GCOS

GLOBAL CLIMATE OBSERVING SYSTEM

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GRUAN

GRUAN Implementation Plan 2017-2021

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IMPLEMENTATION PLAN
FOR THE GLOBAL CLIMATE OBSERVING SYSTEM
REFERENCE UPPER-AIR NETWORK 2017–2021

CAPSULE

This document provides a roadmap for implementation of the Global Climate Observing System (GCOS) Reference Upper-Air Network (GRUAN) for the period 2017 to 2021, detailing the high-level actions required to reach the goal of establishing a fully operational reference upper-air network for climate. It also highlights potential pathways by which GRUAN could aid implementation of various actions arising within the latest GCOS Implementation Plan (GCOS-200). It serves as an update to, and supersedes, the previous GRUAN Implementation Plan (GCOS-165). It should be interpreted in conjunction with the GRUAN Manual and Guide (GCOS 170 and 171 respectively). The new GRUAN IP consists of fewer, more high-level, objectives than previous GRUAN Implementation Plans and shall leave the mapping of specific action items to achieve these to the annual Implementation and Coordination Meetings mechanism.

1. INTRODUCTION

The Global Climate Observing System (GCOS) Reference Upper-Air Network (GRUAN) is operated under the joint auspices of GCOS and the World Meteorological Organization (WMO). Instigated with the formation of a Working Group under the governance of GCOS's Atmospheric Observations Panel for Climate (AOPC) in 2003, the effort is now over decade old. Since 2008, a Lead Centre, hosted by DWD[1] at its Lindenberg facility, has overseen day-to-day operational aspects of the network. The current governance structure for GRUAN is outlined in Figure 1.

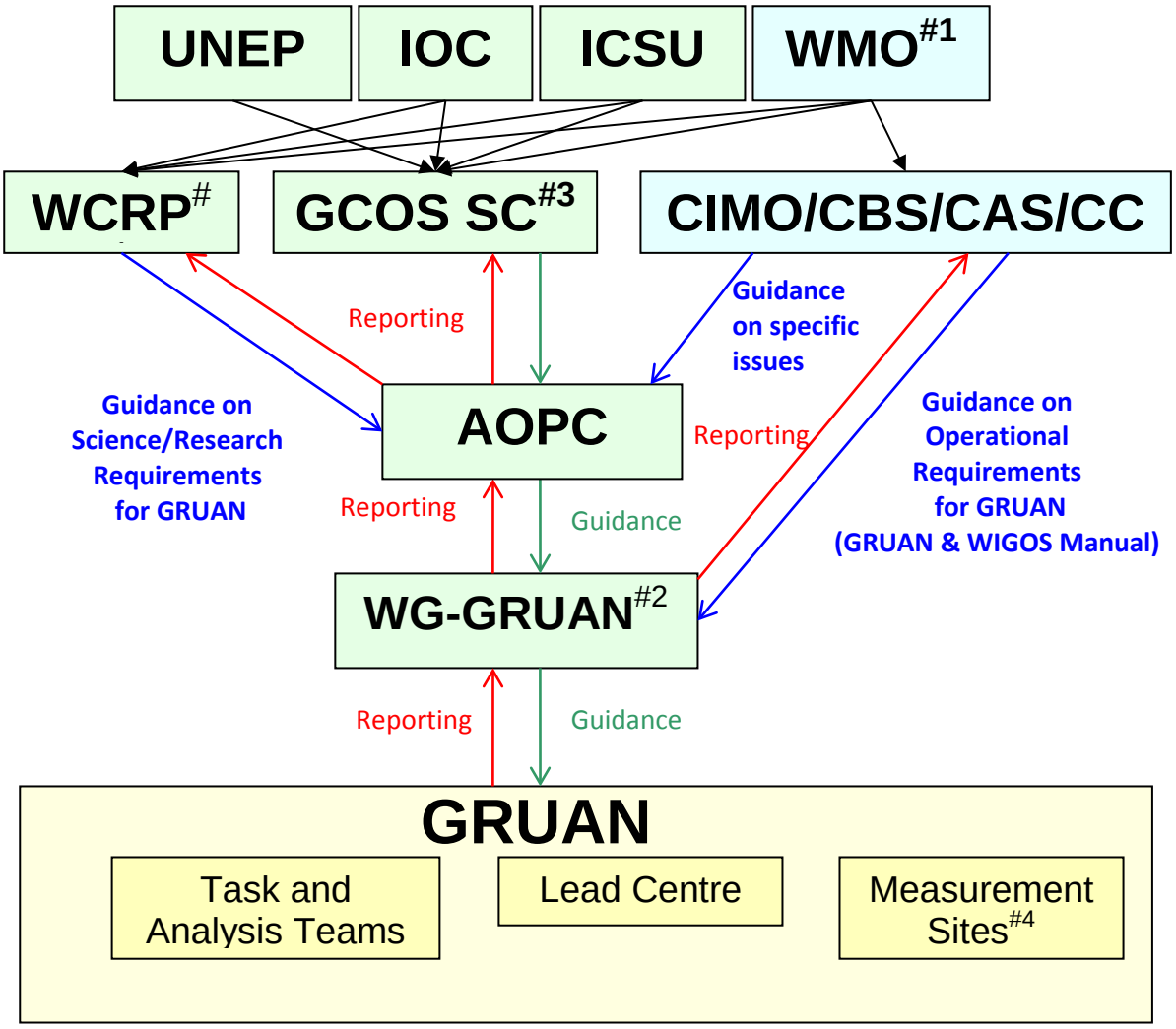

Figure 1. Schematic outline of the structure of GRUAN.

Notes

1. WCRP identifies scientific and research requirements for GRUAN, while WMO identifies operational requirements.
2. Composition of WG-GRUAN to be determined by the AOPC in consultation with WMO and should include:
   - one representative from each of CIMO, CBS, CAS and CCl; these representatives will be responsible for reporting back to their respective Technical Commission;
   - others (according to its Terms of Reference)
3. Global Climate Observing System Steering Committee.
4. GRUAN Measurement Sites are contributed by Members of WMO.

[1] A full list of acronyms is provided in Appendix 1.

There have been two previous GRUAN Implementation Plans (IPs, GCOS-134 and GCOS-165). The first was published in 2009 and was intended to cover the four years up until envisaged operational status of the network. The second was published in 2013 and was intended to cover progress up until 2017. These Implementation Plans have helped to ensure the transition from idea to reality of GRUAN (Bodeker et al., 2016). As with any implementation plans, progress against specific items has been somewhat mixed.

This IP supersedes the previous IP. Following a decision at the Seventh Implementation and Coordination Meeting (ICM-7, GCOS -198), this IP has been made a much shorter, more high-level document than the two prior IPs. Instead of detailing specific time-bound actions, this IP articulates the envisaged high-level work and achievements within the period. Detailed action plans, articulating specific SMART[2] tasks to be done, shall be developed at the annual ICMs with the express aim of meeting these aspirational goals.

The co-chairs of WG-GRUAN maintain a spreadsheet that tracks specific actions that remain active and use this spreadsheet, in addition to this IP and the ICMs, to ensure delivery of long-term goals and specific tasks.

The remainder of this IP is structured as follows: Section 2 defines the intended strategic target that is envisaged to be achieved by 2021. Section 3 outlines how this Implementation Plan interacts with and complements the much more holistic GCOS Implementation Plan (GCOS-200). Section 4 outlines envisaged work within the IP period towards the targets articulated in the GCOS IP and the GRUAN vision articulated in Section 2. This includes matters pertaining to governance, reporting, coordination and liaison with stakeholders.

2. STRATEGIC OVERVIEW

As detailed in GCOS-112, the purpose of GRUAN is to:

i) Provide long-term high quality climate records;
ii) Constrain and calibrate data from more spatially-comprehensive global observing systems (including satellites and current radiosonde networks); and
iii) Fully characterize the properties of the atmospheric column.

Today GRUAN consists of a network of 22 sites that are distributed fairly unevenly across the globe with few sites in the tropics, and no sites on continental Africa or South America (Figure 2). WIGOS and GRUAN should actively pursue GRUAN expansion in the tropics and in Africa and South America. Sites have varying capabilities, funding mechanisms and affiliations to third party networks and organizations; and many have yet to undergo formal GRUAN assessment and certification.

[2] Specific, Measurable, Achievable, Realistic and Timebound

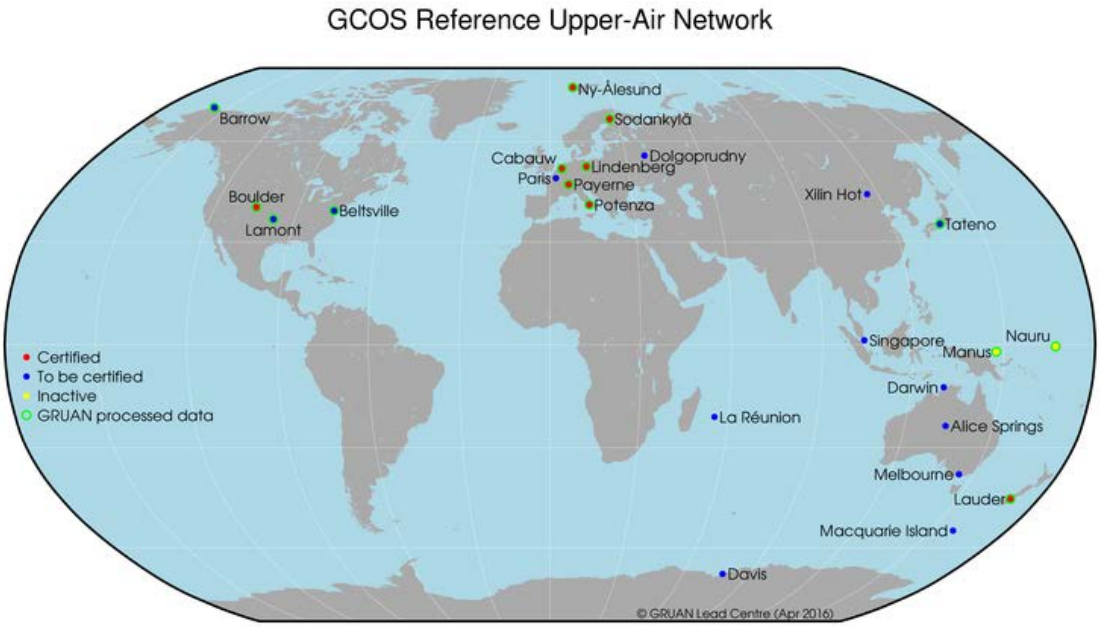

Figure 2. Current GRUAN network configuration as of April 2016.

The methodological aspects that underpin what shall constitute a GRUAN reference measurement are documented in the peer reviewed literature (Immler et al., 2010), and data adhering to these principles are being processed and served for one specific type of radiosonde instrument (Dirksen et al., 2014) flown at a subset of the sites and served through NOAA's National Centers for Environmental Information. Reference quality data are close to being ready for a number of additional measurement techniques.

By the end of the period of this IP (through 2021), if it is successfully implemented, GRUAN shall consist of:

- A network of approximately 30 to 40 sites (at least 25 of which shall have been certified with subsequent regular auditing) and will be more globally equitably located. 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 (and higher where feasible) of temperature, pressure, water vapour, wind speed and direction, and ozone[3]. To the extent possible, these measurements will be made using complementary measurement systems including sondes[4] and in-situ remote sensing equipment. Measurements will be made to documented GRUAN standards with each data stream processed centrally, and backed up by substantive metadata.
- A set of sustainable long-term measurements being used by recognized target stakeholders (climate change monitoring and detection, satellite-based measurements, NWP, process studies), as demonstrated in the peer-reviewed literature, to improve our collective 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.

The actions detailed below all contribute to one or more of these stated objectives.

[3] 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 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 that lay the ground-work for such data streams beyond the horizon of this IP.

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

3. THE BROADER CONTEXT OF THE THIRD GCOS IMPLEMENTATION PLAN

The third version of the GCOS Implementation Plan was published in November 2016 (GCOS-200). This GCOS Implementation Plan is concerned with the totality of the global observing system capabilities including many non-reference quality observations and covers also the Oceanic and Terrestrial domains. The charge given to GRUAN is to create reference quality data products of upper-air essential climate variables. Therefore, the two documents naturally differ substantively in scope and style. The present GRUAN Implementation Plan can, at least in part, be considered a response to the GRUAN-relevant components of the GCOS Implementation Plan in a similar sense to satellite agencies issuing such a response to prior GCOS Implementation Plans.

Changes to ECVs of relevance to GRUAN

Discussions in preparation for the third version of the GCOS Implementation Plan have led to changes to several surface and upper-air atmospheric ECVs that are of direct relevance to GRUAN:

- Hydrometeors have been added to the 'clouds' ECV in recognition that this complements the precipitation surface ECV and permits better closure of the hydrological cycles.
- Solar irradiance at top of atmosphere is now to be measured as spectrally resolved.
- The upper-air radiation ECV has been modified to clarify that in addition to TOA radiation there is interest in monitoring the vertical radiation profile.
- Lightning has been added as a specific ECV.
- There is increased interest in columnar profiles of radiatively active trace gases and other minor constituents.

Many of these modifications primarily speak to longer-term aspirations for GRUAN development beyond the intended lifetime of the current GRUAN Implementation Plan. However, they should be borne in mind in discussions at annual ICMs and in the formation of annual work plans. GRUAN should, over the longer-term, strive to provide reference quality measurements of these atmospheric parameters.

GRUAN progression action item

There is one action within the GCOS Implementation Plan which pertains to general progression of GRUAN:

Action A15:	Implementation of GRUAN
Action	Continue implementation of the GCOS Reference Upper-Air Network of metrologically traceable observations, including operational requirements and data management, archiving and analysis and give priority to implementation of sites in the Tropics, South America and Africa.
Benefit	Reference quality measurements for other networks, in particular GUAN, process understanding and satellite cal/val.
Who	Working Group GRUAN, National Meteorological Services and research agencies, in cooperation with AOPC, WMO CBS, and the Lead Centre for GRUAN.
Time-frame	Implementation largely complete by 2025.
Performance Indicator	Number of sites contributing reference-quality data-streams for archive and analysis and number of data streams with metrological traceability and uncertainty characterisation. Better integration with WMO activities and inclusion in the WIGOS manual.
Annual Cost	10-30M US$

Section 4 of this current GRUAN Implementation can be considered a GRUAN expansion of Action A15 in the GCOS Implementation Plan that provides a more detailed measurable and achievable basis to work towards completion of this GCOS Implementation Plan action. When GCOS is assessing progress against Action A15, the progress of the items detailed in Section 4 herein provides a natural basis for the exercise.

GRUAN relevant specific action items

There are five remaining actions that have been identified following a review of the GCOS Implementation Plan as relevant to GRUAN. These items are much more specific and hence represent de facto actions to be covered under the current GRUAN IP. For their associated justification see the atmospheric section of the GCOS Implementation Plan (GCOS-200). These actions are reproduced below followed by some observations of how GRUAN may contribute within the coming four years to their resolution.

Action G13:	Review of ECV observation networks
Action	For all ECV products not covered by a review following actions G11 and G12: develop and implement a process to regularly review ECV observation networks, comparing their products with the ECV product requirements; identify gaps between the observations and the requirements; identify any deficiencies and develop remediation plans with relevant organizations; and ensure the data is discoverable and accessible. This action may also contribute to the definition of reference grade observing network and standards The GCOS science panels should identify stakeholders who will perform this review and regularly check all ECV products are being reviewed.
Benefit	Increase quality and availability of climate observations.
Who	Organizations listed in Annex A.GCOS Panels to maintain oversight.
Time-frame	Develop and demonstrate review process in 2017. Review each ECV's observing systems at least every 4 years.
Performance Indicator	Reports of results of ECV reviews produced by panels each year.
Annual Cost	100k-1M US$, Also part of work of panels

Action G13 builds on the tiered networks framework first put forth in Seidel et al., 2009 and discussed at the networks meeting in Ispra (GCOS-182) and then taken forwards by GAIA-CLIM (Thorne et al., in prep). The associated work for GRUAN shall consist of expert advice from WG-GRUAN upon request from AOPC.

Action A23:	Measure of water vapour in the UT/LS
Action	Promote the development of more economical and environmentally friendly instrumentation for measuring accurate in-situ water vapour concentrations in the UT/LS.
Benefit	Improved UT/LS water vapour characterisation, water vapour CDRs.
Who	NMSs, NMIs, HMEI and GRUAN.
Time-frame	Ongoing.
Performance Indicator	Number of sites providing higher quality data to archives.
Annual Cost	10-30M US$

Action A23 concerns itself with issues over cost and environmental friendliness of current UTLS in-situ sensors capable of measuring humidity. It responds directly to concerns raised episodically in GRUAN ICMs. GRUAN should continue to seek and support funding to develop lower cost and more environmentally friendly alternatives to the frost point hygrometers currently used. This GCOS IP action could provide a useful basis for lobbying funding bodies to consider such opportunities.

Action A28:	In-situ Profile and Radiation
Action	To understand the vertical profile of radiation requires development and deployment of technologies to measure in-situ profiles.
Benefit	Understanding of 3D radiation field, model validation, better understanding of radiosondes.
Who	NMSs, NMIs, HMEI.
Time-frame	Ongoing.
Performance Indicator	Data availability in NMS archives..
Annual Cost	1-10M US$

Action A28 directly arises from the recent measurements performed by Task Team radiosondes co-chair Rolf Philipona of Meteoswiss at Payerne and at Sodankyla. GRUAN should consider the viability of starting a program of such ascents either across the network or at a representative sub-set of sites to be directly responsive to this action point. This consideration should concern the usual aspects of traceability, uncertainty quantification etc. but may also be concerned with where and how frequently such a program

of measurements should be carried out to provide a useful series. As such a degree of research is required to understand the spatio-temporal variability to ensure any program instigated provides representative series. This may be achieved / facilitated by the scheduling task team.

Action A31:	Validation of satellite remote sensing
Action	Engage existing networks of ground-based, remote sensing stations (e.g., NDACC, TCCON, GRUAN) to ensure adequate, sustained delivery of data from MAXDOAS, CCD spectrometers, lidar, and FTIR instruments for validating satellite remote sensing of the atmosphere.
Benefit	Validation, correction, and improvement of satellite retrievals.
Who	Space agencies, working with existing networks and environmental protection agencies.
Time-frame	Ongoing, with urgency in initial planning to minimize data gap.
Performance Indicator	Availability of comprehensive validation reports and near real-time monitoring based on the data from the networks.
Annual Cost	1-10M US$

Action A31 talks to the need to ensure a sustained conversation with satellite providers. GAIA-CLIM has provided an improved basis for this but funding runs solely through 2018. The next WG-GRUAN membership refresh may consider whether better representation is required from this community. GRUAN remains willing to engage with these communities.

Action A34:	Requirements for in-situ column composition measurements
Action	Define the requirements for providing vertical profiles of CO_2, CH_4, and other GHGs using recently emerging technology, like balloon capture technique[56]
Benefit	Ability to provide widespread, accurate, in situ vertical profiles economically; an excellent tool for validating satellite retrievals and improving transport models.
Who	GCOS AOPC and space agencies.
Time-frame	Requirements to be defined by 2018.
Performance Indicator	Update to Annex A to include vertical profiles and XCO_2.
Annual Cost	< 5M US$

Action A34 speaks to emergent composition in-situ profiling technology. Several GRUAN sites have run this technology either in campaign mode or programmatically. There is scope to work with NDACC and TCCON to produce a set of high-quality series traceable to recognized community composition standards. Consideration could be given to instigation of a programmatic capability of such measurements within GRUAN. Again, how frequently and at what sites such measurements need to be taken to meet users needs should be investigated.

4. ENVISAGED SPECIFIC PROGRESS WITHIN THE GRUAN IMPLEMENTATION PLAN PERIOD

4.1 Management tasks

Continuous ongoing management tasks are those required to communicate, develop plans and monitor progress in support of the development of GRUAN on a sustained basis. These tasks include, but are not necessarily limited to, the following:

- Day to day management of the network by the Lead Centre
- Annual ICMs that bring together WG-GRUAN, Lead Centre, sites and other stakeholders and set detailed annual workplans
- Internal progress reporting to WG-GRUAN
- Reporting to sponsors including attending meetings as required
- Review and curation of GRUAN documentation
- Annual reviews of the network status

Action 1

Action: Ensure day-to-day operation of the GRUAN network including undertaking annual Implementation and Coordination meetings and sponsor reporting activities.

Who: Lead Centre and WG-GRUAN

Time-frame: Continuous

Performance indicator: Satisfaction of sponsors, documentation available online

Benefits: Network coordination and buy-in from sites, network visibility within user community.

4.2 Reference observations

Reference observations are the core rationale for GRUAN. The underlying principles of traceability and uncertainty quantification have been documented in Immler et al., 2010 and the processing applied to the Vaisala RS92 (Dirksen et al., 2014). Further particulars are available in the GRUAN Guide and the GRUAN Manual.

By 2021 several additional data streams from in-situ (including operational and frostpoint sondes) and remote sensing instruments are expected. GRUAN products for any specific instrument type are processed by a single dedicated centre, which processes all data for the measurement series from all sites contributing to the measurement stream in a consistent manner to assure comparability. For example the RS-92 is processed by the Lead Centre but other radiosonde models when available may be processed by other processing centres.

Each GRUAN data product must be backed up by Technical Documentation describing the instrument practices and, ideally, a peer reviewed paper documenting the properties of the GRUAN data product. In addition, GRUAN data products/streams are subject to strict version control. GRUAN data sets have DOI numbers. GRUAN will look to partner with existing networks and activities where possible in developing data best practices and data support infrastructure in a cost-effective manner and to avoid duplicative effort. Products need to be inter-operable and synergistic and this needs to be borne in mind when developing new data streams.

Action 2

Action: Develop an average of at least one new data stream per year between 2017 and 2021

Who: Task Teams, Lead Centre, WG-GRUAN, sites, contributing / collaborating networks.

Time-frame: By 2021

Performance indicator: For each data product there exists:

i) a Technical document describing how the measurements are to be taken;
ii) a paper describing the traceability and uncertainty quantification;
iii) a centrally processed data stream that is publically accessible.

Benefits: Improved ability to characterize atmospheric column properties at sites, complementary measurements allow independent verification of adequacy of uncertainty budgets calculated.

4.3 Data dissemination, usage and review

GRUAN data are, by policy, made publically available without restriction once processed and released. GRUAN data started flowing to users through the official GRUAN Data Centre in mid-2011. At present this consists of a single stream of RS92 radiosonde data from a subset of sites, although substantial data from other instruments is archived by the Lead Centre and / or the sites, which may be able to be reprocessed upon development of new products. By 2021 this will expand to consist of multiple data streams of GRUAN priority 1 and 2 ECVs from a range of instruments providing measurement complementarity. Where possible GRUAN data streams should be disseminated in NRT (Section 4.9).

The WG-GRUAN shall instigate data stream reviews at least every four years (per data stream). The data streams shall be evaluated for efficacy and operational anomalies by relevant experts once sufficient data are available. Feedback shall be provided to the Lead Centre for dissemination to sites and the processing facility concerned.

Action 3

Action: Deploy data streams as they develop via the data portal and monitor indicators of usage such as publications that use the data.

Who: Lead Centre, Task Teams, sites

Time-frame: Continuous

Performance indicator: Data are publically accessible and there is demonstrable evidence of growing usage within the community.

Benefits: Long-term network utility and viability, return on investment

Action 4

Action: Periodic review of data streams for usage and issues raised

Who: WG-GRUAN, Task Teams, invited experts (as deemed necessary)
Time-frame: Continuous, for any given stream at least once per four years.

Performance indicator: Brief report available on data stream and its usage with any actions required clearly stated.

Benefits: Ensuring that data streams remain cutting edge forcing periodic re-review and (as deemed necessary) reprocessing

4.4 Network expansion and certification

GRUAN currently consists of 22 sites of which 9 have been certified following the procedures detailed within the GRUAN Guide (GCOS-171). The aspiration for GRUAN is to eventually consist of 30-40 sites which are globally distributed and that meet stakeholder needs. These needs were ascertained from a dedicated meeting (GRUAN-RP-4) and are envisaged to be revisited periodically. By the end of the period covered in this implementation plan it is reasonable to envisage that the network shall consist of at least 25 certified sites (where certification implies it is producing at least one GRUAN data product and meets additional selection criteria) and a number of additional candidate sites towards a 'final' configuration envisaged for 2025 in the GCOS Implementation Plan (Section 3).

Action 5

Action: Recruit and retain on average not less than one extra candidate station per year. Station selection to be cognizant of user priorities.

Who: WG-GRUAN, Lead Centre

Time-frame: Continuous

Performance indicator: At least 30 sites present on map at the end of the IP period.

Benefits: Better more equitable network coverage, reference quality measurements in new regions important to stakeholders.

Action 6

Action: Review and re-review sites as detailed in the GRUAN manual so that there are at least 25 certified sites at the end of the IP period.

Who: WG-GRUAN, Lead Centre

Time-frame: Continuous, for any given site at least once per four years.

Performance indicator: Certified sites visible on up-to-date map; sites demonstrably delivering data streams via the relevant GRUAN data portal(s)

Benefits: Certification ensures a minimum quality to end users and a degree of compatibility / comparability of their data streams and quality to the contributing sites.

4.5 Science issues

There remain several open science questions relating to either specific instrumentation or generic issues such as scheduling of measurements, their combination etc.. These constitute scientific issues that need to be resolved for network operations and design rather than science applications that employ the data. Such scientific application activities are key to a successful and vibrant GRUAN, but are not under the purview of network management activities and hence cannot be mandated under an 'implementation' umbrella. A key challenge in the period of the current IP is the retirement of the RS92 model by Vaisala which necessitates robustly addressing the change management challenge on a network basis for the first time. This challenge extends to propagating the lessons learnt to GUAN and to WIGOS.

Action 7

Action: Undertake research to understand the effects of scheduling for different instruments and end-uses and provide quantitatively based advice on scheduling.

Who: Task Team on scheduling, Lead Centre, WG-GRUAN

Time-frame: Continuous

Performance indicator: Publications and evidence for progress in annual ICM reports, advice dispensed to sites and taken up.

Benefits: Optimal use of observational assets to meet stakeholder needs.

Action 8

Action: Create through appropriate value added product generation approaches optimal estimates of the column ECV properties by combining multiple complementary instrument data streams building upon their respective strengths.

Who: Task Team on Ancillary Measurements, Science Coordinators, WG-GRUAN, Lead Centre

Time-frame: 2019 for first products, 2021 for more mature set of products

Performance indicator: Papers published and such estimators being produced and made available for data arising from GRUAN stations on a sustained basis.

Benefits: Better characterization than possible by any single instrument, better understanding of the instruments at GRUAN sites and their performance.

Action 9

Action: Using the transition away from RS-92 as an example instigate and propagate a change management protocol for quasi-network wide changes.

Who: Lead Centre, Task Team on Radiosondes, WG-GRUAN

Time-frame: 2019

Performance indicator: Change management accomplished without introducing inhomogeneities, paper(s) published, results disseminated to GUAN and broader GOS sonde networks through GCOS / WIGOS

Benefits: Better characterization than possible by any single site, economies of scale, broad scientific insights

4.6 Organizational issues

GRUAN is now relatively mature and stable in terms of management. DWD have now committed to longer-term hosting of the Lead Centre facility. However, there are some recognized issues that need addressing around coordination with similar networks and ensuring periodic review of governance.

Action 10

Action: Ensure sustained interactions with other networks interested in upper-air measurements of ECVs to realize synergies through cross-fertilization of governance activities, collaborative projects, joint peer-reviewed publications etc.

Who: WG-GRUAN, Lead Centre, Task Teams

Time-frame: Continuous

Performance indicator: Memoranda of understanding enacted, appropriate cross-representation, joint participation in research projects

Benefits: Scientific insights, mitigation of capability redundancies, better governance in the framework of WIGOS.

Action 11

Action: Periodically review WG-GRUAN membership and terms of reference and whether task teams still relevant / additional task teams needed.

Who: WG-GRUAN, Lead Centre, Task Teams, AOPC

Time-frame: Review internally at GRUAN ICMs as a standing item but raised to AOPC only when a substantive suggested modification agreed by GRUAN community and then only infrequently.

Performance indicator: Discussions occur and are documented in the ICM reports

Benefits: Ensure continuous relevance of activities and relevant expertise is recruited and retained to address the present challenges.

4.7 Outreach

GRUAN will only prove to be a successful network if the observations made end up being used and add substantive value to scientific studies. It is therefore important that opportunities are taken to inform stakeholders and end users about GRUAN.

Action 12

Action: Sustained engagement with the user community to ensure usage and exploitation of data arising from GRUAN activities.

Who: WG-GRUAN, Lead Centre, Task Teams

Time-frame: Continuous

Performance indicator: Papers published, presentations given, participation in international activities

Benefits: Ensures usage by expert community to drive value.

4.8 Expanding to include additional Upper Air Essential Climate Variables

In its founding GRUAN was intended eventually to fully characterize all upper-air ECVs and their constituent components. To date it has been the over-arching ethos to 'start small, but start' and that remains the case with additional data streams for the priority 1 variables and the inclusion of ozone measurements being the envisaged advances in GRUAN measurement streams in the 2021 time horizon. In addition GRUAN will explore the potential to add measurement capabilities to respond to the GCOS IP as detailed in Section 3. However, initial scoping is required to when and how to bring in additional measurements in the future.

Action 13

Action: In collaboration with partner networks, assess the relevance and tractability of the full suite of remaining GRUAN target variables defined in GCOS-112 (updated with new ECV definitions in the third GCOS IP) in the context of measurement capabilities and measurement programmes underway in partner networks.

Who: WG-GRUAN, Lead Centre, Task Team on Ancillary Measurements

Time-frame: 2020

Performance indicator: Report available and some data streams for new ECVs not yet considered at a minimum under demonstrable development (stretch target: at least one additional ECV now has a GRUAN product).

Benefits: After network expansion the next benefit would be in starting to observe all important facets of the column at the sites which requires expanding the ECV set.

4.9 WIGOS interactions, including Near-Real Time applications

The GRUAN network should constitute a sustained contribution to the global observing system of highest quality data and products. Some users require data within strict cut-off limits for near real time operations. The challenge is two-fold. Firstly, GRUAN needs to be fully integrated into WIGOS and the various technical commissions as a contributing network. Secondly, for those data that can be used in NRT products need to be made available where possible and practicable within their cut-off windows.

Action 14

Action: Elaborate and improve upon recognized role within WIGOS as a contributing network. Contribute to documentation in the WIGOS regulatory materials as to the nature of that contribution with subsequent recognition at Commission level.

Who: GCOS Secretariat, AOPC, WG-GRUAN, Lead Centre

Time-frame: CG-19

Performance indicator: Inclusion in relevant regulatory materials

Benefits: Recognition by NMSs who provide sites and / or analysis capabilities. Visibility with stakeholders such as the satellite cal / val community.

Action 15

Action: Develop and deploy NRT data streams of GRUAN products for use by stakeholders where both practicable and useable.

Who: Lead Centre, Task Teams, processing centres

Time-frame: Continuous

Performance indicator: Data streams available

Benefits: Increased usage, better constrained data for NRT applications than currently available.

5. SUMMARY

We have detailed herein a set of actions designed to provide a high-level vision for the development of GRUAN in the timeframe 2017-2021. This Implementation Plan in addition recognises and responds to the GRUAN relevant items contained in the third GCOS Implementation Plan released in November 2016. Detailed work plans agreed at each ICM shall create SMART actions that provide the detailed workplan to address the 15 actions. Tracking of progress can be achieved through a consideration of the annual ICM reports published by GCOS.

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Acronyms

AOPC	Atmospheric Observations Panel for Climate
CAS	Commission for Atmospheric Sciences
CBS	Commission for Basic Systems
CCl	Commission for Climatology
CIMO	Commission for Instruments and Methods of Observation
DOI	Digital Object Identifier
DWD	Deutscher Wetterdienst
ECV	Essential Climate Variable
GCOS	Global Climate Observing System
GRUAN	GCOS Reference Upper Air Network
ICM	Implementation and Coordination Meeting
IP	Implementation Plan
LC	Lead Centre
NMS	National Meteorological Service
NOAA	US National Oceanic and Atmospheric Administration
NRT	Near Real Time
NWP	Numerical Weather Prediction
SMART	Specific, Measurable, Actionable, Realistic, and Timebound
UTLS	Upper Troposphere and Lower Stratosphere
WG-GRUAN	Working Group on GRUAN
WIGOS	WMO Integrated Global Observing System
WMO	World Meteorological Organization