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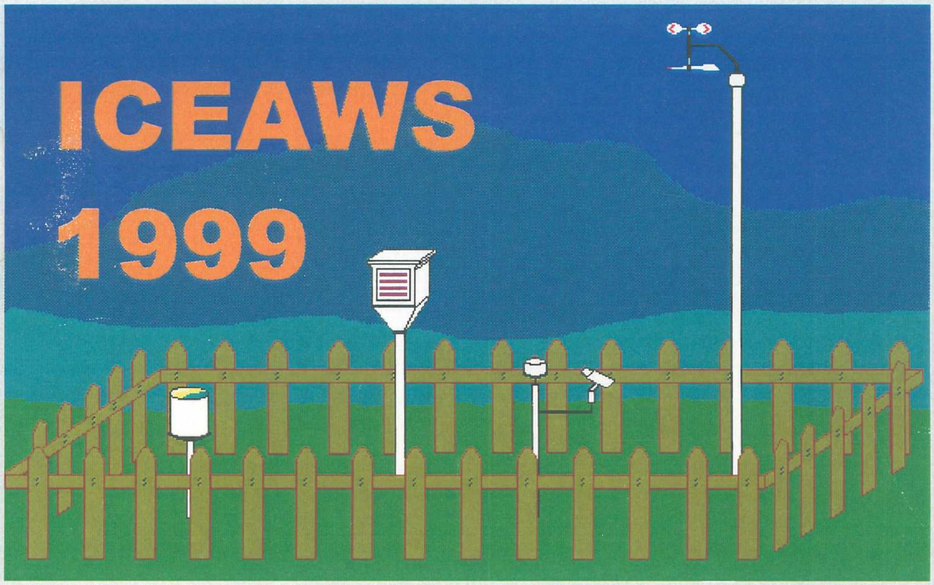
2nd International Conference on Experiences with Automatic Weather Stations



27 to 29 September 1999
Vienna, Austria

Central Institute for Meteorology and Geodynamics
Vienna, Austria

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FOREWORD

It is a pleasure for me to welcome all participants of this second International Conference on Experiences with Automatic Weather Stations and I am pleased that the ZAMG is able to host it again after the first conference in 1995.

The objectives of the conference are to open direct contacts between the different parties of the meteorological community - the technicians and developers on the one hand and the climatologists on the other hand. The first are primarily responsible for meeting the needs of users with their systems and algorithms and will give reviews of the different techniques and guidelines which are used to handle the data of AWS. The climate people are interested in addressing especially questions of quality, homogeneity and comparability of related data.

I want to underline the need for automation of all meteorological observations. There is a growing need for meteorological data in support of a range of activities such as environmental monitoring, transport, agriculture, manufacturing and construction industries, research and development, educational and recreational activities. As a result of these requirements, and recognising that it is often difficult to obtain manual observations at weekends and overnight, many authorities are turning to the use of Automatic Weather Stations. Due to increasing pressure of budgetary constraints we know that automation is also the main way of cutting costs to acquire data. Automation of surface weather observations reduces costs, increases areal coverage and provides data continuously at frequent intervals and for any observation time.

Because of many changes in sensor design, in observation techniques, in the interrogation time and data processing algorithms the new generation of weather stations will inevitably introduce inhomogeneities into the climatic record of sites with a long history of conventional observations. Data measured on the same place and with the same environmental conditions but by different systems usually show slight discrepancies. Due to one of the most important questions of today "Changing Climate?" there should be brought special emphasis on the homogeneity of the meteorological data series. This conference shall bring us some answers to these questions.

Peter Steinhauser

Director of Central Institute for Meteorology and Geodynamics

Vienna, Austria

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In the present volume the short abstracts of all contributions are published. The extended proceedings of the conference are published on a CD-ROM. This electronic form gives many advantages to the publisher and the user. The production is much cheaper especially using colour pages and the format and the length of the abstracts are not so limited than in a printed version. The CD-ROM will enable users to conduct more efficient and timely searches than the printed issues. One can search the tables of contents electronically and display the preprint pages on the screen or just print them.

Most of all I want to thank Hartwig Dobesch, Elisabeth Koch and Gabriele Seifriedsberger acting as local organizers and several other colleagues of the ZAMG, who had taken care of all the difficulties and the program planning from the beginnings to the end of the conference.

Ernest Rudel

Program Chairperson

SESSION 1
Experiences with Data of AWS

SESSION 2

Homogeneity in Time Series of Different Parameters when Changing the Meteorological Network to Autostations

SESSION 3

Present Weather Sensors and Manual Observations

SESSION 4

Criteria for the Quality Control and Management of Data of AWS

THE ROLE OF AUTOMATIC OBSERVATION SYSTEMS IN FUTURE DEVELOPMENTS WITHIN WMO PROGRAMMES

Peter Scholefield, WMO, Switzerland

On behalf of Professor Obasi, Secretary General of the World Meteorological Organization, I would like to say how much WMO welcomed this opportunity to be a co-sponsor of this important conference to demonstrate its commitment to improved observations of the atmosphere.

As you are well aware, Automatic Weather Stations (AWS) are but one of number of fully automated observing systems that WMO's National Meteorological and Hydrological Services are becoming increasingly dependant on for observations of the weather, water and climate conditions. Other automated observing systems include satellites, weather radar, wind profilers and even remote video cameras. The increasing pressure of budgetary restraint is a major driving force behind the proliferation of automated observing systems, which are considerably less costly to operate than the traditional manual observation programmes. Other advantages of automated observing systems are the accuracy of measurement for some parameters such as temperature and pressure and the increased frequency with which observations can be made available. The latter advantage is becoming increasingly important as the Internet's World Wide Web is becoming a popular source of weather information with the capability to provide near-instantaneous observations from all over the world. WMO, through its World Weather Watch (WWW), World Climate (WCP) and Hydrology and Water Resources (HWR) Programmes, is pursuing a number of initiatives to adapt and take advantage of the technological developments in the areas of automated observing and telecommunications systems. Of particular interest to this meeting, will be the results of recent ongoing work within the WWW programme to address the requirements and representation of data from automatic weather stations. An expert meeting on this subject was convened in De Bilt, Netherlands in April of this year by the WMO Commissions for Instruments and Methods of Observations (CIMO) and for Basic systems (CBS). Also represented were experts from the WMO Commissions on Agricultural Meteorology (AgM), on Climatology (CCl) and on Hydrology (CHy). Inadequacies relating to "present weather sensors", the application of WMO codes and the development of composite observing systems were among the principal topics discussed at the meeting. The Meeting agreed that an AWS cannot report visual observations in a manner comparable to a human observer nor should it do so because it observes and reports weather differently. Complicating the issue is the fact that there are no clear and agreed definitions of "present weather" and no clear statement of requirement of such data from users. To address this latter problem, the experts proposed a table of requirements relevant to WMO Programmes. The Meeting recognized the significant work on examining approaches and benefits of composite observing technologies. The experts considered that combinations of observations from various types of instruments could significantly reduce the need for subjective human observations to obtain a complete picture of the atmosphere within the next 10 to 20 years. However, surface point observations are still crucial for now and into the foreseeable future for in situ calibration and ground truth purposes. Despite limitations in the use of presently available WMO codes for transmission of some automatically-observed parameters, the experts concluded that not-yet-covered requirements should be implemented by using binary codes only. Furthermore, the Meeting was of the opinion that there is no need for the development of a code(s) which is specifically designed to encode automatically generated observations. It is noted that a number of the presentations at this conference will deal with the climatological use of data from AWSs, which is topic is particular concern within the WMO's World Climate Programme. At its twelfth session in August 1997, the WMO Commission on Climatology noted the shrinking meteorological observation networks on the one hand and on the other hand, the welcome growth of automated surface observations. It agreed with plans to include guidance on the management of climate data from automatic stations and metadata into the Guide to Climatological Practices. In cases where it is planned to automate an observation site, the Commission urged WMO Members to allow for a suitable period of parallel observations to facilitate the maintenance of a homogeneous historical climate record at the site, particularly for reference climatological stations including those in the GCOS Surface and Upper Air Networks. CBS, at its extraordinary session in October 1998, endorsed a set of best practices for Global Climate Observing System (GCOS) Surface Network Stations (GSN), which included providing a sufficiently long period of overlap with dual operation of old and new systems. This plea for an overlap when switching from manual to automated observing systems was reiterated by the CCl Working Group on Climate Data at its December 1998 meeting. It took a broader view in recommending compliance by WMO Members with the procedures adopted by CIMO to minimize inhomogeneities in the data when monitoring systems are changed at observing sites. This issue of declining climate observation networks has been raised to the international political arena through the Conference to the Parties (COP) to the UN Framework Convention on Climate Change (UNFCCC). In a decision at its fourth session in November 1998, the COP urged parties to undertake programmes of systematic observations, including the preparation of specific national plans and the use of best practices, such as those adopted for the GSN. WMO Congress, at its 13th session in May of this year was pleased to note this international attention to observing networks. However, it felt that the decisions of the Conference of the Parties do not adequately identify the important role of historical climate data and databases. Congress emphasized that urgent and sustained international action was needed to secure these historical data. Furthermore, it urged its Members to undertake measures to test the homogeneity of all long climatological time series they possess, to homogenize them as far as possible and to make such high quality time series available. It is evident from these recent high level deliberations that interest in historical data from AWSs will heighten as increasing amounts of AWS data enter into historical records.

In conclusion, there is widespread interest in AWS within the technical programmes of WMO and the future development of these programmes will become increasingly dependent on, not only the real-time output from AWS, but also on how the data are subsequently incorporated into the valuable historical records. Finally, I would like to extend WMO's appreciation to the Central Institute for Meteorology and Geodynamics for its support and initiative in organizing this second AWS conference which I expect will be just as successful or more so than the first one held here in May 1995. I look forward to joining you in these important deliberations over the next three days.

REQUIREMENTS OF DATA FROM AUTOMATIC WEATHER STATIONS

Ernest Rudel, Austria

There exist operational accuracy requirements and typical instrumental performance for most of the sensors used in autostations. On the opposite very insufficient definitions for present weather elements are available.

The paper deals with the present situation of determination of "present weather" with instrumental aspects, with the used procedures and algorithms and deficencies and requirements from the point of view of instrument developers.

AUTOMATIC WEATHER STATIONS IN ICELAND

Þordur Arason, Iceland

I will review the buildup of the Icelandic network of automatic weather stations (AWS). During this decade we have set up a network of simple AWS, and currently the Icelandic Meteorological Office receives data from over 100 AWS every hour. We also operate a few more sophisticated AWS. I will briefly discuss the quality control of the data from our AWS.

Furthermore, I will show examples of comparisons between data from AWS and human observations.

AWS DATA - NEW INPUT TO AIR QUALITY MODEL

Kathrin Baumann, Ulrike Pechinger, Matthias Langer, Erwin Polreich, Austria

In environmental modelling, meteorological preprocessors provide estimates of the atmospheric turbulence, stability and mixing height based on synoptic observations and radiosoundings.

Besides of temperature and wind data, the net radiation to ground is needed for heat flux computation. Conventional preprocessors parameterise the net radiation from cloudiness observations or sunshine duration data. From TAWES stations, measurements of the global radiation are available and may be used instead.

TAWES provides furthermore new parameters as e.g. ground temperatures. These may improve ground heat flux computation significantly.

Data quality and data availability are essential needs for this application. Experiences with a new meteorological preprocessor at the Department for Environmental Meteorology of ZAMG are presented.

COMPARISON OF DATA GENERATED BY AUTOMATIC VS. A TRADITIONAL WEATHER STATIONS

Vilma Castro, Costa Rica

During one year, measurements were done simultaneously by an automatic and a traditional weather station under tropical conditions (San Jose, Costa Rica). The results are presented.

EXPERIENCES WITH AWS IN THE CZECH REPUBLIC

V. Chalupský, L. Coufal, Czech Republic

The Czech service started developing the AWS in 1994 with the intention of replacing a part of its network of conventional climate stations manned by volunteer observers. After two years of development and testing, gradual construction was started, area by area. The objective is to create a network of some 80 stations; about one half of them have been erected so far.

The brief experience gained so far suggests a number of unquestionable advantages (for example, the accuracy and uniformity of measurement times; large volume of continuously read data; speed of data transmission and its variability; etc.). The observer is not totally excluded from the station's operation; he enters (by way of interaction with the control computer) values obtained by observations. Still at the station, these values are compared with measured values, and the observer is warned of evident or possible errors.

The homogeneity of the data obtained is obviously lost during wind measurements where the sensors used have a considerably higher quality, and all the more so because wind direction and velocity (force) was determined in the past by estimate. Similar problems (a completely different way of measurement) occur with relative air humidity and water vapour pressure. The experience collected so far is illustrated in graphs. The system's stability is provided for by regular sensor calibration.

The entire system (transducers, derived results, software) is described using block diagrams. Its applications under other than standard conditions are illustrated on examples (solar observatory equipment, measurements taken from a vessel in a water reservoir). The development and testing of new, better-quality sensors to expand the existing automatic measurements is envisaged.

The station constitutes the first link in a data collection, processing, presentation and archiving chain, with which it makes for a unified technological line.

RADOME: THE MÉTÉO-FRANCE SURFACE OBSERVING NETWORK

Pierre Gregoire, France

Météo-France has recently decided to expand his surface observing network to 500 stations. About 350 AWS will be added to the existing staffed stations. Hundreds of AWS are already installed but they don't belong to Météo-France and their quality and time permanence are not currently guaranteed. Quality objectives for RADOME have been set.

The main objective of RADOME is to be a tool for nowcasting but this network will also be used for climatology. Regional computers will concentrate the AWS data typically on a one hour basis and will allow the network administration and supervision to detect failures.

PRELIMINARY ASSESSMENT OF THE SPECIFICATIONS FOR FUTURE AUTOMATIC WEATHER STATIONS

L. De Leonibus, U. Vecchi, P. Pagano, Italy

In the framwork of the EUMETNET Programme on Observations, a project for the development of standard specifications for future Automatic Weather Stations has been set up.

The present scenario of use of AWS in EUMETNET countries is presented, with an outline of the architecture proposed for the final specification of AWS.

CLIMATE CONTINUITY OF WIND SPEED WITH ASOS

Thomas J. Lockhart, U.S.A.

It has been shown that the ASOS average wind speed and direction instrumentation meets the accuracy requirements stated by NWS. This accuracy statement relates to the point of measurement. The cups will measure and report the speed to which the cups are exposed. The vane will report the direction from which the wind blows at the vane location. The representativeness of these values is site specific.

It has also been shown that the peak wind speed will be underestimated by ASOS as compared to the CONV system (Lockhart, 1996). The Astoria, Oregon comparison suggested the range to be between 8% and 35%. The large range is a result of several differences. The CONV cup was at 6.1 meters while the ASOS was at 10 meters. They were 152 meters apart along the direction of the wind. Since the lower cup showed the highest speed, a correction for the height difference would make the speed difference larger.

If the NWS implemented the international WMO guidance (WMO, 1996), the ASTM standard (ASTM, 1996b), the ASCE standard (ASCE, 1995), and the AASC recommendation of a 3-second running average for peak wind speed, the ASOS peak wind speed would provide data closer to CONV. Lockhart (1997) reports the maximum difference between a 3-second running average and a 5-second clock average (ASOS) is 5% for a data sub-set from San Gorgonio Pass in California. A change of ASOS to the 3-second standard would soften the climate continuity impact for the important peak wind speed and it would comply with the standards which provide meaning to the value of a peak wind speed measurement.

AUTOMATION OF PRECIPITATION MEASUREMENT IN COLD CLIMATES

P.Y.T. Louie, J.R. Metcalfe, B.E. Goodison, and B.E. Sheppard, Canada

The measurement of precipitation using automatic devices still has many problems and challenges to be overcome before accurate and reliable measurements can be achieved. With the increasing trend in many countries to replace manual observations with the use of automated meteorological and climatological sensors and systems, there is a need to evaluate the reliability and accuracy of these new techniques especially with respect to precipitation in cold climates where solid and mixed precipitation measurements are more problematic and prone to larger errors. During the WMO Solid Precipitation Measurement Intercomparison study, automatic gauges (including weighing and tipping bucket types) were tested at several evaluation stations in Canada, Finland, Germany, and Japan. The WMO Intercomparison study provided an opportunity to investigate, identify the problems, and provide solutions to some of the challenges of using automatic gauges for winter precipitation measurement. This paper provides a brief summary of the results for automatic precipitation gauges used in the WMO Intercomparison study. It then focuses on Canadian experience with automatic gauges in measuring winter season precipitation and the current efforts in developing specifications and an evaluation process to select commercially available all weather precipitation sensors for use at Canadian climate stations which are being automated.

LONG-TERM COMPARISON OF AUTOMATIC WEATHER STATION (AWS) AND CLIMATOLOGICAL DATA

B. Gajar, D. Kubjatková, M. Ondráš, I. Zahumenský, Slovakia

The automation of the National Observing System (NOS) is the necessary step in the effort to increase the frequency of data, to improve the accuracy, consistency and other aspects of data quality. A very important part of the automation of meteorological stations is the comparison of data from both manned and automatic sources to estimate their accuracy, reliability and timeliness. Surface part of the National Observing System comprises of 27 professional meteorological stations with 23 VAISALA MILOS 500 Automatic Stations (AS) and 4 USA ESC 8800 AS.

SHMI developed an Integrated Meteorological System (IMS) that is used at all manned professional meteorological stations in routine regime. Automatic data check routines are run in IMS for internal validity and consistency of raw data. IMS processes the raw data and produces 1 minute, 10 minutes and 1 hour data sets as well as WMO routine messages (SYNOP, METAR) and national message (INTER). All messages are archived in National Meteorological Data Base - Climatological and Meteorological Information System (KMIS) which has performed comprehensive data quality control.

In 1996 a new project was set-up for Long-term Comparison of manually observed and measured data with those from AWS MILOS 500 and ESC 8800. The aim is to evaluate the accuracy and reliability of the automatic measurements of sensors connected to AWS and the accuracy and reliability of the manual measurements made by observers with the objective to find the proper strategy for the automation of the NOS in the future. The regular inter-comparison of meteorological data measured by traditional instruments and by sensors of AWS at all meteorological stations has been performed from August 1997. During 1998 further automation of data processing and reporting of the performance of the Project was done. Our partner in the project is VAISALA Oy.

The evaluation of the comparison is carried out separately for each station (three times a day) and for the whole network on monthly basis (necessary in order to study the temporal stability of differences). Data analysis has been made by the calculations of the monthly means of the statistic parameters (e.g. the bias, the standard deviation) for individual station and individual parameters and for whole network as well.

The results we have received so far demonstrate some important facts that will be incorporated in the national philosophy for automation of NOS. For example, some automatic measurements can completely substitute the climatological ones (the air pressure and the air temperature). However there is a need for more detail analysis of measuring procedures, more detail real time quality control procedures of measurements.

SET-UP AND REAL TIME QUALITY CONTROL OF DATA FROM THE AUTOMATIC HYDROMETEOROLOGICAL NETWORK IN THE BASQUE COUNTRY

M. Navazo, M. Maruri, J.A. Aranda, X. Gezuraga,
J.A. García, G. Pérez, y L. Alonso, Spain

In 1991 the SVM (Basque Meteorological Service) began the deployment and operation of an automatic surface hydrometeorological network, oriented mainly to supply data to the so-called PPI (flood prevention plan). Flood return periods are quite small in most of the short length hydrologic basins of the Basque Country oriented to the Cantabrian Sea. Meteorological surveillance of severe weather episodes in the area is also accomplished by a meteorological radar, owned and operated by the INM (Spanish Weather Service) and a Boundary Layer Profiler-RASS System, set up and operated by the SVM.

The network starting with 28 AWS, nowadays it has more than 85 AWS sparsed over the Basque Country (roughly 7000 km2), a quite high density network. The stations are equipped with several sensors (every of different design for the same variable), each with its own problems. Quality control and validation of data become quite complex tasks, when multiplying the number of sensors and the number of stations, specially when the network is still growing and changing its configuration due to scientific, technical and social requests.

Experience has shown that real time quality control of data is indispensable for data management and maintenance purposes. Most of the stations transmit meteorological and/or hydrological data every 10 minutes to the central control station in Vitoria, by radio, telephone or both , and those data are made available in real time by modem connection to registered users, and will also be available via Internet connection, in the next future.

The work to be presented shows the evolution and the adaptations made to the automatic quality control programs of the network stations data, from its start to nowadays, how this interacts with the database design and requirements, and how this is integrated today in the operational system. The methodology applied is based on procedural designs which apply different types of tests to the data and assign quality control flags, in real time. The most outstanding results obtained will be detailed, as well as some insight on future developments.

METEOROLOGICAL DATA FROM THE PORTUGUESE AUTOMATIC STATION NETWORK

Luis Filipe A. C. Nunes, Renato A. C. Carvalho, Portugal

The Portuguese Automatic Surface Network, initially constituted by 22 Automatic Weather Stations in 1996, is now operating with 47 AWS, and will continue to grow to reach 93 AWS in mainland and Azores and Madeira Islands. These AWS generate SYNOP reports plus 10 minute meteorological data, for several parameters, both to be transmitted hourly to the Central System at the Meteorological Institute headquarters in Lisbon.

This growing number of stations and the large amount of information, due to the high frequency of data production and transmission, has forced the implementation of a new system to process the data and to control its quality, in a more automatic and efficient way.

The main purposes of such a system are the AWS data management, at Central level, in order to its validation, to allow the preparation for long-term archive and to have data ready to supply users, plus the control of the AWS network performance.

Various levels of data control are being implemented, by using algorithms developed/ /adapted to filter the 10 minute data from AWS, with adequate criteria to identify suspect values and eventually to disregard wrong values. Those levels are constituted by real-time and non-real-time procedures, the 1st one filters data outside the instrumental range and is automatically applied within the AWS itself. In near real-time there is another level of control that is not fully automatic, because human action is needed to run computer programs that evaluates data availability, for instance, counts the number of reports received per hour and calculates the duration of data failure.

The 2nd level is applied after data retrieve via telecommunications networks, to check for data format and file structure and also to complement the instrumental checks level. At a 3rd level, climatological limits are applied, in non-real-time, to check the data in order to search for extremely high and/or low values. These climatological limits have been established for 6 geographic regions (4 in mainland, 1 in Azores Islands and 1 in Madeira Islands) for each month of the year, and calculations were made with 1961-90 series to find the corresponding extreme values.

Regarding deeper analysis of AWS data, further developments are being prepared to be applied as higher levels of control, behind the basic ones.

The 10 minute data to control are: atmospheric pressure at m.s.l., air temperature at the heights of 1,5m and 5cm, relative humidity, soil temperatures, wind speed and direction, rain amount and intensity and radiation.

AWS - DATA MANAGEMENT AND QUALITY CONTROL

M. Ondráš, I. Zahumenský, Slovakia

The present National Observing System (NOS) comprises a network of 27 Automatic Weather Observing Stations (AWOS). The strategy of combination of manned and unmanned stations both equipped with automatic weather stations of different configuration will prevail in future. Some of AWOS, depending on the importance and user requirements, are equipped with intelligent weather sensors. There is a clear tendency to use more and more intelligent weather sensors. For the decision making on future NOS in respect of automation 2 experimental polygons were set-up. These polygons are essential part of the experimental basis of two development sub-project regarding the automation of NOS. One is dealing with the long-term areal data comparison of automatic (from AWOS) and manned generating data. (In more details described in the presentation Long term comparison of AWS and Climatological Data, Gajar, Kubjatková, Ondráš, Zahumenský.) The second is dealing with the testing of existing methods, procedures, algorithms, data quality control of intelligent sensors and the development of more sophisticated procedures and algorithms of data processing and subsequent verification of them. (In more details described in the presentation Experience and data processing of FD12P and CT25K at SHMI, Ondráš, Zahumenský.) Other relevant sub-project of Automation of NOS is Climatological & Meteorological Information System, based on INGRES relational database, where further quality control, data processing and archiving is done. The brief outline of the structure of the Project of Automation of NOS in Slovakia from Data Management and Quality Control point of view:

I. Data Acquisition System

AWOS data processing:

Real time Quality Control (QC): Formal checks of AWOS & sensors (voltage, heating etc.), extreme values, time variability, consistency (cross checks between different met. parameters).

Calculation: data smoothing, averaging

Formatting: conversion and compilation of data messages

II. Data Processing System

Collection of the data messages (data files)

Data monitoring (Quality management I)

Data QC (near real time): completeness of data sets, consistency (internal, time), extremes.

Remedial actions: filling data gaps, data correction.

Data flagging (Quality management II)

Compilation of WMO coded messages and user messages

Control and comparative measurements

Data: presentation, storage, dissemination

III. Data Archiving System

Non real time QC: data completeness, formal checks, extreme values, data consistency (time, internal); Filling the data gaps; Data correction; Flagging.

THE IMPLEMENTATION OF THE DCP NETWORK AT THE ITALIAN METEOROLOGICAL SERVICE

P. Pagano, F. Avenali, L. De Leonibus, Italy

A DCP pilot network has been operational at the Italian Meteorological Service since 1984. Biulting up on that experience a new "second generation" DCP station, has been developed and the deployment of a first set of 50 stations is nearly completed.

A second set on 60 additional DCP stations, with the aim of having a final spacing of some 50 km for the surface observing network has been already purchased and the deployment is foreseen for the next two years.

The stations measure 12 parameters: atmospheric pressure, wind speed, wind direction, air temperature, air humidity, visibility, precipitation, soil temperature, global solar radiation, sunshine duration, snow depth, atmospheric discharges. The stations work both in automatic and semi-automatic way, allowing the insertion of data observed by the operator. A standard SYNOP message is formatted hourly from the observed data and transmitted to METEOSAT for further distribution via GTS.

The experience gained with the deployed stations and their characteristics together with an outline of the observing network are described.

CORRECTING RADIATION BALANCE DATA OBSERVED BY A MOBILE WEATHER STATION

Erwin Petz, Martin Piringer Austria

In environmental meteorology, dispersion categories are still widespread to characterize near-surface pollutant dispersion. According to OeNorm M9440, they are obtained by three different methods, one of them being a combination of radiation balance and horizontal wind. A one year time series of such data have been measured with a mobile weather station with automatic data registration at a location in southern Graz to calculate a locally representative statistics of dispersion categories at the site of a planned tunnel exit of a major road. The radiation balance data showed three systematic deviations from the course expected: 1.) a zero-point displacement due to spurious voltage of about 0,5 mV; 2.) radiation shielding effects because of a building south of the instrument relevant in the winter months; and 3.) negative values during daytime on days with snowcover (on the instrument). The presentation will focus on algorithms to correct these deviations. The resulting statistics of dispersion categories will be compared to a "conventional" one obtained via cloudiness and horizontal wind data

AUTOMATIC WEATHER STATIONS IN AUSTRALIA: A CLIMATE PERSPECTIVE

Neil Plummer, Australia

A brief history of automatic weather stations (AWSs) in Australia will be given. As with any major change in observation system, the introduction of AWSs into the Australian observation network has had both positive and negative impacts. The mechanisms in place to help ensure that there is minimal negative impact on the Australian climate record will be discussed. These mechanisms include: ensuring two years of comparison observations (for at least the Australian Reference Climate Station network) when an AWS replaces a manual station; three monthly meetings between observation networks managers, climate data managers and climate data users; and the development of an integrated quality monitoring system.

PORTUGUESE URBAN AUTOMATIC METEOROLOGICAL STATIONS NETWORK

V. Prior, R. Carvalho, Portugal

In the last year, the Portuguese Meteorological Institute decided to implement a national Urban Automatic Meteorological Stations Network. The network will be in operational mode in the end of 1999 and will consist in 19 meteorological stations, 5 regional concentrators and 1 national centre.

The criteria for the selected urban areas was mainly the number of inhabitants: 1 AWS per 50.000 inhabitants and 1 per 100.000 inhabitants for Lisboa (1.000.000) and Oporto (300.000)

The meteorological stations and the concentrators (Regional and National concentrators/ centre) will be installed in the following urban areas:
1 Braga, 3 Oporto, 1 Vila Nova de Gaia and 1 Regional Centre in Oporto
1 Coimbra with 1 Regional Centre
6 Lisboa, 1 Setúbal, 1 Odivelas, 1 Lavradio, 1 Queluz, 1 RC and 1 NC in Lisboa
1 Évora with 1 Regional Centre
1 Faro with 1 Regional Centre
1 Funchal (Madeira Island) with 1 Regional Centre

In the project we will use the DataTaker (DT50) acquisition systems, for wind measurements the R. M. Young sensors, for temperature and air humidity the Thies instruments, for global radiation the Kipp & Zonnen sensors and for the amount of precipitation the R. M. Young sensors. For data transmission between AWS and Regional and National concentrators we will utilise the GSM network. One Portuguese company in collaboration with the Meteorological Institute will develop the necessary software for data collection, processing and archive.

The basic meteorological data, namely the air temperature and relative humidity, dew point and wet bulb temperatures, precipitation amount, duration and intensity, global solar radiation and wind speed and direction will be organised in the regional and national concentrators in different data bases; from these data bases different kinds of visualisations will be possible. A set of meteorological data will be available for each station describing the meteorological conditions for different applications namely for urban weather watch, air pollution meteorology and climatological studies in urban areas.

For air pollution dispersion, the data available will be wind speed and direction at height of 6m, the wind direction standard deviation, air temperature and relative humidity and global solar radiation.

In order to support the weather forecast activities especially for warnings and civil protection actions, all AWS may be programmed to send alarm messages (for the beginning and for the ending) as far as certain established thresholds are reached for the following meteorological variables:

mean wind speed in 10min: 15m/s; instantaneous wind speed: 23m/s; total precipitation in 5min: 5mm; air temperature: 0ºC and 40ºC.

USE OF AWS DATA IN CLIMATOLOGY - EXPERIENCES AND PERSPECTIVES AT DWD

Reinhard Spengler, Germany

The automation of observation stations of the Deutscher Wetterdienst (DWD) started nearly ten years ago. This caused considerable changes concerning the use of the AWS data in climatology. Firstly, due to different methods and techniques of observation and data-collection in comparison with conventional procedures and secondly, due to the availability of new data of very high resolution (ten-minutes data, one-minute data).

Experiences at other National Meteorological Services indicated, that the automation would not work without any challenges. This was the reason why DWD initiated several mechanisms when the first AWS were in operation to receive objectively information on how AWS data are equivalent to conventional surface weather observation and to document the impact of the changes on the continuity of climate data.

In the presentation it is planned to show the impact and changes on DWD-data management, the use of new tools/procedures necessary for monitoring and improving the quality of AWS data and the experiences gained in managing AWS data.

The first part will demonstrate how to deal with gaps in time series, with changes in the periods of time to calculate maximum, minimum and mean values and with problems caused by missing visual observations which are usually used to check the internal consistency in data sets.

In the second part, it is planned to present the procedures and methods used, e.g., control measurements, continuation of conventional observations, additional quality control procedures for data of high resolution and methods of homogeneity checks. Related to those topics, results will be given of the meteorological parameters air temperature, air pressure, humidity, precipitation and wind.

Finally, the conclusions of the discussed experiences will be presented with regard to the development of the AWS within the DWD-project "Meßnetz 2000" and the related data management and quality assurance procedures. The plans of this project how to improve the data quality and continuity will be shown, as well as the expected difficulties with ongoing automation will be discussed.

COMPARISON OF PRECIPITATION TOTALS MEASURED BY AWS AND CONVENTIONAL RAINGAUGE IN THE WARM HALF-YEAR

P. Stastny, M. Tekusova, D. Bjel, Slovakia

The main aim of the presented paper is to estimate the degree of agreement between different methods (AWS measurements and conventional manual observations) used at professional meteorological stations in Slovakia. The results of observations are realized in the warm half-year of the years 1998 and 1999. The comparison of 24-hour precipitation totals measured by raingauges with corresponding integrated values of one minute totals from AWS has been made in our meteorological network.

Except the measurements mentioned above, we have chosen some simultaneous observations for detailed quantitative analysis of rainfall with different intensity and lasting.

The gained results are evaluated from the point of view of perspective use of AWS in climatological network so that homogeinity of rainfall measured will not be changed in the future.

The final part of the study concerns also the planed project concentrated on estimation of the differences between precipitation measuring by AWS instruments and evaluated digitized records of pluviographs.

ICING OF SENSORS

Bengt Tammelin, Finland

There is a growing need for meteorological data, and especially reliable wind measurements, in support of activities like design of high structures and wind power production located in region of cold climate. Ice free sensors are needed also to improve the meteorological services.

The EUMETNET had a project on Specification of Sewere Weather Sensors, coordinated by the FMI. The project studied icing effect on various meteorological measurements and possible regions of icing. Also a market study in ice free sensors was performed. According to the questionnaire sent to the National Meteorological Services icing of sensors is taken into account quite poorly. On the other hand there is an increasing need to erect automatic weather stations in icing conditions in various parts of Europe. At these site ice free sensors have to be used to be able to produce reliable meteorological data to be used by the meteorological services and applications.

The paper will present the key results from the EUMETNET SWS SWS project.

COMBINED AUTOMATIC MEASURING NETWORK FOR METEOROLOGY, HYDROLOGY AND ENVIRONMENTAL PROTECTION IN SLOVENIA

M. Tomazic Spiller, S. Zlebir, Slovenia

Hydrometeorological Institute of Slovenia is governmental institution, responsible for the monitoring of meteorological, hydrological, air quality and water quality monitoring. Beside classical observations and measuring network, automatic measuring network was set up some ten years ago. Network was developed and conceptually changed with time and nowadays we have a modern system of 46 stations, transfering measured data to our data base on half-hourly basis.

Configuration of the network is described in paper. Part of the network stations are combined, measuring meteorological, hydrological or environmental parameters at the same location. Airport met stations are also a part of the system. Data archive is based on Oracle relational data base. Different data quality-assurance procedures are fully or partially implemented and described: automatic data control, preventive maintenance, regular calibrations and network status information flow. Experiences with meteorological part of the network are given.

EXPERIENCE AND DATA PROCESSING OF FD12P AND CT25K AT SHMI

B. Gajar, M. Ondráš, I. Zahumenský, Slovakia

Automation of observing systems brings more uniform measurements, better reliability and a higher frequency of observations that are available in the real time. The crucial point in the development of new automatic weather station is to find new procedures and algorithms that would include special data processing of measured data in order to extrapolate the weather over a wider area.

Without automatic measurement of weather phenomena the automation is not complete. For this reason, FD12P present weather sensors were installed at four and CT25K ceilometers at eight MILOS500 automatic weather stations for a testing and development period. The main testing site is at Prievidza aviation meteorological station equipped with special hardware and testing system for this purpose.

The FD12P and CT25K data monitoring and comparison with the manually observed data is one of the tasks of the SHMI's sub-project regarding automation of the National Observing System. It deals with the testing of existing methods, procedures, algorithms, data quality control of intelligent sensors and the development of more sophisticated procedures and algorithms of data processing and subsequent verification of them.

Data from FD12P sensor and CT25K ceilometer are monitored and compared with manual observation in the real-time regime. Data analysis is performed in case of false alarms and false detection. The next step will be an evaluation of the results. Non-real time data processing is performed regularly day by day in tabular and graphical way. The reference observations for this purpose are the climatological and regular and/or high frequency special synoptic observations.

Some examples of preliminary results

FD12P

- In some cases rapid unreasonable increase of precipitation intensity;
- Rain in the form of small drops in case of light intensity is often interpreted as drizzle. As a result there is high frequency of drizzle during periods with only light rain;
- Snow in case of light intensity is often interpreted as snow grains. As a result there is high frequency of snow grains during periods with only light snow;
- The detection of solid precipitation is often incorrect (e.g. ice pellets reported as snow or snow grains; snow grains often reported in case of snow only).

CT25K

- Correct detection of the cloud height in case of well-defined cloud base.
- No detection of clouds with diffuse base or detection of vertical visibility instead.
- In case of uniform cloudiness there are cases with the rapid changes in the detection status and in the detected values.

DANGERS AND ADVANTAGES OF AUTOMATISATION CONCERNING HOMOGENEITY OF LONG-TERM TIME SERIES

Reinhard Böhm, Austria

Technological progress in instrumental equipment may increase the quality of measurements but on the other hand may also cause breaks in climatic time series. Based on experience gained by the project ALOCLIM (Austrian Long-term Climate) the presentation discusses both aspects concerning temperature and some other elements. The change to automatic sensors in Austria in the 1980s and 90s did not cause major inhomogeneities in temperature series, mainly due to the decision not to change the temperature screens. On the other hand the new hourly data of the automatic stations (50 hourly data sets of 10 years) could be used to do a high quality re-homogenisation of the early parts of long-term series which had many changes in observing hours. All kinds of calculation formulas (observing hours were not standardised in the early times of climatic measurements) can be compared now with the "true mean". The resulting inhomogeneities are quite large and can be removed now more accurately thanks to automatisation.

HOMOGENEITY OF AUSTRIAN SUNSHINE DURATION DATA SETS

W. Schöner, H. Mohnl, Austria

In the 80ies of the last century continuous measurements of sunshine duration were started in Austria. From the beginning up to the 80ies of this century Campbell-Stokes instruments were used. During this time period homogeneity of time series is determined by station relocations, changes in the station surrounding, servicing of the instruments, changes of interpretation guide lines and changes at the Campbell-Stoke instrument (glass sphere, paper). Starting in 1981 an automatic climatic monitoring system was established in Austria. In course of time the sunshine duration recorder by Campbell-Stokes was replaced by the electronic sensor Haenni Solar at 50 sites. In December 1998 135 instruments of the opto-electronic prototyp have been in operation. This modifications in the measuring system may cause changes in recorded time series with respect to their homogeneity. Our experiences show that both the documented breakpoints and the non-documented breakpoints in Austrian sunshine duration series can be homogenised. For homogenisation of non-documented breakpoints we used relative homogeneity tests and a ratio correction method. The first part of the paper summarises our experiences regarding the homogenisation of available long-time series in Austria. The second part of the paper reports on the considerable divergences between the data series obtained by the Campbell-Stokes and the Haenni-Solar systems. Intercomparisons show differences which are caused by different technical features.

THE DATA INHOMOGENEITY PROBLEM AS ALTERNATIVE SEARCH TO RANDOMNESS

Raymond Sneyers, Belgium

The theoretical problem raised is a quite general one, the solution of which is valid for any data acquisition process. The fact that, on one side, the process is traditional and, on the other side, an automatic one, makes no difference. The single question is the determination of the relation bounding the one to the other the two observation procedures and of the stability of this relation.

In this paper, it is shown that, on the statistical point of vue, the solution of this problem is obtained with testing against appropriate alternatives, the assumption of randomness of the differences between corresponding observations provided by each procedure, and this, in the non- parametric rank case. The considered example concerns the extreme temperature values given by an automatic station and by traditional thermometer readings.

EVALUATION OF SOLFEGE PRESENT WEATHER SYSTEM CAPABILITIES

J. L. Gaumet, F. Zanghi, France

Météo-France is moving towards the definition of a fully automatic observation network, likely to take charge of all the meteorological parameters currently observed within the world weather watch.

In this paper, will be discuted three instruments connect to the SOLFEGE automatic present weather station (the precipitation identifier device, the state of soil identifier and a visibilimeter), and in addition the software called VAMOS which has been developed for merging all the sensor information. It runs in a fully automatic and unmanned manner and produces real-time reports on the local sensitive weather.

The message delivered by instruments are as identical as possible to the human observations, especially in the field of precipitation recognition : Detection, identification (rain, drizzle, snow, hail and the qualitative intensity), freezing nature of the rain/drizzle, characteristic (shower, continuous/intermittent).

Two kinds of qualification are currently underway for the SOLFEGE project :

A « sensor oriented » qualification which allows to test and qualify individually each new equipment.

A « user oriented » qualification performed in « Centre-Est » Region, with a network of 4 SOLFEGE stations around the regional Météo-France Forecast Centre of Lyon.

Consequently, statistical results which show that present weather stations can provide very useful informations to forecast, especially by night, will be presented in this paper.

ASOS BLOWING SNOW ALGORITHM

Richard N. Parry, M. Douglas Gifford, U.S.A.

The ASOS precipitation identifier sensor (**L**ight **E**mitting **D**iode **W**eather **I**dentifier, LEDWI) discriminates between rain and snow based on the apparent fall velocity of the precipitants passing through the sample volume. During blowing snow episodes, the LEDWI may report rain due to the increase in apparent fall velocity of the snow. To prevent the incorrect reporting of rain during these episodes, a multi-sensor algorithm has been developed to evaluate the meteorological conditions and report blowing snow when appropriate. The paper examines the logic used to arrive at an ASOS output report of blowing snow.

QUANTITATIVE ICE ACCRETION CAPABILITIES OF THE AUTOMATED SURFACE OBSERVING SYSTEM

Allan C. Ramsay, U.S.A.

The capability to reliably report freezing rain has been developed over the past decade. The Automated Surface Observing System (ASOS) currently has over 600 sites equipped with Rosemount 872C3 Ice Detectors.

These sensors are used in conjunction with the output from the precipitation identifier sensor to report the occurrence of freezing rain.

This paper describes an algorithm which was developed to quantify the amount of ice accretion on various surfaces.

Results of the algorithm can be tailored to meet the needs of the intended customer.

A MULTI-SENSOR FREEZING DRIZZLE ALGORITHM FOR THE AUTOMATED SURFACE OBSERVING SYSTEM

Allan C. Ramsay, U.S.A.

The Automated Surface Observing System (ASOS) currently uses the Rosemount 872C3 sensor to detect ice accretion. When the precipitation identifier sensor (**L**ight **E**mitting **D**iode **W**eather **I**dentifier, LEDWI) confirms the presence of liquid precipitation, the ASOS reports a freezing rain event.

The Rosemount sensor is capable of detecting ice accretion during periods of light drizzle which cannot be detected by the precipitation identifier sensor.

This paper explains the multi-sensor algorithm developed to infer the presence of freezing drizzle which would otherwise go unreported.

The algorithm is also capable of distinguishing between rime, glaze, „wet" snow, and frost.

CAPABILITIES OF THE ASOS IN DETERMINING PRESENT WEATHER AND VISUAL OBSERVATIONS

M. Douglas Gifford, U.S.A.

The Automated Surface Observing System (ASOS) is the primary means of providing surface observations to the aviation community in the United States.

While the system utilizes many sensors to produce an automatic output, approximately half of the operational ASOS sites also rely on human interaction to produce the final official observation.

This paper outlines the current and future capabilities of the ASOS in reporting present weather phenomena, obscurations, visibility, and runway visual range.

Supplemental hydrologic data and climatological information are also discussed.

FIELD EVALUATION OF A SINGLE-SITE LIGHTNING SENSOR ON THE AUTOMATED SURFACE OBSERVING SYSTEM

Allan C. Ramsay and William Whisel, U.S.A.

The Automated Surface Observing System (ASOS) will implement the use of National Lightning Detection Network (NLDN) information in the near future. In order to begin automated reporting of thunderstorm activity at unmanned sites, the National Weather Service decided to employ the Global Atmospherics, Inc. (GAI) Model TSS924 lightning sensor. This paper describes a comparison of the TSS924 sensor data to an on-site observer's reports. An additional comparison between the TSS924 output and National Lightning Detection Network data is also discussed.

PHOTODIODE PYRANOMETERS IN CLIMATOLOGICAL MEASUREMENTS

Vilma Castro, Costa Rica

The advantages and disadvantages of photodiode sensors (Li-Cor LI200S) used as radiation sensors in automatic wheather stations, as oposed to traditional actinographs or expensive radiometers, is studied through statistical analysis of data. Their suitability for climatological measurements is assessed.

CLIMATOLOGICAL HUMIDITY MEASUREMENTS IN THE TROPICS USING LOW COST DRY-WET THERMISTORS

Vilma Castro, Costa Rica

Electronic devices for air humidity measurements with hygroscopic capacitance sensors were tested for periods longer than a year under tropical conditions in Costa Rica. Some of them showed a calibration drift that produced errors as high as 20% relative humidity after several months of use. To present a low-cost alternative for electronic air humidity measurements, two thermistors were used as wet-dry thermometers. It was proved that thermistors are appropriate to be used year after year in a very practical way, without replacement or recalibration.

EFFORTS TO ESTABLISH STANDARDS FOR SURFACE MESONETS OBSERVATIONS IN SPAIN

A. Ezcurra, A. Guerra, C Almarza, J. A. Aranda, A. Riuss,
J. Cunillera, M. Donezar, E. Roca, Spain

In recent years Spain has gone from being a country with relatively sparse surface observations to one that has a number of mesoscale networks maintained by a variety of official institutions. Many of the mesonets are dedicated to the field of agricultural (including forest management), air pollution, hydrology but some are on others field as well. In general we can pointed out that the common cause of this development is the increase of appreciation for the applications of meteorological measurements for a variety of uses and the reduction on instrumentation costs. Most of this new networks has been deployed in rough areas in which values of meteorological surface variables presents a great degree of horizontal variability and are affected by locally phenomenology. Yet the meteorological community is no generally aware of these data sources, and some potential research use of these data are not realized. This paper primary presents a survey of these mesonets to illustrates their location, their mainly application, the number of stations and their general characteristics. One of the conclusion when regarding characteristics of networks is that all networks have diverse standards for their measurements. In particular this situation is reflected in the different heights at which meteorological measurements are carried out and the different characteristics of sites where stations are located that can strongly affect meteorological measurements. Then difficulties of using or combining data from different sources with different standards pose a problem for meteorological applications. With this regard a panel of discussion has been recently initiated in Spain by several institution that maintain meteorological networks in order to establish some recognized common standards for calibration and quality control of data. One of the first conclusion of this panel is that there is a great need of supplying no only the meteorological data but also associated metadata information as type of instrumentation, data-processing and local site conditions when meteorological data providers are aware about quality standards of their meteorological data base.

QUALITY CONTROL ALGORITHMS USED IN THE AUTOMATED SURFACE OBSERVING SYSTEM

M. Douglas Gifford, Richard N. Parry; U.S.A.

The Automated Surface Observing System (ASOS) was developed as a multi-agency effort to support aviation operations in the United States. Accurate, timely reporting of weather parameters is of primary importance in the operation of the ASOS. Therefore, automated algorithms have been implemented to monitor the quality of sensor data prior to their use in calculations of weather parameter values. These data quality control (QC) algorithms are designed to remove erroneous sensor information while retaining valid sensor data.

QUALITY OBJECTIVES FOR RADOME

Michel Leroy, France

Quality objectives have been explicitly defined for RADOME, the Météo-France surface observing network. The maximum measurement uncertainties have been defined for wind, temperature, humidity, solar radiation. Instrument characteristics are not the more important factors for the quality of measurements. The site environment is the major problem. WMO recommendations for instrument sitting are not always followed, especially when numerous AWS have to be deployed. Météo-France has defined a site classification from 1 (WMO recommendations) to 5 (never to be done).

The existing RADOME sites have been documented. Météo-France recognizes that we are not able to set up the only class 1 stations and we allow class 2 or class 3. Despite this, numerous stations will be moved because of a bad environment. This approach and the status of the network will be presented.

QUALITY CONTROL AND DATA MANAGEMENT AT THE AUSTRIAN DEPARTMENT FOR CLIMATOLOGY

Wolfgang Lipa, Austria

To receive quality checked and completed Austrian current climate data sets as soon as possible a data-correction group was formed in October 1997. Their task is to take the 10 minute values and create hourly and daily data sets, to check and complete them and calculate regional hourly data sets. The differences between synoptic and climate data are caused not only by the fact of data-checking, but also by the definition. Synoptic data are data of today, climate data are all data sets older then one day.

At midnight, the computation starts with building hourly data sets for each Austrian online-station as well as for the nearest foreign synoptic-stations. When data checks are running error messages will be produced, and regional hourly data sets will be generated containing peak values of temperature and wind speed for example.

Early in the morning, all hourly data from the day before are calculated and flagged in special data tables.

The checking, correction and completing procedures are running with a special GIS application, which will be presented by R. Potzmann in "data control and visualisation with a desktop GIS".

The main topic of this contribution is the description of data-check rules, flag control and their computer implementation.

The procedure supports our own consultants as well as clients like insurance companies etc. with a checked and completed topical data sets including quality flag values.

AWS MEASUREMENT IN THE EXTREMAL CLIMATIC CONDITIONS OF THE HIGH SUDETES, POLAND

Krzysztof Migala, Mariusz Szymanowski, Poland

The AWS system was applied in the Meteorological Observatory at Mt. Szrenica (1362 m a.s.l.), in 1993. The Observatory works from the late fifties and is situated on main ridge of Karkonosze Mts. (the Sudetes), where hard rime occurs during 7 months per a year.

Not all the sensors offered in the world market are able to work correctly there and some technical ideas were applied to avoid troubles. In order to maintain a homogenous measurement series, parallel measurements with traditional methods are still conducted.

VAISALA WIND SENSOR TESTING

P. Nejedlik, S. Handzak, P. Stastny, Slovakia

The Instrumental measurement of wind data at Slovak Hydrometeorological Institute (SHMI) in the last thirty to forty years was based on the anemograps METRA (FUESS - type) with the analogue record. The instrument were well maintained and in the beginning of eighties a uniform procedure of half automatic data processing was introduced. Spreading the VAISALA automatic weather stations at SHMI in the recent years the technology of wind data acquiring has changed in sensors, methods of data recording, data transport and final data management, as well. This article deals with the wind data comparison produced by both METRA and VAISALA anemographs placed under the same exposure. Though the differences in the final comparison has underline the necessity of the sensors and data processing testing (preferably parallel measurement) before the instrument change.

APPLICATION OF TAWES DATA FOR EMERGENCY RESPONSE MODELLING

U. Pechinger, M. Langer, K. Baumann, Austria

In case of an accident at a nuclear power plant in the vicinity of Austria meteorologists are asked, whether, when and where eventually released nuclear material will affect Austria and which concentrations and depositions are to be expected. In addition to modelling the large scale transport and dispersion based on the ECMWF forecasts, the data from the automatic meteorological monitoring network TAWES of the Central Institute for Meteorology and Geodynamic are used for impact assessment. The 10 minute averaged TAWES data provide the real-time input for calculating diagnostic wind fields and trajectories. The results of a diagnostic wind field model strongly depend on the quality, density and representativity of the input data in the area of interest. Results of the wind field model and on the representativity of the TAWES wind data are presented.

DATA CONTROL AND VISUALISATION WITH A DESKTOP GIS

Roland Potzmann, Austria

Because of the enormous amount of data that is delivered by AWS's an automatic and computer-assisted data-examination is indisputable. The automatic procedures can recognise only errors within the narrow bounds of its 'intelligence' however, and at best can suggest corrections or supplementations. The final control, completion of lacking data and correction of error values remains in the responsibility of the meteorologically experienced specialist. A tool therefore should be offered with which he is able to get all relevant information (station-data, radar-pictures, satellite-images). In the climate-department of the ZAMG ARCVIEW has been used, it enables to combine most different data-sources (point-data, images, grid data) in a simple manner.

The program-package GEKIS (Geographic Climate Information System) consisting of MS ACCESS for the tabular representation and database-connection and ARCVIEW for the spatial representation will be demonstrated in a live-presentation.

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