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150 YEARS FOEHN STATION ALTDORF, SWITZERLAND – A CLIMATOLOGY

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1. INTRODUCTION

In Altdorf, in the Uri part of the Reuss Valley, foehn observations have been recorded from 1864 until 2008 at a station whose position was changed only marginally during this time. Hence, this is the longest time series of foehn events in the Alpine massif. Based on the three main parameters temperature, humidity, and wind, the occurrence of foehn was originally subjectively determined at the so-called climate observation times in the morning, at noon, and in the evening. These triple observations were concentrated in monthly sums for each of the observation times.

At the end of 2008, these observations were discontinued. Based on a 28 year long overlap of triple observations with automatic station data, a method was developed by which triple observations can be extracted from newly available objective parameters (Richner et al., 2014). This procedure allows a seamless continuation of the classical long time series.

In 2013, the time series reached a length of 150 years, a convenient occasion for a climatological analysis.

2. THE DATA AND ITS SEGMENTATION

The time series consists of the monthly sums of the triple observations, i.e., of morning, noon, and evening foehn occurrence from 1864 to 2014. These monthly sums can be totaled for morning, noon, or evening occurrence and, of course, for the year.

The foehn year

Foehn frequency has a distinct seasonal variability. In the mean, the lowest frequency is found in August, the highest in April (see Fig. 1).

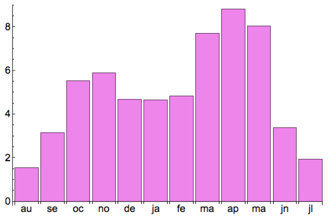

Figure 1: Mean monthly sums of triple observations from August 1864 to July 2014.

For the climatological analysis, it seems logical to define the year by foehn occurrence and not by the (arbitrary) calendar year. Hence, a foehn year runs from August to July, thus, the 150 year time series from August 1864 to July 2014. The foehn year is labeled by the calendar year in which it begins.

Fig. 2 shows the year-to-year variation of the yearly totals within the foehn year August to July. Quite clearly, there is no discernible trend.

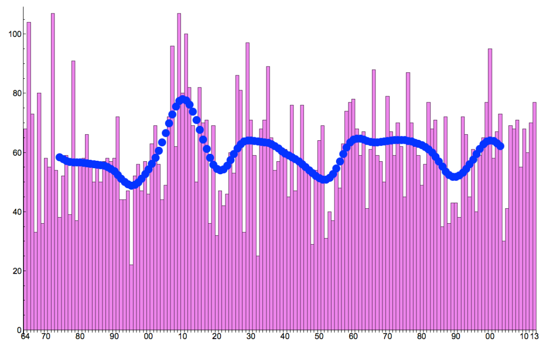

Figure 2: Yearly sums of triple observations within a foehn year (August to July). The blue line represents the values after Gauss-filtering with a filter length of 20 years.

The climatological periods

Climate normal periods run usually from 1901 to 1930, 1931 to 1960 and so on. For the analysis of the 150 year foehn time series, however, it is more logical to divide the 150 years into five 30 year periods, i.e., 1864 to 1893, 1894 to 1923 etc. to 1984 to 2013. With this, climate normals for periods of equal lengths can be compared.

3. BASIC STATISTICAL PROPERTIES

Fig. 3 shows yearly foehn frequencies as box whisker plots. As can be readily seen, the variability within the climate periods is significantly larger than the differences of the means and medians from period to period. Again, there seems to be no significant change of foehn frequency within the last 150 years.

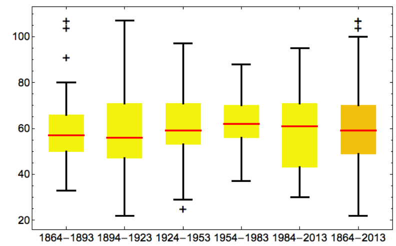

Figure 3: Box whisker plots showing the distribution of yearly sums of triple observations within the five climate periods and for the entire time series. [The box spans the distance between two quantiles surrounding the median (horizontal red line), i.e., from the 25 percent quantile to the 75 percent quantile. The vertical lines ("whiskers") above and below the box span either the full data set or the data set excluding outliers. Outliers (crosses) are defined as points beyond 3/2 of the interquantile range from the edge of the box.]

Comparison of the morning, noon, and evening observations

The left frame of Fig. 4 represents the inter-annual variation of foehn at the three observation times. The relative frequencies (right frame) show that during summertime, morning foehn events are more rare than evening events, during wintertime the situation reverses. It is assumed that this seasonal variation is linked to sunrise and sunset via local wind systems. The relative frequencies of foehn at noon time remain surprisingly constant over the year.

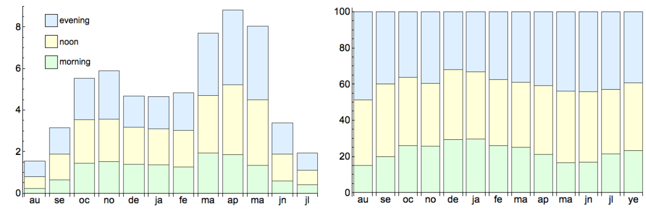

Figure 4: Mean frequencies for morning, noon and evening foehn observations for each month covering the 150 years. The left frame shows the absolute numbers, the right frame the relative values. In the rightmost column, the relative yearly means are depicted.

Foehn and weather situation

Since 1958, there are different objective weather classifications for the Alpine region available. Using the GWT26_Z500 classification scheme (Weusthoff, 2011), foehn occurrence was correlated with weather classes. The highest correlation was found with the type 2 class, the south-west flow (Fig. 5, correlation coefficient 0.59). While this had to be expected, it is surprising that there were years with quite high and quite low ratios of triple observations per occurrence of south-west flow.

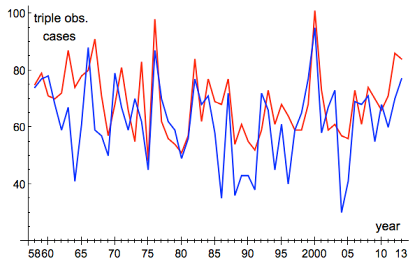

Figure 5: Yearly sums of triple observations (blue) and of days with south-westerly flow (red).

4. OPEN QUESTIONS AND FUTURE WORK

Is there an explanation for the peak in foehn frequencies around 1910?

Why are evening foehn observations fewer in winter months? It is hoped that an analysis of the so-called foehn calendar with foehn/no foehn information for every hour from 1955 to 2008 will provide some clues.

Why are there years with frequent synoptic south-west situations but with relatively low foehn frequencies? Maybe synoptic analyses might give an answer.

5. LITERATURE

Gutermann, T, B. Dürr, H. Richner, S. Bader, 2012: *Föhnklimatologie Altdorf: die lange Reihe (1864-2008) und ihre Weiterführung, Vergleich mit anderen Stationen.* e-Collection ETH Zürich; DOI: 10.3929/ethz-a-007583529

Richner, H., B. Dürr, T. Gutermann, S. Bader, 2014: The use of automatic station data for continuing the long time series (1864 to 2008) of foehn in Altdorf. *Meteorol. Z.*, **23(2),** 159 - 166; DOI: 10.1127/0941-2948/2014/0528

Weusthoff, T., 2011: Weather Type Classification at MeteoSwiss – Introduction of new automatic classifications schemes. Arbeitsber. MeteoSchweiz, **235**, 46 pp.