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Item 8

GRUAN, WMO Observing Systems and WIGOS

(Submitted by the GCOS Secretariat)

Summary and Purpose of Document

This document outlines the links between GRUAN and existing WMO-led observing systems, such as the Global Observing System and the Global Atmosphere Watch. It further introduces the concept of the WMO Integrated Global Observing System (WIGOS) and related pilot activities, and concludes with points for discussion whether GRUAN, or part thereof, could be designated a WIGOS pilot project.

GRUAN, WMO Observing Systems and WIGOS

Content of this Paper

This paper briefly recalls the objectives of GRUAN and its relation to existing global networks coordinated by WMO. It then outlines the areas of collaboration between the GRUAN community and WMO Technical Commissions, Expert Teams and possible linkage to the WMO Integrated Global Observing System (WIGOS) initiative. The paper concludes with points for discussion whether GRUAN, or part thereof, could be designated a WIGOS pilot project.

1. GRUAN and WMO Global Observing System

The GCOS Reference Upper-Air Network is being implemented with the objective to¹:

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

Scientific evidence clearly shows that there is a pressing need to implement GRUAN, since the currently available upper-air observation data record is generally not adequate to, for example, ascertain long-term upper-air temperature trends to the accuracy required to answer scientifically-relevant questions (see GCOS-112 chapter 3 for full scientific rationale).

The GRUAN, eventually consisting of 30-40 sites worldwide, will be built primarily on sites that are part of the existing comprehensive WMO Global Observing System (GOS) (see Fig. 1) and its subset, the GCOS Upper-Air Network (GUAN) (see Fig. 2), as part of a tiered system of networks (Fig. 3). The WMO GOS, encompassing the majority of operational radiosoundings in the world, is the backbone for all meteorological applications, such as numerical weather prediction and aeronautical forecasts. The GUAN as the “global backbone for climate” of the GOS, is designed to provide global coverage and long-term observations necessary to characterize hemispheric and global scale changes in upper-air temperature, wind and humidity.

GRUAN is designed to fill the set of above-mentioned objectives that are not met by the current GUAN. This will be achieved by making full use of the worldwide best upper-air observational capability and expertise, and therefore, not all initial and potential GRUAN sites (see Fig. 4) are collocated with current GUAN sites, but also include other measurement sites that meet the necessary requirements (see GCOS-112, pp9-10). It is important to stress, however, that the proposal to establish the GRUAN is not and should not be seen as a replacement or substitute for the established GUAN network. Unlike the GUAN, GRUAN is not conceived to provide globally complete and spatially homogeneous coverage.

A broad range of instrumentation requirements need to be met for a site to become part of GRUAN, such as GPS receivers, high-quality radiosondes, lidars, surface radiation instruments, and trace gas measurements. Operations of a GRUAN site are expected to follow the GCOS Climate Monitoring Principles and, as appropriate, operational practices defined by WMO. Collocation of GRUAN candidate sites with sites of other global networks meeting these requirements is sought, such as sites in the Baseline Surface Radiation

¹ GCOS-112: GCOS Reference Upper-Air Network (GRUAN): Justification, requirements, siting and instrumentation options (April 2007, WMO/TD No. 1379); <http://www.wmo.int/pages/prog/gcos/Publications/gcos-112.pdf>

Network (BSRN), the WMO Global Atmosphere Watch (GAW) ozone networks, and the Network on the Detection of Atmospheric Composition Change (NDACC) (cf Appendix 1).

In 2007, WMO launched an initiative towards enhanced integration between WMO observing systems and agreed to refer to it by the acronym WIGOS (WMO Integrated Global Observing System).

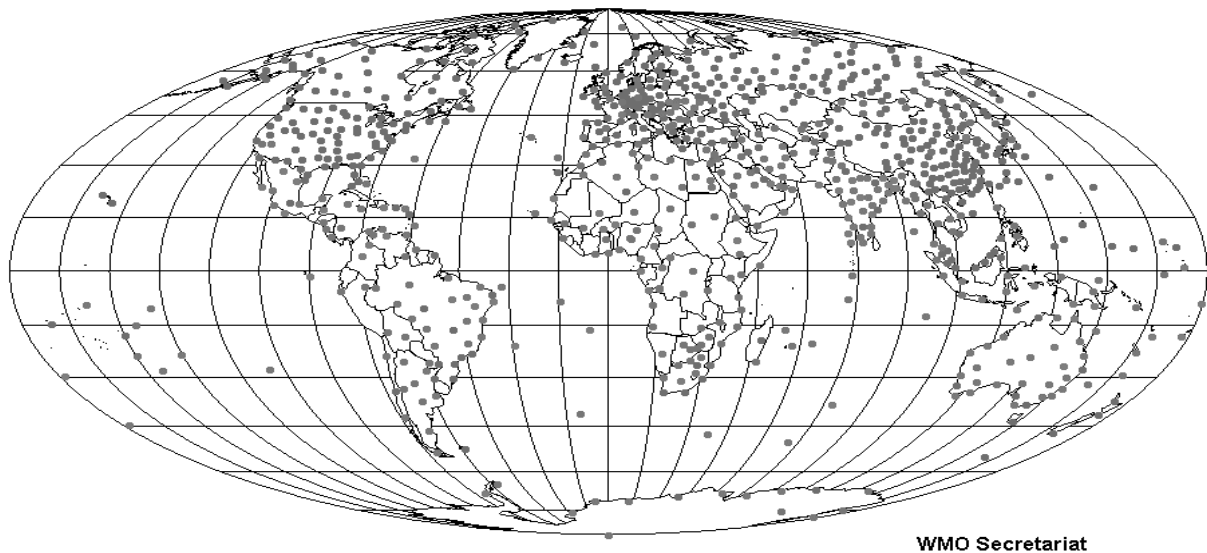


Fig. 1 : The upper-air (radiosonde) observing network of the WMO Global Observing System (GOS) (Status April 2008)

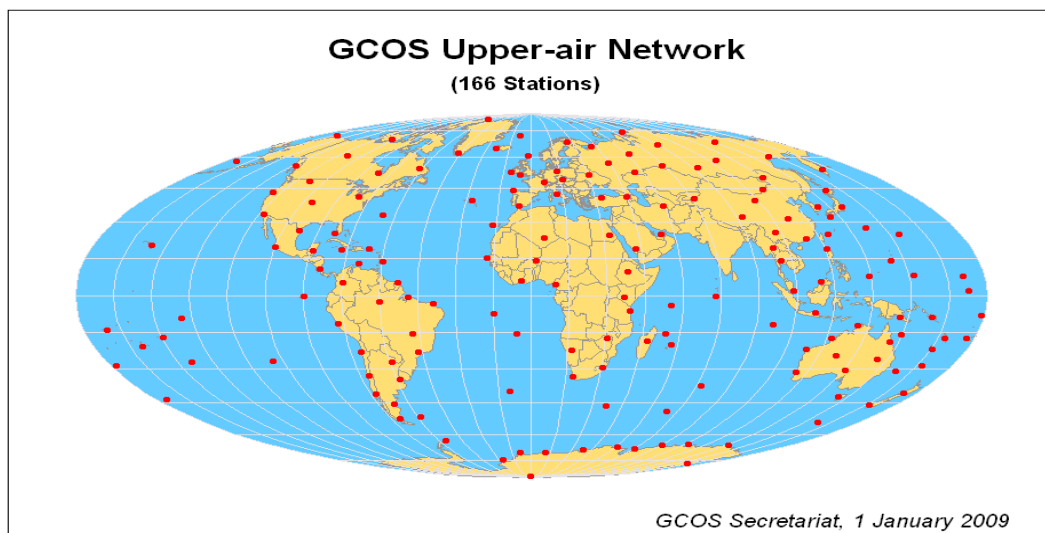


Fig. 2: The GCOS Upper-Air Network of radiosondes (Status January 2009) – a subset of the WMO GOS in Fig. 1

- initial GRUAN site
- potential GRUAN site
- GUAN site
- ✕ BSRN site
- GAW (global)
- GAW (regional)

GCOS Reference Upper-Air Network

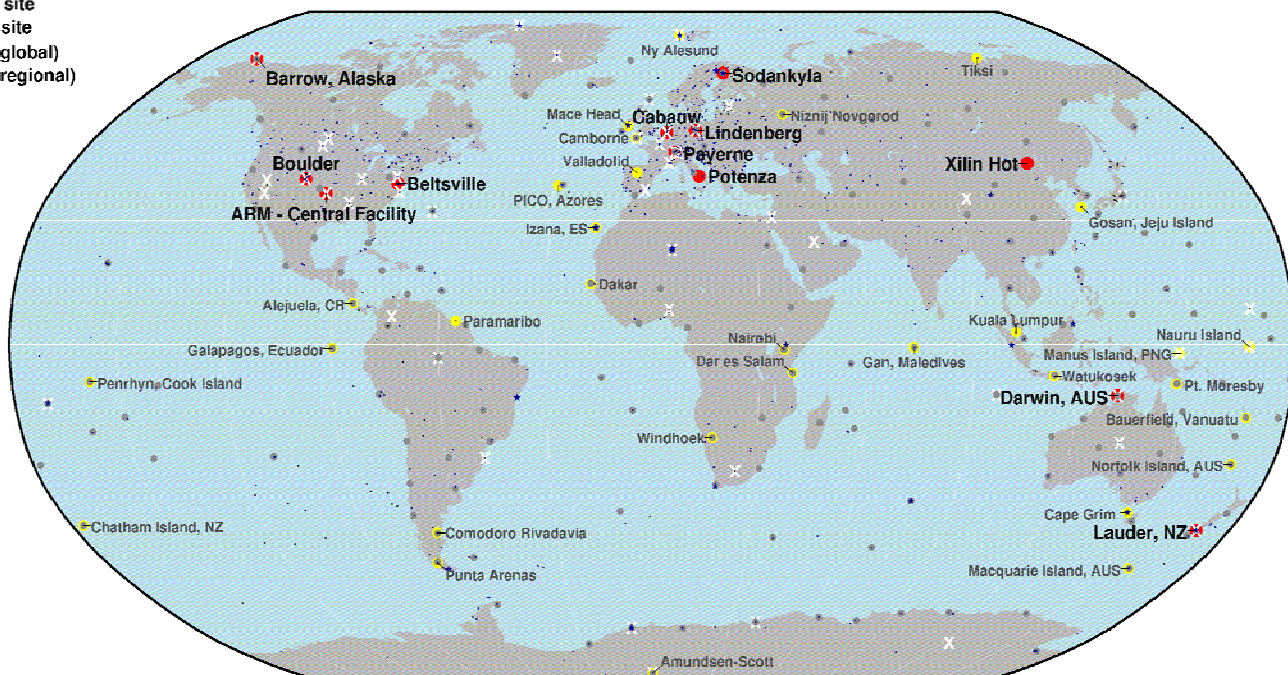


Fig. 3: GRUAN initial and potential candidate sites

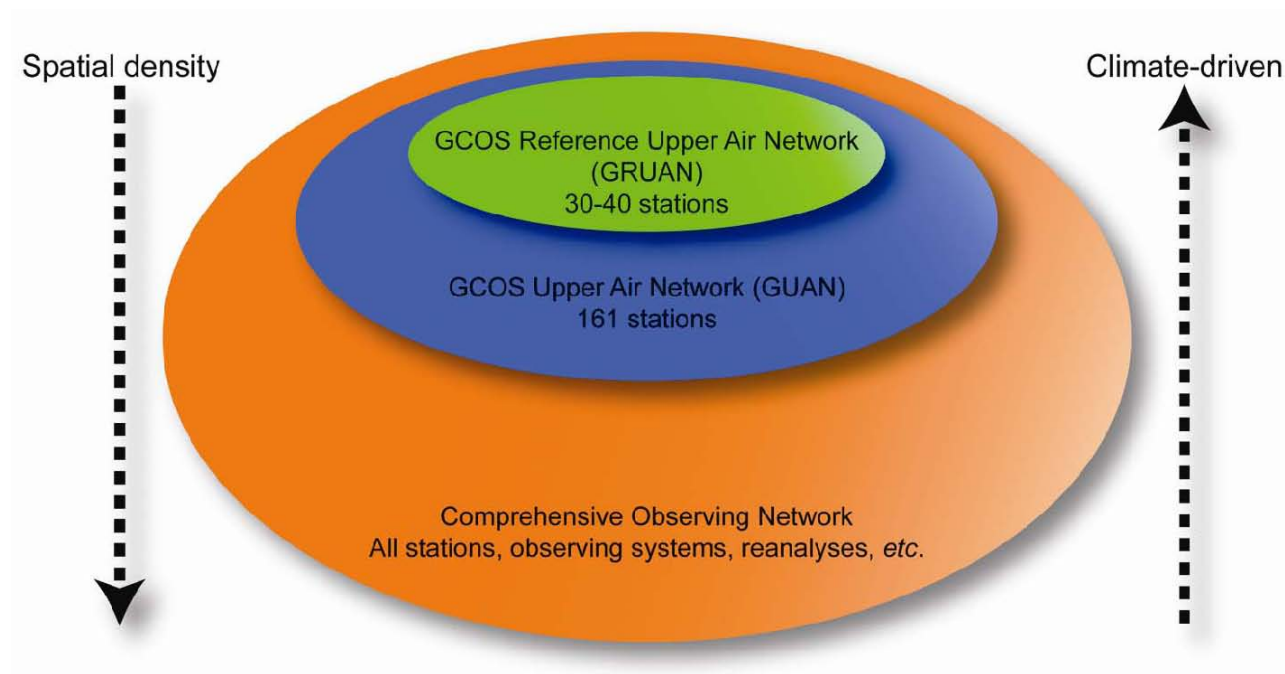


Fig. 4: GRUAN as part of a tiered set of networks – the comprehensive observing network here represents the WMO GOS (Fig. 1), with GUAN as a climate subset (Fig. 2) and GRUAN as the reference-quality climate network (Fig. 3).

2. Benefits of existing WMO Networks for GRUAN

The operation of existing WMO Networks in the past decades is providing invaluable expertise to the implementation of GRUAN in terms of, among others:

- Data dissemination and data policy issues
- Telecommunication and archiving issues
- Development of standard practices for instruments and network operations
- National support to observations in general
- Technical expertise and guidance
- Training and capacity building

WMO has developed a set of technical regulations, through the *WMO Basic Document Series No. 2, Technical Regulations (WMO-No. 49)*, and associated manuals and guides, which provide the organizational and operational backbone for coordinated and consistent observational data by all Member countries within the WMO Global Observing System. These manuals² and guides have been developed by expert teams under the WMO Technical Commissions (Commission for Basic Systems (CBS), the Commission for Climatology (CCI), and the Commission for Instruments and Methods of Observations (CIMO)). For example, they specify the timing of launches, site characteristics, methods of observation, calibration standards etc. Since a manual of operations for the GRUAN is yet to be developed, expertise by these technical bodies and the experience of its associated experts, possibly through the GRUAN Lead Centre, will be essential. The first draft outline for such a manual draws upon existing guidance material from, among others, WMO and BSRN, and then has placeholders for GRUAN-specific elements (cf ICM-1/doc. 7.1).

In addition to activities on the part of the WG ARO and the GRUAN Lead Centre, implementation of a GRUAN data dissemination strategy will benefit from expertise by WMO CBS expert teams, the WMO Information System (WIS) programme, with further details to be discussed at ICM-1 under item 5.

The organization of a major intercomparison campaign of operational and research radiosondes in the context of GRUAN is planned for 2010 under the joint auspices of the Lead Centre, GCOS and CIMO. CIMO will also play a key role in developing a calibration strategy for GRUAN. Indeed, formal links to CIMO exist since the President of the Commission (currently: Dr John Nash, UK) is a standing member of the WG ARO.

3. Benefits of GRUAN for existing WMO Networks

The GRUAN will provide reference-quality upper-air measurements for climate at a limited number of sites globally (see Fig. 3), and thus an anchor point for existing global networks, for both climate and non-climate purposes. GRUAN sites are also expected to be part of a global calibration and validation strategy for satellite data records and derived products (e.g., within GSICS). Since stringent requirements on calibration and quality control of data will be introduced at GRUAN sites, their implementation is set to be beneficial to the overall advancement of observational networks, and to spearhead the development of better measurement capabilities. Further, since GRUAN sites are encompassing a broad range of instruments, partly due to their collocation with existing sites in other networks (cf. Appendix 1), lessons to be learned from integrated analysis of the datasets taken at those sites can

² For example, the Manual on the Global Observing System (GOS) (WMO-No. 544)
http://www.wmo.int/pages/prog/www/OSY/Manuals_GOS.html

provide valuable insight for the integration of remotely-sensed and *in situ* observations within the context of WIGOS.

Most GRUAN initial and candidate sites are already part of the existing WMO networks, hence the benefit to these networks of augmenting these sites to conform with GRUAN requirements is apparent. Moreover, WMO has recognized the value of observing systems outside of the remit of national meteorological services, since “their data provide a valuable contribution to WMO Programmes”³ and to national meteorological services.

4. The WMO Integrated Global Observing System Initiative (WIGOS)

Endorsed by WMO Congress XV in 2007, the vision of WIGOS is to benefit society through enhanced availability and integration of global weather, climate and water observations contributed by constituent systems under the umbrella of the GOS. The purpose of WIGOS is to create an organizational, programmatic, procedural and governance structure that will significantly improve the availability of observational data and products and which will provide a single focus for the operational and management functions of all WMO observing systems as well as a mechanism for interactions with WMO co-sponsored observing systems (e.g., GCOS).

Integration in the context of WIGOS should be defined as establishment of a comprehensive, coordinated and sustainable system of observing systems, ensuring interoperability between its component systems. It will be an organizational framework facilitating standardization and interoperability and ensuring availability of, and access to, good-quality data and products, and associated metadata.

The key areas of integration have been defined⁴:

1. Standardization of instruments and methods of observations
2. WMO Information System infrastructure
3. End product quality assurance

Some of the operational goals of WIGOS are to:

- Facilitate improved data management including archival and data retrieval capabilities;
- Facilitate technological innovation opportunities;
- Continue on-going coordination with instrument manufacturers and scientific institutes in the development and testing of next generation observation instruments;
- Develop appropriate regulatory documentation including organization and recommended practices and procedures.

Some of the data availability goals of WIGOS are to:

- Facilitate access, in real/near-real time and delayed mode, of observations required for WMO and WMO co-sponsored programmes
- Build on the WMO Information System (WIS; one building block thereof being the Global Telecommunication System)
- Respect data sharing policies of its components, including those for real, near-real time and delayed modes
- Increase interoperability between systems with particular attention given to space-based and in-situ components of the systems

³ WIGOS Development and Implementation Plan, version 1.1.1, November 2008, EC-WG/SG-WIGOS-1, Final Report, Appendix XV

⁴ WIGOS Concept of Operations, version 1.1.1, November 2008, EC-WG/SG-WIGOS-1, Final Report, Appendix XIV

5. WIGOS Pilot Projects

The WIGOS Pilot Projects (WPPs) are designed to test concepts of integration and identify problem areas. Each WPP should have a realistic, i.e. not overly ambitious, implementation plan with clearly defined time frame, tasks, activities and achievable deliverables and deadlines for each individual phase, taking into account existing guidance⁵ and using the template given in Appendix 2. Activities of WPPs begun in the period 2007-2009 should be completed, and be evaluated by the WMO Executive Council and its sub-groups, by June 2010.

In the case of GRUAN, a Project could focus on a particular GRUAN site or small number of sites, or a particular aspect of GRUAN implementation.

Being part of the phased implementation of WIGOS leading up to WMO Congress XVI in May 2011, the status of Pilot Projects has to be regularly reported to WMO Executive Council through its Sub-Group on WIGOS (Chair: Dr John Nash, UK), as well as to relevant WMO Technical Commissions, such as CBS. This work would have to be done either by the GRUAN Lead Centre, the GCOS Secretariat, members of the WG ARO or whoever from the GRUAN community would be most involved in the Project. Guidance and some support to reporting duties will be provided by the WIGOS Planning Office in the OBS Department at WMO Secretariat (Head: Dr Wenjian Zhang; Planning Officer: Igor Zahumenský). Limited resources are allocated by the WIGOS Planning Office to Pilot Projects to support meetings and travel by participants. New Projects can still be initialized until June 2009.

The WMO CBS Implementation Coordination Team on the Integrated Observing Systems (ICT-IOS; Chair: Dr James Purdom, USA) in September 2008 noted that a GRUAN Pilot Project could make a significant contribution to the development of WIGOS, since implementation of the GRUAN was in the spirit of existing WIGOS Pilot Projects. The Team recommended that the groups overseeing GRUAN consider following the example by the other Pilot Projects. On the other hand, the ICT-IOS concluded that it was premature for CBS to endorse the implementation of GRUAN before GCOS provided clarification of how the GRUAN would be established in the context of the WMO GOS.

The following Pilot Projects are currently underway:

- *Pilot Project I:* Joint GOS-GAW Pilot Project to accelerate implementation of WIGOS/WIS;
- *Pilot Project II:* Initiation of Global Hydrological Network addressing a GCOS Requirement;
- *Pilot Project III:* Integration of Airborne Meteorological Data Relay (AMDAR) into WIGOS;
- *Pilot Project IV:* Elaboration of the underpinning/crosscutting role and responsibilities of the Instruments and Methods of Observation Programme in the context of WIGOS;
- *Pilot Project V:* Integration of Marine Meteorological and other appropriate Oceanic Observations into the WMO Global Observing System.

6. Discussion: Should GRUAN or part of its implementation become a WIGOS Pilot Project?

In a teleconference in August 2008 between the GRUAN Lead Centre, the WG ARO Chair, the WMO CBS Rapporteur on GCOS Matters (Dr Matthew Menne, National Climatic Data Center, USA) and the GCOS Secretariat, it was decided to discuss this issue at the GRUAN ICM-1.

⁵ WIGOS Development and Implementation Plan, version 1.1.1, November 2008, EC-WG/SG-WIGOS-1, Final Report, Appendix XV

Action items in the current GRUAN work plan that could be designated a Pilot Project

Action items in the current GRUAN work plan (GCOS-121, section 6) relate to the key areas of integration in WIGOS (and thus, possible areas for a Pilot Projects) in the following way:

Area 1: Standardization of instruments and methods of observation

- item 4: Planned radiosonde intercomparison campaign in 2010
- item 5: Development of a GRUAN manual of operational practices

Area 2: WMO Information Systems Infrastructure

- item 11: Development of GRUAN data dissemination practices

Area 3: End product quality assurance

- Item 3: Development of a strategy to detect change in quality at GRUAN sites;
- item 8: Resolve QC/QA procedures

Possible opportunities of designating GRUAN or a part thereof as a WIGOS Pilot Project:

- Some action items in the GRUAN work plan clearly need expertise and support by WMO, such as by its Technical Commissions; a formal link through a WIGOS PP can help facilitate these actions
- The prospect to tap funds reserved for WIGOS for GRUAN purposes; the yearly WG ARO meeting, the GRUAN ICM or resources needed to carry out GRUAN work plan items could possibly be supported that way
- GRUAN implementation will have a formal link to the WMO Observing Systems and WIGOS (with mutual benefits as given in section 2 and 3), and will contribute to the integration of different observing systems; GRUAN operations need to be coordinated with other upper-air observing networks
- GCOS and the WG ARO demonstrate commitment to collaborate with its sponsor WMO, leading to higher visibility and support at the level of WMO constituent bodies, Technical Commissions (CBS, CIMO) and their expert teams
- Successful steps in implementing GRUAN should be broadly communicated; showcasing milestones to WMO constituent and technical bodies help raise the profile of GCOS and benefits WMO itself
- Being a WIGOS pilot project or part of WIGOS would have no implications on GRUAN data policy in terms of data delivery: the WIGOS Concept of Operations states explicitly that WIGOS “*respects data sharing policies of its components, including those for real, near-real time and delayed modes*”

Possible drawbacks of designating GRUAN or a part thereof as a WIGOS Pilot Project:

- Not immediately clear if benefits (direct and in-kind support) at least match overhead
- WIGOS concept and implementation are themselves in a development stage and therefore not particularly specific
- Some WMO funds are available for WIGOS, but no guarantee for availability in support of GRUAN

- Additional administrative workload and meeting time on GRUAN Lead Centre, GCOS Secretariat, Chair WG ARO, others in GRUAN community
- GRUAN is in its initial stage of implementation and cannot promise too much in the next two years in terms of real measurements
- Specification of a WIGOS Pilot Project could possibly be done at a later stage, once the GRUAN has constituted itself and made real progress in implementation

Appendix 1

Collocation of GRUAN sites with other Network Sites

(cf. GCOS-121, Appendix IV)

('Conf'd' (confirmed site) as of 10 February 2009, cf ICM-1/doc 4.0)

No.	Station Name and Country	Conf'd?	GUAN	BSRN	NDACC	SHADOZ	GAW
Initial GRUAN Sites							
1	Darwin, Australia		X (94120 ⁶)	X			X
2	Xilinhote, China	Y					
3	Sodankylä, Finland	Y	X (2836)		X		X (G)
4	Lindenberg, Germany	Y	X (10393)	X			X
5	Potenza, Italy	Y					
6	Cabauw, Netherlands	Y		X			
7	Lauder, New Zealand			X	X (P)		X (G)
8	Payerne, Switzerland	Y	X (6610)	X	X		X
9	Barrow, AK, USA		X (70026)	X			X (G)
10	Beltsville, MD, USA			Two BSRN close by (Chesapeake Lt., USA; Rock Springs, PA, USA)			X
11	Boulder, CO, USA			X			X
12	Lamont, Southern Great Plains, OK, USA		X (72451 Dodge City/Mun., KS, USA)	X			X
Potential GRUAN Sites							
13	Comodoro Rivadavia, Argentina		X (87860)				X
14	Cape Grim, Australia						X (G)
15	Macquarie Island, Australia		X (94998)		X		X
16	Norfolk Island, Australia		X (94996)				X
17	Punta Arenas, Chile		X (84934)				X
18	Alajuela, Costa Rica		X (78762 Juan Santa Maria Airport)			X	X (Here-dia)
19	Penrhyn, Cook Islands		X (91801)				X (Raro-tonga)
20	San Cristobal/ Galapagos, Ecuador		X (84008)			X	X
21	Watukosek, Indonesia		x (96935 Surabaya)			X	X
22	Mace Head, Ireland						X (G)
23	Nairobi/Dagoretti, Kenya		X (63741)			X	X
24	Kuala Lumpur, Malaysia					X	X (Se-pang Airport)
25	Gan, Maldives		X (43599)				X
26	Windhoek, Namibia		X (68110)				
27	Nauru, Nauru			X			X

28	Chatham Island, New Zealand		X (93986)				X
29	Spitsbergen, Ny Alesund, Norway			X	X (P)		X (G)
30	Port Moresby W.O., Papua New Guinea		X (92035)				
31	Manus, Papua New Guinea			X			
32	Pico/Azores, Portugal		X (8508 Lajes/Santa Rita)				X (Santa Maria)
33	Tiksi, Russian Federation						X
34	Nizhnij Novgorod, Russian Federation		X (27459)				
35	Dakar, Senegal		X (61641)				
36	Paramaribo, Suriname				X	X	X
37	Jeju Island, South Korea						X (Cheju)
38	Valladolid, Spain						
39	Izana/Canarias, Spain		X (60018 Tenerife/Guimar)				x (G)
40	Dar es Salaam, Tanzania		X (63894)				
41	Camborne, UK		X (3808)	X			X
42	Amundsen-Scott, Antarctica (Station operated by the USA)		X (89009)	X (South Pole)	X (P)		X (G, South Pole)
43	Bauerfield, Vanuatu		X (91557)				

Appendix 2

**Pilot Project (PP) Proposal Template
Implementation of GRUAN**

Project Name	
Acronym	
Project Type	
Project Status	
Project Overview	
Project Aims	
Partners/Participants	
Project cost	
Funding Source(s)	
Project Timescale	
Expected Key Deliverables	
Project Links	
Project Summary	
Date of Last Update	
Contact Person	