119; Prell W. L., et al., 1986. Paleo., 1: 137; Martinson D. G., et al., 1987. Quaternary Res., 27: 1). The former refers to intervals (i.e. with letters: 5a, 5b, etc.), whereas the latter refers to points, not intervals (i.e. with numbers: 5.1, 5.2, etc.). Hence, these two systems of nomenclature are not interchangeable (Shackleton N. J., 2006. Quaternary Sci. Rev., 25: 3458).

It is my belief that the formulation “MIS 8e as the terrestrial equivalent of marine isotope event 8.5” (L. M. Dupont, interactive comment) will add confusion to this subject. An increasing number of papers mistake one system for the other and consequently the error is further propagated incorrectly. Indeed an accurate definition of this specific time span could be found in the literature: “Following the notation of Tzedakis et al. (1997), MIS 9a corresponds to the interval containing isotopic event 8.5 and, by extension, the other deglacial intervals of the MIS 9 complex have been redefined as 9c and 9e” (Tzedakis P. C., et al., 2001. Quaternary Sci. Rev., 20: 1583; Fig. 2).

I fully agree that MIS 8e has never been defined (L. M. Dupont, interactive comment). However, my opinion is that there is no real need to define this interval. A variety of alternatives are possible to refer to this time span in the manuscript: 3IMI-8 if the comment refers to the MD01-2443 $U^{k'}_{37}$ -sea surface temperature ($U^{k'}_{37}$ -SST) reconstruction on the Iberian margin (Martrat B., et al., 2007. Science, 317: 502); or the Mafra, MD-12 and MD-11 if the comment refers to the MD01-2443 pollen zones (Roucoux K. H., et al., 2006. Earth Planet. Sci. Lett., 249: 307; Tzedakis P. C., et al., 2004a. Science, 306: 2231); or the Bueu (MD97-9-12 and MD97-9-13) if the interest lies in the pollen zones defined in the paper.

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TWO A PRECISE, TRANSPARENT DESCRIPTION OF EVERY EVENT IS NEEDED

[388, 17: “at 307 ka during MIS 9c”]; [388, 27 to 29: “Forest extent is strongly reduced at the end of MIS 9b in SW Iberia (etc.) oscillations 3IMS-10 and 9”]; [389, 1 to 3: “cool/arid suborbital event at ~315 ka which is not detected (etc.) the MIS 9c ice volume minimum”]; [389, 5: “during the MIS 9a-8 transition. At ~282 ka, a 2°C SST decrease”]; [389, 10 to 11: “Finally, at ~276 and 273 ka, two severe SST decreases and forest collapses (etc.) MIS 9a-8 transition”]; [395, 18 to 21: “Indeed, the difference of cooling between D-O stadials and Heinrich events (etc.) southern European sites”]

Above are examples of excerpts where the line of reasoning in the discussion is not easy to follow.

It would be highly advisable *TO CLARIFY*:

(A) *WHICH EVENT* the text is referring to

(B) *WHICH PROXY AND LOCATION* are being discussed

(C) *THE FINAL PURPOSE* of the comment made

TO CLARIFY (A)

USE THE MD03-2697 POLLEN ZONES

I suggest the MD03-2697 pollen zones serve as the axis on which to structure the discussion precisely; i.e. emphasize these pollen labels (MD97-), as opposed to the marine isotope stage (MIS) nomenclature (e.g. MIS 9c, MIS 9a-8 transition, etc.). Otherwise, it would appear, for example, that the forested intervals were totally equivalent to the marine isotopic warm substages and would unnecessarily lead to confusion in a subject which is already clear (Roucoux K. H., et al., 2007. Elsevier, *Developments in Quaternary Science*, van der Meer J. J. M., series editor, 7: 359; Shackleton N. J., et al., 2003. *Global Planet. Change*, 36: 151). Owing to this, it would be highly recommendable for the MD03-2697 pollen zones to appear in all the figures, not only in Fig.

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2 (see below).

Using the ages to refer to a specific event in the text should be avoided as much as possible (e.g. ~ 315 ka, at ~ 276 and 273 ka, etcetera). The age models are continually improved in studies to follow.

As elegantly noted in (Rousseau D. D., et al., 2006. *Quaternary Sci. Rev.*, 25: 2025), it is necessary to honour originally published designations wherever possible, while respecting the purpose for which they were intended. In my view, any event stratigraphy may take into account: (i) the location for which the events are defined and (ii) the proxy used to define these events. For example, it is always didactic to remember that Greenland interstadials and stadials (GI and GS, respectively; Dansgaard/Oeschger events) were specifically defined by $\delta^{18}\text{O}_{ice}$ from this location only (Bjørck S, et al., 1998. *J. Quaternary Sci.*, 13: 283 and references there in); or to emphasize that the Heinrich events (Broecker W. S., et al, 1992. *Clim. Dynam.*, 6: 265) were solely described as marine sediment layers containing a large concentration of ice-rafted debris and a scarcity of foraminifera at particular northeast Atlantic mid-latitudes; or to stress that intervals of relatively warm sea surface water events (prefixed with a W) and marine cold-water events (prefixed with a C) were originally noted using $\delta^{18}\text{O}_{calcite}$ variations in fossil calcite foraminifera skeletons, *N. pachyderma* (sinistral) percentages and ice-rafted debris at specific north Atlantic locations (McManus J. F., et al., 1994. *Nature*, 371: 326). This is the bottom line in the useful INTIMATE event stratigraphy proposal (Bjørck S, et al., 1998; Hoek W. Z., et al. 2007. *Quaternary Sci. Rev.*, 27: 1).

Following the reasoning, it is not correct to name the new events in the paper as “15a”, “13a”, “8a”. The nomenclature used is the same as the one defined in (Martrat B., et al., 2007) but the manuscript does not present a new $U^{k'}_{37}$ -SST profile supporting this addition. The Iberian margin interstadial and stadials (IMI and IMS, respectively) were defined by means of the $U^{k'}_{37}$ -SST reconstruction in Iberian margin cores (Martrat B., et al., 2007). They are not expected to be exactly the same as events described by other proxies in distant or relatively closer regions, either in intensity or rates of change. This

does not mean that the events named in the paper as “15a”, “13a”, “8a” do not exist. Indeed one of the main advantages of an *event* stratigraphy is that “as stratigraphical investigations become increasingly more sophisticated, this will inevitably lead to even finer subdivision of stratigraphical records; (etc.) the alphanumeric system that has been devised can readily incorporate such developments, without the need for proliferation of new terms” (Bjørck S, et al., 1998). Hence, once these three events are clearly defined in a $U^{k'}_{37}$ -SST profile (not in a pollen profile) with resolution higher than the one shown in the MD01-2443 core, a new subdivision could be proposed: e.g. the event 3IMI-15 could be substituted by two: 2IMI-15a and 2IMI-15b; in exactly the same way as with the 1IMS-2, which is divided into 1IMS-2a, 1IMS-2b and 1IMS-2c.

The pollen zone stratigraphy proposed in the paper certainly refers to (i) an specific location “MD97” and (ii) proxy e.g. “-9-5 pollen zone”; i.e. abbreviated core name, the marine isotope stage (MIS) and a number from the bottom to the top. I would suggest omitting the MIS number on the label, because this designation was actually intended for $\delta^{18}O_{calcite}$ measurements in marine sediments; perhaps it would be useful to indicate instead whether the interval refers to interstadials or stadials, as was done in the pollen zones of the previous studies (Desprat S., et al., 2005. Quaternary Sci. Rev., 24: 1361; Desprat S., et al., 2007. Elsevier, Developments in Quaternary Science, van der Meer J. J. M., series editor, 7: 375); or simply number them exclusively for the discussion in the present paper, the same as in (Sanchez-Goñi M. F., et al., 2000. Quaternary Res., 54: 394; Sanchez Goñi M. F., et al., 2008. Quaternary Sci. Rev., in press). This must be consistently maintained, failing which, an explanation must be given. For example, in the present paper, forested intervals MD97-9-7, MD97-9-8 and MD97-9-9 are named as Sanxenxo B, whereas they were labelled as Sanxenxo C in (Desprat S., et al., 2007); are they equivalent?; other examples: there are now two pollen zones defined between Bueu and Sanxenxo B (MD97-9-10, MD97-9-11), whereas there was only one in the previous study (MD97-9-S4) (Desprat S., et al., 2007).

TO CLARIFY (B)

GO FROM MD03-2697 POLLEN ZONES TO OTHER PROXIES AND/OR PALEOARCHIVES

If the MD03-2697 pollen analysis is the basic reference, it will be easier to follow the comparisons in the text, either with marine proxies in the same MD03-2697 strata or with the indicators from cores ODP-980, MD01-2443 or EPICA-Dome C.

[386, 9: “insolation (Fig. 5)”]; [386, 18: “(Figs. 4 and 5)”]; [387, 1: “(Fig. 5)”]

Throughout the text, reference should be made as to which particular profile every comment is addressed: e.g. “Fig. 5D” instead “Fig.5”. The figures in the text should be presented in an orderly manner: e.g. Fig. 5 is mentioned before Fig. 4. in the discussion. Please consider changing the order of these two figures, or better, merge them as a single figure (see below). The redundant MD03-2697 profiles may then be eliminated [$\delta^{18}\text{O}_{\text{calcite}}$ benthic and planktonic; summer SST derived from isotopic data; temperate forest percentages and *Quercus* (deciduous type)].

[386, 17 to 18: “summer SST from”]; [388, 19 to 22: “to a summer SST cooling”]

This is a very important nuance. Please delete *summer* when referring to the sea surface temperature in core MD01-2443. The $U^{k'}_{37}$ reconstruction in the Iberian margin cores does not provide *summer* temperatures, but *annual* mean estimates at surface level ($U^{k'}_{37} = 0.033 \times \text{SST} + 0.044$, $r^2 = 0.96$; $n = 370$; linear from 0°C to 29°C). The calibration used provides *annual* mean estimates at surface level, given that the *annual* mean SST measured in the core-top sites are compared with the $U^{k'}_{37}$ estimates in these same core-tops (Martrat B., et al., 2007, sup. online mat.; Müller P. J., et al., 1998. *Geochim. Cosmochim. Ac.*, 62: 1757).

TO CLARIFY (C)

SIMPLIFY THE STRUCTURE OF THE RESULTS AND DISCUSSION; ADD MORE SUBHEADINGS

Where possible, describe and discuss events as time progresses. The key ideas for-

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mulated in the abstract and conclusions must be more gradually developed in sections 4 and 5. The subheadings appear scarce for the many complex aspects discussed. A proposal for regrouping the text in line with the arguments given could be as follows:

4. Results and interpretation (mainly Table 1, Fig. 2 and Fig. 3). i.e. [382, 18 to 26]; [383]; [384]; [385, 1 to 8]

Could this section perhaps be split into two?

4.1. Forested intervals: Pontevedra, Sanxenxo and Bueu

4.2. Open vegetation intervals

5. Discussion (mainly Figs. 4 and 5 ?; new Fig. 5?)

5.1. Interglacial, climatic optimum, intermediate climatic amelioration? i.e. [383, 23 to 24]; [385, 11 to 26]; [386]; [387, 1 to 4]; [387, 26 to 27: “maximal extent of the deciduous oak forest and mediterranean plants (etc.) climatic optimum”]

This section would include definition of a *climatic optimum* and discussion; why is MD97-9-2 considered more stable than other forested intervals within the Sanxenxo or Bueu?; equivalent periods in the marine proxies of other cores?; what about northern European lands?; what is the meaning of *interglacial* in the paper?. In continental studies, *interglacial* and *interstadials* are warm phases of two different magnitudes, and their distinctiveness is purely a matter of intensity and duration (Mangerud et al., 1974. *Boreas*, 3: 109 and references there in). In studies mainly focused on marine cores, due to the influence of traditional marine oxygen isotope stratigraphy, the term *interglacial* is also applied to very long periods, longer than the precessional climatic rhythm, which comprise long, stable, warm *interstadials* punctuated by short, less abundant *stadials* (e.g. “MIS 5 interglacial” is used in the literature, but definitely adds confusion; it should be e.g. “MIS 5 complex”). It would be advisable to label all warm pollen zones as *interstadials* (e.g. MD97-I1, MD97-I2, MD97-I3), and then

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discuss whether, due to their intensity, duration or particular taxa, some *interstadials* could be considered as *interglacials*.

5.2. Severe forest reductions i.e. [388, 14 to 29]; [389, 10 to 12]; [389, 15 to 29]; [390, 1 to 7]

The discussion would be easier if events were described as time progresses (e.g. MD97-9-4; MD97-9-6; MD97-9-8; MD97-9-10 and MD97-9-11; MD97-8-1 and MD97-8-3, etcetera); after providing a description, it would be very interesting to include the quantification of their severity and categorize them accordingly: e.g. why was MD97-9-4 less severe than MD97-9-10?; MD97-9-8 less severe than MD97-9-6?; what taxa point to this?

5.3. Slight forest reductions i.e. [387, 25 to 28]; [388, 1 to 13]; [389, 1 to 3]; [389, 4 to 10]; [389, 13 to 14]; [390, 8 to 15]

This section would discuss the new, less severe events; what taxa are used to differentiate them? Again, ideas would flow better if sentences were reordered to describe the events as time progresses: “15a”, please avoid this notation (refer to it simply as an event at the onset or within MD97-9-3, marked by e.g. maximal extent of *Taxus*, *Fagus* ?); “13a”, please avoid this notation (an event within MD97-9-5?); “8a”, please avoid this notation (an event within MD97-9-13?).

5.4. Stability of the Pontevedra versus the Holocene, Eemian, Arousa or Vigo i.e. [390, 17 to 28]; [391]; [392, 1 to 4]

This section would include comparison of MD97-9-2 with other equivalent intervals; better if it referred to pollen assemblages of other Iberian cores; e.g. the Eemian in MD99-2331, the Arousa or the Vigo in MD01-2447; what about their decline and glacial inception? If the interest lies in marine proxies in cores ODP-980, MD01-2443, please use the proper nomenclatures (e.g. IMI and IMS only for the Iberian margin $U^{k'}_{37}$ -SST estimates, MIS for $\delta^{18}O_{calcite}$, etcetera).

5.5. Instability of the Sanxenxo versus equivalent forested periods i.e. [392, 5 to 29];

[393]; [394, 1 to 16]

5.6. Is variability at the end of Sanxenxo similar to events in the last glacial? i.e. [394, 17 to 29]; [395]; [396, 1 to 19]

This section would include a comparison of the MD03-2697 pollen zones with pollen zones from last glacial, perhaps from cores MD95-2042, MD04-2845? (Sanchez-Goñi M. F., et al., 2000; Sanchez Goñi M. F., et al., in press); which taxa abundances allow this correlation? It would improve if illustrated with an additional figure.

THREE COMPLETE TABLE 1, FIG. 2 AND FIG. 3; MERGE FIG. 4 AND 5; ADD NEW FIGURE?

TABLE 1.

As previously observed (L. M. Dupont, interactive comment), I also recommend showing not only the pollen zone identification but also the depth, age and number of samples.

A number of questions could be posed: is it possible to quantify the severity of droughts in stadial intervals?; in the area of study, could a stadial be moist?; could an interstadial be dry? Answers would be of interest to the reader. Hence, it would be very useful for non experts in palynological interpretations if a palaeoenvironmental classification were added for each zone; for example, comments on moisture availability, temperature seasonality, etcetera; similar to the information in continental studies; see e.g. (Allen J. R. M., et al., 2000. Quaternary Int. 73/74, 91. Table 2, Table 5).

When a comparison is made to core MD01-2443, it would be very useful to add, in the text and/or in Table 1, a proposal of equivalences with the pollen zones from (Roucoux K. H., et al., 2006; Tzedakis P. C., et al., 2004a) or the IMI and IMS from the U^{k'}₃₇-SST profile (Martrat B., et al., 2007): e.g. MD97-9-4 ~ MD-4 ~ 3IMS-14. This would be an illustration of text assertions such as: [388, 19 to 22: "almost each reduction (etc.) 2007"]].

FIGURE 2.

I would advise grouping the taxa categories defined in the text and/or providing their definition in the figure caption: e.g. pioneer: *Cedrus*, Cupressaceae, *Betula*, etc.; temperate forest: *Quercus* (deciduous type), etc.; mediterranean: *Quercus* (evergreen type), *Olea*, *Phillyrea*, *Pistacia*, *Cistus*, etc.; steppe or semi-desert: *Artemisia*, Chenopodiaceae, etc.; heath: Ericaceae, *Calluna*, etc.; ubiquitous herbs: etc.

Of particular importance is the distinction highlighted in Fig. 4 and Fig. 5 between temperate forest percentages [temperate ~ moist? or dry?; please specify the taxa included], *Quercus* (deciduous type) and ubiquitous herbs.

FIGURE 3.

Please include the pollen zone labels (MD97-) as shown in Fig. 2; position them near the pollen assemblages, e.g. on the right of the ubiquitous herbs; then move the marine isotope nomenclature e.g. on the left of the *N. pachyderma* (sinistral) percentages. This would facilitate land-sea correlations and easier graphical representation of text assertions such as: [385, 25 to 26]; [386, 1 to 3: “boundaries of isotopic substages (etc.) 2002”].

Also add the same lines as the ones defining the pollen zones, not the lines showing abrupt changes; to follow the discussion in section 4, it would help if the same lines are applied to the MD03-2697 marine proxies in this figure.

FIGURES 4 AND 5.

I suggest merging these two figures. This would leave room for the additional figure requested in order to include a comparison of the MD03-2697 pollen zones with pollen zones from last glacial (L. M. Dupont and anonymous referee; interactive comments). Please check all the subdivisions; some are currently incorrect in the figure caption (e.g. Fig. 5D is labelled as Fig. 5 (a) D). Please add the pollen zone labels to the pollen profiles of core MD03-2697 (MD97-). The 3IMI and 3IMS must apply to the $U^{k'}_{37}$ -SST profile in core MD01-2443 only; delete them from the pollen profiles of core MD03-2697.

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TECHNICAL COMMENTS

[378, 1 to 2]; [379, 2 to 4]; [386, 5 to 7]; [386, 11]; [394, 18 to 20]

If correct, I can find no explanation for this in (Shackleton et al., 2000, Paleo., 15: 565), which concerns the last glacial, not the MIS 9 or highstands.

[397, 21: “We are also grateful to P. N.”]

Change “P. N.” to “N. J.”

Please check the references: e.g. [400, 8: “25, 17-18”] This should be “25, 2197-2211”; [402, 9: “3268-3277, 2007”] This should be “2006”; [404, 12: “Spahni, R.: Atmospheric”] Add the other authors.

Sincerely,

Belen Martrat.

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