Compilation of Investigations about Climatological Impacts on Ambient Air Pollution in the Surroundings of Transalpine Motorways: Brenner, San Bernardino, Gotthard

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At the request of the Tyrolean State Government ("Landesbaudirektion, Abt. Gesamtverkehrsplanung")

Summary of the following report (15.09.2002, German only):
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(OEKOSCIENCE AG: Siegrist & Thudium,
At the request of the Tyrolean State Government; the South Tyrolean "Landesamt für Luft und Lärm",
and the Swiss Agency for the Environment, Forests and Landscape).

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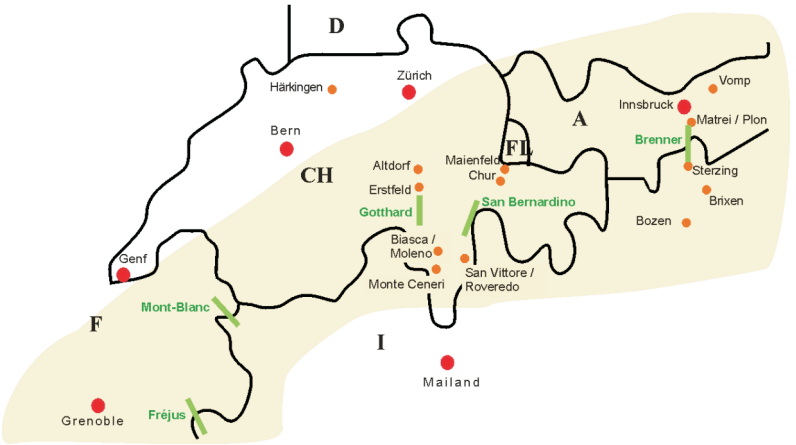
Introduction

The consequences of transalpine road traffic on air quality were investigated for this report in several alpine valleys on an international level. Alpine regions are obviously confronted to particular problems. The air pollution is intensified by the narrow topography and by the meteorological situation with frequent inversions which prevent the exchange of air masses. The employed methods are described and the knowledge about the impact of transalpine road traffic, especially of the haulage, is compiled, based on earlier studies by Oekoscience AG. The aim of the study is the comparative description of the traffic situations and of the air hygienic conditions in the alpine valleys considered. The results may support future planning strategies for the transalpine traffic. The report serves as a discussion basis for cooperation between the individual regions. A comprehensive bibliography including a list of former studies by Oekoscience AG about this subject is part of the original report.

Investigation Areas

This study deals with the entire inner Alpine Bow (from Fréjus to Brenner). However the emphasis lies on the central and eastern part, because data are scarce for the French routes Mont-Blanc and Fréjus, and because there are only a few basic studies about these regions available. The map gives an overview of the entire region and the names of places and measuring stations mentioned in the original report. The most important Alpine passes and road tunnels are represented by a green line.



These are the investigated regions:

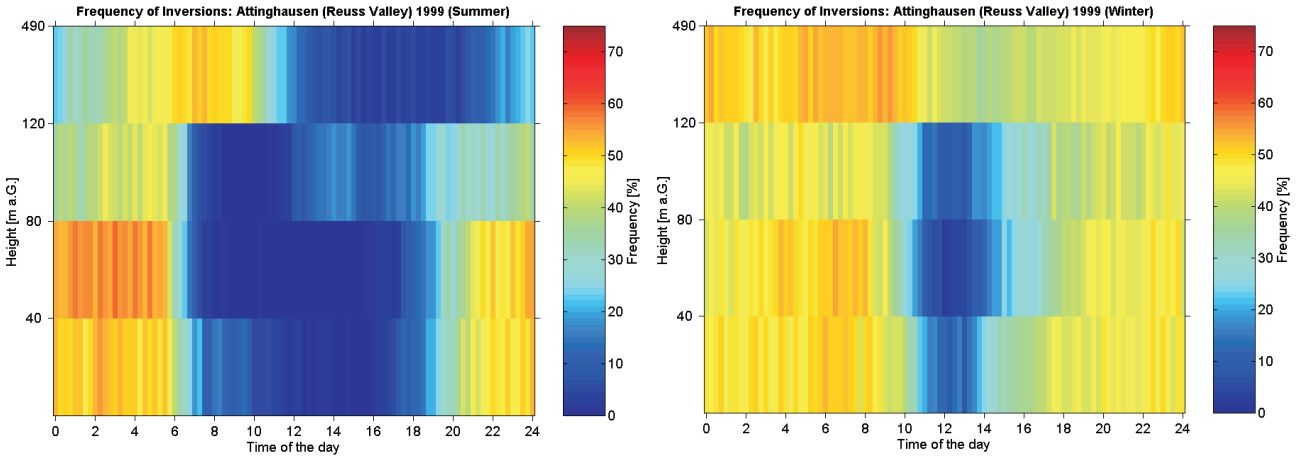
- **Lower Inn Valley, Tyrol / A: Inn Valley motorway A12** between Volders and Jenbach (northern approach road to the Brenner Pass)
- **South Tyrol / I: motorway A22 (south of the Brenner)** within the Eisack Valley between Sterzing and Bozen
- **Rhine Valley / CH: A13 (north of the San Bernardino)** between Chur and Maienfeld
- **Misox / CH: A13 (south of the San Bernardino)**, mainly the lower part near Roveredo
- **Reuss Valley in the canton of Uri / CH: A2 (north of the Gotthard)** between Amsteg and Altdorf

Individual periods between autumn 1998 and the end of 2000 were chosen as investigation periods for each region, depending on the available data.

The lower Inn Valley is best covered with measuring stations compared to the other areas. Therefore data from seven air quality measuring sites in varying distances to the motorway could be used. Data from 1-3 permanent measuring sites and from eventual mobile campaigns were employed for the other regions.

Layers of Air Temperature

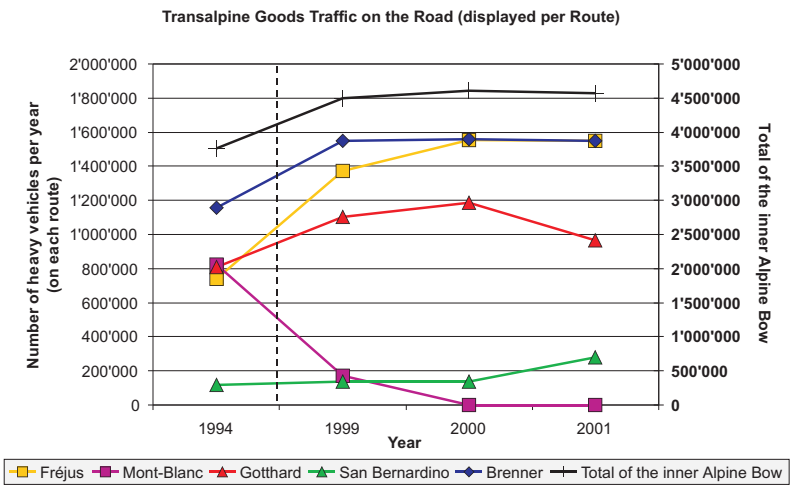
The meteorological circumstances play a major role for the dispersion of pollutants. The vertical structure of the air temperature is of major interest, apart from the wind conditions. Temperature normally decreases with height. The stratification is called an **"inversion"**, if the air temperature rises with height. The vertical exchange of air masses is limited during such situations. Hence the pollutants are accumulated close to the surface. The stratification of the lower atmosphere is determined by profile measurements of air temperature installed on the valley slopes in every investigation area (apart from South Tyrol).



The figures show the **frequencies of inversions** in a daily cycle for the temperature profile near Attinghausen (Reuss Valley) during the summer (left figure, May - August 1999), and the winter situation respectively (right figure, January, February, November, December 1999). The x-axis represents the time of the day, the y-axis the height above ground. Thus the occurrence of inversions in various air layers can be distinguished. Low inversion layers have a particular effect on air quality, because the pollutants are accumulated in a limited volume of air close to the surface. The colour shows the frequency of inversions. While inversions dissolve almost every day during summer days, they persist all day long during 20% of the winter days. During the winter days when they dissolve, this happens only for a few hours. It becomes obvious for both seasons that inversions occur mainly during the night.

Traffic counts

Vehicles are counted officially on all the major transalpine routes. This is done partly by permanent automatic counting stations, partly during special campaigns. The total number of vehicles per year has been continuously increasing on all transalpine routes for many years. The Brenner Pass shows the highest traffic density of all the investigated routes. The local portion of passenger and goods traffic varies considerably between the individual valleys. The distinction between various vehicle categories is at least as important as the total number of vehicles. The heavy vehicles produce most of the air pollution even if their total number is significantly smaller than the number of passenger cars.



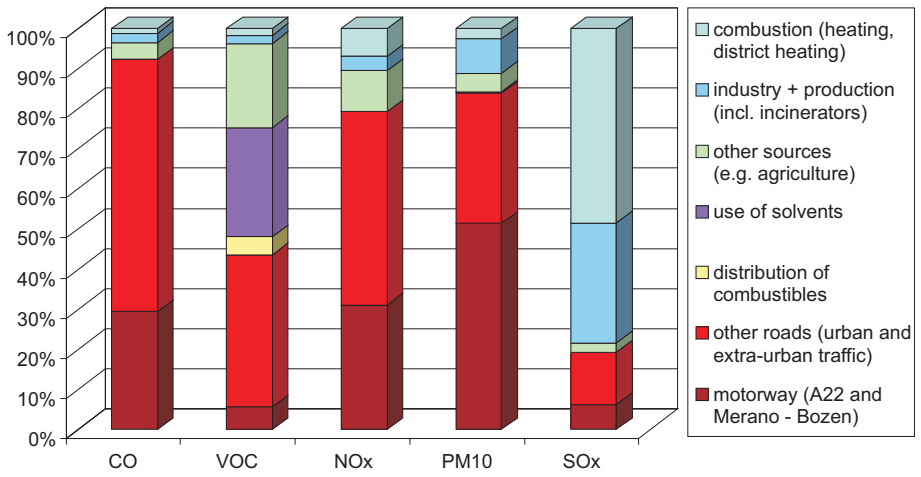
Source: Bundesamt für Raumentwicklung, Bern (2002): Alpinfo 2001. Alpenquerender Güterverkehr auf Strasse und Schiene.

The figure shows the development of goods traffic (all kinds of haulage vehicles > 3.5 t of total weight) on the major Alpine transit routes within the inner Alpine Bow from 1994 till 2001. The total transalpine haulage within this Alpine region (including some other rather small routes) has increased from 1994 until 2000 from 3.8 million vehicles to 4.6 million vehicles per year. It stagnates during the year 2001. The closing of the tunnels at the Mont-Blanc (since 24th March1999) and at the Gotthard (24th October - 21st December 2001) may be clearly recognized. While the haulage declines drastically on these axes, it increases at the same time on the Fréjus, and on the San Bernardino respectively.

Emissions

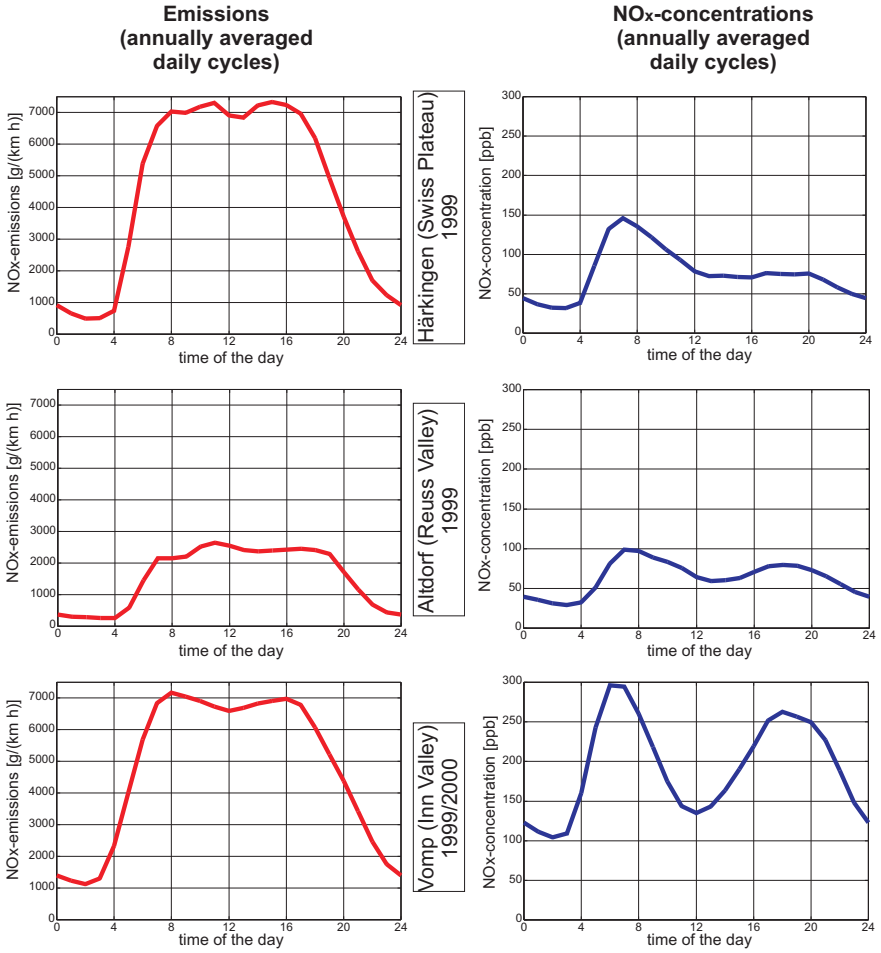
The motorway is the dominant source of air pollution in all the investigated regions. The emissions were calculated for each region from the traffic counts and the official emission factors for the various vehicle categories.

The Sources of Pollutant Emissions in South Tyrol, Year 2000



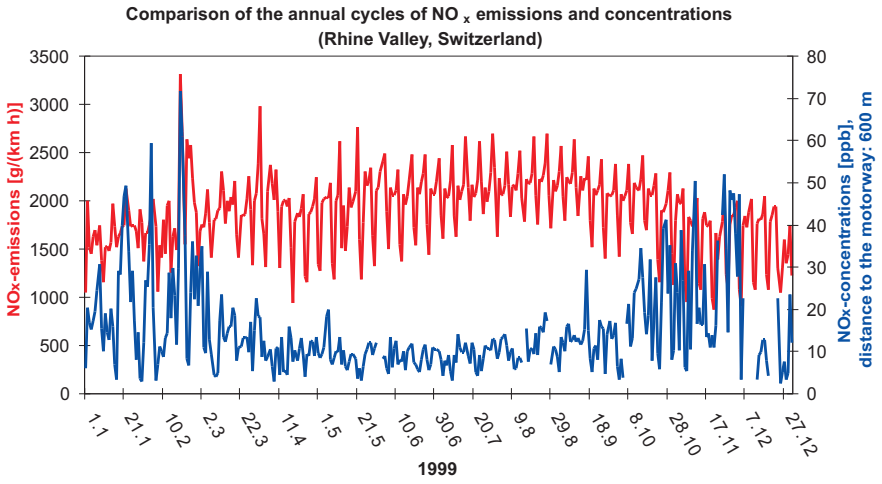
The **emission inventory** for the South Tyrol (cf. figure) identifies road traffic (red) as the main source of CO, NO_x, and PM10 within the whole province. The influence of the motorway A22 is very dominant for the whole region. The emission inventory demonstrates that the influence of heating and industrial plants on the exhaust of nitrogen oxides, particulate matter and carbon monoxide is much less significant than the one of road traffic.

Various studies have identified the haulage as the main producer of traffic emissions and especially of particulate matter PM10. Future NO_x-emissions from the motorways in the Inn Valley and on the Brenner pass have been calculated from the expected development of traffic on these roads until the year 2010. They will hardly decline but rather increase during several years, in spite of improved engines. This is the result of an enhanced haulage. Therefore an improvement of the air quality cannot be expected in the near future, if the traffic flow continues to grow with today's rate. These findings are valid also for all the other investigated alpine valleys.



Emissions and ambient air concentrations

The following figures demonstrate that there is no linear correlation between the emissions and the ambient air concentrations of pollutants. The annually averaged daily cycles of the NO_x-emissions (red) and the measured concentrations (blue) are displayed for three regions: Härkingen as an example for a fairly flat region on the Swiss Plateau, and the two alpine valleys Reuss Valley and lower Inn Valley. The emissions in the Inn Valley and at the highly frequented motorway intersection at Härkingen are of about the same magnitude, whereas the ambient air concentration of NO_x close to the motorway in the Inn Valley is three times higher. However the NO_x-concentration in Härkingen and in the Reuss Valley are comparable to each other, even though the traffic emissions in Härkingen are much higher than those in the Reuss Valley. It can be concluded that the pollution load in an alpine valley caused by a certain amount of emissions is roughly three times as high as in a wide open area.

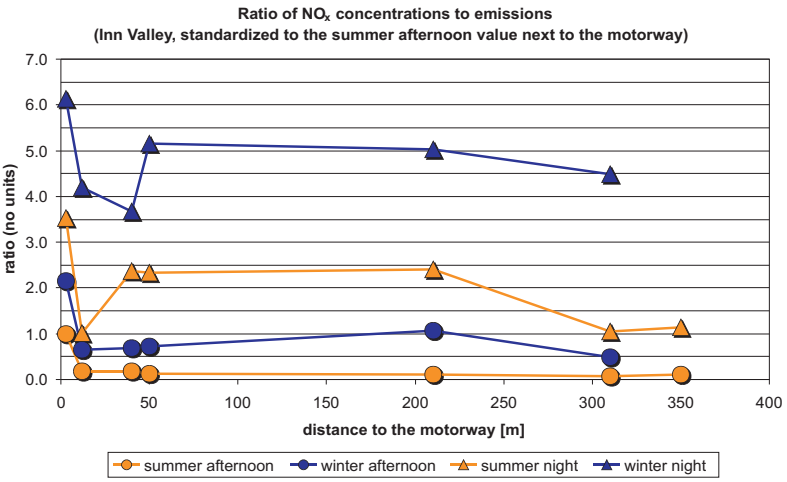


This figure confirms the hypothesis from the previous page, that there is no direct correlation between the emissions and the ambient air concentrations. It shows an annual cycle of the NO_x-emissions (red) by the motorway in the Rhine Valley and the concentration (blue) at a distance of 600 m to the motorway. The highest concentrations are reached in winter, even though the mean emissions are highest during the summer. The concentrations depend not only on the emissions but also on other influencing factors like topography and meteorological conditions. The emitted pollutants accumulate close to the ground during inversion situations which occur mainly at night-time and during the winter. They are dispersed within a larger volume during good exchange conditions.

Inversions near the surface are less frequent in flat areas than in narrow alpine valleys. In addition, there is a larger horizontal area available for dispersion in open regions.

Horizontal Dispersion and Temporal Variations

The ratio between the ambient NO_x-concentration at a particular measuring site and the simultaneous emissions of the motorway allows the comparison of the pollution situations of various sites or time periods independently of the actual emissions. The higher the ratio the more pollution is caused by a distinct emission.



The daily variations are more pronounced than the seasonal ones. Thus the highest values are reached during winter nights. The values during summer nights are still higher than those during the day in winter. The NO_x-concentrations related to the emissions are always highest directly at the motorway, no matter during which time of the day and which season. However the dependence on exchange conditions rises with increasing distance to the motorway. Therefore the sites further away from the motorway are still highly affected during the night and during the winter season. The load of air pollution caused by the same amount of traffic is 5 times higher during a winter night even at a distance of 300 m to the motorway than directly at the motorway during a summer day! This signifies that an increasing number of nocturnal vehicles would negatively affect the residential areas in a distance a few hundred metres away from the motorway.

Conclusions

- Alpine valleys are especially susceptible to air pollution caused by road traffic because of their topographical situation and the meteorological conditions with frequent inversions. Emissions have a larger impact on such regions than on flat areas.
- This impact is worst during the night because of stable atmospheric conditions which suppress the exchange of air masses. Therefore a limitation of nocturnal haulage makes sense not only because of the noise but also because of air hygienic reasons.
- The air quality in residential areas a few hundred metres away from the motorway depends particularly on the prevailing exchange conditions.