

## ***Interactive comment on “Monthly resolved biannual precipitation oxygen isoscape for Switzerland” by Z. Kern et al.***

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Thanks for the in-depth review of our manuscript. Below we give a detailed response to the raised points.

First of all, we should emphasize that our work is, primarily, a methodological study and our motivation is to design a computation scheme involving the realized PBL relationship and test its robustness rather than deeply analyse the isotope patterns over the Alpine region. One of our general impressions gained from the referee report is that this motivation was not articulated clearly in the original manuscript. In order to stress it more in the revised version, as a first step, we suggest to modify the title:

Precipitation isoscape of high reliefs: interpolation scheme designed and tested for  
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monthly resolved oxygen isotope records of an Alpine domain

Referee #1: This manuscript releases a database of precipitation  $^{18}\text{O}$  data from Switzerland together with an analysis of the geographical drivers of this parameter, showing different isotope-elevation relationships in winter and summer attributed to the impact of atmospheric boundary layer height. Using a climatology of this parameter from atmospheric analyses, and interpolation and kriging methods, a cartography (isoscape) is established for 1995 and 1996, when the station network is densest. This manuscript provides several interesting results (the  $^{18}\text{O}$  database, the analysis of the isotope-elevation-boundary layer height aspects) but the form and the analyses of the results are not at sufficient quality for allowing publication in the present form.

Authors: Thanks for the recognition of the “several interesting results” of our work. We try to further improve the form and the discussion to reach the merit for publication.

Referee #1: insufficient description and analysis of the isotopic records especially the unpublished ones from Bern University. Missing discussion of the quality of the datasets, accuracy of the measurements, homogeneity of the data (calibration).

Authors: We were aware of possible ‘intra-network’ discrepancies. Therefore we compared nearby stations with visual comparison of the (regression analysis) to test spatial consistency. We will add a paragraph and three charts into the Supplementary material showing cross-correlation between Thonon vs Nyon, Konstanz vs St. Gallen and Bregenz vs St Gallen. These graphs are also shown in this document.

We also note that  $\text{d}^{18}\text{O}$  data archived in the ISOT, or the Swiss stations of the GNIP database and the KUP network were all measured at the stable isotope lab of the Climate and Environmental Physics Division of the University of Bern, using the same instrument, the same standards and usually during the same analytical run, this situation further affirms the homogeneity of the used data. Furthermore, our lab participated in the intercomparison programmes organized of the IAEA and always documented excellent agreement with the consensus values of the analysed intercomparison samples

in blind tests. (Lippmann et al. 1999, Gröning et al. 2003, Ahmad et al. 2012)

Referee #1: lack of discussion of the quality of the PBL data from von Engel and Teixeira, 2013.

Authors: Seven different methods were tested by von Engel and Teixeira (2013): (1) minimum gradient of relative humidity, PBLRH; (2) maximum gradient of potential temperature, PBLTp; (3) maximum gradient of virtual temperature, PBLTv; (4) minimum gradient of specific humidity  $q$ , PBLq; (5) minimum gradient of refractivity  $N$ , PBLN; (6) scaled  $q$  that identifies the altitude where  $q$  decreases by 50% from its surface value, PBLsq; (7) breakpoint method which searches for the break point in the  $N$  profile, PBLBP. To avoid misdetection of near surface inversion as a very low PBL height all data below 50 m were excluded from the analysis. Overall the methods associated with the identification of vertical gradients of either relative humidity PBLRH, potential temperature PBLTp, or virtual temperature PBLTv appeared to be the most robust. Compared PBL climatologies based on these methods it was concluded that i) the two temperature based methods produce very similar results, ii) PBLRH showed large variability over mountainous regions (for instance, over the Alps) for all seasons. Therefore we used PBLTp in our analysis.

Referee #1: section 3.2, lack of discussion of the results (Figures 3, 4, 5 are almost not described/discussed).

Authors: As noted above our primary motivation is to design a computation scheme involving the realized PBL relationship and test its robustness rather than deeply analyse the precipitation isotope patterns over the Alpine region. Therefore we concentrated mainly on the pattern difference observed after database reduction in a concise discussion. We appreciate our referee's opinion so we are ready to expand section 3.2 and discuss more details; however we would prefer to refrain from detailed description of the regional isotopic patterns.

In addition we will add a new section to the discussion to explain the observed distor-

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tion of  $\delta^{18}O_p$  profile over high reliefs by the seasonal changes of atmospheric static stability, stratified atmospheric flow, low-level deflection of winds around the terrain.

Referee #1: section 3.3 should be completely revised. The first half of the section should be placed in the introduction. The second half of the section is focused on Greenland and has nothing to do with the work shown here. This should be replaced by a discussion of the results obtained here.

Authors: We will include a paragraph into the 'Introduction' section to describe the peculiar application of empirical altitude dependence of precipitation isotopes in paleoaltimetry, however we are convinced, especially based on a new part about the atmospheric static stability and stratified atmospheric flow (see comment to referee 2), that our results provides implications on this issue (as indicated in the sub-heading) and we are to keep a part in the discussion, namely the above mentioned seasonal contrast of stratified atmospheric flow and the related deviation of precipitation isotopic ratios.

Referee #1: Figure 1 a (map) could allow a color code showing the start and end dates of the individual records.

Authors: The map became too complicated when we tried the bipartite color coding of the markers. Therefore we decided to add a fourth panel (Fig.1) to this figure showing the availability of the records for the studied period (1995-2000) in a beam graph.

Referee #1: Figures 3, 4, 5 : why selected these months specifically? Please discuss the suppl. information showing the whole set of monthly maps and justify the selected periods. Avoid having a subset of supplementary maps in the main work.

Authors: The final selection of these six monthly set of maps is a kind of a compromise to show the major findings best and in addition to demonstrate their multiple occurrence. We have generated 120 maps (72 isoscapes and 48 difference maps) in our work. We feel that it is needless to show the complete collection, but document that the work is really done. Electronic Supplementaries have been set-up by many pub-

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lishers exactly for this reason to report about similar additional information. If we keep the annual set of maps in the 1-page size for the manuscript then hardly any detail can be read in the stamp-size maps, alternatively assuming that maps are reproduced in a reasonable size it will roughly triplicate the length of the paper adding many superfluous 'decoration' because the main findings regarding the effects due to dataset reduction is best illustrated by the selected three set of maps. However we would like to ask for Editorial help in this question.

Referee #1: Consider releasing the 18O database as supplementary information.

Authors: Interpolated product is released with the ACPD manuscript in netCDF format. monthly  $\delta^{18}\text{O}_p$  series from 1995 January to 2000 December from the NISOT and KUP archive will be included into the Supplementary material as .txt format. However, a special restriction term for the use of Italian data was not to distribute them to a third party. Regarding IAEA and ANIP records these are available for the corresponding web-resources.

Referee #1: precipitation weighted 18O: please discuss the uncertainty associated with the information on precipitation amounts.

Authors: We used the monthly precipitation totals for the Swiss stations (ISOT, KUP and the five IAEA stations from Switzerland) provided by MeteoSwiss and the precipitation records provided in the corresponding dataset at each other station to calculate the amount weighted monthly and annual  $\delta^{18}\text{O}_p$  values for the 1995-2000 period.

Precipitation data from MeteoSwiss are quality controlled, on daily basis, partly by manual inspection and by computer assisted automated spatio-climatological approach (Scherrer et al., 2011). Earlier evaluation of the Alpine rain-gauge records reported variable quality status from various data providers (Frei and Schär, 1998). From our region of interest Southern Germany and South-east France were found to be thoroughly controlled (range test, spatial consistency) while relatively poorer data quality was found for Northern Italy. Different daily reading times (eg. 07:00 CET in Austria;

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07:30 in Switzerland; 09:00 in Italy) (Frei and Schär, 1998) might also introduce further inconsistencies; however its significance has very likely vanished for monthly totals. This paragraph has been attached to the 2.1 section.

Referee #1: Minor points :

- p9896, line 13 : allows - p9903, line 1 : "our suspicion" rather than "our suspect"

Authors: Thanks! mentioned errors will be corrected.

References:

Ahmad, M., Aggarwal, P., van Duren, M., Poltenstein, L., Araguas, L., Kurttas, T., and Wassenaar, L. I.: Fourth interlaboratory comparison exercise for  $\delta^2\text{H}$  and  $\delta^{18}\text{O}$  analysis of water samples (WICO2011). IAEA Report, Vienna, 63pp., 2012

Frei, C. and Schär, C.: A precipitation climatology of the Alps from high-resolution rain-gauge observations. *Int. J. Climatol.*, 18, 873–900, doi: 10.1002/(SICI)1097-0088(19980630)18:8<873::AID-JOC255>3.0.CO;2-9, 1998,

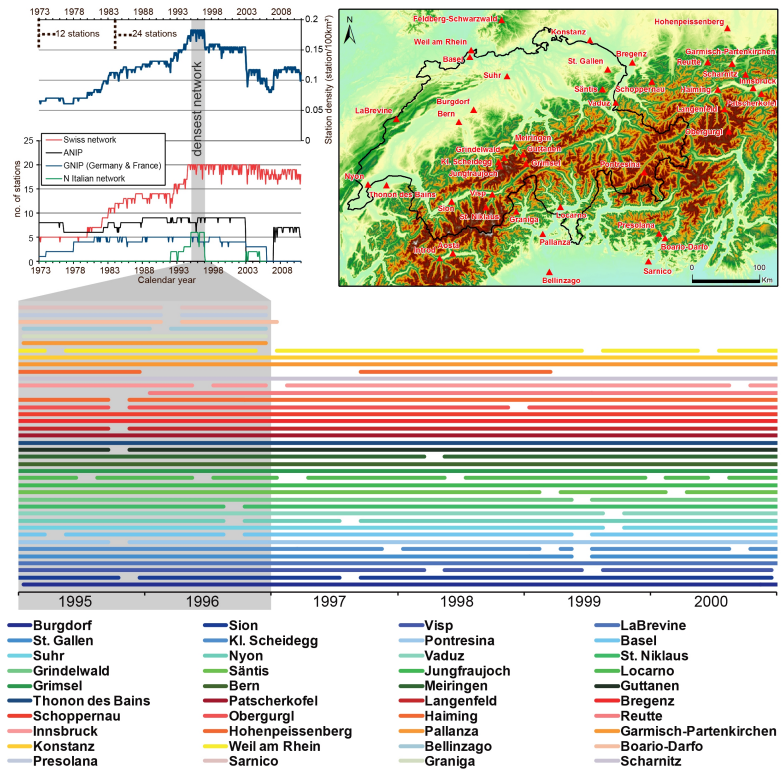
Gröning, M. Graeber, S. Bhattacharya, S. K. van Duren, M. Andreescu L.: Third interlaboratory comparison exercise for  $\delta\text{D}$  and  $\delta^{18}\text{O}$  analysis of water samples (WICO2002-Part 1). IAEA Report, Vienna, 43 pp., 2003

Lippmann, J., Gröning, M. Rozanski K.: 2nd interlaboratory comparison for deuterium and oxygen-18 analysis of water samples. IAEA Report, Vienna, 44 pp., 1999 Scherrer SC, Croci-Maspoli M, van Geijtenbeek D, Hotz C, Frei C and Appenzeller C: Operational quality control of daily precipitation using spatio-climatological plausibility testing *Meteorologische Zschr.* 20, 397-407, doi: 10.1127/0941-2948/2011/0236 2011.

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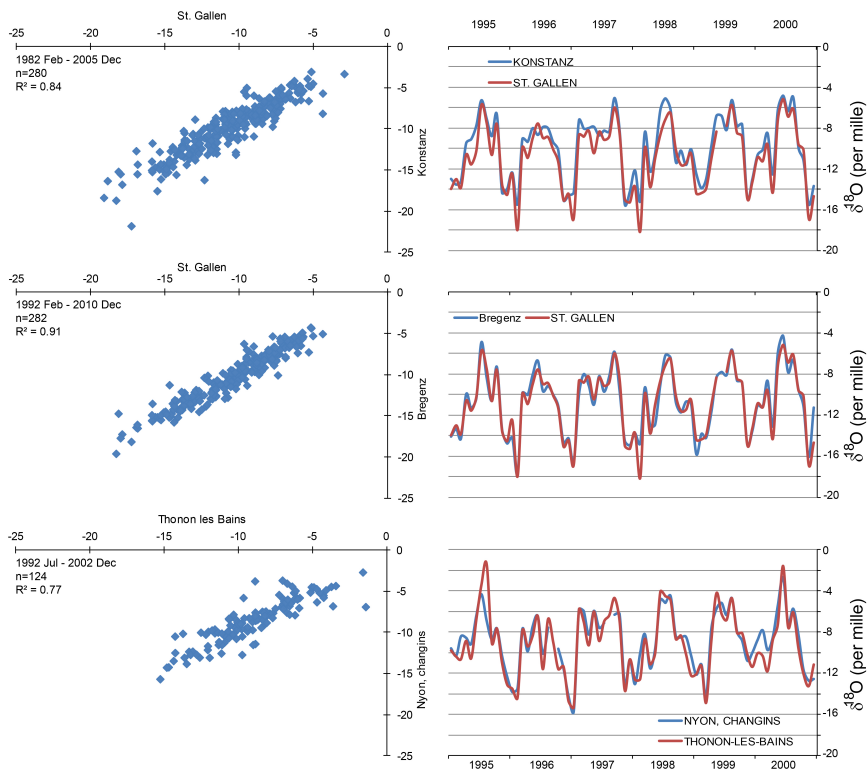
Interactive comment on Atmos. Chem. Phys. Discuss., 13, 9895, 2013.

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**Fig. 1.** Spatial and temporal distributions of the 43 stations with available records of monthly stable oxygen isotope ratio of precipitation over Switzerland and its border region. Temporal distribution

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**Fig. 2.** Data consistency graph between nearby stations of different measuring networks. Three station comparisons are shown between the German and Swiss networks (Konstanze – St. Gallen), Austrian and

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