TEMPERATURE COMPARISON BETWEEN SOME ALPINE DOLINES IN WINTER TIME

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Abstract: Researches of extreme temperature minima in Alpine dolines of Switzerland, Germany and Austria indicate extreme temperatures in these concave relief shapes under certain atmospheric conditions. In the past two years, systematic measurements have also been done in Slovenian and Italian Alpine dolines, where similar extreme temperatures occur. However, detailed temperature comparison between the dolines has not been done so far. The article shows temperature comparison between Alpine dolines Mrzla Komna (SI), Glattalp (CH), Grünloch (A) and Lago di Fosses (I) in the period from 12 December 2005 to 6 February 2006. Three selected cases during the period, when appropriate atmospheric conditions for very low minimum temperatures occurred, have been additionally analyzed. The comparison shows similar temperature conditions in all the dolines in spite of quite diverse elevation, size and geographical position.

Keywords: *the Alps, doline, sinkhole, nocturnal cooling, extreme minimum temperatures*

1. INTRODUCTION

It was around 80 years ago when first scientific studies began in the well-known Austrian limestone sinkhole Grünloch near Lunz (Schmidt, 1930). Until 1984, it was the only known Alpine doline where temperatures can drop below –50°C, with official record of –52.6°C (Geiger, 1965). Temperature measurements started that year in Glattalp, an alpine doline in central Switzerland. Despite the fact that this doline usually does not get as low temperatures as Grünloch, –52.5°C was measured there on 7 February 1991 (Elektrizitätswerk des Bezirks Schwyz). In the past few years, studies of extreme temperatures in Alpine dolines have also begun in Germany, Italy and Slovenia. Very low temperatures occurred in some of these dolines during the winter of 2005/2006: –38°C in Lago di Fosses in Veneto /Italy/ and –41°C in Mrzla Komna in Julian Alps /Slovenia/.

The aim of the article is to compare temperature conditions in four selected Alpine dolines. The lowest lying of them, Grünloch, is a 1-km-diameter limestone doline on the Hetzkogel Plateau 5 km south of Lunz in Lower Austria. The base of the doline lies at 1270 m MSL and the lowest pass 54 m higher (Whiteman et al., 2004). Mrzla Komna consists of a small doline with 150 m in diameter, embedded in the plateau of Lepa Komna, situated near Bohinj Lake in the Julian Alps. Its ground lies at 1592 m and the lowest pass is 30 m higher. Glattalp lies in the Schwyz canton with its base at 1852 m MSL. The doline is oblong and measures from 2 to 6 km in diameter. The lowest pass is very narrow and only 8 m above the ground (personal contact 2). The highest of the dolines, Lago di Fosses, is situated in the Italian Dolomites inside the Sennes and Fosses Plateau near Belluno with its ground at 2142 m MSL and the outflow elevation of 2163 m MSL. It measures 500 m in diameter on average (personal contact 1).

Figure 1: Alpine doline Mrzla Komna in wintertime.

The selected dolines are known for very strong temperature inversion, which builds up under appropriate atmospheric conditions. Minimum air temperatures below –30°C are quite frequent there according to available data, while the absolute records surpass those measured at the highest meteorological stations in the Alps.

2. DATA AND METHODS

Datasets from aforementioned Alpine dolines were collected after personal contact with researchers and *in situ* measurements in the Slovenian doline. Data were put together and some detailed analyses were done for specific synoptic situations during the winter of 2005/2006, when appropriate conditions for extreme temperature minima appeared in the entire Alpine region. We have analysed the following periods: 9-17 January, 24-25 January and 1-4 February.

Air temperature in the dolines was measured by a digital sensor inside a radiation shield that minimizes net radiative forcing on measured air temperature. Thermometers were placed on the floor of the doline or just a few metres above it, mostly one to three metres above surface, so the measured temperatures from different dolines could be directly compared. The thermometers are of different types with different resolution and accuracy, as are the thermometer shields. This altogether can result in an error of order of 1°C to 2°C, especially during the daylight, in calm and sunny weather.

3. RESULTS

3.1 Overall temperature comparison

The meteorological station in Mrzla Komna began to operate on 11 December 2005, while temperature records from other dolines span the entire 2005/2006 meteorological winter. The amount of fresh-fallen snow was above the average that winter and unfortunately snow completely covered the temperature sensor in Grünloch probably on 7 February. Two weeks later the same happened to the station in Mrzla Komna. The temperature comparison between all four dolines is thus limited to the period between 12 December 2005 and 6 February 2006.

The overall temperature statistics of the selected period is shown in Table 1. Some data were missing and we replaced them with linearly or subjectively interpolated values. The average temperature was calculated from all the values from 0000 to 2400 CET on given day with the first and the last value being half-weighted in comparison to other values. Day is defined as a period from 0000 to 2400 CET in other statistics.

The coldest dolines during the given period were Glattalp and Lago di Fosses, while Grünloch and Mrzla Komna were somewhat warmer. The average diurnal temperature range was the largest in Mrzla Komna and the smallest in Glattalp. The lowest measured temperature was –41°C in Mrzla Komna and the highest 6°C in the same doline.

Table 1: Average temperature (Tavg), average daily minimum (Tminavg) and maximum (Tmaxavg) temperature, absolute minimum (Tmin) and absolute maximum (Tmax) temperature and average diurnal temperature range (Tran) in °C for the period from 12 December 2005 to 6 February 2006. Elevations of the lowest point of the dolines (MSL m) have been added.

Doline	Elevation	Tavg	Tminavg	Tmaxavg	Tmax	Tmin	Tran
Lago di Fosses	2142	–14.3	–21.9	–7.3	3	–38	14.7
Glattalp	1852	–15.4	–21.3	–8.8	3	–35	12.5
Mrzla Komna	1592	–12.1	–20.1	–3.5	6	–41	16.7
Grünloch	1270	–11.7	–18.0	–4.3	5	–40	13.7

3.2. Temperature comparison for selected cases

3.2.1 January 9-17, 2006

A period of dominating anticyclonic weather in the Alps persisted for several days in the middle of January 2006. Though the temperatures at 850 hPa were near 0°C most of the time, deep snow cover and partly very dry air mass above the dolines enabled build up of an intense temperature inversion.

A pronounced inversion developed on the first day in all of the dolines, except in Grünloch, where inversion built up on the next day. The inversion persisted more or less intensely for the next 7 or 8 days. Temperatures below –30°C were, except for Grünloch, quite frequent in the period. In Mrzla Komna, the daily maximum temperature remained below –20°C for five consecutive days (Fig. 2).

The absolute minimum temperatures in dolines were measured on 15 January, except for Grünloch, where it was on 17 January. The doline of Mrzla Komna was the coldest with –40°C, followed by Lago di Fosses with –38°C, whereas in Glattalp and Grünloch air-temperature reached –35°C and –34°C, respectively.

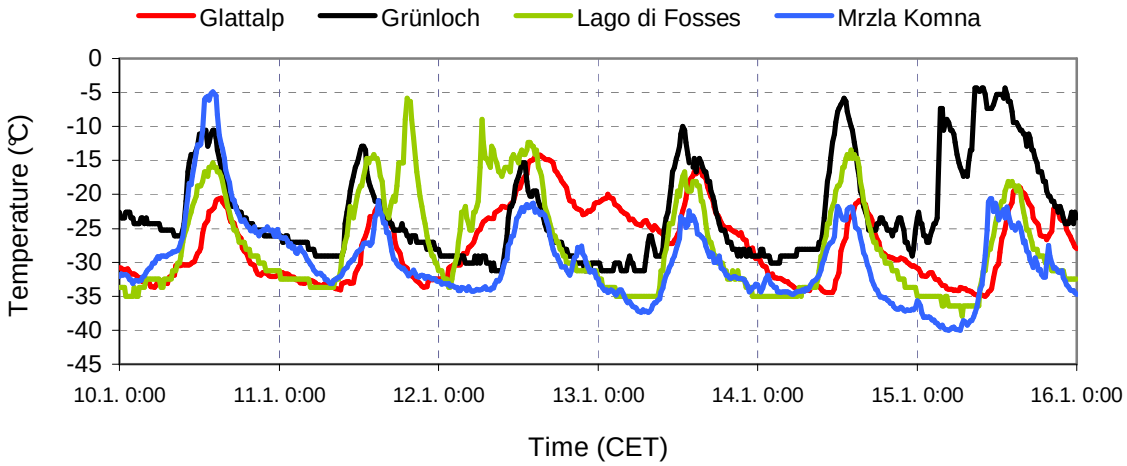

Figure 2: Temperature series from 10 January to 15 January 2006.

3.2.2 January 24-25, 2006

Between a ridge over Western Europe and a cut-off low in the Mediterranean Sea, relatively cold air was advected with eastern to northern flow into the eastern Alps. Temperatures were around –5°C at 850 hPa level there, while in Switzerland it was warmer (Fig. 3). Dry air mass above the level of the dolines and not too strong winds resulted in an intense nocturnal radiational cooling, especially in the eastern part of the Alps, where conditions for cooling were more favourable (Fig. 3).

Mrzla Komna experienced the coldest night in the whole winter with a temperature minimum of –41°C in the morning of 25 January (Fig. 4). Meanwhile, the temperature sensor in Lago di Fosses measured –36°C. In Grünloch, the minimum temperature of the period, –40°C, was reached a day earlier, while in Glattalp the temperature dropped to –31°C on both days of the period.

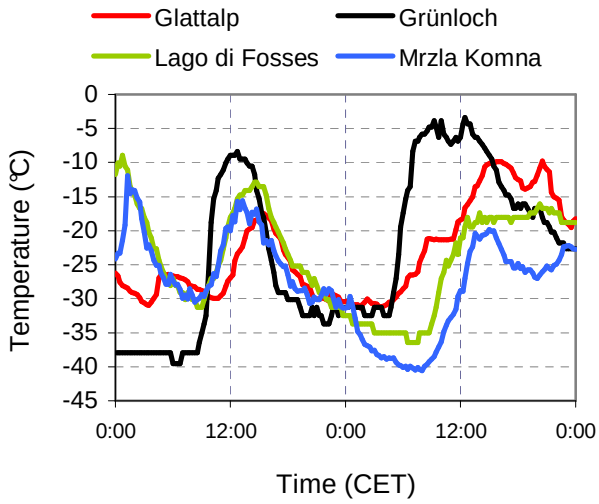

Figure 4: Temperature series from 24 January 0000 CET to 26 January 2006 0000 CET.

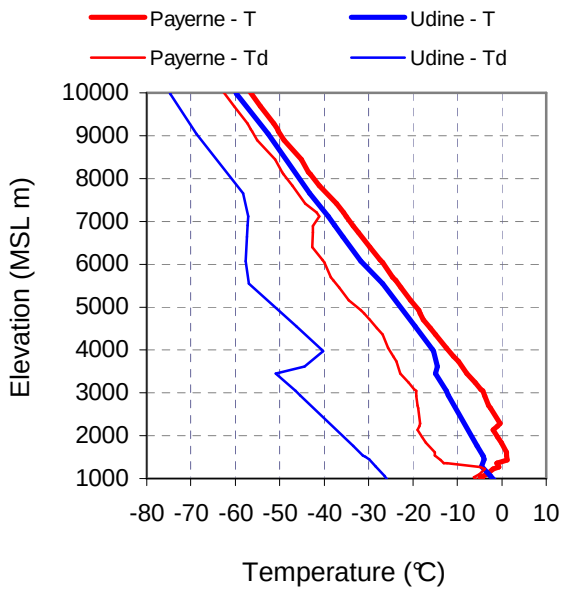

Figure 3: Soundings from Payerne, Switzerland and Udine, Italy on 25 January 2006 0100 CET. Thick lines denote air temperature and thin lines dew point temperature. Data source: http://weather.uwyo.edu/upperair/europe.html

3.2.3 February 1-4, 2006

Only few days later, there was another interesting period, which has been analyzed. A ridge was situated over Western Europe and cold-air pool in the NE Europe during the first four days of February. Mild and dry air with temperature around 5°C at 850 hPa was present in the Alps on the first day of the period and then temperatures lowered due to cold-air advection from northeast during the next three days.

Clear and calm weather conditions prevailed during the period and consequently the diurnal temperature cycle was obvious in all the dolines (Fig. 5). The temperature minima were much higher than a week before, the lowest measured temperature was –32°C in Grünloch on 3 February and in Lago di Fosses one day later.

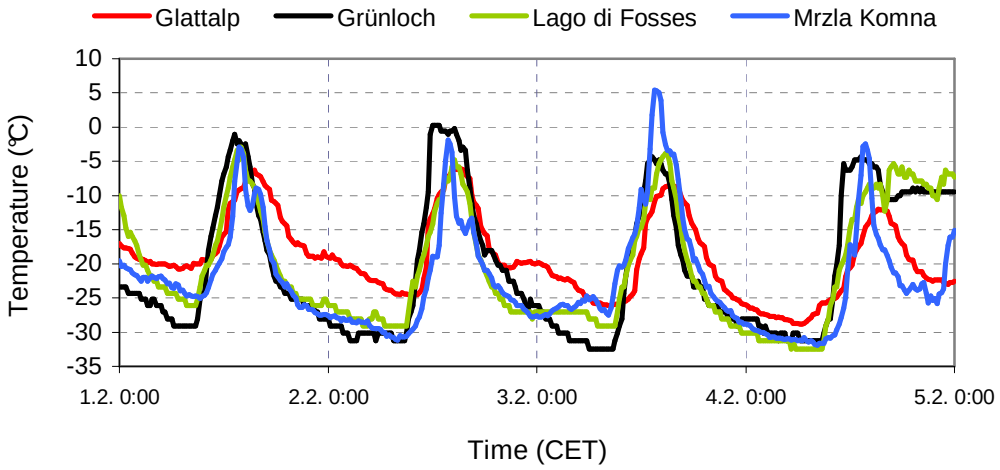

Figure 5: Temperature series from 1 February to 4 February 2006.

4. CONCLUSION

The comparison between dolines in different Alpine regions in the period of 12 December 2005-4 February 2006 has shown quite similar temperature conditions in four Alpine dolines of similar topographic characteristics but in different regions. The average air temperature, average daily minimum and maximum temperatures were lower in the highest two dolines, while the absolute minimum temperatures were lower in the lowest two dolines.

The analysis of the temperature data for the three selected cases within the period from 12 Dec 2005 to 6 February 2006 indicates the importance of dry air and calm wind conditions for strong nocturnal radiational cooling. Temperatures below –30°C occur quite frequently in such cases and temperature inversion can persist for several consecutive days.

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Personal contact 2: Daniel Schelbert and Daniel Zgraggen, Elektrizitätswerk des Bezirks Schwyz

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