Clim. Past Discuss., 7, C1257–C1267, 2011
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Climate of the Past Discussions

CPD
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Interactive Comment

Interactive comment on "Temperature variability at Dürres Maar, Germany during the migration period and at high medieval times, inferred from stable carbon isotopes of *Sphagnum* cellulose" *by* R. Moschen et al.

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Responses to the general interactive comments of the anonymous referee #1:

Anonymous referee #1 points to the dependency of the d13Ccellulose values of Sphagnum capillifolium and Sphagnum magellanicum on growing season temperature published by Ménot and Burns (2001) who have determined statistically significant Dd13C/DT coefficients for both Sphagnum species. Referee #1 argues that the temperature coefficients of -0.20‰ and -0.41‰ (although statistically significant) were obtained on a large dispersion of points and that they, thus, are associated to uncertainties which must be reflected in temperature reconstructions using the Ménot and Burns coefficients. The referee requests to mention the uncertainty associated to the temperature coefficients and to propagate the uncertainties to our own temperature reconstruction. Because of this important remark, we have located a serious error in our approach of transferring the temperature coefficients of -0.20‰ and -0.41‰ of Ménot and Burns (2001) to the palaeorecord of Dürres Maar: We have used the Ménot and Burns coefficients to calculate the past temperature variability at Dürres Maar. Our approach, however, was a misuse of the coefficients since we have calculated temperature variability from Dd13C/DT. Instead one has to use the opposite approach to reconstruct past temperature variability (DT) from the stable carbon isotope composition of Sphagnum cellulose (Dd13C) by using the DT/Dd13C approach. In the revised manuscript we have corrected our temperature reconstruction by using the data concerning the d13Ccellulose values of S. capillifolium and S. magellanicum shown in figure 2 of Ménot and Burns (2001) and the corresponding temperature data of table 1 of Ménot and Burns (2001) to estimate transfer functions regarding the DT/Dd13C relationship for both species (T = –2.35 * d13Ccellulose – 46.35 for S. capillifolium (R2 = 0.51) and T = –0.82 * d13Ccellulose – 8.969 for S. magellanicum (R2 = 0.28)). The first transfer function was applied on the S. capillifolium var. rubellum dominated peat section developed from AD 1 to ~AD 1450, the second on the S. magellanicum dominated section grown after the rearrangement of the bog ecosystem in the first half of the 19th century. The used transfer functions enable us to reconstruct a local Sphagnum related growing season temperature stated in centigrade (Fig. 5). As the referee proposes, for both time intervals the corresponding 95% prediction intervals were calculated, they are discussed in the text of the revised manuscript, and are shown in figure 5b.

Anonymous referee #1 points to the important issue of the Suess effect. In the revised manuscript we have explained our account for the Suess effect by adding Table 2 to chapter 4.4. In table 2 we show the raw d13Ccellulose values of all samples which are younger than 1850 AD with their corresponding d13C correction factors calculated from annual correction factors shown in Leuenberger (2007), and the resulting Sphagnum d13Ccellulose values corrected for the Suess effect, i.e. the antropogenically induced decrease in atmospheric 13CO2. On the basis of our age-depth model, a top and a bottom age was calculated for each sample, narrowing the time span of any 2 cm peat increment accumulated to a specific number of years. Afterwards a d13C correction factor was calculated as mean of six to seven annual correction factors given for the time span each individual peat increment has been accumulated (full years). The first correction factor for sample number one (first row of table 2) is the mean of the annual correction factors from 1998 to 2003 given by Leuenberger (2007) for Europe (-1.66 (in 1998) + -1.69 (in 1999) + -1.72 (in 2000) + -1.75 (in 2001) + -1.78 (in 2002) + -1.81 in 2003)/6 = -1.735). Thus, the given d13C correction factors are an approximation, however, since differences between individual annual factors are smaller than 0.05‰ this approximation is a sufficient for the correction of the d13Ccellulose decrease in the case of a time span of six to seven years during each peat increment has been developed (for details see Leuenberger et al. 2007).

Responses to the specific interactive comments (details) of reviewer #1 are the following:

- Indeed, unfortunately there are some mistakes with the affiliations of the authors. During typesetting something went wrong and our corrections make things even more puzzling. The Copernicus office apologises for that, however, the paper was already published on-line. They argued that because it is a discussion paper, one can insert the right affiliations into the final revised version.

The right affiliations are the following:

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- page 541, lines 17-20: Referee #1 states that a micro-topography effect can be associated to a “canopy effect” known from shrubs and particularly forest communities leading to mixed CO2 from direct atmospherical and indirect and 13CO2 enriched (“degraded”) sources. Although we do not know any study on the gas exchange measurements regarding differences between on open peat and peat covered by different vegetation communities, we feel that, if measurable, such an effect should be rather small on open kettle-hole peat communities investigated in this study. Pointing to different CO2 sources for Sphagnum photosynthesis is, however, an important note because in a very recent study it has been assumed that in wet habitats variable carbon sources for Sphagnum photosynthesis, such as CO2 release by methanotrophic bacteria are likely, complicating the relationship between the stable carbon isotope composition of Sphagnum cellulose and environmental variables (Markel et al. 2010). We have addressed on that issue on page 541.

- page 543, lines 25-26: Referee #1 states that mixed CO2 sources for Sphagnum photosynthesis are very likely and would contribute to an artificial ageing of the peat. Any effect of artificial ageing, however, is not evident from our results. Since one cannot absolutely exclude such effect, no matter how minor such effect is, we have addressed on that issue on page 543 and have deleted the sentence “it is unlikely that they derive carbon from the underlying older peat” in the revised manuscript.

- page 544, line 18: simmering for one hour at 85°C prevent samples from remaining in good shape. Simmering at 85°C helps achieving a fragmentation of the Sphagnum

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plants into their different morphological parts, e.g. into single leaves, branch fragments and the less fragile stem sections. We feel that the sentence on page 544, lines 19-21 clarifies the procedure.

- page 544, line 22: we have tested this important issue on a total of 39 samples from the same core from Dürres Maar. We have compared the stable carbon isotope composition of Sphagnum stems, branches and the 355-630μm sieve fraction separated from these 31 samples. There was a significant d13C offset of $\sim$1.5‰ between the Sphagnum stems and branches (see Moschen et al. 2009 for details). Almost the same offset of $\sim$1.5‰ has been observed between the 355-630μm sieve fraction and the stems. The d13C offset between the branches and the respective 355-630μm sieve fraction was $\pm$0.2‰ the determination coefficient between the d13C values of branches and the respective 355-630μm sieve fraction is 0.88 (n = 39). A talk on that issue was held in 2010 at the EGU general assembly, Vienna, Austria.

- page 546: The ash content was measured on the bulk peat material. Although already displayed on page 546, line 12 we have clarified this in the first sentence of paragraph 4.5.

- page 552, lines 20-24: We do not fully understand this note regarding the disagreement between the Esper et al. (2002) reconstruction and our results. Our interpretation of the differences between both studies is, however, that it is not surprising that the records do not fit on decadal time scale since it is obvious that a temperature reconstruction on a local scale must exhibit differences compared to a northern hemispheric reconstruction and that radiocarbon dating is less accurate than tree-ring dating.

- page 553, lines 9-16: With this paragraph we would like to state that we did not expect an absolute agreement in magnitude and timing of the intervals of relative warmth and cold between our regional reconstruction and the Northern hemispheric reconstruction of Esper et al. (2002). The comparison of our results with the Esper et al. (2002) reconstruction rather indicates a concurrent development of the multi-centennial temperature signals. These very similar multi-centennial signals are, however, superimposed by a high-frequency regional signal from the West Eifel Volcanic Field. In consequence these results point to regional inconsistencies in natural climate variability as known from modern observational data (e.g. the Greenland/Arctic Ocean example). Regarding this important issue, we have decided to modify figure 6. In the revised manuscript, the tree ring-based northern hemispheric temperature reconstruction of Esper et al. (2002) is replaced by the also tree ring-based central European summer temperature reconstruction recently published by Büntgen et al. (2011). A comparison of our reconstruction with the Büntgen et al. (2011) data has several advantages. First, Büntgen et al. (2011) have reconstructed summer temperature variability. Such is more comparable to our reconstructed Sphagnum growing season temperature. Second, the Büntgen et al. (2011) time series is a more regionalised reconstruction of central European summer temperature and, therefore, substantially better suited to be contrasted with our local reconstruction from the West Eifel Volcanic Field located in western central Europe. Third, the Büntgen et al. (2011) time series depict the entire time span from presence to the turning point AD/BC. This is also our period under investigation.

- page 554, lines12-24: The referee states that the relatively weak chronological control and the variety of environmental variables which are integrated by the Sphagnum d13Ccellulose value weaken the chronology (and the strength of temperature/Sphagnum d13Ccellulose relationship) of the older part of the record, too. We absolutely agree with the reviver's comment. However, for the older part of the record no instrumental data is available and one has to keep in mind that the time resolution of any peat based proxy time series wouldn't reach the annual resolution and precise age, tree-ring data series offer. Therefore, we think that for the older part of the record this issue is not as important as for the time span for which (annually) meteorological observations are available.

- page 554 and following: the meteorological record is available at the KNMI Climate Explorer (http://climexp.knmi.nl/ecatemp.cgi?someone@somewhere+57+TRIER+)

- Figure 3: In the revised manuscript, we have added a stratigraphical column referring to species succession as mentioned in the text.

- Figure 4: If the revised manuscript will be accepted for publication in CP all figures will be printed as colour figures.

- Figure 6: We have replaced the bold line for the running means by a bolder (?) line. However, in the revised manuscript the tree ring-based northern hemispheric temperature reconstruction of Esper et al. (2002) is replaced by the also tree ring-based central European summer temperature reconstruction recently published by Büntgen et al. (2011).

References:

Büntgen, U., Tegel, W., Nicolussi, K., McCormik, M., Frank, D., Trouet, V., Kaplan, J.O., Herzig, F., Heussner, K.-U., Wanner, H., Luterbacher, J. and Esper, J: 2500 years of European climate variability and human susceptibility, Science, 331, 578-582, 2011.

Esper, J., Cook, E.R. and Schweingruber, F: Low-frequency signals in long tree-ring chronologies for reconstructing past temperature variability, Science, 295, 2250-2253, 2002.

Leuenberger, M.: To what extend can ice core data contribute to the understanding of plant ecological developments of the past. Terrestrial Ecology, 1, 211-233, 2007.

Ménot, G. and S.J. Burns: Carbon isotopes in ombrogenic peat bog plants as climatic indicators: calibration from an altitudinal transect in Switzerland, Organic Geochemistry, 32, 233-245, 2001.

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Figure 3:

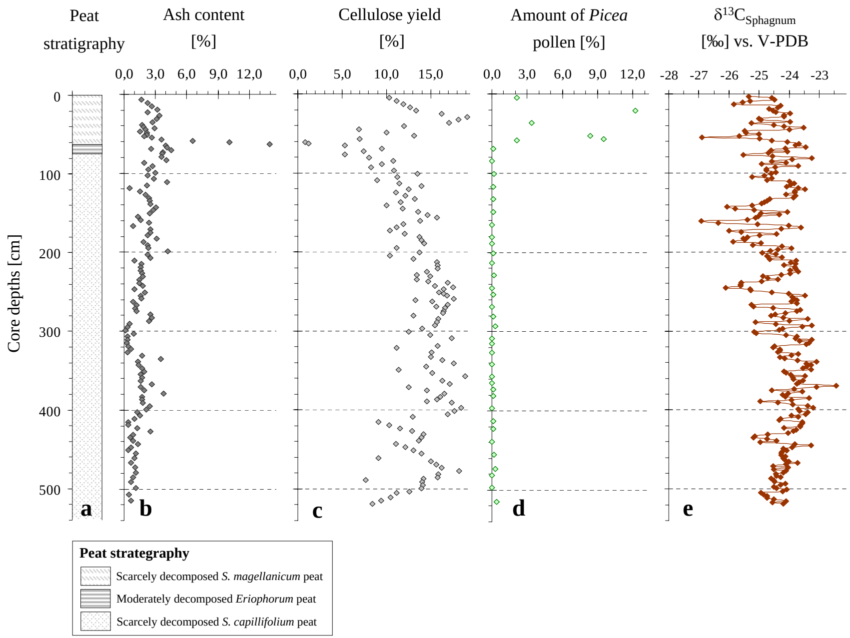

Fig. 1. revised figure 3

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Figure 4:

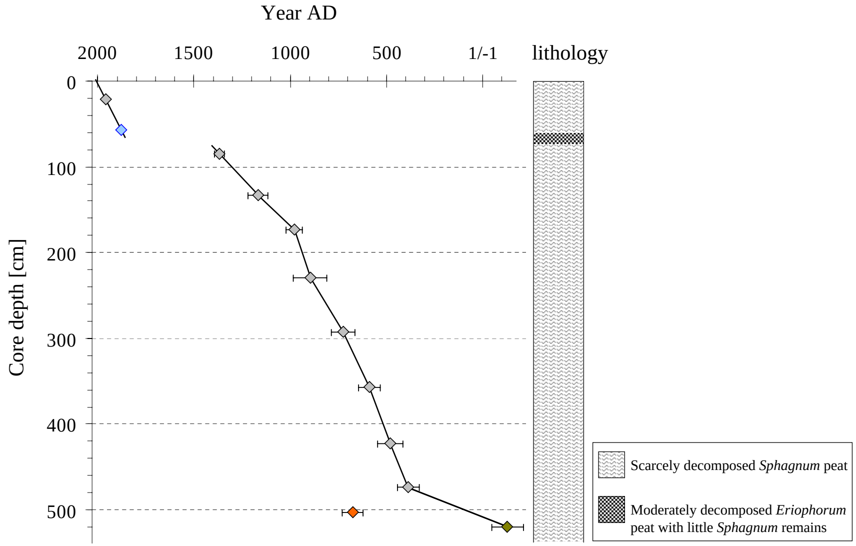

Fig. 2. revised figure 4

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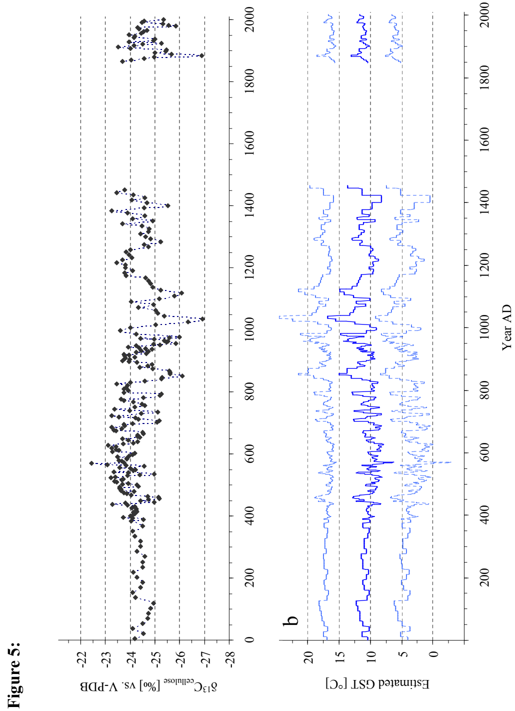

Fig. 3. revised figure 5

Figure 6:

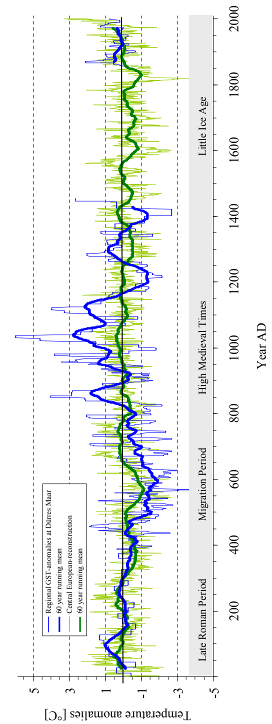

Fig. 4. revised figure 6

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