

EFFECTIVE VENTILATION

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Poster 13

**ANALYSIS OF THE INFLUENCE OF TOPOGRAPHY
ON CLIMATIC EXPOSURE OF BUILDINGS
(Climatological Data Transfer)**

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1. INTRODUCTION

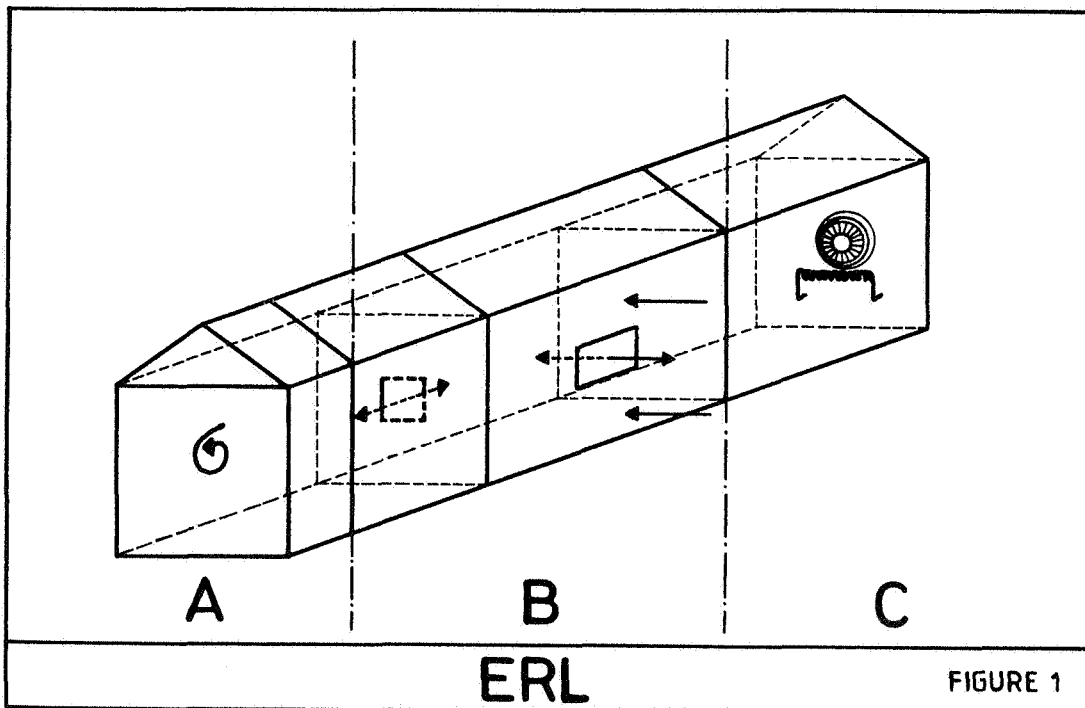
This text contains comments to the poster presented at the 9th AIVC Conference in Gent, Belgium. The project under consideration in the poster (Climatological Data Transfer) is one of the numerous research fields of the Swiss ERL program (Energierrelevante Luftströmungen in Gebäude - Energy Relevant Air Flow in Buildings).

2. OBJECTIVES OF THE ERL PROGRAM

The ERL program is subdivided into three fields of research, namely:

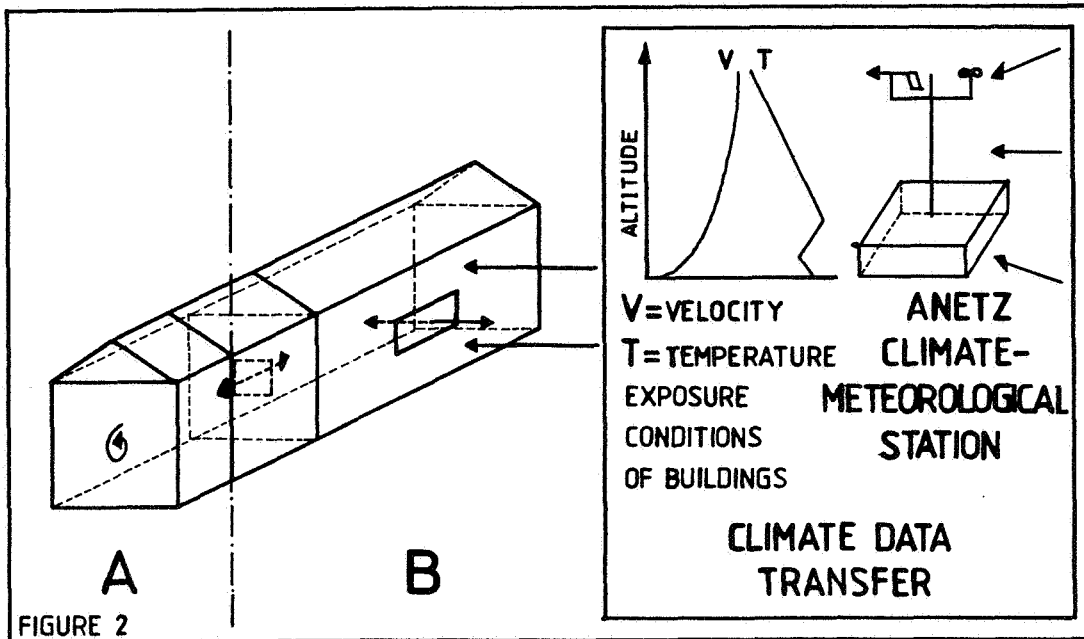
- A: Analysis and modelling of air flow within buildings considered as closed entities
- B: Analysis and modelling of air flow taking place between various buildings, partially open to the exterior environment
- C: Optimisation of ventilation and air-conditioning systems.

The objectives of these three fields of research are interlinked, the final goal of the ERL program being theme C. The climatological data transfer project is included under theme heading B.



3. OBJECTIVES OF THE CLIMATOLOGICAL DATA TRANSFER PROJECT

The main goal of this study is to set up a methodology and a modelling system capable to determining the climatic exposure of buildings situated in a particular location of Switzerland, on the basis of corrected data obtained from the automatic meteorological station network "ANETZ". The envisaged modelling system should be accessible to engineers so that they may know the magnitudes of climatological data which can influence air conditioning and ventilation systems.



4. SPECIFICITY OF RESEARCH IN THIS FIELD

Much work has been undertaken in the field of meteorological data analysis, and several authors have studied wind effects on constructions. Such work has generally contributed to the elaboration of various national standards concerning wind loads on buildings. These studies are generally related to strong or extreme wind conditions.

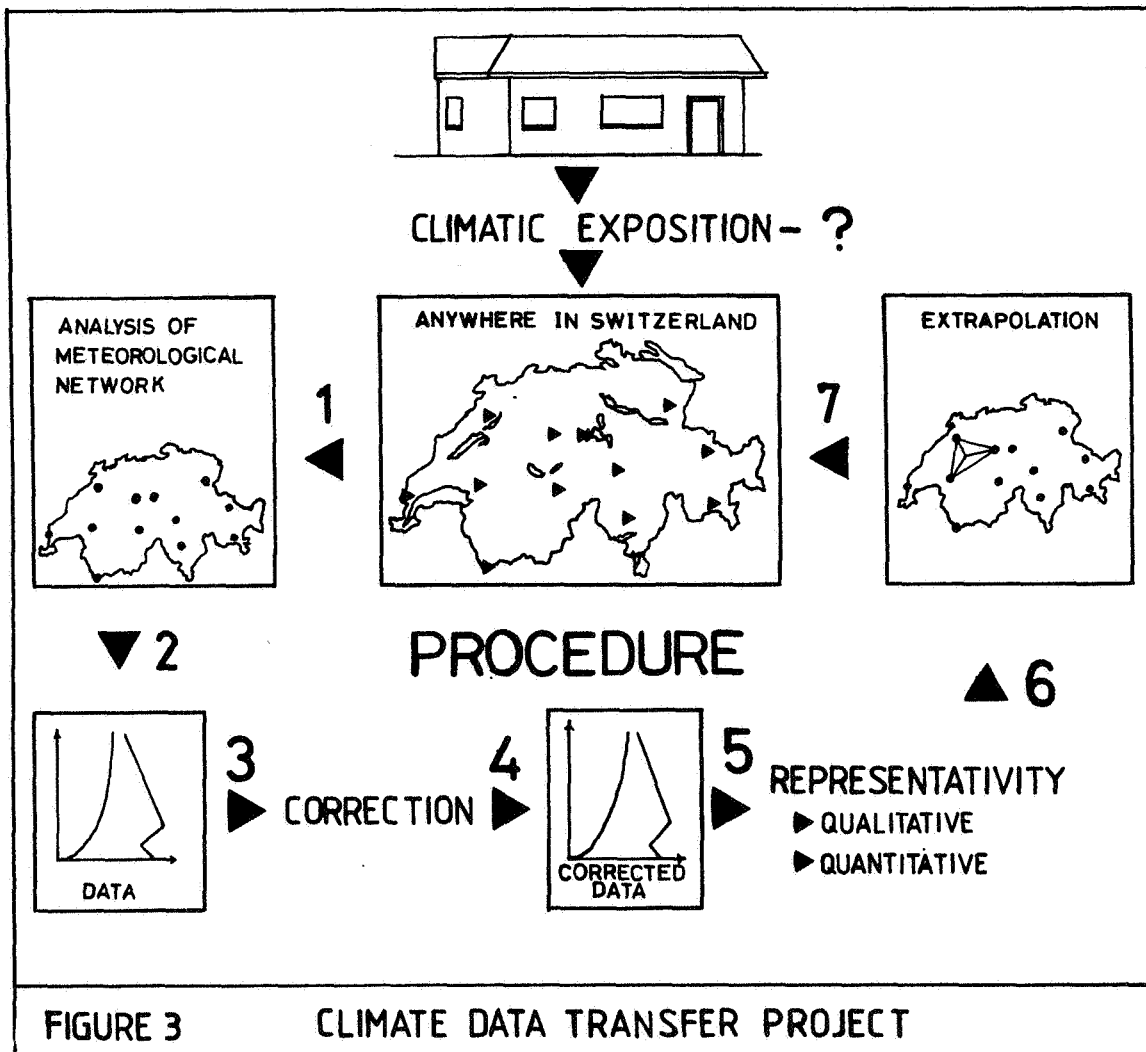
To our knowledge, however, no work has been carried out on light to moderate winds in complex terrain. This is consequently the principal objective of the present study.

5. ORGANISATION OF THE CLIMATOLOGICAL DATA TRANSFER PROJECT

The authors of the present project plan to use data supplied by the automatic meteorological station network ANETZ, which was set up and is administered by the Swiss Meteorological Institute.

However, it has been observed that certain parameters, in particular wind velocity and direction, are perturbed by the proximity of other instruments, the presence of obstacles (trees, buildings), and the complexity of Swiss topography.

Consequently, the first phase of the project consisted in visiting each station in the ANETZ network in order to draw up an inventory of potential problems. The second phase, currently being carried out, aims to establish corrections to the perturbed data mentioned above, while at the same time investigating the representativity of the ANETZ network. The following phases of the project will begin once these preliminary studies have been concluded.



6. ANALYSIS OF THE ANETZ NETWORK

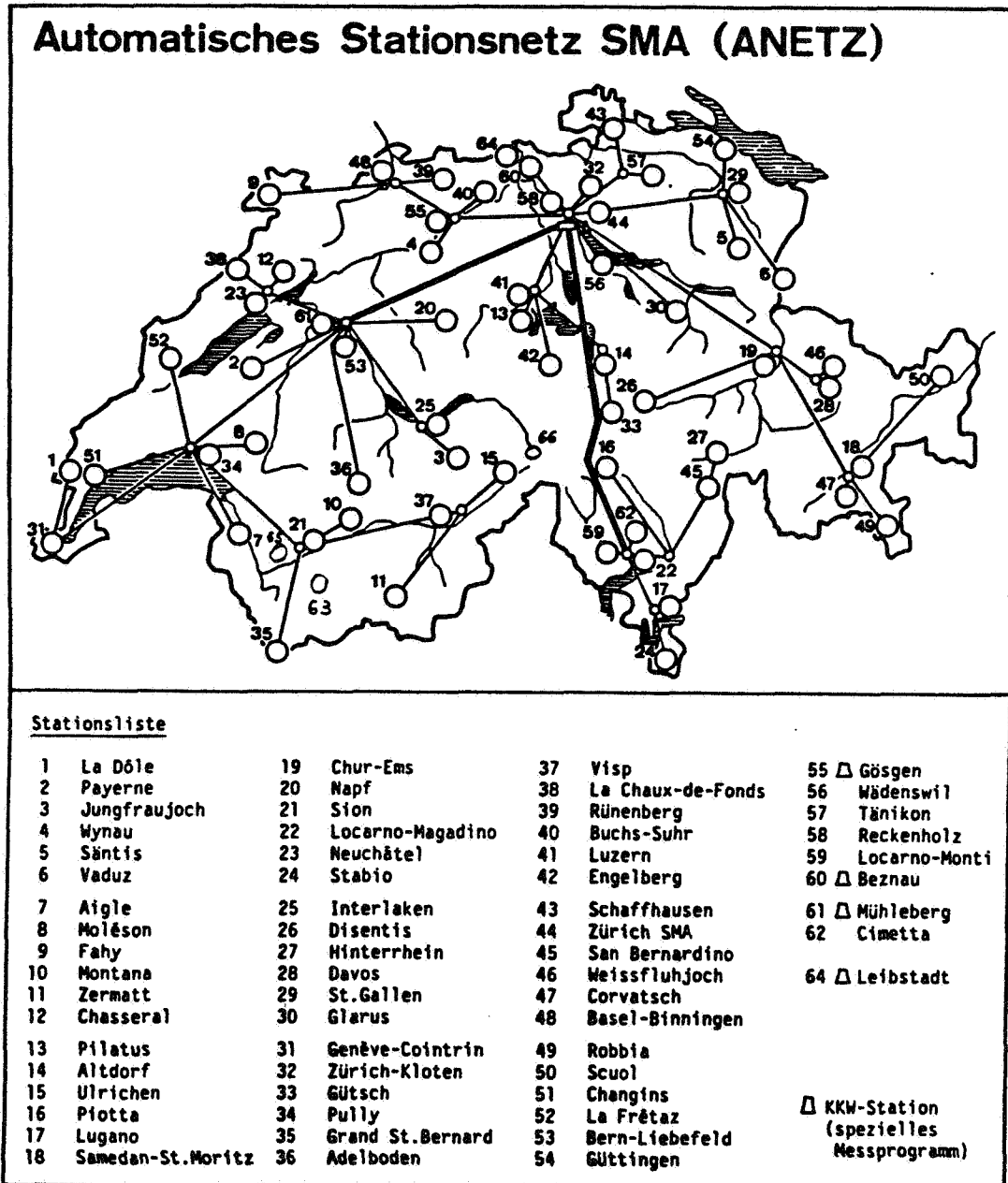


FIGURE 4

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The 64 existing meteorological stations have been analyzed. This work comprises three aspects:

a. Observation

On the spot, the following parameters have been noted:

- Estimation of the time evolution of the environment in the vicinity of the station
- Simplified topographic profiles
- Presence of nearby obstacles
- Complexity of local orography
- Principal morphological features
- Surface characteristics and vegetation
- Sources of wind
- Localisation of the instruments
- Interactions between wind-measuring equipment
- Orientation of wind-measuring instruments
- Estimation of the probable behavior of wind-measuring instruments.

b. Photography

At each station, a 360° panoramic view was taken in the vicinity of the instrumented mast, with a 50 mm focal lens. More general views of the station were taken at various locations, and the instruments were photographed in detail. These documents will enable updating of information on each station, and yield precise indications required for wind-tunnel tests (see paragraph 9).

c. Summary of observations

In order to optimize wind-tunnel tests (see sub-heading 9), three types of classification have been established according to the scale of the problem considered. Information gathered during this research forms also the basis of the methodology necessary for the correction of ANETZ meteorological data.

7. INVENTORY OF PROBLEMS

The ANETZ meteorological network is a somewhat complex ensemble and the risk of errors is consequently high. It should be noted, nonetheless, that the network functions remarkably well, and for example breakdowns in data transmission are extremely rare.

The following list gives an idea of the chief potential sources of data error, although at this time it is not possible to estimate the real importance of such errors:

a. Geographical location of the stations

This is chiefly related to the complex orography characteristic of Switzerland, as well as to the presence of natural (trees...) or man-made (buildings...) obstacles.

b. Material chosen

The ANETZ stations are not always equipped with identical instruments, due to the constant upgrading of material and the diversity of climatic conditions. This poses problems as to the uniformity of transmitted data; such data requires correction in order to enable intercomparisons.

c. Technical Reliability of the installations

Numerous breakdowns can occur, such as the breakdown in communications, fortunately very rare, or more subtle problems such as the slow drift of information registered by a particular instrument.

d. Reliability of data

First ANETZ records date back to 1978. It is, however, inadvisable to work with such data prior to the end of the year 1980.

e. Maintenance of the equipment

It is often possible that instruments are not cleaned after rain or the sprinkling of fertilizer used for fields neighboring a particular station.

f. External perturbations

Several external sources of wind can disturb wind measurements at an ANETZ station: Flyover by a helicopter, presence of a nearby road, etc. Damage due to animals is also a particularly disturbing factor for anemometric readings.

g. Interactions between instruments

A lightning rod, mast, or light marker (such as at an airport) located near an anemometer may significantly influence its behavior.

Due to the fact that it is impossible to take into account all these problems simultaneously, the following hypotheses have been put forth:

- The equipment is technically reliable
- They are satisfactorily maintained
- The data is free of technically-induced perturbations.

Only the problems linked to disturbances in anemometer and wind-vane measurements are taken into account. These can be indentified on three different scales:

- General orography, with for example the presence of a mountain summit within a few kilometers radius
- Local features, such as the wake produced by obstacles within a radius of a few hundred meters
- Interactions between measurement equipment.

8 . STATION TYPOLOGY

In order to apply a correction to data influenced by the above mentioned factors, individual stations have been grouped together according to three types. Correction factors will be determined by wind-tunnel tests.

8.1 Classification according to anemometer type

- | | |
|-----------------------|-------------|
| a) Schiltknecht type: | 35 stations |
| b) Lambrecht type: | 19 stations |
| c) SIAP type: | 10 stations |

This classification has been further refined by taking into account other features in the neighborhood of anemometers, such as antennas or light markers.

8.2 Classification according to nearby obstacles

It is envisaged to summarize information relative to obstacles in order to establish a "Standard obstacle type" to be tested in a wind-tunnel. The model obstacle should then need only minor modifications in order to reproduce the environments around each station.

8.3 Classification according to topography

The local topography of each station has been classified according to simple geometric forms such as those shown in the following figure.

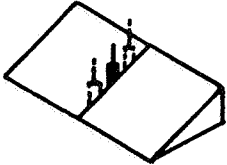
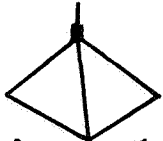
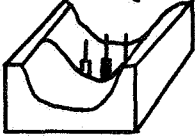


TYPE	DESCRIPTION	SCHEMA	ANETZ NO
A	Station situated on a regular slope		x, ...
B	Station situated on a mountains summit		y, ...
C	Station situated in a valley bottom		z, ...
D	Station situated on a pass		t, ...
E	Topography too complex		u, ...

FIGURE 5

ANETZ STATION TYPES

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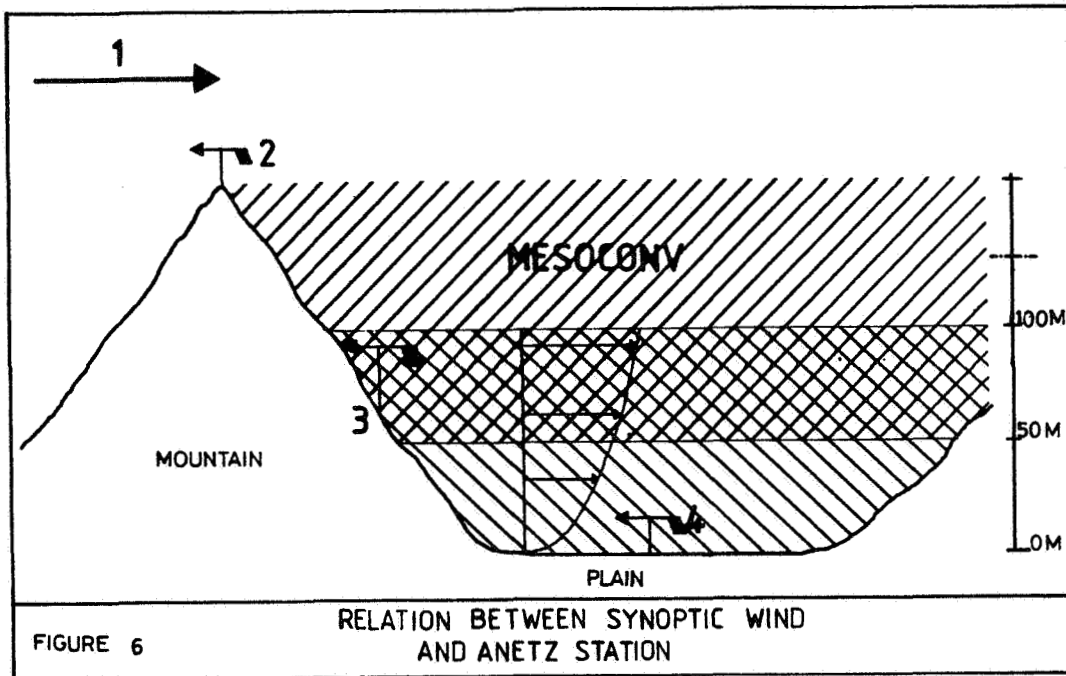
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9. CORRECTIONS AND REPRESENTATIVITY

The methodology established for ANETZ data correction may also be used to identify the representativity of each station, that is to say the area of validity of the measurements.

9.1 Correction strategy

The following figure summarizes schematically typical orography of Switzerland, and ANETZ stations located on flat ground, on a slope, or on a mountain summit.



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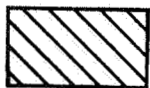
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- (1) Synoptic wind
- (2) High-altitude mountain station
- (3) Station based on a slope
- (4) Station located on flat ground (plain).



MESOCONV

Domain of application of the MESOCONV meteorological models



Domain of application of power and logarithmic wind profile laws.

It is planned to set up a relation between the synoptic wind and that observed at the surface in order to compare data measured by the ANETZ network and extrapolate the measurements to any point in Switzerland.

The method which is envisaged is briefly described below. The relation between the synoptic wind and summit or high-altitude stations will be established by wind-tunnel tests (scale 1:5000) for the twelve stations in this category (Relation 1-2 as shown in Fig. 6).

The link between the upper-level station and slope stations down to about 20 m above a flat surface will be achieved through numerical simulations with a meso-meteorological model (MESOCONV). (Relation 2-3 in Fig. 6)

Power or logarithmic wind-profile laws will enable the link to be made between slope stations and stations located on a plain (relation 3-4).

In this manner, it will be possible to obtain wind relationships between the surface and the synoptic wind.

9.2 Topographic corrections

The aim here is to apply corrections to data perturbed by orography within a 3-5 km radius around the station. The twelve high-altitude stations will be modeled at a 1:5000 scale.

The scale models, mounted on a circular base with a 2 m radius, will be placed on a turntable and experimented upon in a wind-tunnel. The synoptic wind will be reproduced by the wind-tunnel fans. The model will be equipped with a wind-vane and a hot-wire anemometer. For each degree of rotation, wind speed and direction will be measured. This will yield a correction matrix containing 720 values.

As previously mentioned, twelve scale models have been chosen which should enable global corrections on this scale for Switzerland.

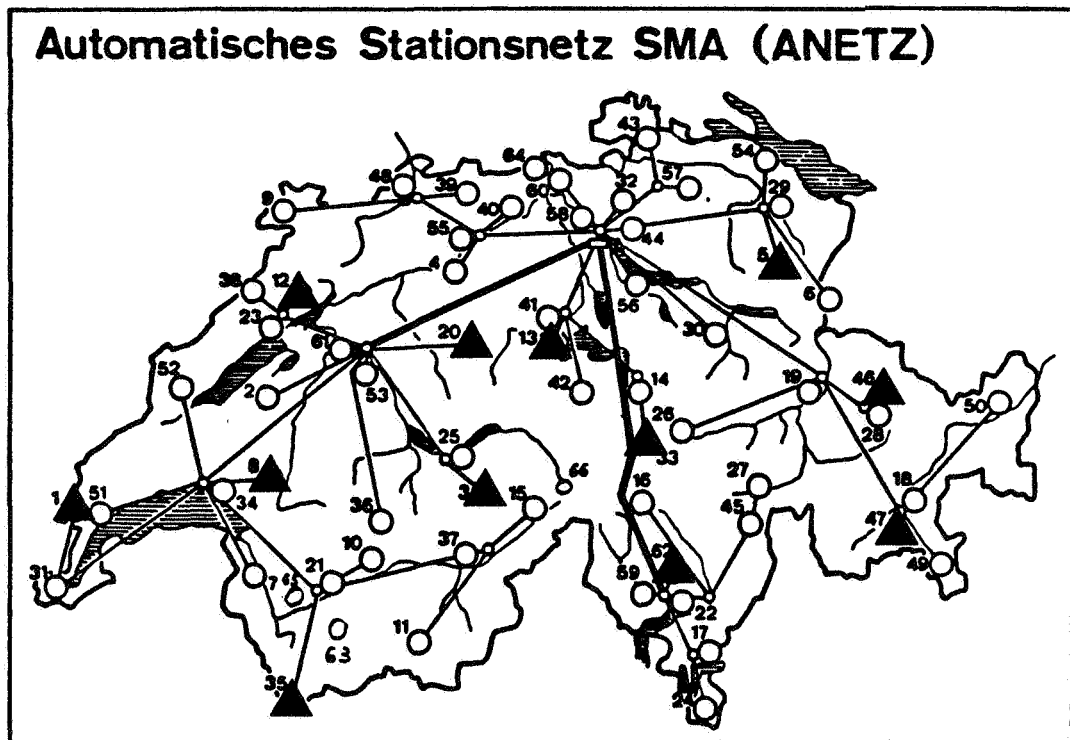


FIGURE 7

9.3 Correction taking into account obstacles

Only those obstacles present within a radius of 300-500 m around the station will be considered. A complete inventory of these features has been drawn up. The configurations of each station will be regrouped into a number of classes, in order to organize the wind-tunnel tests in a rational manner.

A standard model will be constructed, and it will be sufficient to displace certain parts of this scale model in order to reproduce in the wind-tunnel the environment of each station. The wind-tunnel will be used to simulate airflow at 10 m above the ground. The model will rotate degree by degree, yielding a new 720-value matrix (velocity and direction over 360°).

9.4 Correction for wake effects of instruments

The third and last type of correction concerns the anemometers and wind-vanes themselves. These instruments are often surrounded by objects of various forms which generate turbulence, such as antennas, light markers in the vicinity of airports, masts, pylons, or other instruments located nearby for inter-comparison purposes. These latter objects are generally placed between 3 and 5 m from the ANETZ wind instruments. As mentioned previously, a 720-point correction matrix will be established for each wind-tunnel experiment. Because of the similarity of configuration of a number of ANETZ stations, only about 15 wind-tunnel simulations are needed to test the 64 ANETZ stations.

9.5 Global corrections

Non-corrected data supplied by ANETZ stations will be transformed with two correction matrices, thereby yielding the corrected data sets. Only the twelve high-altitude measuring stations will be modified by the two correction matrices.

9.6 Extrapolation from summits to plain and station representativity

The mesoscale meteorological model MESOCONV enables simulations of wind flow in complex terrain to be made. With this numerical model, a ventilation map of Switzerland will be drawn up, taking into account vertical and horizontal wind variations. Studies undertaken with this model should enable the solution of representativity of the ANETZ network (see paragraph 5) quantitatively. The vertical resolution of the model extends from the surface to a height which ranges from 5000 to 10000 m.

9.7 Link between MESOCONV and the surface

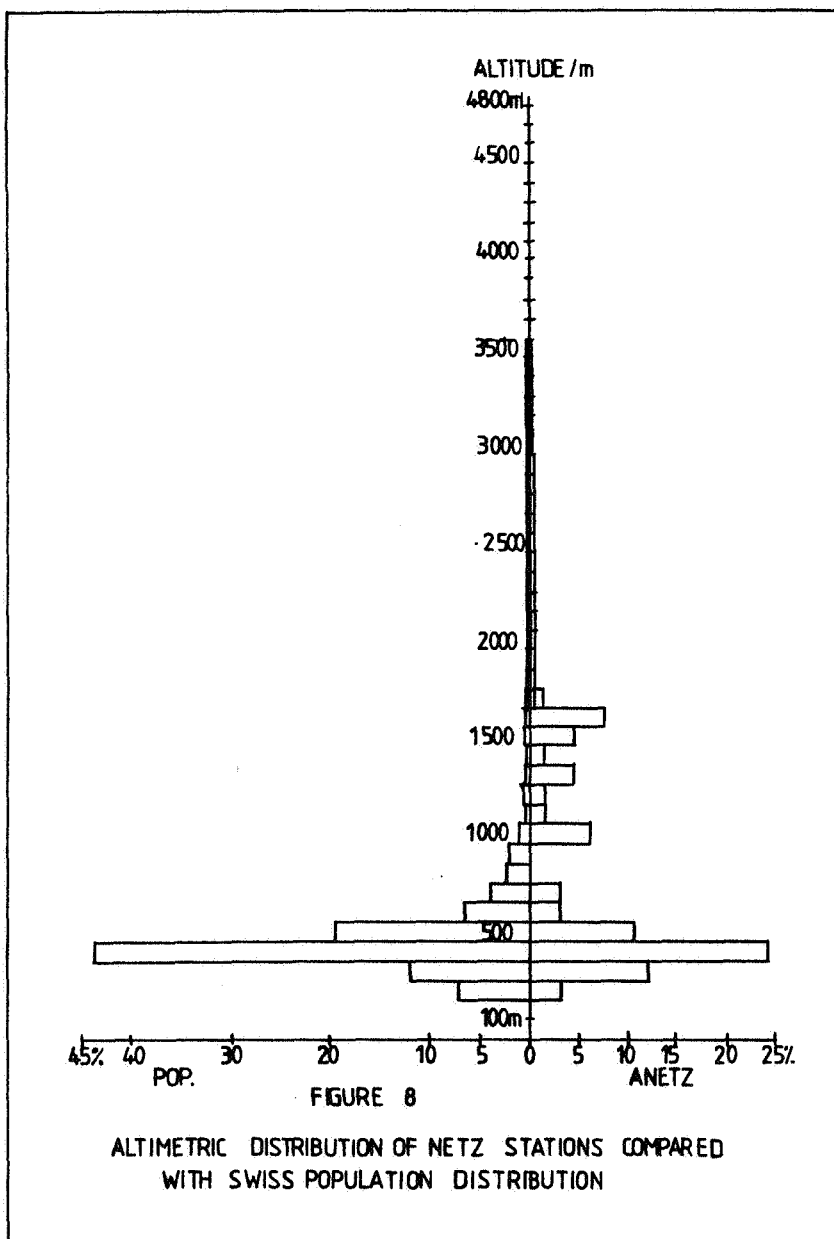
Between the surface and the first MESOCONV model level, wind data at 10 m height can be obtained by applying power law or logarithmic profile relationships, interpolated from data supplied by the numerical model.

10. REPRESENTATIVITY OF THE ANETZ NETWORK

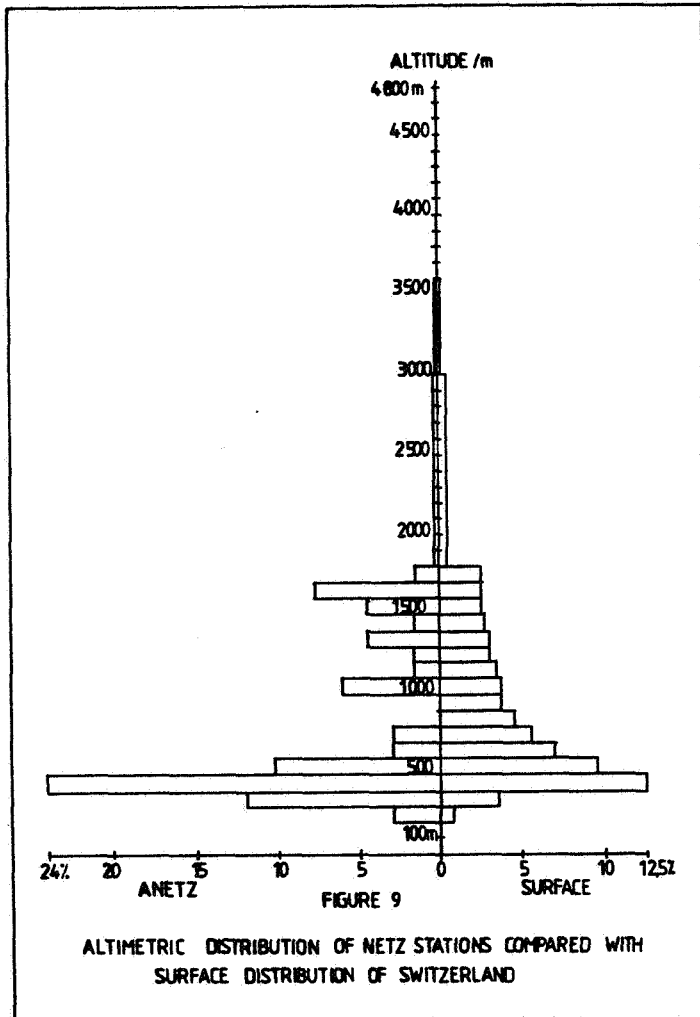
As mentioned above, the area of validity of the ANETZ data will be delimited quantitatively through simulations with the MESOCONV model. Simultaneously, a more qualitative study concerning station representativity will be carried out. This consists in underlining possible gaps in the geographical outlay of the ANETZ meteorological network.

10.1 Altimetric distribution of the ANETZ network

As a first step, the height distribution of the ANETZ network was compared to that of Swiss population as an indicator of density of built-up areas. The following figure summarizes this comparison.



As a second step, the height distribution of the ANETZ stations was compared to the area distribution of various altitudes: for example, 5.6% of the total area of the country lies between 701 and 800 m. The following figure summarizes this relationship.



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11. CONCLUSION

A further study of the qualitative representativity of the ANETZ network is under way, where one is attempting to relate the horizontal distribution of the meteorological stations to height intervals, exposure of the stations, and Swiss climatology basins.

The methodology presented here will be completed by an inverse concept which will enable us, we hope, to answer the question: "What is the climatic exposure of a construction planned at a particular site?".