Comment on *Changes in atmospheric CO_2 levels recorded by the isotopic signature of n-alkanes from plants* from K.S. Machado and S. Froehner

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The recently published invited research article by Machado and Froehner (2017) is presenting δ^{13}C values from sedimentary organic matter (n-alkane), measured on samples collected in the Barigui watershed (Brazil) covering the last 400 years. The derived δ^{13}C time series based on C_{27} n-alkane, beginning approximately in the calendar year 1600 (or 1600 CE; with CE for Common Era) until recent times is subsequently — in their figure 3 — compared with a record, which is believed to be a representative reconstruction of atmospheric CO_2 concentrations covering approximately the last 650 years (with respect to the year 2005 CE). The final conclusion of this article, as reflected in its title, is that changes in atmospheric CO_2 levels are recorded in isotopic signatures on n-alkane from plants. We argue, that this conclusion can not be drawn from the study of Machado and Froehner (2017), since what is shown in their figure 3 is not a time series of atmospheric CO_2 concentration of the last 650 years. The authors show reconstructions of atmospheric CO_2 concentrations based on Antarctic ice cores over the past 650,000 years and use them for the past 650 years by ignoring the fact that the time scale in IPCC (2007), from which, according to the caption of their figure 3, they took this CO_2 time series, is in kyr (1 kyr = 1 kilo year = 1000 years). This is wrong and any conclusion based on this comparison is incorrect. Instead they should have used for a correct CO_2 time series for the comparison with their measurements.

In detail, the plotted time series of atmospheric CO_2 concentrations in figure 3 of Machado and Froehner (2017) is based on figure 6.3 in IPCC (2007) and contains a reconstruction of atmospheric CO_2 from different ice cores (Petit et al., 1999; Indermühle et al., 2000; Monnin et al., 2001; Siegenthaler et al., 2005) as compiled in Siegenthaler et al. (2005). This time series of atmospheric CO_2 started around 650,000 year ago, and ended around year 1600 CE (= year 350 BP, with BP for "before present" defined as "before calendar year 1950") and varies only between 180 ppm and about 280 ppm, showing typically glacial/interglacial variations in atmospheric CO_2 levels. Due to this stop in the ice core time series around year 1600 CE no rise in atmospheric CO_2 caused by anthropogenic emissions during the last 250 years is contained in it. This evolution in atmospheric CO_2 concentration from preindustrial levels of ∼280 ppm (i.e. before year 1750 CE) to modern levels well above 300 ppm is well documented in other ice core (and firn air) records as shown, for example, in Etheridge et al. (1996) (also cited by Machado and Froehner, 2017), but see also MacFarling-Meure et al. (2006), Rubino et al. (2013), Ahn et al. (2012) or Bauska et al. (2015). Furthermore, since the year 1958 CE even observational data of atmospheric concentration of CO_2 from Mauna Loa or other sites are available (Pales and Keeling, 1965; Dlugokencky et al., 2016), clearly showing the unprecedented increase in atmospheric CO_2 concentration. In the Mauna Loa record the atmospheric CO_2 value of the year 2005 CE (the most recent year in figure 3 of Machado and Froehner (2017)) was around 380 ppm, and not around 280 ppm, as suggested by figure 3 in Machado and Froehner (2017).

A recent compilation of atmospheric CO_2, which also covers the time window of interest in Machado and Froehner (2017), is published by Köhler et al. (2017) and plotted in Figure 1. The corresponding data are available from the scientific, freely-accessible database PANGAEA (https://doi.pangaea.de/10.1594/PANGAEA.871273). This atmospheric CO_2 record differs clearly from what is shown on figure 3 of Machado and Froehner (2017), with relatively stable CO_2 values around 280 ppm between 1350 CE and 1750 CE, and then the first gradual and then steep rise until 401 ppm is finally reached at the beginning of year 2016 CE in the calculated smoothing spline.

Therefore, all conclusions of Machado and Froehner (2017) which are based on this comparison of their $\delta^{13}C$ values with the erroneously assumed atmospheric CO_2 values as plotted in their figure 3 need to be rejected, since they are based on a wrong CO_2 time series.

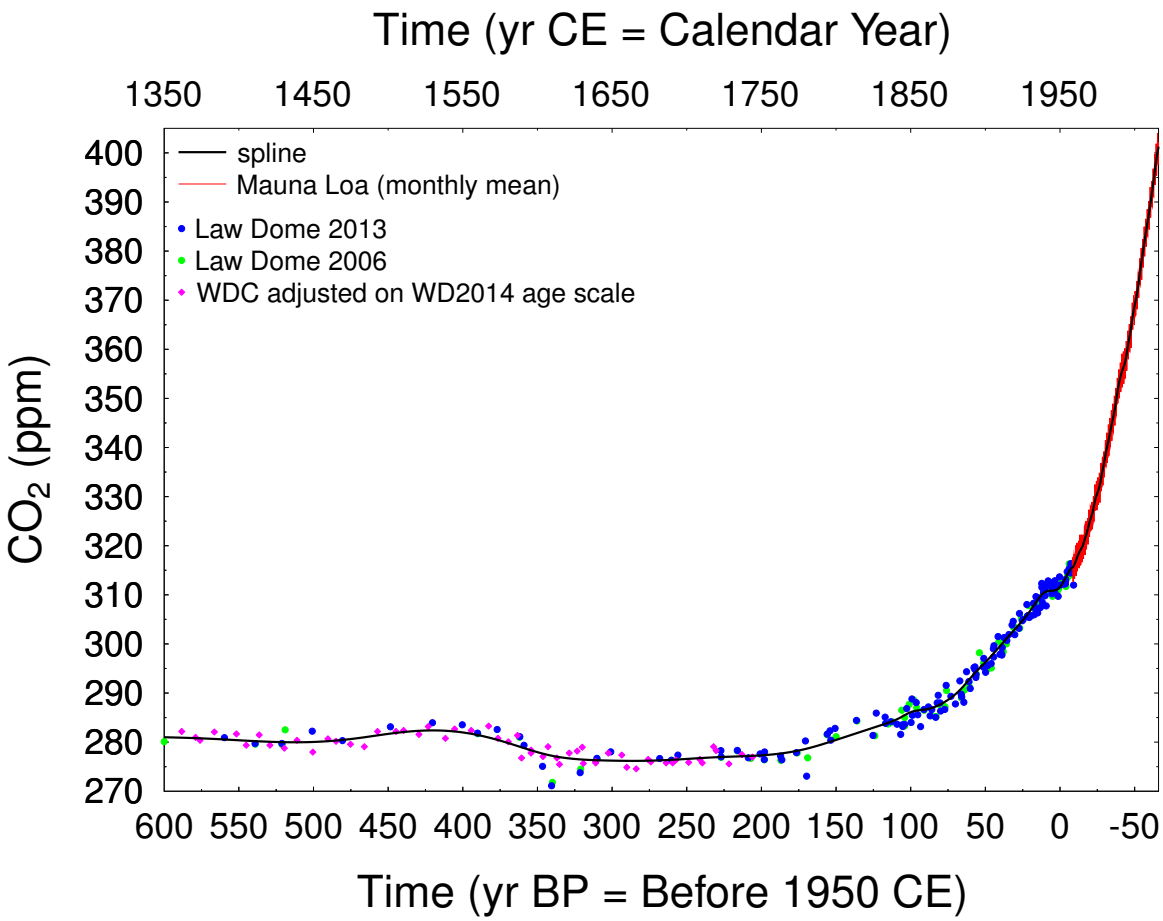

Figure 1: Data of atmospheric CO_2 concentration from year 1350 CE to year 2016 CE (from year 600 BP to year -66 BP). BP is an acronym for "Before Present", where "present" is by definition the calendar year 1950. Data sources: Calculated smoothing spline with variable cutoff period: Köhler et al. (2017); Mauna Loa monthly mean data (March 1958 – start of 2016): Dlugokencky et al. (2016); Data from the ice cores Law Dome (MacFarling-Meure et al., 2006; Rubino et al., 2013) and the West Antarctic Ice Sheet Divide (WAIS) Ice Core (WDC) (Ahn et al., 2012; Bauska et al., 2015). WDC data are plotted on the WD2014 age model (Sigl et al., 2016) and have been adjusted to reduce offsets between different records, see Köhler et al. (2017) for details.

References

Ahn, J., Brook, E. J., Mitchell, L., Rosen, J., McConnell, J. R., Taylor, K., Etheridge, D., and Rubino, M., 2012. Atmospheric CO_2 over the last 1000 years: A high-resolution record from the West Antarctic Ice Sheet (WAIS) Divide ice core, Global Biogeochemical Cycles, 26, GB2027, doi:10.1029/2011GB004247.

Bauska, T. K., Joos, F., Mix, A. C., Roth, R., Ahn, J., and Brook, E. J., 2015. Links between atmospheric carbon dioxide, the land carbon reservoir and climate over the past millennium, Nature Geoscience, 8, 383–387, doi:10.1038/ngeo2422.

Dlugokencky, E., Lang, P., Mund, J., Crotwell, A., Crotwell, M., and Thoning, K., 2016. Atmospheric Carbon Dioxide Dry Air Mole Fractions from the NOAA ESRL Carbon Cycle Cooperative Global Air Sampling Network, 1968-2015, Version: 2016-08-30, Path: ftp://aftp.cmdl.noaa.gov/data/trace_gases/co2/flask/surface/.

Etheridge, D. M., Steele, L. P., Langenfelds, R. L., Francey, R. J., Barnola, J.-M., and Morgan, V. I., 1996. Natural and anthropogenic changes in atmospheric CO_2 over the last 1000 years from air in Antarctic ice and firn, Journal of Geophysical Research, D101, 4115–4128, doi:10.1029/95JD03410.

Indermühle, A., Monnin, E., Stauffer, B., and Stocker, T. F., 2000. Atmospheric CO_2 concentration from 60 to 20 kyr BP from the Taylor Dome ice core, Antarctica, Geophysical Research Letters, 27, 735–738, doi:10.1029/1999GL010960.

IPCC: Climate Change 2007: The Physical Science. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, U.K. and New York, NY, USA, 2007.

Köhler, P., Nehrbass-Ahles, C., Schmitt, J., Stocker, T. F., and Fischer, H., 2017. A 156 kyr smoothed history of the atmospheric greenhouse gases CO_2, CH_4, and N_2O and their radiative forcing, Earth System Science Data, 9, 363–387, doi:10.5194/essd-9-363-2017.

MacFarling-Meure, C., Etheridge, D., Trudinger, C., Langenfelds, R., van Ommen, T., Smith, A., and Elkins, J., 2006. Law Dome CO_2, CH_4 and N_2O ice core records extended to 2000 years BP, Geophysical Research Letters, 33, L14 810, doi:10.1029/2006GL026152.

Machado, K. S. and Froehner, S., 2017. Changes in atmospheric CO_2 levels recorded by the isotopic signature of *n*-alkanes from plants, Global and Planetary Change, 148, 72 – 78, doi:10.1016/j.gloplacha.2016.11.015.

Monnin, E., Indermühle, A., Dällenbach, A., Flückiger, J., Stauffer, B., Stocker, T. F., Raynaud, D., and Barnola, J.-M., 2001. Atmospheric CO_2 concentrations over the last glacial termination, Science, 291, 112–114, doi:10.1126/science.291.5501.112.

Pales, J. C. and Keeling, C. D., 1965. The Concentration of Atmospheric Carbon Dioxide in Hawaii, Journal of Geophysical Research, 70, 6053–6076, doi:10.1029/JZ070i024p06053.

Petit, J. R., Jouzel, J., Raynaud, D., Barkov, N. I., Barnola, J.-M., Basile, I., Bender, M., Chappellaz, J., Davis, M., Delaygue, G., Delmotte, M., Kotlyakov, V. M., Legrand, M., Lipenkov, V. Y., Lorius, C., Pépin, L., Ritz, C., Saltzman, E., and Stievenard, M., 1999. Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica, Nature, 399, 429–436, doi:10.1038/20859.

Rubino, M., Etheridge, D. M., Trudinger, C. M., Allison, C. E., Battle, M. O., Langenfelds, R. L., Steele, L. P., Curran, M., Bender, M., White, J. W. C., Jenk, T. M., Blunier, T., and Francey, R. J., 2013. A revised 1000-year atmospheric δ^{13}C-CO_2 record from Law Dome and South Pole, Antarctica, Journal of Geophysical Research: Atmospheres, 118, 8482–8499, doi:10.1002/jgrd.50668.

Siegenthaler, U., Stocker, T. F., Monnin, E., Lüthi, D., Schwander, J., Stauffer, B., Raynaud, D., Barnola, J.-M., Fischer, H., Masson-Delmotte, V., and Jouzel, J., 2005. Stable carbon cycle-climate relationship during the late Pleistocene, Science, 310, 1313–1317, doi:10.1126/science.1120130.

Sigl, M., Fudge, T. J., Winstrup, M., Cole-Dai, J., Ferris, D., McConnell, J. R., Taylor, K. C., Welten, K. C., Woodruff, T. E., Adolphi, F., Bisiaux, M., Brook, E. J., Buizert, C., Caffee, M. W., Dunbar, N. W., Edwards, R., Geng, L., Iverson, N., Koffman, B., Layman, L., Maselli, O. J., McGwire, K., Muscheler, R., Nishiizumi, K., Pasteris, D. R., Rhodes, R. H., and Sowers, T. A., 2016. The WAIS Divide deep ice core WD2014 chronology - Part 2: Annual-layer counting (0-31 ka BP), Climate of the Past, 12, 769–786, doi:10.5194/cp-12-769-2016.