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1. Introduction

The fifth GCOS Reference Upper Air Network (GRUAN) Implementation and Coordination Meeting (ICM-5) was held at the Royal Netherlands Meteorological Institute (KNMI) at De Bilt, the Netherlands, from 25 February to 1 March 2013 with support from the US GCOS Program Office at the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Centre (NCDC), the NOAA Climate Program Office (CPO) and the GCOS Secretariat at the World Meteorological Organization (WMO). The meeting also included a site visit at the Cabauw Experimental Site for Atmospheric Research (CESAR) and participation in an ozonesonde launch in De Bilt.

The annual GRUAN meetings afford an opportunity for the Working Group on GRUAN (WG-GRUAN[1]; operating under the GCOS / World Climate Research Programme (WCRP) Atmospheric Observation Panel for Climate (AOPC)), the GRUAN Lead Centre, 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 3.

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

- Progress on site certification,
- The updated GRUAN Implementation Plan[2],
- Establishing links with the scientific and meteorological communities,
- Progress of the GRUAN task and analysis teams,
- Review and progress of the work plans for the GRUAN Lead Centre, the WG-GRUAN, and GRUAN task teams.
- Consideration of new data streams to include in coming years as called for in the forthcoming update of the 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 Working Group co-chairs and GCOS Secretariat followed by a review by participants. All documents prepared in support of ICM-5 and all meeting presentations, are available on the GRUAN website at http://www.gruan.org (under Meetings: Cabauw 2013).

2. Opening notes

Dr Frits Brouwer, Director General of KNMI, welcomed the meeting attendees to ICM-5 and expressed pride in hosting GRUAN's ICM-5 meeting. Dr Brouwer presented an overview of KNMI and described its history and responsibilities. He provided a summary of climate related activities at KNMI and emphasized that the Netherlands are vulnerable to the impacts of weather and climate change. The impacts by climate change and severe weather events are seen as some of the major threats to national security. The Netherlands have already experienced increases in temperature and precipitation and as a result the country is working on policies to reduce emissions. KNMI is the principle lead on two major satellite projects, the Ozone Monitoring Instrument (OMI), which was launched on the National Aeronautics and Space Administration (NASA) Aura satellite, as well as the Tropospheric Ozone Monitoring Instrument (TropOMI) which is to be launched on a satellite of the European Space Agency (ESA). KNMI further leads the EC Earth climate model consortium, which comprises 20 partner agencies and institutions, and whose model is built upon the European Centre for Medium-Range Weather Forecasts (ECMWF) forecast model. Dr Brouwer included a description of

[1]The WG-GRUAN was formerly called the Working Group on Atmospheric Reference Observations and its name was changed by AOPC in 2012 to reflect its particular remit better. (For reference see the AOPC meeting report (GCOS-134): http://www.wmo.int/pages/prog/gcos/Publications/gcos-158.pdf)

[2]2009-2013 GRUAN Implementation Plan (GCOS-134): http://www.wmo.int/pages/prog/gcos/Publications/gcos-134.pdf

the CESAR observatory located at Cabauw, which is the prime experimental site for boundary layer meteorology and remote sensing of KNMI. It was built over 40 years ago, when air pollution was a serious problem, requiring enhanced observations to improve the scientific understanding of this important issue.

Arnoud Apituley and Peter Thorne of the organizing committee introduced the agenda for the week, and expressed the meeting's gratitude to the organizers from KNMI, both for the venue and for the trip to Cabauw later in the week. Peter Thorne stressed that the meeting's primary outcomes were to review progress in the past year and to establish a list of specific priorities for the coming year.

Holger Vömel provided an introduction to the concept of GRUAN and its operation for new ICM participants and as a refresher for others. He showed relative humidity time series from Lindenberg and how changes in instrumentation may introduce artificial steps in a measurement series, which preclude an estimate of trends. Frequently changes in instrumentation were not managed, since these observations were made for numerical weather prediction and not for long-term climate studies. Furthermore, the required metadata for interpreting changes in historical time series were often not available or incomplete.

GRUAN is well integrated into the WMO Integrated Observing System (WIGOS) and within GCOS overseen by the Atmospheric Observation Panel for Climate (AOPC). Holger Vömel stressed the importance of defining the meaning of 'reference' within reference observations. Retention of raw data and metadata for future reprocessing based on innovations and improved understanding is seen as essential as is the need for change management within GRUAN.

3. Progress on advancing the GRUAN Implementation Plan

3.1. Status of implementation

The 2009-2013 GRUAN Implementation Plan (IP;GCOS-134)[2] as well as the action plan agreed during the previous ICM-4 (GCOS-161)[3] have been the guiding documents for the progress achieved in the past year. The milestones and achievements were reviewed by Peter Thorne, co-chair WG-GRUAN, and discussed by the meeting attendants. Delays and changes to specific items in the IP and list of action items were noted; however, no significant deviations from the IP were identified. Out of the 23 major action items listed for achievement until ICM-5, 6 have been completed, 13 partially completed and 4 not completed (see Appendix 1). Minor action items from the ICM-4 work plan were also reviewed and are listed in 0.

Since almost all efforts to further the advancement of GRUAN are pursued on a volunteer basis on the part of the WG-GRUAN, task and analysis teams and contributing sites, resource limitations are some of the key issues in the development of GRUAN, leading to delays in the respective action plans. Careful consideration needs to be given to the workload and expectations of each action item to remain realistic in what owners of action items commit to. The meeting, however, agreed that tasks should aim for challenging targets as an expression of the high aspiration of GRUAN. Furthermore, the meeting expressed consensus that delays are largely due to lack of dedicated resources, which should be noted by agencies calling for GRUAN and those supporting GRUAN.

The phrasing of action items needs to be specific and clear, which had already been raised during ICM-4. Clarity avoids confusion and helps owners of action items achieve their expressed goals. A decision was made to continue the use of the online GRUAN Master Action Item list which includes the major and minor items lists from the ICM reports, the IP items and within year items arising from bi-monthly teleconferences between the Lead Centre and the WG-GRUAN. Although this list cannot be publicized, access information for authorized users can be obtained from Greg Bodeker (by email to: greg@bodekerscientific.com).

[3]Report of the Fourth GCOS Reference Upper-Air Network Implementation and Coordination Meeting (GCOS-161): http://www.wmo.int/pages/prog/gcos/Publications/gcos-161.pdf

3.2. Update of the Implementation Plan

The current IP (GCOS 134)[2] covered the period from 2009 through 2013. Since the development of GRUAN is ongoing, this IP needed to be replaced for the period 2013 through 2017 as agreed at ICM-4. In developing this update, the WG-GRUAN has detailed the minimum set of actions required to ensure that GRUAN delivers the services called for by its sponsors and stakeholders, whilst recognizing that not all of these activities can be achieved under current levels of funding. Support by funding agencies for GRUAN within the period 2013 – 2017, will largely determine whether GRUAN succeeds or fails in meeting the outcomes requested by its stakeholders.

Goals to be reached by 2017 include:

- A network of 20 to 30 measurement sites each contributing one or more GRUAN data streams. Beyond 2017, the time horizon for this IP, the network is envisaged to further expand to reach the longer-term goal of 40 contributing sites. Locations for new sites will be guided using network expansion criteria developed to ensure that GRUAN meets the needs of its four primary user communities (climate change monitoring and detection, satellite-based measurements, Numerical Weather Prediction (NWP), process studies). All of these sites data products shall have been subject to regular assessment and certification. The location of new sites will be chosen pro-actively to meet documented stakeholder requirements.
- A network serving reference-quality measurements of vertical profiles from the surface through the lower stratosphere (or higher where feasible) of temperature, pressure, water vapour, wind speed and direction, and ozone[4]. To the extent possible, these measurements will be made using redundant measurement systems including sondes[5] and ground based remote sensing equipment. Measurements will be made to GRUAN standards with each data stream processed centrally, and well documented by metadata.
- A set of sustainable long-term measurements being used by recognized target user communities (see above), as demonstrated in the peer-reviewed literature, to improve scientific understanding.
- A network with operational and research functions, embedded within the overarching WIGOS framework and leading to improved capabilities and practices in other broader components of the Global Observing System and its applications.

Continuously ongoing tasks are reporting, management, cooperation with other networks, and annual Implementation and Coordination Meetings (ICMs).

One of the main tasks of the updated IP includes the development of other GRUAN recognized data streams which satisfy the definition of the term 'reference observation' as outlined in the Report of the Second Implementation and Coordination Meeting (ICM-2; GCOS-140)[6]. Currently GRUAN data are based only on the observations using the Vaisala RS92 radiosonde. It is envisaged that GRUAN will bring in other operational radiosondes (by 2016), frostpoint hygrometers (by 2015), ozonesondes (by 2015), GNSS-PW (by 2015), Lidar (by 2014), MWR (by 2015), and FTIR (by 2015). For each data stream technical documentation is required along with one or more papers describing the GRUAN data product in peer reviewed literature.

Data dissemination will also require monitoring of data usage (within the extent permitted), including feedback files from data assimilation centres into the analysis for data shared over the WMO

[4]Work will have progressed on the consideration of other ECVs and derived quantities identified as target parameters including aerosol attributes, as well as surface net radiation, short-wave downward radiation, short-wave upward radiation, long-wave downward radiation, long-wave upward radiation, and cloud properties including cloud amount/frequency, base height, layer heights and thicknesses. However, it is unrealistic to expect GRUAN data-streams on all these attributes to be flowing on the timescale of this IP from any appreciable number of sites, or to expect that their measurement strategies will be fully defined. There are a number of action items laying the ground-work for such data streams beyond the horizon of this IP.

[5]This includes radiosondes, ozonesondes and water vapour sondes.

[6]Report of the Second GCOS Reference Upper-Air Network Implementation and Coordination Meeting (GRUAN ICM-2), Payerne, Switzerland, 2-4 March 2010 (GCOS-140):

http://www.wmo.int/pages/prog/gcos/Publications/gcos-140.pdf

Information System (WIS) (2013). Data will also be shared with satellite agencies with the goal of using collocated satellite observations as additional quality feedback (various goals through 2015). Regular feedback to contributing sites is planned (2014), which will be used to ensure that standard operating procedures are being followed and that deficiencies in these procedures can be identified and corrected.

As part of the network expansion, it is planned to certify at least 4 contributing sites per year. In support of this effort, the outcomes of the 2012 network expansion workshop will be formalized (2013) and expressions of interest from identified desirable target stations will be solicited (2015). A periodic review of the network composition to ensure GRUAN is still meeting stakeholder needs is also envisaged (2016 and thereafter). This latter issue was discussed in some detail and it was agreed to revisit this topic in future meetings.

Science issues are being addressed by the GRUAN Analysis Team for Network Design and Operations Research (GATNDOR) as well as several task teams. These science topics revolved around the themes of scheduling requirements for temperature and water vapour observations (2014/2015), the scientific basis for choosing different instrument combinations (2014), co-location (2013), and comparison tools to satellites (2014).

It was recognized that by 2017 GRUAN should be in a position to expand to additional variables. A number of activities have been initiated to partner with existing networks and expertize to develop a pathway forwards in this regard and inform post-2017 planning. There also exist a number of deliverables around network visibility and discoverability.

During the preparation of the IP update, it was recognized that certain tasks were required but were ill-posed, had no owner, or covered periods outside the IP update horizon. These action items were retained in the IP as a special section for relevant tasks, which should not get forgotten and should get revisited until resolved.

The discussion also raised the issue of when to know that GRUAN was a success or when it has failed. To stimulate discussion, the challenge was raised to invent scenarios, which would lead to the failure of GRUAN, so that these scenarios could receive special attention. To judge, whether GRUAN is being successful, it is essential to have a metric to measure GRUAN's success. Possible GRUAN success metrics could include: the number of certified or candidate sites, the number of accepted reference data streams, the number of peer-reviewed publications, the number of citations referring to GRUAN, a count of the external data usage or evidence of impact or outreach to the wider GCOS Upper-Air Network (GUAN) or the WMO Global Observing System (GOS). Other metrics may be found and should be discussed at the next meeting. It was noted that GRUAN must know its customers, and in particular understand its most important users of GRUAN data. It was clearly pointed out that GRUAN could be considered a success, if users with a need for reference-quality data go directly to GRUAN for access to those data. Since GRUAN data are in their early stages, feedback from within the GRUAN community is an important tool to steer the required further development.

There was discussion about whether GRUAN aimed to partner with and build upon existing expertise or replace existing measurement protocols etc. Some participants felt, that in parts the IP points towards the latter while the WG-GRUAN co-chairs assured the meeting participants that the reality was the former. GRUAN is looking to partner with existing expertise (including participating sites and other networks / activities), e.g. with the Network for the Detection of Atmospheric Composition Change (NDACC) lidar working group, to develop GRUAN measurements. It was agreed that the IP should be clarified in this regard before being published and subsequent edits to this end have now been undertaken.

3.3. GRUAN Guide and Manual

Greg Bodeker has spent the past year furthering the development of the GRUAN Guide and Manual. At the time of the meeting, it was waiting for approval by the site representatives with a deadline of 15 March. Site representatives were required to sign off on the documents, to sign off with changes or to object. By 27th March all sites had signed off. Greg Bodeker outlined the delicate balance between stakeholder's desires for the documentation to be totally prescriptive or totally unprescriptive. He indicated that the sign-off from the site representatives was the final step that needed to be cleared

before these documents could be published. The group noted their appreciation to Greg Bodeker for his excellent work on this difficult task.

3.4. GRUAN documentation

Greg Bodeker noted the current status of procedures for GRUAN Technical Documents (TDs). He showed existing TDs and outlined the TDs planned for development as envisaged in the draft 2013-2017 IP. There are two GRUAN reports published and one is in process which will expound upon the outcomes of the network expansion workshop. Greg Bodeker raised the issue that the current TD structure is very distinct for different measurement programmes. He outlined six essential components for each of the data stream specific TDs. There was a general feeling that a single document for each data stream was desirable from an end-user and operator perspective. This would require a common structure to be sent in advance to creators of TDs. It was agreed that this guidance would be produced and disseminated with high priority.

The meeting raised the issue of using Digital Object Identifiers (DOIs) for GRUAN data streams which would help in terms of traceability. However, it was not clear whether DOIs would also be appropriate for dynamic data streams. It was agreed that GRUAN should explore this issue further and possibly make use of DOIs, where appropriate.

Doug Sisterson pointed out that peer-reviewed scientific articles in the international literature are extremely important for convincing funding agencies of the value that GRUAN brings to the scientific community. This issue was discussed in detail and the meeting encouraged all participants in publishing their results in the open literature.

Greg Bodeker asked whether GRUAN needed some sort of policing to ensure that all parties involved follow the documentation that has been agreed upon. The discussion pointed out that there is a clear distinction between WG-GRUAN and Lead Centre roles. All participating sites contribute on a voluntary basis and with the resources available to them. Thus compliance to the agreed documentation is difficult to enforce. However, the process of site assessment and certification exists and allows some level of oversight of the procedures being followed at a given site. The biggest concern lies in the management of change, since deviations from good practices have immediate and irreparable impacts on the quality of long time series.

It was agreed that the ICM meetings are an appropriate forum to verify contributing site compliance with procedures and documentation and to discuss ways to address any shortcomings identified. It was also agreed that contributing sites shall inform the Lead Centre of planned changes in their observational programme and detail expected implications of their scheduled changes. This notification is intended to be simple and should just serve as a formal start of the discussion about how to manage the intended change. Such notifications are already called for in the GRUAN Guide and GRUAN Manual. Other required actions related to change management are outlined in the Guide and Manual and the WG-GRUAN co-chairs agreed to summarize these required action items in a short document which will be provided at the next WG-GRUAN teleconference.

3.5. Lead Centre report

In January 2012, the German Meteorological Service (DWD) offered to WMO to continue hosting the GRUAN Lead Centre. The performance of the Lead Centre was considered by AOPC during its meeting in April 2012 where it was decided to accept DWD's offer. This decision establishes the observatory as the Lead Centre beyond the initial five-year period and is a milestone in the development of GRUAN. The integration of the Lead Centre in the Lindenberg Meteorological Observatory requires the allocation of resources. So far a good balance has been maintained with benefits both for the observatory and the Lead Centre. Staffing reduction due to parental leave has delayed the completion of several action items on the Lead Centre in the past year.

The Lead Centre coordinated the successful certification of the first site application from Ny Ålesund. Holger Vömel, Head of the GRUAN Lead Centre, welcomed Marion Maturilli, the representative for Ny Ålesund, with the first GRUAN certificate in recognition for their successful application. He encouraged other sites to follow in this path since the certification process is not an onerous additional work load, and it helps candidate sites to evaluate their operational procedures, improve the quality of their data,

and to become more transparent in the way the site will achieve reference-quality observations. These benefits are clearly in support of the efforts contributing sites bring into GRUAN.

Since different participating sites have different funding mechanisms, the certification process helps both the sites as well as the network in clarifying the funding situation for each site. Some sites may be considered more operational, while other sites are more research oriented. The site application process stresses that a long-term view is expected for every contributing site, even though an explicit long-term funding commitment is unrealistic in the current political and economic climate.

The Lead Centre is also engaging in discussions with the French candidate sites, the national experimental facility (Site Instrumental de Recherche par Télédétection Atmosphérique; SIRTA), located in Palaiseau, and the "l'observatoire atmosphérique du Maïdo" on La Réunion Island. It is expected that these sites will submit their application soon. Other sites such as several sites of Environment Canada, of the Spanish Meteorological Service (Agencia Estatal de Meteorología; AEMET) on Tenerife, of the Australian Bureau of Meteorology (BOM) and of the Chilean Met Service may be approached following initial discussions. Holger Vömel requested guidance for these interactions from the meeting participants.

Currently, data are being received from 13 sites, with over 22,000 radiosonde soundings and associated process metadata archived to date, most of which have undergone at least one reprocessing. The Lead Centre has also collected raw data for Vaisala ozonesonde, various frostpoint and other instruments being launched in the context of GRUAN. The use of the RS Launch Client in the collection of these data is essential, since this tool promotes complete collection of all relevant metadata, which otherwise risks of being lost. Although for a number of these other raw data no GRUAN processing has yet been developed, it can be processed once a GRUAN product for these data has been finalized. Sites are strongly encouraged to submit all raw data to the Lead Centre for safe-keeping, even if no processing to GRUAN products is currently in place.

At sites using the RS Launch Client, the data collection has been running well and without interruption. The processing at the central processing facility at Lindenberg has been running in a very stable manner, requiring only limited intervention. Michael Sommer described the details of the GRUAN data processing in his presentation (see section 5.1). Several weaknesses in the current data processing version have been identified and, once rectified, will require a new data product version. Feedback from the meeting participants and from the scientific community on issues that may not yet have been identified will greatly support the development of the updated data product.

Some progress has been made towards bringing additional data streams into GRUAN in cooperation with the relevant task teams. Since redundant observations are a central element of GRUAN, it is essential to bring in data streams that are not RS-92 radiosondes to complement these measurements.

The Lead Centre has supported the Dynamo / Cindy campaign and has reprocessed Vaisala RS92 observations from the tropical Atmospheric Radiation Measurement (ARM) sites and from the island of Gan. This reprocessing and the following discussions have greatly helped to identify some shortcomings with the current data product. A rigorous comparison of operational Vaisala processing versus GRUAN processing has shown expected differences, but most importantly has identified weaknesses in the operational procedures at these sites. A journal paper on that topic is currently planned by Hungjui Yu et al.

The Lead Centre is currently collecting RS-92 and Electrochemical Concentration Cell (ECC) data at San Cristóbal, Galápagos Islands, Ecuador. Although these data are not considered GRUAN data, the processing of these data provides valuable information about issues at remote sites and requirements for processing and feedback of these data. The lessons learned at this site are also applicable for the tropical GRUAN contributing sites at Manus and Darwin. For example, tropical sites frequently have difficulties maintaining a dry desiccant required in the ground check preparations for the Vaisala RS92 radiosonde. As a result, operators often use a desiccant that is too wet or skip the ground check procedures completely. The latter is not GRUAN compliant since the adjustment for temperature and pressure are essential corrections, which must not be skipped. Feedback to the contributing sites on these issues is considered relevant information and will be included in the site feedback reports.

In addition, the Lead Centre and the sites at Boulder and at Sodankylä have worked with Vaisala on the testing of the RR01 i.e. the Vaisala reference radiosonde. The Lead Centre has also worked with MeteoSwiss colleagues on the radiation calibration of the Swiss radiosonde temperature sensor using the Lindenberg facility. Some results were presented during the Lindenberg site report.

The GRUAN website[7]is providing most of the functionality required by both the WG-GRUAN and the external community of GRUAN data products. Meeting participants were encouraged to provide feedback on the web site and to provide content they wish to see published on this portal. The acceptance of the GRUAN blog[8] is not as well established and currently it is used mainly by GATNDOR. This blog allows both public and private discussions and use of the latter functionality may support deliberations of issues that may otherwise be recurrent or which are crosscutting between groups.

The GRUAN Lead Centre recognizes that the material published on the GRUAN website in many cases does not adequately capture what GRUAN is. In several instances Met Services and funding agencies have difficulties grasping what GRUAN wants and whether it is something they should invest in. This issue needs to be addressed and rectified to provide agencies that may be interested in GRUAN with the relevant information. A regular GRUAN newsletter may support this effort, but is considered too labour intensive given the lack of personnel. Anna Mikalsen from the GCOS Secretariat offered the possibility of articles in the GCOS newsletter.

The Lead Centre presented an overview of all meetings, in which GRUAN was either represented or had a role as organizer. Such meeting participation is seen as essential to strongly promote GRUAN.

Capacity building is considered one of the tasks of the Lead Centre. Training of staff within the GRUAN community will be an ongoing challenge of great importance for the success of GRUAN. The lessons learnt as part of this effort will also help other sites and networks outside of GRUAN auspices in raising their operating standards. It was noted that dedicated resources will be required to increase this effort since it cannot be achieved under current levels of support. The Lead Centre agreed to add a section on training to their regular reports to WG-GRUAN.

3.6. GRUAN visibility and GRUAN launch event

During ICM-4 the desire for a “GRUAN launch event” was raised. The hopes for outcomes of such an event were discussed in detail at ICM-5. The hope was expressed that this event could help raise the visibility of GRUAN since there is an ongoing need to increase awareness of GRUAN and the importance of the goals of GRUAN. It was agreed that a launch event that would celebrate the initial flow of data and the path forward regarding a number of other data streams should be organized such that a wider community is involved. Holding this event just within the context of ICM-6 was considered detrimental since the participation is limited to primarily those already active and engaged in GRUAN. The meeting considered some workshop activities that would link the GRUAN activities to broader GUAN and GOS observations, e.g. in the context of a side-event at the WMO Executive Council in 2014. Key products could be highlighted as part of these events.

It was stressed that the community should write papers using GRUAN data and cite the existing GRUAN literature wherever possible. GRUAN used as a keyword in journal papers makes it easier to search for GRUAN related papers in citation indexes. Members of the GRUAN community should also attend conferences and present their specific GRUAN related results and thus enhance the exposure of GRUAN within the scientific and operational community.

The GRUAN Lead Centre maintains some material on its website that can be used in presentations about GRUAN. The Lead Centre has agreed to periodically review and update these materials to ensure that they reflect the latest status of the network. Members of the GRUAN community were strongly encouraged to make use of this material to make presentations on GRUAN at appropriate venues such as workshops and conferences.

[7] www.gruan.org

[8] http://gruan.wordpress.com/

3.7. Composition and size of WG-GRUAN

At the AOPC session in 2012, the increased size of the WG-GRUAN was questioned and justification for the current size, and particularly for any further expansion, was requested. Establishing an 'executive council' consisting of the co-chairs and head of the Lead Centre was proposed by AOPC as a possible solution for the future. The ICM-5 meeting provided a forum to discuss the size of the WG-GRUAN and its co-chairs presented some initial thoughts.

The size of the WG-GRUAN has not grown over the past year and is currently not expected to increase. At the moment, the WG-GRUAN is composed of 2 co-chairs, 10 task team representatives, 15 specific experts and 8 (6) ex-officio members, where two of these positions (representative CAS and representative CBS) have not been assigned.

The concerns expressed during ICM-4 and by AOPC that this large size might make the WG-GRUAN ineffective, were discussed against the need for a wide range of expertise. The meeting agreed that the WG-GRUAN should not grow beyond its current size. It was also noted that the level of active collaboration by WG-GRUAN members is high and that the number of inactive members is very small (two persons). WG-GRUAN members come from many communities, attesting to the support that GRUAN has within these communities. It was therefore noted that, in the view of meeting participants, there was no need to reduce the size of the WG-GRUAN and that its current size provides the functionality required to support GRUAN at this time. Additional expertise that may be required in support of GRUAN should, in the first instance, be included in the respective task teams.

The issue was raised that a number of WG-GRUAN members have been participating in this effort for a significant amount of time and that some level of group homogeneity could prevent outside ideas being taken up. It was suggested to recommend some form of rotation out of the WG-GRUAN over time. On the other hand long-term members have strong ‘institutional memory’ that is useful to avoid going over old ground repeatedly - so a balance needs to be found. The meeting agreed to ask members of the WG-GRUAN on a regular basis whether they still intend to serve in this function.

4. Network

4.1. Site certification

The site certification process was defined during ICM-3 and has been implemented during ICM-4. The first contributing site that went through the certification process was the Ny Ålesund “AWIPEV” atmospheric observing station, operated by the Alfred Wegener Institute. This site has a long history of high-quality observations in the Arctic. The discussions with the Lead Centre and the preparation of the measurement procedures ahead of the time of the application both helped in an effective certification process. Addressing all issues raised during the application process, Ny Ålesund is now the first site that successfully certified a measurement programme within GRUAN. During the meeting, Marion Maturilli, the Ny Ålesund site representative, was presented with the first GRUAN site certificate. She expressed her gratitude for this process and explained that the process was very helpful in aligning the needed support within the organization as well as in increasing the quality of the observations taken at the site.

The site at Lindenberg also prepared its application material in advance of ICM-5; however, the WG-GRUAN had not finished their deliberations prior to the meeting. Although the Lead Centre is an ex-officio member of the WG-GRUAN, it is excused from the deliberations about this application to avoid a potential conflict of interest. The sites at Cabauw and Lauder are requested to prepare their site applications next.

The process established to handle site certifications seems, based upon the limited experience to date, to be effective and efficient. The communication with the site representatives is maintained through the Lead Centre. It is currently envisioned sites with certified measurement programmes will be audited approximately every four years with less onerous site reporting by exception annually. However, it is likely to be necessary to change the scheduling for site audits depending on the available resources. This implies that a certification, which currently may take more than 6 months,

needs to be compressed and that the interval between audits may need to be expanded. This issue will be revisited during ICM-6 after more experience has been accrued.

4.2. Network expansion workshop report

Greg Bodeker reported on the outcomes of the GRUAN network expansion workshop, which was held from 13-15 June 2012 in Fürstenwalde, Germany, near Lindenberg. The emphasis of this workshop was not to identify new sites, but rather to develop the process for identifying possible future sites and to provide a strong scientific basis for such selection. A secondary goal was to entrain additional expertise into GRUAN. In the preparation leading up to this workshop, four white-papers from the four primary user communities, climate research, satellite observations, process studies and numerical weather prediction, were drafted.

Key outcomes of the workshop were:

- The complete range of atmospheric variability should be sampled by having sites in each of the major climate regions (polar, mid-latitude, subtropical and tropical) in both hemispheres.
- Sites should cover a wide variety of different climate regimes and large-scale modes of variability such as the Northern and Southern Annular Mode (NAM, SAM), El Niño/La Niña–Southern Oscillation (ENSO), Quasi-Biennial Oscillation (QBO), and should also permit detection of expansion of the tropics, changes in the strength of the Brewer-Dobson Circulation, and the monsoon. These phenomena are important because they may change significantly in the future with increases in greenhouse gases and other perturbations to the climate system. In addition, sampling the divergent circulations over the tropical warm pool is vital for our understanding of the climate system because these circulations drive weather patterns around the globe.
- Sites should cover a variety of surfaces such as forest, deserts, snow and ice as well as stations on small, remote islands to represent surrounding ocean conditions, remote mountain top sites but also regions such as the Mediterranean basin with influences of urban pollution.
- It would be beneficial if most of the atmospheric measurements were made under clear-sky conditions to minimize the uncertainties introduced by radiative transfer modeling in the presence of clouds and if relatively simple, climatological vertical profiles of temperature and humidity were observed to avoid complicated features that make trend determination difficult.
- Temporal and spatial co-location is absolutely critical for the calibration and validation of satellite observations and it is preferable to have a smaller number of good quality and easily maintained contributing sites in places where satellite overpasses coincide with regular GRUAN radiosonde launches rather than a higher number of contributing sites with poorer coincidence.
- For monitoring changes in climate, long-term, stable, and homogeneous time series of measurements are required. All else being equal, sites with an existing history of such measurements should be selected. Sites with in-house scientific expertise in analyzing and understanding long-term climate data records, and long-term commitment to supporting both the observational programmes and the ongoing analysis of observations would be ideal.
- GRUAN could benefit appreciably from measurements of water vapour, temperature, ozone, and aerosols conducted by other global networks, such as the Network for the Detection of Atmospheric Composition Change (NDACC), the Baseline Surface Radiation Network (BSRN), the Southern Hemisphere ADditional OZonesondes (SHADOZ), etc. Thus, strong consideration should be given to the selection of some sites from these complementary networks for GRUAN expansion. Priority should be given to sites that enable the required vertical coverage of the measurements.

The economic cost of augmenting the GRUAN network was discussed. A broad range of locations will be identified based on the preferences with consideration for existing infrastructure and in coordination with established networks. Costs are also likely to depend on whether a new site is established in the developed world or in the developing world. The most cost-effective approach is to use existing sites in favourable locations that have the flexibility and are willing to add to their operational schedules (e.g. radiosonde launch times) as required. The possibility of paired sites was raised with the example of the cooperation of the MeteoSwiss Payerne site with Nairobi and that such paired sites may be suitable candidates as they benefit significantly from the collaboration enabling a degree of sustained operation. Similarly the potential candidate sites at Palaiseau and La Réunion act in close concert with one another. The underlying idea is that established GRUAN sites enter a negotiated partnership with a site in a more challenging location. The example pointed out by Bertand Calpini is the partnership

between Payerne and Nairobi in the framework of SHADOZ. Without such a model it would be difficult to see how GRUAN could attain measurements in many regions of the planet. The GCOS Cooperation Mechanism, which GRUAN hasn't used yet, might be a possible vehicle to support selected partnerships of this kind. With a funding mechanism in place, donors could be found which would facilitate adoption of GRUAN protocols at other sites globally.

4.3. Candidate sites update

During the past year contacts have been made with a number of sites who were generally open in engaging with GRUAN. These contacts could be expanded to establish a formal relationship with GRUAN. Potential new sites that were named in the discussions are: Izaña (Tenerife), three sites of Environment Canada (Alert, Eureka, Sandy Lake), four sites of the Chinease Meteorological Administration (CMA; Mt. Waliguan, Nagqu, Kunming and Yangjiang), and four sites of the Australian Bureau of Meteorology (Alice Springs, Melbourne, Macquarie Island, and Davis (Antarctica). Other potential sites were mentioned, but no formal contacts with these sites have taken place. Key considerations when reaching out to new sites are the possible long-term view of the organization in supporting a site and logistical difficulties in the support of GRUAN operations at these sites. The Lead Centre asked the meeting to provide guidance as to the sites that they should actively be engaging with in looking to expand the GRUAN network of contributing sites.

As part of the discussion, it was pointed out that the material provided on the GRUAN web page is often not sufficient to provide an adequate picture of what GRUAN expects from sites and what sites need to be willing to commit to, when participating in GRUAN. This problem needs to be addressed. Greg Bodeker agreed to take the lead in creating a set of materials which more explicitly lay out the expectations of candidate sites as well as the benefits that would accrue from their participation.

5. GRUAN data

5.1. Data flow Vaisala RS92 GRUAN data product

Michael Sommer outlined the flow of GRUAN radiosonde data which are currently processed and archived at the Lead Centre. Data are collected from 13 sites for all radiosondes, checked for inconsistencies and stored in the GRUAN data and metadata repositories. The current volume of data amounts to about 160 GB. The Vaisala RS-92 sonde data are processed using the software developed at the Lead Centre, which acts as the processing centre for this data stream. The data are then disseminated through NCDC. For all other sonde types, the raw data are just archived for subsequent processing, once a data product has been developed.

Version 2 of the RS-92 GRUAN product was launched in August 2012. This version includes several software upgrades to improve the data processing as well some minor changes in the processing routines. The current processing is set up such that only those soundings which pass all quality checks are transferred to the data portal at NCDC (approved status). Files which are being processed completely, but fail to pass at least one of a number of quality controls (checked status) are not transferred to NCDC, but are available at a separate ftp site at the Lead Centre. Soundings, which cannot be processed to due inconsistencies in metadata, data file corruptions or other reasons are considered as bad soundings (bad status). In rare cases processing is aborted due to unknown reasons, most likely related to software issues (unknown status).

Figure 1 shows the status of all processed soundings. On average around 50% of soundings are approved for public dissemination and sent to NCDC as GRUAN data. Approval rates vary tremendously from site to site for a variety of reasons. Data may fail approval for example due to excessive corrections of the pressure sensor measurements in the ground check, inconsistent data between both humidity sensors, or incorrect metadata. More than 30 quality checks have been built into the processing, leading to a high failure rate in these quality checks. Some failures are related to operator errors (e.g. missing ground check) and will require a change in operating procedures. Others are related to issues in the processing software and will be fixed in the next data product version. Yet others are related to the very high requirements on the instrumentation and on the quantification of the uncertainties for the instrumentation. These issues may indicate specific needs for sensor improvements or better characterizations of the sensor performance.

In the current version the rate of data passing all quality checks is lower than it should be for varieties of reasons which were touched upon in discussions arising from this presentation. Improvements of the processing software and the introduction of new quality flags are planned for the next version of the GRUAN RS92 data product, which will significantly increase the amount of data available through NCDC. The comparison of GRUAN data currently available through NCDC with other satellite data within the GRUAN product validation system (GPROVS) showed no issues (see Appendix 9), whereas data that have failed one or several quality checks do show some issues, when included in GPROVS. Careful monitoring of the planned changes is required to avoid the possibility that meaningless data are being distributed and that no sampling bias is introduced by preferentially withholding data from particular seasons, synoptic situations or time periods. It was agreed that consideration would be given to serving all data through NCDC with data either being labelled as good, questionable or missing with reason codes in the next release.

Feedback to contributing sites covering the quality of the data and the rate of approved data is seen as essential value that will distinguish GRUAN data and will make it attractive to supporting agencies. For example a manufacturer independent ground check, which is currently being done at three sites provides valuable information about the stability of the sondes, should be performed by all sites. This becomes clear upon considering the acceptance rates being higher from these sites than all others. Some sensor issues, for example an excessive disagreement between the two heated sensors on the Vaisala radiosonde may slip by without this test. Sensor icing, both for the temperature sensor as well as for the humidity sensor is not being tested for in the current version of the GRUAN data product. This is an important issue that must be addressed in a future revision of the GRUAN data. Operational centres may do a better job on the sensor icing and closer cooperation with these centres may help in identifying these cases.
Participants congratulated the Lead Centre on the creation, analysis and curation of this data stream, which is a significant step towards making GRUAN an operational reality. It was recognized that GRUAN was still in a learning phase and hence that there were likely to be several iterations of this product before it truly stabilized. This work will make it easier for the data streams that follow. Participants urged the Lead Centre to complete and publish both technical documentation and a paper describing the GRUAN data product.

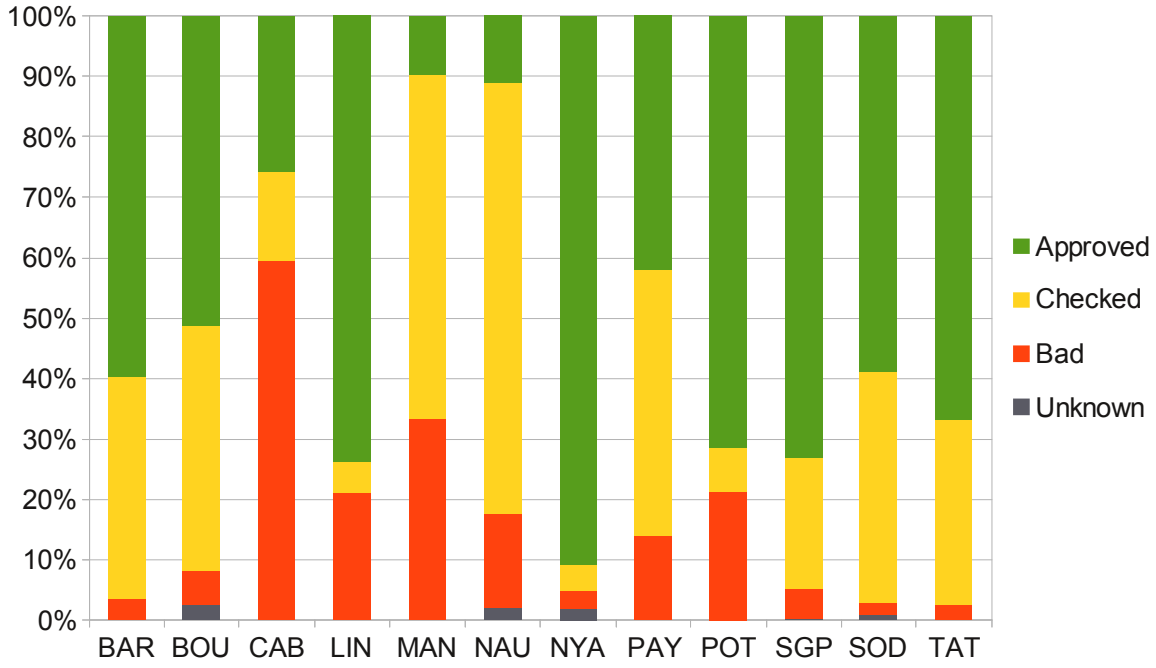

Figure 1: Status of all data files for all sites.

5.2. User review of GRUAN data

GRUAN has been producing data for nearly two years. Greg Bodeker raised the issue that a group of data users outside of GRUAN could provide input to GRUAN data products and that GRUAN may actively seek the advice from such a group. However, it was pointed out that the number of papers using GRUAN data so far is small, but growing. At present feedback from within the GRUAN community may be easier to achieve even though this would not increase the outside visibility. The ICM-5 participants were encouraged to provide feedback to the Lead Centre. It was noted that if and when an external users group is sought for in the future, the Working Group GRUAN may at that time approach AOPC for advice. Although AOPC may not allocate much time for this specific task, AOPC may possibly interface with its sponsors such as WCRP to address this topic. It was concluded that at present it is too early to call for such an external group and that this topic should be revisited during ICM-6.

5.3. The importance and use of uncertainties in GRUAN data

Holger Vömel presented an overview over the importance of uncertainty. The distinction of the different sources of uncertainty is important to identify the elements in the measurement chain, which are most critical for long-term data series. In this process the different categories of uncertainty (random vs. systematic, correlated vs. uncorrelated) are identified and help users of the data in the interpretation of the results depending on the user needs. Comparing the analyzed uncertainties with the specifications of the manufacturer helps identifying the regions of validity for this information and can quantify the regions, where sensor improvements will lead to the most significant gains. Lastly, a clear understanding of the different sources of measurement uncertainty helps defining standard operating procedures, by placing the highest emphasis on those steps in the instrument preparation, which have the strongest impact on the final measurement uncertainty. This analysis also guides the development of new instrumentation and helps in the development of other data streams. Participants were reminded that for reference observations the measurement uncertainty is a central element of the observation. Although requiring additional efforts, quantifying the measurement uncertainty will ultimately lead to increased data quality and by avoiding lower quality observations will also lead to cost savings.

6. Updates from GRUAN task teams and GATNDOR

Note that formal reports from all task teams are provided in appendices 6 - 10.

6.1. Radiosonde task team

Rolf Philipona presented the report of the task team radiosondes. After ICM-4 he has become the co-chair of this task team. In addition there have been a few other changes to the membership roster of this task team due to retirement etc.

The report on the WMO intercomparison campaign has been completed, reviewed, and has been published as GRUAN report (GRUAN-RP-2)[9]. Mr Philipona reaffirmed the value of such intercomparison campaigns to GRUAN and hopes to see further campaigns in future with GRUAN involvement.

The Payerne station flies balloon-borne upward and downward looking radiometers to measure the vertical profiles of the radiative flux. These soundings require a stable balloon platform. Payerne uses a system of two balloons carrying a single payload. At the pivot point, where both balloons are connected, a GPS receiver and matching electronic control the moment, when one of the two balloons is separated from the platform, leading to a slow descent. However, the main benefit of this arrangement is the reduction of pendulum motion in the ascent phase of the sounding.

[9] Miloshevich et al., GRUAN Radiosonde Task Team Review Report on the 2010 WMO Radiosonde Intercomparison (GRUAN-RP-2):

http://www.dwd.de/bvbw/generator/DWDWWW/Content/Projekte/Gruan/Downloads/documents/gruan-rp-2,templateId=raw,property=publicationFile.pdf/gruan-rp-2.pdf

6.1.1 Controlled descent report

Dale Hurst presented recent results of the differences between ascent and descent measurements of temperature and pressure by radiosondes. Boulder's frostpoint observations are primarily taken on descent in order to minimize possible contamination effects of frostpoint measurements on ascent. Temperature and pressure measurements on descent are needed as well to convert frost point measurements to water vapour mixing ratios and relative humidity. Descent frost point hygrometer data in theory is easier to interpret but only if the radiosondes perform without large errors. Controlling the descent rate to approximate the ascent rate improves the quality of frost point measurements in the stratosphere, for which purpose balloons are equipped with pressure controlled valves.

Mr Hurst showed the differences between ascent and descent performance of the Vaisala RS92 and InterMet radiosondes. Sonde GPS altitudes were used to match the ascent and descent measurements. He started by showing the differences for RS-92:

- Pressure differences between ascent and descent show a reduced difference for controlled descent compared to free-fall descent (i.e., balloon burst). Mean ascent-descent pressure differences in the UTLS are not significantly different from zero.
- Temperature ascent-descent differences are large (2-3 °C) and show little dependence on the rate of descent (i.e., controlled vs. free-fall).
- Humidity ascent-descent measurement differences with RS-92 are also quite large.
- Controlled descent reduces RS-92 ascent-descent differences in geopotential height because pressure is the main input to the calculation of geopotential height.

For InterMet radiosondes the controlled descent reduces ascent-pressure and geopotential height differences, but does nothing to improve agreement for temperature or relative humidity (RH). InterMet and RS92 ascent-descent pressure differences are of similar magnitudes in the troposphere but the RS92 differences increase more in the stratosphere than the InterMet differences. There is little difference in the magnitudes of ascent- descent temperature differences between the RS92 and InterMet sondes.

6.1.2 Impact of multi-payload configuration

Hannu Jauhiainen outlined progress to date towards understanding multi-payload configuration effects upon radiosonde performance. The rationale is to provide a justification for specific method(s) of multi-payload rigging to allow easy intercomparison of GRUAN multi-payload configurations between sites and to infer something meaningful about single payload launches from the multi-payload launches. Relevant issues are:

- Balloon size and type (ascent and descent rate and thermal wake effects, moisture degassing, radiation effects)
- Main string (length, material, moisture absorption)
- Flight train (parachute etc may affect radiation and pendulum effects)
- Rig (material, dimensions, colour)
- Instrument assembly on the rig including effects of mutual interference etc.

A survey was sent to all sites to determine what they did for multi-payload rigs and asking for their lessons learnt from their experiences. Replies were received from a number of sites and also experience from WMO intercomparisons and some information from manufacturers. Sites have provided very valuable information and metadata. A review of these various multi-rigging options has been undertaken with quantification of uncertainty components. Single soundings have been used as 'reference'. The next simplest approach is instruments connected together, which can affect the properties of each instrument and the momentum and properties of the pendulum motion. A single rig adds an additional pendulum effect, but the rig additionally starts to have impacts on contamination etc. Fixing the instruments to the rig rather than hanging them freely from it may reduce pendulum effects, but may impact the instrument stability. Instruments can also be connected vertically but instrument wake effects may affect the instruments below and data are not coincident in height. The most complicated type is combined assemblies containing multiple combinations of the preceding aspects, which may complicate the interpretation.

These options to combine different instruments on a single payload will be drafted as a report or paper by summer 2013. More information is still required to complete this task. The quantification of the effects is going to be the hardest part of this task. Currently it is not clear which of these effects matter and which are not so relevant for GRUAN. For example some work has been done on the effects of

varying string length on the impact of the balloon wake. Guidelines will be developed based on the outcomes of these studies. Since these effects are difficult to quantify and most importantly difficult to exclude, it is very important that sites maintain accurate metadata descriptions and use the RsLaunchClient to collect the detailed information on how the rig was set up. This metadata will be useful in the future if and when systematic biases are determined. Holger Vömel reminded the site representatives to be very careful in the way these metadata are collected.

6.1.3 Preparation for large scale change in radiosonde software and hardware

Change management for GRUAN observations is vital and mandatory. Holger Vömel alerted the meeting participants of two anticipated large-scale change events, which are likely to impact most sites.

First, a change in ground equipment software of the Vaisala receiving system is expected, which will change all data formats and possibly have minor impacts on the radiosonde operations. This change will most strongly impact the processing centre, which in this case is the GRUAN Lead Centre. An initial version of this software is already being evaluated and tested at the Lead Centre and upcoming meetings with Vaisala will discuss the implications and evaluate potential changes. At present it is expected that this change will impact only the ingestion of Vaisala radiosonde data, but not the final product. Therefore, the biggest workload may be expected to lie with the Lead Centre in this case providing a good proving ground for change management which others may then follow.

A second change may be expected in the future if and when Vaisala were to release a sonde to replace the RS-92. Such a drastic change would impact all GRUAN sites launching Vaisala RS92 radiosondes and require action from all such sites. Such a change event should be coordinated between all sites using Vaisala RS92 radiosondes to make sure that all sites are involved in this event and to optimize the resources required to manage this change. Therefore, it is highly desired that change management structures are in place at the time such an event occurs. GRUAN should therefore be ready rather than reacting when any such change occurs. A network wide strategy that optimizes the change management is highly desired so that resource issues are not too taxing on any individual site or stakeholder. It was suggested that the radiosonde task team take this on as an action item to develop a strategy to optimize resources and design an action plan that would be implemented once any new radiosonde has been officially released. It was recognized that the involvement of vendors would be critical in managing change particularly when it is a vendor based (driven) change and not a change arising from a contributing site choosing to change vendors.

It was suggested that a mobile radiosonde station could be acquired that could be used temporarily at dedicated sites to aide in this process. Resources for this mobile radiosonde site would have to be found. Alternatively, ARM mobile sites may take up this role. Radiosonde data from these sites could be processed as GRUAN data for RS-92 and possibly for any future radiosonde data stream and evaluated in detail. Doug Sisterson raised how ARM mobile facility data may be utilized given that ARM is capable to deploy around the globe for short period campaigns of a few months to a year or two.

6.2. Bringing other operational radiosondes into GRUAN

Holger Vömel outlined the progress to date towards bringing in radiosondes other than Vaisala RS92 that are flown at GRUAN sites and for which a GRUAN data stream does not yet exist. He noted that sites currently running RS92 may not continue to do so forever and that having other data streams developed would be beneficial in the long term. A list of issues needs to be considered to create a GRUAN estimate and its uncertainty. A measurement system cannot be considered as a candidate GRUAN data stream until these have all been considered. For radiosondes these issues are fairly generic such that they are largely instrument independent, even if the specifics of how they are considered or quantified differ. These must be quantified and verified before a data stream can be added. Verification may use such methods as calibration chambers and laboratory tests. The Lead Centre is collaborating with sites using alternative radiosondes. There has been some collaboration with Payerne and CMA to start to bring in their sondes. The steps necessary to process a new radiosonde within GRUAN need to be formalized. It was agreed by meeting participants that this should be done as a dedicated task of the radiosonde task team.

6.3. Validation of hyperspectral satellite instruments using radiosondes

Xavier Calbet illustrated examples of the validation of hyperspectral satellite measurements using high quality radiosondes. The validation of these measurements can either be done in RH space or in radiance space. Working in the space of relative humidity requires retrieving a RH profile from the spectral information, which requires a forward model. These models have an unavoidable model error, which lead to large uncertainties in the retrieved parameters. For this reason it is often preferred to compare measurements in radiance space. Here the geophysical parameter is modelled into the radiance spectrum the satellite should be seeing. This calculation is much less sensitive to model errors and preferred for hyperspectral instruments. The view of many in the hyperspectral community is that the accuracy of hyperspectral instruments is high enough, so that validation efforts may not be needed. However, the comparison with different types of radiosondes clearly indicates, that these validation efforts are needed, if nothing else o gain confidence in the combined observing system, that includes both satellite and radiosonde observations. Having a reference network such as GRUAN will lend a lot of weight to the quality of the satellite observations and may be able to point at possible unidentified issues.

6.4. Task team GNSS-PW

June Wang introduced two new members of the Global Navigation Satellite System (GNSS) Precipitable Water (PW) task team and reiterated the main task of this team, which is to bring a GNSS data stream into GRUAN. The task team has prepared a series of guidelines and guidance, which now needs to be brought together and implemented. A lot of progress has been made on data formats, centralized data processing and data flow. Some progress has also been made towards preparing a paper describing the GNSS data product. The team has leveraged the expertise of the geodetic community and activities of the WMO Commission for Instruments and Methods of Observation (CIMO) along with an EU COST activity.

The Geoforschungszentrum Potsdam (GFZ) is kindly offering to host the central processing facility. It has significant experience in analysing both ground based and space based GPS measurements including a European land based network. Members of GFZ staff have also been members of this task team and have been involved in this activity from early on. The offer by GFZ was highly appreciated by the meeting and unanimously accepted. The GCOS Secretariat and the Lead Centre were asked to work out the formal details of this cooperation.

A GRUAN data product will be derived from the estimation of uncertainty through the forward model from the raw measurement to the derived PW measure. It will use a combination of theoretical and statistical modeling. The uncertainty is dominated by the time delay and the surface pressure uncertainties. The main challenge will be to quantify the Zenith Total Delay (ZTD) uncertainty since it will be dynamic. However, the advantage is that the resulting uncertainty estimates will be fundamentally related to time reference standards.

Vertical displacement has a large effect on mean difference between GNSS and other instruments based upon an analysis in New Zealand between Invercargill, Lauder and two Dunedin GNSS receivers. The horizontal separation has significantly less impact on this comparison.
The COST action ES1206 is interested in real-time and long-term applications of GNSS data to meteorology and climate. There are 55 participants from 23 countries and it will run for four years starting in May 2013. COST is an enabling mechanism to coordinate the development of research applications. GNSS may be able to derive 3-D field properties if individual satellite slantwise delays can be handled better. The GRUAN task team is included in this effort.

6.5. GNSS-PW data stream development

Kalev Rannat presented the plans for the GRUAN data stream for GNSS-PW. The data stream will look similar to that for radiosondes that already exists for GRUAN. There is a mix of instrumentation set ups within GRUAN that must be accounted for. Some have collocated in-situ meteorological observations while others are not strictly collocated. The latter class has additional uncertainty / complexity in the data stream. The data, based on standard GNSS-formats, will be sentthrough the Lead Centre to GFZ, which will kindly act as the GNSS-PW central processing facility. The Lead Centre will work with GFZ on the details of data flow and data archiving. Lindenberg data will be used first to develop the data flow. The PW format is proposed to be the E-GVAP format, which is well documented and easily convertible. Consideration will be given to serving a version in Network Common Data Form (NetCDF) Climate and Forecast (CF) compliant format so that users can easily

compare to the existing RS-92 data stream. Mr Rannat raised the issue of data usage being required to have a user friendly interface to encourage its use by non-experts. He challenged participants to consider how we can make it more appealing for users to use GNSS-PW data and other GRUAN data products.

6.6. Scheduling task team

Tom Gardiner outlined recent progress on GRUAN scheduling guidance. He noted that often GRUAN data stakeholder needs were in conflict regarding scheduling. He noted that scheduling task team effort was a voluntary effort with limited resource that could be brought to bear. He highlighted task team progress including a piece in the ITS9 proceedings. He also stressed that the task team is still looking for additional members.

The major work since ICM-4 has been collecting bibliographic references to ascertain temperature measurement scheduling requirements. There is a fairly long bibliography and a shorter recommendations document currently with task team members for review. The available literature is very heavily skewed towards radiosondes and trends, which is only a subset of the instrumentation and only one of the stakeholder viewpoints. Help was requested in pointing to literature which discussed the scheduling issue from other user groups' perspectives. The task team considered what the increase in uncertainty might be if data are not collocated in time. This issue has been addressed using four times daily data from Lindenberg soundings and it was found that this is only possible with four times daily data on a site-by-site basis and with substantial seasonal variability. The task team is looking for additional datasets to extend this analysis. In theory this analysis can provide guidance on how different scheduling efforts add uncertainty and how often is enough if user requirements can be well stated in a quantifiable manner.

The discussion raised the issue whether sites are required to launch at synoptic times. This issue has been raised in previous meetings and it was agreed that sites have significant latitude to the scheduling for GRUAN purposes. The GRUAN guide states that for a fully compliant station two launches are made at 00 UTC and 12 UTC and two at satellite overpass. The allocation of resources remains at the liberty of the individual contributing sites recognizing that GRUAN is not the sole stakeholder and in most cases does not provide the funding support.

6.7. Task team on ancillary measurements

Tony Reale (remotely) gave a brief update of the activities of the task team ancillary measurements. He presented the GRUAN Product Validation System (GPROVS), which is an adaptation of the NOAA Products Validation System (NPROVS), with the goal to monitor GRUAN profiles in the context of satellite observations and model output. In this system GRUAN profiles can be used to determine satellite product adherence to specification and to compare these data to outputs form Numerical Weather Prediction (NWP) models such as ECMWF's. One of the major tasks is to develop tools to process and use the uncertainty estimation of data products and to integrate ancillary and radiosonde profiles from GRUAN sites. GPROVS is intended as long-term climate monitoring tool and therefore will maintain long-term co-location datasets.

The utility of this tool was demonstrated using COSMIC observations as stratospheric and tropopause temperature reference data. Comparing these observations with radiosonde observations generally show good agreement, with some notable differences, which require further investigation.

Retrievals from the Infrared Atmospheric Sounding Interferometer (IASI) are using a-priori information from forecast models. At some sites there are indications for very big differences between GRUAN temperature profiles and those from the forecasts. However, these results are preliminary and require further study.

Currently GPROVS uses GRUAN data both from the official NCDC repository as well as some data from the Lead Centre archive. As discussed in section 5.1, there are differences in the quality level between these two data sets. Currently only data passing the very stringent GRUAN quality criteria are transmitted to NCDC. Data where some inconsistencies were found during processing are stored at the Lead Centre and made available for research purposes such as GPROVS. Tony Reale pointed out that the data made publicly available at NCDC have little quality issues, possibly none at all,

whereas some of the lower quality data held at the Lead Centre site do have inconsistencies with the other data available through GPROVS.

Martine De Mazière was appointed as a new member to the task team representing Fourier Transform Infrared (FTIR) remote sensing observations. Thierry Leblanc outlined new work for retrieving temperature profiles from the surface to the stratopause using microwave radiometers. Comparisons of such temperature measurements with radiosonde measurements at Payerne show very promising results.

The cooperation between remote sensing and in-situ observations is seen as an important part of this task team and includes the comparison of uncertainty budgets for sondes and remote sensing instruments; the preparation of recommendations for the best use of collocated and simultaneous ground-based and sonde measurements; and the preparation of recommendations for microwave measurements to minimize co-location errors, i.e. downwind of a sonde launch site. There is a strong overlap with GATNDOR research areas and the participants were encouraged to cooperate closely on these subjects.

6.8. GATNDOR

6.8.1 Co-location uncertainty

Alessandro Fassò presented an update of his work on the quantification of the co-location uncertainty in the comparison of distinct GRUAN measurements. He has undertaken a new statistical approach, based on the heteroskedastic functional regression model which extends the standard functional regression approach and allows us to provide a natural definition of uncertainty profilesand their detailed decomposition into all the different components. Although the method is quite general and data driven (data from Beltsville and Sterling 52 km far away), it was found that the co-location mismatch in relative humidity has an adjustable constant bias that is about 4 %of the global co-location uncertainty. Moreover it turns out that the co-location uncertainty is related to physical quantities and, in principle, it could be reduced by auxiliary information. The proposed method is self assessing in the sense that it is able to consider the information content of the data for the model and to assess the size of the sampling error with respect to the other uncertainty components. The results will be published soon in peer-reviewed literature and will include also the uncertainty budget assessment for pressure and temperature.

6.8.2 Redundancy in measurements

Although redundancy may appear unnecessary, it is an essential part of a reference network to fill gaps, increase sampling, and reduce uncertainty. To optimize redundancy, a reliable quantifiable measure is needed. A linear relationship is not sufficient because most of the time linear assumptions are not valid. Entropy and mutual information are possible non-linear metrics to quantify the value of redundant measurements and the related uncertainty reduction. An application to data (radiosonde, Raman lidar, infrared, microwave radiometry observations) from GRUAN sites (ARM SGP 2010-2012, Potenza 2011-2012, and Sodankylä 2011) has been considered in this study. Initial results imply that there are distinct changes in the reduction of uncertainty with different instrument combinations. This may imply that, based upon such a toolset, useful advice can be provided to new contributing sites or contributing sites that need to change their instrument mix, as to what changes might be most beneficial. Initial analyses indicate how a microwave radiometer is an indispensable tool for estimating the integrated water vapor at GRUAN sites.

6.8.3 Membership

GATNDOR is actively recruiting new members working on current and new topics of interest. Two new members have joined the team. A call for a Ph.D. position for working on a new GATNDOR topic: "Assessment of the impact of comparison model error: use of GRUAN uncertainty covariance matrix and assessment of best vertical resolution to use in RTM modeling for improving satellite validation" has been circulated in April 2012, but is still pending a funding decision.

6.9. Proposals for new task teams

Greg Bodeker discussed the possible need for the creation of new task teams. Several of the task team reports highlighted crosscutting issues, which would benefit from closer cooperation between the

task teams. A synthesis task team may work on combining the results of the different task teams and on the homogenization of the different recommendations. This task team would have to have members from all task teams. The meeting discussed this issue in detail and agreed not to proceed with a synthesis task team at this time.

For the development of a new ozonesonde data product a new task team has been suggested. This task team could potentially include members from outside the GRUAN community and advise GRUAN on the best path forward and could address some of the scientific issues that will arise in the development of this product. However, it was pointed out, that the GRUAN philosophy is not to duplicate efforts undertaken elsewhere, but rather to partner with these groups and to build on existing knowledge. Therefore, it was decided not to form a dedicated ozonesonde task team, but rather to liaise with the relevant experts. The meeting was attended by Herman Smit, Head of the World Calibration Centre for Ozonesondes at the Research Centre Jülich, Germany. It was agreed that GRUAN would cooperate with this centre in the development of the ozonesonde data product.

During ICM-4 a task team on metadata had been proposed. Draft Terms of Reference have been written for this task team and were circulated in advance of the meeting. The goals of this proposed task team would be to identify and categorize metadata requirements for GRUAN and exchange mechanisms, to provide guidance on generic site metadata requirements, to review instrument specific guidance to ensure that all necessary metadata recognized and captured, and to regularly review GRUAN metadata holdings. The meeting decided that this task team is highly relevant and that the formation of such a task team should proceed. Its formation now depends on finding co-chairs and members sufficient to form a viable task team and the WG co-chairs were charged with taking this forward with support from GCOS / WMO.

7. Status of proposed new data streams

7.1. GRUAN Lidar product development

The GRUAN lidar guide that was prepared by Thierry Leblanc and the task team Ancillary Measurements (TT-AM) defines requirements and the underlying philosophy of GRUAN lidar measurements. The fundamental measurement of lidar instruments is a number density of scattered particles. Various aspects of this measurement can be interpreted in terms of the physical properties of the column. The initial target Essential Climate Variables (ECVs) are temperature, water vapour and ozone. Aerosols are also observed, but much harder to quantify as a GRUAN measurement including uncertainties. All lidars participating in GRUAN are associated with at least one other measurement programme. As part of GRUAN, data will be exchanged under agreed protocols through a dedicated data collection tool (Lidar Run Client) and processed at a central processing centre. Raw data will be captured and archived and the Lidar Run Client should be run at least weekly. Certification and training procedures are envisaged to ensure that lidars are sufficiently similar. Lidar data types will conform to the data types as detailed in the GRUAN Guide. If resources permit, the default scheduling should be continuous operation of the lidar (24/7). Where resources are limited there should at least be several long night-time runs per week to get the best possible measurements. The Lidar Run Client is based upon the RS Launch Client used for data collection in balloon soundings and adapted to the different measurement properties of lidar systems.

There are a total of 22 processing steps which require the estimation and propagation of the associated uncertainty across the lidar processing suite for the four lidar streams of interest to GRUAN. These are of greatly varying complexity with some uncertainty components being correlated and some uncorrelated. Some sources of uncertainties can be reduced or removed by instrument improvements or optimizations of the measurement practices. Through standardization of the processing some of the differences between lidar programmes can be reduced whilst recognizing that future innovations will likely occur. Calibration practices currently differ vastly between sites and ideally would be standardized. However, this may currently not be achievable and it is possible, at least theoretically, to work around this issue. The recommendations by the NDACC / ISSI team will be implemented across NDACC and possibly GRUAN in 2014. This will enable a quantification of uncertainties that are comparable across measurement programmes, despite the differences in the processing.

7.2. Bringing ozonesondes into GRUAN

Greg Bodeker outlined the plans to bring ozonesonde data into GRUAN. He stressed that this work will be achieved in collaboration with existing expert groups to avoid duplication of efforts and maximize use of existing knowledge. GRUAN may contribute a unique holistic estimation of uncertainties and the experience of the existing groups can help achieve these aims. How protocols and best practices are linked to the quantification of uncertainties needs to be established. Important aspects are:

- Estimating degradation in pump efficiency
- Measuring the pump flow rate
- Effects of different sensing solutions
- Effects of stoichiometry on response times
- Treatment of background current
- Measuring pump temperature
- Determining the partial ozone column above the top of flight
- Contribution of radiosonde to net error
- Different sondes including BM, ECC and CI
- Absolute calibration of the ozonesonde instrument

Several additional intricacies over and above radiosonde measurements need to be understood. The meeting discussed whether the responsibility for ozonesondes should be added to the radiosondes task team. Although there are some similarities and although the radiosonde related issues are also impacting the ozonesondes data, it was decided not to task the radiosonde task team with including ozonesondes into their agenda. Instead it was agreed, that Greg Bodeker would work with existing expert groups to further this endeavour and report on progress at ICM-6.

7.3. Bringing frostpoint hygrometer measurements into GRUAN

Several steps have been accomplished in the development of a frostpoint GRUAN data product. These steps revolve around the detailed quantification of the uncertainty of the components contributing to the overall measurement, specifically:

- Contamination in upper part of profile
- Appropriate ground check
- Cross-checking between Boulder and Lindenberg
- Dual soundings
- Preparing for a lab intercomparison at AIDA chamber

The speed of creating a GRUAN frostpoint hygrometer data product has been slowed down by a lack of dedicated resources to move the development of this stream forwards.

7.4. Bringing microwave radiometers measures into GRUAN

Nico Cimini gave an overview of the efforts to create a global network of microwave radiometers, which currently consists of 94 sites. Microwave radiometry is a passive measurement technique, which is capable of taking observations in all but the most severe weather conditions. The instruments provide data in real-time and can monitor the atmosphere continuously. They do, however, require regular calibration and maintenance. A variety of instrument types and manufacturers exists across about half of the GRUAN sites, measuring atmospheric profiles of humidity and temperature, although, with a coarse vertical resolution. A big advantage of these instruments is that they provide unique information about the liquid water path.

Connections with GRUAN have grown over the past three years. Current efforts are focused upon defining best practices and quantifying measurement uncertainties. The calibration of microwave radiometers relies upon a combination of black body targets maintained at two temperatures; internal noise diodes; tipping curves; and cryogenic targets. This technique has excellent long-term stability, but all methods of calibration have some practical limitations in the field. Therefore, several different methods are generally used to reduce the measurement uncertainty. Practices have improved such that the calibration frequency can be reduced. The issue for GRUAN is whether these measurements are traceable to an SI standard or not and it has still to be clarified whether any of these methods count as a relative standard. The US National Institute of Standards and Technology (NIST) is currently working on a microwave radiometer blackbody, but this has not yet been used as standard.

An uncertainty analysis can be provided, based upon the variational retrieval and expert model-based priors, which should be consistent with guidance in the Guide to the expression of uncertainty in Measurement (GUM)[10] regarding such uncertainties.

The site at Payerne has undertaken substantive analyses of their microwave radiometer data and found significant jumps in some channels caused by the calibration techniques. There have also been significant research efforts at Lindenberg and on the data from the ARM Southern Great Plane site. Typical reported uncertainties are 0.5-2 °K for the vertical profile of temperature, 0.2-1.5 g/m^3 for the water vapour profile and around 1 mm for the precipitable water vapour. It was clarified that there are really two or three degrees of freedom in the vertical domain in the measurements so fine vertical structure features will not be captured.

A microwave radiometer GRUAN Guide is currently in preparation. This work is based on the work of other networks, most notably MWRnet, which is an international network of microwave radiometers including 61 members and more than 90 radiometers. Support for this network has come from an EU COST action. A proposal with the intent of linking GRUAN and microwave radiometers to the EU FP7 unfortunately was not funded. Meeting participants recognized the substantive efforts that Nico Cimini and colleagues have made towards bringing a GRUAN microwave radiometer stream into existence.

7.5. Bringing FTIR measurements into GRUAN

Martine De Maziere presented an overview of FTIR observations and related projects. NDACC FTIR installations are costly at a typical price of US$ 500.000 per instrument. These instruments measure the solar spectrum and although being able to operate under all day-light conditions usually are run only under clear sky conditions. These instruments are able to simultaneously observe a long list of atmospheric constituents including water vapour and its isotopologues and many of the greenhouse gases (GHG). FTIR instruments operate at a spectral range of 750-4500 cm^{-1} with high resolution. The Total Carbon Column Observing Network (TCCON) is a network for very high precision observations of the total column amounts of CH_4, CO_2, N2O, H_2O, CO and other trace gases. Standardization of the observations within TCCON is achieved through the use of instruments from only one manufacturer and a common algorithm in the retrieval of the trace species.

A holistic list of sources of uncertainties has been defined and efforts are being made to identify methods to quantify these uncertainties. For water vapour there are about three degrees of freedom for tropospheric water vapour, allowing some very coarse resolution vertical profiles. The aim for a GRUAN data product for FTIR measurements is a similar approach as TCCON, where a common algorithm is used for all observations. This requires homogenizing analysis methods across sites, which will require some effort due to current site-to-site differences within GRUAN.

A workshop at NCAR in January 2013 has addressed the uncertainty analysis and homogenization issues. Mathias Schneider (MUSICA project) is working on the consistency of water vapour measurements from ground-based FTIR and satellite (IASI), including vertical sensitivity and uncertainty. Within MUSICA datasets from 1996 through 2011 (roughly 15000 profiles), will be processed in a central data processing facility. As self-reference oxygen column measurements are also retrieved and serve as reference, since they are directly related to the atmospheric pressure at a site. Comparisons of water vapour profiles between FTIR and the Vaisala RS92 sonde show good correlation.

Data for the MUSICA project are provided in GEOMS compliant HDF format with ancillary data on surface temperature and pressure. A key unresolved issue for FTIR observations is that no central storage appears feasible due to the very high volume of spectroscopic data. Uncertainties at each point are currently being worked on as well as traceability to spectroscopic data (TCCON referenced to in-situ standards). Due to the similarity in goals, it is suggested that TCCON becomes a GRUAN affiliated network.

[10] International Bureau of Weights and Measures (BIPM), 2008: Evaluation of measurement data – Guide to the expression of uncertainty in Measurement; available at: http://www.bipm.org/en/publications/guides/gum.html

8. Site reports

8.1. Overview

Dale Hurst reviewed the changes to the site representatives task team membership and discussed the accomplishments during the previous year. The issue of co-location is essential for a number of contributing sites. In some cases the instruments are spread out over a large area and therefore all sites are requested to provide a map (including the elevations), that show, where the instrumentation is located. The site application of Lindenberg could serve as an example for how this map is expected to look like. In the long run, the toolkit being developed by GATNDOR should help with this assessment of co-location issues.

Common issues among the site reports are the roles of different instruments in GRUAN and whether the community is sure of the uncertainties (at the measurement level, existing interdependencies, inverse/forward models). This is an issue in particular for the relationship between remote sensing instruments and in-situ radiosondes. Different methods to use this relationship are being used within GRUAN, e.g. the microwave radiometer may be used to calibrate radiosondes and vice versa. GRUAN may require a clear statement, which remote sensing variable is more suitable for comparisons. Due to issues in the inverse model it may be beneficial to use forward models and do the comparisons in brightness temperature space instead of geophysical profile space. Since GRUAN requires the storage of raw data, the storage of brightness temperatures is already required, allowing further studies on this subject in the future.

Managing change is a central issue affecting all sites and great care has to be taken regarding personnel, resources and equipment. The use of common tools such as the RsLaunchClient is seen as important to work towards the best possible homogeneity of the network. It is essential that contributing sites have change management plans in place, which will be invoked, when change events are about to happen. ARM for example will not implement a change until the management process has been completed and reviewed. Contributing sites are requested to notify the Lead Centre of any upcoming change and briefly discuss the course of action and the expected implications.
Currently only three contributing sites perform manufacturer independent ground checks for radiosondes using the standard humidity chamber. It was suggested that sites should gather on a joint action to acquire this instrument, since the cost per unit is highly dependent of the number of chambers being ordered and a discount can be reasonably expected if ordered in bulk. Sites were also encouraged to consider the installation of webcams that may record the conditions at time of observation as shown for Ny Ålesund.

It was noted that contributing sites have very different degrees of forward planning towards the 2017 IP goals. Therefore, sites should work towards clarification of their longer-term intentions, e.g. which data streams would likely be submitted to GRUAN as and when the data streams are developed and mature. The sites representatives task team agreed to collate responses.

It was recognized that contributing sites or potential new sites had little in the way of documentation as to the benefits of undertaking certification and the value that GRUAN participation may bring to a site. The Lead Centre and WG co-chairs acknowledged that this was an issue and Mr Bodeker volunteered to lead the production of a short document which outlines what is the value of GRUAN participation to the contributing sites.

8.2. Lauder (remotely)

Olaf Morgenstern called in from Lauder, New Zealand to report about the current status of the site, operated by the National Institute of Water and Atmospheric Research (NIWA). Alan Thomas, who is senior technician running the equipment at the site, joined this call. The site is currently going through a transitional period. During 2012 three scientist positions have been cut and a new instrument scientist position has been created. This position, which when filled will take over the role as GRUAN representative, has not yet been filled creating some level of uncertainty. NIWA hopes to have the hiring process completed shortly.

Lauder has upgraded its receiving system for Vaisala RS92 radiosondes and has acquired a Digicora 3 ground system. During 2012, Lauder launched 52 ozone soundings using the RS92 radiosonde and

is currently recording all soundings using both the old and the new receiving equipment. Monthly frostpoint soundings, which are supported by NOAA, have been launched. Sonde data are not yet uploaded to the Lead Centre, but the site will start doing so shortly using the RsLaunchClient. The site staff is working with the Lead Centre to implement the GRUAN standard operating procedures to reach GRUAN goals.

A GPS receiver has been installed with support by the GNSS task team and has been operational since May 2012. This GPS receiver is a dual-purpose receiver and serves both the geological community as well as the atmospheric community. The data are currently being sent to JMA for analysis, but NIWA has applied for funding to install processing software locally. They are ready to share the data with a GRUAN central processing centre.

Funding for a standard humidity chamber to better characterize the radiosonde instruments prior to launch is currently requested. The current pressure sensor is being updated and the site should receive an electronic pressure transducer.

During ICM-3, which was held near the site at Lauder, the collaboration with the New Zealand Metservice had been discussed. The participation of a NZ MetService representative at that meeting had been seen as fruitful. However, presently no coordination of efforts is taking place.

8.3. Cabauw

Arnoud Apituley discussed the changes that happened at Cabauw over the preceding year. In summer 2012, KNMI decided to reduce the radiosonde frequency from two soundings per day to one sounding per day. Voluntary observations of KNMI staff maintained the noontime launches through to the end of 2012. Since the start of January 2013, KNMI launches only one radiosonde per day at midnight at its central facility in De Bilt. Ozone soundings are maintained at a frequency of once per week. The standard humidity chamber, which had been acquired in June 2012, is used for the test of Vaisala RS92 sondes only as part of ozone soundings. The results are currently being reviewed. Cabauw is at present not using the RsLaunchClient, but rather transmitting all soundings using an automated script. This process is not in the interest of GRUAN, since no changes in the operating procedures can be transmitted and relevant metadata are likely to be missed. In particular the ozone sonde data have incomplete metadata and KNMI is currently working on the implementation of the RsLaunchClient to address this situation.

At the Cabauw Experimental Site for Atmospheric Research (CESAR) a Raman lidar is measuring water vapour. The calibration of this lidar using measurements on the tall tower is currently under investigation. This lidar system is currently being expanded to also measure temperature. A lab prototype is currently being tested.

8.4. Lindenberg

Ruud Dirksen presented the summary of recent work at Lindenberg. The standard humidity chamber has been used extensively and the results have been used as an additional rejection criterion for sondes that show measurements outside the acceptable range of 5%. This measurement is an important contributor to the uncertainty budget. Comparisons between the Vaisala RS92 and the cryogenic frostpoint hygrometer (CFH) at Lindenberg, Sodankylä, Yangjiang, and Alajuela show deviations of up to 10% in the temperature range between -30°C and -60°C. These deviations need to be studied more closely, since they are part of the calibration correction applied to the Vaisala RS92. Day-time results including the comparison between the frostpoint hygrometer flown at Boulder and the Vaisala RS92 show good agreement up to tropopause for some sites, but a dry-bias is seen at others.
Lindenberg also tests the Graw DFM-09 radiosonde. The humidity sensor on this instrument is unheated and therefore icing issues need to be considered in addition to time lag. The data quality currently limits water vapour observations to the troposphere. There is a non-negligible warm bias in the temperature measurements of about 0.5K and a higher variability in the RH compared to the RS92.

Radiation experiments on Vaisala RS92 in the pressure range from 4 hPa to 1000 hPa were repeated both with a laboratory lamp, as well as with real sunlight. These measurements generally show good agreement with the fit used in GRUAN processing, and may refine this analysis. At low pressures the effect of the sensor time lag even on the temperature sensor becomes noticeable. These radiation

experiments can be done for new sondes to be included into GRUAN and other contributing sites are invited to cooperate with the site at Lindenberg in this effort.

8.5. Ny Ålesund

Marion Maturilli summarized the status of the site at Ny Ålesund. This contributing site was the first to complete the site application process and is the first site that is an officially certified GRUAN contributing site. The radiosonde launch procedures now include standard Vaisala GC25 ground check, the standard humidity chamber, and an outside comparison with a reference station. All data are being sent to the Lead Centre. The standard humidity chamber has been upgraded to include a temperature check. The workload to achieve this required some preparation of procedures and documents, but the additional effort operationally is not very high (5-10 min additional work per sonde).

Ozonesondes are normally launched once per week, but may be increased to two per week in winter and more during campaigns. The site is part of the NDACC network and is involved in data homogenization.

Fluorescent Advanced Stratospheric Hygrometers for Balloon (FLASH-B) have been flown once per month during winter for stratospheric water vapour observations. It is planned to change the stratospheric water vapour observations to CFH sondes to allow year round observations and to reduce the number of technical difficulties.

The metadata collection at the site includes surface radiation data (BSRN), cloud cover (ceilometer), and snow cover. Daily webcam pictures during the nominal balloon launch time from the higher Zeppelin site are archived to document site changes.

Raman lidar focus has been on aerosols, but is currently being expanded to water vapour observations. The dryness of the site and background light levels limits the altitude achievable in particular during summer months.

At the site, additional remote sensing instrumentation is operated such as a GPS-PW receiver and a microwave radiometer, and it is intended to provide these data as GRUAN products as soon as possible.

8.6. SIRTA and La Réunion

Martial Haeffelin presented the preparations at the GRUAN candidate sites SIRTA and La Réunion. These sites are gearing up to becoming GRUAN sites and are working on aligning their operations with those required by GRUAN. The activities have focused on the development of radiosondes (Modem), lidar and GPS. The ROSEA network of French observatories measuring water vapour for climate is gearing up to include GRUAN observations. IPSL and MeteoFrance have a cooperation agreement on GRUAN objectives. The French radiosonde manufacturer MODEM is committed to provide raw data and support for measurements. Modem is very interested in the participation in GRUAN.

At Réunion Island, weekly ozone sondes are being launched by the University of La Réunion as part of the SHADOZ and NDACC networks. A field campaign is planned in April 2013 with a focus on lidar calibration (Sonde + GPS) and radiosonde intercomparison (Modem M2, Modem M10, and Vaisala RS92). The Maïdo observatory was inaugurated in 2012 and houses the new NDACC lidar. First water vapour profiles were taken in October 2012.

At SIRTA a new Raman lidar for water vapour, clouds and aerosols is being developed, with first measurements expected in 2014. GPS-PW observations are processed using the NASA/JPL software. The comparison of one year of data between the SIRTA GPS-PW and the nearby Modem radiosondes show a small bias.

A Sonde-GPS-Lidar comparison took place in late 2007 at the Observatoire de Haute Provence. The results of this campaign were presented at the ISTP9 L'Aquila in 2012 and at the 2012 AGU fall meeting including an optimal method for lidar calibration.

Future activities will concentrate on the uncertainty evaluation and validation for the new Modem M10 radiosonde and evaluate the impact of GRUAN procedures on resource requirements. This evaluation will be part of the decision whether to proceed with GRUAN participation or not. If the decision is made to implement GRUAN procedures and to move on to site certification, this step is expected in the time period 2014-2015.

Meeting participants welcomed the efforts of these sites and the Modem manufacturer to attain GRUAN status. In particular the partnership between the candidate sites, the manufacturer, and the Lead Centre was seen as a promising model.

8.7. ARM Sites

Doug Sisterson provided an overview of ARM sites. During the last year two new permanent sites have been established plus two additional mobile facilities. The new permanent sites are located on the Azores, at Graciosa Island, and in the Arctic at Oliktok near Barrow, Alaska, where remotely piloted vehicles can be flown. The Southern Great Plains (SGP) site has been restructured from a 325 km x 275 km footprint to 150 km x 150 km. The central facility at SGP site is strongly affected by fracking operations, impacting aerosol and trace gas measurements and by a new large wind farm nearby, which creates false radar signals. Negotiations are under way to minimize the impact of these developments. The ARM site at Nauru, which has been considered a potential GRUAN site and has shared RS-92 data with the Lead Centre, will close permanently from August 2013, with the exception of the BSRN measurements, which will continue.

ARM radars are now deployed at various sites and an extensive set of aerosol and trace gas instrumentation has been installed to provide data to improve climate models. The SGP site had a series of smaller sites and boundary facilities around the central facility (31 sites), which have been reduced in number to 21 sites.

ARM is now working to report uncertainty of all its data products including Value Added Products (VAP). The methods of the Guide to the GUM are used as basis for the uncertainty approach, defining accuracy, precision (including variability in the field), resolution and traceability for each data stream. This information is given to data users, including a changing uncertainty across profile.

The Department of Energy (DOE) hosted a US / European Workshop on Climate Change Challenges and Observations looking to harmonize activities between the US and Europe.

ARM is working with instrument mentors to refine and update procedures, such as the 100% humidity check to bring its operations in line with GRUAN operations and state of the art procedures undertaken by others. ARM has recognized that to date ARM uncertainties have been primarily based on vendor specifications. This is now being reviewed, which may well highlight areas for potential improvements. ARM is ready to collaborate with other groups working on the uncertainty for different instrument types. However, care has to be taken about the use of ‘accuracy’ in this context. ‘Accuracy’ is usually a qualitative description of an instrument, but not a quantitative measure for uncertainty.

8.8. Sodankylä

Rigel Kivi summarized the activities at Sodankylä and the linked site at Pallas. This site has been launching twice daily soundings (00/12 UT) using the Vaisala RS92 radiosonde in an autosonde system. Near-simultaneous manual and autosonde launches have been carried out for several years. ECC ozonesondes are launched once per week and have usually been timed to coincide with the autosonde launch.

Water vapour measurements in the UTLS are being done regularly with 6-12 CFH launches per year, plus additional soundings during intensive campaigns. FLASH hygrometers and Vaisala RR01 research sondes are being launched infrequently. The comparison of the GPS-PW and PW derived from the Vaisala RS92 showed an annually averaged bias of 3.3%.

The Mobile Atmospheric Raman Lidar (MARL) has been refurbished and is operating again since November 2012. A new cloud radar has been installed in 2012 and a HALO Doppler lidar was due in Feb 2013. A CIMEL sun photometer system is scheduled for March 2013 and a new Brewer spectrometer is expected soon. The new Vaisala RR01 sonde includes a DRYCAP humidity sensor,

which has originally been developed for ultra-dry industrial gases. Comparisons between the RR01 and the CFH showed reasonable agreement in stratosphere including observing stratospheric layers, though there are indications of a wet bias in the troposphere.

The Autosonde launcher performance has been assessed using data from a number of stations. Autosonde launcher data include a range of ancillary information and metadata. The comparison between the autosonde data and the parallel (within ~20 min) manual soundings show no significant bias in either temperature or relative humidity. This result has also been grouped by loading time, with no indication that the time of loading autosonde instruments has any influence on a possible bias. The site is currently studying the implementation of the standard humidity chamber in their operations.

8.9. Payerne

Rolf Philipona from MeteoSwiss reported the status of the station at Payerne. Currently this site launches the Meteolabor radiosonde SRS C34 twice daily and performs regular multi-instrument soundings: bi-weekly daytime SRS C34 and RS92 plus bi-weekly night-time SRS C34, RS92 and Meteolabor Snow White.

The temperature comparison shows a systematic difference between the Meteolabor sonde and the Vaisala sonde of about 0.2 °K during night-time and 0.3 °K during daytime. There is also a significant difference between the bias in the troposphere and in the stratosphere. The pattern of this difference is comparable to that observed during the international radiosonde intercomparison at Yangjiang.

The site has carried out soundings with multiple temperature sensors and a vertical plate separating two pairs of sensors, such that one pair is exposed to sunlight, while the other is shaded. These experiments have lead to a significant revision of radiation correction, which had been used in Yangjiang. Further tests with different thermocouple wire thicknesses carried out in the Lindenberg radiation chamber using a Xenon lamp showed a comparable correction of the radiation error. The effects can be matched to the expected impact from the modeled radiative transfer giving cooling at lower elevation, heating in the UTLS and cooling again at higher elevation (for night-time flights). Using these measurements, the uncertainties on SRS-C34 temperature profiles for day and night measurements have been re-evaluated. Currently the site does not perform a manufacturer independent check of the temperature measurements, but may consider it in the future.

8.10. Potenza

Fabio Madonna summarized the GRUAN related activities at the CNR-IMAA Atmospheric Observatory (CIAO). Vaisala RS92 radiosondes are launched once per week at 01:00 local time to coincide with satellite overpasses. These sondes are launched from a Vaisala autosonde launcher. Stratospheric water vapour is not yet measured, but the goal is to start a programme of one measurement per month. An external ground check is being developed in cooperation with the Istituto Nazionale di Ricerca Metrologica (INRIM).

Previously documented issues with the autosonde launcher have been resolved and software and sensors have been upgraded. The time of launch has been moved to 01:00 starting in November2012 following discussions with Tony Reale to optimize satellite coincidences. All Raman lidar water vapour measurements carried out together with sonde launches have been analyzed.

CIAO also operates a microwave profiler, a ceilometer, and aerosol measurements. Radiation measurements are not yet operational but should be soon. In 2013 it is planned to install a lidar super ceilometer, a Raman depolarization lidar, a sun and sky photometer, as well as an in-situ aerosol monitor. CIAO closely cooperates with a proposal to the Italian Space Agency to establish an Italian network of Raman water vapour lidars for satellite validation. For further information, the site has created a new web page: www.ciao.imaa.cnr.it.

8.11. Beltsville

The site report for Beltsville was given by Belay Demoz. This site has performed Vaisala RS92 launches once per week and has funding in place to continue for the next three years. ECC ozonesondes are launched once per month, but may be ramped up to two to three per day during special pollution study campaigns during summer. This site is expecting to start CFH launches once

per month soon. Two Raman lidars are currently being installed and the site is in collaboration for an expansion of the ceilometer network. Several DIAL water vapour lidar are being tested, which may potentially be much simpler than Raman lidars.

Currently soundings are targeted for NPP night-time satellite overpasses in parallel with lidar measurements. These data can be used to implement and evaluate the Site Atmospheric State Best Estimate (SASBE) concept.

The lidar group at the site is studying a lamp mapping technique for lidar calibration in favour of sonde calibration. A Multi-instrument comparison of IPW over five years shows reduced variability with the lamp calibration compared to the sonde calibration. There followed some debate over the advantages and disadvantages of the different techniques of calibration for lidars and it is clear that this is a topic that remains very much open within the lidar expert community at this time. If a calibration technique can be attained that removes any explicit links to radiosonde data this would clearly be beneficial.

8.12. Boulder

Dale Hurst showed comparisons between the Intermet Imet-1 and the Vaisala RS92 radiosondes as part of the dual launch programme at Boulder. These launches are performed weekly as part of the ozonesonde launch programme and monthly as an addition to the frostpoint observations.

Since the sondes are often launched one below the other on a single line, the original time stamps cannot be used to synchronize both data streams. The time lag between the different data streams is evaluated using an optimized correlation coefficient. The temperature differences between the Intermet radiosonde and the Vaisala RS92 are in the range of 0-0.5 K and are statistically significant in the altitude region between 12 km and 18 km. The pressure differences are in the range of 0-3 % and increasing with altitude, though not statistically significant. The relative humidity data of the Intermet Humirel sensor showed biases larger than 15 %RH in the upper troposphere. This has improved with the use of the E+E sensor on more recent models with biases of less than 5 %.

Boulder has been launching frostpoint hygrometers to measure stratospheric water vapour for over 30 years. The comparisons of these observations with satellite observations by the Microwave Limb Sounder (MLS) onboard the Aura satellite agree to better than 3 %. However, the comparison with the long-term monthly zonal averages of HALOE and MLS do not show a consistent picture. The MLS and the frostpoint hygrometers show good agreement, whereas observations by the HALOE instrument onboard the UARS satellite show a time varying and negative offset. These differences are currently not well understood.

Mr Hurst announced the NOAA Global Monitoring Annual Conference in May. A strong GRUAN representation during this meeting might send a strong message about the importance of GRUAN for climate research.

8.13. Xilinhot

Li Wei expressed his thanks to the support from the GRUAN community in the effort to bring the CMA site at Xilinhot to GRUAN standards. Specifically, the visit by June Wang to CMA and the presentation she made on GRUAN as well as the technical input from Lead Centre have provided some visibility within CMA and gave an opportunity for the deputy director of CMA to visit the facility. As a result the Xilinhot GRUAN activity now has official support from CMA and the provincial meteorological bureau with clear targets for the year and potential financial support for future developments.

CMA is currently testing two new radiosonde designs using small bead thermostats and the E+E humidity sensor. They hope to put one of these into operation in 2013 following an intercomparison in June/July. Radiosonde development includes an enlarged cap and the installation of an extra temperature sensor under the radiation cap protecting the humidity sensor. In one example, he showed a difference between internal and external temperature of up to 10° K. CMA is also testing different temperature sensor mounting structures. In all tests the measurements are referenced to Vaisala RS92 radiosondes. Mr Wei is planning to submit a workplan to CMA and is hoping for the support of the GRUAN Lead Centre in this effort. After selection of the suitable radiosonde system for Xilinhot, work with the manufacturer to assess the uncertainties will be required with input from the Lead Centre.

8.14. Tateno

Toru Ueda has taken on the role as site representative for Tateno following the ICM-4 in Japan in 2012. Regular measurements at Tateno include two Vaisala RS92 launches per day, weekly ECC ozonesonde launches, GPS PW, Dobson spectrophotometer total ozone column, and all BSRN radiation measurements. After a transition from the Meisei RS2-91, the Vaisala RS-92 sondes have now been used for three years. The change management of that transition has been published recently and included over 100 comparison flights spread out over four intensive periods covering the four major seasons. Seasonal differences in the profile comparisons of pressure, temperature and humidity were investigated for varying number of soundings, mixing both daytime and night-time soundings. A recommendation was made to launch at least 20 dual soundings during each season to achieve a significant comparison and to minimize the statistical uncertainties in the establishment of any mean bias. Participants welcomed the publication of this study and the support that JMA had provided to GRUAN in changing their plans to enable such an in depth replacement flight campaign and subsequent analysis. A number of participants had further technical questions on the outcomes of this replacement campaign and its analysis. It was clarified that all this data is held by the Lead Centre and available for further study by the research community.

8.15. Format of site report presentations during ICM-6

Greg Bodeker presented some slides on the future of the site presentations day on behalf of the WG-GRUAN. As the number of sites increases, it may at some point not be possible to allow each site to give a detailed site report in the current format. The meeting therefore discussed whether a change should be recommended for the next meeting. It was suggested that discussions are considered the most important aspect of the meeting, and the information relayed during the site presentations may be better presented primarily in a written document in advance of the meeting itself. However, since GRUAN is still in the implementation phase, there is still the need for sites to be able to present their achievements in front of the entire community. Furthermore, not being able to present results in person may bear the risk that some sites reduce their participation in the process. However, dedicated science presentations not relevant for the implementation of GRUAN should be held at dedicated science conferences and presentations at GRUAN meetings should be focused on the implementation of GRUAN. The WG co-chairs stressed that the main intention was that there was a day that was for the sites and ideally run by the sites and it was probably best that the sites manage that day rather than following some prescribed structure. There followed active discussion between participants and the WG-GRUAN and site representatives co-chairs to attempt to ascertain whether the day could and should be changed to be made more relevant to the contributing sites and their needs.

The meeting agreed on the following process. The Lead Centre triggers an annual site report, by sending contributing sites a summary of all data and metadata that were received at the Lead Centre or any other respective processing centre. This feedback gives contributing sites the opportunity to cross check the amount of data being sent to the processing centres and to make sure that the metadata received are correct. Using this information, the contributing sites prepare a structured report, which gives some guidance on the information expected as part of the report, but which leaves ample room for report any issues they wish to raise. Sites will submit this structured report to the co-chairs of the sites representatives task team and the WG-GRUAN at least four weeks prior to the ICM. The WG-GRUAN will provide suggestions to the site task team co-chairs as to what issues arising may warrant discussion at least two weeks before the ICM. The sites task team co-chairs would then structure the site day accordingly based around discussions lead by presentations on selected issues. Since no significant increase in the number of sites is expected in the immediate term the sites should receive ten minutes time to present their report, whereby it is expected, that at least half of this time is reserved for site specific discussions.

9. The integration of GRUAN within the scientific and meteorological community

9.1. EU Workshop “Toward an integrated observing network for Europe”

Gelsomina Pappalardo presented the outcomes of a workshop on a pan-European observation system for geosciences, as part of the Integrated Global Observing System and as a component of

the European research area. The European Strategy Forum on Research Infrastructures (ESFRI) was set up to support a coherent and strategy-led approach to policy making on research infrastructures in Europe and to facilitate multilateral initiatives leading to a better use and development of research infrastructures. The Forum has decided to set up strategic working groups for assistance of several domains, of which one is “Environment and Climate Change”. The planning for Horizon 2020 involves a road map of 48 research pan-European infrastructures, including 9 in environment, one of which involves CO_2, another involves instruments on commercial aircraft, and a third involves atmospheric observations at Svalbard. New initiatives are possible; some could involve some specific non-European partners (e.g., US, Australia). There will be workshops to coordinate planning; first draft report planned for end of 2013. Ms, Pappalardo solicited input from the GRUAN community to several projects (IAGOS, ICOS, and ACTRIS). However, there is a need to be clear about the distinction between monitoring networks, research infrastructures, and research networks. The long-term vision includes moving research infrastructure to operational services, which are expected to be supported by the national meteorological services. GRUAN in Europe is already strongly linked to ACTRIS. Current work involves building critical mass and links to existing networks and international programmes. The international cooperation is being promoted as well for example in a workshop in Washington DC, with the aim to coordinate US and European efforts, and in particular coordinate work with ARM.

The aim for long-term sustainability should be stressed, which GRUAN partners are trying to maintain as well. Although observations might not be supported by ESFRI, research and other activities might be. Therefore, getting GRUAN involved with ESFRI might open some possibilities for new funding sources. Within such a large network, data comparability would be a good focus within Europe.

9.2. Interactions with the metrology community

Andrea Merlone discussed interactions with the metrology community through MeteoMet, which is a large project involving all European national metrological institutes. Planned activities involve events, conferences, and training. MeteoMet has placed a focus on traceability for surface and upper-air observations. The project Aquavit 2 focuses on the traceability of atmospheric water vapour measurements. The second work package focuses on the saturation vapour pressure formula. The third work package focuses on ground-based meteorological observations, which developed a small facility for calibrating temperature, pressure and humidity observation. There is a joint committee to harmonize the GRUAN Guide with the GUM, using consistent, universal, and transferable use of the term uncertainty. There is a 2013 European call for proposed projects, which is supported by WMO. Suggested focus areas are an update of the water vapour pressure formula, a standard radiation shield for radiosonde temperature sensors, as well as several others. Some funding opportunities are available for European partners and Mr Merlone is currently seeking support and advice. The deadline to propose topics is 15 March 2013; full proposals will have to be submitted later. In October 2013, a symposium on temperature and thermal measurements in industry and science will be held in Funchal, Maderia, Portugal. This symposium will include a session on the environment.

9.3. NWP and reanalysis

David Tan discussed interactions with NWP and reanalysis. Currently the SPARC Reanalysis/Analysis Intercomparison Project is in its preparation phase and will have its first workshop in April in Exeter. A second project, CoreClimax, began in January 2013 and aims to examine the connection between reanalyses and climate services. These projects could benefit from possible GRUAN/GUAN connections, where GUAN provides a large data volume, while GRUAN provides reference-quality data and is able to propagate best practices, which may be used in the cal/val of satellite observations. GRUAN data could potentially help to resolve some differences among differing datasets.

During ICM4, it was agreed that feedback from analysis centres should be sent to data providers and appended as metadata to GRUAN measurements. This project is slowly taking shape. Takuya Komori from JMA is working with the GNSS-PW data from June Wang, performing comparisons with ECMWF forecasts. There is a new web interface for reanalysis data from ECMWF, including both output fields and input data. Now surface pressure and sea-surface temperatures, including the 20th century reanalysis interpolated sea-surface temperature results are available at this web interface. There is some enthusiasm, that GRUAN will be the “go to” group for reference-quality data and best practices

in observing the atmosphere. Mr Tan encouraged the meeting and called for patience and persistence.

9.4. Impacting other networks

Holger Vömel discussed the role of GRUAN in impacting other networks and improving observations that are not directly taken in the context of GRUAN. The most immediate network which is indirectly related to GRUAN through its sponsor is GUAN, but also sites that use sondes, which will be included in GRUAN data streams, particularly sites that use Modem and the future Chinese radiosonde. A closer cooperation between GUAN and GRUAN on a regional or global scale could for example help GUAN stations provide high-resolution data instead of the more common low resolution TEMP formatted data. MeteoFrance is open to the collaboration with GRUAN through its two candidate sites SIRTA and La Réunion. Likewise CMA expressed its desire to work well with GRUAN.

It was pointed out that concrete steps taken in this direction should be highlighted during a planned GRUAN launch event, in particular if it were in conjunction with a WMO Executive Council meeting. The meeting decided that the Lead Centre will take action on a closer cooperation between GRUAN and GUAN and work through its sponsor to achieve this goal.

10. KNMI science and Cabauw site visit

As at previous ICM's, the meeting included a site visit with a guided tour of the suite of instrumentation operating at CESAR, which is the prime experimental site for boundary layer meteorology and remote sensing of KNMI. CESAR has a more than 40 year history and plays an important role for the study of boundary layer processes, observations of the free troposphere and climate research. In addition, KNMI allowed meeting participants to witness the preparation and launch of their weekly ozonesonde from De Bilt. Participants regarded these activities as very valuable, allowing deeper insight into how KNMI addresses GRUAN-related issues. Participants in particular appreciated the local staff's hospitality and willingness to answer questions.

As part of the site visit scientists of KNMI and the Dutch geodetic institute presented their work and aspects felt relevant to GRUAN. Ankie Piters presented vertical profile studies of ozone and nitrogen dioxide from the OMI satellite instrument in comparison with the more than 20 years of ozone sonde data. KNMI have also developed and tested a balloon borne instrument to measure NO_2 using chemo-luminescence. It has been launched 30 times in the last 4 years with a typical ceiling altitude of 10 km. There is large variability in profiles with substantial vertical structure which is not typically correlated with water vapour. In theory, it could measure high up, but the solution is prone to boiling. It works through chemiluminescent reaction principles - the reaction of NO_2 with luminol and the light is detected with photodiodes. The electronics amplify the signal which eases interpretation. Surface based intercomparisons suggest an uncertainty of < 10 % but absolute value determination is unknown at present. The sonde participated in DISCOVER-AQ. There are plans to transition towards a production sonde capability.

Anne van Gijsel discussed satellite profile validation using lidar observations. She pointed out that standardization such as that stated as a goal within GRUAN is needed in the validation of satellite observations. There is also the question of what data to report in what manner which has implications for subsequent analyses. There are lidar-to-lidar differences in the apparent performance of the satellite that change through time implying issues in individual lidar programmes contribute substantively to current analysis uncertainty.

Lennard Huisman reported about the reprocessing of 17 years of GPS data from the Dutch geodetic GPS network. The network consists of nine stations operating continuously that typically store at 30 second resolutions. The GPS heights are benchmarked against second-order and first order benchmarks. The first order benchmarks are underground in what is thought to be a stable sand layer. The individual time series from different GPS differ in their characteristics. There is a need to understand what aspects arise from changes in software / processing so need a reprocessing of the entire set. Obvious seasonal cycles in early data implied issues have been better understood over time. This has obvious implications for the importance of retaining raw data, metadata and reprocessing that will apply to GRUAN data analyses.

Reinout Boers showed an example of missing change management and its disastrous impact on the 150 year record of cloud fraction. Changes in land usage in the Netherlands further impact the interpretation of long-term observations and in particular the attribution of atmospheric processes. In his presentation, Mr Boers highlighted the importance of planned change. He closed by cautioning that allowing free data access is not the end of the path but rather the beginning. He cautioned that many users will interpret the data according to strongly held priors and interpret it accordingly.

Gerrit Burgers asked “Is there a business case for AMDAR humidity measurements?” which stimulated a lively discussion about the valuation of different atmospheric observations. Although AMDAR profiles may be cheaper than typical radiosonde observations, there are concerns that the decrease in quality and loss in vertical coverage may impact climate studies and hurt long -term trend estimates.

11. Next meeting

It was agreed to hold the next ICM in the Washington, DC area near the GRUAN site at Beltsville. The proposed dates for this meeting are 10-14 March 2014, but are flexible pending coordination by the organizing committee. It may be coordinated with an ARM users meeting in this area (i.e. schedule not in conflict with that meeting). Special efforts will be made to engage both local scientists and relevant US federal agencies.

The meeting closed by thanking Arnoud Apituley and the KNMI hosts for their excellent hospitality.

12. 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-5 is intended to be specific and clear. Major action items have been separated from minor action items, but both categories will be tracked and discussed in the next meeting.

12.1. 2013-14 GRUAN work plan

No	Action	WHO	Deadline
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
2	Technical documents for GRUAN Lidar stream submitted for review by WG-GRUAN.	TT-AM	Mar. 2013
3	A paper on "Co-location 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
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
5	Retention of collocated satellite / sonde / NWP data within or linked from the GRUAN data archive to facilitate intercomparisons.	TT-AM	Jun. 2013

6	Develop a calibration/validation concept for the EUMETSAT geostationary MTG series based on GRUAN sites.	TT-AM / WG	Jun. 2013
7	A paper on "Quantifying the value of complementary measurements" submitted to a peer reviewed journal.	Madonna	Jun. 2013
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
9	FTIR Technical documents submitted for review by WG-GRUAN.	TT-AM	Jun. 2013
10	Formal establishment of Metadata Task Team – list of members provided to Lead Centre.	WG co-chairs	Jun. 2013
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
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
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 their development. Simple table. (To be delivered to WG, LC and other task team chairs by this date).	TT sites	Jun. 2013
14	Temperature scheduling requirements study	Gardiner	June 2013
15	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)	TT radiosondes / Lead Centre	Jul. 2013
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
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
18	GRUAN report synthesizing the four white papers developed through the GRUAN network expansion workshop.	Bodeker + NEW participants and collaborators.	Nov. 2013
19	A short GRUAN report detailing the process implemented to provide feedback of observation minus background fields to the GRUAN Lead Centre.	Tan / LC	Nov. 2013
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

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 / LC / TT sites	Nov. 2013
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
23	Manuscript(s) detailing operational considerations for controlled descents submitted to a journal or detailed in a GRUAN Report.	TT radiosondes	Dec. 2013
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
25	TD omnibus of all things RS-92.	Lead Centre	Dec. 2013
26	Technical documentation completed for frostpoint hygrometer measurements.	LC / TT radiosondes	Dec. 2013
27	First report on data usage including items such as publications arising, queries received etc.	Lead Centre	Feb. 2014
28	Paper describing the RS-92 product submitted to journal.	Lead Centre	Feb. 2014
29	Manuscript describing the derivation of uncertainty estimates for GNSS-PW measurements submitted to a peer reviewed journal.	TT GNSS-PW	Mar. 2014
30	Short report for inclusion in ICM-6 proceedings summarizing sites processed to date.	WG co-chairs	Mar. 2014
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
32	GRUAN launch activity as agreed between GRUAN participants.	WG co-chairs, Lead Centre, secretariat	May 2014

12.2. Minor action items, which are being tracked elsewhere

- Sites who wish to get a 100% pot to coordinate through Lead Centre (Sites through March 2013)
- Add item to Lead Centre progress report to document training given / received by the Lead Centre and others (Lead Centre, next report).
- Ascertain why some sites are not utilizing the run client facilities (Lead Centre)
- Ascertain whether KNMI can share the RS92 data using the run client (WG co-chairs / AOPC)
- Follow up with GFZ to thank for offering to be GNSS processing centre. (Lead Centre)
- GCOS Secretariat to be asked to formalize role of GFZ as a processing centre within GRUAN (Lead Centre).
- To raise discussion of external assessment at ICM-6 based upon developments in interim.(WG co-chairs)

- Raise a request that AOPC consider how to facilitate GUAN-GRUAN cooperation. How does GRUAN innovation percolate to GUAN / GOS? Put something prior to launch event at EC? (Peter Throne)
- Liaise with Tim Oakley on formalizing ties to GUAN operations (Lead Centre).
- Raise at AOPC the concept of paired sites in the context of network expansion. Plus financial support mechanisms. (Peter Thorne)
- Check that WG “shalls” in Guide and Manual WG are pulled out. WG members be asked to take responsibility for certain aspects to ensure things don’t fall through the cracks. (Greg Bodeker)

Appendix 1 Review of actions in from ICM-4 (GCOS-161)

No	Action	Deadline	Achievement
1	Set up an online repository of all actions, whether they rise to work plans, within year report commitments or IP items. Community owned. Managed by WG-GRUAN chairs. (Bodeker)	May 2012	Completed. A spreadsheet was created and shared with the community. Uptake rates have varied.
2	Discuss with Task Team chairs and WG-GRUAN members how to proceed on creation of metadata task (metadata that is not necessarily instrument specific, but necessary for complete understanding; ensuring metadata consistency between data streams). Report via the blog. (LC, co-chairs)	Sep 2012	Partially completed. Proto terms of reference have been circulated with the meeting materials. However, this was converted into an ownerless action item due to lack of resources.
3	To process 4 or more sites with a focus on those who may benefit from early certification to undertake certification. Work with TT site representative co-chairs in this. (LC, WG, TT sites)	ICM-5	Partially completed. One site certified, one application in process, two additional solicited. This action item remains in effect.
4	RS-92 pre-launch documentation to be revised and submitted as a TD by the summer (LC, TT radiosondes)	Sep 2012	Partially completed. Additional information from some sites is required to complete.
5	Assessment of RS92 (and others?) time lag humidity corrections, comparing the GRUAN processing to other published approaches to be undertaken and submitted to a journal (LC, TT radiosondes)	ICM-5	Partially completed.
6	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. (TT radiosondes)	Sep 2012	Partially completed. Require additional input from several groups / sites to complete.
7	Assessment of auto-sounder influence vs. manual launches to be written up and submitted to the peer reviewed literature (TT radiosondes)	Sep 2012	Partially completed. Information has now been collated and this should be completed by summer.
8	Provide the theoretical basis for GRUAN uncertainty estimates for GNSS-PW. Submission to peer reviewed literature. (TT GNSS-PW)	ICM-5	Partially completed. There has been some significant progress but it is not ready for submission yet.
9	Report on discussions with LC and others on starting the GNSS-PW data flow. Data collection client requirement? Central processing facility? (TT GNSS-PW)	ICM-5	Completed. The meeting presented the results of these discussions. A central processing facility has been identified and a subsequent action item was created.
10	Extend trend sensitivity studies analysis to stratospheric water vapour and submit the resulting analysis to the peer reviewed literature. (Depending on funding)	Dec 2012	Not done.

11	Develop and publish online tools using the NPROVS system to visualize the GRUAN products (incl. uncertainty) and collocated satellite data (GPROVS?) and possibly SASBE products. (TT-AM)	Dec 2012	Partially completed. Progress was presented at ICM-5
12	GRUAN Lidar Technical document (incl. all species) submitted for WG-GRUAN review. (TT-AM)	Dec 2012	Partially completed. Version almost ready for formal review after internal TTAM review.
13	Complete the matrices of measurements started and try to be as detailed as possible taking into consideration new updates, changes, etc. available at the gruan.org web site. (TT sites, LC)	Oct 2012	Completed.
14	Co-location . Identify if the instruments at a site are collocated or distributed and details of the distribution (distance, ownership, etc). Include maps etc. (TT sites)	May, 2012	Partially completed. Some work on co-location for a subset of sites and its ramifications has been undertaken. However, this action item was cancelled due to lack of focus.
15	Submission of a peer-reviewed paper about the topic "Quantify the value of complementary measurement" (GATNDOR)	ICM-5	Partially completed. Paper is being drafted.
16	Peer-reviewed paper about the topic "Co-location of observations" with an emphasis of how to account for mismatches in quantifying and comparing uncertainties (GATNDOR).	Submitted by ICM-5	Partially completed. Report was presented at ICM-5. Action item remains in effect.
17	Development of initial frostpoint hygrometer product and associated technical document. Initial data and advanced draft of technical document available for consideration at ICM-5. (LC / Hurst)	ICM-5	Partially completed. This action item remains in effect.
18	Post online monitoring reports, graphics etc. and link from the NCDC ftp area to make aspects more accessible to the end users. Also link to a (still under development) 'GPROVS' portal. (LC)	Submitted by ICM-5	Partially completed. First monitoring reports have been created and were presented at the meeting. They have not yet been published online. Action item has been extended.
19	Work with sites not launching RS-92 to further development of the processing streams for their standard radiosondes (LC).	ICM-5	Completed. A report was presented and a further action item was developed during the meeting.
20	Create a pedagogical paper (AMT, BAMS?) and supporting materials (online primer / tutorial) illustrating how to propagate not just the GRUAN best estimate but its uncertainty across a span of likely GRUAN applications.	ICM-5	Not done. Has been stayed indefinitely due to lack of owner.
21	Create a formal amendment to the Implementation Plan. To cover through 2016. To be submitted by September 1st to GCOS (AOPC) for consideration as a GCOS report. (WG-GRUAN co-chairs)	Oct 2012	Completed. A draft was completed and discussed at the meeting. A subsequent action item was created.

22	Create a draft technical document on surface meteorological measurement requirements (T, P, U) in support of in-situ and remote sensing activities at GRUAN sites to include aspects on frequency of reporting, calibration and upkeep. (Thorne).	ICM-5	Not done. Has been stayed indefinitely pending resources being available.
23	Work with CIMO / HMEI to discuss how best to incorporate a GRUAN invited talk / talks / town hall / other as appropriate presence at the TECO meeting in Brussels in the autumn of 2012 to allow discussions with manufacturers. (CIMO, LC)	ICM-5	Completed. The Lead Centre was invited to give a keynote address, which was presented by Holger Vömel

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Appendix 2 Status on minor work plan items

- ✓ Completed items
  - o Partially completed
  - x Not completed

- ✓ Propose revisions to terms of reference and membership of WG-GRUAN to AOPC members prior to their late April meeting. WG-GRUAN chairs.
- ✓ Formally instigate and manage GRUAN Technical Documents review protocol as documented in the WG-GRUAN meeting outcomes.
- ✓ Assess the site application currently under consideration and others received as detailed in the site assessment and certification document.
  - o Manual and Guide finalized and signed off, formally adopted and published. (Bodeker)
    - ✓ Remove 'intermediate station' from guide section 5
    - ✓ Change name of 'fully compliant station' (work with sites Task Team to find acceptable terminology)
    - ✓ Tom Gardiner and Andrea Merlone to work with Greg Bodeker on uncertainty language throughout.
    - ✓ Remove seasonally variant scheduling language from guide but retain language that this might be important later.
- ✓ Radiosonde Task Team to resolve second co-chair issue along agreed WG-GRUAN procedures.
- ✓ The radiosonde Task Team will circulate their CIMO intercomparison summary for wide review and then submit to formal review as a GRUAN report by WG-GRUAN by the summer.
- ✓ Further efforts will be made to assess controlled descent mechanisms for balloon payloads. A paper will be prepared on the Payerne solution. Topic to be discussed further at ICM-5. (Hurst, Philipona, Fujiwara)
- ✓ Develop guidance on GNSS-PW data through a GRUAN GNSS data and product table. September 2012. (TT GNSS members)
- ✓ Identify best practices in making and verifying GNSS observations. Report at ICM-5. (TT GNSS members.)
  - o Recommend practices on managing change in GNSS-PW measurements. Presentation at ICM-5. (TT GNSS co-chairs.)
  - o Review of temperature scheduling requirements (as already done for water vapour in the Guide) for scheduling decision support. Presentation at ICM-5. (TT co-chairs.)
  - o Retention of collocated satellite radiances within or linked from the GRUAN data archive to facilitate intercomparisons. Report at ICM-5. (Reale, Sommer)
  - x Investigate use of satellite co-location data as an additional QC/QA tool on GRUAN products over the coming year and report at ICM-5. (Reale, Sommer)
- ✓ Report on progress towards gaining a lidar data stream including run clients and uncertainty estimation. Presentation at ICM-5. (Leblanc)
  - o First draft of Technical Document on bringing microwave radiometer measurements into GRUAN, leveraging MWRnet expertise. Summer 2012 circulated to TT AM members. (N. Cimini and N. Kämpfer.)
  - o First draft of GRUAN FTIR Technical Document, leveraging MUSICA, made available to TT AM members for comment. Summer 2012. (Schneider, Hannigan)
  - o Inventory of AERI instruments to be compiled for TT AM consideration and report to GRUAN community on viability to bring AERI into GRUAN. By ICM-5. (Schneider, Hannigan)
  - o Inquire to EARLINET colleagues on the status of their Centralized Data processing Algorithm and study possible synergy between EARLINET and GRUAN. Report at ICM-5. (Apituley, Leblanc)

- Investigate essential “recipe” of GRUAN ancillary and sonde measurements (including uncertainties) to calculate SASBE with focus on atmospheric temperature and moisture for NPP satellite hyper-spectral products validation. Report to TT AM by ICM-5. (Tobin.)

✓ GATNDOR work plan published for coming year. To be published on the blog. (Madonna)

✓ Circulation of a Ph.D. position for working on a new GATNDOR topic: "Assessment of the impact of comparison model error: use of GRUAN uncertainty covariance matrix and assessment of best vertical resolution to use in RTM modeling for improving satellite validation”.

Appendix 3 Meeting agenda

GRUAN 5th Implementation and Coordination Meeting
De Bilt, Netherlands
February 25th - March 1st 2013

Day 1 (Monday)

Day chair: Arnoud Apituley, Rapporteur: Roger Atkinson

08:00 – 09:00	Registration

Session 1. Welcome

09:00 – 09:10	Welcome from local organizers, practical venue information – Arnoud Apituley
09:10 – 09:20	Welcome from WG-GRUAN co-chairs and aims of workshop
09:20 – 09:35	GRUAN basics for new GRUAN ICM participants – Holger Vömel
09:35 – 10:00	Keynote(s) – Dr. Frits Brouwer (director, KNMI)
10:00 – 10:30	Coffee break

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

10:30 – 11:00	Progress check against ICM-4 Agreed work plan - Peter Thorne
11:00 – 12:00	Progress report from Lead Centre - Holger Vömel
12:00 – 13:00	Lunch
13:00 – 14:00	GRUAN IP refresh: bringing GRUAN to operational status – Peter Thorne and Greg Bodeker
14:00 – 14:45	Network expansion workshop report and subsequent plans including potential new sites to come into GRUAN and update on certification and assessment progress to date – Greg Bodeker
14:45 – 15:15	Coffee break
15:15 – 15:45	GRUAN data flow and RS-92 data stream v2 – Michael Sommer / Ruud Dirksen
15:45 – 16:00	Guide and Manual – Greg Bodeker
16:00 – 16:45	GRUAN technical documents and special reports: status and plans / requirements – Greg Bodeker / Peter Thorne
16:45 – 17:00	Interactions with partner networks and activities incl. NDACC MoU – Peter Thorne / Greg Bodeker
17:00 – 17:30	Discussion of size and membership of WG-GRUAN – Peter Thorne / Greg Bodeker
17:30 – 18:00	Open discussion on day 1 reports as required

Day 2 (Tuesday)

Day Chair: Peter Thorne, Rapporteur: Russ Vose

Session 3. Updates from GRUAN task teams and GATNDOR

08:30 – 08:45	Overview of radiosonde task team activities – Rolf Philipona
08:45 – 09:00	Controlled descent report – Dale Hurst
09:00 – 09:15	Impact of multi-payload configuration – Hannu Jauhiainen
09:15 – 09:45	Overview of task team GNSS-PW – June Wang / Kalev Rannat
09:45 – 10:00	GNSS-PW data stream development – June Wang / Kalev Rannat
10:00 – 10:30	Coffee break
10:30 – 11:00	Overview of scheduling task team – Tom Gardiner / Dave Whiteman
11:00 – 11:30	Preparation for a large scale change in radiosonde software and hardware – Holger Vömel
11:30 – 12:00	GATNDOR update – Fabio Madonna / Alessandro Fassò

12:00 – 13:00 Lunch

Session 4. New data streams and managing change

13:00 – 13:15 The importance and use of uncertainties in GRUAN data – Holger Vömel
13:15 – 13:45 Overview of task team on ancillary measurements – Thierry Leblanc / Tony Reale
13:45 – 14:00 Bringing in radiosonde data that is not RS-92 – Holger Vömel / Michael Sommer
14:00 – 14:15 Ozonesonde product development – Greg Bodeker
14:15 – 14:30 Progress on a frostpoint hygrometer data stream – Holger Vömel
14:30 – 15:00 Proposals for new task teams and task team modifications (to include metadata task team, potential broadening of radiosonde team etc.) – Greg Bodeker / Peter Thorne

15:00 – 15:30 Coffee break

15:30 – 16:00 GRUAN Lidar product development incl. ISSI uncertainty estimates – Thierry Leblanc
16:00 – 16:30 Discussion of issues arising in day 2
16:30 – 18:00 Task Team side meetings

19:00 Social dinner in Utrecht
A reservation will be made at the historical location „Stadskasteel Oudaen". Participation is at your own expense. Please indicate your participation by Monday 4 March at lunchtime. Transportation from KNMI to the city will be by public transport (bus)

Day 3 (Wednesday)

Day Chair: Holger Vömel, Rapporteur: Tom Gardiner

08:30 – 09:00 Bringing Microwave radiometer measures into GRUAN – Nico Cimini
09:00 – 09:30 Bringing FTIR measurements into GRUAN – Martine De Maziere

Session 5. Site reports and updates

09:30 – 09:50 Update from sites task team (to include a discussion on how to catalogue instrument co-location issues) – Belay Demoz / Dale Hurst
09:50 – 10:10 Lauder – Olaf Morgenstern (remotely)
10:10 – 10:30 Cabauw – Arnoud Apituley

10:30 – 11:00 Coffee break

11:00 – 11:20 Lindenberg – Ruud Dirksen
11:20 – 11:40 Ny Ålesund – Marion Maturilli
11:40 – 12:00 SIRTA and La Réunion - Martial Haeffelin

12:00 – 13:30 Lunch to include the ozone sonde launch from the KNMI main facilities in De Bilt

13:30 – 13:50 ARM sites – Doug Sisterson
13:50 – 14:10 Sodankylä – Rigel Kivi
14:10 – 14:30 Payerne – Rolf Philipona
14:30 – 14:50 Potenza – Fabio Madonna
14:50 – 15:10 Beltsville – Belay Demoz

15:10 – 15:40 Coffee break

15:40 – 16:00 Boulder – Dale Hurst
16:00 – 16:20 Xilinhot – Li Wei
16:20 – 16:40 Tateno –Toru Ueda

16:40 – 17:15 Discussion of issues arising from site reports – Peter Thorne

17:15 – 18:00 Discussion of format for site report presentations at ICM-6 – Greg Bodeker

Day 4 (Thursday)

08:30 – 12:00 Presentations by KNMI scientists on Cabauw site science and GRUAN

12:00 – 18:00 KNMI Cabauw site visit – boxed lunches on the bus
The Cabauw site is in a rural area. Depending on the weather, the soil may be wet and muddy, so do not bring your best shoes and you may want to have an umbrella with you. After the Cabauw visit we will drive the bus to pass by the windmills of Kinderdijk, a UNESCO world heritage site. The bus will take us directly to the harbour of Rotterdam where the Euromast is located, where we will have dinner.

19:00 – 22:30 GRUAN Dinner at the Euromast Tower, Rotterdam
Expected cost 50€ per person, including admission to the tower. Transportation will be provided. On return, the bus will drop people off at the city centre in Utrecht if needed and at the Biltsche Hoek.

Day 5 (Friday)

Chair: Greg Bodeker, Rapporteur: Dian Seidel

Session 6. Funding and European visibility

08:30 – 09:00 Outcomes of EU workshop 'Towards an integrated observing network for Europe' – Gelsomina Pappalardo
09:00 – 09:20 Interactions with the metrology community – Andrea Merlone
09:20 – 09:40 Interactions with the NWP and reanalysis communities – David Tan
09:40 – 10:00 GRUAN visibility at conferences and planned GRUAN event – Peter Thorne

10:00 – 10:30 Coffee break

10:30 – 10:40 Break out group report: Task Team Ancillary Measurements
10:40 – 10:50 Break out group report: GNSS-PW
10:50 – 11:00 Break out group report: GATNDOR co-location

Session 7. Sundry programmatics

11:00 – 11:15 Discussion on need for a review of the GRUAN data delivery from a user perspective – Greg Bodeker
11:15 – 11:25 Use of GRUAN data and impacting other networks – Holger Vömel
11:25 – 11:35 Support of stations in developing countries – Greg Bodeker
11:35 – 11:45 Discussion of who polices that we do what we say we are doing. Who ensures that documentation is followed – Greg Bodeker
11:45 – 12:00 Reserved for discussion of issues arising from Friday morning – Peter Thorne
12:00 – 13:00 Lunch

Session 8. Closing

13:00 – 15:00 Agreement on new 12 month plan and next steps
Time and place of next ICM – Peter Thorne
15:00 Close

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Appendix 4 List of participants

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Appendix 5 Lead Centre report

GRUAN Lead Centre progress report 01/2013 covering the period 08/2012 to 01/2013	
Author Holger Vömel GRUAN Lead Centre Lindenberg Meteorological Observatory – Richard Assmann Observatory German Meteorological Service (DWD)	
Summary The GRUAN certification of the site at Ny Ålesund was the first to be completed by the Working Group and the Lead Centre. The sites at Lindenberg, Cabauw and Lauder are currently going through the certification process following the procedures established in the first certification. Progress has been slowed down to due staffing shortages. The GRUAN Lead Centre has participated in several conferences and workshops. Preparation of ICM-5.	
Health of network No update from last report.	
Progress against stated objectives	
Open items	Summary of progress
2. Discuss with Task Team chairs and WG-GRUAN members how to proceed on creation of metadata task (metadata that is not necessarily instrument specific, but necessary for complete understanding; ensuring metadata consistency between data streams). Report via the blog. (Sep 2012)	Terms of references have been drafted and commented. One Lead Centre staff will be member of this Task Team.
3. To process 4 or more sites with a focus on those who may benefit from early certification to undertake certification. Work with TT site representative co-chairs in this. (ICM-5)	The site application for Ny Ålesund has been completed and the site has been formally certified. The application for the site Lindenberg has been handed in to the WG-GRUAN. The application materials have been sent to the representatives of Cabauw and Lauder. The application material is being completed by Cabauw and should be passed on to the WG-GRUAN prior to ICM-5. Completing the application material by a Lauder representative is on hold until that position has been filled.
4. RS92 pre-launch documentation to be revised and submitted as a TD by the summer (Sep 2012)	The completion of this task has been delayed due to staffing shortage at the Lead Centre.
5. Assessment of RS92 (and others?) time lag humidity corrections, comparing the GRUAN processing to other published approaches to be undertaken and submitted to a journal (ICM-5)	The task is in progress. Comparisons of the time lag correction with that by Miloshevich have taken place. The completion of this task has been delayed due to staffing shortage at the Lead Centre.
17. Post online monitoring reports, graphics etc. and link from the NCDC ftp area to make aspects more accessible to the end users. Also link to a (still under development) 'GPROVS' portal. (Oct 2012)	Monitoring reports are being created for all sites, but have not yet been made available for common use. Monitoring reports will be refined to show site specific issues as well as processing specific issues (currently in progress). The completion of this task has been delayed due to staffing shortage at the

	Lead Centre.
18. Work with sites not launching RS92 to further development of the processing streams for their standard radiosondes. Report at ICM-5 on progress. (ICM-5)	The Lead Centre is working with the site at Payerne to include the raw data stream into the GRUAN data flow and to support the site in the development of a GRUAN processing for the Swiss radiosonde. The radiation experiments that were performed at Lindenberg have been analyzed and show the principal equivalency of the correction derived at Payerne and measured at Lindenberg. Discussions with CMA about the preparation of a Chinese made radiosonde have started. The Lead Centre is working with the site to overcome some initial obstacles.
21. Work with CIMO / HMEI to discuss how best to incorporate a GRUAN invited talk / talks / town hall / other as appropriate presence at the TECO meeting in Brussels in the autumn of 2012 to allow discussions with manufacturers. (Aug 2012)	A GRUAN keynote talk was given at the TECO meeting by a Lead Centre representative. Discussions with Vaisala, Graw, Intermet, and Modem took place.

Achievements

Ny Ålesund was the first site to pass the GRUAN certification. As part of the certification process, standardized application material and instructions were developed to help sites in the completion of the application and the guide the Working Group in its evaluation. This application material was sent to the sites at Lindenberg, Lauder and Cabauw. Discussions with site representatives are ongoing to refine the application process. The site at Lindenberg has completed its application and sent it to the Working Group.

All Vaisala RS92 raw data collected so far have been reprocessed as Version 2 of the GRUAN data product (RS92-GDP v2). This reprocessing included some bug fixes of the GRUAN processing routines, a change in the radiation correction for the humidity measurements and slightly changed rejection criteria for the acceptance of data.

Processing of data from the ARM sites has been improved from irregular batch processing to near real time processing and is now available at NCDC.

In cooperation with the Table Mountain Observatory of JPL the Lead Centre has started a development of a LidarRunClient. This program will support lidar stations in the collection of raw data and standardized metadata.

During a meeting between the Lead Centre and the Geoforschungszentrum Potsdam (GFZ) the GRUAN principles were discussed in relation to GNSS measurements of integrated precipitable water vapour . GFZ expressed interest in acting as processing Centre for GRUAN GNSS IPW observations. This issue is being discussed in the GNSS task team.

In January a meeting took place between the Lead Centre and Environment Canada in Toronto. GRUAN principles were discussed and the possibility of bringing in one or several EC sites into GRUAN. No actions were taken. A follow up is needed.

The Lead Centre has participated in the preparation of ICM-5.

The Lead Centre participated in the second workshop on the GEWEX water vapour assessment

A Lead Centre member was co-convener of the upper tropospheric / lower stratospheric water vapour session at the 2012 fall meeting of the American Geophysical Union.

Lead Centre operations

The Lead Centre operations have been impacted by staffing shortages through parenting leave, voluntary work time reductions, and additional tasks placed on the staff within the observatory.

Issues

The status of the site at Lauder is uncertain. Due to staffing reductions at the site, the past GRUAN representative was terminated. A new person is being hired by NIWA, who is expected to take over this role. The impact of this change will be looked at as part of the site certification.

Progress in the development of the frostpoint GRUAN data product and the ozone product have been slowed down due to lack of resources.

Work plan for next six months

Completion of Cabauw and Lauder site certification application

Completion of the GRUAN RS92 data product documentation First draft of the frostpoint GRUAN data product documentation First draft of the ozone GRUAN data product documentation

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Appendix 6 Task team radiosonde progress report

SUMMARY

Francis J. Schmidlin retired in October 2012, but agreed to continue to be within the task team. Joseph Facundo retired in January 2013 and was removed from the member list; but, still reachable through Howard Diamond and Belay Demoz. Carl Bower retired in July 2012 and was removed from the member list.
Due dates of some of the tasks have been changed according to the development of the GRUAN Implementation Plan 2013-2017.
Between September 2012 and January 2013, we had some progress. See below for the details.

Current member list:

Name	Affiliation	Status
Masatomo Fujiwara	Faculty of Environmental Earth Science, Hokkaido University, Japan	co-chair, member of WG-ARO
Rolf Philipona	MeteoSuisse, 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 TASKS REPORTED ON THE PREVIOUS REPORT

Task: Review of the WMO Intercomparison report
Main Contact: Miloshevich and Philipona
Due Date: 2012
Status: finished
Milestone: Lessons from the WMO report are summarized, and review is made from the GRUAN viewpoints. Will be a GRUAN report.
Progress: Published as a GRUAN Report #2.
Issues: None

Task: RS92 pre-launch procedure (TD5)
Main Contact: Dirksen, Miloshevich, Fujiwara
Due Date: August 2012 (originally)
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. Expected to be completed by December 2012. Need some more time.

Task: Time-lag correction issues (including intercomparisons) for RS92 RH measurements

Main Contact: LC (Dirksen, Sommer), Miloshevich, Kats, Fujiwara
Due Date: A paper submitted to a journal by August 2013
Status: Started
Milestone: Various time-lag correction schemes will be compared to create the best correction scheme for GRUAN
Progress: Test calculations were made by Larry Miloshevich.
Issues: Waiting for the GRUAN Lead Centre for further actions.

Task: Multi sounding configuration
Main Contact: Jauhiainen
Due Date: drafted by August 2013
Status: Ongoing
Milestone: Recommendation for the multi sounding configuration is made for GRUAN
Progress: A questionnaire sheet was sent (and re-sent) to several groups, and some responses have been received
Issues: Need some more time to receive more responses

Task: Use of descent data and control descent
Main Contact: Philipona, Hurst et al.
Due Date: Presentation and discussion at ICM-5 (Manuscript by December 2013)
Status: Ongoing
Milestone: The use of descent data and controlled descent for GRUAN sounding is discussed in a document
Progress: Regular descent sounding is made at Boulder and Lauder. Some experiments were made at Lindenberg, Payerne, and NCAR (and under a tropical project named SOWER).
Issues: Still in the experimental phase.

Task: RS92 auto-launcher influence
Main Contact: Kivi, Madonna, Kizu
Due Date: A journal paper submitted by August 2013
Status: Ongoing
Milestone: Influence/effects of using the auto-launcher system is documented
Progress: Information has been summarized at Sodankylä (Kivi), Potenza (Madonna), and Tateno (Kizu)
Issues: None

Task: Chilled-mirror hygrometer data product document
Main Contact: Vömel, Hurst, Philipona, Fujiwara
Due Date: TD by March 2014
Status: Ongoing
Milestone: A GRUAN Technical Document is prepared (for CFH, NOAA-FPH, and Snow White), which include the information on the uncertainty estimation method
Progress: Works are being made by each group
Issues: None

Appendix 7 Task team GNNS-PW progress report

SUMMARY

Besides working on the tasks #4 … #7 and the data flow listed below, the GNSS-PW TT has also been involved in the following activities:
Efforts have been made by the TT and LC on finding candidates for GNSS-data Central Processing. Three institutes expressing interests in hosting the central processing, NOAA (from Seth Gutman), UCAR/COSMIC (from John Braun) and GFZ (from Galina and Jens). A side meeting is set up at ICM5 to discuss this and try to make the decision. The TT thinks that beside the central processing centre, it is also good to have individual analysis centre to process GRUAN data for comparisons, similar to the structures in IGS and E-GVAP.
Jonathan Jones from UK Met office is a Chair of a new COST proposal, “GNSS applications to extreme weather and climate”. The action has officially started, with TT-members participating.
The TT helps Lauder site with advice and to process and validate their GNSS PW data. The TT and Dan Smale from Lauder site have close collaborations. The Lauder Trimble NetR9/zephyr2 GNSS system has been operating continuously since May 2012 with no faults or data quality issues. Yoshinori Shoji processed the data and created the ZTD product. The work is underway to inter-compare with the FPH and FTIR data and the nearby GNSS and radiosonde PW data.
A TT conference call was held on February 7, 2013. Besides discussing the tasks we are working on, the TT also discussed the future of the TT after finishing the tasks listed in the ToR. We agreed that we all are willing to continue to serve (at minimum) until the “GRUAN GNSS-PW” data become available, are inter-compared with other GRUAN data and are used for other applications.
The TT is working on updating the GNSS-PW site survey table by including a new site, Ny Ålesund.

PROGRESS ON TASKS REPORTED ON THE PREVIOUS REPORT

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/John/Seth
Due Date: 9/30/2012
Status: almost finished
Milestone: “GRUAN GNSS Data and Product Table” & “Format Specification for COST-716 Processed GPS Data”
Progress: The TT reaches the consensus that GRUAN should adopt the E-GVAP format, which is detailed in ““Format Specification for COST-716 Processed GPS Data”. The “GRUAN GNSS Data and Product Table” is a summary of the former document and only needs a clean-up to remove the comments.
Issues:

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: before ICM5
Status: Almost done
Milestone: A document
Progress: Jonathan and Siebren de Haan are currently working on a revised document which will be a joint WMO CIMO/GRUAN doc. An updated version (which can take into account anyone's input) can be available in a week or two's time (i.e. in time for everyone to review prior to the ICM5).
Issues:

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/June/Tong/John
Due Date: before ICM5
Status: Moving along

Milestone: A document and later a journal paper

Progress: This task is based on Tong Ning's thesis work. Additional work is to develop algorithm to estimate the uncertainty of zenith tropospheric delay. The TT acknowledges that the first priority is to understand, quantify and correct the systematic errors (biases) in ZTD. John has an idea to use the ZTD measurements within a "reprocessing" of the coordinates at the same time interval that you have estimated the ZTD value. If you would use the previously estimated ZTD as the apriori in a solution that only calculates the height (maybe lat/lon/height) then you might be able to capture the error sources that are significant for the individual ZTD time window.

Issues: This would not capture the errors with spectra with periods longer than a day, and needs to be tested and validated.

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: Geroge/Kalev/June

Due Date: before ICM5

Status: Moving along

Milestone: A document describing recommended practices on managing change in GNSS-PW measurements

Progress: A draft document is prepared.

Issues: Need to shorten it, add more specific requirements, and get TT members' consensus on this.

Task in GNSS-PW data flow: " To report on discussions with LC and others on starting the GNSS-PW data flow. Data collection client requirement?Central processing facility? "

Main Contact: Kalev/June and others

Due Date: before ICM5

Status: Moving

Milestone: The sites send the raw data (RINEX files) to the LC

Progress: The TT reaches the consensus that the RINEX files should be sent to the LC and centrally archived. So the TT members can analyze and evaluate the data, and publish the results.

Issues: We need to ask the LC to send the data flow document to the sites. Then the sites will start to implement it to submit the data to the LC.

Appendix 8 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.

PROGRESS ON TASKS REPORTED ON THE PREVIOUS REPORT

Task: Bibliography of relevant information sources
Main Contact: Tom Gardiner
Due Date: 31-May-2012
Status: Complete*
Milestone: Prepare a document that identifies and briefly summarizes the sources of information (papers, reports, etc) relevant to the scheduling issues.
Progress: First draft of Bibliography document sent to Task Team members for comments.
Issues:* This will be an on-going activity with bibliography extended as new references become available.

Task: Stratospheric water vapour trends
Main Contact: Dave Whiteman
Due Date: 31-Dec-2015
Status: On hold - pending funding
Milestone: Extend trend sensitivity studies analysis to stratospheric water vapour and submit the resulting analysis to the peer reviewed literature.
Progress: Proposal submitted to NASA MAP program for support of this effort. DW lead.

Issues: Awaiting response to proposal.

Task: Resolve differences in times to determine trends
Main Contact: Dave Whiteman
Due Date: 30-Jun-2012
Status: On hold – pending funding.
Milestone: Review the reasons for the difference in the time to detect WV trends in Boers and Whiteman papers.
Progress: No activity possible until funding in place.
Issues: Immediate activity linked to success of NASA MAP proposal.

Task: Temperature scheduling requirements.
Main Contact: Tom Gardiner
Due Date: 25-Feb-2013
Status: Complete*
Milestone: Review of temperature scheduling requirements (as already done for WV in the Guide) for scheduling decision support.
Progress: First draft of temperature requirements document sent to Task Team members for comments.
Issues: Available literature focuses on long-term trend detection requirements. More citable material needed for other GRUAN objectives. * New objective needed for documenting combined scheduling advice.

Task: Scheduling summary document
Main Contact: Tom Gardiner & Dave Whiteman
Due Date: 31-May-2012
Status: Complete

Milestone: Prepare guidance on scheduling issues for inclusion in GRUAN manual.
Progress: Scheduling guidance included in GRUAN manual.
Issues:

Task: TT membership
Main Contact: Tom Gardiner & Dave Whiteman
Due Date: 31-May-2012
Status: Complete
Milestone: Confirmed list of at least 5 TT members including site representation.
Progress: Rigel Kivi has joined the Task Team, bringing total membership up to 7.
Issues:

Task: ITS Presentation and Paper
Main Contact: Tom Gardiner
Due Date: 31-May-2012
Status: Complete
Milestone: Presentation/paper on GATNDOR at GRUAN session at the 9th International Temperature Symposium.
Progress: Presentation made and paper accepted for publication.
Issues:

Appendix 9 Task team ancillary measurements progress report

SUMMARY

This report is presented as an updated to the August 2012 report, noting:
Lidar guidelines submitted to this task team will be presented at ICM-5.
A draft document on microwave radiometer guidelines has been circulated by Nico Cimini et al.
A draft document on FTIR guidelines is currently under preparation.
Following a visit by Michael Sommer to the Table Mountain Facility in December 2012, a first version of LidarRunClient was worked on and Michael will present the outcomes at ICM-5. The first truth-testing will occur when the client is applied to the two lidars currently in operation within GRUAN including the Payerne lidar.
The NPP product cal/val team was approached and is preparing to include available GRUAN profiles in the context of "reference" validation to assess product accuracy and/or adherence to specifications which would include use of available uncertainty estimates.
Task Team on Ancillary Measurements (TTAM) progress report for Aug. 2012
(Modified on Sept. 20, with changes relevant to tasks 2, 3, 5, 18, and 20)

SUMMARY

The GRUAN Task Team on Ancillary Measurements (TTAM) have not met or held a phone conference since the last report (February 2012). Two new tasks were added (19 and 20); #19 is the recent submission by Schneider et al. of an AMT-Discussion paper on the Characterization of H2O products from 10 globally distributed NDACC-FTIR stations, #20 is planned development of GPROVS Phase 2 for integrated GRUAN and satellite profiles validation. Refer to “completed” and “ongoing” lists for all other tasks. The GRUAN-TTAM activities should gear up in the second semester of 2012, with the expected finalization of GRUAN Lidar Guidelines (currently under revision) and the elaboration of the Microwave and FTIR Guidelines (drafts due by ICM-5).
As in previous reports, the tasks below are numbered in the order they were created. Tasks appearing in the “Completed” list will no longer appear in future reports. Tasks appearing in the “New” list will move to the “Ongoing” list only if they progress. Tasks newly defined but for which no progress was identified will remain in the list of “new” tasks until actual progress is reported.

TASKS COMPLETED SINCE PREVIOUS REPORT:

Task 2: Validation Strategies and Results (Satellite): Coordination with JPSS

Main Contact:	T. Reale
Due Date:	ICM-4
Status:	Completed
Milestone:	April 2011: Sounding Operational Algorithm Team (SOAT)
Progress:	Concurred with Suomi NPP cal/val team members and established commitment to pursue routine validation of NPP Environmental DataRecord (EDR) for atmospheric temperature and moisture soundings at GRUAN sites using as benchmark the intensive satellite validation programs established at ARM sites.
Issues:	None

Task 10: Validation Strategies and Results (Microwave): New Publication

Main Contact:	A. Haefele
Due Date:	Recurring
Status:	Completed
Milestone:	Fall 2011: AMT-Discussion paper on suitability of microwave for NWS
Progress:	Löhnert, U. and Maier, O.: Operational profiling of temperature using ground-based microwave radiometry at Payerne: prospects and challenges, Atmos. Meas. Tech., 5, 1121-1134, doi:10.5194/amt-5-1121-2012, 2012
Issues:	None

Task 13: GRUAN Manual Add-ons by TT5 in Secs. 6.4.2 and 7.1.4

Main Contact:	All TT5
Due Date:	CM-4
Status:	completed

Milestone: Feb 2012: TT5 input returned
Progress: "Scheduling" and "Remote sensing instruments" add-ons by TT5 now being finalized (to G. Bodeker)
Issues: None

PROGRESS ON ONGOING TASKS:

Task 1: Inventories of Retrievals and Products from satellites
Main Contact: T. Reale
Due Date: CM-4
Status: Ongoing
Milestone: ICM-4
Progress: Available legacy real-time derived satellite products have been identified for atmospheric temperature and moisture profiling suitable for validation exercises at GRUAN sites including those from newly deployed Suomi-NPP. Associated meta-data and climate oriented legacy products still being pursued
Issues: None

Task 3: Validation Strategies and Results (Satellite): Satellite Products Cal/Val (NPROVS)
Main Contact: Tony Reale
Due Date: ICM-5
Status: Ongoing
Milestone: October 2012
Progress: NOAA Products Validation System (NPROVS) to serve as baseline for developing dedicated interface to access, display and analyze GRUAN (radiosonde) observations via NCDC (and LC) ... GRUAN Products Validation System (GPROVS) Phase-1
Issues: Access to ECMWF (NWP) pinned to sonde

Task 4: 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) and develop IASI and scene retrievals
Issues: Pending coordination with NPROVS

Task 5: Products and Uncertainty Budgets (Lidar): ISSI Team on NDACC Lidar Algorithms
Main Contact: T. Leblanc
Due Date: Summer 2012
Status: Ongoing
Milestone: August 2011: Standardization Tools for Vertical Resolution Validated Sept. 2012:
Meeting #3 (on uncertainties), Next milestone Spring 2013: Docs released and Meeting #4
Progress: Vertical resolution: Tools available, Manual being written, due Oct. 2012. Results posted here: http://www.issibern.ch/teams/ndacc/private/NDACC_Tools_Vertical_Resolution.htm (currently, login needed, but eventually will become public). Tools for "NDACC-standardized" expression of uncertainties to be developed in the winter 2012/2013 (several docs available now).
Issues: Intensive work required for uncertainties

Task 6: Products and Uncertainty Budgets (Satellite): Progress report on G-VAP
Main Contact: M. Schröder
Due Date: Post 2013
Status: Ongoing

Milestone: Second workshop on the GEWEX water vapour assessment (G-VAP) announced: DWD, Offenbach, Germany, 26-28 Sept. 2012
Progress: The workshop preparation is well advanced. In a second circular the G-VAP co-chairs L. Shi (NOAA/NESDIS/NCDC), A. Gambacorta (NOAA/NESDIS/STAR) and M. Schroeder (CM SAF/DWD) distributed an invitation letter together with a data fact sheet to collect information on satellite and validation data records, Approximately 40 scientists registered for the workshop. The assessment was introduced at the International TOVS Science Conference in Toulouse, France. The next step is the distribution of the G-VAP road map and the workshop agenda
Issues: None

Task 7: Inventories of Potential Instruments (Microwave)
Main Contact: N. Cimini
Due Date: Recurring
Status: Ongoing
Milestone: Last: 2nd Workshop, March 2011; Next: TBA
Progress: No new unit has joined MWRnet since last update
Issues: None

Task 8: Validation Strategies and Results (Microwave)
Main Contact: N. Cimini
Due Date: Recurring
Status: Ongoing
Milestone: 14-16 march 2011: Second Meeting in Köln (EG-CLIMET)
Progress: Validation statistics available for some GRUAN sites will be made available and reported on GRUAN microwave radiometer guidelines
Issues: None

Task 9: Validation Strategies and Results (lidar): New Publications
Main Contact: T. Leblanc
Due Date: Recurring
Status: Ongoing
Milestone: AMT Special Issue on MOHAVE-2009; Currently 4 papers published
Progress: 1 paper in AMT-Discuss.: Whiteman et al. (ALVICE lidar), Two more papers to be submitted: McGee (STROZ lidar), and Toon et al. (FTIR).
Issues: No progress since 2/2012 for McGee et al. and Toon et al. papers

Task 11: Meta Data (Microwave)
Main Contact: N. Cimini
Due Date: None
Status: Ongoing
Milestone: TBA
Progress: MWR data from most common units have been collected to start the activities on data and metadata format harmonization
Issues: None

Task 12: Suitability of Equipment: Best Measurement Practices (Lidar Guidelines)
Main Contact: T. Leblanc
Due Date: ICM-5
Status: Ongoing
Milestone: January 2012: Draft version 0.1 released
Progress: Guidelines doc. proposes an overall structure allowing full traceability of instrument and data processing changes. First draft reviewed. Now under revision, including synchronization with latest version of GRUAN Guide. Next expected review: October 2012; Expected completion: ICM-5.
Issues: TBA

Task 16: 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: T. Leblanc and A. Apituley met G. D'Amico at recent lidar conference. EARLINET Single Calculus Chain tested on several co-located lidars, but not yet extended to entire network. GRUAN-EARLINET interaction to be continued.
Issues: None

Task 17: 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: J. Hannigan, together with D. Tobin, will investigate on the possibility to bring AERI instrument into GRUAN.
Issues: progress unknown

Task 18: Suitability of Deployed Equipment: Site Atmospheric State Best Estimate (SASBE)
Main Contact: Tobin/Reale
Due Date: TBA
Status: Ongoing
Milestone: December 2012: Progress report
Progress: Special NPP validations underway at ARM sites being analyzed (D Tobin) to serve as possible benchmark to combine GRUAN ancillary and sonde measurements (including uncertainties) to calculate SASBE for atmospheric temperature and moisture with focus on NPP satellite FTIR/MW products validation
Issues: Volunteers form GRUAN sites to provide synchronized sonde, ancillary profiles including at satellite overpass

NEW TASKS AND PROGRESS TO DATE

Task 14: Suitability of Equipment: Best Measurement Practices (Microwave Guidelines)
Main Contact: N. Cimini
Due Date: ICM-5
Status: New 2/2102
Milestone: Fall 2012: First draft due
Progress: Large amount of material collected from MWRnet activities, and to be compiled for use in the GRUAN Microwave guidelines
Issues: Delays due to late release of GRUAN Guide and Lidar Guidelines

Task 15: Suitability of Equipment: Best Measurement Practices (FTIR Guidelines)
Main Contact: M. Schneider
Due Date: ICM-5
Status: New 2/2012
Milestone: Fall 2012: First draft due
Progress: TT5 FTIR experts will work on a first draft following principles applied in Lidar Guidelines doc.
Issues: Delays due to late release of GRUAN Guide and Lidar Guidelines

Task 19: Characterization of H2O products from 10 globally distributed NDACC-FTIR stations
Main Contact: M. Schneider
Due Date: None
Status: New 8/2012
Milestone: August 2012: AMT-Discussion paper
Progress: Schneider, M., Barthlott, S., Hase, F., González, Y., Yoshimura, K., García, O. E., Sepúlveda, E., Gomez-Pelaez, A., Gisi, M., Kohlhepp, R., Dohe, S., Blumenstock, T., Strong, K., Weaver, D., Palm, M., Deutscher, N. M., Warneke, T., Notholt, J., Lejeune, B., Demoulin, P., Jones, N., Griffith, D. W. T., Smale, D., and Robinson, J.: Ground-based remote sensing of tropospheric water

vapour isotopologues within the project MUSICA, Atmos. Meas. Tech. Discuss., 5, 5357-5418, doi:10.5194/amtd-5-5357-2012, 2012. http://www.atmosmeas-tech-discuss.net/5/5357/2012/amtd-5-5357-2012.html

Issues: None. This paper can serve as basis for the GRUAN FTIR Guidelines

Task 20: Validation Strategies (Satellite): Satellite/GRUAN Products Cal/Val (GPROVS) Phase 2

Main Contact: T. Reale

Due Date: ICM-5

Status: New 8/2012

Milestone: October 2012

Progress: GPROVS Phase-1 to serve as baseline for developing dedicated interface to access, display and analyze GRUAN sonde plus available ancillary data profiles collocated to sonde and/or selected satellite overpass; ... GRUAN Products Validation System (GPROVS) Phase-2

Issues: Access to Ancillary profile data, also see #18

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Appendix 10 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 most of the information and requests centreed around the GRUAN manual and guide, the expansion of GRUAN to include new sites, and the assessment and certification of sites. The composition of the task team has changed:
Marion Maturilli joined as site representative of Ny-Ålesund
Hironobu Yokota was replaced by Toru Ueda (Tateno)
Murray Poulter replaced Karin Kreher and Paul Johnston (Lauder).

PROGRESS ON TASKS IN THE PREVIOUS REPORT

Task: Find a site representative willing to serve as member of TT3 (measurement scheduling)
Main Contact: TT3 co-chairs D. Whiteman and T. Gardiner
Due Date: 31 May 2012
Status: Completed.
Milestone:
Progress: Rigel Kivi has joined TT3.
Issues:

Task: Complete matrix of instruments and capabilities at each site. Post on GRUAN website
Main Contact: Lead Centre
Due Date: 31 May 2012
Status: Completed.
Milestone:
Progress:
Issues:

NEW TASKS AND PROGRESS TO DATE

Task: Site representatives to sign off on the GRUAN Manual and Guide
Main Contact: Greg Bodeker
Due Date: 31 March 2013
Status: In progress
Milestone: Obtain sign-off by 2/3 of site reps
Progress: Documents disseminated to site reps 28 January 2013
Issues:

Task: Compile information about the co-location of instrumentation at sites
Main Contact: Lead Centre
Due Date: 25 Feb 2013
Status: In progress
Milestone: Draft manuscript prepared
Progress: Report from F. Madonna and A. Sasso in GATNDOR on 1 February
Issues:

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Appendix 11 List of acronyms

AOPC	Atmospheric Observation Panel for Climate (GCOS)
ACRF	ARM Climate Research Facility
AEMET	Agencia Estatal de Meteorología
AMS	American Meteorological Society
ARM	Atmospheric Radiation Measurement Program
ATM	Accurate Temperature Measuring radiosonde (NASA reference radiosonde)
BIPM	International Bureau of Weights and Measures
BSRN	Baseline Surface Radiation Network
CBS	Commission for Basic Systems (WMO)
CEOS	Committee on Earth Observation Satellites
CESAR	Cabauw Experimental Site for Atmospheric Research site
CFH	Cryogenic Frostpoint Hygrometer
CGMS	Coordination Group of Meteorological Satellites
CIMO	Commission for Instruments and Methods of Observation (WMO)
CMA	China Meteorological Administration
CM-SAF	Satellite Application Facility on Climate Monitoring
CPO	Climate Program Office (NOAA)
DOI	Digital Object Identifier
DWD	German Meteorological Service (Deutscher Wetterdienst)
EARLINET	European Aerosol Research Lidar Network
ECC	Electrochemical Concentration Cell
ECMWF	European Centre for Medium-Range Weather Forecasts
EDGE	Enhanced Data Rates for GSM Evolution
EG-CLIMET	European Ground-based Observations of Essential Variables for Climate and Operational Meteorology
EMRP	European Metrology Research Project
ENSO	El Niño/La Niña–Southern Oscillation
FTIR	Fourier Transform Infrared Spectrometer
GATNDOR	GRUAN Analysis Team for Network Design and Operations Research
GAW	Global Atmospheric Watch (WMO)
GCOS	Global Climate Observing System
GEOMS	Generic Earth Observation Metadata Standard
GEOS	Geostationary Operational Satellites
GEWEX	Global Energy and Water Cycle Experiment
GFZ	Geoforschungszentrum Potsdam
GHG	Greenhouse Gas
GNSS	Global Navigation Satellite System
GOS	Global Observing System (WMO)
GOSIC	Global Observing System Information Centre (at NCDC)
COSMIC	Constellation Observing System for Meteorology, Ionosphere & Climate
GPROVS	GRUAN Products Validation System
GPS	Global Positioning System
GPS-PW	Global Positioning System Precipitable Water
GRUAN	GCOS Reference Upper Air Network
GSICS	Global Space-Based Inter-Calibration System
GSN	GCOS Surface Network
GTS	Global Telecommunication System
GUAN	GCOS Upper Air Network
GUM	Guide to the expression of uncertainty in Measurement
HMEI	Association of Hydro-Meteorological Equipment Industry
IASI	Infrared Atmospheric Sounding Interferometer
ICM	Implementation - Coordination Meeting (GRUAN)
IGRA	Integrated Global Radiosonde Archive
IPW	Integrated Precipitable Water
ISCCP	International Satellite Cloud Climatology Project
ISSI	International Space Science Institute
IWV	Integrated Water Vapour
JGR	Journal of Geophysical Research

JPL	Jet Propulsion Laboratory (NASA)
JPSS	Joint Polar Satellite System
KNMI	Royal Netherlands Meteorological Institute
LIDAR	Light Detection and Ranging (optical remote sensing)
LUAMI	Lindenberg Upper-Air Methods Intercomparison Campaign
MOL	Lindenberg Meteorological Observatory
MTR	Meisei Temperature Reference
MWRnet	Microwave-Radiometer Network
NAM	Northern Annular Mode
NASA	National Aeronautics and Space Administration (USA)
NCAR	National Centre for Atmospheric Research (USA)
NCDC	National Climatic Data Centre (NOAA)
NDACC	Network for the Detection of Atmospheric Composition Change
NetCDF	Network Common Data Form
NILU	Norwegian Institute for Air Research
NIST	National Institute of Standards and Technology (USA)
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
NOAA	National Oceanic and Atmospheric Administration (USA)
NOAA FPH	NOAA Frost Point Hygrometer
NOAA/NWS	NOAA National Weather Service
NPROVS	NOAA Products Validation System
NWP	Numerical Weather Prediction
NWP SAF	Satellite Application Facility for Numerical Weather Prediction
OMI	Ozone Monitoring Instrument
PW	Precipitable Water
QBO	Quasi-Biennial Oscillation
SAM	Southern Annular Mode
SCOPE-CM	Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring
SGP	Southern Great Plains Site (ACRF)
SI	International System of Units
SIRTA	Site Instrumental de Recherche par Télédétection Atmosphérique
SSI	Scientific Sounding Instruments
STAR	Centre for Satellite Applications and Research
TCCON	Total Carbon Column Observing Network
TD	Technical Document.
TECO	Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (WMO)
TropOMI	Tropospheric Ozone Monitoring Instrument
UKMO	UK MetOffice
UT/LS	Upper Troposphere and Lower Stratosphere
WCRP	World Climate Research Programme
WG-ARO	Working Group on Atmospheric Reference Observations (AOPC)
WIGOS	WMO Integrated Global Observing Systems
WIS	WMO Information System
WMO	World Meteorological Organization
ZTD	Zenith Total Delay

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