

# Application areas and assessment tool for high performing operational radiosounding systems

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CIMO intercomparison campaigns provide the unique framework where to compare and assess different upper air radiosounding systems produced by commercial manufacturers from all over the world during an intense observation period. The outcome of the CIMO intercomparison is to create and define the criteria that will be used to assess the performance of radiosonde systems available on the market and serving as a basis for the selection of operational radiosounding systems best suited for different applications.

## Application areas

The different radiosounding systems that will participate in the next Upper Air Instrument Intercomparison in 2021 (UAI2021) at the Deutscher Wetterdienst (DWD) station at Lindenberg will be evaluated for their performances based on objective criteria that will be entwined with specific application areas. These areas are part of the list of the “application areas” selected by the Observing Systems Capability Analysis and Review (OSCAR) tool and are, each and every one, related to specific requirements.

The radiosounding systems participating to the UAI2021 will be assessed in relation to the following areas:

Table 1: list of application areas extracted from OSCAR.

Name	Focal Point	Respons. Org.	Description
Aeronautical Meteorology	Jitze Van der Meulen <a href="mailto:jitze.van.der.meulen@knmi.nl">jitze.van.der.meulen@knmi.nl</a>	WMO	Meteorological information in support of the safety and optimal efficiency of aviation
Climate Monitoring (GCOS)	GCOS Secretariat <a href="mailto:gcos@wmo.int">gcos@wmo.int</a>	GCOS	The WMO-IOC-UNEP-ICSU Global Climate Observing System (GCOS) is an internationally coordinated network of global observing systems for climate, is designed to meet the requirements for climate observations, which are essential to climate monitoring. Climate observations are fundamental to detect, model and assess climate change, support adaptation to climate change, monitor the effectiveness of policies for mitigating climate change, develop climate information services, promote sustainable national economic development and meet other requirements of the UNFCCC and other convention and agreements.
Climate Science	Michel Rixen <a href="mailto:mrixen@wmo.int">mrixen@wmo.int</a>	WCRP	This application area aims at coordinating international research to improve the understanding, analysis and prediction of the Earth System
Forecasting Atmospheric Composition	Geir Braathen <a href="mailto:gbraathen@wmo.int">gbraathen@wmo.int</a>	WMO	Applications from global to regional scales (with horizontal resolutions similar to global NWP (~ 10 km and coarser) with stringent timeliness requirements (NRT) to support operations such as sand and dust storm and

			chemical weather forecasts.
Global NWP	Erik Andersson <a href="mailto:erik.andersson@ecmwf.int">erik.andersson@ecmwf.int</a>	WMO	Global Numerical Weather Prediction
High Res NWP	Thibaut Montmerle <a href="mailto:thibaut.montmerle@meteo.fr">thibaut.montmerle@meteo.fr</a>	WMO	High Resolution Numerical Weather Prediction
Monitoring Atmospheric Composition	Geir Braathen <a href="mailto:gbraathen@wmo.int">gbraathen@wmo.int</a>	WMO	Applications related to evaluating and analyzing changes (temporally and spatially) in atmospheric composition regionally and globally to support treaty monitoring, climatologies and re-analyses, assessing trends in composition and emissions/fluxes, and to better understand processes, using data of controlled quality (and with less stringent time requirements (not needed in NRT), and used in products such as Ozone and Greenhouse Gas Bulletins, and State/Health of the Atmosphere reports.
Providing Atmospheric Composition information to support services in urban and populated areas	Geir Braathen <a href="mailto:gbraathen@wmo.int">gbraathen@wmo.int</a>	WMO	Applications that target limited areas (with horizontal resolution of a few km or smaller and stringent timeliness requirements to support services related to weather/climate/pollution, such as air quality forecasting.

## Requirements defined for the application areas

Some of the application areas have specific quantitative requirements expressed as a function of the atmospheric region of interest LT (low troposphere), HT (high troposphere) and LS (low stratosphere). The requirements define the threshold values of different parameters shown in the table below (e.g. uncertainty, horizontal/vertical resolution, timeliness...). Each parameter has three levels of requirements specified in color code: goal is marked blue, breakthrough green and threshold orange.

For the list of application areas shown in Table 1, only the aeronautical meteorology, Global NWP and High Resolution NWP have specific and quantitative requirements.

Table 2: List of all Requirements per application areas

Variable	Layer	App Area	Uncertainty	Hor Res	Ver Res	Obs Cyc	Timeliness	Coverage	Conf Level
Atmospheric temperature	LS	Aeronautical Meteorology	2 K	50 km	0.15 km	60 min	60 min	Global	firm
	HT		3 K	70 km	0.3 km	90 min	80 min		
	LT		5 K	100 km	0.6 km	3 h	2 h		
Specific humidity	LT	Aeronautical Meteorology	5 %	50 km	0.15 km	60 min	60 min	Global	firm
			7 %	70 km	0.3 km	90 min	90 min		
			10 %	100 km	0.6 km	3 h	2 h		
Wind (horizontal)	HT	Aeronautical Meteorology	2 m.s <sup>-1</sup>	50 km	0.15 km	5 min	60 min	Global	firm
			2.7 m.s <sup>-1</sup>	63 km	0.238 km	6 min	84 min		
			5 m.s <sup>-1</sup>	100 km	0.6 km	10 min	3 h		
Wind (horizontal)	LS	Aeronautical Meteorology	2 m.s <sup>-1</sup>	50 km	0.15 km	5 min	60 min	Global	firm
			3 m.s <sup>-1</sup>	70 km	0.3 km	7 min	90 min		
			5 m.s <sup>-1</sup>	100 km	0.6 km	10 min	3 h		
Atmospheric temperature	HT	Global NWP	0.5 K	15 km	0.3 km	60 min	6 min	Global	firm
			1 K	100 km	1 km	6 h	30 min		
			3 K	500 km	3 km	24 h	6 h		
Atmospheric temperature	LS	Global NWP	0.5 K	15 km	0.3 km	60 min	6 min	Global	firm
			1 K	100 km	1 km	6 h	30 min		
			3 K	500 km	3 km	24 h	6 h		
Atmospheric	LT	Global NWP	0.5 K	15 km	0.3 km	60 min	6 min	Global	firm
			1 K	100 km	1 km	6 h	30 min		

temperature			3 K	500 km	3 km	24 h	6 h		
Specific humidity	HT	Global NWP	2 % 5 % 10 %	15 km 50 km 250 km	0.5 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
Specific humidity	LT	Global NWP	2 % 5 % 10 %	15 km 50 km 250 km	0.3 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
Wind (horizontal)	HS&M	Global NWP	1 m.s <sup>-1</sup> 5 m.s <sup>-1</sup> 10 m.s <sup>-1</sup>	50 km 100 km 500 km	1 km 2 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
Wind (horizontal)	HT	Global NWP	1 m.s <sup>-1</sup> 3 m.s <sup>-1</sup> 8 m.s <sup>-1</sup>	15 km 100 km 500 km	0.5 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
Wind (horizontal)	LS	Global NWP	1 m.s <sup>-1</sup> 3 m.s <sup>-1</sup> 5 m.s <sup>-1</sup>	15 km 100 km 500 km	0.5 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
Wind (horizontal)	LT	Global NWP	1 m.s <sup>-1</sup> 3 m.s <sup>-1</sup> 5 m.s <sup>-1</sup>	15 km 100 km 500 km	0.5 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm
Wind (vertical)	HS&M	Global NWP	1 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup>	15 km 200 km 500 km	0.5 km 2 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	tentative
Wind (vertical)	HT	Global NWP	1 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup>	15 km 200 km 500 km	0.5 km 2 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	tentative
Wind (vertical)	LS	Global NWP	1 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup>	15 km 200 km 500 km	0.5 km 2 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	tentative
Wind (vertical)	LT	Global NWP	1 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup>	15 km 200 km 500 km	0.5 km 2 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	tentative
Atmospheric temperature	HT	High Res NWP	0.5 K 1 K 3 K	1 km 5 km 25 km	0.3 km 0.45 km 1 km	15 min 60 min 6 h	15 min 30 min 2 h	Global	firm
Atmospheric temperature	LS	High Res NWP	0.5 K 1 K 3 K	10 km 25 km 100 km	1 km 1.5 km 3 km	15 min 60 min 6 h	15 min 30 min 2 h	Global	firm
Atmospheric temperature	LT	High Res NWP	0.5 K 1 K 3 K	0.5 km 2 km 10 km	0.1 km 0.25 km 1 km	15 min 60 min 6 h	15 min 30 min 2 h	Global	firm
Specific humidity	HT	High Res NWP	2 % 5 % 10 %	2 km 10 km 30 km	0.3 km 0.4 km 1 km	15 min 60 min 6 h	15 min 30 min 2 h	Global	firm
Specific humidity	LT	High Res NWP	2 % 5 % 10 %	0.5 km 5 km 20 km	0.1 km 0.2 km 1 km	15 min 60 min 6 h	15 min 30 min 2 h	Global	firm
Wind (horizontal)	HT	High Res NWP	1 m.s <sup>-1</sup> 3 m.s <sup>-1</sup> 8 m.s <sup>-1</sup>	2 km 10 km 20 km	0.5 km 0.7 km 1 km	15 min 60 min 12 h	15 min 30 min 2 h	Global	firm
Wind (horizontal)	LS	High Res NWP	1 m.s <sup>-1</sup> 3 m.s <sup>-1</sup> 5 m.s <sup>-1</sup>	10 km 25 km 100 km	1 km 2 km 5 km	30 min 60 min 12 h	15 min 30 min 2 h	Global	firm
Wind (horizontal)	LT	High Res NWP	1 m.s <sup>-1</sup> 2 m.s <sup>-1</sup> 5 m.s <sup>-1</sup>	0.5 km 2 km 10 km	0.1 km 0.2 km 0.4 km	15 min 60 min 12 h	15 min 30 min 2 h	Global	firm
Wind (vertical)	HT	High Res NWP	1 cm.s <sup>-1</sup> 2 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup>	5 km 10 km 20 km	0.5 km 0.65 km 1 km	15 min 60 min 12 h	15 min 30 min 2 h	Global	speculative

Wind (vertical)	LS	High Res NWP	1 cm.s <sup>-1</sup> 2 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup>	10 km 25 km 100 km	2 km 3 km 5 km	30 min 60 min 12 h	15 min 30 min 2 h	Global	speculative
Wind (vertical)	LT	High Res NWP	1 cm.s <sup>-1</sup> 2 cm.s <sup>-1</sup> 5 cm.s <sup>-1</sup>	0.5 km 2 km 10 km	0.1 km 0.25 km 0.5 km	15 min 60 min 12 h	15 min 30 min 2 h	Global	tentative

For the application area “climate”, only the requirements from the CIMO Guide are available.

Variable	Layer	App Area	Uncertainty	Hor Res	Ver Res	Obs Cyc	Timeliness	Coverage	Conf Level
Upper-Air Temperature	LT	Climate	0.2-1 K 1.2 K 2 K		100 m 800 m 2 km				
Upper-Air Temperature	HT	Climate	0.2-1 K 1.2 K 2 K		100 m 800 m 2 km				
Upper-Air Temperature	LS	Climate	0.4-1 K 1.2 K 2 K		100-500 m 800 m 2 km				
Upper-Air Temperature	HS	Climate	0.4-1 K 1.2 K 2 K		100-500 m 800 m 2 km				
Specific humidity	LT	Climate	4 % RH 6 % RH 10 % RH		50-500 m 800 m 2 km				
Specific humidity	HT	Climate	4 % RH 6 % RH 10 % RH		100-500 m 800 m 2 km				
Specific humidity	LS	Climate	4 % mixing ratio ppmv 6 % mixing ratio ppmv 10 % mixing ratio ppmv		100-500 m 800 m 2 km				
Specific humidity	HS	Climate	4 % mixing ratio ppmv 6 % mixing ratio ppmv 10 % mixing ratio ppmv		100-500 m 800 m 2 km				
Upper wind	LT	Climate	1.4-4 m.s <sup>-1</sup> 6 m.s <sup>-1</sup> 10 m.s <sup>-1</sup>		50-500 m 800 m 2 km				
Upper wind	HT	Climate	1.4-4 m.s <sup>-1</sup> 6 m.s <sup>-1</sup> 10 m.s <sup>-1</sup>		50-500 m 800 m 2 km				
Upper wind	LS	Climate	1.4-4 m.s <sup>-1</sup> 6 m.s <sup>-1</sup> 10 m.s <sup>-1</sup>		250-500 m 800 m 2 km				
Upper wind	HS	Climate	1.4-4 m.s <sup>-1</sup> 8 m.s <sup>-1</sup> 10 m.s <sup>-1</sup>		50-500 m 800 m 2 km				

## WIGOS Data Quality Monitoring System (WDQMS)

Another tool for evaluation of different radiosounding system can be the WIGOS Data Quality Monitoring System (WDQMS) tool. The WDQMS tool has been deployed by WIGOS as a tool for:

1. Real-time monitoring of performance
  - a. data availability and data quality,
  - b. all WIGOS components (GOS, GAW, WHOS, GCW, GCOS),
  - c. searchable by region, country, station type, period, etc.

2. **Delayed mode monitoring of data quality as measured against reference sources of information for non-real time observations**
3. Incident management component for mitigation of issues

Point 2 is of interest for the UAI2021, especially for the possibility to compare the radiosounding profiles with objective, WIGOS-supported references.

A description of the WQMS tool can be found at [https://library.wmo.int/doc\\_num.php?explnum\\_id=5681](https://library.wmo.int/doc_num.php?explnum_id=5681)