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Interactive comment on "Orbital and millennial-scale environmental changes between 64 and 25 ka BP recorded in Black Sea sediments" *by* L. S. Shumilovskikh et al.

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General comments

Shumilovskikh et al. present new and very interesting pollen and algae records from a core located in the Black Sea covering the period between 64,000 years BP (64 ka) and 25 ka. This work shows for the first time the detailed history of the vegetation at orbital, millennial and centennial-time scale in parallel with the evolution of Black Sea environments (productivity, salinity and sea surface temperatures). The main conclusions of this manuscript can be synthesized as follows:

a) maximum forest development in Northern Anatolia is observed at Dansgaard-

Oeschger (D-O) 14 and D-O 12,

b) forest dynamic of this region is controlled by orbital parameters and, in particular, by precession that triggers precipitation changes,

c) maximum forest development in response to D-O warming is reached ~500-1500 years after productivity changes in the Black Sea, possibly due to soil development, and

d) Heinrich events (HE) show a similar impact on Northern Anatolia/Black Sea environments as the other cold phases of the D-O cycles (Greenland Stadials=GS after Svensson et al., 2006).

I recommend this manuscript for publication in the Climate of the Past only after the authors thoroughly address two major issues regarding the interpretation of the data. Addressing both issues will imply the rewriting of the abstract, sections 5.1.2 "Abrupt climate changes", 5.3 "Land-sea correlation and regional comparison", and section 6 "Conclusions".

My major concern is related to main conclusion b) in which the authors explain the maximum expansion of the temperate forest at D-O 14 and D-O 12 as the result of precession maxima (insolation minima, cooler summer and precipitation increase). The authors consider Northern Anatolia as an Eastern Mediterranean region submitted to a Mediterranean climatic regime, and from that they assume that the vegetation dynamics should be modulated by precession as observed by Fletcher and Sanchez Goñi (2008) in the western Mediterranean region. However, the Northern Anatolia region, located northern than 40°N and occupied by the Pontic Mountains, is actually not a Mediterranean region (Polunin and Walters, 1985) but a "Subtropical Regime Mountains" ecoregion (Bailey, 1998). The vegetation is dominated by temperate trees and only scattered Mediterranean trees and shrubs occupy the warm and dry coastal areas of the Black Sea. Actually, the "Subtropical Regime Mountains" ecoregion characterizing Northern Anatolia has a humid subtropical climate, marked by high humidity (especially in summer) and the absence of really cold winters allowing the dominance of broadleaf deciduous forest in this region (Bailey, 1998). Surprisingly, Shumilovskikh et al. do not take into account the effect of obliquity on the dynamics of the temperate forest over the last glacial period in regions above 40°N as demonstrated for Western Europe by Sanchez Goñi et al. (2008). During D-O 14 and D-O 12, obliquity is at a maximum leading to a higher solar income over the entire year, particularly in winter, and therefore optimal forest development. Conversely, the previous and subsequent precession maxima at ~72 ka and ~25 ka do not coincide with strong forest development in Western Europe because obliquity is at a minimum. The authors state that during D-O 14 and D-O 12 forest development reaches a maximum in Northern Anatolia mainly due to precession maxima that leads to less seasonal climate with cooler/wetter summer and reduced seasonality in precipitation. However, during the precession maxima at ~25 ka, when obliquity is at a minimum, forest in Northern Anatolia does not strongly expand. Contrary to Shumilovskikh et al. interpretation, we should expect that the Northern Anatolia forest, located northern than 40°N, be mainly modulated by obliquity as temperate deciduous forest in this region develop under relatively high average annual and winter temperatures, ~10 to 14°C and 7°C, respectively. Minor influence of precession changes cannot be completely rule out, however, as this region is close to 40°N.

In conclusion c), the authors attribute the delay between the forest maximum expansion and the changes in the Black Sea surface conditions in response to the D-O events to the time that soil takes to develop. However, the authors should take into account an alternative hypothesis. We know that the warm phases of the D-O cycles (Greenland Interstadials=GI after Svenson et al., 2006) are composed of several climatic phases in the North Atlantic (Jouzel et al., 2007). Previous studies on the evolution of Iberian vegetation within GI have shown that vegetation is not necessarily responding to soil development but to the successive atmospheric changes related with the position and strength of the westerlies within a GI (Sanchez Goñi et al., 2009). As Northern Anatolia is also influenced by the Atlantic atmospheric processes, the authors should therefore

discuss this alternative explanation.

Specific comments

For consistency, in the abstract, in section 5.1.2 “Abrupt climate changes” and in the conclusions the authors should replace “D-O interstadials” and “D-O stadials” with “the warm phases of D-O cycles” or “GI” and “the cold phases of D-O cycles” or “GS”, respectively.

I suggest to the authors adding the units for the salinity values.

In the “Introduction section” and section 5.1.2 “Abrupt climate changes”, the authors state that Heinrich events do not strongly impact the vegetation of southwestern and southeastern Iberia (Sanchez Goñi et al., 2000 and 2002). This statement is a misinterpretation of what is written in both papers. Heinrich events produced the rapid replacement of the open Mediterranean forest with semi-desert landscapes. Note that in the 2002 paper quantitative estimation of temperatures and precipitations give strong anomalies in the mean temperature of the coldest month and annual rainfall with decreases by 6 to 13°C and 400 to 500 mm, respectively. The authors should modify the text accordingly.

In the section “Material and methods” the authors should add a paragraph discussing the main vegetation source area from where the pollen is originated and recruited in the sediments of core 25-GC1. Additionally, could the authors clearly state that the dinocyst species used as tracer of productivity are not damaged by acetolysis? Could they also add the temporal resolution of the analysis?

In section 5.1.1 “Long-term dynamics”, the authors refer to the “euxinian” vegetation record shown in Figure 3. However, this record is missing in the figure. Could the authors add this record? In the same section, the pollen record is compared with the summer insolation curve at 30°N. Why do the authors chose 30°N if the core is located at 42°N, and represents the vegetation of the Pontic Mountains, a region located northern than 40°N? In this section also, the authors should replace "general increase" with "long-term increase".

In section 5.2.1 "Long-term patterns ", the authors present two hypothesis to explain the occurrence of subtropical and fully salinity species during the interval 64-25 ka. The authors may add the reference of Dorale et al. (2010) showing that the sea level during MIS 5a was particularly high, close to that of MIS 5e.

In section "Land-sea correlation and regional comparison" authors should replace "During MIS 3, the glaciers retreated and climate..." with "During MIS 3, the glaciers retreated from their MIS 4 position and climate...". It is also more appropriate to replace "correlation" with "comparison" in the title of this section.

Figure and legends

Figure 1: Contrary to author statement, this figure represents Europe and Northern Africa landmasses rather than the Mediterranean region. The authors should delimitate the real Mediterranean region, which excludes Northern Anatolia (Polunin and Walters, 1985; Bailey, 1998).

Figure 2, the authors should explain the meaning of PJA.

Figures 3, 4 and 6: there is a mistake in the concentration units. The authors should replace "specimens*cm-3 10-3" with "specimens*103*cm-3".

Figure 3 and 4: Replace "Horizontal grey bars... indicate D-O events..." with "Horizontal grey bands... indicate the warm phases of D-O cycles" or "GI".

Figure 5: Add the obliquity curve and replace "Marine isotope stadia" with "Marine isotope stages".

Figure 6: Replace "The longest D-O events... " with "The longest warm phases of D-O cycles..." or "the longest GI". The term "event" only refers to the change, which only takes few decades in Greenland, and not to the interval produced by it.

Typo mistakes

Page 5451 line 14: Remove "during D-O events". Page 5454 line27: Add "the" before "dominance of P. psilata..."

References

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