

OPERATIONAL MEASUREMENT UNCERTAINTY REQUIREMENTS AND INSTRUMENT PERFORMANCE

	(1) Variable	(2) Range	(3) Reported resolution	(4) Mode of measurement/ observation	(5) Required measurement uncertainty	(6) Sensor time constant	(7) Output averaging time	(8) Achievable measurement uncertainty	(9) Remarks
1. Temperature									
1.1	Air Temperature	-80 - +60°C	0.1 K	I	0.3 K for ≤ -40°C 0.1 K for > -40°C and ≤ +40°C 0.3 K for > +40°	20 s	1 min	0.2 K	Achievable uncertainty and effective time-constant may be affected by the design of the thermometer solar radiation screen Time-constant depends on the air-flow over the sensor
1.2	Extremes of air temperature	-80 - +60°C	0.1 K	I	0.5 K for ≤ -40°C 0.3 K for > -40°C and ≤ +40°C 0.5 K for > +40°	20 s	1 min	0.2 K	
1.3	Sea surface temperature	-2 - +40°C	0.1 K	I	0.1 K	20 s	1 min	0.2 K	
2. Humidity									
2.1	Dewpoint temperature	-80 - +35°C	0.1 K	I	0.1 K	20 s	1 min	0.5 K	
2.2	Relative Humidity	0 - 100%	1%	I	1%	20 s	1 min	0.2 K	Wet-bulb temperature (psychrometer) If measured directly and in combination with air temperature (dry bulb) Large errors are possible due to aspiration and cleanliness problems (see also note 11)
						40 s	1 min	Solid state and others 3%	Solid state sensors may show significant temperature and humidity dependence
3. Atmospheric pressure									
3.1	Pressure	500 - 1 080 hPa	0.1 hPa	I	0.1 hPa	20 s	1 min	0.3 hPa	Both station pressure and MSL pressure Measurement uncertainty is seriously affected by dynamic pressure due to wind if no precautions are taken Inadequate temperature compensation of the transducer may affect the measurement uncertainty significantly
3.2	Tendency	Not specified	0.1 hPa	I	0.2 hPa			0.2 hPa	Difference between instantaneous values
4. Clouds									
4.1	Cloud amount	0/8 - 8/8	1/8	I	1/8	n/a		2/8	Period (30 s) clustering algorithms may be used to estimate low cloud amount automatically
4.2	Height of cloud base	0 m - 30 km	10 m	I	10 m for ≤ 100 m 10% for > 100 m	n/a		-10 m	Achievable measurement uncertainty is undetermined because no clear definition exists for instrumentally measured cloud-base height (e.g. based on penetration depth or significant discontinuity in the extinction profile) Significant bias during precipitation
4.3	Height of cloud top	Not available							
5. Wind									
5.1	Speed	0 - 75 m s ⁻¹	0.5 m s ⁻¹	A	0.5 m s ⁻¹ for ≤ 5 m s ⁻¹ 10% for > 5 m s ⁻¹	Distance constant 2 - 5 m	2 and/or 10 min	0.5 m s ⁻¹ for ≤ 5 m s ⁻¹ 10% for > 5 m s ⁻¹	Average over 2 and/or 10 min Non-linear devices. Care needed in design of averaging process Distance constant is usually expressed as response length Averages computed over Cartesian components (see Part III, Chapter 3, section 3.6 of this Guide)
5.2	Direction	0 - 360°	1°	A	5°	1 s	2 and/or 10 min	5°	
5.3	Gusts	0.1 - 150 m s ⁻¹	0.1 m s ⁻¹	A	10%		3 s	0.5 m s ⁻¹ for ≤ 5 m s ⁻¹ 10% for > 5 m s ⁻¹	Highest 3 s average should be recorded
6. Precipitation									
6.1	Amount (daily)	0 - 500 mm	0.1 mm	T	0.1 mm for ≤ 5 mm 2% for > 5 mm	n/a	n/a	The larger of 5% or 0.1 mm	Quantity based on daily amounts Measurement uncertainty depends on aerodynamics collection efficiency of gauges and evaporation losses in heated gauges Average depth over an area representative of the observing site
6.2	Depth of snow	0 - 25 mm	1 cm	A	1 cm for ≤ 20 cm 5% for > 20 cm				
6.3	Thickness of ice accretion on ships	Not specified	1 cm	I	1 cm for ≤ 10 cm 10% for > 10 cm				
6.4	Precipitation intensity	0.02 mm h ⁻¹ - 2 000 mm h ⁻¹	0.1 mm h ⁻¹	I	(trace): n/a for 0.02 - 0.2 mm h ⁻¹ 0.1 mm h ⁻¹ for 0.2 - 2 mm h ⁻¹ 5% for > 2 mm h ⁻¹	< 30 s	1 min		Uncertainty values for liquid precipitation only Uncertainty is seriously affected by wind Sensors may show significant non-linear behaviour For < 0.2 mm h ⁻¹ : detection only (yes/no) sensor time constant is significantly affected during solid precipitation using catchment type of gauges
7. Radiation									
7.1	Sunshine duration (daily)	0 - 24 h	60 s	T	0.1 h	20 s	n/a	The larger of 0.1 h or 2%	
7.2	Net radiation, radiant exposure (daily)	Not specified	1 J m ⁻²	T	0.4 MJ m ⁻² for ≤ 8 MJ m ⁻² 5% for > 8 MJ m ⁻²	20 s	n/a	0.4 MJ m ⁻² for ≤ 8 MJ m ⁻² 5% for > 8 MJ m ⁻²	Radiant exposure expressed as daily sums (amount) of (net) radiation
8. Visibility									
8.1	Meteorological optical range (MOR)	10 m - 100 km	1 m	I	50 m for ≤ 600 m 10% for > 600 m - ≤ 1 600 m 20% for > 1500 m	< 30 s	1 and 10 min	The larger of 20 m or 20%	Achievable measurement uncertainty may depend on the cause of obscuration Quantity to be averaged: extinction coefficient (see Part III, Chapter 3, section 3.6, of this Guide). Preference for averaging logarithmic values
8.2	Runway visual range (RVR)	10 m - 1 500 m	1 m	A	10 m for ≤ 400 m 25 m for > 400 m - ≤ 800 m 10% for > 800 m	< 30 s	1 and 10 min	The larger of 20 m or 20%	In accordance with WMO-No. 49, Volume II, Attachment A (2004 ed.) and ICAO Doc. 9328-AN/908 (second ed., 2000)
9. Waves									
9.1	Significant wave height	0 - 50 m	0.1 m	A	0.5 m for ≤ 5 m 10% for > 5 m	0.5 s	20 min	0.5 m for ≤ 5 m 10% for > 5 m	Average over 20 min for instrumental measurements
9.2	Wave period	0 - 100 s	1 s	A	0.5 s	0.5 s	20 min	0.5 s	Average over 20 min for instrumental measurements
9.3	Wave direction	0 - 360°	1°	A	10°	0.5 s	20 min	20°	Average over 20 min for instrumental measurements
10. Evaporation									
10.1	Amount of pan evaporation	0 - 100 mm	0.1 mm	T	0.1 mm for ≤ 5 mm 2% for > 5 mm	n/a			

Notes:

1. Column 1 gives the basic variable.
2. Column 2 gives the common range for most variables; limits depend on local climatological conditions.
3. Column 3 gives the most stringent resolution as determined by the *Manual on Codes* (WMO-No. 306).
4. In column 4:
 - I = Instantaneous: In order to exclude the natural small-scale variability and the noise, an average value over a period of 1 min is considered as a minimum and most suitable; averages over periods of up to 10 min are acceptable.
 - A = Averaging: Average values over a fixed period, as specified by the coding requirements.
 - T = Totals: Totals over a fixed period, as specified by coding requirements.