SOME RESULTS FROM ATMOSPHERIC SOUNDING IN CASES WITH FOEHN IN SOFIA VALLEY

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ABSTRACT

Sofia Valley is surrounded by Vitosha Mountain from the South. One of the typical characteristics of local climate in Sofia Valley is the manifestation of foehn in some specific synoptically situations. In accordance of the power and depth of the foehn in some cases the temperature increased and the balloon is going down. In these situations the process of the sounding has problems in determination of the beginning and the end of foehn.

In the presented paper some soundings with a foehn are analyzed. The obtained results show problems, which have to be, solved in future development of the software of the data processing.

INTRODUCTION

Sofia, the capital of Bulgaria, is situated in the valley of the same name. The highest surrounding mountains are the Balkans to the North, and Vitosha and Ljulin to the South. Sofia aerological observatory is located near the northern slope od Vitosha mountain. Station's altitude is 590 m and this of the highest Vitosha peak – Cherni vruh – 2290 m. In case of southerly winds passing over the mountain in Sofia occurs foehn wind. Foehn situations in Sofia are observed when Mediterranean cyclones pass along the line Belgrade – Carpathians towards Bessarabia [1].

Foehns are descending strong winds from the mountains, accompanied by increase of air temperature and decrease of air humidity. Foehn is one of characteristic winds in the Sofia valley, blowing usually from south-southwest and displays most strongly over the southern city parts, where NIMH is situated. Foehn formation is related to the transformation of air flow by the orography. Foehn over Sofia is usually generated when south or southwest flow passes over Vitosha and Ljulin mountains and downslopes on the lee side (towards Sofia valley), experiencing adiabatic worming and drying. A massive lenticular cloud develops along the southern part of Vitosha crest.

Foehn situations are observed about 30 times a year on the average [2]. Table 1 shows the monthly frequency of foehn.

Table 1. Mean frequency of foehn in Sofia

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
2.6	2.6	4.3	3.6	2	1.3	0.5	1.1	1.9	3.8	3.8	2.5	30

The average surface wind velocity in case of foehn is 15-20 m/s, and in some cases it is gusty strong wind blowing at speed of 25-30 m/s. In December 1970, for instance, it reached 35 m/sec, and 40 m/s at Cherni vrah. In such clearly pronounced situation in December 1979 the temperature in Sofia reached 17.3 ^{o}C. While overflowing the Vitosha mountain, on the lee side arises a big rotor, comprising the Sofia Aerological observatory. Particularities of the radiosounding in foehn situations over Sofia valley are poorly studied. [3].

ANALYSIS OF SOME CASES OF ATMOSPHERIC SOUNDING UNDER THE FOEHN CONDITIONS

It has been found that when radiosounding is carried out in such cases, after the start the radiosonde, following the wind direction, turns to Vitosha and at some height enters the strong “jet” of the descending air (Fig. 1). Its further behaviour depends on the part of the jet it has entered.

The maximum vertical velocity of the foehn jet, established in our practice, is about 12 m/s, and in many cases it is 5-6 m/s. Having in mind that the average upward velocity of the sonde is 5-6 m/s, in such cases the radiosonde starts to descend. The drop can sometimes reach 1500-2000 m and pressure begins to rise. Usually the pressure rise is several tens of hPa, reaching 150 hPa in some cases. There are cases with several successive downward motions of the sonde. Temperature differences in foehn jets are of the order of several tenths to 7-8 ^{o}C . In some cases of weakly pronounced foehn these differences can be negative. Cases of sonde passing along the jet are also possible.

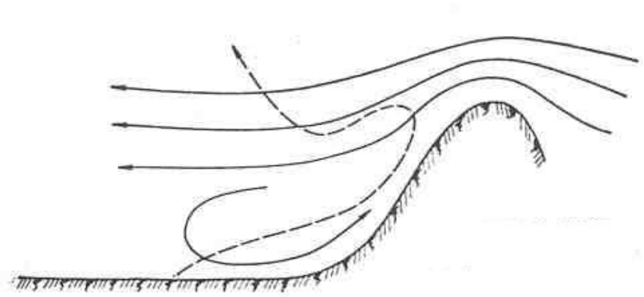

Fig.1 Scheme of the foehn (possible trace of radiosonde - - - - >)

Radiosounding data processing in foehn situations is more specific, and several problems arise in consequence, which could be generally grouped in the following way:

1. Slowing the process of sonde ascending due to decrease of the ascent rate, which normally is about 5-6 m/s, and in such case could drop down under 1 m/s. (Fig.2.);
2. Balloon return to lower height due to wind gust (3,4);
3. Cases where the lifting process is disturbed more than once (5).

These events are with different duration and are accompanied by corresponding fluctuations of values of meteorological elements, usually following the balloon movement.

Some particular cases are discussed to illustrate the behavior of balloon sonde.

Situation of slowing down of the process of lifting (group 1) is shown in Figure 2a and 2b.

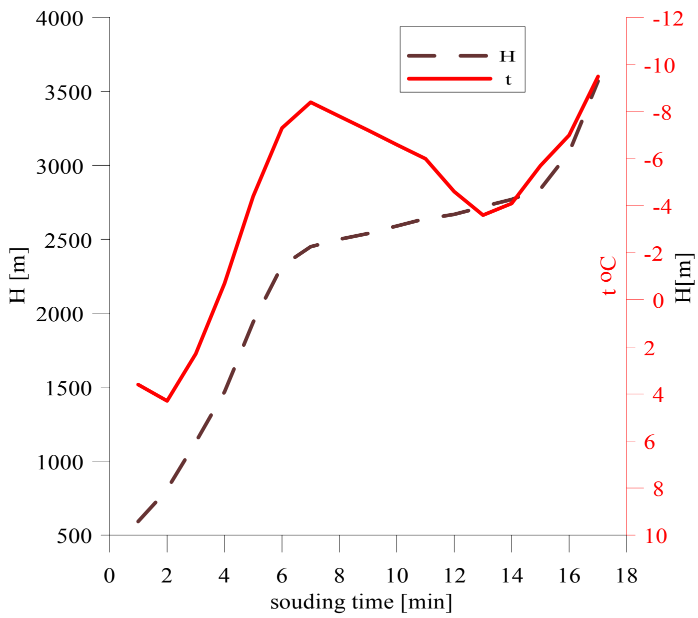

Fig.2.a. Vertical temperature prfile group 1

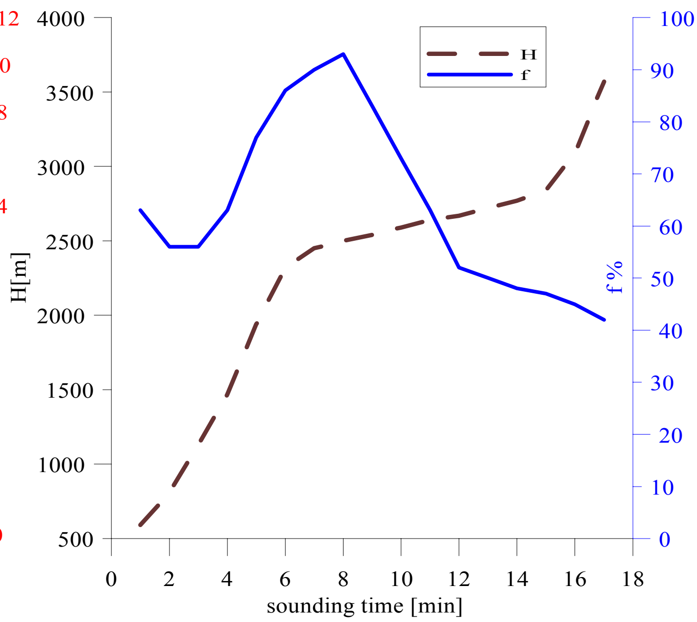

Fig.2.b. Vertical humidity prfile group 1

As shown in Figure 2, from height 2450 m up to 2840 m the sonde falls in the foehn flow, resulting in the decrease of the ascent rate by some 2 m/s, i.e. the balloon ascent rate becomes 4 m/s. Temperature rise of some 5 ^{o}C is registered in this section (fig. 2.a). At the same time relative humidity decreases from 93% to about 46% (Fig. 2.b).

The reverse motion of the sonde due to foehn effect is shown in Figs 3 and 4.

As seen in Fig. 3, at height 2700 m sonde enters a strong foehn flow with descending vertical velocity of 8-9 m/s, which leads to reducing of its height to 2040 m. Air temperature increases by 7,8 ^{o}C (Fig. 3.a). Humidity also changes, decreasing by some 56% (Fig. 3.b).

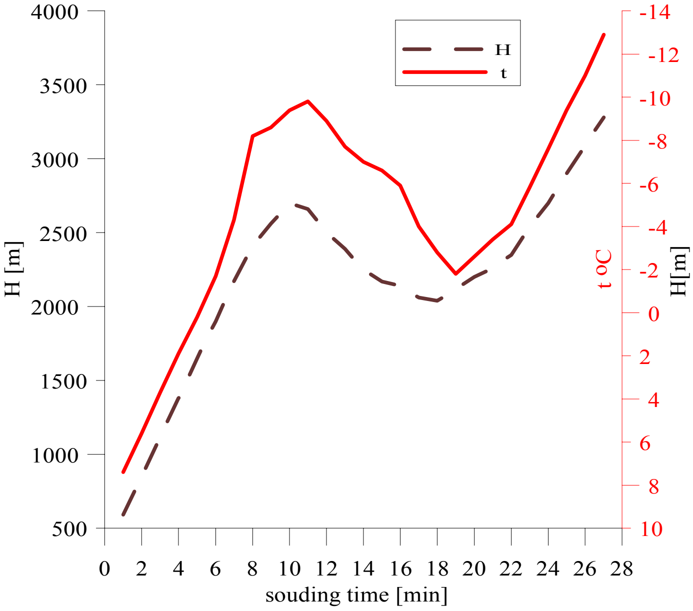

Fig.3.a. Vertical temperature prfile group 2

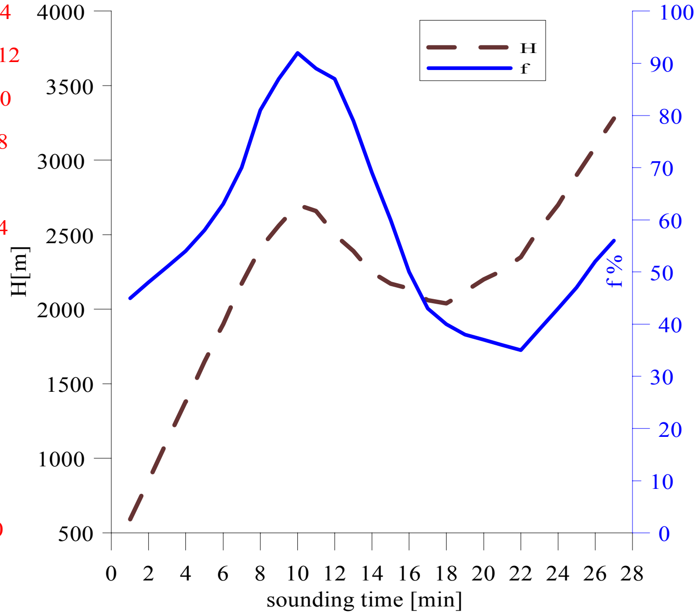

Fig.3.b. Vertical humidity prfile group 2

Similar case is shown in Figure 4, where the return of the sonde commences at 1800 m and reaches 1400 m, and the vertical velocity increases from 7 m/s in the beginning to more than 9 m/s. Most probably the sonde crosses different sections of foehn flow, causing different variation of temperature and humidity in separate track sections. The general trend is of temperature increase (of about 6 ^{o}C, Fig. 4.a). Relative humidity at the same time shows a trend to decrease by some 30% (Fig. 4.b).

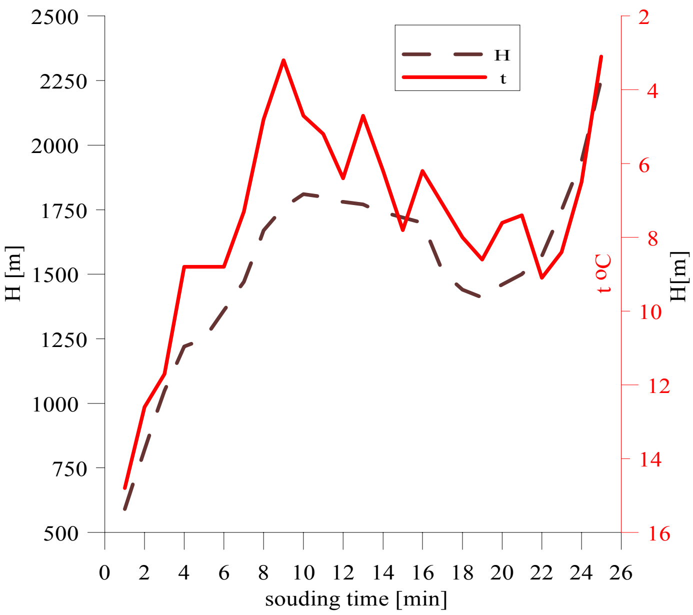

Fig.4.a. Vertical temperature prfile group 2

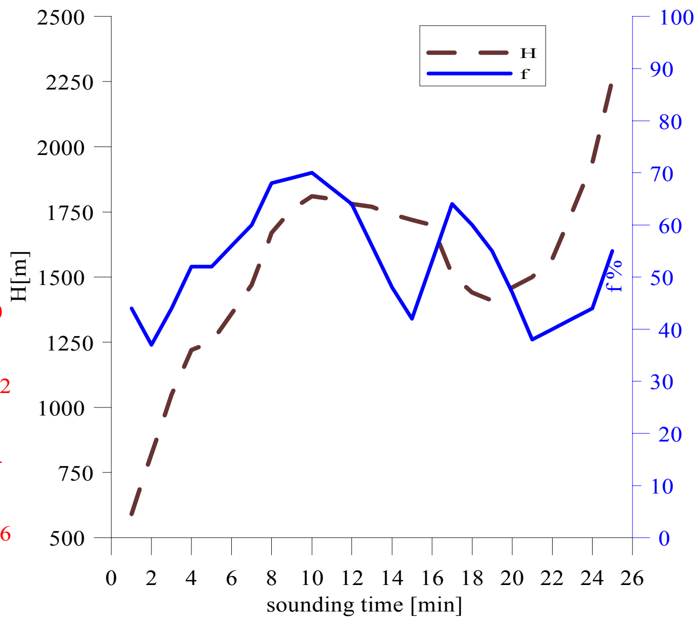

Fig.4.b. Vertical humidity prfile group 2

All cases discussed so far concern the sound entry into foehn at heights about and above 200 m. Group 3 is illustrated by an instance (Fig. 5) where sonde passes various sectors of foehn rotor as shown in Fig. 1.

At height 1290 m balloon sonde enters an air flow with downward velocity of about 7 m/s, which returns the sonde down to 1240 m. This motion is accompanied by a temperature increase of some 1,5 ^{o}C, while humidity remains constant. Then balloon continues to ascend with about normal velocity up to 2200 m. At this height sonde enters the upper part of the foehn rotor and returns to about 2120 m. In these cases temperature increase of 1,4 ^{o}C is registered, while the relative humidity increases with about 10%, which could be due to entering the periphery of foehn cloud.

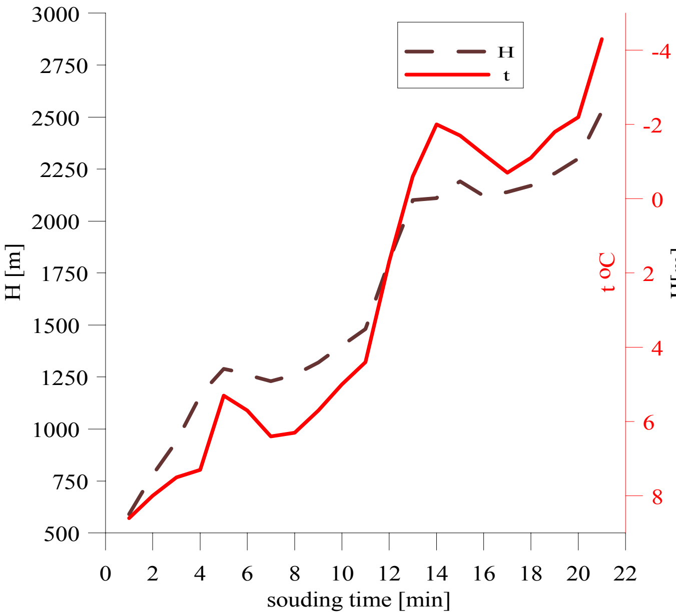

Fig.5.a. Vertical temperature prfile group 3

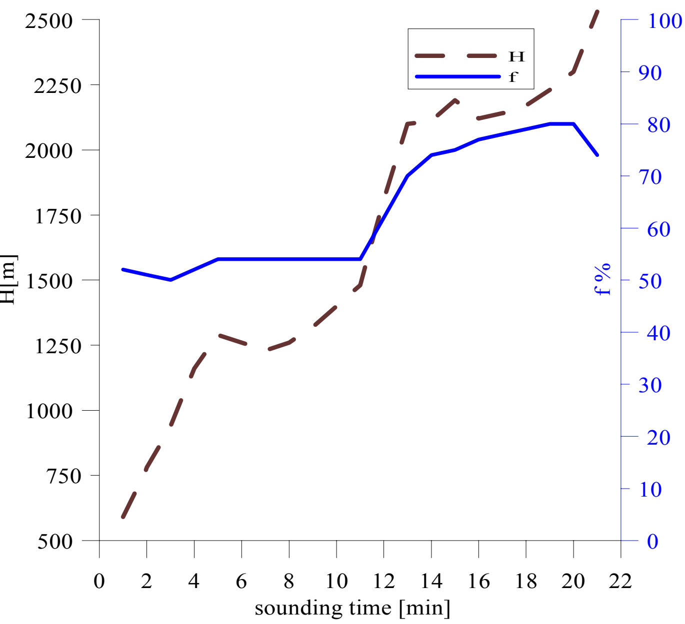

Fig.5.b. Vertical humidity prfile group 3

In atmosphere radiosounding practice cases of disturbed sonde raising arouse doubt. The above discussed foehn situations are of this type. According to the conventional practice and coding requirements in these cases we have adopted following approaches of data processing:

1. In case of motion corresponding to group I data are processed as in a standard case of sonde in flight;
2. In the rest of cases (group II and III) sections where the sonde is swept along by the foehn flow are cut out from the sounding. In order to separate such foehn situations from the random errors, we assume such cases, where the decrease of height is accompanied with the corresponding variation of meteorological

elements, confirmed in several successive reports. For beginning of foehn we assume the height where the return motion of the sonde starts. The end of foehn is the level 100-200 m higher than the one where return motion starts.

This processing reduces data to convenient for international exchange kind, but reflects actually existing local phenomena. These type of phenomena are of substantial interest for a number of important for the local climate studies.

DISCUSSION

All considered cases are based on soundings that used RKZ-5 radiosondes and Meteorite radar. They are processed with software developed in NIMH. Since 2001 the sounding system is replaced by Vaisala DIGICORA3and RS90 radiosondes. In December 2001 there was a foehn situation, when the sounding was interrupted from the moment of the sonde return motion. It was an obvious foehn event, followed for some time, but was interrupted by the software as the pressure increased by 50, and a message for balloon burst was issued. The new software version, provided in 2002 has been improved for such cases. Due to decrease of Mediterranean cyclone frequency [4] we didn't observe more foehn cases during upper-air sounding. So, we didn't have a chance to test the software improvement in practice.

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