GRUAN guide and GRUAN manual

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The idea of this talk is ….

- Share ideas and get feedback for the planned review of the GRUAN guide and manual to ensure that both documents reflect the current status of the network
- Discuss requirements for GRUAN stations and measurement programs

The documents (probably not so used by the GRUAN «veterans») may still be the tools to learn more about GRUAN, in particular for new stations and for any interested users.

Overall impressions of guide and manual

- Very extensive and sometimes exceeds the measurement practices applied at the GRUAN stations.
- Outdated in some parts and others may be simplified/synthetized.
- Sometime lack of support by literature for recommended measurements time schedule and practices.
- Before updating, discussion and consensus are needed ...

… Following slides are referred to some main steps where discussion is needed before updating …..

GRUAN policy for uncertainty

The GRUAN policy for dealing with measurement uncertainty shall be:

i) Describe/Analyse all sources of measurement uncertainty to the extent possible.

ii) Quantify/Synthesize the contribution of each source of uncertainty to the total measurement uncertainty.

Made properly (RS92 under improvement)

iii) Verify that the evaluated net uncertainty is in agreement with the required target uncertainty.

- This will be discussed during the breakout session #2.
- What's our target uncertainty? No specific mention to it only some general guidelines, it needs to be clarified.

Uncertainties in GRUAN

While a specific sensor might perform well, if its value depends on another sensor that performs less well, this source of uncertainty needs to be accounted for …….

…… A list of sources of measurement uncertainty will be defined in the GRUAN common approach to the measurement uncertainty evaluation. Every GRUAN site shall measure, collect, and provide all information necessary to establish an uncertainty budget for every measurement, according to the common approach.

- We need to provide more details on the "common approach" in the GRUAN manual. Beyond certain level of independence of the site on the measurement practices, we have a common pre-launch procedure that must be reflected. Do we have any discrepancies between the sites in the metadata collection?

Verify and validate

- *Verify measurement uncertainties: All site to carry on comparisons with redundant observations, routinely.*

It looks a mandatory requirements but in practice it is more a recommendation. Isn't it?

- *Validating measurements: standardized tests must be performed across the entire GRUAN network, regardless of the type of instrument considered.*

Do we need to distinguish between generic comparison and GDP comparisons?

Development of CDRs for ECVs

Development of climate data records of ECVs within GRUAN shall be consistent with the Guideline for the Generation of Datasets and Products Meeting GCOS Requirements (GCOS.143):

i) Periodic review of climate data records produced by GRUAN should be undertaken by an external body to provide an independent assessment of its quality and thereby improve the confidence that the user community has in the product. -> Never done

ii) Provide a facility for user feedback on the quality, usefulness and applicability of the data products. -> Not available

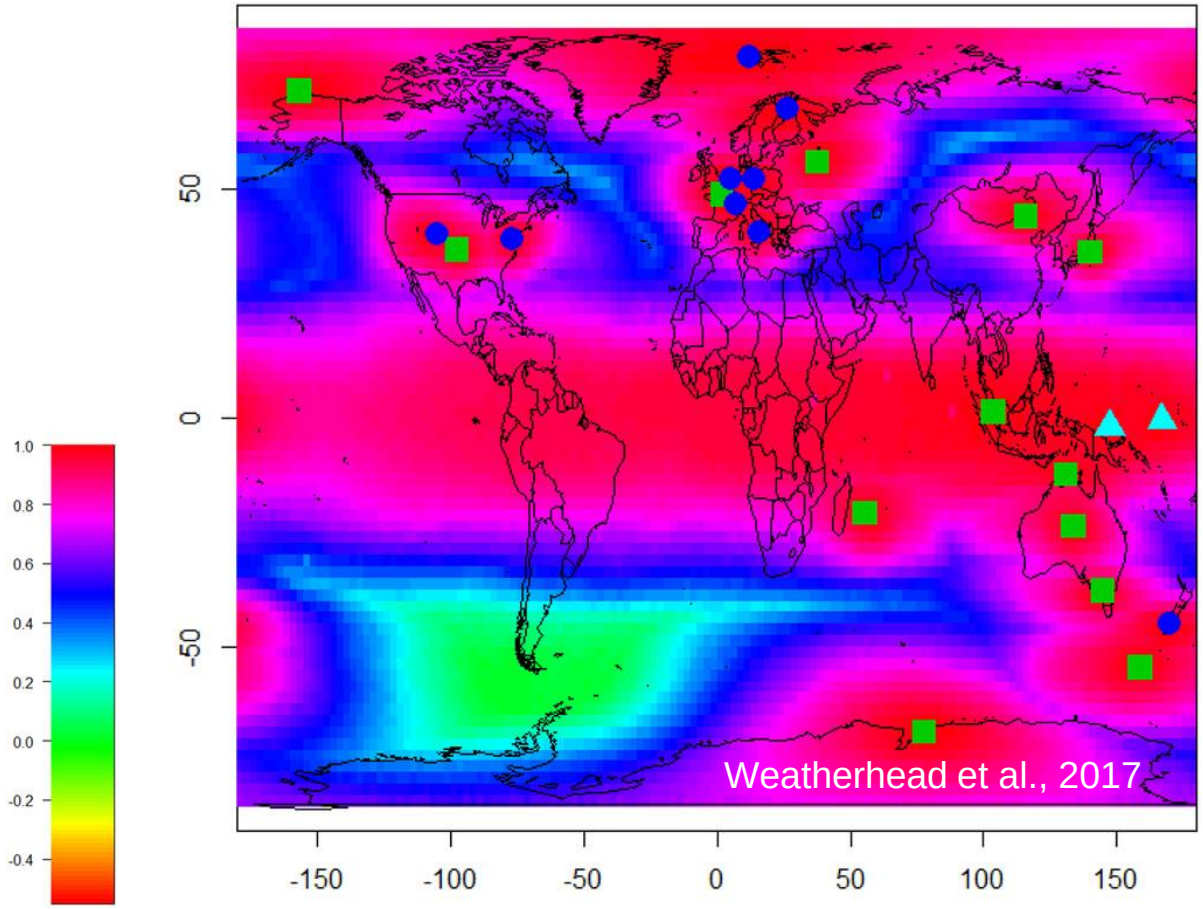
iii) A quantitative maturity index describing the level of scientific maturity (1=initial, 2=experimental, 3=provisional, 4=demonstrated, 5=sustained, 6=benchmark) should be included in the description of the climate data record. -> possible upon external evaluation and maturity matrix approach.

iv) A full description of the climate data record should be published in the international peer reviewed literature.

- Points i) and ii) are a good framework to develop in the next months. Maybe the iii) could be used only internally and remove from the guide. Opinions?

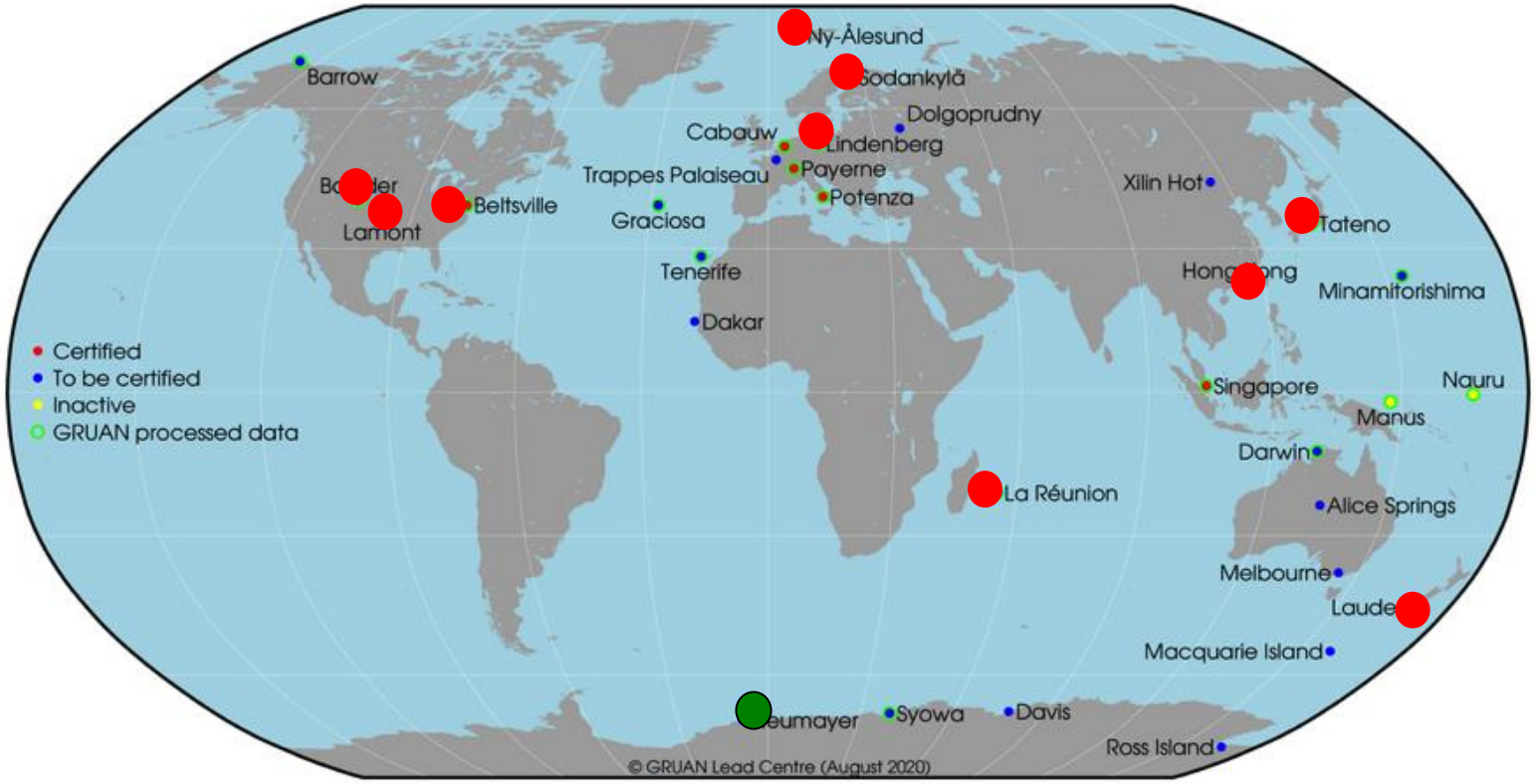
Requirements for the sites

- Stratospheric water vapour measurements are key for monitoring climate changes.
- However, a related measurement program might not be sustainable at every site.
- From, we may learn more about sites' representativeness in the stratosphere from existing publications
- May we consider the option to have a network where only a subset of sites are fully equipped? For all other sites, stratospheric water vapour measurements will be always highly recommended.



Level of redundancy of representativeness for each location around the world based on the proposed 24-site GRUAN. The correlation listed is the highest correlation that would exist if the single most important station for that location were removed.

GRUAN sites with CFH/FPH measurements



- Measurements in South America are needed.
- If the current measurement programs will continue, is it needed to have still as a mandatory requirement for new stations to measure water vapour in the stratosphere? Could it imply any further study (by the SCG?) about it?

Section to clarify

- *Instrument calibration:* are these information preserved in GRUAN data archive? It would interesting to archive them if not yet done.
- *Site auditing: it is expected to have regular visit to the sites … «A site visit by selected members of the WG-GRUAN and the GRUAN Lead Centre. Such a visit would include discussions with the scientists responsible for the measurement programmes at the site».* Need to update for reflecting the regular practices, linked to the ICM site visit.

Other parts may be simplified

- *Measurement scheduling*: No scientific basis, it seems for the current, and probably not considered especially at minimum entry sites.
- Same applied to ancillary measurements in particular to the lidar.
- *Surface measurements*: do we need more specific requirements on the near-surface measurements? Are these requirements same as those set for/by GSRN?

ACTION

A draft of the GRUAN guide and manual will be elaborated after ICM-15 and send out to the WG GRUAN for further discussion.

Quantify/synthesize sources of uncertainty

The second step is, where possible, to quantify and correct for any measurement biases. Uncertainty in such bias corrections, which shall also be diagnosed, documented and quantified, then contributes to the total measurement uncertainty budget. Techniques to fully describe the shape of the Type-A uncertainty distributions must then be developed and higher order moments of the distribution (e.g. the skewness or kurtosis) would need to be reported as part of the measurement uncertainty description……. This approach can be used no matter how structured or asymmetrical the individual PDFs might be. This approach has been used to estimate asymmetric errors in ozonesonde measurements (Bodeker et al., 1998). Once all biases have been corrected for, and assuming all remaining Type-A uncertainties have a known statistical distribution, the resultant net uncertainty on the measurement can be reported as a single value composed of Type-A and Type-B uncertainty components.

- Needs updating also considering the current structure of files of the latest GRUAN GDPs

PDF uncertatinty shape

….. Given that some systems may quote uncertainties as 1σ values, it is imperative that it is clearly stated in the GRUAN metadata that the values are 2σ uncertainties. For more complex distributions of measurement uncertainty it may be necessary to quote the most likely value i.e. the peak in the PDF for the measurement and parameters that detail the shape of the PDF (or a pointer to the PDF itself).

- Now coherent with the latest GRUAN GDPs, RS92 GDP needs reprocessing

Verify measurement uncertainties

Redundant observations from complementary instruments can be used to verify measurement uncertainties that have been evaluated a priori.

If coincident observations of the same ECV are available and are subjected to the same uncertainty analysis, the degree to which the measurements agree within their stated uncertainties is indicative of the validity of the measurement procedure.

If measurements agree within their uncertainties, the uncertainty estimates on the individual measurements are more likely to be correct. Formal methods, based on the availability of large sets of data, have been developed to evaluate whether uncertainties are over-estimated or under-estimated (Immler et al., 2010).

We should carry out comparisons with redundant observations, routinely

Validating measurements

Once the uncertainty on a measurement has been calculated, the question then becomes: how well does this uncertainty represent the robustness of this measurement? Two approaches are available for validating any measurement, viz. 1) by comparing redundant measurements, and 2) by laboratory analysis of the measurement system.

When redundant measurements are present, their uncertainty must be evaluated using standardized consistency tests such as those described in Immler et al., (2010). These standardized tests must be performed across the entire GRUAN network, regardless of the type of instrument considered.

- Should this be described in a distinct way if comparison measurement are GDPs or not?

Requirements for GDPs: radiosondes

Two section outlines requirements

Requirement from GCOS:

- Requirements consistent with state-of-the-art capability
- GRUAN measurement targets

Interplay of science goals and scheduling frequency

- Trend detection
- Satellite validation and radiation studies
- Process studies

- Is it too sophisticated the current structure? Should we focus only the real capabilities for the available technologies and on GCOS requirements?

Moving Beyond Priority 1 ECVs

For each new variable, or set of variables (e.g. cloud properties may be treated as a single set ofmvariables), planned to be brought online within GRUAN, the following are required:

A task team: The goal of the task team is to provide the scientific basis and oversight required to bring the new variable online in GRUAN..... Membership of this task team should include one member of the GRUAN

Lead Centre, at least one member of the Ancillary Measurements Task Team, a representative of the central processing facility for that ECV (see below), at least two members of the WG-GRUAN, at least one internationally recognized instrument expert for each of the instruments likely to provide measurements of the ECV of interest, and other members of the international communitywith expertise in the processing, quality control and interpretation of the resultant data. In some cases, more than one position on the task team may be filled by a single person. The task team is likely to remain in effect only in the lead-up phase prior to those data products flowing to users hrough the GRUAN data archive.

- I propose to simplify this structure and have a more detailed description on the cooperation with affiliated networks.

Fully equipped GRUAN site

1) Make at least double, and preferably triple, redundant measurements of all GRUAN priority 1 and 2 ECVs and, specifically:

a. Four times daily radiosonde measurements of temperature, pressure and humidity, submitted in NRT to the WIS (WMO Information System) sufficient to achieve NWP- based QA/QC. Temperature profiles to ~30 km either at 00, 06, 12 and 18 UTC or at 00, 06, 12 and 18 LST (local solar time)

b. maximize coincidence with satellite overpass.

c. Hourly observations of integrated precipitable water vapor

d. Weekly ozone profile measurements.

2) Periods of high temporal and spatial resolution measurements capable of revealing variation of key atmospheric variables.

3) Periodic intercomparisons including other instruments used across the network.

4) A demonstrated commitment to a measurement programme extending 30 years or more into the future.

5) Fulfil all mandatory operating protocols defined in Section 5.3.

6) Fully equipped GRUAN sites are strongly encouraged, but not required, to measure priority 3 and 4 ECVs.

7) Adhere to all operational protocols defined in the series of GRUAN technical documents.

Minimum entry GRUAN site

1. 1 weekly production radiosonde with the best technology currently available at the site;
2. 1 monthly radiosonde capable of capturing the moisture signal in the UT/LS and all other priority 1 variables to the best level possible with current technology, launched together with weekly radiosonde;
3. At least twice daily observations of integrated precipitable water vapour. and should aspire to making:
4. Regular 00 and 12 LST (as a preference over UTC) launches of a production radiosonde with the best technology currently available;
5. Dual launches of sondes with highest quality humidity sensing capability in the UT/LS (flying the monthly radiosonde together with a second sonde also capable of measuring water vapour in the UT/LS); and
6. Periodic intercomparisons of a large range of sonde types.

Surface measurements

While GRUAN is, by definition, an upper-air network, surface measurements at sites should also be made in such a way that:

They are made according to WMO guidelines (WMO-no. 8), including traceability to SI standards. The CIMO classification for stations should be applied.

The surface measurements provide ground-truthing for vertical profile measurements. For example, comparisons between ozonesonde measurements of ozone at the surface against a high precision standard, provides essential information for quantifying uncertainties in the ozonesonde measurement.

- Do we need more specific requirements on the near-surface measurements? GSRN?

Instrument calibration

Establishing reliable calibration procedures for the instruments being used within GRUAN, and applying these uniformly across the network, is an absolute prerequisite for achieving the GRUAN goals. …… it is equally important that site-to-site differences in calibration procedures do not compromise the goal of achieving homogeneity across GRUAN as a whole so that a measurement of a given parameter at one site is directly comparable to a measurement of the same variable at a different site. …… While achieving a common data processing for each instrument will be facilitated through processing the raw data at a single central data processing facility (see Section 8.1), the same approach cannot be used for calibration procedures. … developing travelling calibration standards, where possible. … GRUAN sites shall maintain a "GRUAN site working standard" for each fundamental measurement unit, e.g. a thermometer periodically calibrated to a National Metrology Institute or other accredited agency standard since this ensures traceability to an SI standard. A mechanism shall be implemented to address the compatibility of those systems with the rest of the network that may not be traceable to SI standards. However, the goal is to ensure that all measurements within GRUAN are traceable to SI standards. …. Each site shall maintain accurate and complete metadata records and provide these to the GRUAN archives. Copies of calibration certificates shall be submitted to the GRUAN metadatabase.

- Is there room to improve and harmonize the calibration time schedule at the sites? Can the availability of this information be required to certifiy a site?

Measurement scheduling

Schedule A

This schedule is designed for instruments making one or more measurements per week. Where there is an expected seasonal cycle in natural variability and that cycle is not yet known, intervals between measurements should be constrained by $(4/N) < t < (10/N)$ where t is the interval in days and N is the number of measurements being made each week. Under such a schedule, on average, $52 \times N$ measurements will be made each year. Once a climatology of the seasonal cycle in natural variability has been determined, during the 5 months of the year exhibiting highest natural variability, intervals between measurements should be constrained by $(3.5/N) < t < (6.5/N)$ where t is the interval in days; this should result in a total of $N \times 30$ measurements through those 5 months. For the remaining 7 months of the year intervals between measurements should be constrained by $(7/N) < t < (13/N)$; this should result in a total of $N \times 22$ flights through those 7 months. On average, this will result in $52 \times N$ measurements being made each year but with a higher frequency ($\sim N \times 6$/month) in the months of higher natural variability and a lower frequency ($\sim 3 \times N$/month) during months of lower natural variability. Within the measurement windows defined above, measurement times should be selected to maximize the altitude reached based on knowledge of local conditions, to maximize coincidence with relevant satellite overpasses, and to minimize factors that may contribute to measurement uncertainty e.g. making flights at night rather than during day for instruments requiring corrections for solar heating.

Measurement scheduling

Schedule B

This schedule is designed for instruments making one or more measurements per month. Where there is an expected seasonal cycle in natural variability and that seasonality is not yet known, intervals between measurements should be constrained by $(20/N) < t < (40/N)$ where t is the interval in days and N is the number of measurements being made each month. Once a climatology of the seasonal cycle in natural variability has been determined, during the 4 months of the year exhibiting highest natural variability, intervals between flights should be constrained by $(15/N) < t < (25/N)$ where t is the interval in days; this should result in a total of $N \times 6$ flights through those 4 months. For the remaining 8 months of the year, intervals between flights should be constrained by $(35/N) < t < (45/N)$; this should result in a total of $N \times 6$ flights through those 8 months. As with Schedule A, within the measurement windows defined above, measurement times should be selected to maximize the altitude reached based on knowledge of local conditions, to maximize coincidence with relevant satellite overpasses, and to minimize factors that may contribute to measurement uncertainty e.g. making flights at night rather than during day for instruments requiring corrections for solar heating.

- How many sites at the minimum entry level are using these protocols? Do we need to simplify or is there a scientific basis to outline this protocols?

Site auditing

1. Certification of GRUAN sites will not be a single event. Periodic (every 3-4 years) complete auditing of the measurement programmes included in the GRUAN certification for a site will be conducted to ensure that the programmes continue to meet GRUAN standards. Such an audit may include:
2. A review of annual reports from sites on GRUAN activities.
3. A written report from the site – essentially an update of the original report written to initiate the assessment and certification process.
4. A site visit by selected members of the WG-GRUAN and the GRUAN Lead Centre. Such a visit would include discussions with the scientists responsible for the measurement programmes at the site.

- Visit is made during ICM-15, quite unfrequent: suggest to revise it

GNSS and lidar

GPS integrated precipitable water

The GNSS receivers at GRUAN sites shall track GNSS satellites with a sampling interval of 30 seconds or less. The minimum requirement for GNSS raw data submission is daily (24 hour) files with a 30 second sampling interval.

Surface meteorological observations shall be made at GNSS sites at intervals of no more than 60 minutes. An observation interval of 10 minutes is preferred.

An hourly sampling interval is required for GNSS tropospheric products and associated supplemental data, including zenith tropospheric delay, zenith wet delay, precipitable water, surface pressure and atmospheric water-vapour-weighted mean temperature.

Lidar

A minimum of 6 hours per week spread over 2 to 4 nights of operation may be suitable for long term monitoring. Additional details can be found in Section 3.1 of the GRUAN Lidar Guidelines document, which applies the general scheduling guidelines described in Section 7.5 specifically to lidar operations.

When redundancy between programmes at the same GRUAN site can be identified, the lidar should be operated according to the following recommendations:

For sites performing at least daily radiosonde flights: the lidar does not need to be operated every night, but when operated, its running time should be coincident with the first night-time flight of the day. The first half-hour of the radiosonde flight must fully encompass the lidar data acquisition period, i.e., must be included between lidar start and end times.

For sites performing weekly or monthly radiosonde flights: the lidar must be operated at least on the nights (days) of the radiosonde flights. The first half-hour of the radiosonde flight must fully encompass the lidar data acquisition period, i.e., must be included between lidar start and end times

For sites performing frost-point hygrometer (FPH) flights: the lidar must operate at least on the nights (days) of the FPH flights. Extended hours of lidar operation (e.g. all night or at least 4-5 hours) are recommended in an attempt to extend and/or optimize the profiles in the UT/LS. The first full hour of the FP flight must fully encompass the lidar data acquisition period, i.e., must be included between lidar start and end times.