INFLUENCE OF METEOROLOGICAL PROCESSES ON WINTERTIME POLLUTION EPISODES DURING THE BRENNER-SOUTH ALPNAP MEASURING CAMPAIGN

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Abstract: The paper presents some preliminary results from an intensive field campaign performed between January and March 2006 along the River Adige Valley (Northern Italy) within the project ALPNAP, supported by the European Regional Development Fund under the initiative Interreg III B "Alpine Space" (www.alpnap.org). Three target areas, specifically representative of typical valley environments, have been identified along the River Adige Valley, close to the towns of Salorno, Aldeno and Rivalta-Peri respectively (Figure 1). Intensive field measurements have been successively performed at each target area, aiming at highlighting to what extent complex and varying meteorological phenomena are locally affected by topographic factors and how they affect in turn air pollutant transport processes, primarily those emitted by the motorway running along the whole valley. The good performance of the deployed intstrumental setup allowed a more detailed picture of the complex processes leading to the high-concentration episodes typical of the winter season.

Keywords: *Local scale meteorology, pollutant dispersion, experimental campaign, ALPNAP.*

1. INTRODUCTION

Atmospheric boundary layer processes and local circulations occurring over complex terrain deserve great interest, not only for their peculiar effects on local-scale meteorology (Barry, 1981; Whiteman, 1990; Egger, 1990; de Franceschi et al., 2002; Rotach and Zardi, 2007; de Franceschi et al., 2007) but also because they variously induce many effects on human activities, and in particular on the transport of pollutants from different sources, such as civil and industrial plants and traffic (Bader and Whiteman, 1989). As an example of recent research in this field, the research project VTMX (Vertical Transport and Mixing) has investigated atmospheric processes, in particular under transition conditions, in the Salt Lake City basin, Utah, which is characterized by complex orography (Alexandrova et al., 2003).

The increasing demand for people mobility and exchange of goods between Central-Northern Europe and the Mediterranean area has produced increasing trafic flows, both on roads and on railways, along the relatively few main corridors ploughing through the Alpine barrier (Figure 1). However this poses serious problems about the environmental impact of transport infrastructures on a delicate environment, such as the Alps, and about their effects on human health.

Based on these premises, the project ALPNAP was conceived as an opportunity to increase the understanding of air pollution phenomena along the major transport routes in populated Alpine valleys and to improve the available tools for air quality protection, through the action of a network of regional experts aiming at the demonstration of advanced science-based methods to monitor, assess, and predict air pollution and noise and their impact. Starting in January 2005, various project activities have been jointly carried out by the 11 Partners from four Alpine countries, and the completion of the project is exepcted by the end of 2007.

Among the project activities, a key action was the design, set up and execution of suitable field measurement campaigns in Winter 2005-2006.

In the following the field measurements performed on the Southern side of the Brenner Pass corridor and their experimental setup will be presented, along with some preliminary results obtained so far.

2. THE FIELD MEASUREMENT CAMPAIGNS

Detailed investigations at selected target areas have been carried out on the Southern side of the Brenner transit route during the Intensive Observing Period (IOP) covering the period 9 January - 13 March 2006. The field measurements were designed so as to investigate successively three different Target Areas (hereafter TA),

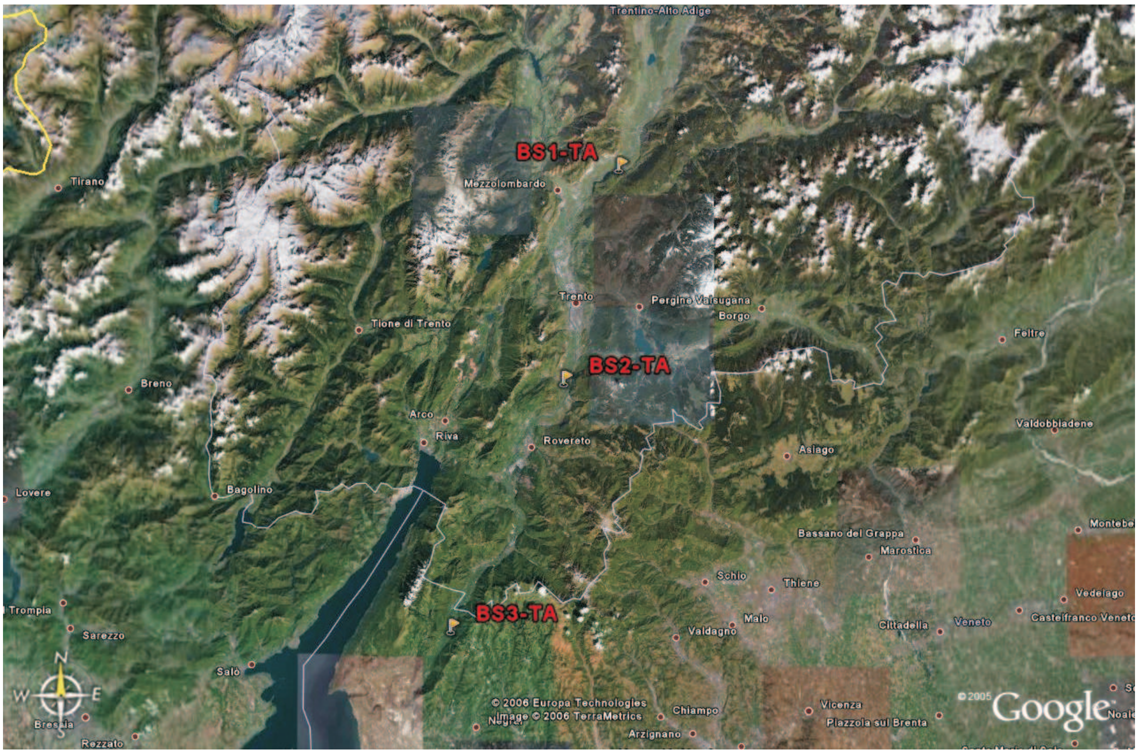

Figure 1: Location of the three "Brenner South" Target Areas (BS1 - BS2 - BS3), representative of typical Alpine valley transects along the "Autobrennero - A22" highway, South of the Brenner Pass (Source GoogleEarth)

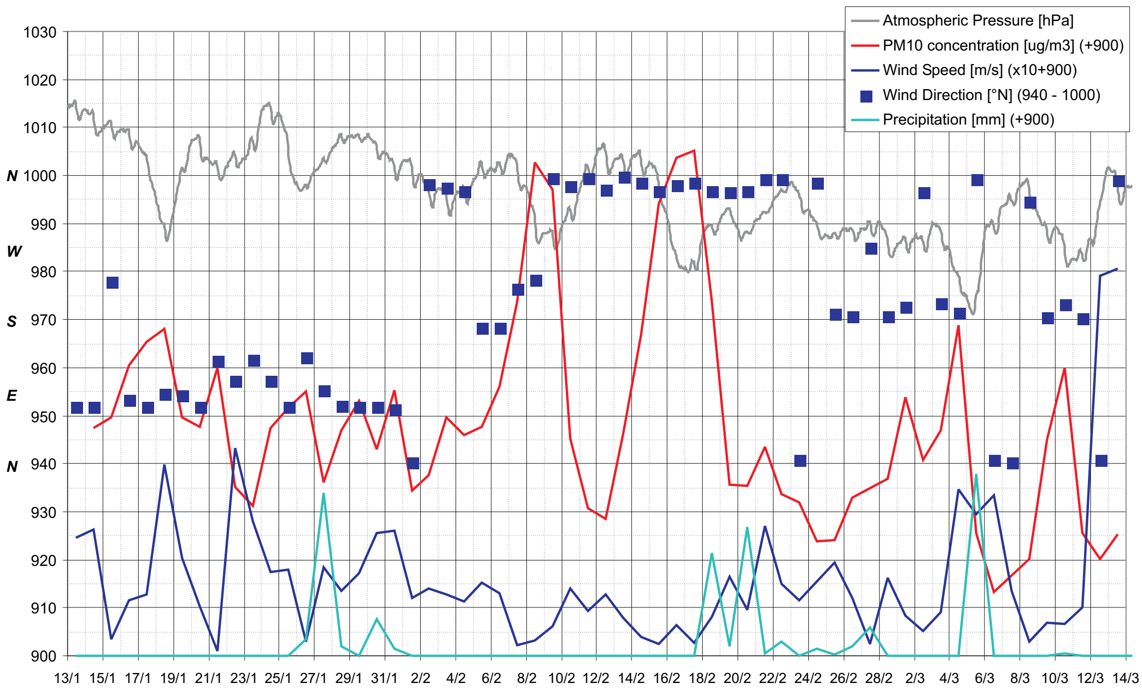

Figure 2: Overview of the main meteorological quantities (atmospheric pressure, wind and precipitation) and daily mean PM_{10} concentration. The value for atmospheric pressure, as well as for PM_{10} concentration (shifted by 900 in the graph), is an average along the whole Brenner corridor (i.e. from Bolzano to Verona). The (vectorial) daily average for wind speed (magnified by a factor 10 and shifted by 900) and direction (remapped from 0°-360° to 940-1000) are evaluated for each TA under consideration, while the reference daily total precipitation (shifted by 900) is referred to Trento.

selected for their features (e.g. orographical characteristics) specifically affecting processes determining air-quality (Figure 1). The measurement schedule was planned so as to cover various phenomena occurring at each TA for more than one week, in order to capture various weather and traffic conditions, and in particular the most critical ones, leading to typical winter peak episodes of air pollution in the area. As the main target of the project was the impact of pollutants poduced from transit transport, each TA was selected far enough from the major adjacent urban areas to minimize their direct influence on pollutant concentration, but close enough to minor towns so that the Health Impact Assessment be statistically signficant.

The rationale behind the IOP design has been thoroughly discussed with local authorities and led to a unique experimental setup, which had never been deployed with such an effort in these areas before. The instruments included 4 air-quality mobile stations (owned and operated by the local Environmental Agencies), that were placed at selected locations across each valley section, not only on the valley floor but also along the sidewalls, in order to get measurements of concentration at various distances and heights in the direction normal to the main road axis. In particular in the choice of the above locations the following criteria have ben kept: a) one site close to the highway, in order to measure concentrations representative of traffic emissions; b) a second site located in a rural area between the highway and the towns; c) a third one inside the towns where other major sources of pollutant were expected; d) the last site at a higher location on the slopes of the valley in order to capture concentrations due to the background or far field transport and appreciate vertical gradients. The devices for turbulence measurements (i.e. ultrasonic anemometer and open-path IRGA), the energy-balance instrumentation (i.e. 4 channel radiometer, ground heat flux, ground surface temperature and air temperature from 0.1 m to 5 m) and the SODAR for the retrieval of wind profiles (up to a height of approximately 400 m a.g.l.) were located by the middle of each of the valley sections under investigation in order to provide data representative of the whole TA. Moreover, a set of 5 air temperature and relative humidity sensors have been located on one slope at each TA, in order to get pseudo-vertical measurements representative of the thermal structure of the atmosphere within the valley (Whiteman et al., 2000; 2004).

3. DATA ANALYSIS AND PRELIMINARY RESULTS

One of the first issues addressed before the data analysis and interpretation, was the representativeness of each single field phase, i.e. whether the pollution episodes measured during the investigations at one single TA were due to the specific site or were common to the whole valley and thus were displayed also at the remaining two TAs. All available PM_{10} daily averages between Bolzano and Verona (not shown here) strongly support the hypothesis that, apart from a slight site-to-site variability (amenable to local-scale meteorological phenomena and local emissions), the pollution episodes can be considered almost the same at the different sites.

Another relevant information, gathered from a general overview of the single pollution episodes, allows to point out the relevance of meteorological factors in determining the concentration levels. Since the daily and weekly cycles of traffic along the highway are very similar during the whole measurement period, emissions can be considered as having a typical and well defined pattern, thus relating the variability of concentration levels to the atmospheric processes which affects the transport and dispersion of pollutants, as well as the photochemical reactions of various species.

Looking briefly at the correlation between NO concentration and traffic, one may observe that this is relevant only in the two measuring stations near the highway, where also the effect of daily traffic cycles is well recognizable. This observation is also true for NO_2, although a weaker variation is observed, due to inertial effects. As previously recalled, low NO concentration far away from the linear source is mainly determined by chemical transformation from NO to NO_2. On the contrary, lower difference in NO_2 concentration may be observed among different stations, probably due to higher background values, typical of Winter situations, displaying strong atmospheric stability and allowing a persistent stagnation of pollutants.

From a more detailed analysis of the air quality and concurrent meteorological data collected at the various TAs (the schematic comparison of PM_{10} concentrations and meteorological quantities is reported in Figure 2), it is possible to draw a first series of considerations which may require more attention in further deepening the analysis. First of all, the persistence of strong inversion layers, in connection with weak wind conditions close to the ground, are confirmed as the most critical conditions for higher concentration levels. Even the occurrence of weak, and in some cases fully unexpected, local circulations similar to the valley-wind systems typical of the warmer seasons (de Franceschi et al., 2002; Rampanelli and Zardi, 2002), is not able to abate the concentration levels sinche the valley acts as a sort of "confined system" closed North-ward by the higher ridges and South-ward by the narrowing valley and by the air masses pushing from the Po plain. In this sense, weak winds alternating between up- and down-valley direction (Rampanelli et al., 2004) and confined within the valley can lead to a rapid increase in concentrations, since there is no recirculation and the air masses within the valley volume can only be enriched in pollutants.

On the contrary, strong precipitation and/or high wind speed are the most effective processes in lowering the pollution levels along the whole valley, with the exception of strong winds confined at higher levels (i.e. shallow Föhn events) which can also make things worse, confining the pollutants within the lowest levels close to the ground.

In the end, in addition to the above mentioned results, the field measurements highlighted the relevance of proper investigation of the vertical structure of the air temperature and wind speed and direction, as well as the surface energy budget which triggers most of the atmospheric processes at a local scale. Conventional observing networks rely only on ground measurements of the various meteorological variables, where many of the pollution sources are indeed located, but commonly miss the upper air features, which are relevant for a more reliable understanding and prediction of the pollutant transport and dispersion processes, also for planning mitigation strategies and actions.

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