CLIMATIC AND SYNOPTIC ANALYSIS OF THE COLDEST AIR POOLS IN ITALY: FIRST RESULTS

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Abstract - Since the '80s, mountain climatologists had paid their attantion to "*cold air pools*". These sites are characterised by extreme micro-climate conditions due to a particular combinations of synoptic, morphologic and local geographic factors that contribute to achieve very low temperatures. In Italy, such studies started in the mid '90s, following the installation of a number of automatic snow-meteorological gauges in the Alps and the Apennines. In both these mountain ranges "*cold air pool*" were always found on plateaus punctuated by karst hollows, a morphological setting particularly suitable to the soil irradiance during the night. In the present study, hourly temperature data were analysed in detail for three Italian cold air pools: the *sink-hole* of Valmenera-Cansiglio (905 m a.s.l.), the *sink-hole* of Marcesina (1310 m a.s.l.) and the small town of Cimacanale, (1700 m a.s.l.) located in the upper Visdende Valley. The data refer to the 2000-2006 interval. The thermal data of the three study sites were compared with those of neighbouring meteo-stations, located at the same elevation but in a different geomorphological setting or at a higher elevation, in order to point out the microclimatic anomalies. The synoptic conditions favourable to the development of very low temperatures were pointed out by the analysis of ground level and 500 hPa geopotential maps and aerologic diagrams.

Key words: cold air pool, karst, sky-wiew factor, Veneto Alps

1. INTRODUCTION

Whenever the mesoscale synoptic situation is uniform (i.e. levelled pressure, clouds and uniform humidity) the night cooling of the air near the ground, at least within the first 10 m, is function of four factors that, in order of relevance are: site morphology and lithology, sky-view factor, elevation and latitude (Iijima Y and M.Shinoda 2000; Clements et al., 2003; Whiteman et al., 2004;). In winter an additional, necessary factor is the clouds cover of the ground. In sink-hole sites, the absence of gale winds, a high *sky-wiew factor*, the occurrence of topographic karst hollows that trap the cold air sinking to the ground for its irradiance since sunset (Pospichal et al. 2003) and a longer duration of snow on ten ground favour the development of a cool air pool. Such features are found in many Alps and Apennines sites located at an elevation between 1000 and 1500 m a.s.l. and subjected to temperatures lower than -20°C with peaks close to or less than -30°C (tab.1).

Much larger is the temperature difference with sites near slope or mountain top sink-holes. Under air masses of continental-polar origin, very cold and dry, the values of thermal inversion, and hence of negative or positive vertical temperature gradient, become very high and commonly in the Alps they can be as much as 20°C every 100 m of altitude (Komna Plateau-Slovenia – Iztok site, Grünloch – Hetzkogel - Gstettner Alm) (Pospichal et al. 2003).

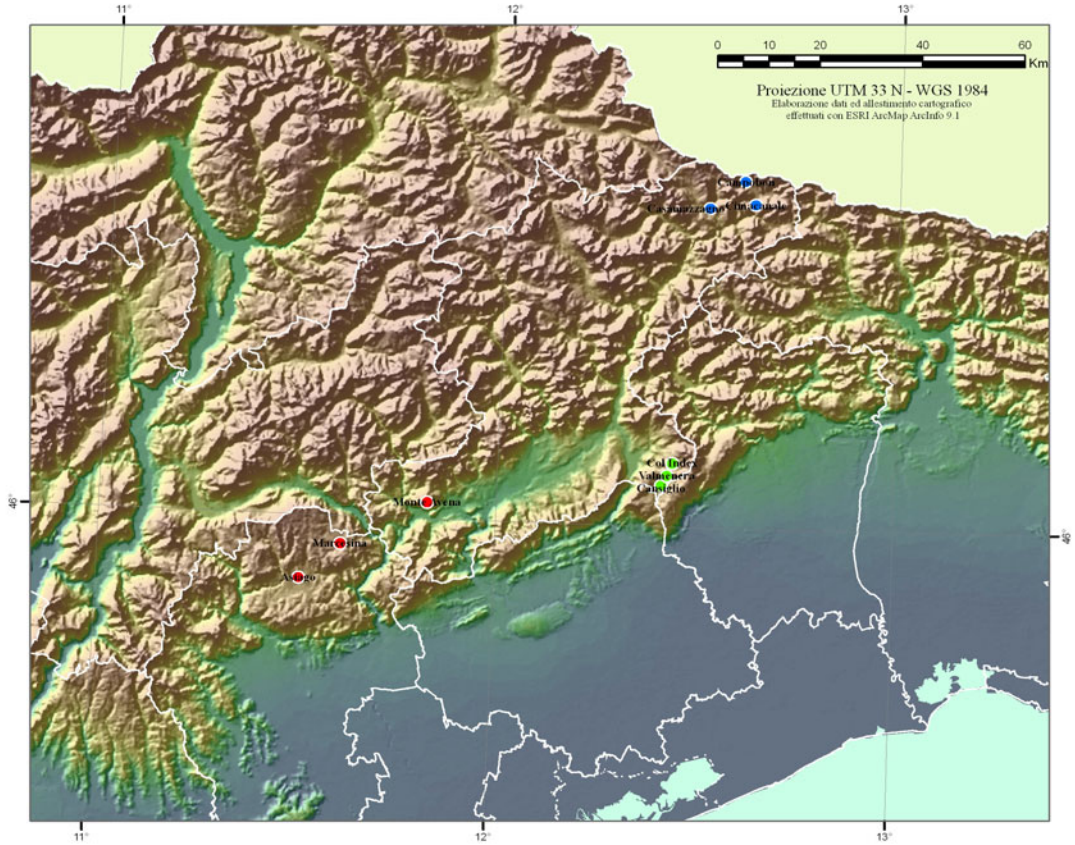

Figure.1 – Study's area DEM with highlighted the position of the meteorological stations

It is worth noticing that such remarkable differences in the night temperatures occur in every month with a lower effect during the summer when there is no snow cover on the ground. Such thermal features are reflected also by the vegetation since locally it consists of high elevation trees such as spruce and larch near the sink-holes and deciduous species, e.g. beech, on the adjoining slopes.

Figure 2 – Winter wiew of the Marcesina Plane (1310 m.a.s.l.) and of the Valmenera sinkhole (905 m.a.s.l.)

2. DATA AND METHODS

In order to point out some winter thermometric features of the most important Italian cold air pools, the half hourly data of Valmenera (905 m a.s.l.), Marcesina (1310 m a.s.l.) and Cimacanale (1700 m a.s.l.) - fig 1 and 2 - were analysed for the 2000-2006 time span. The first two sites are sink-holes located next to the

external border of the Veneto Pre-Alps, less than 80 km far from the sea (fig.1), whereas Cimacanale is located in the headwater of the Piave R. (Visdende Valley), in the heart of Veneto Alps near to the border with Austria, in a closed depression of a valley bottom, deeply embedded, scarcely sunned, with a calcareous bedrock, but devoid of karst forms.

Stations	elev m.	J	F	M	A	M	J	J	A	S	O	N	D
Asiago	1000	-20,8	-23,7	**-26,6**	-13	-3,8	-3,1	1	1,1	-3,1	-16	-16	-23,1
Marcesina	**1310**	-26,4	-29,2	**-34**	-20	-7	-6,6	-1,8	-2,2	-6,7	-16	-20	-28,6
M.Avena	1400	-14	-15,8	-21,6	-9,2	0,4	-0,5	4,7	4,7	1	-6,7	-8,5	**-29,4**
Valmenera	**905**	-30,4	-27,8	**-35,4**	-18	-5,5	-6,2	-0,8	-1	-4,1	-12	-17	-27,8
cansiglio	1000	-24,2	-20,6	**-27,5**	-14	-3,3	-3,6	6,5	-0,1	-3,7	-9,3	-13	-23,6
Col Indes	1200	-12,9	-13,4	**-15,8**	-7,8	0,3	0,8	4,1	4,4	0,9	-5,1	-6,9	-11,2
Casamazzagno	1400	-17,2	-16,8	**-18,9**	-11	-1,9	-0,5	2	2,9	-1,7	-9	-8,3	-14,2
Cimacanale	**1700**	-24,1	-23,7	**-26,4**	-14	-3,9	-4,2	-1,4	-1,3	-5,7	-10	-15	-22,5
Campobon	2000	-18,4	**-19,8**	**-19,6**	-11	-5,2	-2,9	0,6	0,9	-1,3	-9,1	-13	-19

Table 1 – Minimal absolute values registred in the several stations of the Veneto Alps and PréAlps

The lowest, absolute temperatures vary among -35,4°C at Valmenera, -28°C at the overhanging Consiglio karst plateau, -34°C at Marcesina – with a peak value of -37,1°C in the *sink-hole* monitored by a non standard WMO station at Roda del Corvo (1292 m a.s.l.) – and -27°C in teh town of Asiago, locate don a karst plateau, a few kilometres south-west of Marcesina.
By contrast, in the inner alpine area, the values are not so extreme and range from -26°C at Cimacanale to -19°C in the lower elevated site of Casamazzagno. These particularly low values contrast with those definitely milder relative to Monte Avena (-18°C) and Col Indes (-16°C), located on low gradient slopes with south-east/south-west aspect. In the cold air pools the minimum temperatures may exceptionally go below the freezing point also in July (tab.1)

3. RESULTS

The average monthly vertical thermal gradients, of inverse type, obtained from the mean monthly values reported in tab. 2, are very high, with peaks of 4°C/100 m, especially in the Consiglio Plateau where the temperatures constantly increase from the lower elevated station located in the homonymous *sink-hole* (Valmenera) to the one located on the overhanging slope exposed to south-west (Col Indes). At Marcesina and Cimacanale, the gradient values for the three stations (tab.2) are not reliable since the cold air pool is intermediate between the other two stations. In fact, temperature constantly decreases upslope with a strong thermal inversion with respect to the higher elevated stations. Moreover, at Cimacanale, the reverse thermal gradient is much lower than that observed at Valmenera and Marcesina. This confirms that the night irradiance is less intense in hollows with the *sky-wiew factor* substantially limited by the adjoining highly elevated mountains and by the absence of karst depressions.

STATIONS	ELEV M.	J	F	M	A	M	J	J	A	S	O	N	D	Y
ASIAGO	1000	-10	-9	-4	-1	4	7	9	9	5	2	-3	-7	0
MARCESINA	1310	-14	-13	-7	-3	2	5	7	7	3	0	-5	-11	-2
MONTE AVENA	1436	-4	-4	-1	2	7	11	12	12	8	5	1	-5	4
VALMENERA	905	-14	-13	-6	-1	4	7	9	8	5	3	-3	-11	-1
CANSIGLIO	1000	-11	-9	-4	-1	4	8	10	9	5	3	-2	-8	0
COL INDEX	1183	-4	-4	0	3	8	11	12	12	8	6	1	-2	4
CASAMAZZAGNO	1400	-6	-6	-3	0	5	8	10	10	6	4	-1	-5	2
CIMACANALE	1700	-13	-12	-6	-2	2	6	7	7	3	1	-4	-10	-2
CAMPOBON	1982	-7	-7	-4	-2	3	7	8	9	5	2	-2	-6	1

Table 2 – monthly minimum temperatures (2000-2006) concerning the putting off undergoing study's areas

From table 1 it is evident the cold peaks occurred in all the study stations – with the exception of Monte Avena – on March 1, 2005. On the same day, in the Alps low temperatures such as -36°C at Albstadt (only 864 m a.s.l) in Baden-Württemberg (Germany), -40,3°C at Glattalp (1858 m a.s.l.in the Switzerland Oberland) and -43,6°C at Funtsee (1602 m a.s.l. in Berchtesgaden - Germany) were recorded. Aiming to understand the characteristic synoptic situation of that thermal event, re-analysis NCEP maps at ground and 500 hPa geopotential elevation, relative to 00 UTC hours were considered. The ground level synoptic analysis reveals a pattern common to conditions with very low temperature in the Alps and the Apennines in coincidence with a continental anticyclone field, extending from the eastern Atalantic to the Black Sea, with strong northern winds associated with a downward movement to the Balkans of the Polar Vortex. The aerologic profile, referred to Udine Rivolto station – located in the Friuli plain, 30 km east of the Cansiglio Plateau – shows temperatures very low also near the ground (-7°C, with a minimum in the night of about -11°C) and dew point values close to -20°C, witnessing the occurrence of very cold and dry air along the overhanging air column. The vertical thermal gradient shows a thermal inversion near the ground of about 0,8°C/100 m as far as an elevation of 2600 m a.s.l. The winds, weak near to the ground, take a north-eastern component over 1000 m and become strong over 3000 m a.s.l.

4. CONCLUSION

The analysis of mean thermal values for the Italian cold air pools has shown that under specific synoptic conditions, i.e. with snow on the ground, in particular morphologic setting such as sink-holes and karst phenomena, high *sky-view factor,* (Valmenera – Consiglio *sink-hole* and Marcesina *sink-hole*) the temperature can reach very low peaks with remarkable thermal inversions also in the southern side of the Alpine chain. Such phenomena are surprisingly more relevant in the outer Pre-Alpine domain where the climatic characteristics tend to make a transition to the Mediterranean ones. Vice-versa, in really cold sites, located in hollows surrounded by high mountain peaks with limited *sky-view factor,* (Cimacanale) the absolute values and, mainly, the reverse thermal gradients are relatively low. The continuous upgrading and modernization of snow and meteo stations network in Alpine and Apenninic environments let to monitor remotely located sites where extremely low temperatures are recorded. Recently, a non official monitoring of a few sink-holes in Central Apennines -Castelluccio (1400 m a.s.l.), Sibillini Mts, between Marche and Umbria, and Campo Felice (1520 m a.s.l.) in the Sirente massif – inner Abruzzo – characterised by temperatures close to or lower than -30°C has started. During the last winter season, characterised by temperatures exceptionally high and very limited snow falls at any elevation without any permanence of the snow cover below 1200 m a.s.l. – the monitoring of other sites, located in the Veneto Alps (Busa della Segala, 2000 m.a.s.l., few kilometres of north of marcesina sinkhole; Lago di Fosses, near Cortina d'Ampezzo – 2100 m a.s.l.; I Bech, 900 m a.s.l. near Valmenera and Consiglio; Campi Lussi - 1760 m a.s.l., shortly north-west of di Marcesina) where extreme low values ranging from -20 and -33°C, i.e. much lower than those of the study cold air pools, was initiated. In particular, for the Campi Lussi site it is possible to envisage low peaks of -45°C.

REFERENCES

Pospichal, B., S. Eisenbach, C. D. Whiteman, R. Steinacker, and M. Dorninger, 2003: Observations of the cold air outflow from a basin cold pool through a low pass. Extended Abstracts, Int. Conf. on Alpine Meteorology and MAP-Meeting, Brig, Switzerland, MeteoSwiss, Publication **66**, 153–156.

C. D. Whiteman, T.Haiden, B.Pospichal; S.Eisenbach and R.Steinacker, 2004: Minimum Temperatures, Diurnal Temperature Ranges, and Temperature Inversions in Limestone Sinkholes of Different Sizes and Shapes. - J. Appl. Meteor **43**, 1224-1236

Clements, C. B., C. D. Whiteman, and J. D. Horel, 2003: Cold-air pool structure and evolution in a mountain basin: Peter Sinks, Utah. *J. Appl. Meteor.,* **42,** 752–768.

Iijima Y and M.Shinoda 2000: Seasonal change in the cold air pool formation in a subalpine hollow, central Japan. Int J.Climatol., **20**, 1471-1483