Clim. Past Discuss.,
doi:10.5194/cp-2016-62-RC1, 2016

Climate of the Past
Discussions

Interactive comment on "Large-scale drivers of Caucasus climate variability in meteorological records and Mt Elbrus ice cores" *by* Anna Kozachek et al.

Anonymous Referee #1

Received and published: 29 July 2016

In this study a 100 year record of water stable isotopes from an ice core collected at Mt. Elbrus in the Caucasus is investigated using meteorological data, reanalysis temperatures and atmospheric circulation indices. The main conclusion is that in summer the isotopic composition is influenced by local temperature whereas in winter atmospheric circulation is the main driver.

Generally the data set presented is very valuable and deserves publication. It is from a region bordering Europe and Asia and although the highest mountain of Europe is located in the Caucasus there are no high-elevation meteorological data available. The presented ice core is also the first from the Caucasus reaching bedrock and collected at an altitude with limited surface melt in summer. I image the effort involved in collecting

this ice core and congratulate the authors for this achievement. The stable isotope records show impressively clear seasonal variations, allowing for dating by annual layer counting. However, the annual d18O values did not reveal a relation with regional temperature. The authors attempt to find an explanation for that, but unfortunately this is not convincing.

The most critical point is separating the record into a warm a cold season part. This is conducted by implementing a threshold (average d18O value of -15.5‰ for the entire record), thereby inherently presuming a d18O-temperature relationship and the absence of a trend. This introduces a circular argument when examining the temperature dependence of the resulting warm and cold season record. Nevertheless, no significant correlation with local temperature was found for the entire time period. Only when reducing the data set to the period 1984 to 2013 a significant correlation (r=0.52) was observed, implying that in this period local temperature explains 27% of the d18O variance. This is a weak relationship and not sufficient to draw the conclusion that the summer season isotopic composition depends on local temperature. Similar for accumulation: The highest correlation coefficient r of 0.44 was observed between warm or cold season accumulations and precipitation in the south for the period 1966-2013. Again precipitation explains only less than 20% of the accumulation variability, insufficient to reconstruct precipitation back to 1914 as was proposed.

The missing relation with local temperature is easily explained by the fact that the inter-annual variability of temperature is low, whereas the mean seasonal amplitude of d18O is high (20‰. A slight seasonal shift in precipitation or accumulation from year-to-year therefore affects the mean d18O significantly. There is no need to evoke post-depositional processes (which of course add further biases) or other than local controls. Without clear seasonal marker in the ice core this limitation cannot be overcome. This situation is particularly unfavourable at sites with no distinct cycle of precipitation as assumed for the Elbrus ice core. In cases with a strong seasonal cycle, this normally persists even if slight shifts occur from year-to-year. Examples are the Colle Gnifetti in the Alps, where the saddle location induces an accumulation with strong seasonality biased towards summer, due to snow erosion in winter. There, for decadal scales, the isotope variability correlated with the temperature record at around r=0.65 (Bohleber et al., 2013). A similar situation was shown for Belukha glacier in the Altai, a region where summer precipitation dominates. 10-year averages of d18O and MAR–NOV temperatures were significantly correlated (r=0.83, $p < 0.001$) (Eichler et al., 2009). In both cases there were pronounced trends in temperatures and d18O. This is obviously absent in the Elbrus region over the last 100 years. So, the question is if you could investigate a longer time period (potentially showing a trend in temperature) and longer-term averages to smooth the effect of year-to-year shifts in precipitation/accumulation.

One other point is the dating uncertainty and how you deal with that for correlation analysis with meteorological data. You specify +/- 1 year uncertainty, whereas the first publication on this ice core (Mikhalenko et al., 2015) shows a 2-years difference between annual layer counting of the stable isotope signal and the chemical stratigraphy at 106.7 m. What is correct and how to you consider this in the correlation analysis?

Obviously this is not the first publication about that ice core which is not a problem if you present other data or new analyses. Here this is not so clear and you should state it and reference it where results were already presented before. Examples are the diffusion of stable isotopes, the AWS data from the ice core site, the overlap with the shallow cores, the precision of the stable isotope analysis (0.06‰ for d18O here and 0.07‰ in Mikhalenko et al. (2015)).

I wonder how the entire stable isotope record looks like. In the manuscript only the part down to 126 m out of 182 m is shown, whereas it is stated that the entire core was analysed. Why do you not focus on a longer period, for example back to 1815, since the Tambora volcanic layer gives a nice time marker, detected in most of the ice core records.

In the introduction you state that water stable isotopes are more sensitive to distortion

because of seasonality than aerosol concentrations, which is not correct. The seasonality of aerosol-related species and the isotope signal are comparable, but the anthropogenic aerosol trend exceeds by far any temperature-driven water isotope increase during the Holocene (Wagenbach et al., 2012).

Explain why there are gaps in the data (fig. 2 and 3) and how you treated them for calculating annual averages.

Table 4: Include number of points n or time period for correlation analysis when they are different for the different parameters as for temperature and precipitation.

Bohleber, P., Wagenbach, D., Schoner, W., and Bohm, R.: To what extent do water isotope records from low accumulation Alpine ice cores reproduce instrumental temperature series?, Tellus Series B-Chemical and Physical Meteorology, 65, 17, 2013.

Eichler, A., Olivier, S., Henderson, K., Laube, A., Beer, J., Gaeggeler, H. W., Papina, T., and Schwikowski, M.: Temperature Changes in the Altai Are Driven by Solar and Anthropogenic Forcing, Chimia, 63, 889-889, 2009.

Mikhalenko, V., Sokratov, S., Kutuzov, S., Ginot, P., Legrand, M., Preunkert, S., Lavrentiev, I., Kozachek, A., Ekaykin, A., Faïn, X., Lim, S., Schotterer, U., Lipenkov, V., and Toropov, P.: Investigation of a deep ice core from the Elbrus western plateau, the Caucasus, Russia, The Cryosphere, 9, 2253-2270, 2015.

Wagenbach, D., Bohleber, P., and Preunkert, S.: COLD, ALPINE ICE BODIES REVISITED: WHAT MAY WE LEARN FROM THEIR IMPURITY AND ISOTOPE CONTENT?, Geogr. Ann. Ser. A-Phys. Geogr., 94A, 245-263, 2012.

Interactive comment on Clim. Past Discuss., doi:10.5194/cp-2016-62, 2016.