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CLIMATIC CHARACTERIZATION OF FOEHN EPISODES IN PIEDMONT, ITALY

ABSTRACT: FRATIANNI S., CASSARDO C. & CREMONIN R., *Climatic characterization of foehn episodes in Piedmont, Italy*. (IT ISSN 0391-9838, 2009).

An analysis of the yearly, seasonal and monthly frequency of North and North-West foehn in north-western Piedmont (Italy) has been carried out considering weather stations located in the Susa Valley, one of the largest valleys in the region. The detection of foehn episodes has been performed by adopting synoptic, mesoscale and punctual recognition criteria. The yearly, monthly and seasonal distributions of foehn episodes have been investigated. The foehn event occurred on 16th-18th December 2005 has been selected and analyzed separately as a case representative of all foehn cases in Susa valley. It has been verified that the comparison among the potential temperatures measured at a downstream station and at a reference station representative of the flow at crest level is a good indicator of foehn occurrence.

KEY WORDS: Foehn episodes, Synoptic configuration, Potential temperature, Wind speed, Piedmont, Italy.

RIASSUNTO: FRATIANNI S., CASSARDO C. & CREMONIN R., *Caratterizzazione climatica degli episodi di foehn in Piemonte, Italia*. (IT ISSN 0391-9838, 2009).

In questo studio viene analizzata la frequenza annuale, mensile e stagionale degli eventi di foehn da Nord e da Nord-Ovest, verificatisi nella parte nord-occidentale del Piemonte, usufruendo dei dati meteorologici provenienti dalle stazioni situate in Valle di Susa, una delle valli più grandi della Regione. L'individuazione degli episodi di foehn è stata condotta mediante l'adozione dei criteri sinottico, a mesoscala e puntuale. È stata studiata anche la distribuzione annuale, mensile e stagionale degli episodi di foehn. L'episodio di foehn, verificatosi il 16-18 Dicembre 2005 è stato selezionato e analizzato separatamente come un caso rappresentativo di tutti gli eventi di foehn che hanno interessato la Valle di Susa. È stato quindi possibile verificare che il confronto tra il valore della temperatura

potenziale di una stazione di fondovalle con quello di una stazione di riferimento posta nella parte superiore della montagna, rappresentativa del flusso a livello della cresta, è un buon indicatore per il riconoscimento di un episodio di foehn.

TERMINI CHIAVE: Episodi di foehn, Configurazione sinottica, Temperatura potenziale, Velocità del vento, Piemonte.

INTRODUCTION

The foehn is a katabatic wind occurring when a deep layer of air is forced to cross mountainous ridges. As the air mass moves upslope, it expands and cools, causing water vapour to condensate and eventually to precipitate. This dehydrated air mass crosses the crest and then begins its downsloping motion. As the wind descends to lower levels on the leeward side of the mountains, the air temperature increases dry-adiabatically, in some cases with increments of 20°C (or even more) in short time (a few hours or less). The temperature increment is even greater when the originating air mass is not located at the surface but lies at a higher level (von Hann, 1891). Foehn winds occur also in many other regions in the world and are also called «snow-eater» for their ability to make snow melt rapidly; they are often associated with the rapid spread of wildfires.

The Piedmont region is located in the extreme north-western sector of Italy, and is bounded at the northern, western and southwestern sectors by the Alpine chain and at the southern and southeastern sectors by the Apennines (fig. 1). Turin city is also bounded at the eastern sector by a hill range, causing the frequent occurrence of temperature inversions in the lower boundary layer, especially during wintertime and nighttimes. In certain meteorological conditions, this orographic configuration enhances the onset of North or northwestern foehn winds. In Piedmont, the foehn can typically occur in the northwestern sectors with airflows coming from North, North-West and West, while in few situations the southern sectors are affected by South foehn.

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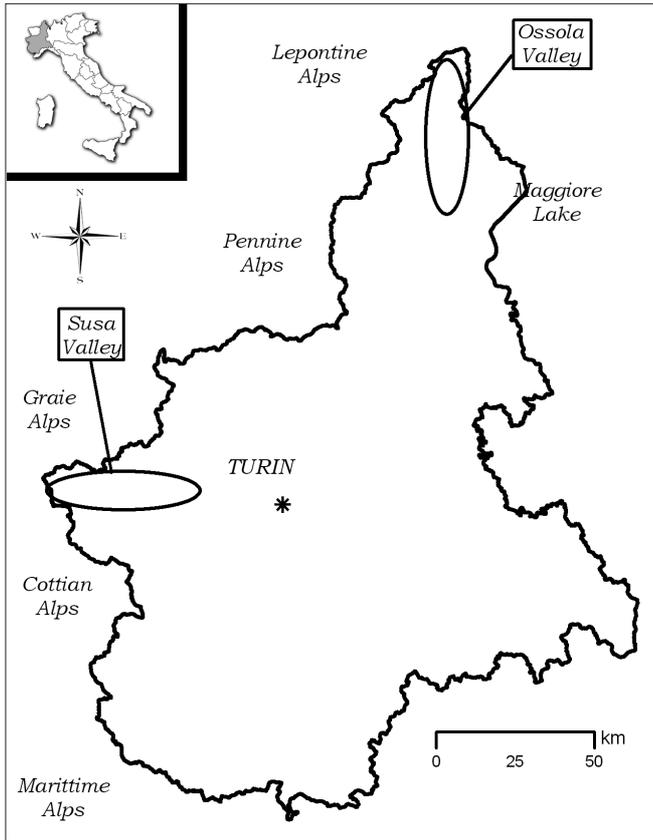


FIG. 1 - The Piedmont region: location of Susa and Ossola valleys.

The synoptic configuration favouring the onset of the North foehn consists in a positive difference of atmospheric pressure between the upwind and the downwind sides of the mountains (Kappenberger & Kerkmann, 1997; Whiteman, 2000). In the case of the alpine foehn, a pressure difference of approximately 4-8 hPa is sufficient to originate a weak event of foehn, while pressure gradients larger than 14 hPa produce intense and long-lasting foehn events with high wind speeds (up to 30 ms^{-1}). In such conditions, a low-pressure centre is present over the Piedmont, the Po valley or the Genoa gulf, while there is a relative ridge on the northern, northwestern or western side of the Alps. Previous studies, carried out on the north-western foehn, have shown that the foehn can arise in every month of the year, with maximum probability of occurrence in February, March and April; the average number of foehn events in the northern and north-western Piedmont valleys were 43 ± 6 and 42 ± 9 , respectively (Cassardo & Musso, 2004).

During wintertime, in occasion of northern or north-western foehn in Piedmont, due to the frequent occurrence of cold atmospheric layers in the first 500-1000 m above ground in the Po Valley, thermal inversions can limit the foehn intrusion to the upper part of the deepest valleys, while the plains remain unaffected by it. Frequently, after the passage of cold frontal systems crossing the Al-

pine chain from West, West-North-West or North-West, the post frontal currents generate weak and short-lasting foehn episodes over the western and/or northern part of Piedmont, favouring the onset of very intense pollution events, as shown by Natale & alii (1999). It is important to note that heavy air pollution episodes caused from industries, occur only when the foehn does not reach completely the Po Valley in the surface layer. It is also important to stress that the foehn episodes cause important effects on agriculture and viticulture, industry very important in Piedmont, such as the stress on natural and cultivated plants with heavy losses of the evapotranspiration, mechanical effects on plants and tree (fallen branches or whole plants, or attract stamp) and the stress on the pets with the consequence to set the production of milk and meat.

DATA AND METHODOLOGY

Every alpine area, as well as every valley and plain, has its own foehn climatology. The valleys where foehn penetrates more easily are generally well known. In fact, most of the foehn episodes in Piedmont involve exclusively the Susa Valley, the Ossola Valley (fig. 1), or both valleys in the same day. Moreover, the foehn sometimes is weak and do not affects the plain but only the higher mountainsides and these are often weak phenomena.

ARPA Piemonte (the Regional Agency of Environmental Protection) manages more than 400 meteorological ground-stations connected in real time to the operative centre in Turin. Several weather stations, located aloft and among the valleys, are equipped by anemometer, thermometer and hygrometer. The analysis of synoptic circulation and the combined measurements of these sensors are used by ARPA Piemonte forecasters to subjectively detect foehn episodes. The method here used for selecting the foehn episodes that have affected the Piedmontese region, has consisted in examining the daily analysis weather bulletins issued by the regional meteorological service of ARPA Piemonte since 2000 to 2006, which report in detail both in time and space the most relevant weather phenomena occurred day by day.

When a foehn episode begins in Piedmont, mountainous stations simultaneously detect an increase of wind speed and a rotation of the wind direction to western or northwestern sectors, while plain stations show a wind direction rotation along the nearest and largest valley axis. At same time, the temperature shows a sharp increase, larger than $10 \text{ }^\circ\text{C}$ in 30 minutes in the strongest episodes, and also the relative humidity decreases to 15-20%, and sometimes even less.

FOEHN ON 16TH-17TH DECEMBER 2005

To better explain the foehn behaviour in Piedmont, a typical northwestern foehn episode involving Susa valley is hereafter analysed in detail.

The Susa Valley, also named Dora Riparia Valley (from the name of its largest river), is a S-shaped glacier valley