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GRUAN Report 5

Cloud observations

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Abstract

This document discusses and summarises two separate topics regarding cloud observations to be collected at the Global Climate Observing System (GCOS) Reference Upper-Air Network (GRUAN) sites: (i) recommendations for reporting the existing cloud observations at GRUAN sites (primarily to help identify "clear" scenes for satellite sensor validation), and (ii) initial recommendations for generating cloud-related GRUAN data products, keeping in mind the GCOS cloud-related Essential Climate Variables (ECVs).

Editor Remarks

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by GRUAN.

Contacting GRUAN Lead Centre

Please contact the GRUAN Lead Centre (gruan.lc@dwd.de) if you have any questions or comments in relation to this document. If appropriate, the Lead Centre will redirect requests to the designated Task Teams (Task Team on Radiosondes, https://www.gruan.org/network/task-teams/tt-radiosondes, Task Team on Satellite-Based Remote Sensing Measurement, https://www.gruan.org/network/task-teams/tt-satellite, and Task Team on Ground-Based Remote Sensing Measurements, https://www.gruan.org/network/task-teams/tt-ground-based).

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1 Introduction

At the GRUAN 11th Implementation and Coordination Meeting (ICM-11) in Singapore in May 2019, it was discussed that standardisation of cloud observations and their reporting is necessary in association with radiosonde ascents at GRUAN sites. An ad-hoc task team led by the Task Team of Radiosonde (https://www.gruan.org/network/task-teams/tt-radiosondes) and Task Team of Ancillary Measurements (now divided into Task Team on Satellite-Based Remote Sensing Measurement, https://www.gruan.org/network/task-teams/tt-satellite, and Task Team on Ground-Based Remote Sensing Measurements, https://www.gruan.org/network/task-teams/tt-ground-based) was formed to develop a proposal on how and when cloud observations should be collected to support the usage and interpretation of radiosonde profiles as well as on how cloud-related information should be included in the data files. Originally, there were two very different motivations behind this discussion:

i) For satellite data calibration and validation purposes (e.g. for hyper-spectral infrared sensors), it would be very useful to have cloud amount information simultaneously with each of the radiosonde GRUAN Data Product (GDP) profiles, to identify (classify) clear-sky conditions for those cases where the presence or absence of clouds matters for interpretation. Note that the presence of low clouds does not affect much the assessment of satellite hyper-spectral measurements which are sensitive to the upper tropospheric humidity (*Calbet et al.*, 2017; *Sun et al.*, 2021).

ii) For improvement of the uncertainty evaluation of radiosonde temperature and humidity GDPs, obtaining information on solar radiation which is a function not only of solar elevation angle and temperature sensor orientation but also of cloud properties above, below, and around the radiosonde.

This task arose from a discussion around the heterogeneity and time sampling of cloud observations taken around the time of a radiosonde ascent. Issues include not only how but also "when" the cloud observation is taken, which is typically at the time of launch. However, with drift and the up-to-one-hour ascent through the troposphere (*Seidel et al.*, 2011), desired information on cloudiness at a given time/height of report is not available. Also, for radiosondes targeting a given satellite, cloud observations at the time of overpass would be of value. There also was a question whether the way cloud observations were taken should be standardised and transmitted with the RsLaunchClient (a software for GRUAN sites to send raw data to GRUAN Lead Centre (LC)) and whether this would potentially help to reduce uncertainty in GRUAN products in the future. This is because these cloud observations may allow better assumptions around direct, diffuse and reflected solar radiation effects on a radiosonde temperature sensor upon ascents, noting that a clear sky ascent may take different assumptions from a cloudy ascent under heterogeneous cloud environments.

Discussions through 2019-2021 including those during the ICM-12 and ICM-13 virtual meetings went beyond the reporting recommendations of already available cloud observations (either manual/visual or automated/instrumental) at GRUAN sites, even to those regarding ideal instrumentations toward vertically resolved cloud-related GDPs. In the future, GRUAN should also consider reporting cloud occurrences because certain cloud parameters are included in the GCOS Essential Climate Variable (ECVs, https://gcos.wmo.int/en/essential-climate-variables). The GCOS ECVs for clouds include: Cloud Amount, Cloud Top Pressure, Cloud Top Temperature, Cloud Optical Depth, Cloud Water Path (liquid/ice), and Cloud Effective Particle Radius (liquid and ice). The cloud base height should also be one of the fundamental cloud parameters as a starting point to distinguish between different cloud types and correlate with radiosonde measurements.

As mentioned above, during the discussions it was found that there are several different aspects regarding "cloud observations"at GRUAN sites. Therefore, we decided to prepare this document summarising overall two separate topics:

i) recommendations for reporting the existing cloud observations at GRUAN sites (primarily to help identify "clear" scenes for satellite sensor validation), and

ii) recommendations for further discussions toward cloud-related GDPs, in view of the list of GCOS cloud ECVs mentioned above.

Section 2 summarises the current status of various cloud observations at GRUAN sites to provide insights into the most feasible approaches. Generally, sites associated with national meteorological services are more likely to have manual (i.e. visual) cloud observations, while sites associated with research institutions are more likely to have access to ground-based remote sensing or surface automated observations. Section 3 provides information on manual cloud observation and discusses their advantages for ease of introduction and disadvantages in terms of the GRUAN concept. Section 4 provides information on automated ground-based cloud observations for future consideration of establishing cloud-related GDPs. Section 5 provides information on in-situ cloud instruments that are flown together with radiosondes both for the purpose of reducing uncertainty in radiosonde temperature and humidity measurements and for future cloud-related GDPs. Section 6 summarises key points when considering cloud-related GDPs. Finally, Section 7 provides a summary of the recommendations on both immediate actions and further discussions.

2 Current status of various cloud observations at GRUAN sites

In Appendix A, Table 1 shows the detailed information on the status of various cloud observations at GRUAN sites from a site survey which was conducted prior to ICM-12 (November 2020). Of the total of 13 sites that provided the information, there are 8 sites that currently do manual (visual) cloud observations, and among them, 6 sites have already been reporting manual observation of cloud type as WMO code to the GRUAN LC when they send radiosonde data, one site has already been reporting manual observation of clouds as text ('weather condition'), and one site is not systematically reporting. Furthermore, some sites indicated the availability of automated instrumentation that could contribute to cloud observations, i.e. laser ceilometer from 3 sites, cloud radar from 2 sites, and all sky cameras from 4 sites. Several sites have two or more techniques in operation, while three sites do not have any kind of routine cloud observations program.

For sites using automatic radiosonde launchers (*Madonna et al.*, 2020), depending on the launcher type and configuration, there may be some co-located automatic weather stations of nearby sites where manual/visual (or even automated) cloud amount observation is being made. An example is the Hong Kong Observatory (see Appendix A). Further, other available information from corroborating surface-based instrumentation could also be investigated for "cloud" reporting. Examples include the "present weather" and "vertical visibility" information provided by some weather stations. This type of information, while not a direct cloud observation, could mitigate and provide a useful proxy for cloud occurrence during radiosonde launch. Solar radiation data from pyranometers can also provide information on cloud conditions.

Currently, the GRUAN data flow tools (RsLaunchClient and gtRsl) can extract cloud information from sounding files (e.g. MWX). In addition, site operators can manually fill in cloud information related to a sounding using the RsLaunchClient, and some sites have already been doing so. At present, there are three meta-data properties which have been used to provide such specific cloud information:

- "WeatherCondition.SynopClouds"
  - Explanation: synop code, e.g. "43571" (WMO 2011/2019 (*WMO*, 2019); see also Appendix B)
  - Sites: LAU, LIN, GVN, PAY, SNG (see Appendix A for these site identifiers)
- "WeatherCondition.CloudsText"
  - Explanation: cloud description as text e.g., "Cb cal", "Cu con med fra", "Ac str tr pe du", "Ci fib"; note that JMA is sending codes based on WMO (2011/2019 (*WMO*, 2019); see also Appendix B)
  - Sites: BEL, LAU, LIN, MTS, SNG, SYO, TAT (see Appendix A for these site identifiers)
- "WeatherCondition.Comment"
  - Explanation: free additional weather comment, e.g. "after rain shower"; note that JMA is sending codes based on WMO (2011/2019 (*WMO*, 2019); see also Appendix B)
  - Sites: sometimes or often used by BEL, LAU, LIN, GVN, MTS, PAY, SNG, SYO, TAT, etc. (see Appendix A for these site identifiers)

All the above information is available in the GRUAN Meta-Data Base (GMDB) which is the raw data. For the GDPs, currently, this information is included only in RS41-GDP.1 and RS41-GDP-BETA.3, but not in RS92-GDP.2 and RS-11G-GDP.1. The cloud information can be found in these GDP NetCDF files at the following global attributes:

- g.SurfaceObs.SynopClouds
- g.SurfaceObs.CloudsText
- g.SurfaceObs.Comment.

It is strongly recommended that all the future versions of the GDPs (for all radiosonde instruments) shall include cloud information that has already existed in the GMDB.

3 Manual/visual cloud observation information

Manual (i.e. visual) cloud observations have historically been conducted at sites operated by national meteorological services for many years and are still being made at many other sites all over the world. As described in Section 2, this is also the case for many GRUAN sites. The parameters include cloud amount in tenths or octas varying with countries (see *Sun and Groisman*, 2004), cloud base height (usually using instruments but also sometimes with human observations), and cloud type (see WMO (*WMO*, 2017), Part I, Chapter 15 “Observation of clouds”), and WMO (*WMO*, 2019); see also Appendix B for further details).

The manual cloud observations are inherently subjective, being probably not suitable to create a GDP, and may not be available under some specific conditions, e.g. during the night of a new moon and at very high (nearly 90°) solar elevation angles for thin cirrus. Also, manual cloud reporting according to WMO coding requires a certain meteorological background and training that personnel at research associated sites often do not have (and thus need training). On the other hand, manual cloud observations play an important role as indicated by many peer-reviewed studies, in revealing long-term climate trends (e.g. *Karl and Steurer*, 1990; *Sun and Groisman*, 2004; *Sun et al.*, 2007, 2015). It is expected that cloud properties including total cloud cover made by methods with different measuring principles may differ from each other to a certain extent. However, manual cloud observations were found to be basically consistent with cloud data measured by satellites or laser ceilometers (*Sun*, 2003; *Sun et al.*, 2015), or climate model simulations (*Free et al.*, 2016) in terms of time-anomaly or temporal variability. In particular, the cloudiness information including cloud amount, type and base height at time and location of radiosonde launches, are very useful for satellite validation to select clear sky cases. For “personed” stations having operators, manual observations might not need much funding that instrumental observations require for the acquisition and maintenance of instrumentation.

It is recommended that cloud amount information manually obtained at radiosonde launch time at GRUAN sites shall be reported. Reporting format should preferably be consistent with octas (see *WMO*, 2017) if possible (see also Appendix B). If manual observations are not available at the site but are available from “nearby” sites, they can be considered; but, validity of the “proximity” of useful observation sites needs to be discussed in the GRUAN community on a case-by-case basis.

4 Automated ground-based cloud observations

WMO (*WMO*, 2017) also presents a laser ceilometer, pyrometer, and sky camera as three examples of the “instrumental measurements of cloud amount”. As shown in Section 2 and Appendix A, several GRUAN sites are operating ceilometers and sky cameras. Technologies for these instruments are being developed rapidly in recent years. For example, ceilometers in the 1990s reported clouds only up to ∼4 km, but some recent high-end models can observe cirrus clouds above 8 km (e.g. *Maturilli and Ebell*, 2018). Note that sky imagers come with cloud detection software. There is recent research to obtain cloud height information from a network of sky imagers (*Blum et al.*, 2021). Figure 1 shows examples of pictures from a sky imager at SIRTA site (which consists of a GRUAN site Trappes Palaiseau (TRP, https://www.gruan.org/network/sites/trappes-palaiseau), and Figure 2 shows measurements from a ceilometer at the same site on the same day as for Figure 1. Another option to detect low and mid level clouds is the use of terrestrial radiation sensors such as pyrgeometers (*Dürr and Philipona*, 2004; *Aebi et al.*, 2018). The advantage of pyrgeometers from pyranometers is that pyrgeometers can detect clouds during nighttime. *Dürr and Philipona* (2004)

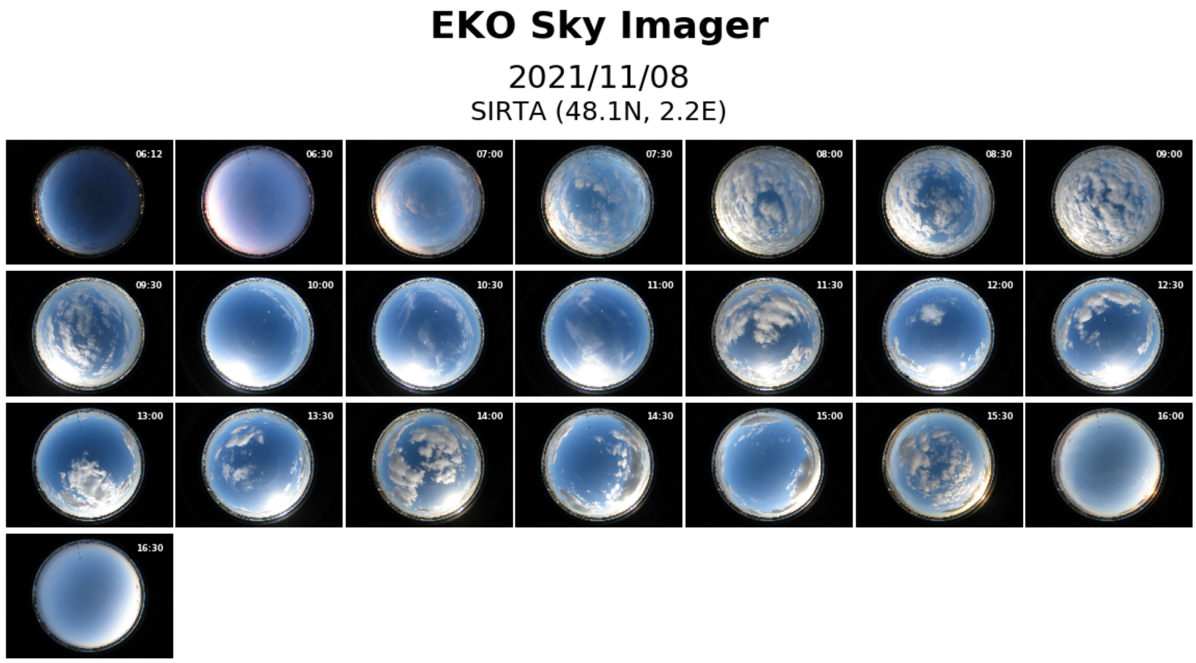

Figure 1: Pictures from a sky imager on November 8, 2021 taken at SIRTA site (48.1N, 2.2E) (or GRUAN Trappes Palaiseau site). Taken from https://sirta.ipsl.fr/bdd/pub/basesirta/1a/srf02/2021/11/08/srf02_1a_skyimgLz2_v01_20211108_000000_1440.png (accessed June 21, 2022).

developed an algorithm to estimate objectively cloud cover based on data from a pyrgeometer and on standard meteorological parameters.

Sky imagers usually do not provide cloud height information, although there are efforts going on by *Blum et al.* (2021). On the other hand, ceilometers are not very suitable to measure cloud amount since their field of view is very narrow, but the advantage is that they provide temporally resolved cloud base height measurements. Combination of these two instruments may be one solution for obtaining more complete, instrumental cloud observation. It is noted that there are other observing networks such as the US National Weather Service's Automated Surface Observing System (ASOS) network (https://www.weather.gov/asos/), ACTRIS Cloudnet (https://cloudnet.fmi.fi), E-PROFILE network (https://e-profile.eu/), Baseline Surface Radiation Network (BSRN, https://bsrn.awi.de/), AErosol RObotic NETwork (AERONET, https://aeronet.gsfc.nasa.gov/), among others, whose data might be useful in combination with GRUAN data.

Recommendations for this section are as follows: For those sites that have ceilometer, sky imager and/or other combination of remote sensing instruments that are capable of providing cloud cover measurements,

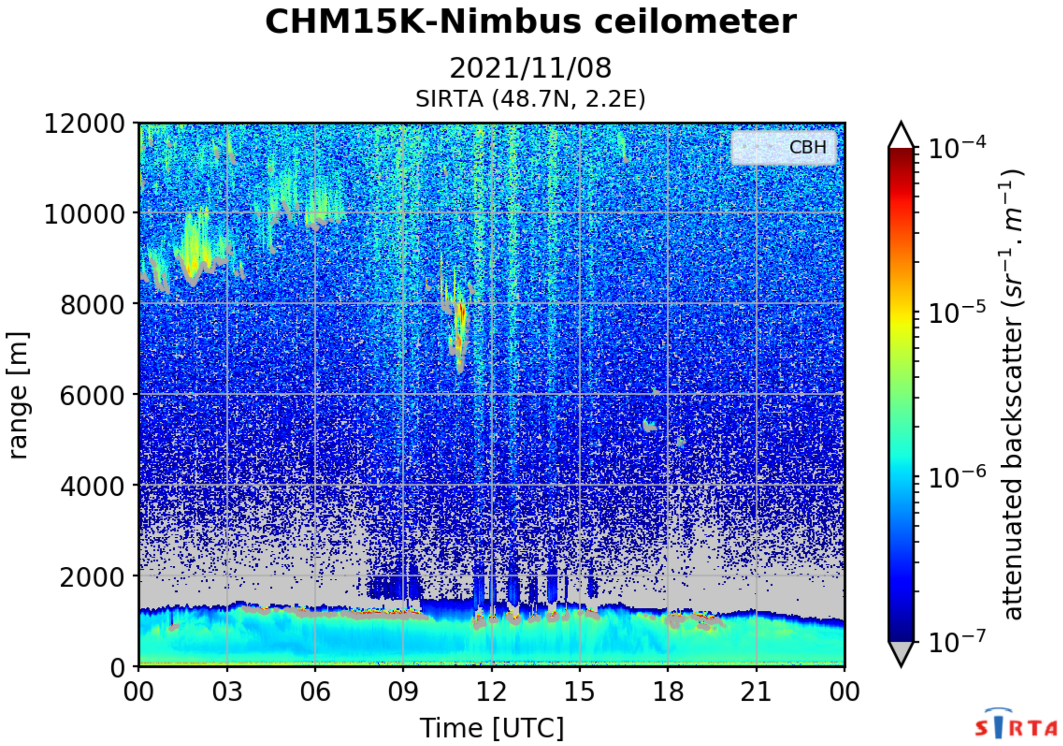

Figure 2: Measurements from a ceilometer at the same site on the same day as for Figure1. Taken from https://sirta.ipsl.fr/bdd/pub/basesirta/1a/chm15k/2021/11/08/chm15k_1a_z1Ppr2R15mF15s_v01_20211108_000000_1440.png (accessed June 21, 2022).

(i) GRUAN LC and the sites should consider to archive and disseminate those data as ancillary measurements only (i.e. not a GDP with uncertainty evaluation) for the radiosonde GDPs,

(ii) GRUAN should consider studying and producing a guide to the reporting, interpretation and value of such multi-instrument cloud information, and

(iii) the Task Team on Ground-based Remote Sensing Measurements shall lead this activity and keep in mind future cloud GDP development.

5 In-situ cloud instruments flown together with radiosondes

There are several balloon-borne particle instruments, measuring backscatter from particles (i.e. size and density information), size distribution, phase of cloud particles (droplet or ice), and cloud particle images (i.e. shape of ice crystals). Examples of such instruments can be found in the Introduction of *Fujiwara et al.* (2016). Some of the instruments presented there might be useful to consider vertically resolved cloud-related GDPs in the future. It is also noted that there are many ways to infer the presence of clouds indirectly using e.g. relative humidity, temperature, pressure, saturation over liquid and/or ice derived by radiosonde (*Wang and Rossow*, 1995; *Poore et al.*, 1995; *Chernykh and Eskridge*, 1996; *Wang et al.*, 2000; *Chernykh et al.*, 2001; *Minnis et al.*, 2005; *Zhang et al.*, 2010, 2013; *Yuan et al.*, 2015).

There is another motivation to obtain cloud information in association with GRUAN radiosonde soundings, which is to reduce uncertainty of radiosonde temperature and humidity GDPs. This is because solar radiation correction is the largest factor for radiosonde temperature uncertainty during daytime flights, and the solar radiation field is strongly affected by cloud distribution below, above, and around the flying radiosonde. Taking actual or real time cloud information into account for future versions of radiosonde GDPs is therefore one avenue to improve the GDPs. For radiosonde GDPs that use radiation models to simulate direct and backscatter solar irradiance (e.g. *Kobayashi et al.*, 2019; *von Rohden et al.*, 2022), representative cloud scenarios have to be used so far, which brings a significant contribution to the uncertainty of the radiation correction. For this purpose, direct radiation measurements may be more straightforward (e.g. *Becker et al.*, 2020; *Kochin et al.*, 2021).

It is recommended that the GRUAN community shall monitor and report proactively on new instruments to measure cloud extent and classify cloud types and to assess their quality in comparison with existing and established methods/instruments. This could be carried out through an active encouragement and call to instrument manufacturers and/or multi-instrument cloud reporting algorithm developers.

6 A road to cloud-related GRUAN Data Products

The development of cloud-related GDPs can be the results of a joint effort within the GRUAN community. GRUAN mission includes the establishment of so-called “priority 2” products covering several ECVs. For clouds, parameters to estimate are related to cloud geometrical, thermodynamical, optical, and microphysical properties. Being a reference network, GRUAN is planning to develop cloud-related products with quantified and traceable uncertainties. In this sense the most mature measurement techniques and those of most common usage at the GRUAN sites should be considered as a priority and cost-effective option for generating cloud-related GDPs.

The two main goals of GRUAN to act as a reference network for cloud observations would be as follows:

(1) Provide ancillary information for the radiosonde GDPs. This is challenging because in the presence of clouds the temporal and spatial coincidence of such information with the radiosonde trajectory is limited, and also because clouds have a very large spatial and temporal variability in both their micro- and macro-physical properties. A possible approach is the integration of ceilometers with total sky imagers or geostationary satellite images to at minimum identify the sky condition and in support of evaluation of the radiosonde GDPs.

(2) Enhance the level of characterisation of the atmospheric column investigated at the GRUAN

sites. For this purpose, profilers (the cheapest are the ceilometers) would be the primary option to consider because they can provide the cloud height at all tropospheric levels, with the limitation under low level thick cloud conditions which anyhow can be solved only using a radar or passive retrievals, although being with much coarser resolution. Ceilometers are also frequently available at GRUAN sites and can provide derived boundary layer height (*Hicks et al.*, 2015).

Priority in the implementation of the two activities above may depend on the sites, and their implementation requires a coordinated effort among the sites, LC, and relevant task teams.

7 Summary of the recommendations

This document discussed and summarised overall two separate themes: (i) recommendations for reporting the existing cloud observations at GRUAN sites (primarily to help identify "clear" scenes for satellite sensor validation), and (ii) recommendations for further discussions toward cloud-related GDPs, keeping in mind the GCOS cloud ECVs.

Recommendations:

- All the future versions of the GDPs (for all radiosonde instruments) shall include cloud information that has already existed in the GMDB (Section 2).
- Cloud amount information manually obtained at radiosonde launch time at GRUAN sites shall be reported. Reporting format should preferably be consistent with octas (see WMO, *WMO* (2017)) if possible (see also Appendix B). If manual observations are not available at the site but are available from "nearby" sites, they can be considered. However, validity of the "proximity" of useful observation sites needs to be discussed in the GRUAN community on a case-by-case basis (Section 3).
- For those sites that have ceilometer, sky imager and/or other combination of remote sensing instruments that are capable of providing cloud cover measurements,
  - (i) GRUAN LC and the sites should consider to archive and disseminate those data as ancillary measurements only (i.e. not a GDP with uncertainty evaluation) for the radiosonde GDPs,
  - (ii) GRUAN should consider studying and producing a guide to the reporting, interpretation and value of such multi-instrument cloud information, and
  - (iii) the Task Team Ground-based shall lead this activity and keep in mind future cloud GDP development (Section 4).
- The GRUAN community shall monitor and report proactively on new instruments to measure cloud extent and classify cloud types and to assess their quality in comparison with existing and established methods/instruments. This could be carried out through an active encouragement and call to instrument manufacturers and/or multi-instrument cloud reporting algorithm developers (Section 5).
- A road to cloud-related GDPs was also presented for future reference (Section 6).

Appendix

A GRUAN site survey results

Table 1 shows information on the status of various cloud observations at GRUAN sites (see https://www.gruan.org/network/sites) at the time the site survey was conducted prior to ICM-12 (November 2020), with some updates for some sites. See also Section 2 for additional information.

It is noted that the Hong Kong (HKO) site is using a Vaisala Autosonde system for routine launches. Cloud information is not observed on site. However, cloud cover information at another "personed" site with operators about 1 km away, where the cloud amount in octas is reported every hour, in addition to visibility, state of sky and weather in WMO code. Moreover, a radiometer at the launch site is available to show the temperature and relative humidity profiles up to 10 km, updated about every 10 min. Furthermore, there is a camera about 1 km south of the site (Camera #14B, Tsim Sha Tsui (looking towards the east), https://www.hko.gov.hk/en/wxinfo/ts/index_webcam.htm), providing real-time weather photos.

Table 1: Overview of cloud observations at GRUAN sites, based on site survey conducted prior to ICM-12 (November 2020), with some updates for some sites.

Site (Identifier)	**Availability of cloud observations for GRUAN soundings**	**Type of observations, quantification, way of submission (GRUAN meta data**
Australia: Alice Springs (ALC), Macquarie Island (MAQ), Melbourne (MEL)	Visual at present	Not submitted
Beltsville (BEL)	Yes	Combination of visual observations and checks with a ceilometer back-scatter profile (Luft, CHM-15K), solar and terrestrial radiation instruments, and satellite images. A text is written in the "WeatherCondition Clouds Text" box.
Boulder (BOU)	No	
Japan: Tateno (TAT), Minamitorishima (MTS), Syowa (SYO)	Yes	Clouds are manually observed by operator. Clouds data are submitted as "WeatherCondition.CloudsText" property for Meisei radiosonde soundings as "NNhCLhCMCH"

Continued on the next page.

Table 1 – *Continued from previous page*

Site (Identifier)	**Availability of cloud observations for GRUAN soundings**	**Type of observations, quantification, way of submission (GRUAN meta data**
La Réunion (REU)	No	Continuous ceilometer measurements
Lauder (LAU)	Usually	The technician may note the WMO code for cloud type and the cloud fraction in 8ths, as well as the cloud height and visibility distance.
Lindenberg (LIN)	Yes	Regular synoptic cloud observations are coded and included in the GRUAN metadata. There are several radiation and cloud detection instruments (e.g. all-sky camera) at the Lindenberg site, but these instruments are operated by another group so the data do not automatically end up in the GRUAN archive.
Ny-Ålesund (NYA)	Only ‘present weather‘	Our station staff reports only the ‘present weather‘at launch to an internal documentary. We can provide this observation also to GRUAN. As an option for cloud estimation, we could also provide surface radiation data (SW and LW, both up- and downward) from BSRN measurements together with ceilometer cloud base height information.
Trappes Palaiseau (TRP)	Yes	Ceilometer (CL31 + CHM15K) + Cloud radar BASTA + HATPRO MWR + sky imager. We do not include this data for the raw data of M10 sensor.
Payerne (PAY)	Yes	Currently the coding of the observation is introduced into the Vaisala software and is available into the MWX archive processing. We have continuous cloud base height measurements.

Continued on the next page.

Table 1 – *Continued from previous page*

Site (Identifier)	Availability of cloud observations for GRUAN soundings	Type of observations, quantification, way of submission (GRUAN meta data
Potenza (POT)	Yes	Ceilometers, radar, optical/infrared/microwave radiometers, photometers, sky camera also available. Cloud base and top height for active sensors is retrieved using the ACTRIS/cloudnet algorithm. For infrared radiometers, the cloud base height comes from the IR cloud temperature and for photometers the optical depth is estimated only. All of these are not used for GRUAN metadata yet. A total sky imager is available and will soon become operational. [See also the footnote #1]
Singapore (SNG)	Yes	Only the 5 digits cloud group observation that goes into the ground input values at launch
Sodankylä (SOD)	Yes	Cloud observations are submitted via Metgraph software, including cloud type and amount of clouds, as surface observations. At the Sodankylä site cloud observations are also made by a doppler lidar and by a ceilometer, though not currently submitted to the GRUAN archive.
Tenerife (TEN)	No	

Footnote #1: Additional information on Potenza (POT): Information on the instrument models is as follows:

- Ceilometers: CHM15K, CL31, CL51.
- MWR: RPG HATPRO and Radiometrics MP3014 (with the IR radiometer at 10.6 microns)
- Radar: 36 and 94 GHz
- Raman lidars 3 wavelenghts
- AERONET CIMEL lunar/solar photometer.

B A quick guide to WMO Manual on Codes for cloud information

WMO (*WMO*, 2017), in Part I, Chapter 15 (“Observation of clouds”), provides information on manual (i.e. visual) cloud observations in octas, cloud-base height (usually using instruments but also sometimes with human observations), and cloud type. The codes used for reporting these observations are summarised in WMO (*WMO*, 2019).

Section B of WMO (*WMO*, 2019) defines various variables including those related to clouds such as “N”, “Nh”, “CL”, “h”, “CM”, “CH”. For example, “N” is explained at page A-204 as:

N: Total cloud cover. (Code table 2700) (FM 12, FM 13, FM 14, FM 22, FM 45)

where FM stands for format. The Code table 2700 can be found at A-313. For example, $N = 6$ means 6 oktas, i.e. cloud cover of 7/10 to 8/10.

When a GRUAN site starts to observe and report cloud information by following the WMO Codes, it is recommended to contact the GRUAN LC.

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Acronyms

GCOS	Global Climate Observing System
GRUAN	GCOS Reference Upper-Air Network
ECV	Essential Climate Variable
GDP	GRUAN Data Product
GMDB	GRUAN Meta-Data Base
ICM	Implementation and Coordination Meeting
JMA	Japan Meteorological Agency
LC	Lead Centre
NetCDF	Network Common Data Format
WMO	World Meteorological Organization

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