Analysis of a Particular Snowfall Situation in Italy

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ABSTRACT

This paper describes a particular snowfall happened on December 13th, 1995; a heavy snowfall, lasting for hours, caused traffic to be blocked and a lot of people to spend nearly twenty four hours in a dreadful scenery of snowflakes falling from the sky, surrounded by dark mountains, and suffering from the hunger, the thirst and the cold. In section 2 an overview of the general geographic characteristics of Italian Apennines is given. In section 3 and 4 the Italian general forecasts and highway road weather network is described. At the end there is an analysis of the meteorological data collected by the road weather stations during this extreme event.

Keywords: snowfall, pressure, road weather station.

1. INTRODUCTION

"*A nightmarish night for more than ten thousand drivers, isolated by a heavy snowfall yesterday, along the Bologna-Florence section of the A1 motorway. First traffic troubles occurred in late morning, when a violent snowstorm hit the road through the northern Apennines, and in a matter of a few minutes the snow layer reached a ten centimetre thickness; at that time the drivers of heavy lorries began to experience some troubles, especially while driving along sloping sections of the route. At 3 p.m. some T.I.R. had got sideways on the road, forcibly blocking the traffic in both directions, to Bologna and to Florence, and two queues had formed, the former 15 km long northward, and the latter 20 km long southward. At 3.30 p.m., when the snow layer thickness had increased up to thirty centimetres, the entries from Bologna and Florence were closed, and since then, only emergency crews were allowed to enter the motorway, just to help people to stand the cold, the hunger, and any kind of troubles they might have to face during the incoming night. But emergency crew task was incredibly difficult , both for the still bad weather and the hundreds of vehicles abandoned under the snowfall by their drivers after the petrol had run out. And the night turned out to be long, for those people isolated through the mountains, in a dreadful scenery where everything seemed to be against them, in most cases without the possibility of getting in touch with their families. Only the day after, roughly at 1 p.m., i.e. twenty hours after the troubles had begun, traffic was starting again, even if quite slowly*." [from the daily "La Nazione", 332, December 14th, 1995]

The above daily passage reports what happened suddenly in Italy, and more precisely along the Apennine pass between Florence and Bologna on December 13th, 1995; a heavy snowfall, lasting for hours, caused traffic to be blocked and a lot of people to spend nearly twenty four hours in a dreadful scenery of snowflakes falling from the sky, surrounded by dark mountains, and suffering from the hunger, the thirst and the cold. Given both the orography structure and the road and railway layout in Italy, this sudden and intense atmospheric event in fact divided Italy into two during some twenty-four hours, and actually many queues formed, along a large number of other motorway sections, all of them leading to the notorious traffic bottleneck known as the Apennine pass. Some brief pieces of information which are given hereafter may turn out to be useful in order let all realise how it is so important from the meteorological viewpoint.

2. SOME GEOGRAPHICAL REMARKS

The Apennine pass is considered to be the most vitally important part of the whole Italian transport system, with regard to both railway and motorway networks. The Apennine motorway route, the Bologna-Firenze section of the A1 motorway, runs between the toll gates Sasso Marconi and Calenzano Sesto Fiorentino at an average altitude of 450 m. above mean sea level with the actual pass at the highest point of 726 metres; it is often characterised by different – sometimes very different - weather conditions on one side of the mountain chain with regard to the other, this being due to the *Stau-Föhn* effect caused, either in one direction or in the other, by the momentary prevailing winds.

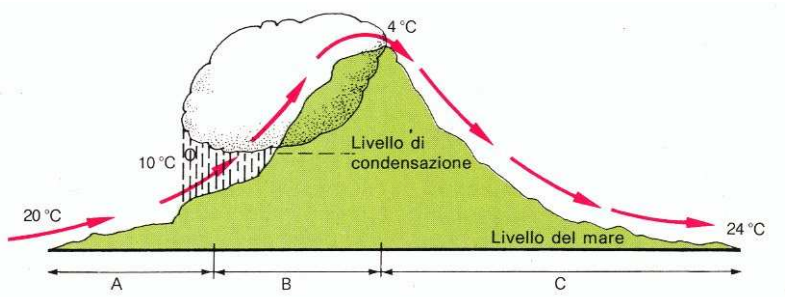

Fig. 1. Stau-Föhn: humid air, condensing while climbing, gets cold at a lower rate than, after precipitation, it gets warm while descending; so air on the right side of the mountain is warmer than the one on the left side.

As a consequence of that, much difference happens to be found between the two sides – clear sky on the former and overcast with possible heavy precipitations on the latter -, but such difference happens also to be found between two points of the route situated at a few hundreds metres from each other, possibly only separated by either a tunnel or a bend of the route, which makes air and ground suddenly differently affected by sun and wind. Thus, drivers crossing the Apennine pass may face, right at the exit of a tunnel, quite completely different weather conditions from the ones at the entry, risking being involved in accidents. Ice, snow and strong winds, particularly affecting the North-South axis crossing viaducts, are the most common atmospheric phenomena likely to trouble traffic along the Apennine pass; furthermore, this is a fog-prone area, mainly in the proximity of watercourses, and is highly risky for aquaplaning. Coming back to the heavy snowfall dramatically reported at the beginning of this paper, and looking back at this extraordinary event causing so many troubles, one wonders whether or not it was really sudden and unpredictable, particularly as for the effects actually affecting human life with regard to traffic. Traffic is not to be considered an *actual* activity, rather a sort of *meta-activity* affecting a lot of other human activities, and therefore people take a particular care in planning their activities with regard to the weather forecast. It is to be questioned whether or not the nearly ten thousand drivers trapped on the Apennines pass on December 13th to 14th , 1995, had given a look to the relevant weather forecast. This takes back to focus the main point of this paper; with particular regard to the heavy snowfall we are dealing about, was it really unpredictable, and, if, on the contrary, it was actually predictable, what could have been done, in order to prevent drivers to spend such an adventurous night under a snowfall on the Apennine pass? As meteorologists we will concentrate only on the first half of the question. Therefore, in order to investigate whether or not that heavy snowfall was really predictable and its perspective effects affecting traffic could have been evaluated in advance, thus enabling roadmasters to take the most appropriate measures, a look has to be given at the forecast issued by the Italian Met Office, the data collected by the Italian Met Office data collection platforms (DCP's) nearest to the site where the snowfall took place, and the data collected hourly by the outstations owned by Autostrade, the concessionaire managing the motorway Apennines pass, installed along the motorway section between Florence and Bologna. It is to be stressed here that, in order to get to know what the present weather is at a particular site along a motorway section, there is no better tool than an outstation installed on site. At this point an overlook at the general weather forecast in Europe and in Italy, following the weather evolution during the week December 11th to 17th , 1995 appears to be quite useful.

3. GENERAL FORECAST

Forecast hereafter reported, dealing with each day of the mentioned week, refer to the 500 hPa pressure level, and are taken from the official forecast issued by the Italian Met Office every day at 12.00 a.m. G.M.T. ; they refer to the situation likely to take place on the next day at 12.00 a.m. G.M.T. Forecast issued on December 11th at 12.00 a.m. G.M.T. , referring to December 12th at 12.00 a.m. G.M.T..

North-East of Poland an air pressure minimum will be located, connected to a -28° C isotherm, bounding an area to be regarded as a cold air cell. This will be the engine running the weather development above the Italian areas over the next six days. Feeble air currents will be high above Italy, and they will be stronger above the eastern side of the peninsula.As for the analysis of the actual weather situation at the ground level on December 11th, at 12.00 a.m. G.M.T., they read absence of precipitations, minimum temperatures around 0° C, and fog banks, more or less widespread all above Italy.

Forecast issued on December 12th at 12.00 a.m. G.M.T. , referring to December 13th at 12.00 a.m. G.M.T..

The above quoted air pressure minimum and the cold air cell linked to it will affect central-eastern Europe, as well as north-eastern Italy .As for the analysis of the actual weather situation at the ground level on December 12th, at 12.00 a.m. G.M.T., a cyclogenesis is forming above the Genoa Gulf, and the 1012 hPa air pressure is more and more sharply deepening. Also air temperature is rapidly falling and first snowfalls show up in Carnia (Tarvisio), and in Lazio (Mount Terminillo).

Forecast issued on December 13th at 12.00 a.m. G.M.T. , referring to December 14th at 12.00 a.m. G.M.T.

The -28° C isotherm will not be a closed line any longer, nevertheless its southern branch will encompass all the northern Italian regions A cold air intrusion will affect the western Mediterranean as well as the Italian seas. As for the analysis of the actual weather situation at the ground level on December 13th, at 12.00 a.m. G.M.T., a wide depression is affecting nearly all the Italian regions, with its minimum located in the middle of the Tyrrhenian sea.. Strong cyclonic winds from N-E are affecting the northern Italia Regions, while the southern ones are being hit by stronger and stronger winds from S-SE. A really intense cold front, linked to the above quoted air pressure minimum, while passing over the Italian regions, causes bad weather conditions to get worse and worse, giving rise to really heavy snowfalls hitting nearly all central and northern Italy, even at low altitudes. Italian Met Service DCP's are reporting snowfalls nearly everywhere and really very low temperatures.

Forecast issued on December 14th at 12.00 a.m. G.M.T. , referring to December 15th at 12.00 a.m. G.M.T.

The wide depression formerly located north-east of Poland will reach central-western Europe, nevertheless, not being intensified any longer by the atmospheric general circulation, it will start an isolation process. The -28° isotherm will get closed again, ad the air pressure minimum will be still moving backwards to W-SW. As for the analysis of the actual weather situation at the ground level on December 14th, at 12.00 a.m. G.M.T., the air temperature is still very low, and weather conditions are really still very bad, with precipitation in form of rain affecting a large number of Italian regions and heavy snowfalls hitting Tuscany, Umbria, and nearly all the northern regions, where snow has been falling for forty-eight hours now. Winds, leaning to a direction from S-SE are getting stronger and stronger.

Forecast issued on December 15th at 12.00 a.m. G.M.T. , referring to December 16th at 12.00 a.m. G.M.T.

The wide depression, now having its minimum located above the Gascogne Gulf, will reach western Europe, being continuously filled up, due to its not being intensified any longer by the atmospheric general circulation and the following thermal modification. The -28° C isotherm will nearly vanish, and a more or less weak stream will channel humid and comparatively warm air to the Italian regions. As for the analysis of the actual weather situation at the ground level on December 15th, at 12.00 a.m. G.M.T., stronger and stronger streams from S–SE are coming, particularly affecting the northern and high/middle Tyrrhenian regions. A humid air flow, coming from the Mediterranean, sliding over a less humid, rather cold air layer, preexistent at the ground level, gives rise to heavy precipitation mainly in form of rain, rather in form of snow in Tuscany, Umbria and the northern regions.

Forecast issued on December 16th at 12.00 a.m. G.M.T. , referring to December 17th at 12.00 a.m. G.M.T.

A high pressure wedge will be steadily present above Italy, and the air will get subsident. Warmer air will be channelled, and in upper air a -20° C isotherm will be present. As for the analysis of the actual weather situation at the ground level on December 16th, at 12.00 a.m. G.M.T., air temperature is more and more increasing, and a flow from S-SE of comparatively warmer air, gives rise to the occurrences of advection fog nearly all over the country, as well as a stratified cloudiness, although with no occurrence of precipitation.

And here three graphs are shown, reporting barometric pressure such as it was collected by the Italian Met Office DCP's nearest the motorway section under consideration during the week December 11th to 17th. Italian Met Office is a branch of the Italian Air Force, therefore they refer more to aircraft meteorology, and are, more or less, located where they may turn out to be more useful for flying vehicles. However, in order to match the requirements of modern life, Italian Met Office is at present turning to other less institutional activities. Anyway, it has to be taken into account that nowadays nearly all the Italian regions have set up their own Met Office, mainly dealing with agriculture, and sometimes even with traffic.

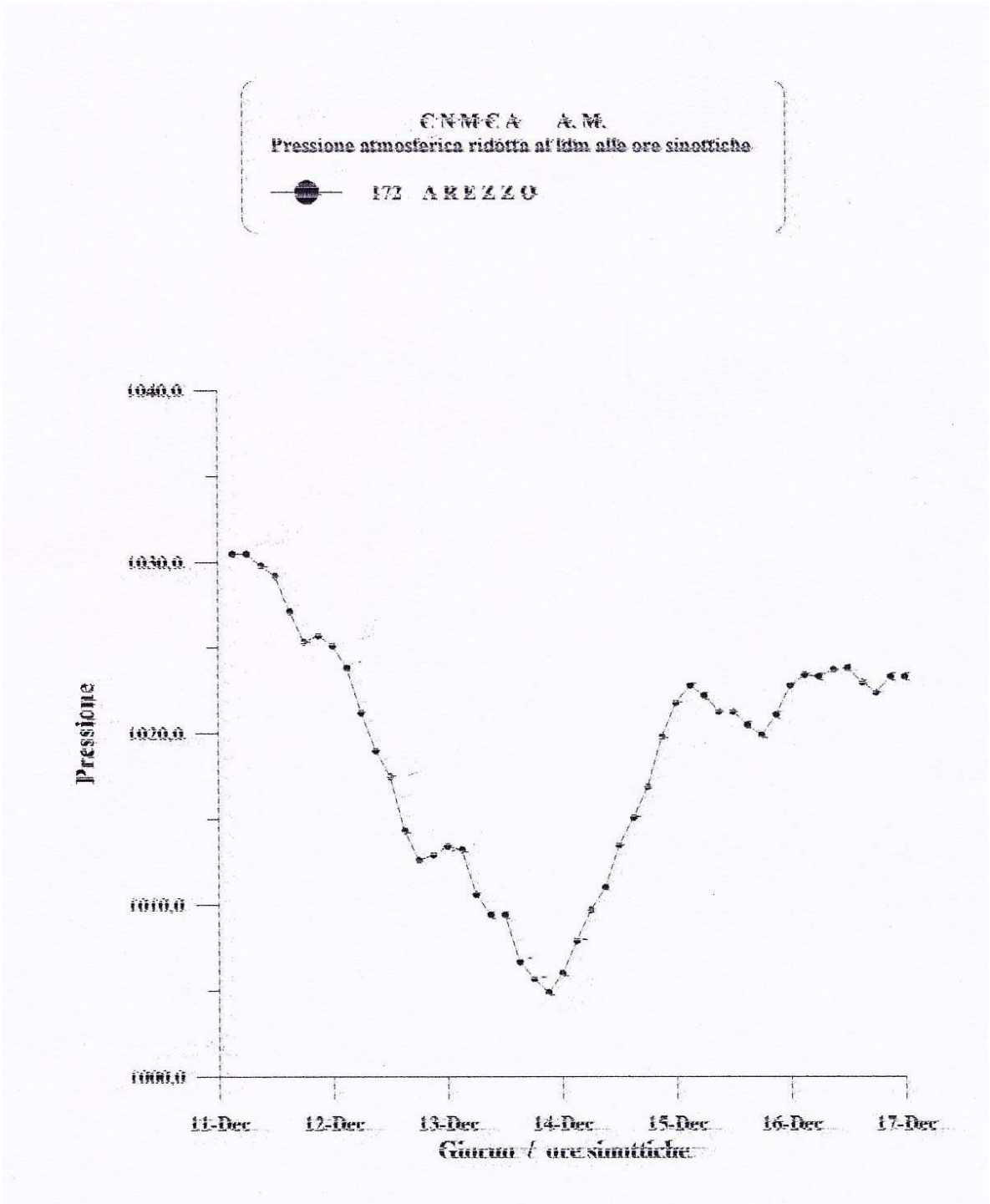

Fig. 2. Pressure Graph: pressure forecast from 11th-17th December at Arezzo

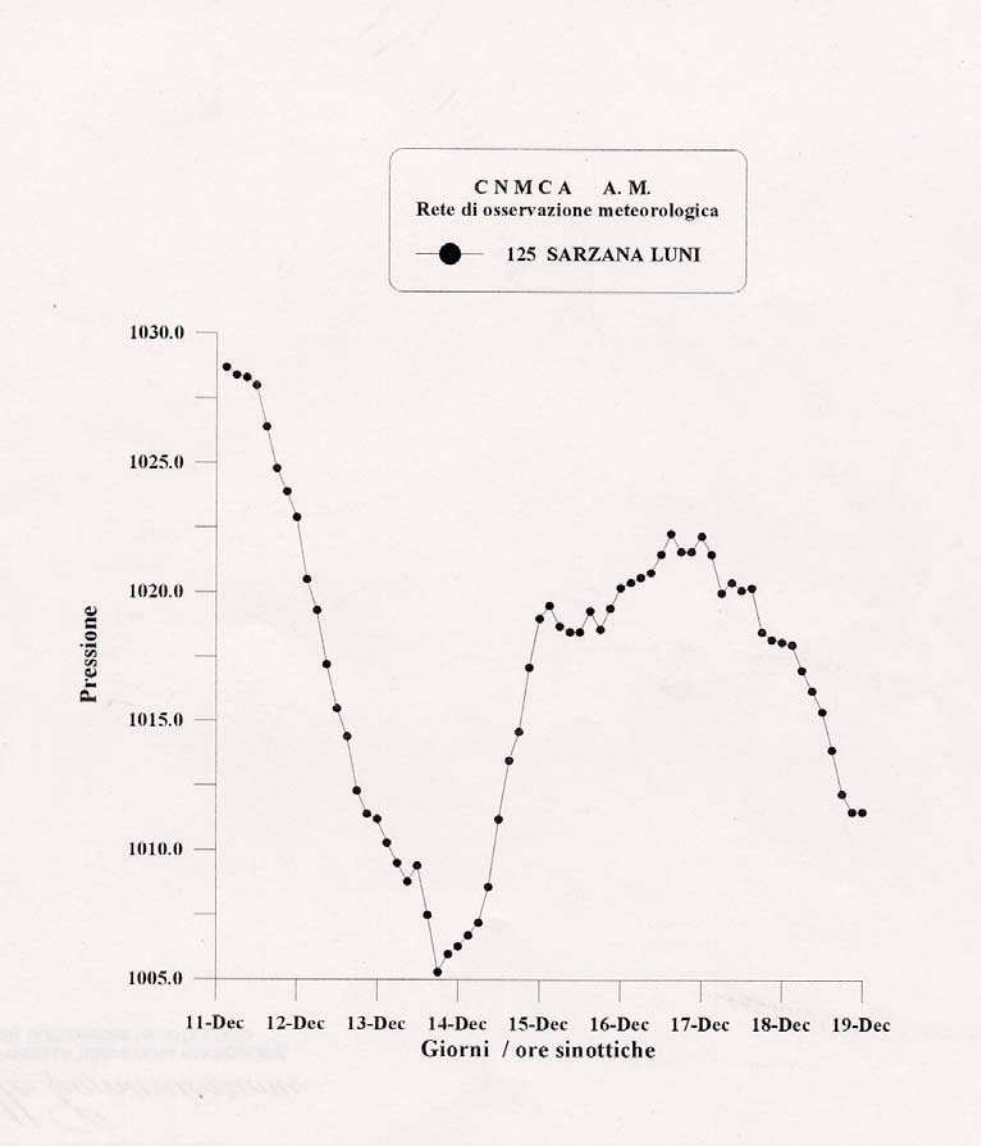

Fig. 3. Pressure Graph: pressure forecast from 11th-17th December at Sarzana Luni

4. HIGHWAY ROAD WEATHER NETWORK

It may be useful as well to give a sketch of the A1 motorway section between Firenze and Bologna, together with the locations of the outstations scattered along the route, owned by the Concessionaire of the A1 motorway. Two kind of outstations have been in operation, for nearly twenty-five years now, along a large number of motorway section under the concession of Autostrade per l'Italia, the former placed in the proximity of toll gates, and the latter placed along the road, where statistic records gave ice highly likely to form. Communication links, performed by means of either, at first, copper wire cables or, more recently, optic fibres, make data from each remote outstation. available to roadmasters in real time.

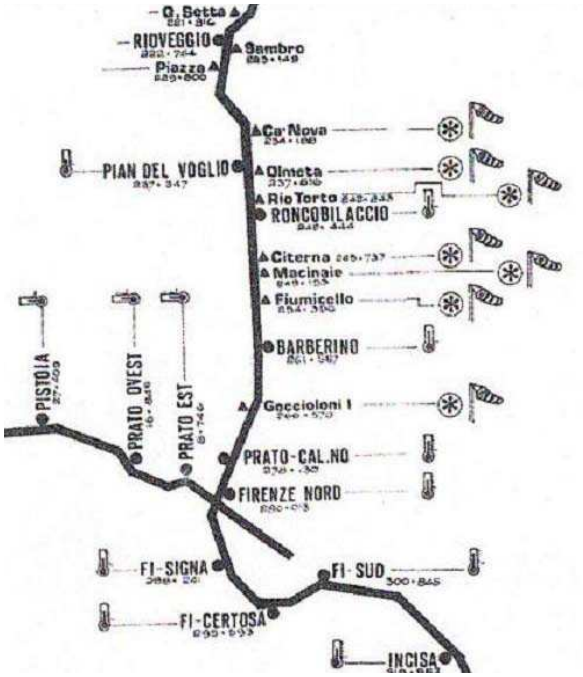

Fig. 4. Highway road weather network

Fig. 5. An "in itinere" outstation

As previously quoted, at present the Highway Society manages a real time meteorological data collection network, an outstation being placed by most of the toll gates scattered along all the sections under their concession. Measures referring to factors such as *air temperature*, *relative humidity* and *atmospheric pressure* are taken every hour and sent to the central control room in charge of traffic safety. A major contribution is given to drivers, under the respect of safety, not only by the knowledge of the status of the various motorway sections, but also by the knowledge of the likelihood of the sudden occurrence of extreme phenomena due either to local effects or quick changes in widely general weather conditions, however capable of affecting traffic heavily. Extreme phenomena to be carefully monitored are *thunderstorms*, *strong winds*, *low visibility* due either to fog or smoke, *ice formation*, and particularly *snow*; a careful attention given to the possible occurrence of each of these phenomena is definitely useful not only for drivers, but also for roadmasters who are able to organise effective operations.

Fig. 6. A toll gate outstation

The data collected in such way are stored on a regular basis to make up a whole data-base from which particular data can be picked out according to whatever sensible *key* in order to get consistent results. Ever since the data collection began, more than ten years of data have been stored, making up a statistical basis, useful for a number of different analysis.

5.A LOOK AT THE DATA COLLECTED BY THE HIGHWAY METEOROLOGICAL OUTSTATIONS

Now this paper focuses on its most important aim, as it has been claimed in the Foreword, i.e. investigating whether or not that notorius snowstorm was predictable, and if so, how early it could have been foreseen. In order to carry out such investigation, four graphs have been plotted referring to the air pressure data collected every third hour by the outstations installed near the toll gates Rioveggio, Pian del Voglio, Roncobilaccio and Barberino. The pressure data, such as they have been used in order to build up the graphs hereafter reported, have not been reduced to the mean sea level, nevertheless they give a really precise idea of the weather situation at the site where the outstation is located. As one can easily realise, in all the location hereafter reported, air pressure falls sharply on December 11th by nearly 15 hPa at Rioveggio, 10 hPa at Pian del Voglio, 12 hPa at Roncobilaccio, and 8.hPa at Barberino. On December 12th at each of the sites under consideration air pressure still falls slightly, at Rioveggio by nearly 4 hPa (following the diurnal variation, anyway!), at Pian del Voglio by nearly 6 hPa (with a slight attempt to follow the diurnal variation), at Roncobilaccio and Barberino by nearly 5 and 8 hPa, respectively. Thus, at the dawn of December 13th barometric pressure is about 978 mPa at Rioveggio, 940 hPa at Pian del Voglio, 935 hPa at Roncobilaccio and 979 hPa at Barberino (such differences depend, of course, on the different altitudes of the sites); these figures are, no doubt very low, far less than the daily average, and should have alerted someone to being on the lookout for an actually quite likely heavy snowstorm, particularly because the air temperatures collected by the four outstation are very low (4.5° C at Rioveggio, -0.5° C at Pian del Voglio, 1.0° C at Roncobilaccio, and 5.0° C at Barberino), but above all, because, the temperature trends are sharply sloping down. During nearly the whole day, on December 13th, barometric pressure and air temperature keep falling sharply, giving rise to the snowstorm and the following troubles for ten thousand drivers. It is arguable that all the data, either really available, or perspectively available to roadmasters, such as they have been shown in the present paper, could have been really useful in order to enable people to understand what was really going on those December days, as well as to forecast an heavy snowstorm and its effects on traffic, however, it is to be believed that a deep knowledge of both the general forecast and the data collected by the outstations scattered along the motorway sections, could have given, at least, a better idea of the atmospheric events likely to take place presently.

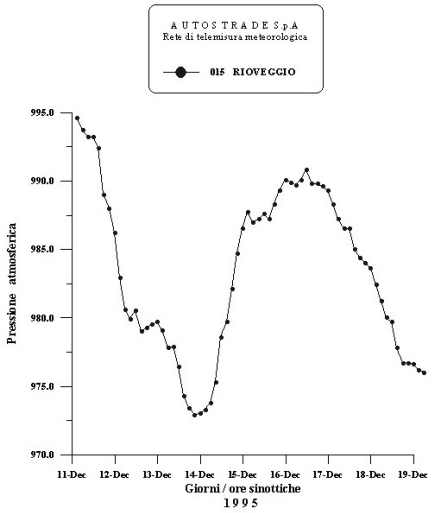

Fig. 7. Pressure data at Rioveggio

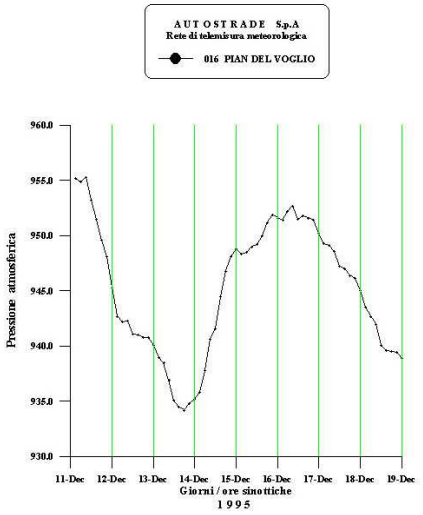

Fig. 8. Pressure data at Pian del Voglio

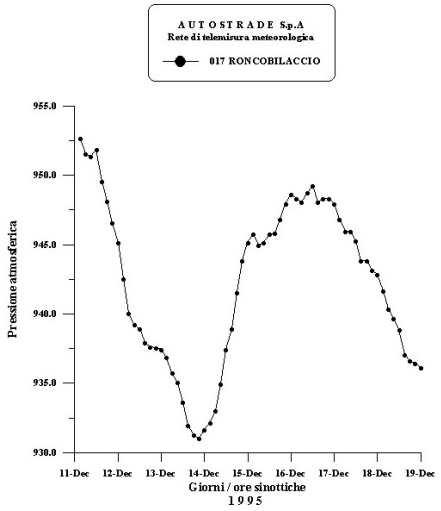

Fig. 9. Pressure data at Roncobilaccio

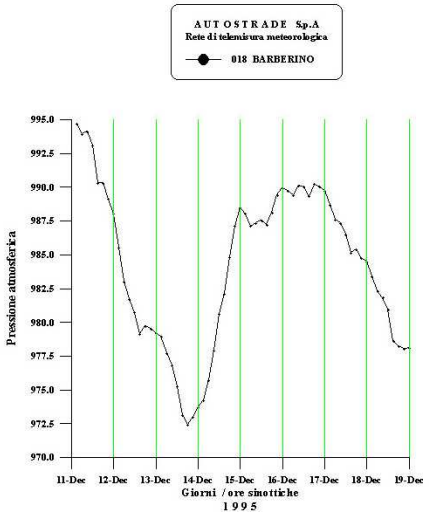

Fig. 10. Pressure data at Barberino

6. CONCLUSION

It has already been clearly stated, in some previous part of the present paper – and even proved, more or less, right in the preceding paragraph – that no better tool exists, for appropriately detecting the present weather, than a reliable outstation installed along the particular motorway section to be monitored; this entails therefore, that a particularly careful attention should be paid to the data collected by remote outstations, even more than the attention paid to the nationwide disseminated general forecast, even if, however, they should be , somehow or other, be "melted" with these ones. That seems to be, according to what we have shown in the present paper, the proper procedure to follow in order to explain the meaning of the data remotely collected in terms of atmospheric phenomena likely to affect traffic. Anyway, coming to the day by day practice, what should the crews on duty at the central control rooms of a road agency do, in order to get reliable pieces of information, really helpful in order to take the most appropriate measures while managing winter operations?

They should concentrate on the charts issued by the Met Office, and study carefully how data collected by remote outstations match the general forecast; after this, they should produce a sort of nowcasting, which will forcibly based on their experience, their skill, and their personal knowledge about the route sections to be monitored, and take action accordingly. Such procedure, gives however rise to some major constraints; first of all, it requires forcibly time – sometimes you don't know how long studying carefully a chart may take -, and normally the crews on duty have got a lot of things to do during their shift; second, it has to be taken into account that the members of the crews are not professional meteorologists, so that, a particular atmospheric situation can be read in two different ways by two particular members (and by the way, both of them may be wrong!). Such constraints are to be overcome if the viewpoint is changed, and computers will be delegated to perform activities requiring a lot of operations and the evaluation of particular situation; however, it is nowadays well known that computers, appropriately "learned", are able to issue weather forecast as a result of some weather "models". Thus, if data remotely collected by the outstations scattered along the motorway section could be put together with more general weather data in the "melting pot" of an appropriately designed model, the local nowcasting issued in this way would be the result of the same actions performed by the crews on duty at the central control rooms, however far better than those ones, due to the deterministic set of rules followed by the algorithms running under the model. Moreover, the amount of data processed by the model, as well as the use of skilled techniques, will produce a local nowcasting which turns out to be really effective from both time and space viewpoint, with a time miscalculation of about half an hour, and a space miscalculation of one/two km. Under this respect, a previous paper is to be recalled, in which some interesting results are given about an innovative technique of forecasting air temperatures, at the data collection site, one, two and three hours ahead of the last detected measurement. This approach focuses on the results obtained from Artificial Neural Networks (ANN) in processing some temperature time series in order to predict temperature up to three hours later. The hypotesis consists of assuming that air temperature T at a fixed time t^* depends only on the temperature time series detected over a previous time period, independent of any physical factor.

7. REFERENCES

[1] Basile,Butini,Selvi, *La previsione del tempo lungo tratte autostradali*, Rivista Autostrade 2/2001.

[2] Air Ministry Met Office, *Handbook of Aviation Meteorology*, Her Majesty Stationery Office, London, 1960.

[3] Ufficio Generale per la Meteorologia, *Cartello Meteorologico*, 1995, 11,12,13,14,15,16,17 Dicembre

[4] La Nazione, *Bufera sulla A1*, n.332/1995.

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