Sub-hourly AWS data BUFR template

Prepared by :	Tanja Kleinert, Observations Programme Management Team
Purpose :	To report on the progress of the Task Team drafting a sub-hourly AWS data BUFR template and to present the final draft of the BUFR template for sub-hourly AWS data reporting from surface land stations
Action for STAC :	To note the progress report concerning sub-hourly AWS data reporting of surface land stations and to approve the proposed draft BUFR template as well as the proposed way forward.
Proposed Conclusions :	STAC approves the proposed sub-hourly AWS data reporting template as well as the way forward with regard to WMO.

EUMETNET
European Meteorological Services Network

GIE EUMETNET, Avenue Circulaire 3,
1180 Bruxelles, Belgique
Reg. 0818.801.249 – RPM Bruxelles

Sub-hourly AWS data BUFR template

1. Background

The majority of EUMETNET Members expressed their interest in the international exchange of sub-hourly AWS data when replying to the EUMETNET Observations Programme Management Team´s (Obs PMT) questionnaire circulated in summer 2015.

The results of the questionnaire were presented to STAC12 as well as to Assembly A16. Assembly asked EUMETNET Members to work towards an international exchange of sub-hourly AWS data from all surface land stations beginning with RBSN and EUCOS stations until 2022 at the latest recommending using 10 min intervals. Furthermore, the Assembly noted that the EUMETNET Task Team will collaborate with WMO developing an appropriate draft BUFR template for n-minute data reporting (Decision A16.06).

2. Task Team progress of work

The Task Team drafting the new BUFR template for sub-hourly AWS data reporting met in online conference meetings on 17th October 2016 as well as on 9th November 2017. Task Team Members have been nominated from DWD, FMI, Météo-France and UK Met Office. Enrico Fucile and Marijana Crepulja, both ECMWF as well as Sibylle Krebber, DWD, joined the second meeting as members of the WMO Inter-Programme Expert Team on Codes Maintenance (IPET-CM). Further discussions and drafting of the template took place via email exchange.

The Task Team drafted a new BUFR template for reporting sub-hourly AWS data which was circulated among EUMETNET Members via email on 26th January 2018. Obs PMT received 12 replies containing either approvals of the template but also comments and questions. Change requests have been added to the template. The final draft version of the BUFR template is attached. Questions and comments from Members have been replied to in Annex II of the BUFR template.

3. Proposed way forward

Provided that STAC16 approves the draft BUFR template for sub-hourly AWS data reporting, the template will be proposed to IPET-CM (next meeting end of May 2018) for consideration, validation and official WMO approval – via fast-track procedure if applicable.

4. Request to STAC

STAC is asked to note the progress report concerning sub-hourly AWS data reporting of surface land stations and to approve the proposed draft BUFR template as well as the proposed way forward.

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ANNEX to EMN-STAC16 Doc06: Sub-hourly AWS BUFR template

TM 3 07 092 - BUFR template for AWS surface observations from n-minute period

Revised 05.03.2018 (according to comments from EUMETNET Members)

This template is proposed to be used for representation of observation data from surface-based automatic weather stations obtained in n-minute intervals.

Main principles:

- All groups of data have replication factors: if your automatic system doesn't code the group, the 0 31 001 factor is put to 0 and the group is « closed »
- Main data are able to be qualified with an Associated field significance

This BUFR template further expands as follows:

Table References		Element Name	Unit, Scale	Element Description
		(WIGOS identifier) (1)		
3 01 150	0 01 125	WIGOS identifier series	Numeric, 0	
	0 01 126	WIGOS issuer of identifier	Numeric, 0	
	0 01 127	WIGOS issue number	Numeric, 0	
	0 01 128	WIGOS local identifier (character)	CCITT IA5	
		(Surface station identification)		
3 01 001	0 01 001	WMO block number (2)	Numeric, 0	
	0 01 002	WMO station number (2)	Numeric, 0	
2 08 040		Change width of CCITT IA5		
0 01 019		Long station or site name	CCITT IA5, 0	40 characters
2 08 000		Change width of CCITT IA5		
		(Year, month, day)		
3 01 011	0 04 001	Year(3)	Year, 0	
	0 04 002	Month(3)	Month, 0	
	0 04 003	Day(3)	Day, 0	
		(Hour, minute)		
3 01 012	0 04 004	Hour(3)	Hour, 0	
	0 04 005	Minute(3)	Minute, 0	
		(Latitude, longitude (high accuracy))		
3 01 021	0 05 001	Latitude (high accuracy)	Degree, 5	
	0 06 001	Longitude (high accuracy)	Degree, 5	
0 07 030		Height of station ground above mean sea level	m, 1	
0 01 023		Observation Sequence number	Numeric, 0	
		(INSTANTANEOUS DATA)		
		(Air pressure)		
1 08 000		Delayed replication of 8 descriptors		
0 31 000		Short delayed descriptor replication factor	Numeric, 0	Open or close (1/0)
0 07 031		Height of barometer above mean sea level	m, 1	
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 10 004		Pressure	Pa, −1	Measured value of the air pressure at the sensor location and sensor height
0 10 051		Pressure reduced to mean sea level	Pa, −1	
0 07 004		Pressure (standard level)	Pa, −1	
0 10 009		Geopotential height of the standard level	gpm, 0	
2 04 000		Cancel associated field		

Table References		Element Name	Unit, Scale	Element Description
		(Temperature and humidity)		Data measured in different heights (e.g. 2m and 0cm or 5cm for ground temperature)
1 15 000		Delayed replication of 15 descriptors		
0 31 001		Delayed descriptor replication factor	Numeric, 0	
0 07 032		Height of sensor above local ground	m, 2	
0 08 010		Surface qualifier	Code table, 0	
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 12 101		Temperature/Air-temperature (scale 2)	K, 2	
0 12 103		Dew-point temperature (scale 2)	K, 2	
2 02 129		Change scale		
2 01 132		Change data width		
0 13 003		Relative humidity	%, 1	Mandatory to report (presuming a humidity sensor is installed), data width 11 Bits
2 01 000		Cancel change data width		
2 02 000		Cancel change scale		
0 13 009		Relative humidity (original measured value)	%, 1	
2 04 000		Cancel associated field		
0 07 032		Height of sensor above local ground (set to missing to cancel the previous value)	m, 2	
0 08 010		Surface qualifier (set to missing to cancel the previous value)	Code table, 0	
		(Soil temperature and soil moisture)		
1 07 000		Delayed replication of 7 descriptors		
0 31 001		Delayed descriptor replication factor	Numeric, 0	
0 07 061		Depth below land surface	m, 2	
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 12 130		Soil temperature	K, 2	
0 13 111		Soil moisture	g kg^{-1}, 0	
2 04 000		Cancel associated field		
0 07 061		Depth below land surface (set to missing to cancel the previous value)	m, 2	
		(Visibility)		
1 05 000		Delayed replication of 5 descriptors		
0 31 000		Delayed descriptor replication factor	Numeric, 0	
0 33 041		Attribute of following value	Code table, 0	
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 20 001		Horizontal visibility	m, −1	
2 04 000		Cancel associated field		
		(Cloud)		
1 13 000		Delayed replication of 13 descriptors		
0 31 000		Short delayed descriptor replication factor	Numeric, 0	Open or close (1/0)
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 20 010		Cloud cover (total)	%, 0	
2 04 000		Cancel associated field		
1 07 000		Replicate 7 descriptors four times		4 cloud layers
0 31 001		Delayed descriptor replication factor	Numeric, 0	
0 08 002		Vertical significance	Code table, 0	
2 04 018		Add associated field		

Table References		Element Name	Unit, Scale	Element Description
0 31 021		Associated field significance	Code table, 0	Quality flag
0 20 011		Cloud amount	Code table, 0	
0 20 013		Height of base of cloud	m, −1	
2 04 000		Cancel associated field		
0 08 002		Vertical significance (set to missing)	Code table, 0	
		(State of ground and snow depth measurement)		
1 05 000		Delayed replication of 5 descriptors		
0 31 000		Short delayed descriptor replication factor	Numeric, 0	
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 20 062		State of ground (with or without snow)	Code table, 0	
0 13 013		Total snow depth	m, 2	zero snow depths should be reported when measured
2 04 000		Cancel associated field		
		(PERIOD DATA)		
		(Present weather)		
1 05 000		Delayed replication of 5 descriptors		
0 31 000		Short delayed descriptor replication factor	Numeric, 0	Open or close (1/0)
0 04 025		Time period (= - n minutes)	Minute, 0	
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 20 003		Present weather		
2 04 000		Cancel associated field		
		(Precipitation)		
1 05 000		Delayed replication of 5 descriptors		
0 31 000		Short delayed descriptor replication factor	Numeric, 0	Open or close (1/0)
0 04 025		Time period (= - n minutes)	Minute, 0	
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 13 011		Total precipitation / total water equivalent of snow	kg m^{-2}, 1	
2 04 000		Cancel associated field		
		(Wind)		Data measured in different heights
1 15 000		Delayed replication of 15 descriptors		
0 31 001		Delayed descriptor replication factor	Numeric, 0	
0 07 032		Height of sensor above local ground	m, 2	
0 08 021		Time significance = 2 Time averaged	Code table, 0	
0 04 025		Time period = −10 minutes, or number of minutes after a significant change of wind	Minute, 0	
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 11 001		Wind direction	Degree true, 0	
0 11 002		Wind speed	m s^{-1}, 1	
2 04 000		Cancel associated field		
0 08 021		Time significance = missing value	Code table, 0	
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 11 043		Maximum wind gust direction	Degree true, 0	
0 11 041		Maximum wind gust speed	m s^{-1}, 1	
2 04 000		Cancel associated field		
0 07 032		Height of sensor above local ground (set to missing to cancel the previous value)	m, 2	

Table References		Element Name	Unit, Scale	Element Description
		(Sunshine)		
1 05 000		Delayed replication of 5 descriptor		
0 31 000		Short delayed descriptor replication factor	Numeric, 0	Open or close (1/0)
0 04 025		Time period (= - n minutes)	Minute, 0	Default 10 minutes
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 14 031		Total sunshine	Minute, 0	
2 04 000		Cancel associated field		
		(Short- and long-wave radiation)		
1 010 000		Delayed replication of 10 descriptors		
0 31 000		Short delayed descriptor replication factor	Numeric, 0	Open or close (1/0)
0 04 025		Time period (= - n minutes)	Minute, 0	Default 10 minutes
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 14 002		Long-wave radiation, integrated over period specified	J m^{-2}, -3	Upward long-wave radiation According to BUFR Table B, under Class 14, Note (2): negative values
0 14 002		Long-wave radiation, integrated over period specified	J m^{-2}, -3	Downward long-wave radiation According to BUFR Table B, under Class 14, Note (1): positive values
0 14 004		Short-wave radiation, integrated over period specified	J m^{-2}, -3	Upward short-wave radiation According to BUFR Table B, under Class 14, Note (2): negative values
0 14 028		Global solar radiation (high accuracy), integrated over period specified	J m^{-2}, -2	
0 14 029		Diffuse solar radiation (high accuracy), integrated over period specified	J m^{-2}, -2	
0 14 030		Direct solar radiation (high accuracy), integrated over period specified	J m^{-2}, -2	
2 04 000		Cancel associated field		
		(UV radiation)		
1 13 000		Delayed replication of 13 descriptors		
0 31 000		Short delayed descriptor replication factor	Numeric, 0	Open or close (1/0)
0 04 025		Time period (= - n minutes)	Minute, 0	Default 10 minutes
0 02 071		Spectrographic wavelength	m, 13	UV-A: 315 nm
0 02 072		Spectrographic width	m, 13	UV-A: 85 nm
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 14 072		Global UV irradiation, integrated over period specified	J m-2, 0	UV-A irradiation According to BUFR Table B under Class 14, Note (8) *(ISO 21348: UV-A wave length range 315 ≤ λ ≤400 nm)*
2 04 000		Cancel associated field		
0 02 071		Spectrographic wavelength	m, 13	UV-B: 280 nm
0 02 072		Spectrographic width	m, 13	UV-B: 35 nm
2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 14 072		Global UV irradiation, integrated over period specified	J m-2, 0	UV-B irradiation According to BUFR Table

Table References		Element Name	Unit, Scale	Element Description
				B under Class 14, Note (8) *(ISO 21348 UV-B wave length range 280 ≤ λ ≤ 315 nm)*
2 04 000		Cancel associated field		

1) WIGOS Station Identifiers shall be used for n-minute period observations.
2) According to WMO letter 37992/2017/OBS/WIS/DRMM/DRC/WIGOS/ID issued 30 October 2017 Members are asked to follow the guidelines:
   When Members report data from observation sites that have traditional station identifiers, such as WMO block number (0 01 001)/WMO station number (0 01 002) and buoy platform identifier (0 01 005), they should also be reported in addition to corresponding WSI (3 01 150), to ensure the continuity of data use. On the other hand, the traditional station identifiers should be reported as "missing" when observation sites do not have the traditional identifiers.
3) The time identification refers **to the end of the n-minute period**.

Items to be considered by WMO Working Groups and Task Teams:

IPET-CM: Proposal to consider the definition of a new descriptor for reporting the actual sending time of a message in a particular message (e.g. an extended time significance). Such a descriptor is only available for bulletins containing several messages of different stations at present. It could be considered to introduce a time significance (0 08 021) to the template but unfortunately the table for this descriptor is saturated already and no further additions are possible.

WMO WG-AWS and IPET-CM: Proposal to consider the definition of new code figures for existing code table 0 20 062 to be able to report different states of ground which are observed automatically (see code table 0 20 062 below).

0 20 062

State of the ground (with or without snow)

Code figure		
0	Surface of ground dry (without cracks and no appreciable amount of dust or loose sand)	without snow or measurable ice cover
1	Surface of ground moist	
2	Surface of ground wet (standing water in small or large pools on surface)	
3	Flooded	
4	Surface of ground frozen	
5	Glaze on ground	
6	Loose dry dust or sand not covering ground completely	
7	Thin cover of loose dry dust or sand covering ground completely	
8	Moderate or thick cover of loose dry dust or sand covering ground completely	
9	Extremely dry with cracks	
10	Ground predominantly covered by ice	with snow or measurable ice cover
11	Compact or wet snow (with or without ice) covering less than one half of the ground	
12	Compact or wet snow (with or without ice) covering at least one half of the ground but ground not completely covered	
13	Even layer of compact or wet snow covering ground completely	
14	Uneven layer of compact or wet snow covering ground completely	
15	Loose dry snow covering less than one half of the ground	
16	Loose dry snow covering at least one half of the ground but ground not completely covered	
17	Even layer of loose dry snow covering ground completely	
18	Uneven layer of loose dry snow covering ground completely	
19	Snow covering ground completely; deep drifts	
20–30	Reserved	
31	Missing value	

Notes:

(1) The definitions in code numbers 0 to 2 and 4 apply to representative bare ground and numbers 3, 5 to 9 and 10 to 19 to an open representative area.

(2) In all instances the highest code figures applicable are to be reported.

(3) In the above code table, whenever reference is made to ice, it also includes solid precipitation other than snow.

1. Initial proposal to use quality flags (to be reconsidered by WG-QC):

For the most important parameters the provision of quality flags is proposed.
The Task Team proposes the use of 18 bits (descriptor **2 04 018** in connection with descriptor **0 31 021**) to code a composite flag in future. Descriptor **0 31 021** refers to the following code table with 6 bits at present (either use code figure **6** or use code figure **22-62** for local use):

0 31 021

Associated field significance

Code figure		
0	Reserved	
1	1-bit indicator of quality	0 = good
		1 = suspect or bad
2	2-bit indicator of quality	0 = good
		1 = slightly suspect
		2 = highly suspect
		3 = bad
3–5	Reserved	
6	4-bit indicator of quality control class	0 = Unqualified
	according to GTSPP	1 = Correct value (all checks passed)
		2 = Probably good but value inconsistent with statistics (differ from climatology)
		3 = Probably bad (spike, gradient, ... if other tests passed)
		4 = Bad value, impossible value (out of scale, vertical instability, constant profile)
		5 = Value modified during quality control
		6–7 = Not used (reserved)
		8 = Interpolated value
		9 = Missing value
7	Percentage confidence	
8		0 = Not suspected
		1 = Suspected
		2 = Reserved
		3 = Information not required
9–20	Reserved	
21	1-bit indicator of correction	0 = original value
	(see Note 2)	1 = substituted/corrected value
22–62	Reserved for local use	
63	Missing value	

Notes:

(1) Associated field significance shall be used initially in conjunction with the quality of observed data.

(2) The code figure 21 may be used within corrected messages with the substituted/corrected values identified.

(3) Further applications may be developed.

Each parameter within the group of descriptors from 2 04 018 "Add associated field" to 2 04 000 "Cancel associated field", e.g. for all wind measurement, is preceded by 18 bits. The meaning of the 18 bit quality flag is given by the "Associated field significance" (descriptor 0 31 021). E.g. if the "associated field significance is 6, i.e. a code table of the "4-bit indicator of quality control class according to GTSPP", a value of 4 for the "associated" quality flag means that the parameter is a "bad value, impossible value (out of scale, vertical instability constant profile)".

2 04 018		Add associated field		
0 31 021		Associated field significance	Code table, 0	Quality flag
0 11 001		Wind direction	Degree true, 0	
0 11 002		Wind speed	m s^{-1}, 1	
2 04 000		Cancel associated field		

EUMETNET held a workshop on Automatic Quality Control in May 2017. It was agreed at the end of the workshop to establish a new Working Group on Automatic Quality Control (WG-QC). It was proposed to STAC15 (Athens, October 2017) that ideally the WG-QS would find suitable quality flags to be used in this BUFR template for n-min AWS data reporting in future.

STAC15 approved the following:

ACTION STAC15.02:
STAC tasked the newly introduced STAC WG QC to define suitable new code or flag tables for quality flag reporting to be incorporated into the new BUFR template for sub-hourly AWS data reporting after they agreed on common quality flags for the two quality control levels QC0 (at the station) and QC1 (before GTS/WIS ingestion).

Hence, the newly introduced WG-QC has been tasked to define quality flags which shall be introduced to this BUFR template in due course.

Comments regarding QC from EUMETNET Members - to be considered by WG-QC:

- **CHMI:** Descriptor 0 31 021: We would like to know the recommended time schedule of transfer of corrected/ changed values (immediately, daily, monthly?)
- **AEMET:** Descriptor 0 31 021: The above mentioned table doesn't take into account the temporary consistency nor internal consistency as result of the quality control applied to the data. Nevertheless, this is included in the descriptor 0 33 020 ('Quality control indication of following value', see code table below). In any case, the results of the AEMET's quality control shall adapt to the template finally selected.

0 33 020

Quality control indication of following value

Code figure	
0	Good
1	Inconsistent
2	Doubtful
3	Wrong
4	Not checked
5	Has been changed
6	Estimated
7	Missing value

- **SMHI:** There is no natural mapping between this coding and the quality system we use (Nordklim), which means we have to create this mapping functionality. We need a more detailed specification to accomplish this. We also need an explanation to why the same information seems to be repeated (eg. a suspected value can be indicated in several different positions).
  We suggest that the quality flags shall be kept separate for each parameter. As we read this document the suggestion seems to be that the same quality flag is used for Temperature, Humidity and DewPoint as well as Wind direction and Wind speed. Except for the Dew Point which is calculated, the other values come from different sensors and should therefore have individual quality flags.

2. Descriptors removed from the original template, to be introduced in OSCAR/Surface

3 01 091		**Surface station instrumentation**	
	0 02 180	Main present weather detecting system	Code table, 0
	0 02 181	Supplementary present weather sensor	Flag table, 0
	0 02 182	Visibility measurement system	Code table, 0
	0 02 183	Cloud detection system	Code table, 0
	0 02 184	Type of lightning detection sensor	Code table, 0
	0 02 179	Type of sky condition algorithm	Code table, 0
	0 02 186	Capability to detect precipitation phenomena	Flag table, 0
	0 02 187	Capability to detect other weather phenomena	Flag table, 0
	0 02 188	Capability to detect obscuration	Flag table, 0
	0 02 189	Capability to discriminate lightning strikes	Flag table, 0

		Wind	
0 02 002		Type of instrumentation for wind measurement	Flag table, 0

		Visibility	
0 07 032		Height of sensor above local ground	m, 2

		Temperature and humidity instrumentation	
3 01 130	0 03 002	Generic type of humidity instrument	Code table, 0
	0 03 003	Configuration of sensors	Code table, 0
	0 03 004	Type of Shield or Screen	Code table, 0
	0 03 005	Horizontal Width of Screen or Shield (x)	m, 2
	0 03 006	Horizontal Depth of Screen or Shield (y)	m, 2
	0 03 007	Vertical Height of Screen or Shield (z)	m, 2
	0 03 008	Artificially Ventilated Screen or Shield	Code table, 0
	0 03 009	Degree of Forced Ventilation at time of reading	m-3 s-1, 1
	0 33 003	Quality of humidity measurement	Code table, 0

		Precipitation instrumentation	
0 07 032		Height of sensor above local ground	m, 2
0 02 175		Method of precipitation measurement	Code table, 0
0 02 178		Method of liquid water content measurement of Precipitation	Code table, 0

		Radiation instrumentation	
0 07 032		Height of sensor above local ground (for radiation)	m, 2

		State of ground and snow depth	
0 02 176		Method of state of ground measurement	Code table, 0
0 02 177		Method of snow depth measurement	Code table, 0

Would an addition of the metadata information ‘Accuracy of suntracking’ to OSCAR/Surface be possible?

3. Descriptors removed from the original template, identified not to be suitable for AWS data reporting

0 02 001		Type of station	Code table, 0

Reason: Descriptor 0 02 001 "Type of station" is not needed in this BUFR message format which is created for reporting automatically measured (AWS) data only.

0 20 012		Cloud type	Code table, 0
0 20 032		Rate of ice accretion	Code table, 0

Reason: Parameters are not automatically observed (basing on manual observations).

0 13 059		Number of flashes	Numeric

Reason: The observation "Number of flashes" isn´t an in situ measurement but remote sensing, thus shouldn´t be considered in this template.

0 11 016		Extreme counter-clockwise wind direction of a variable wind	Degree true, 0
0 11 017		Extreme clockwise wind direction of a variable wind	Degree true, 0
0 20 031		Ice deposit (thickness)	m, 2
0 14 016		Net radiation, integrated over period specified	J m-2, -4

Reason: From the Task Team´s perspective, the template should be only for general parameters with widespread use. These parameters aren´t reported by NMHSes of the Task Team Members.

0 33 041		Attribute of following value" with "Height of base of cloud	Code table, 0

Reason: The code table for this descriptor isn´t suitable for automatically measured cloud base data from ceilometers. If a ceilometer does not see a cloud layer(s), there can be either higher clouds or no clouds at all (see code table copied from Manual on Codes, WMO No. 306 below).

0 33 041

Attribute of following value

Code figure	
0	The following value is the true value
1	The following value is higher than the true value (the measurement hit the lower limit of the instrument)
2	The following value is lower than the true value (the measurement hit the higher limit of the instrument)
3	Missing value

Note: This descriptor will be associated with visibility data or height of clouds data to specify if the value is bounded. If the reported data is the true value, the code figure is 0. However, the measurement can hit the limit of the instrument measurement capability. If the reported value is higher than the true value, the code figure is 1; if the reported value is lower than the true value, the code figure is 2.

4. Reasons for particular additions or amendments

Descriptor 0 01 015 ”Station or site name”
In this descriptor, the station name is defined to be 20 characters and 7-bit ASCII characters. From the Task Team´s perspective, NMHSes should be prepared for longer names and other characters especially when starting to use additionally reports from 3rd parties. Hence, it is proposed to use descriptor 0 01 019 ”Long station or site name” (32 characters) instead.

Descriptor 0 07 031 “Height of barometer above mean sea level”
The height of pressure sensor has been moved from the block concerning station meta data to the pressure data block due to the following reasons:

- To handle the barometer/sensor height the same way as for other parameters,
- There is no need to encode this descriptor for stations not measuring pressure.

Descriptor 0 10 004 “Pressure”
The n-min AWS data reporting is seen as addition to the hourly SYNOP BUFR reports. Hence, the reporting practice for pressure measurements should be the same as for SYNOP BUFR reports. Consequently, in the BUFR template for n-min AWS data reporting pressure measured at the sensor location and sensor (barometer) height shall be reported. Pressure measurements for aviation purposes should not be considered in this template. In this case separate aviation related products should be issued.

Group “Soil temperature and soil moisture”
Although these parameters should ideally be reported on an hourly basis, it has to be noted that it would take years to add these descriptors to the globally approved WMO BUFR template for hourly reporting (B/C1). Considering the interest of data users to receive information on soil temperature and soil moisture, it is proposed by the Task Team to provide this information in this new BUFR template for n-min AWS data reporting although very small variability of soil temperature and moisture at the greater depths (e.g. >20 cm) are considered.

“Wind” and “Temperature and humidity”
From the Task Team´s perspective, it should be possible to report wind, temperature and humidity from different heights (= profiles). Hence, descriptors 0 31 001 ”Delayed descriptor replication factor” have been added for these parameters.

Descriptor 0 13 009 ”Relative humidity, original measured value”
It is proposed to report descriptor 0 13 009 ”Relative humidity, original measured value” in addition to the relative humidity values limited to 100% (0 13 003 “Relative humidity”). Some Members store this parameter and therefore are in a position to report it. Despite the fact that 0 13 009 is reported in higher resolution (0 13 009: one decimal place, 0 13 003: integer) the usefulness and risk of wrong interpretation of this information has been discussed controversially in the Task Team:

In principle, it is not good practice to modify observations and then record only the modified value. If at any time in the future, there is a need to revise the algorithms, it is almost impossible to revert to the raw measurement. If NMHSes report both values users might be at least in a position to identify suspect time series.

On the other hand, humidity sensors in general are designed to measure the amount of water vapour in air. When the sensor element gets in contact with liquid water, it may show abnormally high humidity readings. The result is a significantly overshooting value, which is not a signal of the sensor being somehow out of its normal adjustment. After evaporation of the liquid water it will return to its normal response curve.

There is a risk users might use the unlimited humidity value (over 100 %) in a wrong way or come to wrong conclusions. Nevertheless, it might be best to report both humidity values and give guidance about the correct use of them. Hence, the Element Description for 0 13 003 "Relative humidity" indicates that data providers are obliged to report this descriptor (presuming a humidity sensor is installed). It would be up to the data provider/ NMHS to decide whether 0 13 009 "Relative humidity, original measured value" will be reported in addition or set the descriptor to missing.

Descriptor 0 01 023 "Observation Sequence number"

It is proposed to add an "Observation Sequence number" to the BUFR template to allow data providers to distinguish between BUFR messages originally sent and potential correction messages. Correction messages could either be issued

- due to technical problems at site (e.g. particular parameters weren´t available at data retrieval or BUFR generation time and are delivered with delay) or
- because values of particular parameters have been identified to be erroneous and have been corrected during the quality control process.

Members/users could easily sort messages in their databases or applications correctly and could use the most reliable message of a particular observation time by considering the information given in descriptor "Observation Sequence number".

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Member	Comments and questions	Response
Cyprus Meteorological Service, CYPRUS	The Cyprus Department of Meteorology has no objections or other commends concerning the template. Additionally I would like to apprise you that the Department of Meteorology does not intend at this stage to adopt the new standard to disseminate sub-hourly data due to the need of developing new conversion tools and the inability of our Department to devote human resources for this purpose.	acknowledged
CHMI, CZECH REPUBLIC	We accept the proposal. I am sending some comments included in the Word document. - 0 31 021 We would like to know the recommended time schedule of transfer of corrected/ changed values (immediately, daily, monthly?) - 0 07 032 set to missing is redundant here. The height of sensor for visibility was removed from this template.	**Regarding item 1 (0 31 021):** Question has been added to the section concerning the quality flags; to be forwarded to WG-QC **Regarding item 2 (0 07 032):** Descriptor removed from template
ESTEA, ESTONIA	The proposed draft BUFR template is suitable for us.	acknowledged
FMI, FINLAND	Reporting the minimum ground temperature - Measuring ground temperature is quite harmonized and common in Europe and it would be important to report the parameter. There could be two possible way to report it as a part of the new sub-hourly BUFR message o As a temperature value itself with the information of the height of the measurement, using descriptor 0-31-001 o As a separated temperature value with an own descriptor Observation Sequence number, descriptor 0-01-023 - It would be more reasonable to use the actual sending time of the message, e.g. yyyymmddhhmmss, than use corrected messages. Station identification, traditional WMO numbers - It has been planned to start the operation with this new template in 2022. In this case, is it necessary anymore include the traditional WMO numbers as a part of the message? WIGOS identifier should be enough. State of ground	**Regarding item 1 (ground temperature):** Option 1 is preferred. Details on how to encode ground temperature has been added to the Element Description for 'Temperature and Humidity' **Regarding item 2 (Observation Sequence Number):** So far no descriptor exists to report the actual sending time of a message in one particular message (such a descriptor is only available for bulletins containing several messages of different stations). It could be considered to introduce a time significance (0 08 021) to the template but unfortunately the table for this descriptor is saturated already and no further additions are possible. A request to define a new descriptor (e.g. an extended time significance) can be forwarded to IPET-CM for consideration. **Regarding item 3 (removal of WMO ID):** Assembly had asked EUMETNET Members to work towards an international exchange of 10-minutes SYNOP data from all surface land stations beginning with RBSN and EUCOS stations until 2022 the latest (Decision A16.06, No. 3). Hence, Members might start to report sub-hourly AWS data with this template immediately after WMO validation and approval. Following the request of IPET-CM (37992/2017/OBS/WIS/DRMM/DRC/WIGOS/ID) WMO IDs should also be reported in addition to corresponding WSI, to ensure the continuity of data use.

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FMI, FINLAND *(continued)*	- There should be created own codes for different states of ground which are observed automatically. The codes could be included to the existing code table 020062. UV radiation - Measuring UV radiation is relatively uncommon in Europe. Is the measuring of UV radiation common enough to include the parameter in the message?	**Regarding item 4 (state of ground):** Acknowledged and Agreed. However, the definition of new codes for different states of ground which are observed automatically have to be discussed by WMO WG-AWS and approved by IPET-CM. **Regarding item 5 (UV radiation):** UV radiation is measured and reported by Météo-France. Hence, this descriptor should be kept in the template. In operational use this descriptor can be set to "0" (descriptor 0 31 000).
Météo-France, FRANCE	The final template seems to meet the needs of Météo-France for sub-hourly BUFRs including more information, especially quality flags.	acknowledged
DWD, GERMANY	Change proposals were provided in a separate Word document. DWD provided the following comments: DWD is supportive of the activities considering international exchange of 10 min BUFR AWS data. The template should allow even tighter temporal resolution (e.g. at least 5 min) and it is noted and appreciated that the template isn´t fixed to a temporal resolution of 10 minutes. DWD is looking forward to use the template for data exchange with neighbouring countries. It should be evaluated whether larger NMHSes could help smaller NMHSes by generating and distributing these AWS BUFR messages to support and accelerate the European data exchange. Decoding systems have to be adapted to the new template. Therefore, early notification about the approval of the template and a test period would be important.	acknowledged and change proposals have been incorporated
HNMS, GREECE	After having forwarded the BUFR template for sub-hourly AWS data to the relevant sections of our Meteorological Service (HNMS), they found that the proposed BUFR template is OK. Therefore, we have not any additional comments.	acknowledged
OMSZ, HUNGARY	We looked through the new BUFR template (for sub-hourly AWS data reporting from surface land stations), and have not found any significant remark, only we have one comment: the Long station or site name (0 01 019) descriptor is 32 characters, but we have a station whose official name's length exceeds this (Budapest Pestszentlorinc-kulterulet is 35 characters). This station currently has the name "Budapest - Lorinc" in the OSCAR system. If you can take this into account, thank you very much!	Descriptor 0 01 019 has been widened to allow 40 characters (2 08 040 'Change of width of CCITT IA5')

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IMGW, POLAND	**Descriptor 0 20 010:** Cloud cover = cloud amount (ref. 0 20 011), at least according to WMO No. 8, Part I, Chapter 15. How to distinguish between 0 20 010 and 0 20 011? **Descriptor 0 20 011:** Unclear - which cloud amount (cover ?) we are expected to express and how (clouds in any particu-lar layer in each of 3 levels)? **Water equivalent of snow** is generally associated with the snow depth not total precipitation. -> Descriptor Total precipitation / total water equivalent of snow : 1.) Unclear - total precipitation is generally expressed in mm (volume/area). The unit kg m-2 is used rather for measurements of dew and icing. What is the reason for such fundamental change of unit? 2.) As we understand - water equivalent of snow in kg m-2 as measured by weighing-recording gauges? **Descriptor 0 07 032 Height of sensor above local ground**: we understand the height of sensor should be given to decimal place, e.g. 12.25 m? **Descriptor 0 07 032 Height of sensor above local ground (set to missing to cancel the previous value):** Unclear - does it relate to any secondary sensor or to correct the above value? **Note 3) The time identification refers to the end of the n-minute period:** very important information. **Initial proposal to use quality flags:** potentially acceptable. **2. Descriptors removed from the original template, to be introduced in OSCAR/Surface**: potentially acceptable with one remark: Accuracy of sun tracking? **3. Descriptors removed from the original template, identified not to be suitable for AWS data reporting:** potentially acceptable. **4. Reasons for particular additions or amendments:** potentially acceptable. Only considering very small variability of soil temperature and moisture at the greater depths (e.g. >20 cm), the purpose of such high frequency of reporting is questionable.	**Regarding Cloud cover and Cloud amount:** Descriptor 0 20 010 Cloud cover (total) refers to the total cloud cover (see B/C1 regulation - B/C1.4.4.1 'Total cloud cover (0 20 010) shall embrace the total fraction of the celestial dome covered by clouds irrespective of their genus. It shall be reported in units of a per cent.') whilst 0 20 011 Cloud amount refers to the cloud amount of each of up to 4 cloud layers which can be reported. **Regarding Total precipitation / total water equivalent of snow:** According to Manual on Codes I.2, Part B (https://library.wmo.int/opac/doc_num.php?explnum_id=3421, page 297 of pdf) the descriptor 0 13 011 refers to 'Total precipitation / total water equivalent of snow' (official element name) and considers the reporting in kg m^{-2} which is the SI unit for mm. Yes, the water equivalent of snow is considered as measured by weighing-recording gauges. **Regarding descriptor 0 07 032 Height of sensor above local ground:** Yes, the height of the sensor should be given to decimal place (e.g. 12.25m). **Regarding descriptor 0 07 032 Height of sensor above local ground (set to missing to cancel the previous value):** According to Manual on Codes the definition of a sensor height has to be cancelled again; otherwise the height of sensor would refer also to the next parameter. See Note (5) in Class 7: " Previously defined value of 0 07 032 may be cancelled by setting 0 07 032 to a "missing value".", page 276 of pdf mentioned above. **Regarding Accuracy of sun tracking:** There is no descriptor existing for this parameter according to Manual on Codes. But WMO might consider to incorporate such a metadata information into OSCAR/Surface. **Regarding small variability of soil temperature:** acknowledged and text amended.
AEMet, SPAIN	We agree with the proposed template. We have only a remark related to the descriptor 0 31 021. This table don't take into account the temporary consistency nor internal consistency as result of the quality control applied to the data. Nevertheless, this is included in the descriptor 0 33 020 ('Quality control indication of following value'). In any case, the results of the AEMET's quality control shall adapt to the template finally selected.	**Regarding item 1 (0 31 021):** Question has been added to the section concerning the quality flags; to be forwarded to WG-QC

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SMHI, SWEDEN	SMHI is in the process of upgrading the automatic meteorological observation network; exchanging loggers, switching to IP-based communication and launching a new data collecting system. The installation of the new technology at site started in 2016. By the end of 2020 all observation stations will be equipped with the new technology. From this spring we will start collecting sub-hourly data from the new stations. Most of the meteorological parameters will be collected every minute and gradually the calculations of other parameters will be moved from the local stations to the central database at SMHI. Regarding the new BUFR template in general, we have no comments. We can use this for sending our sub-hourly data when the relevant stations are modernized. We only suggest a small editorial change in the document. The headings "INSTANTANEOUS DATA" and "PERIOD DATA" are important but easy to miss. You could remove parentheses or divide the table to make it clearer. Regarding the quality flags, we have the following feedback: • There is no natural mapping between this coding and the quality system we use (Nordklim), which means we have to create this mapping functionality. We need a more detailed specification to accomplish this. We also need an explanation to why the same information seems to be repeated (eg. a suspected value can be indicated in several different positions). • We suggest that the quality flags shall be kept separate for each parameter. As we read this document the suggestion seems to be that the same quality flag is used for Temperature, Humidity and DewPoint as well as Wind direction and Wind speed. Except for the Dew Point which is calculated, the other values come from different sensors and should therefore have individual quality flags.	**Regarding item 1 (repeated information):** The proposed descriptors for quality flags can be repeated to allow the reporting of quality flags for each parameter and all reported heights/positions separately. **Regarding item 2 (separate quality flags for each parameter):** see answer above - it is intended to report separate quality flags for each parameter in all reported heights; Associated fields are treated as separate data items and precede the data (see detailed description to associated fields in Manual on Codes Vol.A.2, Section 4, page 240 out of 966 of pdf in https://library.wmo.int/opac/doc_num.php?explnum_id=3421). WG-QC may consider whether it would be useful to define more precise quality flags depending on the parameter and the type of measurement.
MeteoSwiss, SWITZERLAND	We write w.r.t. your request for review of the New BUFR template for sub-hourly AWS data reporting from surface land stations to inform you, that we have no comments and support the proposed template.	acknowledged