National Report of Switzerland

Introduction of a Precise Swiss Positioning Service "*swipos*" and Progress in the Swiss National Height Network "LHN95"

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1 Introduction

The Geodetic Division of the Swiss Federal Office of Topography *(swisstopo)* tries to keep pace with the technological development in geodesy. Two large projects, which were already the subject of the last national reports [Gubler et al., 1998; Schneider et al., 1999], are the focus of the Swiss national geodetic survey.

- Project AGNES (Automated GPS Network for Switzerland) is presently being changed from the status of a Pilot Network with 10 permanent stations (1999) to a productive status. A precise positioning service covering all of Switzerland will be made available within the next two years by *swisstopo*.
- Progress has been made in the development of a new National Height Network LHN95. It is planned to complete the project by the end of 2001. In introducing the new Swiss Geoid [Marti, 1997], precise new orthometric heights which are compatible with GPS heights will be available for all surveying demands in Switzerland.

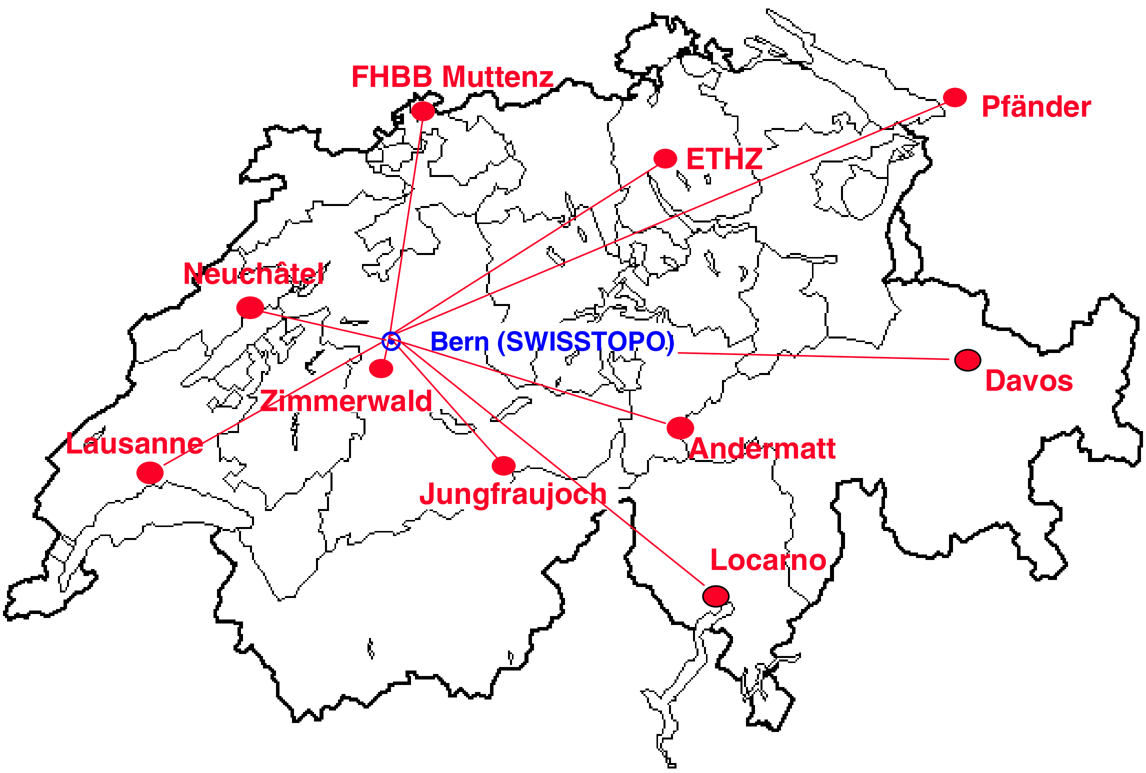

Fig. 1: AGNES Network: Pilot network 1999

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2 Precise Positioning Service *"swipos"*

2.1 AGNES Network

In the concept of the new National Survey of Switzerland, *swisstopo* decided to establish a new multi functional network of permanent stations called Automated GPS Network for Switzerland (AGNES). This network has the following main objectives:

- online realization of the new reference system CHTRS95
- promotion of the new reference frame LV95 in cadastral surveying (rapid transition from the old frame LV03) for economic reasons
- determination of recent crustal movements in and around the country (Central Alpine Area)
- scientific applications in atmospheric research
- basic structure for differential positioning services (*swipos*®)

The concept of AGNES [WILD et al., 1996] and the installation of the pilot network was already described in previous national reports [GUBLER et al., 1998; SCHNEIDER et al., 1999]. This pilot network with 10 stations (see Fig.1) is presently being densified to a surface-covering configuration of about 25 stations (see Fig. 2).

In a first phase (2000) the final coverage will be reached for the Swiss Plateau, the Jura and in the Valais. With the installation of 4 additional stations in the Grisons and in southern Switzerland, the network will be completed by summer 2001. In the last phase temporary sites on roofs and buildings will be moved to stable ground. Finally, most sites (antennas) shall be placed directly on bedrock [WILD et al., 2000].

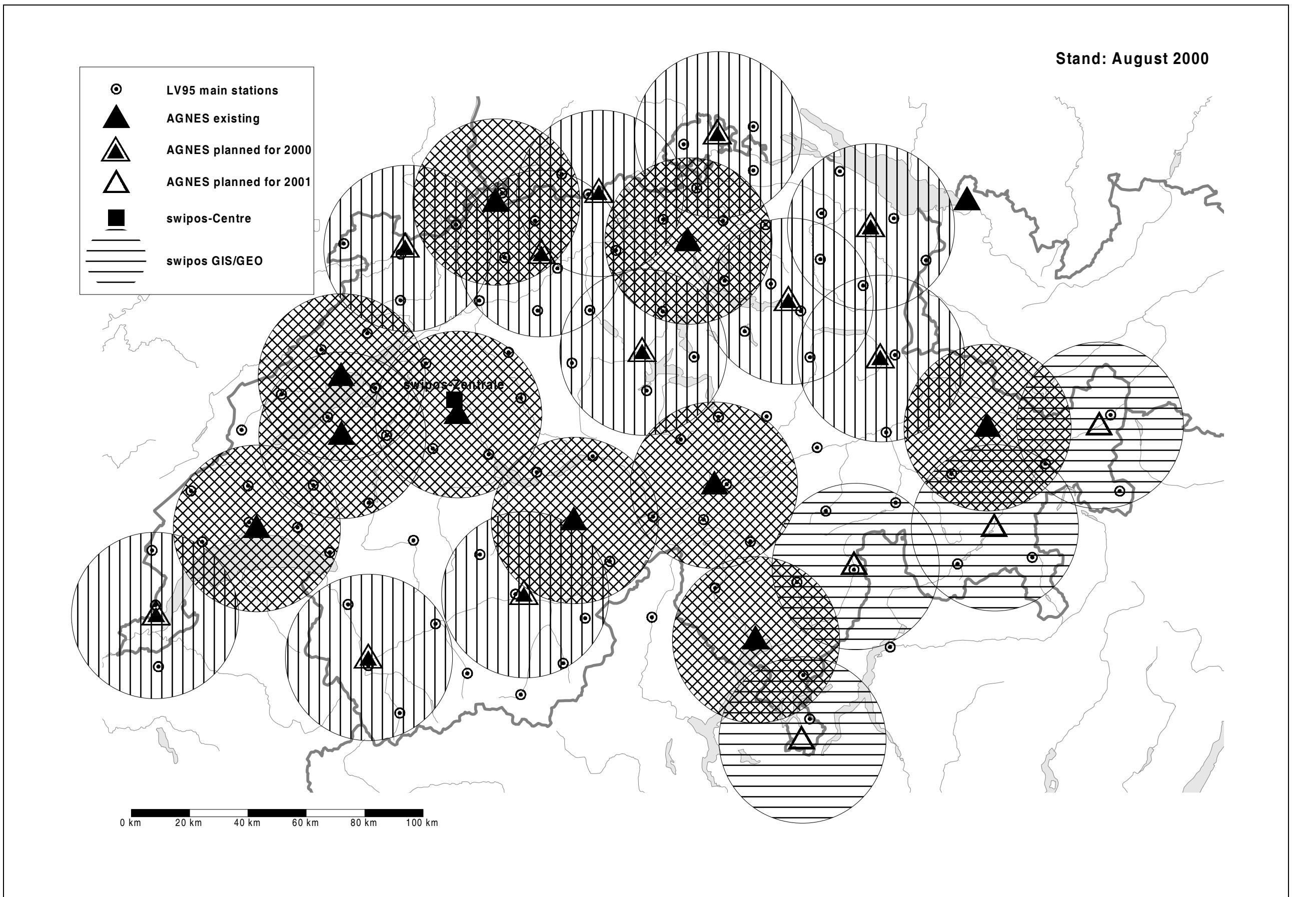

Fig. 2: AGNES: Densification 2000-01

2.2 *swisstopo* Analysis Center

swisstopo has been running its own analysis center since 1997. Three different permanent configurations are processed daily using Bernese GPS software (see Tab.1).

Figures 3 and 4 show the distribution of the processed sites. A weekly solution (Fig. 3) is sent to the BKG Frankfurt where these data are introduced into the weekly EUREF solution.

Tab.1: *swisstopo* Analysis Center: Daily data download and processing

Permanent network	Stations	Delay of Processing [days]
EUREF Subnet	18	7
AGNES enlarged	32	8

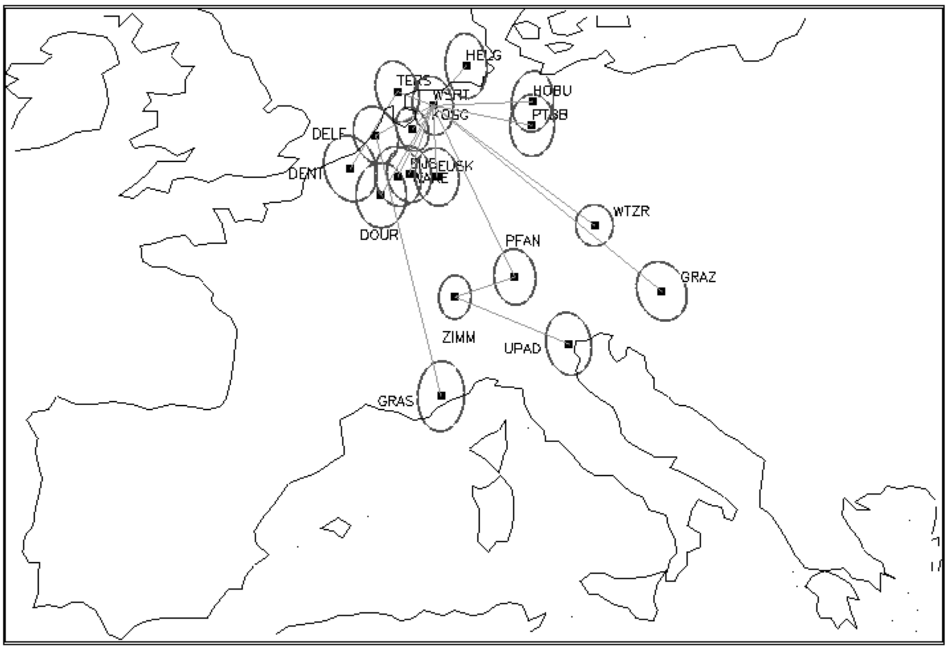

Fig. 3: EUREF Subnetwork for daily data download and processing: Day 154 (Jun 02, 2000)

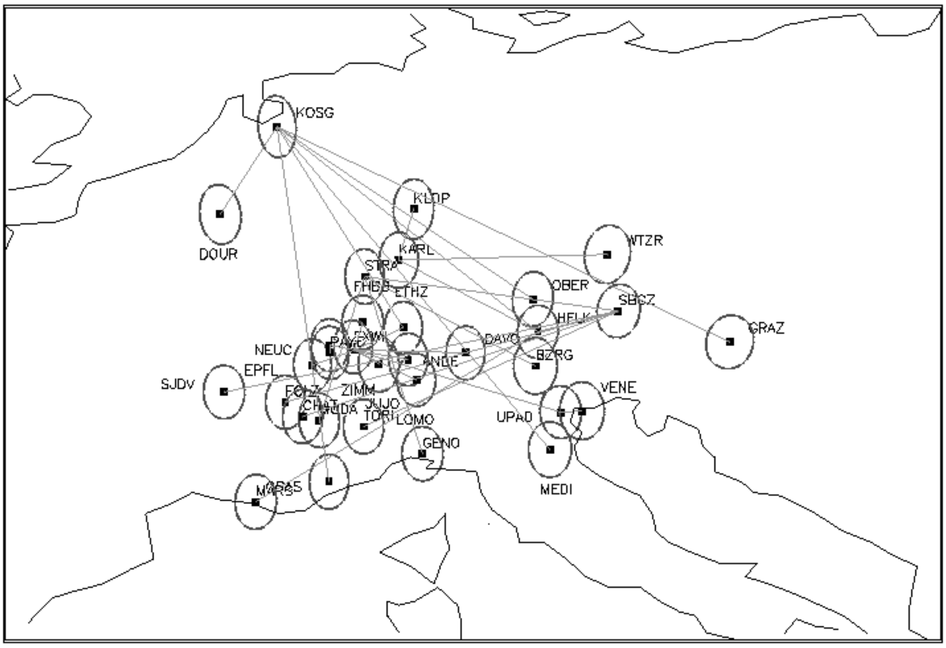

Fig. 4: Enlarged AGNES network for daily data download and processing: Day 146 (May 25, 2000)

2.3 Real-time Data Network

Besides the off-line applications of AGNES, a new system for real-time data communication is being developed which makes surface-covering RTK applications available to the user. The country-wide data network of the Swiss Federal Administration is the backbone of the system (see Fig. 5). The user is either connected by Internet (post-processing) or by GSM (RTK) to the *swipos* communications server in Wabern (see Fig. 6).

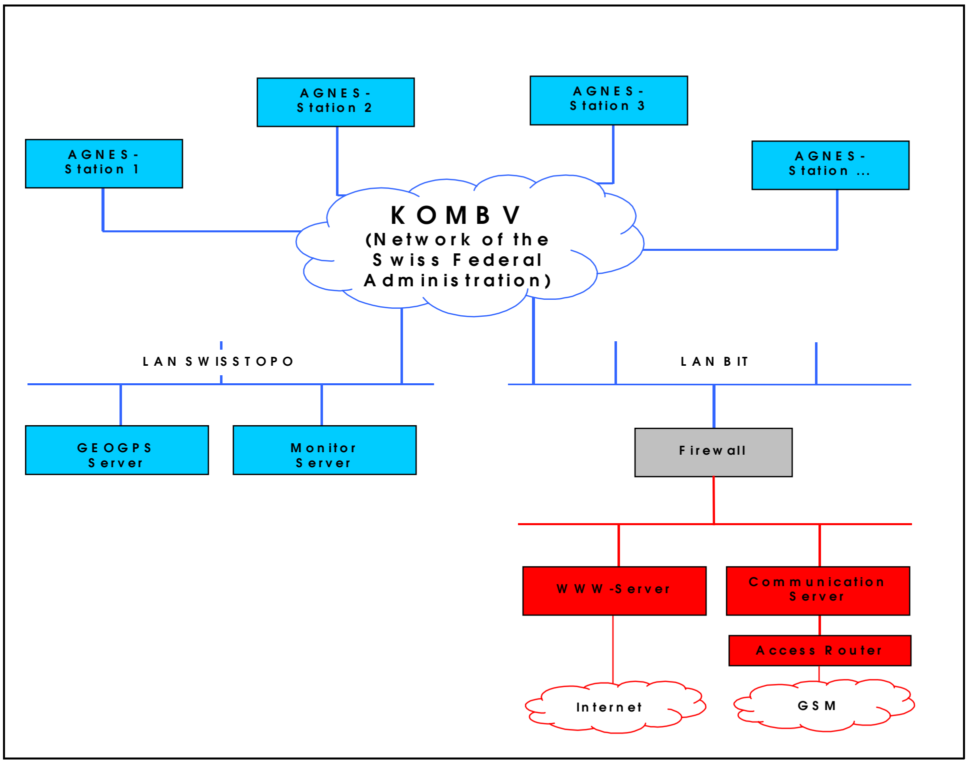

Fig. 5: AGNES real-time data communication

2.4 Concept of the *"swipos"* services

A study revealed the commercial potential of the GNSS differential positioning services in Switzerland. The market is divided into three customer segments for which three different products are available (see Tab. 2).

Tab.2: *swipos* products of *swisstopo*

Product	Accuracy (m)	Applications
swipos-NAV	1 - 10	navigation
swipos-GIS	0.1 - 1	GIS data collection
swipos-GEO	0.01 - 0.1	surveying

The first product ***swipos*-NAV** with a designated accuracy of 1-10 m (1 sigma) was developed for the general navigation user. This service was already introduced in 1995 (pilot project) and improved to a surface-covering service at the end of 1999.

The navigation corrections (RTCM 2.0) are generated at a permanent GPS tracking station and distributed over FM/RDS (Radio Data System) by the third chain of the Swiss Broadcasting Corporation.

The correction data are converted into an RDS-compatible format (DCI System) and subsequently encrypted to make the DGPS system proprietary. The user may subscribe to a yearly or a lifetime license. The DGPS service was originally offered on three different levels of precision (see Tab. 3).

Tab.3: *swipos*-NAV licenses

***swipos*-NAV** DGPS Service	Accuracy (m)
"Basic Service"	5 to 10 m
"Intermediate Service"	2 to 5 m
"Premium Service"	1 to 2 m

The "Basic Service" will no longer be provided because of the most recent developments in GPS policy (GPS without S/A). There are some 300 users which profit from ***swipos*-NAV.**

***swipos*-GIS** and ***swipos*-GEO** are designed for either GIS data collection or surveying applications. Two different modes of operation are planned: the user may collect GPS phase observations and perform post-processing by using RINEX data from the nearest permanent station (AGNES), or the data may be downloaded from the Internet: www.swisstopo.ch/de/geo/agnes.htm (see Tab. 4).

Tab.4: *swipos*-GIS/GEO: modes of operation

***swipos*-GIS/GEO** modes	Format /Files	Data transfer
Post-processing	RINEX 1, 5, 30 sec	internet
RTK (online)	RTCM 2.2	GSM (data channel)

Beginning in September 2000, GPS-RTK will be available over the real-time data network (KOMBV) and GSM.

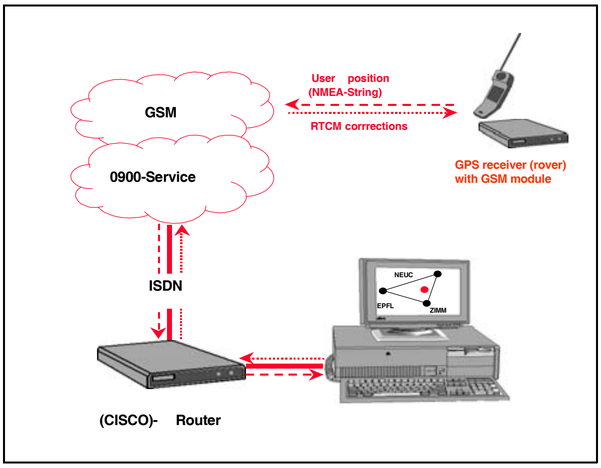

Fig. 6: Data connection of the GPS-RTK user with the AGNES communication server over GSM

2.5 RTK tests and first results

First successful tests of the AGNES pilot network using the concept of "virtual reference stations" [WANNINGER, 1995; WÜBBENA et al., 1996; VAN DER MAREL et al., 1999] were performed in May 2000. A Leica system 530 receiver connected to a GSM phone was used at the new AGNES station Payerne in the triangle Lausanne–Zimmerwald–Neuchâtel. Series of single baseline solutions from Zimmerwald (40 km) and Neuchâtel (20 km) were compared to the post-processing solution from AGNES (ground truth) and to the wide area RTK solution *(see Fig 7)*. The test showed the potential of the virtual reference station concept compared to the single baseline approach. It also prooved the feasibility of the real-time data transfer using the data communications network of the Swiss federal administration together with the GSM service.

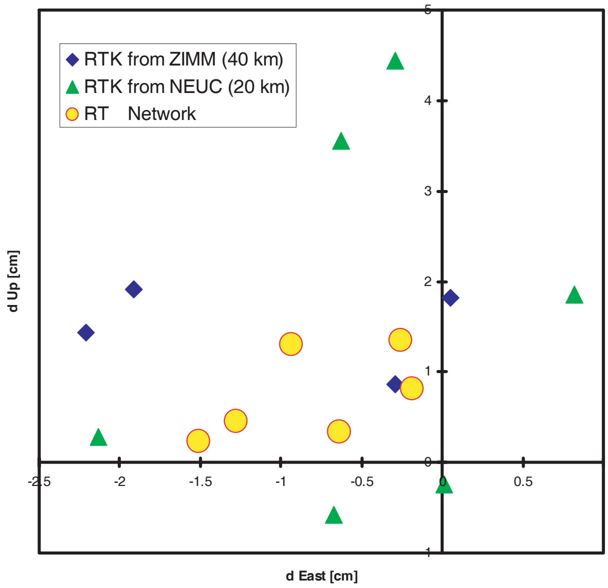

Fig. 7: First results of wide area RTK measurements in the AGNES pilot network

3 Progress in the Swiss National Height Network "LHN95"

3.1 Preparation of network and data

The concept of the new Swiss National Height Network LHN95 based on all precise levelling data of the last century and on the GPS reference network LV95 was already presented in the National Report 1997 [SCHNEIDER et al., 1997].

Since 1996 *swisstopo* has made a large effort to collect the old original levelling data from the archives. All 1st and 2nd order lines were treated back to the year 1902 and are now available in a database for the kinematic network adjustment. Besides the levelling and gravity data, the co-ordinates of all benchmarks were also digitized.

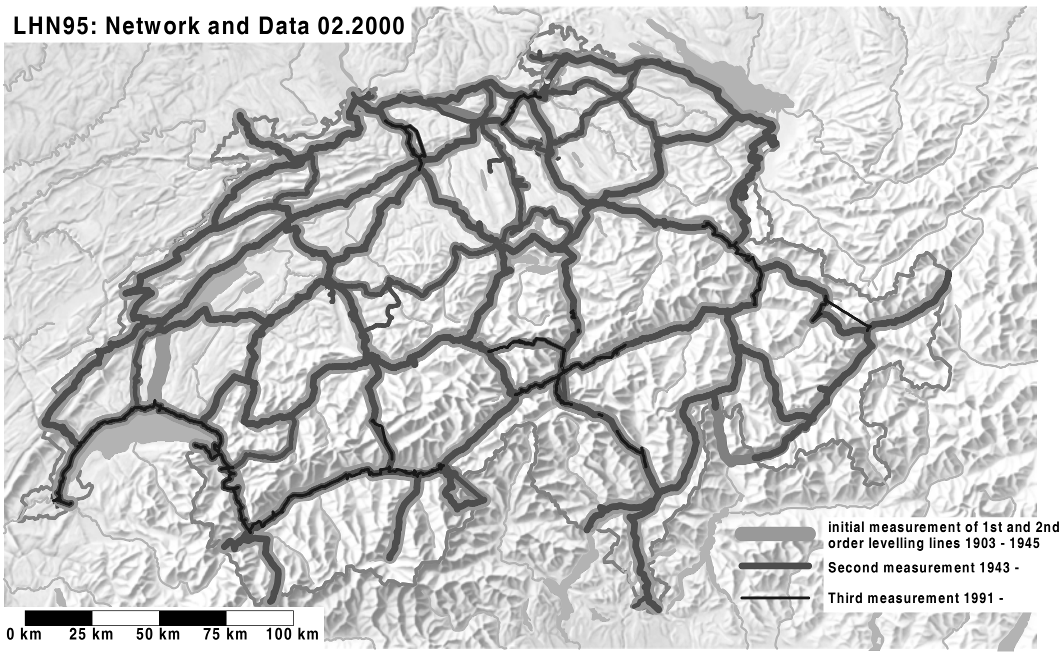

Fig. 8: LHN95: Network and data

3.2 Preliminary kinematic adjustments

In a first step the potential and the vertical velocities of the network nodes were computed. In order to compute the orthometric heights, observed or interpolated surface gravity values are used.

The results of the preliminary kinematic adjustment confirm the known pattern of vertical crustal movements in Switzerland and their geophysical interpretation [GUBLER et al., 1981]. In order to keep the results comparable to earlier investigations, the velocity of the same benchmark group at Aarburg (see Fig.9) is set to zero.

More details and a higher significance of the discrete velocity field is obtained from the kinematic adjustment of the combined 1st and 2nd order levelling network. The height changes are correlated with the tectonic map revealing highly significant uplifts over the entire Alpine arc, some zones of subsidence in the Jura and invariant heights in the Molasse Basin.

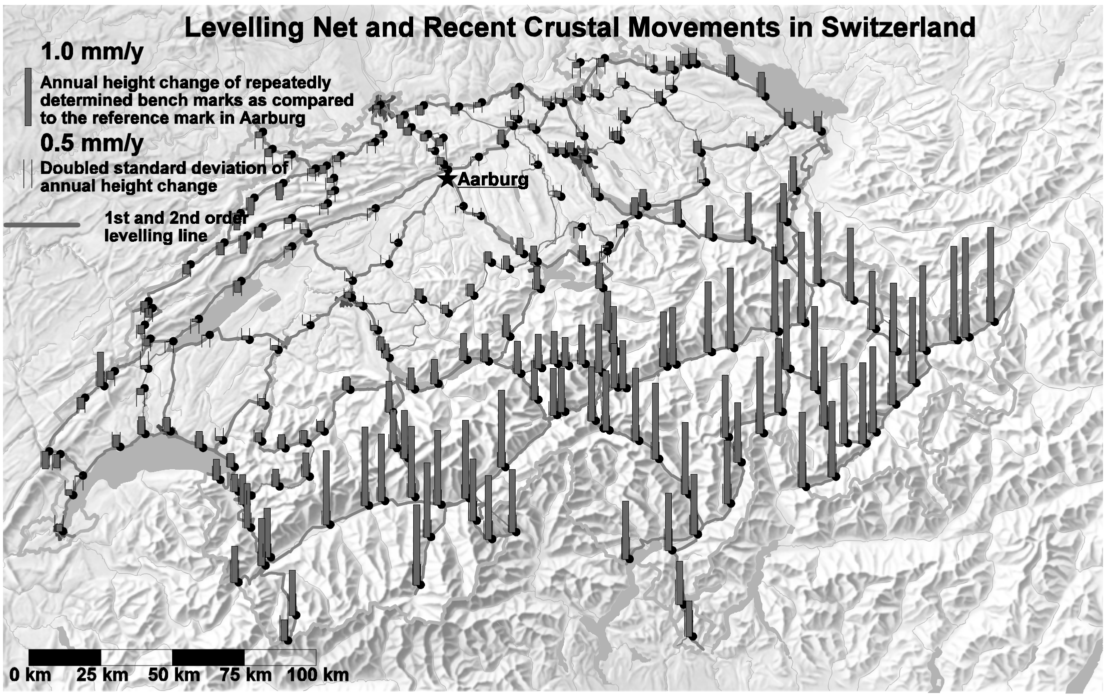

Fig. 9: LHN95: Vertical velocity estimates from preliminary kinematic adjustment

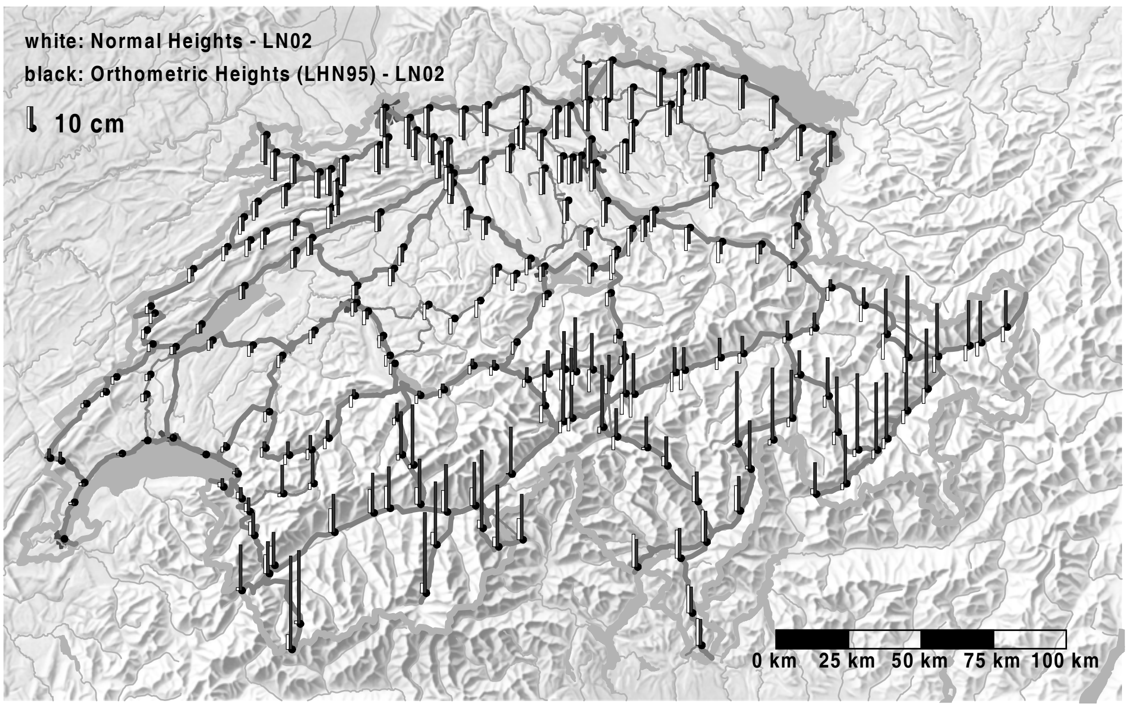

Fig. 10: Comparison of orthometric heights (LHN95) and normal heights with the old heights (LN02)

3.3 Comparison of various height systems

The decision for selecting the orthometric height system for CHTRF95 was already discussed in an earlier national report [SCHNEIDER et al., 1997]. The advantage of easier interpolations on the smooth surface of the geoid model, even in the rough Alpine topography, was the main reason for the choice.

However, LHN95 normal heights will be available upon demand. In order to estimate the consequences brought about by the introduction of the new system, height changes for both orthometric and normal heights with respect to the old system were computed (see Fig.10).

3.4 Application in large projects

First practical applications of the new National Height Network were found in the large tunnel projects AlpTransit Gotthard (length: 57 km) [SCHNEIDER et al., 2000] and Lötschberg (33 km) [SCHLATTER et al., 2000]. A simulation of systematic errors revealed that the maximum breakthrough errors given by the project engineers can only be observed when gravity corrections are applied. These corrections, which have to be applied to the tunnel levellings, are of the same magnitude for both orthometric and normal heights (see Fig.11).

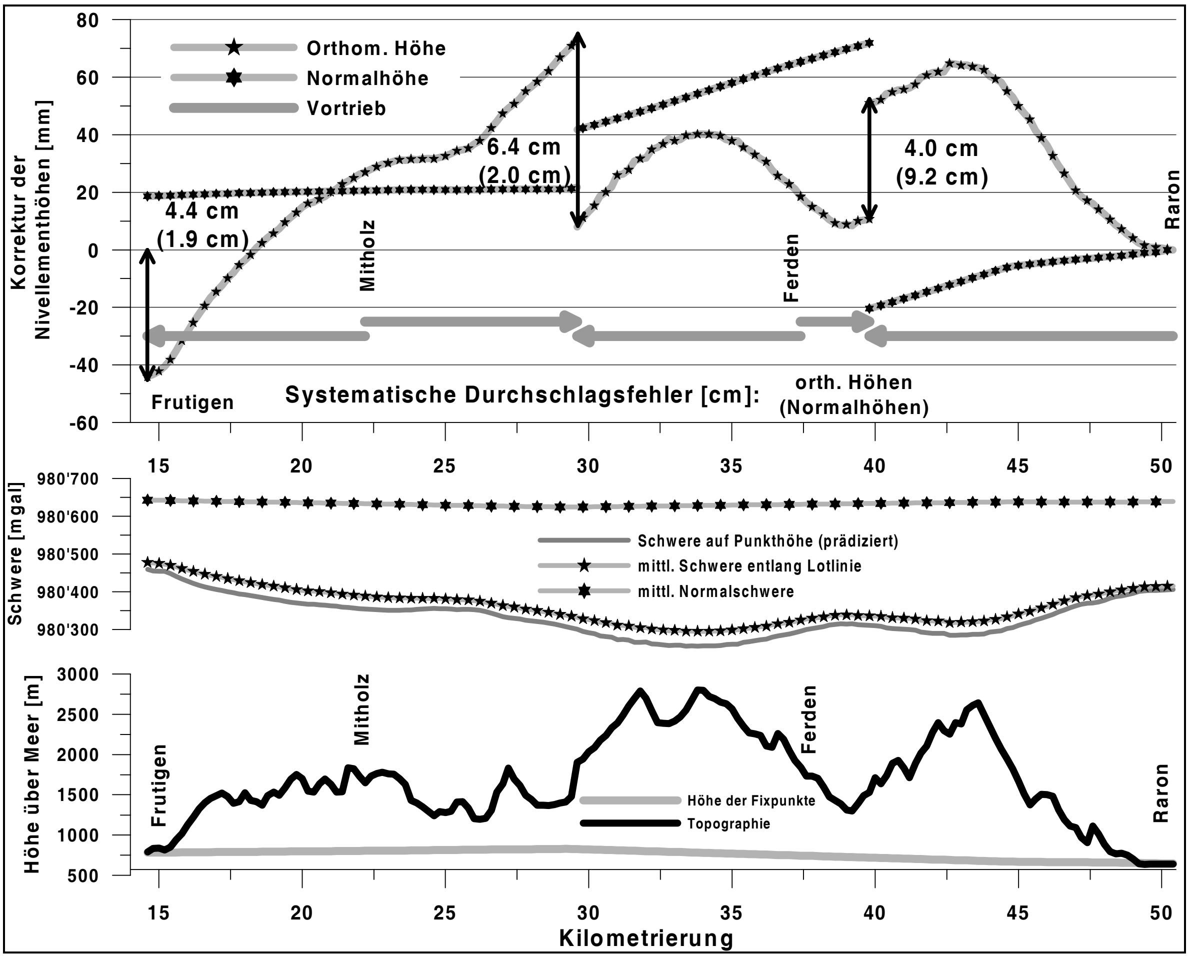

Fig. 11: Simulation of systematic breakthrough errors for the planned Lötschberg Base Tunnel using different height systems

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