SwissMetNet: The New Automatic Meteorological Network of Switzerland

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Abstract

The Federal Office of Meteorology and Climatology MeteoSwiss maintains the national meteorological and climatological network of Switzerland. The project SwissMetNet (SMN) was launched in 2001 with the goal to renew and unify the prevailing ground-based networks. The present contribution describes the principal ideas, concepts and designs underlying the new network.

1. Introduction

The Federal Office of Meteorology and Climatology MeteoSwiss maintains the national meteorological and climatological network of Switzerland. The measurements are used for various purposes such as monitoring of the basic meteorological parameters, meteorological warnings, input for numerical weather forecasts, and climate analysis.

In 1998 an inquiry among users and customers was carried out for evaluating the requirements for the future strategy of MeteoSwiss for the observations in a general sense, and more specifically for the new ground-based meteorological network. As a result, the project SwissMetNet was launched in 2001 to renew and unify the ground-based networks ANETZ (automatic network of 72 stations built between 1975 and 1989), ENET (extended automatic network of 44 stations for storm and avalanche warnings built in the 1990's), KLIMA (conventional network of 25 stations with human observations) and AERO (network for eye observations at 17 stations mainly used for civil aviation).

In the phase I of the project, the ANETZ stations are being renewed between 2005 and 2008. The remaining stations will be handled within the future Phase II (2008-2011).

As MeteoSwiss seeks to cover both meteorological and climatological needs with the new network, it must be taken into account that the renewal of automatic weather stations can have a large impact on the homogeneity of a climate series in terms of site relocation, instrumental characteristics, local data acquisition systems, reliability of the data transmission, data storage, etc.. Therefore, the broad technical and scientific knowledge based on experiences with the former (automatic) networks must be considered in terms of maintenance aspects, forecasting and climatic representativity. Furthermore, new findings gained with special scientific networks (e.g. GAW/BSRN radiation network) have to be considered and, if needed, integrated.

For the renewal of the ANETZ until the end of 2006, approximately 45 stations have already been renewed and are either operational or in test.

2. Building the new network

2.1 Meteorological/climatological criteria

The general outline of the new network in terms of measuring sites, station concepts and equipment has been defined in a new measuring concept based on the inventory of the clients' needs and operational constraints [1, 2].

For the replacement of the present automatic networks, three general station types were defined within the measuring concept. Each station was correspondingly attributed to one of the three station types according to meteorological and climatological (representativity; long time-series or reference station for other stations) criteria:

- WESTA B (Weather station 'basic'): fully equipped station with high quality sensors (see Picture 1) and high availability under difficult meteorological conditions.
- WESTA S1 (Weather station 'supplementary 1'): station with a reduced set of high-quality instruments with perfect operation and high availability under difficult meteorological conditions.
- WESTA S2 (Weather station 'supplementary 2'): station with a reduced set of instruments with lower requirements for quality and availability. New instruments can be introduced after a thorough functionality test.

Picture 1: View of the model Westa B SwissMetNet station located at Aigle, VS, Switzerland, representing a complete configuration, but without snow height measurements.

Before planning and constructing a new station, a careful evaluation of the actual technical and climatological characteristics for each former station is made during a meteorological visit on site and classified according to the general recommendations of the WMO [3] and more specific criteria issued by Meteo France [4]:

- Geographical and topographical classification and check of the immediate surroundings of a station
- Classification of the most important parameters (air temperature and humidity, precipitation, wind and solar parameters) according to a scale ranging from 1 to 5, where 1 was the best classification (fulfillment of all WMO recommendations) and 5 the worst classification (immediate impact on the measurements by artificial influences.

Although meteorological and climatological criteria primarily determine the site selection for a new station, many technical, financial, practical and legal aspects have also to be taken into account.

In order to avoid that the new network introduces a bias in a time series due to changes in location, new stations should be constructed at exactly the same sites, as long as the former sites have proven to be climatologically representative. In practice, a new station is either constructed exactly at the same location as the old one, or a few meters next to it or at a new site which could be located up to several kilometers away. For various reasons (space, topography, land ownership etc.) it is not always possible for the new station to be built at exactly the same site as the former one. It may happen that it will have to be completely dislocated. In the latter case a new site has to be found in the vicinity of the old one showing more or less the same meteorological conditions as the former one, although being several kilometers away in the worst case.

2.2 Visit procedures

Following the meteorological/climatological evaluation of each station, the visiting team makes one or more proposals for the location of the new automatic station which is then reviewed and approved in an internal inquiry at MeteoSwiss. After approval, the planning and construction works are initialized and performed under the direction of a general planning company selected by the Federal Office for Buildings and Logistics (FOBL) which is responsible for the construction and is the “owner” of the station.

It must be kept in mind that the goal stated by MeteoSwiss is to achieve the whole renewal of the networks without suffering any data loss. In other words, a continuous operation of the networks (old and new stations) must be guaranteed, which is a challenge in itself and a not negligible complicating factor during the installations at complex locations.

From the start of the planning tasks to the acceptance tests and official operation of the station, a typical time span of half a year is needed. During this time, one or more technical visits on the site, the planning of the fundaments and metallic structures, the electrical wiring (including telecommunications), the contractual negotiations with the land owners, the actual building, the site acceptance tests and the meteorological/climatological acceptance tests are carried out. In practice and on average, 20 automatic stations can be renewed per year.

When the new station is constructed at exactly the same place as the old one, additional planning efforts become necessary to bridge the construction phase with measurements from a mobile station.

2.3 Mobile stations

In places where space is restricted, the new station has to be built at exactly the same place as the former one. In such a case a temporary mobile station is needed in order to assure measurements during the construction and acceptance phase.

Picture 2: View of the mobile station installed nearby the SwissMetNet station at the Napf Mountain during construction in autumn 2006. The dedicated trailer (which can be transported by helicopter) may be seen at the bottom of the picture.

The mobile station measures the most important meteorological parameters (air temperature and humidity, precipitation, global radiation, wind speed and direction and air pressure) and is normally in operation for 4-5 months.

3. SwissMetNet – the new network

3.1 Configuration of the site facility

Most of the site facilities usually remain at the same locations in order to preserve the consistency especially for long climatological time series. However, efforts are made to reduce the number of distributed fields. For this reason, a normalized SwissMetNet field was defined as displayed in Figure 1. This allows among others to standardize all metallic infrastructures which simplifies the maintenance and reduces the costs.

3.2 Data acquisition system for automatic stations

The new automatic stations are equipped with an Automatic Data Acquisition System (ADAS) located on the field facilities which performs the measurements and collects, preprocesses and transmits the data to a central data acquisition system every 10 minutes (1 minute for special stations).

The Central Data Acquisition System and Network and Instrument Monitoring and Data Analyzing System (CDAS/NIMDAS) polls the data from the stations, monitors the network, the stations and their instruments and performs a first quality control, based on plausibility tables, to detect instrumental problems. The data are then transmitted through the Message Handling System (MHS) and then to the MeteoSwiss Data Warehouse System (DWH) where they are stored, quality checked and processed automatically or interactively. Direct data transfer for special applications is also possible.

The ADAS stations and CDAS/NIMDAS dual servers are building a single network which is delivered by the company Almos/Telvent.

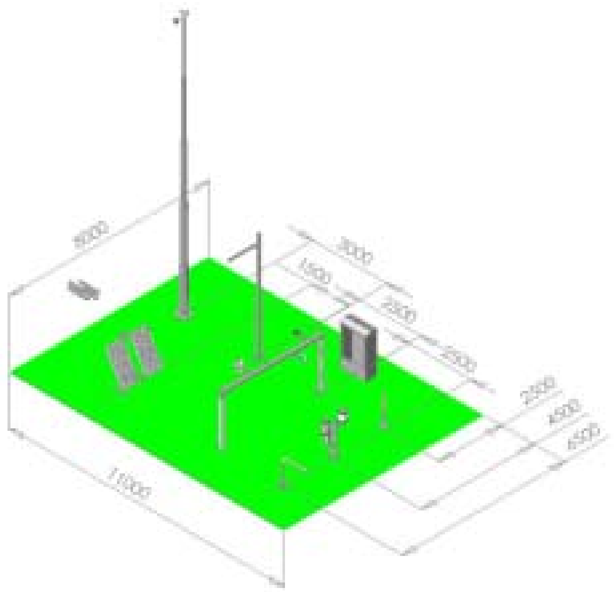

Figure 1: Schematic view of the SwissMetNet standard Westa B station whith the following setup looking from the north side: Wind mast, solar collectors, snow height mast measurement bridge and data acquisition enclosure, radioactivity, precipitation gauges and ground temperatures (see "live" application on Picture 1).

3.2.1 General System Architecture

The new system for automatic stations is based on client-server architecture with full transparency. Each station is considered as a client which communicates with the dual servers and exchanges data via TCP/IP sessions. The dual server architecture assures full redundancy in the case of a server breakdown. Any person logged on the network is able to connect to the central station (dual servers) and as such to each weather station (ADAS) from any access point on the WAN. This allows to perform remotely very powerful problem diagnostics and configuration changes.

The central server consists of a data acquisition part (CDAS) and a network and instrument monitoring part performing first plausibility checks on the data (NIMDAS). Data transmission between the stations and the central data acquisition system is established through the strategic telecommunications network of the Federal Office of Informatics and Telecommunications using fix line, internet and/or wireless technology from the station to the nearest access point of the network.

3.2.2 ADAS – Automatic Data Acquisition System

The Automatic Data Acquisition System (ADAS) installed in the enclosure of a station has the following characteristics and tasks:

- low power consumption
- monitoring of the instruments (see Table 1) and of the technical status of the station
- immediate raise of predefined meteorological alarms (e.g. wind alarms in a storm event) and of technical alarms in the case of ADAS and instrumental problems or configuration changes

Parameter	Unit	B	S1	S2
Ground temp.: -5, -10, - 20 cm	°C	(x)	(x)	
Luminosity	lux	x		
Pressure	hPa	x	x	x
Relative humidity	%	x	x	x
Air temperature: 2m	°C	x	x	x
Air temperature: 0, 5cm	°C	x	x	
Precipitation	mm	x	x	x
Rain detection	Minute	(x)		
Radioactivity	nS/h	(x)	(x)	
Short-wave incoming radiation	W/m2	x	x	x
Short-wave reflected radiation	W/m2	(x)		
Long-wave incoming radiation	W/m2	(x)		
Snow height	cm	(x)	(x)	
Snow temperatures	°C		(x)	
Sunshine duration	min	x	(x)	(x)
Wind speed	m/s	x	x	x
Wind direction	deg	x	x	x
Wind gusts	m/s	x	x	x
Redundant temperature	°C	x		
Redundant humidity	%	x		
Redundant precipitation	mm	(x)		

Table 1: Parameters measured at the different station types. (x) means that this parameter is measured only at selected stations.

3.2.3 CDAS/NIMDAS – Central Data Acquisition System

The main tasks of the CDAS/NIMDAS are as follows:

- data collection from the ADAS (meteorological, house keeping and alarm data) using a TCP/IP protocol
- forward the data in a bulletin format to the Data Warehouse (DWH) via Message Handling System (MHS)
- system monitoring (ADAS, instruments, communications, servers etc.) and alarm management including remote problem diagnostics and maintenance for each station
- first quality and plausibility check on the data for instrumental problem detection

Three main software packages are delivered by Almos/Telvent to fulfill all these tasks:
- MetConsole® for the functionalities of the CDAS/NIMDAS,
- MetEdit® for the configuration and settings of the system,
- MetQuery® for the data retrieval.

3.3 Station network and parameters

The parameter set measured at each automatic station is presented in Table 1. Some of the parameters are only measured at selected stations according to station type (low land or mountain station) or to specific requests from the customer, e.g. ground temperatures for agro-meteorological needs. According to the recommendations of the measuring concept, reliable instruments from the old networks should be preserved and new instruments be tested and compared to the former ones prior to operational use in order to assure the continuity of the climatological time series.

4. First Results from new stations

4.1 Method

The meteorological and climatological release of a new station is made after a statistical analysis of one to three months of data. Comparisons and plausibility checks are performed between the new station and the former station if still available, or the mobile station, or other neighboring stations if necessary. If the results are within a certain tolerance range, the station is released. If there are doubts about a parameter, the instrument and its measuring chain are checked at the station and if necessary changed.

4.2 Inter-comparisons

Good agreements were generally obtained when comparing former ANETZ-stations with new SMN-stations [5].

- Typical instrumental differences could be observed for global radiation, where the K&Z CM21 pyranometer at the SMN station is known for overestimating on the order of 5-10% compared to the K&Z CM5 at ANETZ-stations at high irradiance levels.

- Instrumental problems occurred relatively frequently for redundant relative humidity (underestimation of the ANETZ-sensor by 5-10% in comparison to the Rotronic or THYGAN-sensor of the SMN station).
- In the beginning, some problems occurred with the orientation of the wind sensors to the north and with the leveling of global radiation instruments. Both problems could successfully be detected with statistical analysis.
- Site-related problems could frequently be observed for +5cm/0cm-temperatures and ground temperatures. The first problem occurred because of missing ground vegetation (due to the construction works) at the new SMN-stations which resulted in higher maxima during the day (differences of up to 10 °C) and deeper minima (differences of up to 5 °C) during the night. Ground temperatures showed differences between SMN and ANETZ on the order of +3 to -2 °C, but generally showing a synchronized fluctuation. These differences can be explained by the fact that the SMN ground-temperature sensors are not yet in close contact with the surrounding ground material (higher amplitude at SMN-stations) and that some of the new SMN-stations had different ground- and therefore heat-conduction characteristics.
- Microclimatological differences could occur for sites with larger distances between former ANETZ- and SMN-station.

5. Conclusions

The construction and introduction of a new meteorological and climatological network requires a careful planning and realization to meet the required meteorological and climatological standards. These standards have to be clearly defined in advance. A continuous meteorological and climatological evaluation has to be made from the planning phase until the final release and official operation of the station.

A systematic data analysis between former and new stations with respective parallel phases must be part of the QA/QC efforts for releasing a new station. Such analysis prevents from introducing instrumental inconsistencies in a climatological time series and helps to explain site-related differences in view of homogenization efforts. Preliminary results from the introduction of the first 40 new SMN-stations show generally a good agreement between former ANETZ- or mobile stations and the SwissMetNet stations.

Though the renewal of the meteorological networks is by far not yet achieved, it can be already mentioned that the new SwissMetNet has already brought some major improvements in the fields of:

- maintenance, due to the high standardization of the components,
- monitoring of the network's state with the full transparency of the system,
- quality control of the whole network through the implementation of daily automatic procedures.

Future developments are planed such as the use of GIS tools for the spatial monitoring and quality control of the network.

References

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