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Report of the Sixth GCOS Reference Upper Air Network Implementation and Coordination Meeting (GRUAN ICM-6)

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1. Introduction

The sixth GCOS Reference Upper-Air Network (GRUAN) Implementation and Coordination Meeting (ICM-6) was held from 10 to 14 March 2014 near the GRUAN site of Howard University at Beltsville, MD, USA. The meeting was supported by the US GCOS Program Office at the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Centre (NCDC), the NOAA Climate Program Office (CPO), Howard University, and the GCOS Secretariat at the World Meteorological Organization (WMO). The meeting included a site visit to the Beltsville atmospheric observing facility of Howard University and the NOAA National Weather Service (NWS) Sterling Field Support Center at Sterling, VA, USA.

The annual GRUAN meetings afford an opportunity for the Working Group on GRUAN (WG-GRUAN), the GRUAN Lead Centre, Task Teams, and representatives from initial and prospective GRUAN sites and other stakeholders to review progress to date, highlight issues and exchange views. The meeting agenda is included as Appendix 2.

The meeting's main goals were to update participants on GRUAN progress and to discuss new developments, with a focus on:

- Maximizing the utility of GRUAN activities and measurements to benefit the Global Observing System. In this regard the presence of representatives from the WMO Integrated Global Observing System (WIGOS), NOAA and NASA was noted with appreciation by attendees.
- Progress on site certification,
- Progress on network expansion,
- Establishing links with the scientific and meteorological communities,
- Review the progress of the work plans for the GRUAN Lead Centre, the WG-GRUAN, and GRUAN task teams,
- Consider new data streams to include in coming years as called for in the current GRUAN Implementation Plan.

Rather than being a full record of the meeting, this report summarizes and synthesizes key discussions and outcomes. The meeting notes were recorded through an online collaboration by the meeting participants and finalized by the Lead Centre in cooperation with the WG-GRUAN and GCOS Secretariat. All documents prepared in support of ICM-6, and all meeting presentations, are available on the GRUAN website at http://www.gruan.org (under Meetings → Beltsville 2014).

2. Opening Notes

Dr Vernon Morris, Director of the NOAA Center for Atmospheric Sciences (NCAS), provided opening remarks on behalf of Dr Wayne Frederick, President of Howard University. Dr Morris recognized the growing importance of the atmospheric sciences in the strategic goals of Howard University. The graduate programme in atmospheric sciences, which was inaugurated in 1998, is one of Howard University's youngest programmes. It has grown to a significant and diverse programme producing many minority PhD graduates, many of whom continue working within the field. NCAS is a consortium of NOAA and six universities and is

led by Howard University. The core mission of NCAS is to conduct research and applications development in support of the NWS and air-quality research. NCAS also collaborates with the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) and the NOAA Office for Atmospheric Research (OAR).

Dr Morris noted that Howard University was committed to ensure sustainability and technological capability and in that context was committed to site assessment and certification of the Beltsville site. Beltsville is central to many of the Howard University programme efforts and GRUAN plays a central role in this. Howard Diamond of the NOAA US GCOS Office and Mitch Goldberg of NESDIS were acknowledged for their support of the measurement programme.

Dr Robert Detrick, Director of NOAA/OAR provided remarks on behalf of NOAA. He thanked Howard University for hosting the meeting and recognized the long-standing cooperation between Howard University and NOAA. He congratulated GRUAN on their significant progress over the past decade, taking the idea from a challenge by the climate science community through to a working network that was starting to produce significant results. Dr Detrick noted that while substantial further progress is required, the trajectory of GRUAN is seen as strongly encouraging by NOAA.

Dr Detrick noted that NOAA remains strongly committed to GRUAN and that NOAA continues to play an active role in the global observing system. He noted how GRUAN recognizes the importance of good observations to advance our knowledge of the changes in the climate system and our ability to project future changes. Dr Detrick pointed out the synergistic value of reference quality *in situ* and satellite observations and thus the value of GRUAN to NOAA's significant satellite investment. The US Climate Reference Network (CRN) was highlighted as a significant and synergistic effort. NOAA has hosted several early GRUAN meetings. Both the Climate Program Office and US GCOS Office intend to continue to support GRUAN, and NOAA would like to see additional US input to and support of GRUAN. International partnerships are seen as key to long-term sustainable measurement programmes by NOAA. Dr Detrick stressed that the value and progress of GRUAN needs to be collated and highlighted on a regular basis to retain support at senior levels within organizations such as NOAA.

Dr Dave Goodrich, former director of the GCOS Secretariat at the time of GRUAN's formal inception, provided some personal reflections on progress to date. Dr Goodrich reminded people that six years ago at Lindenberg, the ethos of 'start small, but start' had been given as a mantra for GRUAN's development. He noted that it is a formidable undertaking to start and maintain a long-term measurement programme. Long-term measurements are needed for many reasons and must be demonstrably used and exploited by scientists. Dr Goodrich recognized that GRUAN and its scientists were key to meeting long-term science needs on a sustained basis. He stressed that it is the commitment of the scientists that will ultimately lead to the success of GRUAN. He noted the substantial progress made to date in advancing GRUAN and how this was a testament to sustained engagement by a number of highly committed scientists and institutes, not least of all the German Meteorological Service, Deutscher Wetterdienst (DWD) and GCOS.

Dr Holger Vömel, head of the GRUAN Lead Centre, introduced the paradigms of GRUAN

and outlined its measurement philosophy for new participants (and as a reminder to others). The ongoing and urgent need for GRUAN is demonstrated for example by the recently published 5th Assessment Report of the International Panel on Climate Change (IPCC)[1]. Although in the lower troposphere an increase in Integrated Precipitable Water (IPW) has very likely occurred, the absence of a homogenized data set of upper-tropospheric humidity across multiple satellite platforms, for example, presents some difficulty in documenting coherent trends from these records. Worse still is that the confidence in long- term water vapour trends in the lower stratosphere is low.

GRUAN was created to address these issues of ambiguity in climate monitoring above the surface and to provide homogenous data sets that can be used to answer these questions. The goals of GRUAN are to provide reference observations for long-term climate studies, satellite validation, atmospheric processes, and numerical weather prediction. Deliberate measurement redundancy, traceability, and management of change are essential tools to achieve these goals. Measurements of water vapour and temperature have been given the highest priority to date, but other measurements, leading to the full suite of upper-air ECVs eventually as an aspirational goal, are slowly to be included into the measurement suite of GRUAN as it further develops.

The definition of the term “reference observation” as used within GRUAN requires traceability to SI or an accepted standard, a comprehensive uncertainty analysis, storage of raw data, collection of metadata, documentation in public literature, as well as extensive validation. These exacting requirements are necessary to assure our knowledge of long-term climate changes.

Management of change is an essential element of GRUAN requiring that new systems are evaluated prior to implementation, as well as extensive parallel observations, using the old and new systems. Transfer functions must be applied to old data where required. These issues are also encountered by other climate oriented networks such as the Network for the Detection of Atmospheric Composition Change (NDACC), the Global Atmospheric Watch (GAW) programme or the Southern Hemisphere Additional Ozone Sonde (SHADOZ) programme. Dr Vömel highlighted that the forthcoming Vaisala RS-41 sonde would necessitate GRUAN addressing change management soon for the RS-92 data stream.

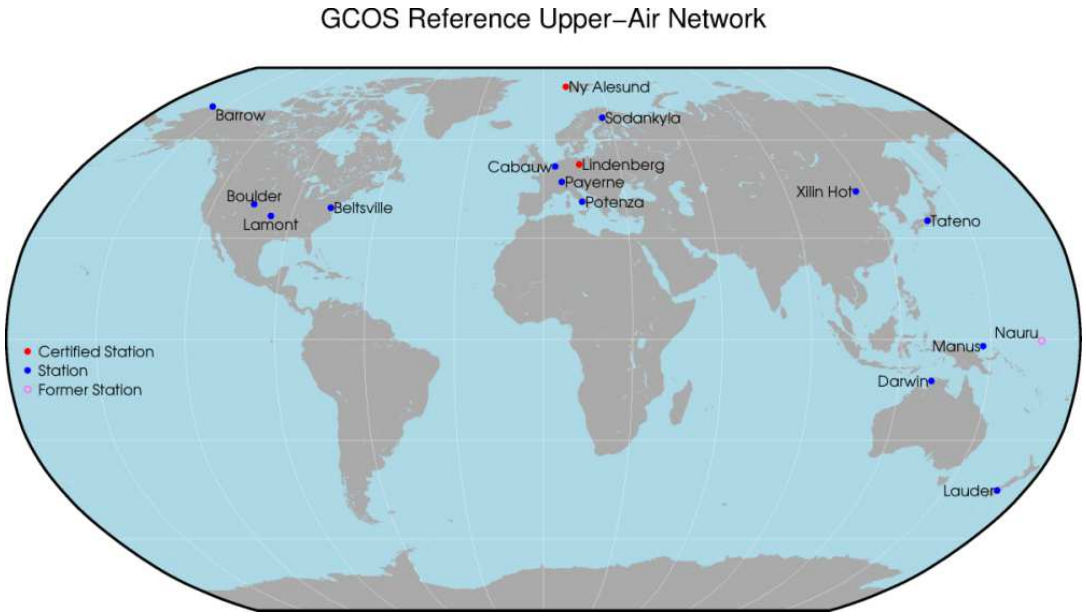
3. Progress on advancing the GRUAN Implementation Plan

3.1. Lead Centre progress

Dr Holger Vömel provided an update on the Lead Centre activities (see also Appendix 4). The Lead Centre formalized its cooperation with the Geoforschungszentrum Potsdam (GFZ) on Global Navigation Satellite System (GNSS) data processing and agreed to cooperate with the World Calibration Centre for ozone sondes at the Research Center Jülich in the development of a new GRUAN Electrochemical Concentration Cell (ECC) ozone sonde data product.

[1] Available under: http://www.ipcc.ch/report/ar5/

The GRUAN site at Lindenberg is now the second certified GRUAN station following Ny-Ålesund, which had been certified at the beginning of last year. Both sites have installed plaques on the entrance of their station buildings to demonstrate their status as a certified site. Two sites are well advanced in their certification process (Boulder and Lauder) and four more sites are in discussion with the Lead Centre on the site certification process (Beltsville, Cabauw, Payerne, and Sodankylä). Their certification application is pending. The Lead Centre has created a new map, which indicates the different status of GRUAN stations and highlights those stations that have successfully passed the site certification process.



The Lead Centre has worked with the sites to generate data reports which provide information about the number and status of data that have been submitted. These data reports form an important component of the annual site reports and provide a clear idea as to the status of their observational performance. The Lead Centre noted the need for feedback from scientists using GRUAN data.

The Lead Centre has now submitted the RS-92 product description paper to the peer-reviewed literature. There is also significant work on new data products (frostpoint hygrometer, Modem radiosonde, GNSS, ECC ozone sonde, lidar, see Section 5).

3.2. Review of action items

A review of the specific action items agreed upon during ICM-5 is given in Appendix 1. As in previous years, the rate of progress is directly influenced by the available resources. Much of the GRUAN work, at least beyond the Lead Centre activities, is done without dedicated funding streams. Peter Thorne also reviewed the actions scheduled in the GRUAN Implementation Plan. The large majority of these actions are progressing either on track or with some delay. The following actions identified in the Implementation Plan are not

progressing, in most cases since either no one could be found to take on this role or because these tasks were formulated in a too unspecific manner to be supported with the limited resources available.

- Develop simple network metadata explorer for easier data exploration and visualization.
- Assess relevance/tractability of the full suite of remaining GRUAN target variables.
- Instigate user review group to meet on biennial basis. This requires further discussion with AOPC before pursuing further.
- Define generic surface instrument requirements.
- Ascertain whether black box software or streamlined GRUAN processing software is better for rapid data delivery.
- Estimate contributions from all terms in the error budget in the satellite retrieved temperature and humidity profiles.
- Assess the utility versus cost and logistical overhead of regular site specific intercomparisons.

The development of GRUAN is limited by the available funding and institutional support. Participants noted that collaborative proposals for funding among participants in similar networks may help to some extent. However, operational commitments of many GRUAN participants may make responding to proposals difficult. In particular, recent proposal opportunities have not been targeted toward funding staff at sites and therefore routine operations need to rely extensively on permanent staff.

Currently no one is monitoring proposal opportunities that could provide GRUAN funding and there is little in the way of efforts to shape future proposal calls. At some sites, such as Beltsville, the cooperation between education (students and professors) and research and funding agencies such as NOAA and NASA may be attractive. For all proposals, it will be important to show the utility of GRUAN data. GRUAN European partners are active in an Horizon 2020 (H2020) proposal which was submitted in late March 2014. Much of the work plan is directly or tangentially aligned with GRUAN objectives. If successful, this will help bring resource to address some subset of GRUAN requirements.

4. GRUAN as a potential ‘force multiplier’ for the global observing system

4.1. A view from the Network for the Detection of Atmospheric Composition Change

Dr Martine De Maziere explained the Network for the Detection of Atmospheric Composition Change (NDACC) philosophy and structure. Hurdles in long-term operation and other challenges may be similar between NDACC and GRUAN. Dr Holger Vömel expressed the gratitude for the fruitful and growing collaboration between the networks. This collaboration was recently formalized through an agreement counter-signed by both networks. Continued attendance at each other’s annual meetings by senior network personnel is envisaged.

4.2. A view from the NOAA Center for Satellite Applications and Research

Al Powell, director of the NOAA Center for Satellite Applications and Research (STAR) provided a high-level overview of NOAA STAR in the context of ICM-6. GRUAN is seen as important to provide reference profile observations for environmental data records (EDRs) and radiative transfer (RT) models, where both priority 1 and 2 ECVs play a role. Cooperation and sharing of expertise is a high priority for satellite data product validation. In this effort, the integration of GRUAN with the Joint Polar Satellite System (JPSS) validation programme, the NOAA PROducts Validation System (NPROVS), to create an NPROVS+ interface is essential. One goal is to accelerate the transfer of satellite observations from scientific research and development into operational use. A strong emphasis is placed on the importance of uncertainties, which play a central role in the interpretation of the observations and the scientific results obtained from these observations.

4.3. NOAA PROducts Validation System

Tony Reale of NOAA STAR presented an overview of the NOAA Product Validation System (NPROVS+), which has been optimized to integrate GRUAN observations. The NPROVS+ system makes use of the uncertainties, which are provided as part of the GRUAN Vaisala RS-92 data product, to compare observations between satellite observations and *in situ* observations relative to their uncertainties following Immler et al., 2010[2]. At the core of this effort is the ability to establish co-location data sets between *in situ* observations and a broader range of satellite observations. This work evaluates the differences between observations normalized by their combined uncertainties. In many cases, uncertainties are available only for the GRUAN *in situ* observations and not for satellite, nor for other remote sensing observations. In this case, the comparison is done using only the uncertainties of the radiosondes. The frequent inconsistency between these observations clearly indicates the need for a better understanding of the uncertainties of the remote-sensing observations and the effects of irreducible match-up differences (difference in sampling volume and time averaging).

4.4. Site Atmospheric State Best Estimate demonstration study

Often no single instrument can provide a best estimate for a particular parameter under all conditions. Combining data from different instruments allows for the construction of a Site Atmospheric State Best Estimate (SASBE). John Dykema showed how the interpolation in time may be done for a sonde observation, which takes time to complete its sounding; in particular the spatio-temporal resolution of radiosondes impacts the SASBE method. The uncertainties provided with the GRUAN measurements have not yet been included in this analysis, but it is planned to do so.

4.5. EUMETSAT use of GRUAN data products

Dr Xavier Calbet presented a calibration/validation strategy including consistency checks for collocated ground based and satellite data, involving radiative transfer calculations. An

[2] Available under: http://www.atmos-meas-tech.net/3/1217/2010/amt-3-1217-2010.html

example of IASI observations over the GRUAN site at Manus Island demonstrates that it is possible to get a good match between the observed radiances and the radiances calculated based on GRUAN radiosonde profiles. However, it is difficult to obtain large numbers of collocations, since the number of observations is small compared to the number of satellite observations. Notwithstanding this, initial results combined with expert knowledge suggest the radiative transfer model used to calculate the expected radiances may require a few percent scaling of the humidity profiles to account for model deficiencies.

4.6. A view from the Global Space-based Inter-Calibration System

Mitch Goldberg (presenting remotely) introduced the Global Space-based Inter-Calibration System (GSICS) and described its goals and strategies. GSICS should support collaboration with GRUAN with a view to draw mutual benefits. On one hand, GRUAN could benefit from GSICS in using accurately calibrated satellite measurements as 'travelling reference standards' for GRUAN stations. On the other hand, GRUAN, in combination with forward radiative transfer models, could provide useful references for the calibration of e.g., space-based microwave measurements. GRUAN could also support the validation of the use of GSICS corrections in Level-2 products through three-way collaboration between GSICS, GRUAN, and downstream communities like SCOPE-CM. GSICS will need to strike a balance between expanding its scope of activity and fostering partnerships and interaction with communities with adjacent or downstream fields of activity. Particular attention should be paid to the cooperation with the community involved in Radiative Transfer Model (RTM) developments, and other thematic application communities.

4.7. A view from NASA

Jack Kaye, associate director for research of the Earth Science Division within NASA's Science Mission Directorate, provided an overview of important upcoming NASA earth observing missions and their potential synergies with GRUAN. There is a strong push not only for rapid delivery of data, but also for accuracy.

The Global Precipitation Measurement (GPM) Core Observatory, a joint Earth-observing mission between NASA and the Japan Aerospace Exploration Agency, was launched on 27 February 2014. GPM joins the Tropical Rainfall measurement Mission (TRMM), which was launched in 1997, in providing advanced information on global structures of precipitation. Due for launch this year are the Orbiting Carbon Observatory 2 (OCO-2), which is a follow up to the failed OCO mission in 2009. The CATS (Cloud-Aerosol Transport System) is a space-borne lidar that is scheduled to be launched to the International Space Station (ISS) later in 2014. The Stratospheric Aerosol and Gas Experiment (SAGE III) is scheduled to be launched to ISS in 2015.

NASA plays an important role in several ground based networks, e.g., NDACC, SHADOZ, and is supporting an initiative for tropospheric ozone lidars at five stations across the US. A fleet of aircraft (Global Hawk, ER-2, WB-57, DC-8 etc) is used in a number of campaigns to provide *in situ* observations in support of the satellite programmes. NASA also has a significant investment in Global Positioning System Radio Occultation (GPS-RO) observations. A large over-subscription to the funding programmes indicates the importance

and interest in the subject. Although the focus of NASA is on satellites that look down on planet Earth, and thus provide a global context and information about parameters, which are out of reach of *in situ* observations, ground based networks remain important for the calibration and anchoring of these observations.

NASA engages in the inter-calibration project between NASA and non-NASA satellites. However, it is hard to get support for this sort of activity, since there is no immediate scientific question supporting these activities.

4.8. A view from NOAA/NWS

Dr John Murphy (director of the NWS office for science and technology) outlined the current restructuring efforts within the NWS. Large budgets are spent and tools are put into place to assess the impact of individual components of the observing system and to evaluate the impact of changes on the installed systems, including cost analyses. Although GRUAN has only a small number of sites, it is important to provide reference observations to the NWP community. These data may be used to validate other data, in particular satellite remote sensing observations, as well as NWP products. They may also be used in their own right as independent long term data records. The high precision and high vertical resolution is a key element in developing a deeper understanding of the processes affecting the atmospheric column.

The restructuring of NWS was guided by the recommendations of the NOAA Observation Systems Council (NOSC) and its subcommittee the Observation Systems Committee. Within these groups NOAA performed an Observing System Integrated Analysis (NOSIA), which examined NOAA's upper-air observing portfolio. So far the observation portfolios are built around the forecasting process, which includes observations, data assimilation, the actual forecasting, and dissemination. The second NOSIA will include a better representation of dedicated climate observations. With the restructuring of the NWS it is expected that the NWS will be better able to strengthen its engagement in GRUAN.

4.9. GRUAN and the WMO Integrated Global Observing System

Lars Peter Riishojgaard gave an overview of WIGOS and its connections to GRUAN. WIGOS is a framework for integrating all WMO observing systems and WMO contributions to co-sponsored observing systems. WIGOS is a WMO strategic priority area and together with the WMO Information System (WIS), WIGOS is a WMO contribution to Global Earth Observation System of Systems (GEOSS). The existing observing systems will continue to be owned and operated by a diverse array of organizations and programmes, national as well as international, and WIGOS is not an approach to replace these systems. WIGOS is maturing, now having an actual project office and regulatory material, and being on track for formal approval by WMO Congress in 2015. WIGOS can most likely not be called operational by 2016, but the major parts of the WIGOS framework will be in place. It remains a challenge to integrate observing systems developed within separate communities and cultures for different purposes (weather, climate, atmospheric composition, agriculture, hydrology, etc.) under one umbrella; however, WMO Members have clearly expressed both, the scientific need and practical desire, to do so.

Shortcomings of the current data delivery and dissemination require a revision of the current system. GRUAN served as a WIGOS Pilot Project and is an important example for WIGOS as to how to deal with climate data requirements. Lars Peter Riishojgaard noted how of all observation system components radiosondes may have the highest impact on NWP on a per observation basis. Thus, the work done by GRUAN to improve radiosonde observations is of high value. Both the GRUAN certification process and the GRUAN metadata standards are important to WIGOS. On the other hand, the WIGOS Manual and Guide may be important to GRUAN. The input from GRUAN for network design and expansion are welcome.

Important challenges for GRUAN and WIGOS will be for example how GRUAN data can be delivered in near-real-time without interfering with the purpose and operation of the network. Communications capabilities and the organizational culture remain an important aspect of GRUAN that must be considered. The lack of funding expressed clearly by the network needs to be considered in greater detail.

It is hoped that within the WMO strategic priority areas, a concerted effort can be made to expand GRUAN, especially in the tropics and in Africa (WMO Region I) and South America (WMO Region III). WIGOS and GRUAN will actively pursue this issue collaboratively.

4.10. GRUAN and the future shape of GUAN

Peter Thorne presented a draft document on the interface of the GCOS Upper-Air Network (GUAN) and GRUAN, which is to be submitted to AOPC and to be discussed in a separate network meeting prior to the next AOPC Session. The topic was the relative roles of GRUAN and GUAN and a set of proposals for how GUAN sites could be upgraded to distinguish themselves from the larger upper-air network.

The meeting reaffirmed the tiered structure of the global upper-air network as outlined in the GRUAN Implementation Plan[3], consisting of GRUAN, GUAN and a comprehensive observing network including all stations. An important difference is the management of GUAN, which does not have a community, analogous to the GRUAN community, which holds regular meetings. It is overseen by small groups via AOPC and the Commission for Basic Systems (CBS). The impact of GUAN, since it was initiated, varies from country to country, including not shutting stations, advocacy for external support of stations, and continuity studies of sorts. Equally, some countries have treated GUAN stations no differently to their remaining radiosonde stations.

A number of operating procedures being implemented at GRUAN sites cannot be feasibly implemented in the wider GUAN network; however, the lessons learned at GRUAN sites should be transferred to GUAN sites with the support of the appropriate mechanisms. Active monitoring of performance and assessment and certification of sites is rigorously being implemented in GRUAN and may to some extent be implemented within GUAN as well, with large expected benefits to the wider network.

[3]GCOS-134: http://www.wmo.int/pages/prog/gcos/Publications/gcos-134.pdf

The lessons from change management procedures, which are required at GRUAN sites, may be applied at GUAN sites without requiring the same rigor of change management. This is meant to reach out to GUAN and to offer the lessons that GRUAN may be able to provide.

The cooperation between the WMO Commission for Instruments and Methods of Observation (CIMO) and GRUAN during the last radiosonde intercomparison campaign was seen as highly beneficial for both sides and it was recommended to maintain this cooperation in upcoming radiosonde intercomparisons. Although some GRUAN sites may be well positioned to host such an intercomparison, well equipped GUAN sites may equally be suited to host such intercomparisons.

5. Review of existing / emerging data streams

5.1. Status of metadata activities with GRUAN

Metadata provide information about data and their characteristics which is required to fully understand the data and their fundamental quality. One particular problem is that due to the large amount of data, metadata require automatic handling and must be well structured. For this purpose the GRUAN metadata database was created, which has been operational for the past 5 years. This database contains information about the sites, the measurement systems, instrument and sensor level information. One important aspect is that the database also contains information to handle change management, which requires some level of traceability over time. The RSLaunchClient is an essential tool to help collect both metadata and raw data. Metadata are included in GRUAN data products, which are in netCDF format. To make sure that metadata can be used interoperably between data centers the climate and forecast convention had been chosen. With the use of these metadata, GRUAN data can be accessed through the WMO Information System (WIS) via Global Information System Centers (GISC) such as the GISC of DWD in Offenbach.

Site generic metadata describing the site such as photos of sites and equipment could be included. The NWS uses such a way of documenting a site and agreed to provide a sample of their metadata design.

Dr Arnoud Apituley serves as the GRUAN liaison to the WIGOS Metadata Task Team. This task team covers the Global Observing System, (GOS), Global Atmosphere Watch (GAW), GRUAN, etc. The goals are to improve the quality and availability of data and metadata. GRUAN as WIGOS Pilot Project served to define the data dissemination among all GRUAN partners. The WIGOS core metadata - semantic standard document is under development. Within this document, all metadata will be classified as mandatory, conditional, or optional. Within GRUAN, it may be considered to make all relevant metadata identified by WIGOS mandatory (noting that some WIGOS metadata pertains to domains or issues outside GRUAN’s purview).

5.2. Metrological interactions

Metrology for Meteorology is a European metrology research programme focusing on national measurement institutes. The AquaVit-2 water vapour measurement intercomparison at the AIDA chamber in Karlsruhe, which took place in April 2013, compared a large number of water vapour instruments, including several radiosonde sensors. AquaVit-2 was organized as part of the MeteoMet project. The Earth Dynamics Investigation Experiment (EDIE), a small portable chamber for testing sensors under ground-based environmental conditions, has been taken to pyramid station at the foot of Mt. Everest and will be taken next to the GRUAN site at Ny-Ålesund. Three main work packages within Meteomet2, which will start in 2014, focus on air sensors (WP-1, which is GRUAN oriented), water sensors (WP-2) and land sensors (WP-3). In September 2014, the Metrology for Meteorology conference will be held in Brdo, Slovenia. GRUAN participants were encouraged to attend.

5.3. Status of selected data streams

5.3.1. Vaisala RS-92 GRUAN product status

Dr Ruud Dirksen from the GRUAN Lead Centre provided an overview of the current RS92 product. It uses the calibrated raw sensor data and then corrects for systematic errors including radiation, calibration and sensor time-lag. Laboratory experiments have been used to calculate radiation effects on temperature. The uncertainty of the correction is due to incomplete knowledge about the albedo, the sensor orientation, parameter uncertainties in the fitting parameters and the ventilation. These uncertainties are combined into a total uncertainty and provided vertically resolved with the data. Comparison of GRUAN derived and Vaisala corrections are currently consistent, but require further study. GRUAN stations are required to follow the standard operating procedures prescribed by Vaisala. However, the GRUAN processing removes the recalibration of the humidity sensor during the Vaisala check to remove the influence of the condition of the desiccant on the measurements. As a manufacturer-independent ground check, Lindenberg, Ny-Ålesund, DeBilt and recently several other stations use the Standard Humidity Chamber (SHC). This additional ground check indicates a possible wet bias of the Vaisala RS92 by up to 5% at 100% RH. The test is also very sensitive to changes in the production process. This test demonstrates the importance of developing and implementing manufacturer independent ground checks in reference observations.

A manuscript describing Version 2 of the GRUAN data product for the Vaisala RS92 measurements has been submitted at Atmospheric Measurement Technologies (AMT) and is currently under review at their discussion section (AMTD).

5.3.2. Bringing non-RS-92 sondes into GRUAN

Dr Holger Vömel introduced the GRUAN technical note 1 (GRUAN-TN-1), which describes the steps required to bring non-Vaisala RS92 sondes into GRUAN. It has been distributed to several manufacturers and feedback has been collected. This technical note requests information such as the measurement range, sensor calibration range, calibration accuracy, and time resolution of data transmission from the manufacturer. Where known, information

about uncertainty, time lag constants, and pre-launch recalibration needs is also requested. Deficiencies in documentation can be monitored and potentially filled. This technical note envisions a close collaboration between a site and the manufacturer. A potential site is requested to provide information about chamber tests of the radiosonde, ambient tests that may shed light on production variability, and dual launches with GRUAN accepted sonde, which the site may already have done or plans to do. This information is essential and will be combined to process the data and to estimate the uncertainties of the observations. Finally, pre-launch checks of the instrumentation must be defined to monitor the behavior of the instruments and to provide confidence in the stability of the observations.

Dr Martial Haeffelin summarized the substantial preparatory work undertaken to date for the Modem M10 radiosonde. Dr Haeffelin highlighted significant progress attained as a result of sustained interactions of a number of French investigators across a range of institutions and collaboration with both Payerne and the Lead Centre. Thus far, substantial work has documented the radiosonde sensor operation, calibration and data processing. Two documents are currently planned, one dealing with the temperature measurements, one dealing with the relative humidity. Several tests have already been conducted or are currently in planning: the Maïdo Lidar Calibration Campaign (MALICCA) on La Réunion Island, two radiosonde intercomparison campaigns at Payerne, laboratory tests at Lindenberg and comparisons with the Japanese temperature reference sonde. An essential result will be the derivation of temperature and relative humidity measurement uncertainties, which will be essential components in a finalized GRUAN processing code. This work will then be documented and published in AMT. Through this work it is expected that the entire French operational radiosonde network including the sites in the southern hemisphere is going to benefit. This was noted by meeting participants as a prime example of how GRUAN innovations and understanding can benefit the broader global observing system.

5.3.3. Frostpoint hygrometer progress

Dr Holger Vömel presented the current status of a GRUAN data product for the Cryogenic Frostpoint Hygrometer (CFH). The basic steps follow those outlined in the GRUAN Technical Note TN-1. This instrument covers the entire range of frostpoint temperatures expected in the atmosphere and it is calibrated over this entire range. Time lag constants are not well understood and require additional lab work. A pre-launch recalibration is not required for this instrument. At the laboratory intercomparison campaigns AquaVIT 1 and 2 this instrument was tested in controlled conditions and showed generally very good agreement with the campaign consensus. The largest measurement uncertainty is the frost control stability and this is typically random. Dual CFH-launches on the same balloon provide some indication of the sonde production variability. So far all CFH sondes within GRUAN have been launched with a Vaisala RS92 sonde for the validation of the humidity measurement uncertainties. A manufacturer independent ground check is currently under development and will form an essential element of a CFH GRUAN data product. There are both random and systematic uncertainties to assess in each sounding, but most systematic errors should become random in time series except for thermistor calibration errors, which are likely to be very small. The next steps will be to implement a ground check, to complete processing routines, and to merge these data with the parallel RS92 data product. This data product will be developed in cooperation with NOAA/ESRL, which operates the very similar NOAA frostpoint hygrometer. Presently no development of a Snow White sonde product was envisaged given its very

distinct measurement technique. It was noted that commensurate edits to work plans would be required.

5.3.4. Lidar data stream progress

The first non-radiosonde data product that is under development is the GRAUN data product for Raman lidar water vapour observations, led by Dr Thierry Leblanc. Based on the RsLaunchClient, the LidarRunClient has been developed in cooperation with the Lead Centre to upload metadata along with raw data. Based on these combined data a GRUAN Lidar Analysis Software Suite (GLASS) is being developed, which also allows evaluation of the combined standard uncertainty for a GRUAN lidar data product. It is important to recognize that all candidate lidar systems are unique adding to the difficulty of having automated processing software. The evaluation of the different terms of uncertainty, which may be systematic or random, correlated or uncorrelated, is currently under way in cooperation with a group at the International Space Science Institute (ISSI) in Bern. The concept of the LidarRunClient and GLASS was based on Payerne water vapour Raman lidar measurements. It is expected that the first GRUAN lidar “operational” product will be available in 2015.

The discussion pointed out two open questions that should be further discussed by the Task Team on Ancillary Measurements (TT-AM) and the WG-GRUAN:
1) The amount of raw data to be uploaded to a centralized, yet to be identified, GRUAN facility is anticipated to be very high for systems running 24/7 and acquiring data at very high time resolution (e.g., Cabauw, every 10 sec, leading to 5GB/day upload). Also, not all raw data from a particular instrument may be relevant for the data product (e.g. raw aerosol channels being submitted in the data stream of the water vapour product). Further design of the GRUAN Lidar Data Stream, and the Lead Centre and other GRUAN centralized organizations must take into account this new demanding feature.
2) One of GRUAN’s objectives/recommendations is to use consistent data processing to its best ability across the network. This centralized processing approach has now been applied to the processing of RS92 data and has been proposed for lidar. However, Raman lidar setups can be very different from site to site. In the case of water vapour Raman lidars, not only can data be used for a wide variety of science and validation applications, but the profiles may be calibrated using different methods depending on available infrastructure (radiosonde, IPW, lamp, etc.). The possibility of using multiple calibration methods should be confronted against the vision of consistent data processing, and solutions must be found for a practical implementation in both the LidarRunClient and GLASS.

6. Updates from GRUAN Task Teams and GATNDOR

All task teams have now been in operation for five years. This provides an opportunity to review and revise the Terms of Reference (ToR) as well as the membership of all task teams. The current ToR of the Task Teams can be viewed at the GRUAN website. It was agreed that the chairs of Task Teams and the WG-GRUAN would review and revise the ToR language by 1 June 2014. People interested in joining were encouraged to volunteer.

6.1. Radiosonde Task Team

The progress report from the Radiosonde Task Team is available in Appendix 5. Dr Ruud Dirksen provided an update on behalf of the Task Team chairs, who were both unable to attend the meeting. The task to evaluate the different time lag correction approaches in RS92 humidity measurements is ongoing and will be finalized after the Vaisala RS92 paper has been completed. Information on the use of auto-launchers at Sodankylä and Potenza and its impact on the data quality has been collected; a peer reviewed paper is under development. This also impacts the sites of the Japan Meteorological Agency (JMA), which uses auto-launchers. There was little progress on evaluating controlled descent mechanisms. This topic will be revisited during ICM-7. Recommendations for multi-payload launch configurations need to developed, and this is planned to take place during summer. The requirements for the collection of non-Vaisala RS92 data are well under way. Currently, the RsLaunchClient has been configured to collect raw data for the Meteolabor sonde and is being prepared for the Meisei sonde. GRUAN data products need to be developed for these radiosondes, which will be the task of the respective sites. An Upper Troposphere / Lower Stratosphere (UT/LS) frostpoint water vapour data product is currently under development (see section 5.3.3) and data collection client requirements are defined as part of this process.

6.2. GNSS-PW Task Team

The progress report from the GNSS Precipitable Water (Global Navigation Satellite System (GNSS-PW) Task Team is available in 0. Dr Kalev Rannat reported on the GNSS Integrated Precipitable Water (IPW) data stream. Central processing of all GRUAN GNSS data will be done at GFZ, which will support continuity and quality of the data. Gaps in the data stream may be planned, but may also happen unplanned. Guidelines, which have already been established for data handling and data processing, should be followed. More documentation may be required. Access to data and metadata should be user friendly; uncertainty analysis should be transparent.

The details of the uncertainty estimation need to be paid attention to, regardless of the source of the uncertainty. Like for all GRUAN data, the uncertainties will be based on individual observations, which actually depend on the observation conditions.

6.3. Measurement Scheduling Task Team

The progress report from the Measurement Scheduling Task Team can be found in Appendix 7. The goals of this Task Team are to develop guidance for GRUAN sites on measurement schedules and associated site requirements in order to meet the GRUAN objectives of climate trend detection, satellite calibration/validation, and studies of meso-scale processes and events. The main information sources are from peer-reviewed literature, GRUAN documentation, and currently unpublished studies of which the group is aware. The group may perform some limited new analyses using existing data sets, where critical gaps exist. The Task Team has performed a review of temperature measurement requirements, which is currently under review within the GRUAN community. The focus of this review is on sonde measurements and long-term trend detection, although a number of

the conclusions are more generally applicable. A peer-reviewed paper is currently in preparation.

One key result is that at least four launches are likely to be needed per day to capture the diurnal variability of temperature. This can be used to predict temporal mismatch correction (and uncertainty) as function of altitude and season, where long-term data sets are available. After verification of the results at some intensive observation sites such as Lindenberg and the ARM site at Southern Great Plains (SGP), it may be possible to use the European Centre for Medium-Range Weather Forecasts (ECMWF) model data to extend this analysis to other sites with less frequent observations. It may also be possible to extend these results to water vapour measurements, although no work has been done with this parameter.

This work may also shed light on addressing what level of remaining systematic radiation effect can be tolerated. Dr Gardiner pointed out that in particular the Lindenberg data set may be well suited for studying this.

6.4. Ancillary Measurements Task Team

The progress report from the Ancillary Measurements Task Team is available in Appendix 8. One of the main tasks of this Task Team is to interface with other expert teams (such as NDACC, TCCON, MWRnet, etc.) and to bring expertise from these networks into GRUAN. The European COST Action ES1303 TOPROF works to establish operational ground based profiling, using ceilometers, doppler lidars and microwave radiometers to improving weather forecasts. This project will run until 2017 and a number of scientists involved in this project are also part of GRUAN.

The European Research Council (ERC) project MUlti-platform remote Sensing of Isotopologues for investigating the Cycle of Atmospheric water (MUSICA) works on integrating Fourier Transform Infrared (FTIR) spectrometer observations within NDACC and METOP/IASI observations to produce consistent global long-term water vapour products. This is one of two major efforts on FTIR observations. The second is the network of Atmospheric Emitted Radiance Interferometers (AERI) which may be a potential GRUAN FTIR instrument. Johnathan Gero will join the Task Team as AERI representative and will coordinate current AERI operations and formulate reasonable plans for a possible inclusion into GRUAN.

The Network of Remote Sensing (NORS) is a demonstration project using NDACC data in support of the Copernicus Atmospheric Service (CAS) and tries to ensure long-term quality data with network consistency, timely data delivery, and full documentation. Metadata, use guides, and documented uncertainties are essential tools that are similar to those of GRUAN. The cooperation with NORS advances the NDACC data in this direction.

GRUAN Lidar, Microwave and FTIR Products are slowly, but steadily being developed. In 2014, the GRUAN Lidar, GRUAN Microwave, and GRUAN FTIR Guides should be completed. Version 1 of a “full scale” GRUAN lidar data stream should be ready by end of 2014 and it is hoped that this will be followed by a “full scale” GRUAN FTIR data stream by end of 2015.

6.5. GATNDOR update

Dr Tom Gardiner presented the current status of the GRUAN Analysis Team for Network Design and Operations Research (GATNDOR) on behalf of Fabio Madonna, who was unable to attend. One of the key efforts of this team has been quantifying the value of redundant measurements at GRUAN sites. A publication addressing this topic is currently in preparation.

A new topic has been proposed, “Improving satellite validation through an assessment of best vertical resolution and of the value of uncertainty covariance matrix of atmospheric variables to use in radiative transfer modeling”, which may be a full PhD position, however, funding to address this topic has not been secured.

A discussion about the future of GATNDOR identified a lack of critical mass within the group, which is in part due to the fact that as it stands all efforts are volunteer efforts without funding. This may not be a sustainable situation and is not a good model for a standing science committee.

As an outcome of the discussion, it was agreed to consider dissolving GATNDOR and to look for an alternative solution to addressing scientific issues that may arise from GRUAN. A “GRUAN Scientific Coordinator” (title still open to discussion) could take on a more coordinating role. This person could identify projects that are highly relevant for GRUAN purposes and work with the GRUAN co-chairs and the GRUAN community to secure funding for these projects. As part of the effort the real efforts and costs related to these projects need to be established. It was further agreed that if the following 6 months this person could not be identified, the proposal of a GRUAN Scientific Coordinator would be dismissed.

7. GRUAN site activities and research

The meeting format during ICM-6 has been slightly different than in previous years. To accommodate a larger number of sites and to be able to focus more on specific topics relating to one or more sites, all sites were required to submit site reports for ICM-6. Site reports were submitted by ARM (Barrow, Lamont, Manus, Nauru, Darwin), Beltsville, Boulder, Lauder, Lindenberg, Ny-Ålesund, Payerne, Sodankyla and Tateno. Site reports were not submitted by Cabauw and Xilin Hot. All submitted site reports are provided in Appendix 10. The Lead Centre generated automatic data reports for all data submitted as part of the GRUAN Vaisala RS92 data product. These data reports can be found at the GRUAN website[4].

7.1. GRUAN data flow

Dr Michael Sommer presented an update on GRUAN data flow and station monitoring. He outlined the current internal structure of the data flow. This includes the internal work flow that leads from raw data to GRUAN product data, which are published at NCDC. The work

[4] www.gruan.org

flow also begins to provide statistics about the quality of the data - the so-called “DNA of GRUAN”. The quality checks include checks for formatting and data completeness and some limited checks on operating procedures.

The processing adds flags at each task and then makes a decision as to whether to publish to NCDC or retain. The three flags (approved, checked, or rejected) were described and the audience discussed if these terms were well defined. Rejected sondes are sondes that could not be processed either due to data inconsistencies or due to unknown processing issues. Checked data are those that were processed but did not meet certain GRUAN requirements on the data quality and level of uncertainty. Automatic station reports are generated based on the data and the metadata, which have been submitted. These reports include general information about the station, information about the GRUAN measurement systems, which are available and planned, and a third section where the Lead Centre provides individual comments / feedback to the site. At the moment, GRUAN has only one data stream, i.e. the GRUAN Vaisala RS92 data product. The station reports, as well as the GRUAN summaries, currently only consider the Vaisala RS92 data submitted. As soon as other data streams come online, these will be considered as well. Currently, several metadata and potential new data streams (e.g. CFH, etc.) are close to roll-out, but no final GRUAN product is available, yet.

A summary of the data products (quantity and quality, plus processing comments) can show the data quality as monthly averages. These may be used to identify clusters of issues at a site, which may need to be addressed either on the site level or the processing level. Metadata, for example, are used to plot ground-check statistics, in which changes in operational procedures and improper sonde preparations may easily be identified.

The current version of the GRUAN Vaisala RS92 data product does not allow for rapid feedback to the sites, if problems are discovered in processing. This rapid feedback will be included in the upcoming version of the GRUAN Vaisala RS92 data product that should be available by ICM-7. The site representatives will be polled on what they feel is sufficient. Those sites which would like to see specific feedback comments are encouraged to communicate their needs with the co-chairs of the Sites Representatives Task Team.

The Lead Centre has also started monitoring the Vaisala RS92 data sent in near-real-time through the Global Telecommunication System (GTS). This is done in response to the requirement by WMO to submit near-real-time from GRUAN stations, even if these data are just the operationally processed data. The receiving systems at all sites should be configured such that they send high-resolution data with full metadata description to the GTS. A number of sites still send their radiosonde data in low resolution with limited metadata to the analysis centers and a few sites are currently unable to send their data into the GTS. These sites may be able to provide their data through other partner institutions. It was agreed that all sites work towards providing high-resolution data with full metadata in BUFR format. Lars Peter Riishojgaard would be happy to help to make this a reality. The Lead Centre will work with WMO and the sites to address this issue and report an update at ICM-7.

7.2. Maïdo observatory: A new high-altitude station facility at La Réunion Island

Dr Stephanie Evan gave an update on the Maïdo observatory on La Réunion Island, France, as a candidate GRUAN site in the Indian Ocean. The observatory is located on the western (dry) side of the island at 2200 m above sea level, generally above the marine boundary layer. It has clear nights that allows for better conditions for observations. MeteoFrance, CNRS, NDACC, SHADOZ, and many other communities are collaborators. Instrumentation includes sensors to characterize optical and chemical properties of aerosols, lidars for tropospheric and stratospheric ozone, a GNSS station and others. Weekly ozone soundings as part of SHADOZ are launched near the airport. The station has a water vapour lidar (see Keckhut et al. 2014) capable of profiling up to 20 km. A comparison with the NASA traveling Raman lidar is planned this year and NDACC certification will follow. This effort may include CFH soundings if this can be organized in time.

7.3. Updates from Lauder

Dr Richard Querel presented an update of personnel and measurement activities at the Lauder site. He began working at Lauder in 2013 and a new FTIR measurement scientist is expected to start in May 2014. Site improvements include the addition of a standard humidity chamber (SHC) for the Vaisala RS92 manufacturer, independent ground check, and a GPS receiver for GNSS-PW measurements. Lauder has nearly compiled its response to the questions posed by the WG-GRUAN on site certification and will submit it soon. A new FTIR is expected to be installed in 2015. The possibility of moving MetService radiosoundings from Invercargill to Lauder was discussed. The cooperation between NIWA and the New Zealand MetService with their radiosonde site at Invercargill had previously been discussed during ICM-4 in Queenstown, New Zealand. Timing with the larger-scale “Deep South” National Science Challenge or under the auspices of a US-New Zealand agreement was mentioned as beneficial to revisiting this request.

7.4. Updates from Ny-Ålesund

Dr Marion Maturilli gave an update on Ny-Ålesund, the first certified GRUAN site last year. A certification festivity took place on 26 April 2013 in the presence of Dr Holger Vömel from the Lead Centre, with participation of the village. The certification process was seen as highly beneficial in funding discussions within the institute. It is a substantial effort to conduct soundings during winter, with annually changing station staff. The contract personnel (3FTE for each winter) are trained at the Lead Centre. CFH launches are coordinated with the Lead Centre and the first test launch has been performed in September 2013. Starting in January 2014, the first regular CFH launch took place (to be repeated every second month) and these launches include iMET +CFH+RS92. A cooperation with METEOMET is scheduled to start in June 2014 and a calibration facility will be installed at the site. An intensive radiosonde campaign in the framework of the Arctic Research Collaboration for Radiosonde Observing System Experiment (ARCROSE) in collaboration with JAMSTEC took place in September 2013. One of the goals of ARCROSE was to understand the arctic circulation, as well as data assimilation and the efficacy that either more stations or more launches may bring to improved weather forecasts.

7.5. Cabauw Site Status

The parent organization of the Cabauw GRUAN site, KNMI, last year announced budget cuts that required contributions of non-KNMI partners for site operations and the removal of remote-sensing measurements from base funding. A bridging period is planned during which programmes will be continued (to the extent possible) but time is of the essence to prevent irreversible reductions in capabilities.

7.6. Tateno: transition to Meisei

Dr Nobuhiko Kizu reported on change management from the Vaisala RS92 to the Meisei RS-11G. JMA must consider the impact force of falling sondes, since a considerable fraction of sondes land in populated areas. At the same time, JMA was faced with significant budget cuts as a result of the Tohoku earthquake and subsequent tsunami, forcing JMA to undertake substantive cost saving measures in observations, including upper-air observations. Some sites were forced to reduce their observational frequency from twice per day to one per day and reduction in sonde costs is of high priority. Requirements also include separation of ground receiving system and sonde hardware. Meisei was selected by JMA through this process. Advantages of this change are mainly cost saving in ground equipment, algorithms, reduced impact force of falling sonde, and others. Future plans include producing a change management report and developing a Meisei GRUAN data stream.

7.7. Multi-thermistor activities at NWS

Dr Michael Hicks outlined the radiosonde and multi-thermistor radiosondes (MTR) activities at the NWS Sterling Field Support Center (SFSC). MTR radiosondes are being launched to evaluate the radiation impact of solar radiation on the radiosonde temperature measurements. The MTRs launched at SFSC include three aluminum-coated, one white-coated and one black-coated thermistor, but may also use different combinations of these sensors. A total of 12 MTR balloon payloads were launched combined with operational radiosondes under different cloud conditions. The mean errors of the differently coated sensors are evaluated separately to find an optimal solution to the solar correction. This work is ongoing and there is interest in coordinating some of these activities with the radiation correction measurements obtained at the Lead Centre.

7.8. Validation of Aura MLS stratospheric water vapour by the NOAA FPH

Dale Hurst described the NOAA frostpoint hygrometer, which has been used for nearly 35 years and which is useful for validation of space-borne measurements. He showed a comparison of stratospheric frostpoint hygrometer and Microwave Limb Sounder (MLS) water vapour measurements over the three NOAA frostpoint hygrometer sites: Boulder, Hilo and Lauder. The demonstrated agreement between 68 and 26 hPa is better than 1%. At 83 and 100 hPa significant differences between the two sets of data exist, with MLS showing a wet bias of 4 -10 %. Differences between the two instruments at different stratospheric levels were examined for temporal trends and basically none were found, indicating the neither instrument is drifting with time. However, the trends that can occur in these differences are

considerably larger than the trends detected, so the records must be extended if small but significant trends can be ascertained.

7.9. Trend detection and lessons for GRUAN

It is well known that the autocorrelation in a data set is a key factor in determining the time to detect trends. The autocorrelation in a data set depends on the natural variability of a parameter, which may vary with altitude. For water vapour this means that it may be easier to determine trends in the UT compared to the LS. Raman lidar data may therefore be better suited for UT trend detection than LS trend detection. The time to detect a trend may be decreased by increasing the frequency of measurements to reduce random measurement errors. However, the value of a higher frequency of measurements will be limited by the autocorrelation and thus the time to detect trends may not be decreased beyond the point where autocorrelation limits the value of repeated measurements. Thus, there is a trade-off between reduced random uncertainties and increased autocorrelation of the data. New results indicate that for trend detection of water vapour in the LS, one high-quality measurement per month may be sufficient. MLS measurements from 2004 - 2013 indicate a high degree of redundancy in monthly means calculated at a variety of sites within the 35 - 45 degree band. Measurements at one site give similar results to other sites. Additional stations would be more attractive at different latitude locations. This has implications for certification decisions and prioritization of sounding capabilities across GRUAN. For 2004 – 2013, MLS data shown that the middle latitudes require the shortest periods to determine the trends. A high performance Raman water vapour lidar operating for 7 measurements per month and 5 - 10 hours per night can reveal trends in LS water vapour in approximately 12 years. One measurement per month by frostpoint hygrometer may be able to reveal the same trend in approximately 5 years. Large systematic uncertainties are related to the traditional calibration of Raman water vapour lidar and techniques need to be developed to minimize their impact.

7.10. Raman calibration issue

Dr Monique Walker pointed out the dependence of most Raman Lidar calibrations on other water vapour measurements such as radiosondes or frostpoint hygrometers. Thus there is a need to develop an independent calibration technique in order for Raman lidar to satisfy the GRUAN objective of providing a redundant, independent measurement of water vapour. Systematic errors in the calibration instruments directly transfer to the Lidar measurements and are some of the largest sources of systematic uncertainty in the traditional approach to Raman water vapour lidar. A lamp mapping technique can be applied with the Lidar in its normal mode of operation for independent calibration purposes. The results of experiments performed indicate agreement within 5 – 7 % between the independent lamp calibration approach presented and the traditional radiosonde based approach.

7.11. First results from the Vaisala RS-41

Dr Rigel Kivi reported on first results from the new Vaisala RS-41 sonde made at Sodankylä, Camborne and other sites. This new sonde significantly reduces the weight compared with

the RS92. It uses a platinum resistor for temperature sensing, which should have better stability, and uses a new humidity sensor, which reduces solar radiation effects and no longer requires a 0 % relative humidity re-calibration. A short range wireless link between the sonde and the ground check reduces the opportunity for operator error. The new software offers real time remote access and easy operation. Test flights of RS92/RS41 dual launches at several sites indicate that the two systems are similar in temperature, but show a slight difference in humidity near the tropopause from test flights done in Malaysia. A comparison with CFH was also shown. Uncertainty in both temperature and humidity is expected to be less than that of RS92.

7.12. Managing the change to the Vaisala RS-41 within GRUAN

Dr Holger Vömel described the steps necessary in the change that will be coming with the RS92 to RS41 sonde transition. GRUAN stations are required to manage this change accordingly and minimize the impact on GRUAN data. Since a number of sites are expected to be impacted, it was proposed that all of these sites collaborate such as to minimize the cost on any single partner and ensure robustness across multiple climatic conditions. The transition to the Vaisala RS41 radiosonde also requires an update of the receiving system to the MW41 software. This software produces new file formats and the processing of these data requires new routines. The change management has to make sure that all metadata and raw data are being collected. The following tasks need to be addressed to efficiently manage and coordinate this change event within the network:

- Provide information about the status of the RS41 developments;
- Provide guidelines about when to start implementing the change;
- Define the proper setup of the new MW41;
- Coordinate the setup of the new system to be consistent at all sites;
- Coordinate dual launches between RS92 and RS41 at different sites;
- Make sure all dual launches are appropriately transmitted and stored in the GRUAN metadata database;
- Develop the GRUAN data product for the RS41;
- Evaluate the impact on the long term time series;
- Include all sites that consider switching to RS41 in this task;
- Coordinate activities with the RS92 processing center (Lead Centre).

It was agreed that the change management team would include all sites that currently use the Vaisala RS92, the Lead Centre, Dr Thierry Leblanc of the JPL Table Mountain Facility, as well as Hannu Jauhianen of Vaisala. It was further agreed that the actions of this group should be coordinated with the GUAN network through the GCOS Implementation Manager, and the WIGOS project manager Lars Peter Riishojgaard. If this discussion identifies sites from the GUAN, which would like to participate, these sites should be included in this effort. The inclusion of GCOS and WIGOS should ensure that the lessons learnt by GRUAN can be propagated to the broader Global Observing System that will also be confronted with this change on the same timescale,

8. Network expansion

8.1. Network expansion workshop progress

Dr Greg Bodeker presented the current status of the network expansion effort. He started by providing an overview of the 2012 workshop (see ICM-5 report[5]). One aim of this workshop was to identify locations best suited for the goals of GRUAN based on scientifically sound reasoning. For example, the variability and autocorrelation of mid-tropospheric temperatures varies strongly with geographic region. Optimized site locations may be based upon the expected time to detect trends based on model simulations. Sites that provide a short time to detect trends may be pursued with higher priority.

The cooperation with different networks may be used to gain information about the status of potential sites, as well to be able to engage sites through their affiliation with other networks.

The question whether monthly stratospheric water vapour soundings are an essential requirement for a site to become part of GRUAN was discussed. Whilst still somewhat academic until a GRUAN product exists for such measurements, it was recognized that these measurements are important, yet require large resources, which not every site may be able to provide. It was agreed that this question should not preclude inviting sites into GRUAN. This question may be answered individually during the site assessment. One important criterion will be based on how much value a site brings to the network, and some flexibility will be required when bringing sites into GRUAN. The most important requirement for all operations at a GRUAN site will be how the measurements are being taken.

8.2. SHADOZ

Dr Anne Thompson gave a brief description of the Southern Hemisphere Additional Ozonesondes (SHADOZ) network. This network was initiated over 16 years ago to provide observations in tropical and southern hemispheric regions that generally had very sparse *in situ* ozone measurement coverage. The initial network consisted of 15 sites and some of these sites have records over the entire 16 years period. The archive contains more than 6,000 ozone sonde profiles with accompanying pressure, temperature and humidity profiles. Some stations have had data gaps that have been or are being resolved. A large reprocessing effort is underway to increase data homogeneity and to address some of the system changes that have happened during the course of the project. New scientific findings include a lower stratospheric ozone decrease between 1984 through 2009 based on SAGE-II and SHADOZ data and a contrasting lower stratospheric ozone increase over 2002 - 2011 from SCIAMACHY and SHADOZ data. A strong upward trend in middle to upper tropospheric ozone has been detected for winter at two southern hemispheric stations. Dr Thompson highlighted the site at Irene, South Africa, and potential capacity building activities, which may lead to further activities at that site.

[5] GCOS-167: http://www.wmo.int/pages/prog/gcos/Publications/gcos-167.pdf

8.3. SOWER

Dr Holger Vömel standing in for Dr Masatomo Fujiwara presented the Soundings of Ozone and Water in Equatorial Regions (SOWER) project, its motivations, activities and experiences. Sites are in Indonesia (e.g., Biak, Kototabank, Watukosek), Vietnam (Hanoi), Kiribati (Tarawa, Christmas Island) and Ecuador (Galapagos). Instrumentation includes balloon-borne ozonesondes and frostpoint hygrometers. The focus is on tropical ozone climatologies and the dehydration of air masses. One science approach involves the Lagrangian MATCH technique to measure the changes in air mass composition during transit through the western tropical Pacific region. The infrastructure of several SOWER sites was discussed, including the institutions that run the weather observation sites where SOWER operates. Infrastructure and cooperation are critical to GRUAN's desire to expand into much-needed tropical countries and islands.

8.4. Science and network activities at Beltsville

Prof. Belay Demoz elaborated on the collaboration between Howard University, NOAA and NASA centered around the Howard University site at Beltsville, which is also a GRUAN site. Regular operations were reviewed, including once per month ozone soundings. Intercomparisons of IPW measurements at the site include data from a Differential Absorption Lidar (DIAL), two Microwave Radiometers (MWRs), RS92, two Raman lidars and a GNSS-IPW receiver. A US network of ceilometers exists but saves only cloud base height, not the full profile data. It is envisioned to utilize this network to obtain full profile data of lower tropospheric particles and clouds.

Since not all GRUAN sites, such as Beltsville, measure daily or twice daily radiosonde profiles, these sites are encourage to cooperate with their nearest national meteorological service operational launch site to submit at least daily radiosonde profile data to GRUAN. In the case of Beltsville, this would be the NOAA/NWS site at Sterling, MD. Howard University has cooperative agreements with Senegal and South Africa. These cooperations may be used to establish GRUAN sites in those countries.

8.5. Network expansion plans

Some small efforts have been undertaken to bring in new sites into GRUAN, however, many of these efforts are limited by the available resources of the GRUAN participant championing bringing in new sites. Some discussions have happened with the China Meteorological Administration (CMA) to bring in three additional sites. However, no concrete action has yet taken place. A discussion with Environment Canada has not led to a specific proposal and may need to be pursued further if and when the Canadian monitoring capability funding becomes clearer.

The meeting participants agreed that a more coordinated and formal approach to network expansion was warranted at this time. The meeting agreed to approach the following countries/institutions/sites:

- Bureau of Meteorology (BoM), Australia: Matt Tully of BoM attended the meeting representing BoM. There is great interest of GRUAN in involving BoM due to their location and observational capability. In particular with the withdrawal of ARM from their tropical western Pacific site, the station at Darwin, which is a BoM station, should be maintained within GRUAN. It was agreed, that this contact would be furthered with GRUAN being represented by Howard Diamond and Greg Bodeker.
- US NWS: The NWS maintains a large network of radiosonde sites. The site at Sterling, MD, is located close to the GRUAN site at Beltsville and could be included in GRUAN. The site at Hilo is located at a strategic location and is a site of the NOAA frostpoint hygrometer and near the Mauna Loa baseline observatory of NOAA. The NWS may want to contribute other sites as well. It was agreed, that Howard Diamond, Belay Demoz and Dale Hurst would represent GRUAN in furthering this contact.
- South Africa: Howard University maintains a cooperative agreement with the South African Weather Service (SAWS). The SAWS runs the sounding site at Irene, which is also part of the SHADOZ network. Belay Demoz and Anne Thompson will represent GRUAN and work on establishing a GRUAN site in South Africa.
- Senegal: Howard University maintains a cooperative agreement with the École Supérieure Polytechnique at Dakar. A site in this country would be well suited for characterizing dust, which may help satellite validation activities. It was agreed that Belay Demoz should represent GRUAN in this activity.
- Ecuador: The radiosonde site at San Cristobal, Galapagos has been part of the SHADOZ network and has hosted a number of SOWER campaigns. This site is well located in the eastern equatorial Pacific. The Instituto Nacional de Meteorologia e Hidrologia (INAMHI) has established two additional radiosonde sites, which could potentially become part of GRUAN as well. It was agreed that Dr Holger Vömel would represent GRUAN to further this contact.
- Vietnam: The Aero Meteorological Observatory of Vietnam is operating radiosondes and ozonesondes at their Hanoi site. This location has also hosted several SOWER campaign observations. It was agreed that Dr Masatomo Fujiwara together with Shin-Ya Ogino would represent GRUAN to further this contact.
- Bolivia: In cooperation between NASA Goddard and the Universidad Mayor de San Andrés at La Paz, a lidar system has been established at that site. This site is well located and could possibly host a GRUAN site. However, funding needs to be established to make this happen. Dr Marcos Andrade of the Universidad Mayor de San Andrés attended the meeting. It was agreed that Dr David Whiteman and Dr Greg Bodeker would work with Dr Marcos Andrade to find an appropriate partner in Bolivia and to establish the funding for this project.
- Canada: Environment Canada had in the past shown some minor interest in GRUAN, however, this contact has not resulted in actionable progress. It was agreed that Dr Richard Querel would take on a coordinating role to further this contact.
- Chile: Richard Querel agreed to scout potential partners and to establish a line of communication.
- Spain: Dr Xavier Calbert agreed to approach the Agencia Estatal de Meteorología (AEMET) and to further a contact with the goal to bring the site at Izana, Canary Islands, as candidate into GRUAN.

The communication with these potential sites may need to go through various channels. Working through WMO will assure that the upper level management is involved and will be able to support the developments of GRUAN sites in these countries. Since GRUAN is an essential element in the Global Climate Observing System, it should be noted that these activities are important steps within the Global Framework for Climate Services (GFCS) to strengthen observations and monitoring of climate and to work on capacity building.

9. Meetings

9.1. ICM-7

The next ICM will be hosted by the GRUAN site at Potenza, Italy, which is run by the Consiglio Nazionale delle Ricerche (CNR). The proposed time frame is to hold the meeting for one week within the three week period between 23 February and 15 March. Accommodation will be available in Matera, which is about one hour from Potenza. The meeting will likely be hosted in one of Matera's historical buildings. A site visit at the CNR-IMAA Atmospheric Observatory (CIAO) in Potenza is planned.

9.2. Past meetings

Significant efforts for outreach from the GRUAN community took place last year. A number of important presentations were:

- 21 - 22 May 2013: NOAA GMD climate monitoring conference in Boulder (Presentation by Bodeker)
- 27 - 29 May 2013: Workshop on Research Applications of High-Resolution Radiosonde Data Stony Brook University, New York (Presentations by Seidel, Wang, Vömel)
- 5 - 6 June 2013: TEMPERATUR 2013 (Presentation by Vömel)
- 30 September - 2 October 2013: GEWEX Water Vapour Assessment (G-VAP) Fort Collins (Presentations by Wang, Reale, Schröder)
- 30 September - 4 October 2013: NDACC Steering Committee Meeting, Frascati (GRUAN represented by Vömel)
- 5 - 6 December 2013: SPARC WAVAS II Workshop on Satellite Data Quality Assessment, Pasadena, (Presentations by Hurst, Vömel)
- 12 - 17 January 2014: SPARC 5th General Assembly, Queenstown (Presentations by Bodeker, Seidel)
- 22 - 23 January 2014: German National GCOS Meeting (Vömel)
- 26 - 28 February 2014: COST Action Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate (GNSS4SWEC) (Presentations by Rannat, Kivi, Vömel)

9.3. Other upcoming meetings

Peter Thorne discussed a number of upcoming meetings, which may have an explicit GRUAN representation:

- 6 - 8 May 2014: GRUAN-GSCIS-GNSSRO WIGOS workshop at WMO headquarters, Geneva. The workshop is by invitation only and will have a strong GRUAN representation.
- 9 - 13 June 2014: 17th Symposium on Meteorological Observation and Instrumentation, Westminster, USA, with GRUAN special session, including six oral presentations and one poster on GRUAN.
- 7 - 16 July 2014: CIMO-XVI, TECO-2014, METEOREX-2014, St.-Petersburg, Russian Federation
- 16 - 21 August 2014: World Weather Open Science Conference, Montreal, Canada. This conference includes a session on weather observation.
- 15 - 17 September 2014: International workshop on Metrology for Meteorology and Climate, Brdo, Slovenia. Currently planned participation by Greg Bodeker and Stephanie Kremser, and possibly by Tom Gardiner, Marion Maturilli, Martial Haeffelin.
- 13 - 17 October 2014: The WCRP Climate Symposium 2014, Darmstadt, Germany.

In 2015 the next WMO congress will convene in Geneva. The meeting agreed that a GRUAN launch event as side event during the WMO congress should be organized, which focuses on GRUAN, the importance of reference observations for climate science, services, monitoring, and possibly on network expansion. The organization of this side event should be coordinated with the GCOS Secretariat.

10. GRUAN work plan

The final session agreed on a specific GRUAN work plan for the forthcoming year based on the preceding discussions. Similar as during the previous meeting, the work plan discussed during ICM-6 is intended to be specific and clear. These action items will be tracked and discussed in the next meeting.

10.1. 2014-15 GRUAN work plan

No	Action	Who	Deadline
1	GRUAN report synthesizing the four white papers developed through the GRUAN network expansion workshop. Circulation of 1st draft to author team	Greg Bodeker	Apr 14
2	Co-chairs to provide desired metrics on data usage / impact metrics to extent possible	WG-GRUAN co-chairs	May 14

3	Responses to requests from sites for letters from WG-GRUAN / GCOS to be actioned. Letters to be drafted and sent. Letters requested in site reports or at ICM-6	WG-GRUAN chairs, Lead Centre, GCOS Secretariat	May 14
4	A document detailing the operational challenges related to multi-payload soundings submitted either to peer reviewed literature (first choice) or to WG-GRUAN for review as a GRUAN report	TT radiosondes	Jun 30
5	Prepare plan for GRUAN launch activity at WMO congress and report plan to GRUAN community at ICM-7	WG-GRUAN, Lead Centre, Lars Peter Riishojgaard	Jun 14
6	Define necessary steps to undertake transition from RS-92 to RS-41.	TT-Sites, Lead Centre, HMEI, WIGOS project officer, GCOS Implementation Manager	Jun 14
7	TT and WG terms of reference to be revised by chairs and submitted to AOPC for approval to incl. inter-alia discussion around scientific coordinator role	TT and WG chairs	Jun 14
8	To close the feedback loop for instrument and processing performance, TT sites to summarize how they wish to receive near-real-time feedback.	TT sites, Lead Centre	Jun 14
9	Submitted BAMS article on the next steps in GRUAN including network expansion and some highlights. Greg Bodeker to contact BAMS editor. Paper to be submitted to ensure publication in time for WMO congress	WG-GRUAN, Greg Bodeker	Sep 14
10	TD omnibus of all things RS-92. Lead Centre to send everything to Bodeker Scientific for collation and editing. Gaps to be identified and Lead Centre will try to address the gaps. Greg Bodeker and Peter Thorne to determine how to accommodate updates.	Greg Bodeker, Lead Centre	Sep 14
11	Technical documentation completed for frostpoint hygrometer measurements	Lead Centre, Task team radiosondes	Sep 14
12	A short GRUAN report detailing the process implemented to provide feedback of observation minus background fields to the GRUAN Lead Centre	David Tan and Lead Centre	Oct 14

13	Sites reporting either TEMP or not reporting on the GTS / WIS to work with Lead Centre, WIGOS and HMEI to ensure GRUAN sonde launches are sent as 2s resolution BUFR. Briefly report progress and issues to ICM-7.Data flowing through WIS as BUFR high vertical resolution for as many sites as possible.	Lead Centre, TT sites, WIGOS project office, GCOS Implementation Manager, HMEI	Oct 14
14	An assessment of the advantages and disadvantages of manual vs. autosonde launches written up and submitted to the peer reviewed literature	TT radiosondes	Nov 14
15	Each site to produce a proposal of how they will document by photos seasonal and long-term site changes (regular e.g. quarterly from stated locations / daily webcam shots etc. as appropriate to their specific case, and 'on change'). Proposals collated and documented for WG-GRUAN review and feedback	TT sites	Nov 14
16	Technical documentation for GRUAN Lidar stream (Lidar Guide) submitted for review by WG-GRUAN	TT ancillary measurements	Dec 14
17	Microwave radiometer technical documentation (Microwave Guide) submitted for review by WG-GRUAN	TT ancillary measurements	Dec 14
18	FTIR technical documentation (FTIR Guide) submitted for review by WG-GRUAN	TT ancillary measurements	Dec 14
19	Manuscript(s) detailing operational considerations for controlled descents for frostpoint hygrometers submitted to a journal or detailed in a GRUAN Report	TT radiosondes	Dec 14
20	Manuscript describing the derivation of uncertainty estimates for GNSS-PW measurements submitted to a peer reviewed journal	TT GNSS-PW	Dec 14
21	In collaboration with partner networks, assess the relevance and tractability of the full suite of remaining GRUAN target variables defined in GCOS112 in the context of measurement capabilities and measurement programmes underway in partner networks. GRUAN report identifying potential target data streams and partners	WG-GRUAN Chairs, Lead Centre, TT ancillary measurements, TT site representatives	Dec 14

22	Develop frostpoint hygrometer data products. Guidance needs to account for operation of CFH, NOAA FPH. Paper submitted to a peer reviewed journal.	Lead Centre, Task Team Radiosondes	Dec 14
23	Develop a GRUAN ozonesonde data product in consultation with NDACC and GAW. Completed technical documents	Greg Bodeker, Lead Centre, Herman Smit	Jan 15
24	Lead Centre to report on data usage / impact metrics (following recommendations from #2) to extent possible	Lead Centre	Mar 15
25	Revise the RS-92 data stream based upon feedback received - revised version 3 release including qc flags vectors and data in different vectors (good, questionable, missing), including implementation of performance feedback.	Lead Centre, TT radiosondes	Mar 15
26	Perform demonstration study of SASBE at time of satellite overpass based on a realistic set of assumptions about the availability and colocation of sondes and ancillary measurements. Focus is on temperature and water vapour	TT ancillary measurements	Mar 15
27	Instigate a user review group to meet on a biennial basis. User review group terms of reference drafted and agreed to by WG-GRUAN for subsequent consideration by AOPC	WG-GRUAN Chairs	Mar 15
28	Develop GRUAN data product and processing stream for Modem radiosondes. First draft of technical document describing processing streams for all Modem radiosondes	CNRS, Lead Centre, TT radiosondes	Mar 15
29	Determine the status of BSRN and re-engage with GRUAN. Report back to WG on BSRN status and whether their measurements are reference quality and if not what we would need to do extra. Invite someone to ICM-7 from BSRN. GRUAN representation at BSRN meeting in September	Richard Querel	Mar 15
30	Develop an advanced ‘template document’ for non-RS92 radiosondes for later distribution to specific users	Lead Centre, TT radiosondes	Mar 15
31	Develop a GRUAN GNSS-PW product. Technical documentation completed for GNSSPW measurements (GNSS-PW Guide)	TT GNSS-PW	Mar 15

32	Pedagogical paper on appropriate propagation of uncertainties and generic code – paper draft available for comment	Greg Bodeker	Mar 15
33	Reports from WG and GRUAN community members on efforts to further contributory site set. Single page write ups for each site by selected GRUAN leads at ICM-7 (list of sites and contact points in main report) and also reports on phone calls	WG-GRUAN, Lead Centre, ICM-6 participants	Mar 15
34	Develop GRUAN humidity and temperature lidar data products in collaboration with NDACC. Paper describing GRUAN lidar products submitted to peer reviewed journal	TT ancillary measurements	Jun 15
35	Establish closer working ties between tropical GRUAN sites and SHADOZ sites - short report on how to establish greater linkages	Greg Bodeker	Jun 14
36	Prepare public outreach material. This includes updating the GRUAN brochure	Greg Bodeker	Jun 14

Appendix 1. Review of actions in from ICM-5

No	Action	Who	Deadline	Status
1	Revise IP language to be clearer that we are looking to partner with rather than duplicate work of other experts and that in very many cases we are not the experts. Also that GRUAN sites are owned and operated by third parties and not GRUAN.	WG Co-Chairs (PT lead)	Mar. 2013	Done
2	Technical documents for GRUAN Lidar stream submitted for review by WG-GRUAN.	TT-AM	Mar. 2013	A *very* comprehensive GRUAN lidar programme guide (100 pages in total) was circulated for comment on 2 December 2012 to Peter, Greg, Holger and the ancillary measurements task team. Still needs to be brought to a level suitable for circulation amongst the WG. Work will resume in 2014.
3	A paper on "Collocation of observations" with an emphasis of how to account for mismatches in quantifying and comparing uncertainties submitted to a peer reviewed journal.	Fasso and GATNDOR.	May 2013	Statistical modelling of collocation uncertainty in atmospheric thermodynamic profiles A. Fassò, R. Ignaccolo, F. Madonna, and B. B. Demoz Atmos. Meas. Tech. Discuss., 6, 7505-7533, 2013
4	Provide a two-page structure outline of the expected format of an omnibus TD for each data stream taking as a starting point the lidar guide (which we may suggest some changes to …) and publish as a GRUAN report.	WG Co-Chairs	May 2013	This document was published as GRUAN Technical Note 2.
5	Retention of collocated satellite / sonde / NWP data within or linked from the GRUAN data archive to facilitate intercomparisons.	TT-AM	Jun. 2013	Done
6	Develop a calibration/validation concept for the EUMETSAT geostationary MTG series	TT-AM / WG	Jun. 2013	A bid was put together to the relevant EUMETSAT call, led by KNMI.

	based on GRUAN sites.			
7	A paper on "Quantifying the value of complementary measurements" submitted to a peer reviewed journal.	Madonna	Jun. 2013	Paper is to be submitted following copy-editing for English by ARM programme
8	Microwave radiometer Technical documents submitted for review by WG-GRUAN. (Two different documents - one for June and one for later).	TT-AM	Jun. 2013	Still in progress with Nico Cimini. This task is linked with the EU action TOPROF (http://www.toprof.imaa.cnr.it/) , where the MWR Working Group should carry its activities forward
9	FTIR Technical documents submitted for review by WG-GRUAN.	TT-AM	Jun. 2013	Still in progress
10	Formal establishment of Metadata Task Team – list of members provided to Lead Centre.	WG Co-Chairs	Jun. 2013	While it is true that we did not establish a formal metadata task team, we identified that this would simply not be possible and we found a way around that → Arnoud Apituley has kindly agreed to stand as a GRUAN rep on the WIGOS metadata Task Team. So perhaps while that was 'not achieved' it was 'resolved'.
11	Send maps of instrument locations, including elevation information to TT sites representatives chairs. Use as a template information on the Lindenberg site which will be circulated to site representatives by Lead Centre.	Sites	Jun. 2013	Done.
12	Documentation (as brief GRUAN report) that makes clear what additional work is required by sites to join GRUAN.	Bodeker / Lead Centre / TT sites	Jun. 2013	Updated flyer has been posted on the GRUAN web page.
13	Survey sites for ascertaining which of the specific new data streams envisaged in the IP refresh they may have capability to deliver, whether they may consider submitting them, and whether they are interested in participating in	TT sites	Jun. 2013	Done. We now need to discuss how best to utilize these results and also publicize them.

	their development. Simple table. (To be delivered to WG, LEAD CENTRE and other task team chairs by this date).			
14	Temperature scheduling requirements study	Gardiner	Jun 2013	Currently in the process of finding reviewers for this GRUAN report (#3)
15	Formally document what generic steps would be required to bring a new production sonde type into GRUAN as a GRUAN report.	TT radiosondes / Lead Centre	Jul 2013	Available as a GRUAN technical note through gruan.org
16	Online tools based on the NPROVS system to visualize and monitor GRUAN profiles, collocated satellite, and NWP data (GPROVS).	TT-AM / WG	Aug 2013	Rather than being a one-off action, this is an ongoing action and has been flagged as such on the GRUAN Master Action Item list.
17	A document detailing the operational challenges related to multi-payload soundings submitted either to peer reviewed literature (first choice) or to WG-GRUAN for review as a TD.	TT radiosondes	Oct. 2013	Hoping for 1st draft by the time of this meeting with final document completed by 30 June 2014.
18	GRUAN report synthesizing the four white papers developed through the GRUAN network expansion workshop.	Bodeker + NEW participants and collaborators.	Nov. 2013	Nearly ready for circulation amongst the workshop participants → mostly thanks to the efforts of Anna Mikalsen.
19	A short GRUAN report detailing the process implemented to provide feedback of observation minus background fields to the GRUAN Lead Centre.	Tan / LEAD CENTRE	Nov. 2013	Now slated for completion by October 2014. The action has not been totally dormant: the potential feedback parameters have been discussed with GRUAN Lead Centre, June Wang and Tony Reale. Some prototype feedback data were prepared at ECMWF and sent to DWD.
20	An assessment of the advantages and disadvantages of manual vs. autosonde launches written up and submitted to the peer reviewed literature.	TT radiosondes	Nov. 2013	Now slated for completion in November 2014

21	Define a site reports format expectation and roll out to sites for formal annual progress reports (Roll out November 2013, site reports due by end of Jan 2014).	WG / LEAD CENTRE / TT sites	Nov. 2013	Done. See site reports at www.gruan.org
22	A paper submitted to a peer reviewed journal that provides a more accessible version of the GRUAN network expansion workshop report (e.g. a BAMS article).	Bodeker and workshop participants / contributors.	Dec. 2013	This will be more than just a more accessible version of the GRUAN network expansion workshop report. It will be the next chapter in the GRUAN story and will include a discussion of expansion of the network.
23	Manuscript(s) detailing operational considerations for controlled descents submitted to a journal or detailed in a GRUAN Report.	TT radiosondes	Dec. 2013	Now slated for completion June 2014
24	Revise the RS-92 data stream based upon feedback received - revised version 3 release including qc flags vectors and data in different vectors (good, questionable, missing).	Lead Centre	Dec. 2013	Version 3 of the data stream will be delayed. Several issues have been discovered and placed into the list of revisions.
25	TD omnibus of all things RS-92.	Lead Centre	Dec. 2013	To be discussed at this meeting
26	Technical documentation completed for frostpoint hygrometer measurements.	LEAD CENTRE / TT radiosondes	Dec. 2013	Documentation as well as processing are well under way. A first draft will be available at ICM-6.
27	First report on data usage including items such as publications arising, queries received etc.	Lead Centre	Feb. 2014	Not done. e.g. Google Analytics to show usage of GRUAN website.
28	Paper describing the RS-92 product submitted to journal.	Lead Centre	Feb. 2014	Paper submitted
29	Manuscript describing the derivation of uncertainty estimates for GNSS-PW measurements submitted to a peer reviewed journal.	TT GNSS-PW	Mar. 2014	Now slated for completion in October 2014. What resourcing is required to get this done?
30	Short report for inclusion in ICM-6 proceedings summarizing sites processed to date.	WG Co-Chairs	Mar. 2014	Done as part of LEAD CENTRE report.

31	Investigate site-specific "recipes" of GRUAN ancillary and sonde measurements (including uncertainties) for comparison with sounding products, focusing on atmospheric temperature and moisture. Manuscript submitted.	TT-AM	Mar. 2014	This has now been replaced with 'Perform demonstration study of SASBE at time of satellite overpass based on a realistic set of assumptions about the availability and colocation of sondes and ancillary measurements. Focus is on temperature and water vapour'.
32	GRUAN launch activity as agreed between GRUAN participants.	WG Chairs, Lead Centre, secretariat	May 2014	This was superseded by AOPC and should be carried over to 2015 WMO full congress. Want to have most sites certified before this event, which happens every 4 years.

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Appendix 2. Agenda

GCOS Reference Upper Air Network (GRUAN)
6th Implementation and Coordination Meeting (ICM)
Greenbelt, Maryland - USA

Dates: 10-14 March 2014

Location: Hilton Garden Inn, 7810 Walker Drive, Greenbelt, Maryland

Organizing Committee: Greg Bodeker, Belay Demoz, Howard Diamond, Jim Fitzgibbons, Anna Mikalsen, Bill Murray, Tony Reale, Dian Seidel, Peter Thorne, Holger Vömel, David Whiteman

Hosted by: Howard University

Meeting supported by: NOAA GCOS Office, GCOS Secretariat, Howard University

Theme: "Maximizing the utility of GRUAN activities and measurements to benefit the Global Observing System"

Notes: Speakers should plan to speak for half of allotted time and leave the second half for discussions.
We will maintain minutes using a real-time google docs meeting summary document. The link is available here. Everyone is encouraged to contribute to the meetings.

Day 1 (Monday)

Day chair: Greg Bodeker; Rapporteur: David Whiteman

08:00 – 09:00 Registration

Session 1: Welcome

09:00 – 09:05 Welcome from local organizers – Belay Demoz
09:05 – 09:10 Welcome from WG-GRUAN (Working Group on GRUAN) co-chairs and aims of workshop
09:10 – 09:30 Welcome remarks from Dr Wayne A. I. Frederick (Howard University Interim President)
09:30 – 09:50 NOAA keynote address – Robert Detrick (Assistant Administrator for Oceanic and Atmospheric Research, and Acting Chief Scientist, NOAA)
09:50 – 10:00 GRUAN: Starting Small and Becoming Formidable – Dave Goodrich (former Director GCOS Secretariat)
10:00 – 10:20 GRUAN basics for new GRUAN ICM participants – Holger Vömel

10:20 – 10:50 Coffee break

Session 2: Progress updates from WG-GRUAN and Lead Centre

10:50 – 11:10 Progress check against ICM-5 agreed work plan – Peter Thorne
11:10 – 11:30 Progress report from Lead Centre – Holger Vömel
11:30 – 12:00 Network expansion progress report – Greg Bodeker

12:00 – 13:00 Lunch

13:00 – 13:30 GRUAN Implementation Plan – Peter Thorne
13:30 – 14:00 Funding opportunities discussion – Greg Bodeker

Session 3: Review of existing / emerging data streams

14:00 – 14:30 Metadata in GRUAN – Michael Sommer
14:30 – 14:50 GRUAN interaction with the WIGOS metadata task team – Arnoud Apituley
14:50 – 15:00 Meteomet – Tom Gardiner

15:00 – 15:30 Coffee break

15:30 – 15:50 RS92 radiosonde data stream specification, performance and characteristics of early data flow – Ruud Dirksen
15:50 – 16:00 Bringing non-RS92 sondes into GRUAN – Holger Vömel
16:00 – 16:20 Preparatory work for the Modem radiosonde – Martial Haeffelin
16:20 – 16:35 Cryogenic Frostpoint Hygrometer (CFH) data stream – Holger Vömel
16:35 – 17:00 Lidar data stream – Thierry Leblanc
17:00 – 17:30 Global Navigation Satellite System-Precipitable Water (GNSS-PW) data stream – Kalev Rannat

17:30 – 18:00 Open discussion on Day-1 reports – Peter Thorne

Day 2 (Tuesday)

Day chair: Peter Thorne, Rapporteur: Arnoud Apituley

Session 4: Updates from GRUAN Task Teams and GATNDOR

09:00 – 09:30 Radiosondes – Ruud Dirksen
09:30 – 10:00 GNSS-PW – June Wang and Kalev Rannat
10:00 – 10:30 Measurement schedules and associated instrument-type requirements – Tom Gardiner and Dave Whiteman

10:30 – 11:00 Coffee break

11:00 – 11:30 Ancillary measurements – Tony Reale and Thierry Leblanc
11:30 – 12:00 GRUAN Analysis Team for Network Design and Operations Research (GATNDOR) – Fabio Madonna

12:00 – 13:00 Lunch

Session 5: GRUAN as a potential "force multiplier" for the global observing system (I)

13:00 – 13:15 A view from the Network for the Detection of Atmospheric Composition Change (NDACC) – Martine De Maziere / Mike Kurylo
13:15 – 13:25 A view from NOAA STAR – Al Powell (STAR Director)
13:25 – 13:45 NOAA PROducts Validation System (NPROVS+) – Tony Reale
13:45 – 14:00 Site Atmospheric State Best Estimate (SASBE) – John Dykema
14:00 – 14:15 Collocation White Paper – Xavier Calbet
14:15 – 14:30 A view from the Global Space-based Inter-Calibration System (GSICS) – Mitch Goldberg
14:30 – 14:45 A view from NASA – Jack Kaye
14:45 – 15:00 A view from NOAA/NWS – John Murphy
15:00 – 15:15 A view from the Global Observing System (GOS)/WMO Commission for Basic Systems (CBS) – Lars Peter Riishojgaard

15:15 – 15:30 Coffee break

15:30 – 17:30 Parallel sessions:
Breakout 1: Review and discussion of the new LidarRunClient prototype (Thierry Leblanc)
Breakout 2: Review of specifics of RS-92 data stream and uncertainty caLead Centreulation (Ruud Dirksen)
Breakout 3: Collocation analysis and uncertainty estimation (Alessandro Fasso)
17:30 – 18:00 Report back from breakouts and open discussion of items arising on Day 2

Day 3 (Wednesday)

Session 6: GRUAN site activities and related research
Day chairs: Belay Demoz, Rapporteur: Dale Hurst

09:00 – 09:30 GRUAN data flow – Michael Sommer
09:30 – 10:00 Lead Centre generated sounding reports and Discussion – LEAD CENTRE and Sites

10:00 – 10:30 Coffee break

10:30 – 10:50 Maïdo observatory: A new high-altitude station facility at Réunion Island – Stefanie Evan (La Réunion)
10:50 – 11:10 Updates from Ny-Ålesund – Marion Maturili
11:10 – 11:25 Change management for the RS92 - Meisei transition at Tateno – Nobuhiko Kizu (Tateno)
11:25 – 11:40 First results from the Vaisala RS-41 – Rigel Kivi (Sodankylä)
11:40 – 11:50 Managing the change to the Vaisala RS-41 within GRUAN – Holger Vömel

11:50 – 12:00 Open Discussion

12:00 – 13:00 Lunch

13:00 – 13:20 Validation of Aura MLS stratospheric water vapour by the NOAA FPH – Dale Hurst (Boulder)
13:20 – 13:40 Trend detection and lessons for GRUAN – Dave Whiteman
13:40 – 14:00 Raman calibration issue – Demetrius Venable (Beltsville)
14:00 – 14:30 SHADOZ ozonesonde network – Anne Thompson
14:30 – 15:00 SOWER water vapour sonde network – Holger Vömel

15:00 – 15:30 Coffee break

15:30 – 15:50 Updates from Lauder – Richard Querel
15:50 – 16:10 Activities in future NWS networks Belay Demoz (Beltsville)
16:10 – 16:30 Multi-thermistor activities at NWS – Mike Hicks
16:30 – 18:00 Open Discussion – Greg Bodeker

Day 4 (Thursday)

Tour of Sterling and Beltsville facilities and presentation by local scientists/students

09:00 Leave Hilton Garden Inn to travel to Howard University Beltsville research campus [7501 Muirkirk Rd., Beltsville , MD 20705]
09:30 – 11:30 Tour of the Howard University Beltsville Site
11:30 – 12:30 Boxed lunch

12:00 – 12:45 Travel to Sterling, VA – NOAA/NWS site
[43741 Weather Service Road, Sterling, VA 20166]
directions at http://www.nws.noaa.gov/ops2/ops22/sfsc%20html/index.html

12:45 Sign in and welcome at NOAA/NWS Sterling site
13:00 – 15:45 Tour of NOAA/NWS Sterling site
15:45 Travel to the Air and Space Museum

16:30 – 17:30 Guided tour of highlights of the Smithsonian National Air and Space Museum's
Steven F. Udvar-Hazy Center in Chantilly, VA.

17:30 Travel to Bungalow Lake House

18:00 Dinner at the Bungalow Lake House (at own expense)
46116 Lake Center Plaza. Sterling, VA 20165
http://www.bungalowlakehouse.com

19:30 Bus tour of Washington DC, National Mall and Memorial Parks
including walking tour of the Lincoln Memorial, guided by Dave Goodrich.

22:00 Return to Hilton Garden Inn

Day 5 (Friday)

Day chair: Holger Vömel, Rapporteur: Dian Seidel

Session 7: GRUAN as a potential "force multiplier" for the global observing system (II)

09:00 – 10:00 GRUAN representation at AOPC – Peter Thorne
(Please note the discussion document for this agenda item, which should have been read prior to the discussion)

10:00 – 10:30 Coffee break

10:30 – 11:00 Discuss specific actions on how to expand the network and which organizations to specifically approach – Holger Vömel

Session 8 Forthcoming meetings

11:00 – 11:15 Upcoming GRUAN/GNSS-RO/GSICS meeting – Stephan Bojinski / Peter Thorne
11:15 – 11:30 Other upcoming meetings discussion – All

Session 9: Miscellaneous items of business

11:30 – 11:45 Discussion of Terms of Reference for WG and Task
11:45 – 12:00 Discussion of GRUAN launch event during WMO Congress in May 2015

12:00 – 13:00 Lunch

13:00 – 13:30 Presentation and discussion of synthesis of Tuesday session – Greg Bodeker
13:30 – 15:00 Agreement of work plan for 2014/5 and discussion of outstanding issues Peter Thorne
15:00 Close

Appendix 3. List of Participants

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Appendix 4. Lead Centre report

GRUAN Lead Centre progress report 01/2014

covering the period 08/2013 to 02/2014

Author

Holger Vömel
GRUAN Lead Centre
Lindenberg Meteorological Observatory – Richard Assmann Observatory
German Meteorological Service (DWD)

Summary

Major tasks have been the distribution of individual data submission reports to sites and the start of the GNSS-PW data flow. The GRUAN Vaisala RS92 processing paper is almost complete and will be presented at ICM-6. A new version of the RsLaunchClient has been developed and is being distributed to the sites. The flow of GNSS raw data has started.

Health of network

One site (Nauru) has been closed. The closure of two other sites (Manus and Darwin) has been announced and is expected to occur this year. It is hoped that the radiosonde component of the site at Darwin can be maintained. ARM has established a new site in the Azores and may be able to bring this site into GRUAN. Network expansion is becoming urgent.

Progress against stated objectives

Open items	Summary of progress
Formally document what generic steps would be required to bring a new production sonde type into GRUAN as a GRUAN report. (Short report, submitted to review) (Jul. 2013)	Done. A technical note (TN-1) was completed and reviewed by the Task Team Radiosondes. It has been sent to all relevant GRUAN parties, who are planning to include new production radiosondes into GRUAN. Discussions have happened with Modem, Intermet (USA) and CMA.
A short GRUAN report detailing the process implemented to provide feedback of observation minus background fields to the GRUAN Lead Centre. (Nov. 2013)	This action is delayed due to staffing shortages.
Define a site reports format expectation and roll out to sites for formal annual progress reports (Roll out November 2013, site reports due by end of Jan 2014).(Nov. 2013)	Site data reports have been sent out to all sites. Comments have been received from some sites and have been included in the update of the site reports. These reports will be distributed to all sites prior to ICM-6
Revise the RS-92 data stream based upon feedback received - revised version 3	Version 3 of the data stream will be delayed. Several issues have been discovered and placed

release including qc flags vectors and data in different vectors (good, questionable, missing). (Dec. 2013)	into the list of revisions.
TD omnibus of all things RS-92. (Dec. 2013)	To be discussed at ICM-6.
Technical documentation completed for frostpoint hygrometer measurements. (Dec. 2013)	Documentation as well as processing are well under way. A first draft will be available at ICM-6.
First report on data usage including items such as publications arising, queries received etc. (Feb. 2014)	This item is technically not doable, since currently no data tracking is in place and cannot be put into place due to the regulations at NOAA.
Paper describing the RS-92 product submitted to journal. (Feb. 2014)	Paper nearing submission

Achievements

Reports detailing the status of data submission, data quality and specific issues have been sent to all sites that have submitted data. These reports are generated automatically based on the data and metadata stored in the GRUAN database. They list among other things the amount of data, the instrument source for these data as well as some quality checks for the Vaisala RS92 radiosonde, which are being processed at the Lead Centre. Some comments have been received from the sites and the report format has been modified to take these comments into consideration. These reports will be resent to the sites with the request to submit them with their own station report to ICM-6.

The first initial data flow for GNSS data from a few selected sites to GFZ has started. GNSS data are not yet being processed as GRUAN data product, which still has to be developed. Initial discussions to accomplish this this task have taken place between GFZ and the Lead Centre.

Lead Centre operations

- The paper for the GRUAN Vaisala RS92 processing is nearing completion and will be presented at ICM-6.
- The Lead Centre participated at the NDACC steering committee meeting in Frascati, Italy. This cooperation is seen as an essential partnership and was recognized as such by all. It was agreed to share frostpoint data with NDACC as well.
- Data flow with Lauder is currently in the process of being set up. Vaisala RS92 data flow from Payerne is in the process of being started, data flow for Meteolabor sonde data is not imminent.
- Maintenance of the GRUAN website and inclusion of the ICM-6 meeting page.
- Preparation of ICM-6, organizing committee discussions, handling the registration and participants list.
- Version 0.5 of the RsLaunchClient (RLEAD CENTRE) has been finished and is currently being distributed to the sites. All sites starting data submission should use this version. The most significant feature is a validation of all metadata collected prior to data submission to minimize the amount of incorrectly submitted data.
- The documentation for this version of the RsLaunchClient is currently under review (GRUAN Technical Document TD-3).
- The LidarRunClient, which has been developed in cooperation with the Lead Centre, has been installed at Payerne. This site is testing the features of this software.
- Herman Smit from the GAW ECC world calibration center in Jülich visited the Lead Centre

and discussed the further cooperation between both. It was agreed to cooperate with him on the development of the data product, which will include many of the topics currently being worked on in the framework of the SI2N ozone sonde homogenization effort. It was agreed to continue this cooperation informally. Formalizing this cooperation is not in the interest of either party and the expected bureaucratic overhead is considered excessive.

Training by Lead Centre

- Training of AWI staff going to Antarctica and to Ny Alesund.
- The newly appointed ARM CFH instrument mentor visited the Lead Centre and got a first glimpse of the CFH sounding operations.

Issues

- The number of tasks and projects is exceeding the resources available at the Lead Centre. No additional staff is to be expected at DWD, which will limit the rate of development of the Lead Centre. External funding cannot be acquired due to the very large bureaucratic overhead.

Work plan for next six months

- Finalize the GRUAN frostpoint data product.
- Begin development of version 3 processing of the GRUAN Vaisala RS92 data.
- The GRUAN website, which is hosted by DWD will need to move to a new web content management system. A significant work load is expected to make this transition smooth for external users.
- Several technical documents have to be developed to describe the GRUAN sonde preparation requirements and the requirements for other radiosondes.

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Appendix 5. Task Team Radiosonde progress report

Task Team progress report for March 2014 – Radiosonde

SUMMARY

We have currently 9 tasks, some of which are ongoing and some are not yet started.

Here is the current member list:

Name	Affiliation	Status
Masatomo Fujiwara	Faculty of Environmental Earth Science, Hokkaido University, Japan	co-chair, member of WG-ARO
Rolf Philipona	MeteoSwiss, Switzerland	co-chair
Ruud Dirksen	GRUAN Lead Centre, DWD, Germany	
Frank Schmidlin	USA	
Alexander Kats	Central Aerological Observatory/KOMET, Russia	
Hannu Jauhiainen	The Association of Hydro-Meteorological Equipment Industry, Finland	HMEI representative
Michael Hicks	Howard University, USA	
Larry Miloshevich	MILO-Scientific, USA	
Rigel Kivi	Finnish Meteorological Institute, Finland	
Nobuhiko Kizu	Japan Meteorological Agency, Japan	
LI Wei	China Meteorological Administration, China	

PROGRESS ON CURRENT TASKS

Task: *Assess time lag in RS92 humidity corrections, comparing the GRUAN processing to other published approaches.*

Main Contact: *Ruud Dirksen with assistance from Michael Sommer, Larry Miloshevich, Masatomo Fujiwara and Alexander Kats*
Due Date: *25-Feb-2014*
Status: *Ongoing*
Milestone: *Manuscript describing the results of the humidity time lag assessment submitted to a journal.*

Progress: *Test calculations were made by Larry Miloshevich. Will be restarted after finishing the paper describing the GRUAN RS92 data product.*

Issues: *Waiting for the GRUAN Lead Centre for further actions.*

Task: *Assess the effects of the use of auto-launchers compared to manual launches on measurement uncertainty estimates for radiosondes.*

Main Contact: *Rigel Kivi & Nobuhiko Kizu*
Due Date: *30-Nov-2014*
Status: *Ongoing*
Milestone: *Publication in the peer reviewed literature.*
Progress: *Information has been summarized at Sodankyla (Kivi), Potenza (Madonna), and Tateno (Kizu)*
Issues: *None*

Task: *Assess controlled descent mechanisms for balloon payloads and issues around use of descent data*

Main Contact: *Rolf Philipona, Dale Hurst and Masatomo Fujiwara*
Due Date: *30-Jun-14. Presentation at ICM-6. 30-Jun-14. (31-Dec-2014 for a document adoptable across GRUAN)*
Status: *Ongoing*
Milestone: *Manuscript(s) detailing operational considerations for controlled descents submitted to a journal or detailed in a GRUAN Report. If deemed applicable, a technical document that supports the adoption of controlled descent across GRUAN.*
Progress: *Regular descent sounding is made at Boulder and Lauder. Some experiments were made at Lindenberg, Payerne, NCAR (and under a tropical project named SOWER).*
Issues: *Still in the experimental phase.*

Task: *Assess multi-payload launch configurations for GRUAN usage.*

Main Contact: *Hannu Jauhiainen and Masatomo Fujiwara*
Due Date: *30-Jun-2014*
Status: *Ongoing*
Milestone: *Document detailing the issues surrounding multi-payload soundings to be drafted and submitted either to peer reviewed literature (first choice) or to WG-GRUAN for review as a TD*
Progress: *A questionnaire sheet was sent (and re-sent) to several groups, and some responses have been received*
Issues: *Need some more time to prepare a draft for circulation within the GRUAN community for comments*

Task: *Define the non-RS92 data collection client requirement, identify the central data processing facility, and initiate data flow.*

Main Contact: *Holger Vömel, Michael Sommer, Rolf Philipona, Lead Centre, Radiosonde task team*
Due Date: *1-Sep-2015*
Status: *Ongoing*
Milestones: *Assessments of non-RS92 data collection client requirements. Data flow through NCDC portal*
Progress: *First tests with RS-Launch client to submit non-RS92 data to the Lead Centre. Built up of data processing facility and data files with final product and uncertainties of each parameter for non-RS92 radiosondes.*
Issues: *Submission of Meteolabor radiosonde data in preparation.*

Task: *Develop a UT/LS water vapour data product supported by appropriate technical documentation. The technical documentation must account for operation of CFH, NOAA FPH, Snow White and possibly FLASH-B.*

Main Contact: *Holger Vömel, Rolf Philipona, Masatomo Fujiwara and Dale Hurst*

Due Date: *1-Mar-2014*
Status: *Ongoing*
Milestone: *Technical documentation completed for frostpoint hygrometer measurements*

Main Contact: *Holger Vömel, and Dale Hurst*
Due Date: *1-Mar-2015*
Status: *Ongoing*
Milestone: *Peer reviewed publication on frostpoint hygrometer GRUAN data product submitted.*

Task: *Define the frostpoint hygrometer data collection client requirement, identify the central data processing facility, and initiate data flow.*

Main Contact: *Holger Vömel, Lead Centre, Radiosonde task team*
Due Date: *1-Sep-2015*
Status: *Not yet started*
Milestone: *Data flow through NCDC portal*

Main Contact: *Radiosonde task team*
Due Date: *1-Dec-2015*
Milestone: *Assessment of data usage, issues and potential improvements for this data stream*
Progress: *Not yet started*

Task: *Finalize the definition of GRUAN data products for RS92 radiosondes: Technical document describing pre-launch procedure (TD5)*

Main Contact: *Ruud Dirksen and Masatomo Fujiwara*

Due Date: *25-Feb-2014*
Status: *Ongoing*
Milestone: *Review of the pre-launch ground-check/ground-calibration procedures*
Progress: *A questionnaire sheet was sent to the relevant GRUAN sites in August 2012*
Issues: *There is a preliminary version of TD5 whose missing perspective is to consider the current practice at the relevant GRUAN sites. The questionnaire is for this purpose.*

Task: *Define the ozone sonde data collection client requirement, identify the central data processing facility, and initiate data flow.*

Main Contact: *Holger Vömel, Lead Centre Radiosonde task team*
Due Date: 30-Jun-2015
Status: Not yet started
Milestone: *Data flow through NCDC portal*

Main Contact: *Radiosonde task team*
Due Date: *30-Jun-2017*
Status: *Not yet started*
Milestone: *Assessment of data usage, issues and potential improvements for this data stream*

Appendix 6. Task Team GNNS-PW progress report

SUMMARY

TT conference call held on Friday, 20. September 2013.

The TT has worked on topics listed on the GRUAN Master Action Item list:

a) Develop the GNSS-PW GRUAN data product including technical documents that detail the estimation of measurement uncertainties, data collection client requirements, and central data processing.
b) Define the GNSS-PW data collection client requirement, identify the central data processing facility, and initiate data flow.

The main effort is made on issues with the closest due dates in a:

- Manuscript describing the GRUAN GNSS-PW uncertainty estimates submitted to peer reviewed literature (Tong & Elgered, 1. Oct 2014, pending on Tong's availability)
- Technical documentation completed for GNSS-PW measurements (June Wang, Kalev Rannat, 1. March, 2015)
- Technical document describing recommended practices on managing change in GNSS-PW measurements (George, June Wang, Kalev Rannat, 30. Sept. 2013).
- Document providing guidance on GNSS-PW data through a GRUAN GNSS data and product table (Yoshinori, John and Seth, 1. Oct. 2013).

Parallel work is going on or getting started with subtopic b:

- Complete set of GRUAN technical documents describing all aspects of GNSS-PW data flow (June Wang, Kalev Rannat, 1. Dec. 2014).
- Data flow through NCDC portal (Lead Centre, June Wang, Kalev Rannat, 1. Jun. 2015)
- Assessment of data usage, issues and potential improvements for this data stream (GNSS TT 1. Sept. 2016).

Besides working on the tasks #4 … #7 and the data flow listed above, the GNSS-PW TT has also been involved in the following activities:

1. GNSS data flow and processing: GFZ has officially accepted the invitation for data processing.
   According to the discussions between GFZ and LEAD CENTRE the long term data archive will be maintained by LEAD CENTRE, data conversion and processing will be done by GFZ. Accepted data will be receiver proprietary format (if the GFZ conversion tool accepts this format) in any sample-rate, or RINEX version 3, with 30 sec sample rate. Both, LEAD CENTRE and GFZ, installed FTP server to exchange GNSS raw and RINEX data, metadata and products. Lindenberg and Ny-Ålesund are the first two sites for data flow. The work is in progress (next connections should be Lauder and Sodankylä, but additional work needs to be done for supporting met-RINEX data flow and some hardware setups). After the data can be regularly obtained from the first sites, the next step will be to specify the needs for related metadata and if/how to develop a similar tool for GNSS-data as it is done for radiosondes.
2. TT members participating in COST Action ES1206 WG 3, Objectives in here: http://w3.cost.eu/fileadmin/domain_files/ESSEM/Action_ES1206/mou/ES1206-e.pdf
   Kalev visited GFZ Potsdam in frames of COST ES1206 STSM. Part of the work covered the topics of GNSS-data flow and quality control (particularly while visiting LEAD CENTRE, Lindenberg).
3. A spotlight on Lauder GNSS site on http://xenon.colorado.edu/spotlight/index.php?product=spotlight&station=laud. Thanks

go to Dan Smale for putting it together!

PROGRESS ON CURRENT TASKS

1) **Task #4 in ToR**

"To develop guidance on the type, amount, format, temporal resolution and latency of data and associated metadata needed to be stored from the ground-based GNSS measurements and other auxiliary data sources, and data archive and dissemination methods."

Main Contact: *Yoshinori* **Due Date:** *9/30/2013* **Status:** *Done*
Milestone: "GRUAN GNSS Data and Product Table" & "Format Specification for COST-716 Processed GPS Data"
Progress:
Issues: The table will be updated by GFZ whenever the E-GVAP document is updated (not very frequently).

2) **Task #5 in ToR**

"To identify best practices in making and verifying GNSS observations for GRUAN and other climate applications defined in Task 1. "
Main Contact*: Kalev/Galina/Jens/Jonathan* **Due Date:** *30. Sept. 2013* **Status:** *Done* **Milestone:** Technical document describing recommended practices in GNSS-PW measurements. **Progress:**
Issues:

3) **Task #6 in ToR**

"To follow the guidance on reference quality upper-air measurements outlined in Immler et al. (2010) and provide guidelines for GNSS-PW uncertainty analysis including ways to calculate uncertainties for each data point as required by GRUAN and include them in the final data products."
Main Contact: *Gunnar, Tong, June* **Due Date:** *1. Oct. 2014* **Status:** *Pending*
Milestone: Manuscript describing the GRUAN GNSS-PW uncertainty estimates submitted to peer reviewed literature.
Progress: In progress, but delayed.
Issues: The consensus was that it is good idea for Tong to visit GFZ for two months to work on additional analysis and prepare the manuscript. However, Tong can't leave his current job for two months to work on something else. Current plan is for him to not do any additional analysis and just write the manuscript based on the chapter of his thesis.

4) **Task #7 in ToR**

"To address the question of how to better manage changes applied to ground-based GNSS measurements in both hardware and software and to make sure that the changes will be taken into account for long-term data analysis. "
Main Contact: *George/Kalev/June* **Due Date:** *30. Sept. 2013* **Status:** *Done*
Milestone: Technical document describing recommended practices on managing change in GNSS- PW measurements.
Progress: Issues:

Appendix 7. Task Team Scheduling progress report

SUMMARY

The primary objective for the Task Team is to develop defensible, quantifiable, scientifically- sound guidance for GRUAN sites on measurement schedules and associated site requirements, in order to meet the GRUAN objectives.

In terms of scientific outputs from the Task Team, while the activities of the team remain a voluntary one without specific funding the main information sources are from the peer-reviewed literature, GRUAN documentation, and currently unpublished studies of which the group is aware. Some limited new analyses are being undertaken by Team members using existing data sets to start to address areas where critical gaps exist that prohibit scientifically defensible choices.

In addition to the progress on the tasks described below, other activities this year have included :

- the publication of a summary of Scheduling TT and GATNDOR research linked to the earlier presentation at ITS 9 : *Sampling and measurement issues in establishing a climate reference upper air network ; T. Gardiner, F. Madonna, J. Wang, D. N. Whiteman, J. Dykema, A. Fassò, P. W. Thorne, and G. Bodeker ;AIP Conf. Proc. 1552, pp. 1066-1071; doi:http://dx.doi.org/10.1063/1.4821422, 2013.*
- Research lead by NPL on the use of multiple daily sonde launch data to predict temporal mis-match uncertainties as a function of altitude and season. This study has looked at long term data records from Lindenberg and ARM-SGP sites and the high-density 6-month data set from Manus during the Dynamo campaign. It is planned to submit a paper on this work in 2014, and the option to use modelling outputs to extend the application to the global scale has been discussed with ECMWF.

PROGRESS ON CURRENT TASKS

Task: *Extension of trend sensitivity studies to include stratospheric water vapour and also extension of trend studies into the LS.*

Main Contact: *Dave Whiteman* **Due Date:** *31-Dec-13* **Status:** *On-going*

Milestone: *Paper on extension of trends sensitivity studies analysis to stratospheric water vapour and submission to a peer reviewed journal.*

Progress: *A draft paper on 'Lower Stratospheric Water Vapour Trend Detection – Needs and Current Assessment' has been prepared. This studies the needs for and current capabilities of water vapour trend detection in the lower stratosphere using data from balloon-borne frostpoint hygrometer (FPH) and Microwave Limb Sounder (MLS).*

Issues: *An application for funding in this area was unsuccessful, so work has had to continue on an ad-hoc basis.*

Task: *Review of temperature scheduling requirements (as already done for WV in the Guide) for scheduling decision support.*

Main Contact: *Tom Gardiner* **Due Date:** *30-Sep-13* **Status:** *Completed*

Milestone:

Progress: *The review has been completed, and a draft GRUAN report on its outcomes has been submitted to the lead centre : 'Review of Operational Requirements for Temperature Sonde Measurements'. This review bringstogether the information in the peer-reviewed literature to provide guidance to the GRUAN community on the requirements for sonde temperature measurements, covering aspects such as measurement scheduling, measurement uncertainty, change management and network design.*

Issues: *None*

Appendix 8. Task Team Ancillary Measurements progress report

SUMMARY

The Task Team on Ancillary Measurements oversees the production and integration of ancillary measurements in compliance with GRUAN best measurement practices. These are defined respectively for MWR, FTIR and lidar ground measurements. Satellite observations also provide a source of ancillary measurement and their integration for use in overall validation, weather and climate applications is facilitated by the team.
During the last year, there has been slow progress in several areas assigned to the Task team: as part of the future GRUAN Lidar data stream, a beta-version of LidarRunClient utility was developed and tested for the Payerne lidar. This utility is the lidar-equivalent of the already operational RsLaunchClient used by GRUAN for radiosonde data. Still on the lidar side, a comprehensive review of measurement and algorithm uncertainties is now nearly completed (final report under revision by ISSI Team), and three AMT papers are in preparation. The outcome of the ISSI Team will be used to update and finalize the GRUAN Best Measurement Practices and Lidar Guidelines document untouched since spring 2013. On the Microwave and FTIR sides, similar Best Measurement Practices and Guidelines documents are being written, with a potential submission date to GRUAN-WG matching that of the Lidar document, i.e., Fall 2014. A comprehensive review of the FTIR uncertainty budget is nearly completed, and will be used for the GRUAN FTIR Guidelines. The TT-AM members have confirmed the appropriateness of including an AERI representative in to TT-AM (namely J. Gero) to work on the development of a potential GRUAN AERI Product. On the satellite side, the integration of hyper-spectral and microwave satellite based radiances into the ground/satellite collocation datasets and specific use of "uncertainty" in satellite product analysis were completed including infrastructure to append ancillary measurements as available. Advances in the computation of site atmospheric state best estimates (SASBE) were achieved.
The composition of the task team has changed as follows:
Martine de Mazière, co-Chair of the NDACC, has joined the TT-AM to enhance NDACC-GRUAN collaborations, and to bring her long-time expertise in FTIR measurements.
Jonathan Gero (U.Wisc.) has been invited to join the Task Team to work on the development of a GRUAN AERI product.

Progress on Current Tasks:

Task (0); Product / Sensor Inventory: Survey current and legacy satellites, sensors and associated nrt (weather) and post processed (climate) derived satellite products for atmospheric temperature and moisture profiling suitable for validation and application in determining atmospheric column at a given GRUAN site.

Main Contact: Reale / Schroder **Due Date:** **Status:** Ongoing

Milestone: Spread sheet of satellites, sensors and products suitable for site bases analysis

Progress: Coordination with 2nd Workshop GEWEX water vapour assessment (G- VAP)

Issues: Restore to Master Action List?

Task (5): Retain Collocated Radiances: Retain radiances associated with satellite products collocated with GRUAN reference (NPROVS+)

Main Contact: T. Reale **Due Date:** Feb 2013 **Status:** Ongoing

Milestone: Complete satellite collocation data record containing derived profiles and "all" associated radiance data within 500km of ground target for selected sat/sensor combination

Progress: Data now routinely stored for CrIS, ATMS onboard S-NPP with infrastructures in place for VIIRS, MetOp (IASI, ATMS, AVHRR) and EOS Aqua (AIRS, AMSU, MODIS)

Issues:

Task (7): SASBE at Satellite Overpass

Main Contact: Dykema /Reale **Due Date:** April, 2014 **Status:** Ongoing

Milestone: Routine SASBE in at each site at time of satellite overpass for T and H20 vapour for use in satellite product validation; weather

Progress: SASBE (from Tobin) compared to various RAOB combinations and differences analysed using satellite averaging kernels computed for 6 month test data set from SGP

Issues:

Task (8): Generic SASBE

Main Contact: Dykema **Due Date:** Dec 2016 **Status:**

Milestone: Routine SASBE at each site for climate monitoring

Progress: Defined as routine SASBE any time RAOB in launched for use in climate monitoring, focused on temperature and H20 vapour profile

Issues: Reference processing of dedicated sonde desired

Task (10): Feedback to LEAD CENTRE on RS92 storage, performance

Main Contact: Sommer / Reale **Due Date:** Feb, 2013 **Status:** Ongoing

Milestone: Set up mechanism for routine feedback to LEAD CENTRE

Progress: Interaction among LEAD CENTRE and NOAA STAR staff established, issues identified, routine programme under development

Issues: Various sources of data from ARM sites, ie synoptic vs dedicated RAOB, are ambiguous

Task (36): FTIR best measurement practices and suitability of equipment (FTIR Guidelines)

Main Contact: J. Hannigan **Due Date:** ICM-5 **Status:** Ongoing

Milestone: When first draft submitted

Progress: TT5 FTIR experts will work on a first draft following principles applied in Lidar Guidelines doc. De Maziere, Schneider & Hannigan met and created an outline but no further action to date. Action is still in process.

Issues: Slow progress due to time availability

Task (39): Examine FTIR and IASI Retrievals and Products long-term consistency (2007-2012):

Main Contact: M. Schneider **Due Date:** 2016 **Status:** Ongoing

Milestone: Feb. 2011: start of MUSICA (http://www.imk-asf.kit.edu/english/musica)

Progress: Examine long-term consistency (the whole IASI period: 2007-2012)

Issues: Pending coordination with NPROVS

Task (43): Microwave radiometer best measurement practices and suitability of equipment (Microwave Radiometer Guidelines)

Main Contact: N. Cimini **Due Date:** ICM-5 **Status:** Ongoing

Milestone: Spring 2013: Updated draft due

Progress: Large amount of material collected from MWRnet activities, and to be compiled for use in the GRUAN Microwave guidelines. First draft delivered Feb 2013 (V0.4).

Issues: Behind schedule

Task (44): Inventories of Potential Instruments (Microwave)

Main Contact: N. Cimini **Due Date:** Recurring **Status:** Ongoing

Milestone: Last: 2nd Workshop, March 2011; Next: TBA

Progress: Six new unit-members have joined MWRnet since last update

- St.Petersburg State University, St.Petersburg, Russia
- NERSC, Bergen, Norway
- KIT/IMK-IFU, Karlsruhe, Germany
- AWI, Potsdam, Germany
- Institute of Heavy Rain, China Meteorological Admin., Wuhan, China
- MeteoFrance, Toulouse, France

Issues: None

Task (45): Validation Strategies and Results (Microwave)

Main Contact: N. Cimini **Due Date:** Recurring **Status:** Ongoing

Milestone: 18-20 March 2014: First TOPROF WG meeting (Payerne)

Progress: Validation statistics are available for some GRUAN sites and will be reported on GRUAN microwave radiometer guidelines. Observation minus model background (O-B) statistics at selected GRUAN sites are planned within the EU COST Action TOPROF (first WG meeting: 18-20 March 2014).

Issues: None

Task (53): Report on lidar products and uncertainty budgets developed by the ISSI Team on NDACC lidar algorithms

Main Contact: T. Leblanc **Due Date:** Summer 2013 **Status:** Not yet started

Milestone: When main Report and AMT papers are published (2014)

Progress: Main Report under revision by ISSI team and 3 AMT papers in preparation.

Issues: Huge quantity of results, taking longer than expected to compile

Task (52): Paper describing GRUAN lidar products submitted for peer review

Main Contact: T. Leblanc **Due Date:** Late 2014 **Status:** Not yet started

Milestone: When published (2014-2015)

Progress: Not yet started

Issues: Pending completed Guidelines and data processing software

Task (51): Technical documents submitted for review by WG-GRUAN

Main Contact: T. Leblanc **Due Date:** Summer 2013 **Status:** Ongoing

Milestone: When submitted to GRUAN-WG

Progress: None in 2013.

Issues: Delayed due to lack of funding/availability

Task (54): Suitability of Equipment: Best Measurement Practices (Lidar Guidelines)

Main Contact: T. Leblanc **Due Date:** ICM-5 **Status:** Ongoing

Milestone: When final version released (fall 2014)

Progress: Guidelines doc. proposes an overall structure allowing full traceability of instrument and data processing changes. First draft reviewed. Now under revision. Next expected review: October 2014; Expected completion: ICM-7.

Issues: Delayed due to lack of funding/availability

Task (55): Interface with other expert teams: EARLINET Centralized Algorithm (lidar)

Main Contact: A. Apituley **Due Date:** TBA **Status:** Ongoing

Milestone: Aug 2012: First report due

Progress: The EARLINET single caLead Centreulus chain (SCC) has now been upgraded to a more operational level. All EARLINET groups can now upload data. Since WV Raman lidars should be able to provide aerosol data as well from the nitrogen Raman channel, a possible coupling could be established between the LidarRunClient (for WV) and aerosol – through SCC.

Issues: None to date

Task (60): Suitability of Equipment: AERI as a potential GRUAN FTIR instrument (FTIR)

Main Contact: J. Hannigan **Due Date:** TBA **Status:** Ongoing

Milestone: Aug 2012: First report due

Progress: No inventory at the moment. However, successful contacts with J. Gero in 2013. TT-AM FTIR expert recommend AERI representative to be added to TT-AM, coordinate current AERI operations, and formulate reasonable plans for inclusion into GRUAN

Issues: None to date

Appendix 9. Task Team Site Representatives progress report

SUMMARY

The **Task Team of Site Representatives** continues to serve as the conduit through which information and requests from the Lead Centre and Working Group are disseminated to the GRUAN measurements sites. During the last 6 months two documents were requested from each site detailing their potential data streams and maps of instrumentation. Ultimately these were delivered to LEAD CENTRE.

The composition of the task team has changed as follows.
Dr Richard Querel joined NIWA (Lauder site) and has become the contact for GRUAN.

PROGRESS ON CURRENT TASKS

Task: Survey sites to ascertain which of the specific data streams (envisaged in the IP refresh) they may have capability to deliver, if they would consider submitting them to GRUAN, and would they be interested in participating in their development. A survey table was completed by each site and these documents delivered to WG, LEAD CENTRE and other task team chairs.
Main Contact: Dale Hurst and Belay Demoz **Due Date:** 17-Jul-2013
Status: Completed 07-December-2013
Milestone: Table of potential data streams delivered.
Progress: **Completed**
Issues:

Task: Report details of the locations of instruments at a site: are they collocated or distributed? Each site is to provide details of the distribution of their instruments (distances, elevations, ownership, etc), including a scaled map showing this.
Main Contact: Belay Demoz and Dale Hurst **Due Date:** 17-Jul-2013
Status: Completed 07-December-2013
Milestone: NA
Progress: **Completed**
Issues: *ARM submitted URLs where maps of their sites can be viewed*

(Intentionally blank)

Appendix 10. Site reports

GRUAN Station Report for ARM Climate Research Facility ARM Sites

Reporting for the period Feb 2013 to Feb 2014
Date: 05-MAR-2014
Primary author: Douglas Sisterson
(email: dlsisterson@anl.gov)

Overview

Currently, the ARM Climate Research Facility Southern Great Plains (SGP), as well as all ARM fixed sites, are candidate GRUAN Sites. The ARM Sites currently provide Vaisala RS-92 radiosonde data from the SGP; the North Slope of Alaska (NSA) Site in Barrow, Alaska; and from the Tropical Western Pacific (TWP) Manus Site in Papua New Guinea.

The Lidar data at the SGP and NSA Barrow Sites could be provided to the Lead Centre.

None of the ARM Sites currently employ the RSLaunchClient.

The Department of Energy ARM Programme Managers announced in late January 2014 that it would be making substantive changes to the ARM Climate Research Facility to better serve the climate research community. The ARM Facility is now embarking on a reconfiguration strategy for even better observations of atmospheric processes to constrain high-resolution process models. Key elements of the new strategy include the creation of two "Super Sites" in the United States:

> **Southern Great Plains**—measurements at the SGP site in Oklahoma will be augmented to include additional scanning and profiling remote sensors and more detailed measurements of the land-atmosphere interface.
> **North Slope of Alaska**—aerial operations will link measurements from Barrow and Oliktok, and unmanned aerial systems will provide additional spatial information around Oliktok.

To support the expansion of the continental U.S. site in Oklahoma, operations at ARM sites in the Tropical Western Pacific (TWP) will end at Manus about December 2014 and Darwin about June 2015. Data obtained from these sites will remain available to the scientific community through the ARM Data Archive to support continuing research in tropical climate.

Future observations in the tropics or other climate regimes will continue to be supported through deployments of the ARM Mobile Facilities via the selection of field campaigns proposed by the science community.

This reconfiguration does not affect operations of the new ARM Eastern North Atlantic (ENA) site in the Azores or the mobile facilities. The ENA Site at Graciosa Island is a marine-influenced site that is expected to be fully completed by the end of 2014.

ARM leadership will work with the science community in the coming year to optimize this new measurement strategy at the Super Sites, with the continued goal of improving the understanding of atmospheric processes and the representation of those processes in climate models.

DOE sponsored a U.S./European Workshop on Climate Change Challenges and Observations in November, 2012. The Workshop identified high-level science questions that provided a framework for identifying measurement gaps and priorities. The ensuing discussions generated several common themes where progress could be made in closing these gaps. The joint workshop was a critical first step in enhancing the collaboration among climate research activities to better serve the international science community. Its findings will be useful for setting priorities within DOE and the participating European centers as well as establishing milestones for future collaborations. Many of the participants involved have ties to GRUAN.

Change and change management

To improve the quality of the RS-92 data, the ARM Programme has procured Vaisala Meteorological Automated Weather Systems (MAWS) stations that will be installed at all ARM fixed sites and mobile facilities in 2014. This will provide consistency for surface data points for the ARM radiosonde data.

In addition, through an agreement between Argonne National Laboratory and the NOAA National Climatic Data Center, funds have been provided to support Cryogenic Frostpoint Hygrometer (CFH) launches. Those funds have been used to implement CFH launches at the SGP Site using GRUAN recommended sondes and systems, with the first launch expected in March or early Arpil 2014. We anticipate 2 nighttime launches per month.

Although the ARM Programme is undergoing changes over the next few years, it is anticipated that the SGP and NSA Barrow Sites will not change their current baseline instrument locations. The SGP Supersite will now be managed by Nicki Hickmon at Argonne National Laboratory and Douglas Sisterson will be take on the instrument coordination and data quality managing role for the ARM Climate Research Facility.

In addition, there may be interest for the ARM ENA Site in the Azores to participate in GRUAN when the site becomes fully operational in 2014.

Resourcing

The US Department of Energy (DOE), Office of Science, Office of Biological and Environmental Research continues to provide resources to fund the ARM Climate Research Facility.

Site assessment and certification

Still under consideration.

GRUAN related research

The ARM Programme has undertaken a major effort to harmonize the representation of instrument uncertainty for climate observations by ore than 300 instruments systems that provide over 2500 data streams the climate research community.

Douglas Sisterson and Maria Cadeddu and other ARM Instrument Mentors are currently working with Fabio Madonna on a publication that demonstrates the usefulness of entropy and mutual correlation concepts for the studying the use of redundancy of in-situ and ground-based remote sensing instruments at four GRUAN Sites (including the ARM SGP Site).

WG-GRUAN interface

Nothing required at this time.

Items for ICM-6 plenary discussions

Nothing required at this time.

Future plans

Additional instruments will be added to the SGP Site, but the specific locations will be determined from input received at DOE sponsored Workshops, DOE Programme Managers, and ARM Climate Research Facility senior management. Additions to the SGP are expected to start in late 2014 and continue will into 2015. No additions of instrumentation are planned for the NSA Barrow Site in 2014.

GRUAN Station Report for Beltsville, Howard University

Reporting for the period Feb 2013 to Feb 2014
Date: 28-Feb-2014
Primary author: Belay Demoz
(email: bbdemoz@howard.edu)

Overview

While data RS92 has been collected routinely at the site once a week, RsLaunchClient is just starting to work. This has been mainly due to lack of manpower at the site but is now rectified. A postdoctoral researcher, Dr Ricardo Sakai, has started working on earnest and all data will be submitted going back to 2010. All the RS92 data stream will be submitted.

Change and change management

A recent incident, complete fire damage, of the launch facility has forced the site to re-group and use temporary facilities at the site. A full recovery of the instrumentation and data as well as impact study is planned in the future. This has been communicated to the GRUAN WG. Data stream (GPS and RS92) have continued using the mobile NASA system, ALVICE (David Whiteman).

Resourcing

Howard University site is run through a proposal-based funding, and graduate student run operation. It is closely aligned with the Sterling Test site of the NWS. Funding and personnel changes are routine; the university has made extensive commitments to atmospheric research as is evident in the recent fire incident. However, the site and its non-operational structure has a larger capacity for input into GRUAN than is occurring. This is mainly limited by manpower issues.

Site assessment and certification

The site should be ready to do the certification in 2014 – as soon as recent changes in Howard University management that are responsible for research and resource decisions are settled.

GRUAN related research

The site is actively involved in the Sites task Team (TT6; Belay Demoz), the ancillary measurements task team (Dave Whiteman). Site personnel are contributing and leading work in the Trend analysis work (Whiteman and Vermeesch), co-location paper (Demoz) and the 1st-principle Raman lidar calibration work (Whiteman, Walker, Venable). The site is also targeting its launches to be co-located to satellite overpass – at night and analysis of that work will be made soon.

WG-GRUAN interface

A formal letter to the Howard University from WMO would be appreciated. But, this needs to be coordinated with Howard Diamond, the GRUAN US-lead and substantial funding supporter.

Items for ICM-6 plenary discussions

Uncoordinated changes in the reference sondes (e.g. RS92 recent changes) and the consequences and impact on sites data management and resource needs to be thought of carefully. This could be a drain in funding and unnecessary stress to management.

Future plans

The site is geared for substantial engagement and upgrade in instrument management changes. It is engaged with advising NWS with a ceilometer-network and plans to submit and complete data stream to GRUAN and stay current. In a month, it will start launching CFH/monthly and has secured resources to do that for the next 2-years.

GRUAN Station Report for Boulder

Reporting for the period Feb 2013 to Feb 2014
Date: 21-Feb-2014
Primary author: Dale Hurst email: Dale.Hurst@noaa.gov

Overview

Currently only the weekly RS92 sounding data from Boulder are being processed into a GRUAN data product. We also regularly submit sounding data from ozonesondes (ECC) and the NOAA frostpoint hygrometers (FPH) when these instruments are part of the RS92 payload. It is envisioned that both the ECC and FPH data from Boulder will become GRUAN data streams in the near future. Other data streams available include GNSS-IPW from the Marshall Field Site balloon launching site near Boulder (and potentially the NOAA building in Boulder), Dobson and FTIR measurements of column ozone, and FTIR measurements of column water vapour, CO2 and methane. For more details of potential data streams see the "New Data Streams Survey" for Boulder that was submitted to the Lead Centre last December.

Change and change management

The only appreciable change at Boulder has been a greatly reduced use of RS80 radiosondes and a greatly increased use of InterMet radiosondes for balloon soundings. Our supply of RS80 sondes is now nearly depleted.

Resourcing

The Global Monitoring Division within the Earth System Research Laboratory of NOAA continues to struggle to continue many long-term monitoring programmes in the face of sustained federal budget cuts during years of rising equipment and personnel costs. The Boulder GRUAN site depends on funds from GMD (and hence the federal budget) to continue our weekly ozonesonde soundings and monthly FPH + ozonesonde soundings at Boulder, our similar sounding programme at Hilo, Hawaii and our monthly FPH + ozonesonde soundings at Lauder, New Zealand. Financial support from GCOS has greatly assisted with our programme's ability to continue at Lauder. Our ability to continue GRUAN-related activities at Boulder depends largely on the future of GMD's federal funding.

Site assessment and certification

The application for certification of the Boulder site was submitted to the Lead Centre on September 30, 2013. To date no feedback on this application has been received by the Boulder site manager.

GRUAN related research

The NOAA FPH was part of the AquaVIT-2 water vapour measurement intercomparison campaign conducted last April at the AIDA environmental chamber in Karlsruhe, Germany. There were about 20 different instruments measuring chamber-controlled water vapour mixing ratios from less than 1 ppm to several thousand ppm over a wide range of chamber pressures. The results of this intercomparison have not yet been released by the referees.

A paper was recently published that compares stratospheric water vapour data retrievals from the Aura Microwave Limb Sounder (MLS) with in situ water vapour measurements by the NOAA FPH at Boulder, Hilo and Lauder. The reference is:

Hurst, D. F., A. Lambert, W. G. Read, S. M. Davis, K. H. Rosenlof, E. G. Hall, A. F. Jordan, and S. J. Oltmans, Validation of Aura Microwave Limb Sounder stratospheric water vapour measurements by the NOAA frostpoint hygrometer, *J. Geophys. Res*. *Atmos*., *119*, doi:10.1002/2013JD020757, 2014.

Dale Hurst continues to serve as a member of the GRUAN working group, co-chair of the task team of site representatives and manager of the Boulder GRUAN site.

June Wang, Seth Gutman and John Braun continue to serve as members of the task team of GNSS-IPW measurements. June is also a member of the GRUAN working group and is intimately involved in the development of a GNSS-IPW data product for GRUAN.

James Hannigan is a member of the task team of ancillary measurements for his expertise in solar FTIR measurements of water vapour and trace gases.

WG-GRUAN interface

We appreciate the continued support of the Boulder GRUAN site through presentations and papers that include data from Boulder, especially those in easy view of ESRL management and NOAA administrators.

Items for ICM-6 plenary discussions

I would like to see some sort of code associated with each RS92 sounding that does not pass quality control, issued as soon as the sounding is processed. For example a three digit code for PTU where the first digit describes the problem (or success) of P, the second for T and the third for U. The code could automatically be sent by e-mail or appended to an existing report file kept on the NCDC or GRUAN ftp sites. This type of immediate feedback would be very helpful in knowing that there was a problem with the last RS92 flight and in trying to make the subsequent RS92 soundings a success.

Future plans

The Boulder site is trying to scrape though another year of inadequate federal funding without having to discontinue any measurement programmes.

GRUAN Station Report for Lauder (LAU)

Reporting for the period Feb 2013 to Feb 2014
Date: 28-Feb-2014
Primary author: Richard Querel
(email: Richard.Querel@niwa.co.nz)

Overview

Lauder continues to launch ozonesondes (1 per week) and frost-point sondes (1 per month). Our radiosonde program now conforms to GRUAN requirements. All DigiCORA III based ozonesonde flights (Dec.2012 to present) have been uploaded through RsLaunchClient. Frost-point sondes for the same period are also ready for uploading. GNSS data since May 2012 is ready for uploading. All other systems (LIDARs, Microwave radiometers, UV/Vis and UV spectrometers, FTIR, TEI, surface radiation measurements, etc.) are operational and submitting regularly to NDACC, BSRN, WOUDC, TCCON and other partner networks.

Change and change management

- Dr. Richard Querel (new Measurement Scientist permanent position) has been appointed to manage the ozone measurement program and the UV/vis task of the trace gases measurement program.
- After 1-year of dual-system comparison measurements, our Marwin receiver has been disconnected and we are only recording telemetry with the new Vaisala DigiCORA III sounding system.
- We have introduced a humidity chamber test as a standard procedure in our sonde flights: Dr. Schulz & Partner GmbH: SHC Standard Humidity Chamber for radiosondes (SPRH-100)
- We have installed a Vaisala PTB110 barometer and data logger in the balloon/sonde prep. room.
- Ground check (GC25) and PTU measurements are now being performed in the balloon/sonde preparation room, rather than outside at the Met shed.
- Our standard ozonesonde preparation procedure is being rewritten and updated.
- We are requesting funds to upgrade our ozonizer (current unit from NOAA with Serial # 001!).
- We are also proposing the purchase of an ozone calibration source for testing purposes.
- We have successfully uploaded radiosonde data to GRUAN (through RsLaunchClient).
- Our GNSS-IWV was installed in May 2012. A subset of that data has been locally processed and successfully validated with frost-point sonde IWV data. The GNSS data is ready to send to GRUAN.

Resourcing

- Lauder's GRUAN operations are partly funded through our Government-funded core research. The core funding for the GRUAN measurements has remained static since the last financial year; no change is anticipated for the coming (2014/2015) FY.
- We receive GRUAN-specific funding from NOAA to support their frost-point hygrometer flights (sondes and consumables supplied by NOAA, staff time from NIWA's ozonesonde program). NOAA funding also supports the alignment of our procedures and test equipment to GRUAN requirements.

- Two new permanent scientist positions have been filled. This will address staffing issues at Lauder as well as begin a generational change-over. Dr. Richard Querel began in November 2013. The second scientist will be starting late-April 2014.

Site assessment and certification

- All requested site-assessment documentation has been submitted. The current year of ozonesonde data (RS92+ECC) has been uploaded to the GRUAN metadata system. Our frost-point sonde data is also ready for upload. We are awaiting further instructions in regards to our GNSS data stream.

GRUAN related research

-No GRUAN-specific publications to report.

WG-GRUAN interface

- Recently (over the past couple of years) we have been experiencing a highly variable background current in our ozonesondes. Having attempted the solutions suggested by other groups, we think it would be beneficial if there were a community mailing list or discussion board where particular problems and issues could be shared and discussed with other sites.
- What is the status of a standardized operating procedure and processing scheme for ozonesondes?
- What is the current state of usage/adoption of the RS41 in our community? Is a changeover from the RS92 planned?
- Is there any plan for a dedicated research-grade radiosonde?
- What is the status of the radiosonde co-location transfer function work being done by GATNDOR?

Items for ICM-6 plenary discussions

- See above in WG-GRUAN interface.

Future plans

- We will continue with our ozonesonde and frost-point sonde measurements. We intend to compare our in-house processed sonde output to the GRUAN products once available. We hope to be given approval to begin uploading out GNSS data.

GRUAN Station Report for Lindenberg

Reporting for the period Feb 2013 to Feb 2014
Date: 21 February 2014
Primary author: Holger Vömel
(email: Holger.Voemel@dwd.de)

Overview
Lindenberg currently provides Vaisala RS92, CFH, ECC ozone, Graw and GNSS/IPW to the GRUAN database. CFH, ECC ozone and GNSS/IPW are currently being developed as GRUAN data products.

Change and change management
Lindenberg changed the bubble flow meter for the ECC ozone sonde preparation from a style that require sucking air into the flow meter to the more common style, where air is pushed into the flow meter. Both flow meters were checked volumetrically and both were used in parallel routine operations for 34 soundings. The mean difference between both instruments is smaller than 0.14 s at 3 σ. No impact to the long term ozone sonde series is to be expected.

Resourcing
The GRUAN station Lindenberg is almost exclusively supported by DWD base funding. DWD is under continued pressure to reduce staff and staffing cuts may be expected in the future.

Site assessment and certification
The site is certified.

GRUAN related research
Lindenberg studies the radiation correction of several radiosondes, and currently works with Modem to characterize their sonde. Lindenberg is involved in the development of the CFH GRUAN data product and the ECC ozone data product.

WG-GRUAN interface
Lindenberg is well integrated into the GRUAN structure and has good communications with the Working Group. Support by the Working Group is seen as important to maintain the high level of science done at the site, in particular support visible to DWD management.

Items for ICM-6 plenary discussions
Cooperation between sites

Future plans
Publication of the characteristics of other radiosondes.
Lindenberg is preparing to study the impact of the Vaisala RS41 radiosonde.

GRUAN Station Report for Ny-Ålesund

Reporting for the period Feb 2013 to Feb 2014
Date: 25-Feb-2014
Primary author: Marion Maturilli
(email: marion.maturilli@awi.de)

Overview

The Ny-Ålesund radiosonde programme was operated as scheduled, launching daily RS92 radiosondes provided to GRUAN using the RSLaunchClient. During campaign periods, the launch frequency has been higher, resulting in an overshoot of the planned schedule.
GRUAN guidelines are followed, and additional ground check procedures (100% humidity chamber, additional ambient condition measurement) are performed prior to each launch.
RSLaunchClient is also used for the once weekly ozone sondes, and the data stream to the GRUAN Lead Centre is similarly established. We expect to contribute to the GRUAN ozone sonde data stream once the formal data product has been defined.
The site has started the use of CFH sondes, with a planned schedule of 1 launch every 2 month. The launch staff has been introduced to the instrumentation and preparation procedures at the GRUAN Lead centre in August 2013. After setting up the receiving system and software at Ny-Ålesund, the first test launch took place in September 2013. Adjusting the standard CFH payload and optimizing the procedures to the local research base conditions, the regular CFH sounding programme has started in January 2014. We expect to contribute to the GRUAN CFH data stream once the formal data product has been defined.
Dataflow of Ny-Ålesund GNSS data to the GRUAN Lead Centre and the GRUAN GNSS processing centre at GFZ has started in September 2013. The current dataflow includes manufacturer raw data, converted raw data (RINEX) and instrument logs, containing all equipment changes.

Change and change management

The CFH measurement programme has initiated. After a test phase in 2013, we are now scheduled to have 1 launch every 2 month from January 2014 onwards.
A new overwintering team took over at the station in May 2013. They had an introduction to radiosounding and to GRUAN at the Lead Centre in March 2013, and were introduced and trained on site in April 2013. The same procedure will apply to the next overwintering team. Other personal involved in campaign activities is trained on site.
During the reporting period, no changes have been applied to the operating procedures, instruments, data processing algorithms or operating environments of instruments.

Resourcing

Currently no funding problems.
Resource challenges have been faced due to the remote location in receiving cryogen for CFH measurements, but the problems are known now and will be avoided in the future.

Site assessment and certification

Already certified.

GRUAN related research

In September 2013, a 2 week intensive campaign with 6 radiosondes per day has been conducted at the station. Primarily intended for a German-Japanese cooperation project on data assimilation, the high frequency of radiosonde profiles is a valuable data source for the study of measurement redundancy at Ny-Ålesund, involving microwave radiometry and GNSS.

No GRUAN related publication so far.

WG-GRUAN interface

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Items for ICM-6 plenary discussions

Introduction of the new Vaisala RS41 radiosonde. When will GRUAN be ready to import RS41 raw data files ? Will there be official GRUAN recommendations for instrumental change ?

Future plans

In June 2014, the Meteomet project will install a calibration chamber in Ny-Ålesund and calibrate meteorological sensors used for BSRN and GRUAN procedures.

CFH measurement optimization will be finalized to a Ny-Ålesund CFH standard payload.

GRUAN Station Report for Payerne

Reporting for the period Feb 2013 to Feb 2014
Date: 21.02.2014
Primary author: Rolf Philipona
email: rolf.philipona@meteoswiss.ch

Overview

GNSS data are measured regularly since several years. We need information how to submit these data streams to GRUAN.
Lidar measurements are made. Data submission is in preparation.
The SRS-C34 radiosonde is in operation since January 2011. Measurements are taken UT00:00 and UT12:00. Data submission is in preparation. We hope to be able to submit SRS-C34 data during 2014 for all measurements since 2011.
Vaisala RS92-SGP are launched in parallel with SRS-C34 every two weeks. In the future we will launch this multisoundings only once per month, one flight during the night and one flight during the day. Data submission will be made with RsLaunchClient for the two sondes per flight.

Change and change management

So far we made multisoundings between SRS-C34 and RS92-SGP every two weeks. Starting January 2014 we will make multisoundings only once per month with one sounding during nighttime and one during daytime.

Resourcing

No specific changes.

Site assessment and certification

We have submitted a first draft of the certification document. We hope to be able to submit the data in 2014 and then become certified by the end of this year.

GRUAN related research

We investigated the upper air temperature trends above Switzerland from 1959 to 2011 and compared the measurements with surface measurements in the lower troposphere. A paper appeared in July 2013.
E. Brocard, P. Jeannet, M. Begert, G. Levrat, R. Philipona, G. Romanens, S.C. Scherrer, 2013: Upper air temperature trends above Switzerland 1959-2011. *J. Geophysical Research*, **118**, 4303-4317, doi:10.1002/jgrd.50438.
We investigated the radiation errors on upper-air radiosonde temperature measurements. A paper on this issue was published in October 2013.
R. Philipona, A. Kräuchi, G. Romanens, G. Levrat, P. Ruppert, E. Brocard, P. Jeannet, D. Ruffieux, B. Calpini, 2013: Solar and thermal radiation errors on upper-air radiosonde temperature measurements. *J. of Atmospheric and Oceanic Technology*, **30**, 2382-2393, doi:10.1175/JTECH-D-13-00047.1

We have made several dual and triple soundings in order to determine the reproducibility of radiosondes and to determine the uncertainty of the measured parameters.
We are testing a new humidity sensor for the SRS-C34 radiosonde.
We conducted a radiosonde intercomparison between the MODEM, Meteolabor and Vaisala radiosondes. Results are in preparation.

WG-GRUAN interface
Most important at the moment is a good collaboration with the Lead Centre and the task teams.

Items for ICM-6 plenary discussions
Unfortunately I cannot make it to ICM-6.

Future plans
Get the measured radiosonde data to the Lead Centre in 2014. Bilateral intercomparisons with other radiosonde manufacturers.

GRUAN Station Report for Potenza

Reporting for the period Feb 2013 to Feb 2014
Date: 26-Feb-2014
Primary author: Fabio Madonna
(email: fabio.madonna@imaa.cnr.it)

Overview
Currently, only RS data are provided to the GRUAN archive. Aerosol, water vapour, clouds and radiation from lidar, GPS, ceilometers, and radiometers could be included in the future data streams. Ozone sounding is expected to be performed in the near future once per month.

Change and change management
Radiation measurements are now available (irradiance).
No changes in management processes.
Information describing POTENZA site on the GRUAN web page are ok.

Resourcing
To find continuous funding support for radiosoundings not expected in the running project and challenging to be obtained in future projects. Moreover, for this, Potenza is suffering from its position of GRUAN but not RAOB station (RAOB IT stations are under the Army weather service).

Site assessment and certification
POTENZA could be ready for the certification in 2015.

GRUAN related research
GATNDOR: Quantifying the value of complementary measurements; Study of collocation of atmospheric measurements;
Comparison of water vapour Raman lidar profiles and COSMIC.

F. Madonna, P. Burlizzi, A. Giunta, I. Binietoglou, M. R. Perrone, and G. Pappalardo, "Validation of COSMIC water vapour profiles using Raman lidar measurements performed at CIAO" in Lidar Technologies, Techniques, and Measurements for Atmospheric Remote Sensing VII, edited by Upendra N. Singh, Gelsomina Pappalardo, Proceedings of SPIE Vol. 8182 (SPIE, Bellingham, WA 2011) 81820B.

Fabio Madonna, Marco Rosoldi, Jürgen Güldner, Alexander Haefele, Rigel Kivi, Douglas Sisterson and Gelsomina Pappalardo, Quantifying the value of redundant measurements at GRUAN sites, Atmos. Meas. Tech., submitted.

Fassò, A., Ignaccolo, R., Madonna, F., and Demoz, B. B.: Statistical modelling of collocation uncertainty in atmospheric thermodynamic profiles, Atmos. Meas. Tech. Discuss., 6, 7505-7533, doi:10.5194/amtd-6-7505-2013, 2013.

WG-GRUAN interface

They could support us to encourage, at the WMO/GCOS the establishment in Potenza of a RAOB station in order to drain more funding for the station operations.

Items for ICM-6 plenary discussions

Radiosonde scheduling for the stations performing one or two launches per week.

Future plans

Potenza is going to purchase the Standard Humidity chamber. Moreover, a new laboratory for the launch of radiosoundings is in preparation and it will be soon ready for hosting manual launches.

GRUAN Station Report for Sodankylä

Reporting for the period Feb 2013 to Feb 2014
Date: 04-Mar-2014
Primary author: Rigel Kivi (email:rigel.kivi@fmi.fi)

Overview
Sounding measurement programmes are currently contributing to GRUAN data streams. At Sodankylä we have receiving systems for both manual and automated soundings. 52 manual soundings and 690 autosonde launcher soundings have been submitted using the GRUAN operating procedures. The manual sounding dataflow includes Vaisala RS92-SGP, ECC ozone sonde, CFH water vapour, Intermet IMET-1, and Vaisala RS80. The data have been transmitted using RsLaunchClient. We plan to include GNSS dataflow in the future.

Change and change management
No major changes have taken place during the reporting period. DigiCORA sounding software was upgraded on May 8, 2013. New software version 3.66 now replaces version 3.64 software for all setups (manual and automated sonde system). RS92 and RS41 comparison flights were made at Sodankylä and at some other locations. RS41 showed improvements for humidity and temperature measurements compared to the RS92. Also tests with the CFH reference were made.

Resourcing
Budget funding does not cover all the research activities, therefore external funding is needed to continue with these activities.

Site assessment and certification
Our site is not certified yet, we expect that the site will be ready to go through the process within a year or two.

GRUAN related research
GRUAN research in our case is related to GATNDOR and Radiosonde task team.

WG-GRUAN interface
Letters of support will be useful, maybe this can be combined with the certification process.

Items for ICM-6 plenary discussions
Change management issues, for example in case of RS92/RS41. Also external funding possibilities would be useful to discuss with GRUAN partners. Finally, we are interested to include GNSS dataflow.

Future plans

Over the coming year we expect to submit the site certification application, improve some of the instrumentation at the site and participate in the GRUAN task team activities.

GRUAN Station Report for Tateno

Reporting for the period Feb 2013 to Feb 2014
Date: 28-Feb-2014
Primary author: Yoshihiko Tahara
(email: y-tahara@met.kishou.go.jp)

Overview

The Tateno site operated by the Aerological Observatory of the Japan Meteorological Agency (JMA) conducts surface observation and low-layer wind observation up to 1.5 km by using a Doppler lidar, upper-atmosphere observation up to about 30 km by using radiosonde, ozone vertical distribution observation using ozonesondes, total column ozone observation using a Dobson ozone spectrophotometer, ultraviolet observation using a Brewer spectrophotometer and radiation observation. Among these observations, radiosonde sounding data are operationally provided to the GRUAN Lead Centre.

Change and change management

JMA started to use a new type of radiosonde “RS-11G” by Meisei in place of “RS92-SGP” by Vaisala at Tateno in 1 July 2013. For the ground data processing of the new radiosonde, the new software MGPS2 by Meisei on a new PC and a general-purpose receiver were also implemented. The sounding data of the new radiosonde since its operation are sent to the GRUAN Lead Centre, and operational provision was started 20 September 2013.
To confirm consistency and to analyse difference between the previous and new radiosondes, Tateno conducted dual launch experiment between 21 October and 5 November 2013 and 20 to 31 January 2014, and will perform the experiment in spring and summer 2014. In addition, the previous radiosonde is solo launched once a week at 12 UTC on Monday from July 2013 to June 2014.

Resourcing

To reduce the operational cost, the use of cost effective radiosonde and expendable balloon and other equipment are sought continuously.

Tateno is investigating for the launch of radiosondes carrying Cryogenic Frostpoint Hygrometer (CFH) and Meisei Temperature Reference (MTR) in terms of accuracy and cost.

Site assessment and certification

Tateno would like to apply for the GRUAN certification after the establishment of the data processing of the new radiosonde at the GRUAN Lead Centre.

GRUAN related research

(NA)

WG-GRUAN interface

(NA)

Items for ICM-6 plenary discussions

Since the development cycle of radiosonde is getting shorter, new types of radiosonde are expected to be released in market more frequently. To catch up with the cycle, discussion on frequency of the international comparison campaign is necessary.

Future plans

Due to the JMA procurement policy, radiosondes used for a year is determined through a competitive tendering process under the conditions of latest technology, meeting GRUAN requirements and cost effective. As the result of the procurement, radiosonde type might be changed every year.

Appendix 11. List of acronyms

AEMET	Agencia Estatal de Meteorología
AERI	Atmospheric Emitted Radiance Interferometers
AOPC	Atmospheric Observation Panel for Climate (GCOS)
ARCROSE	Arctic Research Collaboration for Radiosonde Observing System Experiment
AMT	Atmospheric Measurement Technologies
ARM	Atmospheric Radiation Measurement (ARM) Program (US Department of Energy)
BOM	Bureau of Meteorology (Australia)
CATS	Cloud-Aerosol Transport System
CAS	Copernicus Atmospheric Service
CBS	Commission for Basic Systems (WMO)
CFH	Cryogenic Frostpoint Hygrometer
CIAO	CNR-IMAA Atmospheric Observatory
CMA	China Meteorological Administration
CNR	Consiglio Nazionale delle Ricerche
CRN	Climate Reference Network
DIAL	Differential Absorption Lidar
DWD	Deutscher Wetterdienst (Germany)
ECC	Electrochemical concentration cell
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential Climate Variable
EDR	environmental data record
EDIE	Earth Dynamics Investigation Experiment
ERC	European Research Council
FTIR	Fourier Transform Infrared Spectrometry
GATNDOR	GRUAN Analysis Team for Network Design and Operations Research
GAW	Global Atmosphere Watch (WMO)
GCOS	Global Climate Observing System
GEOSS	Global Earth Observing System of Systems
GFCS	Global Framework for Climate Services
GFZ	Geoforschungszentrum Potsdam
GOS	Global Observing System
GLASS	GRUAN Lidar Analysis Software Suite
GISC	Global Information System Centers (WMO)
GNSS	Global Navigation Satellite System
GRUAN	GCOS Reference Upper-Air Network
GPM	Global Precipitation Measurement
GPS-RO	Global Positioning System Radio Occultation
GSICS	Global Space-based Inter-Calibration System
GTS	Global Telecommunication System
GUAN	GCOS Upper-Air Network
IASI	Infrared Atmospheric Sounding Interferometer

ICM	Implementation-Coordination Meeting (GRUAN)
IMAA	Istituto di Metodologie per l'Analisi Ambientale
INAMHI	Instituto Nacional de Meteorologia e Hidrologia (Ecuador)
IPCC	International Panel on Climate Change
IPW	Integrated Precipitable Water
ISS	International Space Station
ISSI	International Space Science Institute
JMA	Japan Meteorological Agency
JPSS	Joint Polar Satellite System
MACC	Monitoring of Atmospheric Composition and Climate
MALICCA	Maido Lidar Calibration Campaign
METOP	Meteorological Operational (polar orbiting meteorological satellites)
MLS	Microwave Limb Sounder
MTR	multi-thermistor radiosondes
MWR	Microwave Radiometer
NDACC	Network for the Detection of Atmospheric Composition Change
NESDIS	National Environmental Satellite, Data, and Information Service (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NORS	Network of Remote Sensing (NDACC)
NOSC	NOAA Observation Systems Council
NOSIA	NOAA Observing System Integrated Analysis
NPROVS	NOAA PROducts Validation System
NWP	Numerical Weather Prediction
NWS	National Weather Service
OCO	Orbiting Carbon Observatory
RT	Radiative Transfer
SAGE-II	Stratospheric Aerosol and Gas Experiment II
SASBE	Site Atmospheric State Best Estimate
SAWS	South African Weather Service
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY
SFSC	Sterling Field Support Center
SGP	Southern Great Plains (ARM)
SHADOZ	Southern Hemispheric ADditional Ozonesondes
SHC	Standard Humidity Chamber
SOWER	Soundings of Ozone and Water in Equatorial Regions
STAR	NOAA Center for Satellite Applications and Research
TCCON	Total Carbon Column Observing Network
TOPROF	Towards operational ground based profiling with ceilometers, Doppler lidars and microwave radiometers for improving weather forecasts Period
ToR	Terms of Reference
TRMM	Tropical Rainfall measurement Mission
UT/LS	Upper Troposphere / Lower Stratosphere
WIGOS	WMO Integrated Global Observing System
WG-GRUAN	AOPC Working Group GRUAN
WIS	WMO Information System
WMO	World Meteorological Organization

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