

***Pilot implementation of a BUFR exchange of reports from
Automatic Weather Stations (AWS), including present
weather parameters***

Final Report June 2003



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Date: June 2003

Final Report project PWS-GTS June 2003

0. Summary

The main objective to start up a pilot hourly exchange of AWS BUFR reports containing PWS data has been realized in budget and in time.

The chosen BUFR software from OPERA proved to be adequate to perform its task though some additional features needed to be implemented.

The BUFR template as developed in cooperation with the WMO Expert Team on DR&C was designed in a way that all currently available AWS data could be assimilated.

It has been recommended to further implement the use of BUFR within EUMETNET and WMO by extending pilots as this to more countries and by establishing a new EUMETNET BUFR project, including appointment of a BUFR coordinator.

1. Participation and meetings

From 5 countries which agreed to participate actively in the project finally three participated effectively in the pilot exchange: the Netherlands, Slovakia and Czech Republic (2 of which are not a EUMETNET country). Germany planned to start generation of BUFR messages by July 2003. France participated at first but left the project before the pilot exchange became effective.

A meeting has been organized to discuss the feasibility to use the EUMETNET BUFR software for other EUMETNET projects like PW-GTS and possibly as a standard software package for the WMO migration plan. This meeting was held at 5 November 2001 in Paris and was attended by Joël Martellet (WMO), Claude Pastre (EMN/CO), Konrad Köck (OPERA), Bernd Richter (WINPROF), Dick Blaauboer (PWS-GTS).

During the project most communication was done by email. One formal project team meeting was held 11-12 February 2002 at De Bilt, the Netherlands. The meeting was attended by Eva Cervena (CHMU), Igor Zahumensky, (SHMU), Michel Leroy and Fabrice Zanghi, Météo-France, Piet de Vries, Lex Snijders, Dick Blaauboer, KNMI. During this meeting most of the preparing discussions for the BUFR template has been conducted.

2. Project description and objectives

During its 12th session in Nov-Dec 2000 the WMO Commission of Basic Systems (CBS) (from CBS Newsletter December 2000) *“agreed that BUFR and CREX would be the best means for reporting the full range of observational data from Automatic Weather Stations without deviating from existing WMO recommendations and procedures. The Commission agreed in principle on a strategy to migrate the users to table driven code forms for all surface and upper-air data and agreed on long-term milestones leading to gradually phasing out the use of the traditional character codes. The Commission recommended additions to FM 94 BUFR and FM 95 CREX Tables to improve the transmission of data from automatic stations, especially related to present weather.”*

As a result an Expert Team on Migration to Table Driven Code Forms (ET-MTDCF) has been established.

Furthermore:

“Driven by the need to improve their observing capabilities while decreasing their costs, most EUMETNET Members are conducting activities to automatise rapidly their surface networks. In addition, mesoscale analysis and nowcasting activities are expressing requirements for more frequent collection and exchange of observations (at least hourly for international

exchange with neighbouring countries). This context provides a strong incentive to develop a more efficient exchange of data from automatic stations based on table driven codes developed by WMO (BUFR and CREX)."

Therefore the objective for this EUMETNET project was: **to conduct a pilot implementation of GTS hourly exchange of AWS reports, including automatically measured present weather elements, using BUFR. The starting date for the exchange will be December 1st, 2002.**

It was expected that the work done in this project was closely related to the work done in the ET-MTDCF and therefore the Project Manager, also being member of the ET, was responsible for mutual cooperation.

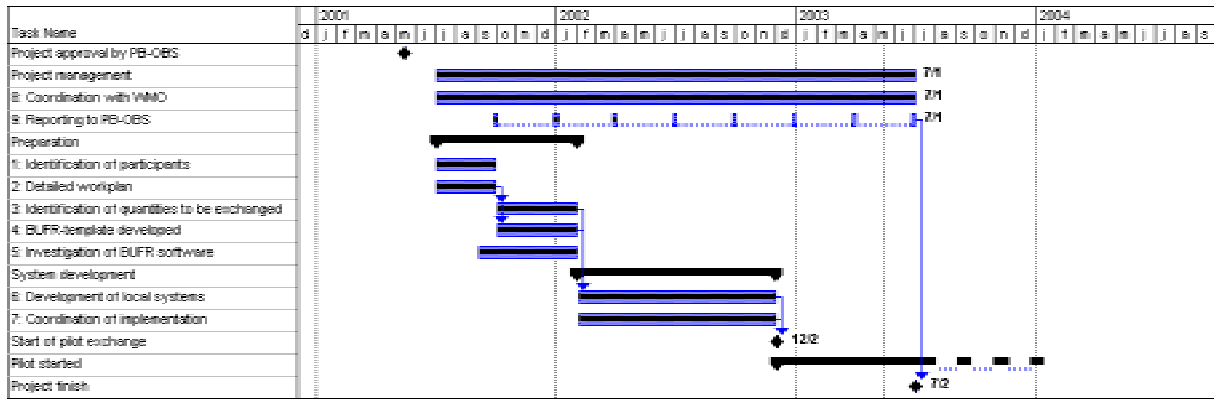
3. Project activities

The following actions were undertaken in accordance with the tasks identified in Annex 1 to the request for proposals:

- Identification of NMSs willing to participate. A minimum of two volunteer members was supposed to be necessary to provide a testbed for the exchange. However, EUMETNET members were encouraged to participate as much as possible.
- A detailed plan and workprogramme, taking into account the advice of CBS 12th session with respect to the ET-AWS proposals and ideas from the first session of the ET-MTDCF, Geneva May 7 to 11, 2001, was approved by the PB-OBS early in the project.
- A subset of specific quantities to be exchanged was identified. This set included parameters related to present weather and obtainable from current technology as well as "manually" observed quantities. The selection was made from the table prepared by the ET-AWS and a draft version of a BUFR template for hourly exchange as prepared by the Czech representative for the WMO Expert Team on Data Representation and Codes (ET-DR&C). The final form has been approved by CBS in December 2002 (see Annex 1)
- Availability and suitability of existing BUFR encoding/decoding software has been investigated. The EUMETNET OPERA BUFR software has been selected to be used for the pilot. It has been concluded that other BUFR software could be used as well as long as the BUFR reports are encoded and decoded correctly.
- Implementation has been coordinated with WMO where possible.
- Coordination with the WMO has been taken place at each major step of the project in order to contribute fully to the process initiated by CBS to introduce the use of table driven codes for all exchanges on GTS. This coordination was facilitated by simultaneous membership of the project manager of the ET-MTDCF.
- Suitable reporting to PB-OBS, in conformity with standard practices established by PB-OBS for programmes in the field of observation, was provided.

4. Workplan

The current status of the workplan can be read from the Gantt chart below.



5. Budget

An overview of planned and realized project costs are given in the table below. The realized amount is for information only. The declared amount won't exceed the planned total.

Costs	Planned (k€)	Realized (k€)
Personnel (project manager)	18.7	38.1
Travel	6.0	0
Consultancy	PM	0
Material	PM	0
Total	24.7 + PM	38.1

6. Coordination with WMO

Coordination with WMO was guaranteed by dual memberships of three PWS-GTS active members and 3 WMO Expert Teams (ET-MTDCF, ET-DR&C, ET-AWS): developments within PWS-GTS were reported to the respective WMO ET's and, the other way around, recommendations from the ET's to respective OPAGs and CBS were implemented by PWS-GTS where applicable.

As a separate activity a EUMETNET proposal to play a significant role in the WMO BUFR software-project has been initiated during a meeting in November 2001, attended by program managers from OPERA, PWS-GTS, WINPROF, representative from WMO/WWW secretariate and EMN/CO. A proposal to start a separate EUMETNET BUFR project and, possibly, offer the OPERA BUFR software as a standard WMO BUFR software has been prepared by the OPERA project manager for the PB-OBS meeting of June 2002. A decision on this has been suspended and a new, comparable proposal for a BUFR software project is on the agenda of the PB-OBS meeting of June 2003.

During its second meeting in May 2002 the WMO ET-MTDCF (migration to table driven code forms) has been updated about the PWS-GTS project. Also a proposal has been made on the use of delayed replication descriptors. The work within EUMETNET is appreciated very much by the ET. Also the OPERA software, possibly next to the ECMWF software, is still considered as a serious candidate for the WMO standard software for the migration process.

During WMO-CBS in Cairns, December 2002, the PWS-GTS project has been mentioned again as a pilot for the WMO migration plan to table driven code forms. It has been announced that the ECMWF will make their BUFR software freely available to NMS's as a contribution to the WMO BUFR software plan. However, ECMWF is not prepared to make the software available on many hardware platforms. The OPERA BUFR software is still a candidate to play a role in the WMO migration plan especially for those countries working with platforms else than UNIX or Windows.

7. Parameters to be exchanged and BUFR-template development

A template for the parameters to be exchanged has been developed. This has been done based on a draft version developed by the Czech representative for the WMO Expert Team on Data Representation and Codes (ET-DR&C). The final version of this template (see annex 1), as included in the final report of the ET-DR&C meeting in Prague, April 2002, has been used for the pilot exchange of BUFR-data.

8. BUFR software

The EUMETNET-OPERA BUFR-software has been used for the pilot exchange, though not by all participants. Since the OPERA BUFR-software has been developed especially for the exchange of radar data some additional requirements were defined by the PWS-GTS project team. These requirements needed to comply with the BUFR-template and other specific AWS issues have been submitted to the OPERA project manager. Some of them have already been implemented while others will be implemented in the next releases of the OPERA BUFR-software. The current status of these additional requirements is known by the OPERA and PWS-GTS project managers.

9. Local system

The local implementation of the exchange of BUFR AWS data has been accomplished in 3 countries, while implementation of BUFR AWS generation is on its way in a fourth country. Though the local situation differs from country to country the general set-up is given by fig. 1a and 1b.

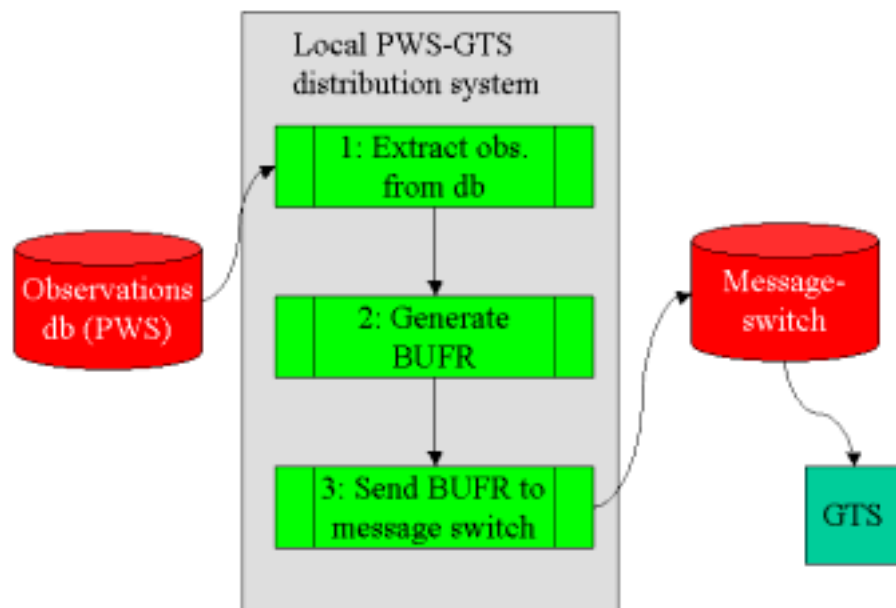


fig. 1 local PWS-GTS distribution scheme

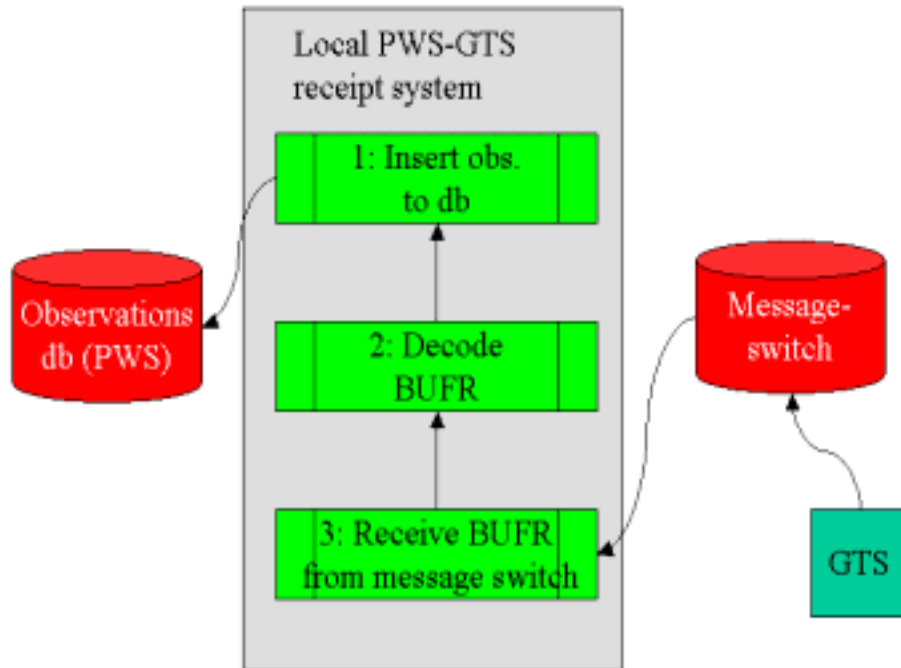


fig. 2 local PWS-GTS receipt scheme

10. Project evaluation

The PWS-GTS project has been executed following the original project plan. The project has been finalized on schedule and on budget. The main objective to start up a pilot hourly exchange of AWS BUFR reports containing PWS data has been realized though not exactly in time with respect to all participants.

The chosen BUFR software from OPERA proved to be adequate to perform its task though some additional features needed to be implemented.

The BUFR template as developed in cooperation with the WMO Expert Team on DR&C was designed in a way that all currently available AWS data (and also “manual” observations) could be assimilated. In near future some enhancements may still be implemented due to still growing experience.

The pilot only has been implemented for the exchange of single station reports. Multiple report BUFR messages may be composed in various ways. It has not yet been decided which way will be most efficient.

11. Recommendations

Based on the experience gained during this project the following recommendations may be made:

- though the pilot is a success as a pilot, the real success will only be achieved as soon as more countries will join in the regular exchange of these data;
- a separate EUMETNET BUFR project as a follow-up of the development of the BUFR software within the OPERA project is strongly recommended, both for use within EUMETNET and for use within the WMO community as a contribution to its migration strategy;
- to achieve further implementation of the use of BUFR it is recommended to appoint a BUFR coordinator for EUMETNET with the objective to coordinate the BUFR

exchange of various observation types within EUMETNET with WMO migration activities like template development, BUFR table definition and so on; this “BUFR coordination” could be a natural task within a new EUMETNET BUFR project;

12. Further information

Further information can be given by the project manager: Dick Blaauboer, KNMI, dick.blaauboer@knmi.nl, phone: +31 30 2206455.

13. Abbreviations

AWS: Automatic Weather Station
BUFR: Binary Universal Form for the Representation of meteorological data
CBS: Commission of Basic Systems (WMO)
CREX: Character form for the Representation and Exchange of data
ET-AWS: Expert Team on Automatic Weather Stations
ET-DRC: Expert Team on Data Representation and Codes (WMO)
ET-MTDCF: Expert Team on Migration to Table Driven Code Forms (WMO)
GTS: Global Telecommunication System (WMO)
OPAG: Open Programme Area Group (WMO)
PWS: Present Weather Sensor

14. References

WMO: CBS-OPAG-IOS /ET-AWS-1 - Expert Team meeting on Requirements and Representation of Data from Automatic Weather Stations, First Session, Geneva, 3-7 July 2000, **Final report**

EUMETNET: Project proposal n°2: Pilot implementation of a BUFR exchange of reports from AWS (including present weather parameters), final draft 14/09/00

WMO: CBS-XII, Geneva, 29 November to 8 December 2000, **Final report**

WMO: CBS-OPAG-ISS /ET-DR&C Expert Team on Data Representation and Codes, Prague, 22-26 April 2002, **Final report**

ANNEX 1:

FROM FINAL REPORT WMO ET-DR&C, PRAGUE, APRIL 2002

A3.1.8 BUFR template for surface observations from one-hour period

This template is proposed to be used for representation of surface observation data from both automatic stations and manned stations.

3 01 090		Surface station identification; time, horizontal and vertical co-ordinates	
3 01 004		Surface station identification	
	0 01 001	WMO block number	Numeric
	0 01 002	WMO station number	Numeric
	0 01 015	Station or site name	CCITT IA5
	0 02 001	Type of station	Code table
3 01 011	0 04 001	Year	Year
	0 04 002	Month	Month
	0 04 003	Day	Day
3 01 012	0 04 004	Hour	Hour
	0 04 005	Minute	Minute
3 01 021	0 05 001	Latitude (high accuracy)	Degree, scale 5
	0 06 001	Longitude (high accuracy)	Degree, scale 5
0 07 030		Height of station ground above mean sea level	m, scale 1
0 07 031		Height of barometer above mean sea level	m, scale 1
0 08 010		Surface qualifier (for temperature data)	Code table
3 01 091		Surface station instrumentation	
	0 02 180	Main present weather detecting system	Code table
	0 02 181	Supplementary present weather sensor	Flag table
	0 02 182	Visibility measurement system	Code table
	0 02 183	Cloud detection system	Code table
	0 02 184	Type of lightning detection sensor	Code table
	0 02 179	Type of sky condition algorithm	Code table
	0 02 186	Capability to detect precipitation phenomena	Flag table
	0 02 187	Capability to detect other weather phenomena	Flag table
	0 02 188	Capability to detect obscuration	Flag table
	0 02 189	Capability to discriminate lightning strikes	Flag table
3 02 001	0 10 004	Pressure	Pa, scale -1
	0 10 051	Pressure reduced to mean sea level	Pa, scale -1
	0 10 061	3-hour pressure change ⁽²⁾	Pa, scale -1
	0 10 063	Characteristic of pressure tendency ⁽²⁾	Code table
0 07 004		Pressure (standard level)	Pa, scale -1
0 10 009		Geopotential height of the standard level	gpm
3 02 072		Temperature and humidity data	
	0 07 032	Height of sensor above local ground	m, scale 2
	0 12 101	Temperature/dry-bulb temperature (scale 2)	K, scale 2
	0 12 103	Dew-point temperature (scale 2)	K, scale 2
	0 13 003	Relative humidity	%
1 01 005		Replicate one descriptor five times	
3 07 063	0 07 061	Depth below land surface	m, scale 2
	0 12 130	Soil temperature (scale 2)	K, scale 2
3 02 069		Visibility data	

	0 07 032	Height of sensor above local ground	m, scale 2
	0 33 041	Attribute of following value	Code table
	0 20 001	Horizontal visibility	m, scale -1
0 07 032		Height of sensor above local ground (set to missing to cancel the previous value)	m, scale 2
0 20 031		Ice deposit (thickness)	m, scale 2
0 20 032		Rate of ice accretion	Code table
0 02 038		Method of sea surface temperature measurement	Code table
0 22 043		Sea/water temperature (scale 2)	K, scale 2
3 02 021	0 22 001	Direction of waves	Degree true
	0 22 011	Period of waves	s
	0 22 021	Height of waves	m, scale 1
3 02 078		State of ground and snow depth measurement	
	0 02 176	Method of state of ground measurement	Code table
	0 20 062	State of ground (with or without snow)	Code table
	0 02 177	Method of snow depth measurement	Code table
	0 13 013	Total snow depth	m, scale 2
3 02 073		Cloud data	
	0 20 010	Cloud cover (total)	%
	1 05 004	Replicate 5 descriptors four times	
	0 08 002	Vertical significance	Code table
	0 20 011	Cloud amount	Code table
	0 20 012	Cloud type	Code table
	0 33 041	Attribute of following value	Code table
	0 20 013	Height of base of cloud	m, scale -1
3 02 074		Present and past weather	
	0 20 003	Present weather ⁽³⁾	Code table
	0 04 025	Time period (= - 60 minutes)	Minute
	0 20 004	Past weather (1) ⁽³⁾	Code table
	0 20 005	Past weather (2) ⁽³⁾	Code table
3 02 075		Intensity of precipitation, size of precip. element	
	0 08 021	Time significance (= 2 (time averaged))	Code table
	0 04 025	Time period (= - 10 minutes)	Minute
	0 13 055	Intensity of precipitation	kgm ⁻² s ⁻¹ , scale 4
	0 13 058	Size of precipitation element	m, scale 4
	0 08 021	Time significance (= missing value)	Code table
0 04 025		Time period (= - 10 minutes)	Minute
3 02 076		Precipitation, obscuration and other phenomena	
	0 20 021	Type of precipitation	Flag table
	0 20 022	Character of precipitation	Code table
	0 26 020	Duration of precipitation ⁽⁴⁾	Minute
	0 20 023	Other weather phenomena	Flag table
	0 20 024	Intensity of phenomena	Code table
	0 20 025	Obscuration	Flag table
	0 20 026	Character of obscuration	Code table
3 02 071		Wind data from one-hour period	
	0 07 032	Height of sensor above local ground	m, scale 2
	0 08 021	Time significance (= 2 (time averaged))	Code table
	0 04 025	Time period (= - 10 minutes, or number of minutes after a significant change of wind, if any)	Minute
	0 11 001	Wind direction	Degree true

	0 11 002	Wind speed	m s ⁻¹
	0 08 021	Time significance (= missing value)	Code table
	1 03 002	Replicate next 3 descriptors 2 times	
	0 04 025	Time period (= - 10 minutes in the first replication, = - 60 minutes in the second replication)	Minute
	0 11 043	Maximum wind gust direction	Degree true
	0 11 041	Maximum wind gust speed	m s ⁻¹
	0 04 025	Time period (= - 10 minutes)	Minute
	0 11 016	Extreme counterclockwise wind direction of a variable wind	Degree true
	0 11 017	Extreme clockwise wind direction of a variable wind	Degree true
3 02 077		Extreme temperature data	
	0 07 032	Height of sensor above local ground	m, scale 2
	0 04 025	Time period (= - 60 minutes)	Minute
	0 12 111	Maximum temperature (scale 2) at height and over period specified	K, scale 2
	0 12 112	Minimum temperature (scale 2) at height and over period specified	K, scale 2
	0 07 032	Height of sensor above local ground (for ground temperature)	m, scale 2
	0 04 025	Time period (= - 60 minutes)	Minute
	0 12 112	Minimum temperature (scale 2) at height and over period specified (for ground temperature)	K, scale 2
3 02 079		Precipitation measurement	
	0 07 032	Height of sensor above local ground	m, scale 2
	0 02 175	Method of precipitation measurement	Code table
	0 02 178	Method of liquid water content measurement of precipitation	Code table
	0 04 025	Time period (= - 60 minutes)	Minute
	0 13 011	Total precipitation / total water equivalent of snow	kg m ⁻² , scale 1
0 07 032		Height of sensor above local ground (set to missing to cancel the previous value)	m, scale 2
3 02 080		Evaporation measurement	
	0 02 185	Method of evaporation measurement	Code table
	0 04 025	Time period (= - 60 minutes)	Minute
	0 13 033	Evaporation /evapotranspiration	kg m ⁻²
3 02 081		Total sunshine data	
	0 04 025	Time period (= - 60 minutes)	Minute
	0 14 031	Total sunshine	Minute
3 02 082		Radiation data	
	0 04 025	Time period (= - 60 minutes)	Minute
	0 14 002	Long-wave radiation, integrated over period specified	J m ⁻² , scale -3
	0 14 004	Short-wave radiation, integrated over period specified	J m ⁻² , scale -3
	0 14 016	Net radiation, integrated over period specified	J m ⁻² , scale -4
	0 14 028	Global solar radiation (high accuracy), integrated over period specified	J m ⁻² , scale -4
	0 14 029	Diffuse solar radiation (high accuracy), integrated over period specified	J m ⁻² , scale -4
	0 14 030	Direct solar radiation (high accuracy), integrated over period specified	J m ⁻² , scale -4
0 04 025		Time period (= - 10 minutes)	Minute
0 13 059		Number of flashes	Numeric

3 02 083		First order statistics of P, W, T, U data	
	0 04 025	Time period (= -10 minutes)	Minute
	0 08 023	First order statistics (= 9 (best estimate of standard deviation)) ⁽⁵⁾	Code table
	0 10 004	Pressure	Pa, scale -1
	0 11 001	Wind direction	Degree true
	0 11 002	Wind speed	m s ⁻¹
	0 12 101	Temperature/dry-bulb temperature (scale 2)	K, scale 2
	0 13 003	Relative humidity	%
	0 08 023	First order statistics (= missing value)	Code table
0 33 005		Quality information (AWS data)	Flag table
0 33 006		Internal measurement status information (AWS)	Code table

- Notes:**
- (1) The time identification refers to the end of the one-hour period.
 - (2) 0 10 061 (3-hour pressure change) and 0 10 063 (Characteristic of pressure tendency) are included in this template, although they refer to 3-hour period preceding the time of observation.
 - (3) Present weather may be represented only by 0 20 003, especially if reported from a manned non-automated station. When encoding present weather reported from an automatic weather station, the sequence of descriptors (proposed under 3 02 076) should be used, if applicable.
 - (4) Duration of precipitation (in minutes) represents number of minutes in which any precipitation was registered.
 - (5) Best estimate of standard deviation is counted out of a set of samples (signal measurements) recorded within the period specified; it should be reported as a missing value, if the measurements of the relevant element are not available from a part of the period specified by 0 04 025.